SEMESTER -3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET201	**CIRCUITS AND NETWORKS**	**PCC**	**2**	**2**	**0**	**4**

Preamble : This course introduces circuit analysis techniques applied to dc and ac electric circuits. Analyses of electric circuits in steady state and dynamic conditions are discussed. Network analysis is introduced with network parameters and transfer functions. This course serves as the most important prerequisite of all many advanced courses in electrical engineering.

Prerequisite : **Basics of Electrical Engineering / Introduction to Electrical Engineering**

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Apply circuit theorems to simplify and solve complex DC and AC electric networks.
CO 2	Analyse dynamic DC and AC circuits and develop the complete response to excitations.
CO 3	Solve dynamic circuits by applying transformation to s-domain.
CO 4	Analyse three-phase networks in Y and Δ configurations.
CO 5	Solve series /parallel resonant circuits.
CO 6	Develop the representation of two-port networks using network parameters and analyse.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2
CO 5	3	3										2
CO 6	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State and explain network theorems (K1)
2. Problems on solving circuits using network theorems. (K2, K3)

Course Outcome 2 (CO2):

1. Distinguish between the natural response and forced response. (K2, K3)
2. Problems on steady state and transient analysis of RL, RC and RLC series circuits with DC excitation and initial conditions. (K2, K3)
3. Problems on steady state and transient analysis of RL, RC and RLC series circuits with sinusoidal excitation. (K2, K3)

Course Outcome 3 (CO3):

1. Problems on mesh analysis and node analysis of transformed circuits in s-domain (K2, K3).
2. Problems on solution of transformed circuits including mutually coupled circuits in s-domain (K2, K3).

Course Outcome 4 (CO4):

1. Problems on analysis of unbalanced Y and Δ configurations. (K2, K3)
2. Evaluation of neutral shift voltage in unbalanced systems. (K2, K3).

Course Outcome 5 (CO5):

1. Define Bandwidth, and draw the frequency dependence of impedance of an RLC network. (K1).
2. Develop the impedance/admittance Vs frequency plot for the given RLC network. (K2).
3. Evalutate the parameters such as quality factor, bandwidth,

Course Outcome 6 (CO6):

1. Problems on finding Z, Y, h and T parameters of simple two port networks. (K2).
2. Derive the expression for Z parameters in terms of T parameters. (K1).
3. Show that the overall transmission parameter matrix for cascaded 2 port network is simply the matrix product of transmission parameters for each individual 2 port network in cascade. (K1).

Model Question paper

QP CODE:

PAGES:4

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET 201

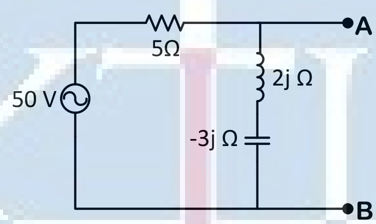
Course Name: CIRCUITS AND NETWORKS

Max. Marks: 100 Duration: 3 Hours

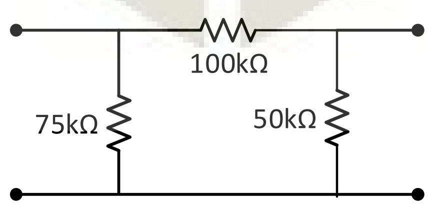
PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. State and explain superposition theorem using an example.
2. Obtain Thevenin's equivalent for the following circuit w.r.t terminals A and B:



3. Define time constant of a circuit. What is the time constant of an RL circuit?
4. How are RLC networks classified according to damping ratios? Sketch the various responses when an RLC series circuit is excited by a DC source.
5. Explain the dot convention used in coupled circuits.
6. Derive the s-domain equivalent circuit of an inductor carrying an initial current of Io.
7. Describe the variation of impedance and phase angle as a function of frequency in a series RLC circuit.
8. Define quality factor. Derive quality factor for inductive and capacitive circuits.
9. Derive the condition for symmetry & reciprocity in terms of T parameters.
10. Obtain Y parameters of the following network:

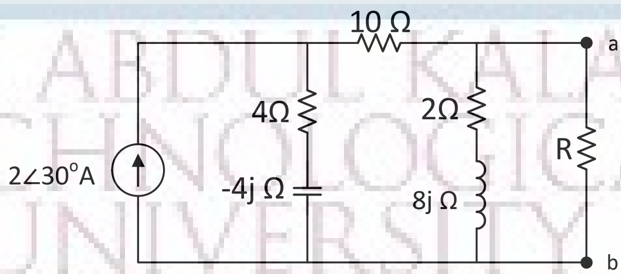


PART B (14 x 5 = 70 Marks)

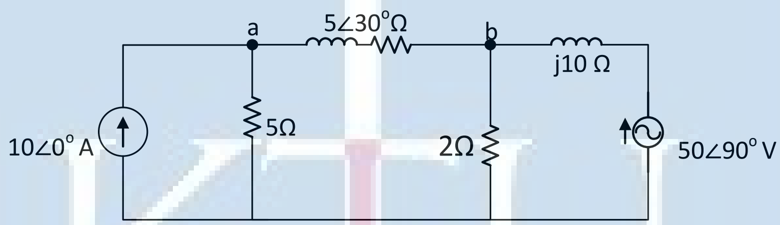
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. With respect to the following circuit,
    a) Find the value of Resistor 'R' that results in maximum power transfer to it. **(10)**
    b) Find the value of maximum power transferred to 'R'. **(4)**

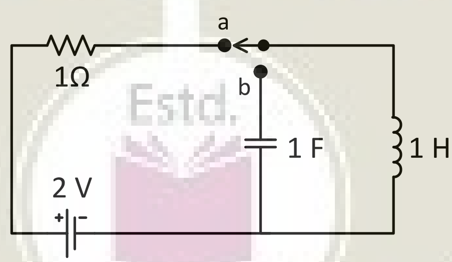


12. With respect to the following circuit,
    a) Find the voltages at 'a' and 'b' using superposition theorem. **(10)**
    b) Obtain the active power dissipated in 5∠30°Ω impedance. **(4)**

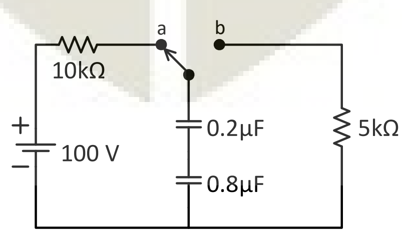


Module 2

13. a) In the following circuit, steady state exits when switch is in position 'a'. At time t = 0, the switch is moved to position 'b' .Obtain an expression for inductor current for time t > 0 **(6)**

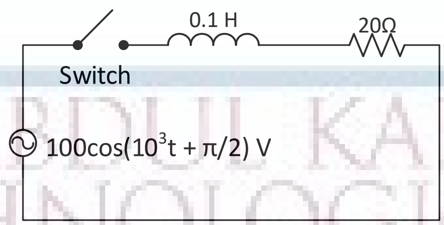


b) For the following circuit, switch 'S' is in position 'a' for a very long time. At time t = 0, the switch is thrown to position 'b'. Find the expression for current through 5kΩ. **(8)**



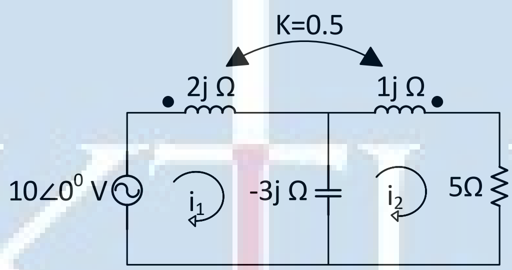
14. a) Given an RC circuit with zero initial charge on capacitor. Find the expression forcurrent after a DCsource 'V_{DC}' is applied to the RC network. Also determine thetime constantofthe circuit. **(4)**

b) Obtain an expression for current in the following circuit after switch is closed attime t=0. Use Laplace transform method. **(10)**

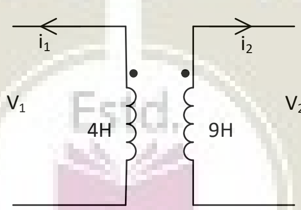


Module 3

15. a) For the following coupled circuit, the coupling coefficient, K =0.5. Write the KVL equations for currents i_1 and i_2. Also obtain the voltage drop across 5Ω resistor. **(10)**



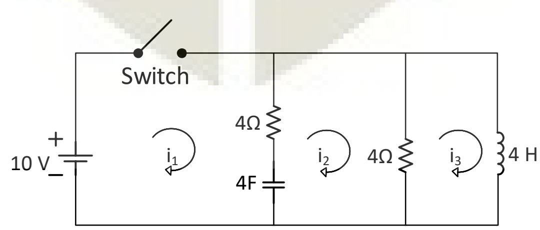
b) In figure, L_1=4H, L_2=9H, coefficient of coupling K=0.5,i_1 = 5 cos(50t-300) Amps, i_2 = 2cos(50t-300) Amps. Write the KVL equations for V_1 and V_2. Find their values at t=0 **(4)**



16. In the circuit shown, at time t = 0, the switch was closed.

a. Model the circuit in s-domain for time t > 0. **(4)**

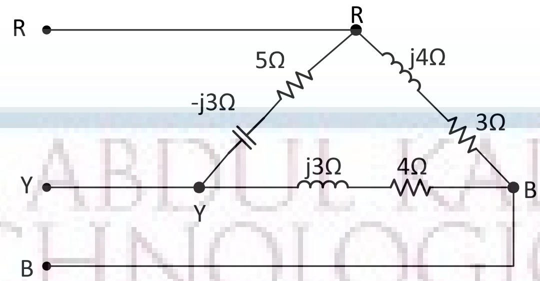
b. Through mesh analysis, obtain the time domain values of values of i_1, i_2 and i_3 Given that the capacitor and inductor were initially relaxed. **(10)**



Module 4

17. The following load is delta connected to a 100V three phase system. Find the phase currents, line currents and total power consumed by the load.

(14)



18. An unbalanced 4 wire, star connected load is connected to a balanced voltage of 400V.
The loads are: $Z_1 = (3 + 6j)\Omega; Z_2 = (2 + 2j)\Omega; Z_3 = (14 + 18j)\Omega$
Calculatea) Line currents **(4)**

b) Current in neutral wire **(4)**

c) Total power **(6)**

Module 5

19. a) Discuss series and parallel interconnection of 2-port networks.

(7)

b) Derive the inter-relationship between Z and Y parameters.

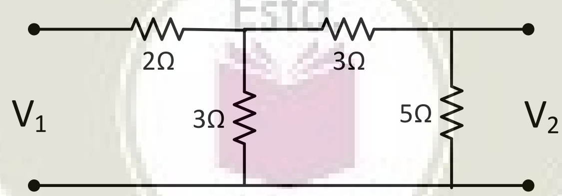
(7)

20. a) A network is given as $I_1 = 2.5V_1 - V_2; I_2 = -V_1 + 5V_2$
Draw its equivalentπ network.

(4)

b) Obtain h parameters of the following network:

(10)



Syllabus

Module 1

Circuit theorems: DC and Sinusoidal steady state analysis of circuits with dependent and independent sources applying Superposition principle, Source transformation, Thevenin's, Norton's and Maximum Power Transfer theorems - Reciprocity theorem.

Module 2

Analysis of first and second order dynamic circuits: Formulation of dynamic equations of RL, RC and RLC series and parallel networks with dc excitation and initial conditions and complete solution using Laplace Transforms - Time constant - Complete solution of RL, RC and RLC circuits with sinusoidal excitation using Laplace Transforms – Damping ratio – Over damped, under damped, critically damped and undamped RLC networks.

Module 3

Transformed circuits in s-domain: Transform impedance/admittance of R, L and C - Mesh analysis and node analysis of transformed circuits in s-domain. Transfer Function representation – Poles and zeros.

Analysis of Coupled Circuits: – Dot polarity convention – Sinusoidal steady state analysis of coupled circuits - Linear Transformer as a coupled circuit - Analysis of coupled circuits in s-domain.

Module 4

Three phase networks and resonance: Complex Power in sinusoidal steady state. Steady state analysis of three-phase three-wire and four-wire unbalanced Y circuits, Unbalanced Delta circuit, Neutral shift.

Resonance in Series and Parallel RLC circuits – Quality factor – Bandwidth – Impedance Vs Frequency, Admittance Vs Frequency, Phase angle Vs frequency for series resonant circuit.

Module 5

Two port networks: Driving point and transfer functions – Z, Y, h and T parameters **-** Conditions for symmetry & reciprocity – relationship between parameter sets – interconnections of two port networks (series, parallel and cascade) — T-π transformation.

Text Books

1. Joseph A. Edminister and MahmoodNahvi, "Theory and Problems in Electric circuits", McGraw Hill, 5th Edition, 2010.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

References:

1. Hayt and Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, New Delhi, 8th Ed, 2013.
2. Van Valkenberg, "Network Analysis", Prentice Hall India Learning Pvt. Ltd., 3 edition, 1980.
3. K. S. Suresh Kumar, "Electric Circuit Analysis", Pearson Publications, 2013.
4. Chakrabarti, "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018
5. R. Gupta, "Network Analysis and Synthesis", S. Chand & Company Ltd, 2010.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Network theorems - DC and AC steady state analysis (12 hours)**	
1.1	Linearity and Superposition principle - Application to the analysis of DC and AC (sinusoidal excitation) circuits. Application of source transformation in electric circuit analysis.	2
1.2	Thevenin's theorem - Application to the analysis of DC and AC circuits with dependent and independent sources.	3
1.3	Norton's theorem - Application to the analysis of DC and AC circuits with dependent and independent sources.	3
1.4	Maximum power transfer theorem - DC and AC steady state analysis with dependent and independent sources.	2
1.5	Reciprocity Theorem - Application to the analysis of DC and AC Circuits.	2
2	**First order and second order dynamic circuits. (9 hours)**	
2.1	Review of Laplace Transforms – Formulae of Laplace Transforms of common functions/signals, Initial value theorem and final value theorem, Inverse Laplace Transforms – partial fraction method. *(Questions to evaluate the Laplace/inverse transforms of any function / partial fractions method shall not be given in tests/final examination. Problems with application to circuits can be given).*	2
2.2	Formulation of dynamic equations of RL series and parallel networks and solution using Laplace Transforms – with DC excitation and initial	1

	conditions. Natural response and forced response. Time constant.	
2.3	Formulation of dynamic equations of RC series networks and solution using Laplace Transforms – with DC excitation and initial conditions. Natural response and forced response. Time constant.	1
2.4	Formulation of dynamic equations of RLC series networks with DC excitation and initial conditions, and solution using Laplace Transforms – Natural response and forced response. Damping coefficient. Underdamped, Overdamped, critically damped and undamped cases.	1
2.5	Formulation of dynamic equations of RL, RC and RLC series networks and solution with sinusoidal excitation. Complete solution (Solution using Laplace transforms).	2
2.6	Formulation of dynamic equations of RL, RC and RLC parallel networks and solution using Laplace Transforms – with DC and Sinusoidal excitations. Damping ratio.	2
3	**Transformed Circuits in s-domain and Coupled circuits (9 Hours)**	
3.1	Transformed circuits in s-domain: Transformation of elements (R, L, and C) with and without initial conditions.	2
3.2	Mesh analysis of transformed circuits in s-domain.	1
3.3	Node analysis of transformed circuits in s-domain.	1
3.4	Transfer Function representation – Poles and zeros.	1
3.5	Analysis of coupled circuits: mutual inductance – Coupling Coefficient- Dot polarity convention — Conductively coupled equivalent circuits. Linear Transformer as a coupled circuit.	2
3.6	Analysis of coupled circuits in s-domain.	2
4	**Three phase networks and resonance. (6 Hours)**	
4.1	Review of power, power factor, reactive and active power in sinusoidally excited circuits. Concept of complex power.	1
4.2	Steady state analysis of three-phase unbalanced 3-wire and 4-wire Y circuits, Unbalanced Δ circuits, Neutral shift.	2
4.3	Resonance in Series and Parallel RLC circuits – Quality factor – Bandwidth – Impedance Vs Frequency, Admittance Vs Frequency and Phase angleVs frequency for series resonant circuit.	3

5	**Two port networks (9 Hours)**	
5.1	Two port networks: Terminals and Ports, Driving point and transfer functions. Voltage transfer ratio, Current transfer ratio, transfer impedance, transfer admittance, poles and zeros.	2
5.2	Z –parameters. Equivalent circuit representation.	1
5.3	Y parameters. Equivalent circuit representation.	1
5.4	h parameters. Equivalent circuit representation.	1
5.5	T parameters.	1
5.6	Conditions for symmetry & reciprocity, relationship between network parameter sets.	1
5.7	Interconnections of two port networks (series, parallel and cascade).	1
5.8	T-π Transformation.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET203	**MEASUREMENTS AND INSTRUMENTATION**	PCC	**3**	**1**	**0**	**4**

Preamble : This course introduces principle of operation and construction of basic instruments for measurement of electrical quantities. Measurement of basic circuit parameters, magnetic quantities, and passive parameters by using bridge circuits, sensors and transducers will be discussed.Familiarization of modern digital measurement systems are also included.

Prerequisite :**Nil**

Course Outcomes :After the completion of the course the student will be able to

CO 1	Identify and analysethe factors affecting performance of measuring system
CO 2	Choose appropriate instruments for the measurement of voltage, current in ac and dc measurements
CO 3	Explain the operating principle of power and energy measurement
CO 4	Outline the principles of operation of Magnetic measurement systems
CO 5	Describe the operating principle of DC and AC bridges, transducersbased systems.
CO 6	Understand the operating principles of basic building blocks of digital systems, recording and display units

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	1	-	-	-	-	-	-	2
CO 6	3	-	-	-	2	-	-	-	-	-	-	2

Assessment Pattern

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	15	20	30
Understand	20	20	50
Apply	15	10	20
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Explain static characteristics of measuring systems.
2. Problems related to measurement errors.
3. Concept of calibration of measuring instruments

Course Outcome 2 (CO2):

1. Explain the construction and working indicating Instruments.
2. Problems related to extension of range of meters

Course Outcome 3(CO3):

1. Describe the principle of operation and construction of energy meter
2. Describe the principle of operation and construction of wattmeter
3. Problems related to two and three wattmeter method of power measurement.

Course Outcome 4 (CO4):

1. Explain the principle of operation of ballistic galvanometer.
2. Describe the procedure for plotting the B-H curve of a magnetic specimen.

Course Outcome 5 (CO5):

1. Explain classification of Transducers
2. Measurement of frequency using Wien bridge.
3. Explain the operation of basic ac/dc bridges
4. Illustrate the principle of temperature measurement using thermocouple.

Course Outcome 6 (CO6):

1. Block diagram of DMM, CRO, DSO, PMU
2. Basic ideas on simulation softwares and virtual instrumentation.
3. Explain the operation of basic ac/dc bridges

Model Question paper
QPCODE: PAGES:3

Reg.No:____________

Name :_____________

APJABDULKALAMTECHNOLOGICALUNIVERSITY THIRD SEMESTERB.TECHDEGREEEXAMINATION,

MONTH &YEAR

Course Code: EET 203

Course Name: Measurements and Instrumentation

Max.Marks:100 **Duration: 3Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. What are the different standards of measurement?
2. State and briefly explain the classification of electrical measuring instruments.
3. What are the special features incorporated in low power factor wattmeter?
4. Write short note on three phase energy meter.
5. Describe the working of hall effect sensors.
6. With the help of a diagram indicate the calibration of wattmeter using DC potentiometer.
7. Describe the method of determination of BH curve of a magnetic material.
8. What are the main requirements in magnetic measurements?
9. Explain briefly about digital voltmeter.
10. What is lissajouspattern. Indicate the factors on which shape of these figures depends.

(10x3=30)

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

1. (a) Explain the essentials of indicating instruments and what are the different methods of producing controlling torque in an analog instrument? **(6)**

(b) Explain with the help of neat sketches, the construction and working of attraction type moving iron instruments. Give the equation for torque of the MI instrument and the merits and demerits. **(8)**

2. (a) Discuss different types of damping. What is the necessity of damping and how damping is provided in PMMC instrument? **(8)**

(b) A moving coil ammeter has fixed shunt of 0.01Ω. With a coil resistance of 750Ω and a voltage drop of 500mV across it, the full scale deflection is obtained. (1) Calculate current through shunt (2) Calculate resistance of meter to give full scale deflection if shunted current is 60A. **(6)**

Module 2

3. (a) Derive the expression for transformation ratio and phase angle of a current transformer using its equivalent circuit and phasor diagram. **(14)**

4. (a) Explain the construction and operation of dynamometer type wattmeter. **(7)**

(b) With a neat block diagram, explain the working of electronic energy meter. What are its merits compared to induction type energy meter. **(7)**

Module 3

5. (a) Draw the circuit and phasor diagram of schering bridge for the measurement of capacitance, Derive the expression for the unknown capacitance.**(10)**

(b) Explain loss of charge method for the measurement of high resistance. **(4)**

6. (a) Explain with the help of neat connection diagram how you would determine the value of low resistance by kelvin's double bridge method. Derive the formula used. **(7)**

(b) Describe the method of measurement of earth resistance and what are the factors which affect the value of earth resistance? **(7)**

Module 4

7. (a)Explain the method of measurement of permeability. **(5)**

(b) What is the principle of temperature measurement using thermistors and compare temperature measurement using RTD and thermistor. **(9)**

8. (a) Explain the working of flux meter. **(4)**

(b) What is a Llyod- Fisher square. Explain the measurement of iron losses in a magnetic material employing Llyod- Fisher square using wattmeter method. **(10)**

Module 5

9. (a) With the help of a neat sketch explain the working of LVDT. Also draw its characteristics. **(6)**

   (b) Explain how CRO can be used to measure the frequency and phase angle. **(8)**

10. (a) How strain is measured using strain gauge. **(4)**

    (b) With a neat diagram, explain the working of a digital storage oscilloscope. **(10)**

(14x5=70)

Syllabus

Module 1

Measurement standards–Errors-Types of Errors- Statistics of errors, Need for calibration.

Classification of instruments, secondary instruments–indicating, integrating and recording-operating forces - essentials of indicating instruments - deflecting, damping, controlling torques.

Ammeters and voltmeters - moving coil, moving iron, constructional details and operation, principles shunts and multipliers – extension of range.

Module 2

Measurement of power: Dynamometer type wattmeter –Construction and working - 3-phase power measurement-Low Powerfactor wattmeters.

Measurement of energy: Induction type watt-hour meters- Single phase energy meter – construction and working, two element three phase energy meters,

Digital Energymeters -Time of Day(TOD) and Smart metering (description only).

Current transformers and potential transformers – principle of working -ratio and phase angle errors.

Extension of range using instrument transformers, Hall effect multipliers.

Module 3

Classification, measurement of low, medium and high resistance- Ammeter voltmeter method(for low and medium resistance measurements)-Kelvin's double bridge-Wheatstones bridge- loss of charge method, measurement of earth resistance.

Measurement of self inductance-Maxwell's Inductance bridge, Measurement of capacitance –Schering's, Measurement of frequency-Wien's bridge.

Calibration of Ammeter, Voltmeter and Wattmeter using DC potentiometers.

High voltage and high current in DC measurements- voltmeters, Sphere gaps, DC Hall effect sensors.

Module 4

Magnetic Measurements: Measurement of flux and permeability - flux meter, BH curve and permeability measurement - hysteresis measurement- ballistic galvanometer – principle- determination of BH curve - hysteresis loop. Lloyd Fisher square — measurement of iron losses.

Measurement luminous intensity-Photoconductive Transducers-Photovoltaic cells

Temperature sensors-Resistance temperature detectors-negative temperature coefficient Thermistors-thermocouples-silicon temperature sensors.

Module 5

Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge.

Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques.

Digital voltmeters and frequency meters using electronic counters, DMM, Clamp on meters.

Phasor Measurement Unit (PMU) (description only).

Introduction to Virtual Instrumentation systems- Simulation software's (description only)

Text Books

1. Sawhney A.K., A course in Electrical and Electronic Measurements & instrumentation, DhanpatRai.
2. J. B. Gupta, A course in Electrical & Electronic Measurement & Instrumentation., S K Kataria& Sons
3. Kalsi H. S., Electronic Instrumentation, 3/e, Tata McGraw Hill, New Delhi, 2012
4. S Tumanski, Principles of electrical measurement, Taylor & Francis.
5. David A Bell, Electronic Instrumentation and Measurements,3/e, Oxford

Reference Books

1. Golding E.W., Electrical Measurements & Measuring Instruments, Wheeler Pub.
2. Cooper W.D., Modern Electronics Instrumentation, Prentice Hall of India
3. Stout M.B., Basic Electrical Measurements, Prentice Hall
4. Oliver & Cage, Electronic Measurements & Instrumentation, McGraw Hill
5. E.O Doebelin and D.N Manik, Doebelin's Measurements Systems, sixth edition, McGraw Hill Education (India) Pvt. Ltd.
6. P.Purkait, B.Biswas, S.Das and C. Koley, Electrical and Electronics Measurements and Instrumentation, McGraw Hill Education (India) Pvt. Ltd.,2013

Course Contents and Lecture Schedule

Module	Topic coverage	No. of Lectures	No of hours
1	**General principles of measurements and classification of meters**		
1.1	Measurement standards–Errors-Types of Errors- Statistics of errors, Need for calibration.	3	**10**
1.2	Classification of instruments, secondary instruments–indicating, integrating and recording- operating forces -	1	
1.3	Essentials of indicating instruments - deflecting, damping, controlling torques.	3	
1.4	Ammeters and voltmeters - moving coil, moving iron, constructional details and operation, principles shunts and multipliers – extension of range.	3	
2	**Measurement of Resistance, Power and Energy**		
2.1	Measurement of power: Dynamometer type wattmeter – Construction and working - 3-phase power measurement-Low Powerfactorwattmeters.	3	**09**
2.2	Measurement of energy: Induction type watt-hour meters-Single phase energy meter – construction and working, two element three phase energy meters, Digital Energymeters - Time of Day (TOD) and Smart metering (description only).	3	
2.3	Current transformers and potential transformers – principle of working -ratio and phase angle errors. Extension of range using instrument transformers, Hall effect multipliers.	3	
3	**Measurement of circuit parameters using bridges, High voltage and high current measurements**		
3.1	Classification of resistance, low resistance, Ammeter voltmeter method, Kelvin's double bridge Medium resistance- Ammeter voltmeter method - Wheatstones bridge High resistance- loss of charge method- measurement of earth resistance.	3	**09**
3.2	Measurement of self inductance-Maxwell's Inductance bridgeMeasurement of capacitance–Schering's bridge Measurement of frequency-Wien's bridge.	2	
3.3	Calibration of Ammeter, Voltmeter and Wattmeter using DC potentiometers.	2	
3.4	High voltage and high current in DC measurements-voltmeters, Sphere gaps, DC Hall effect sensors.	2	

4	**Magnetic, Lumen and Temperature Measurements**		
4.1	Measurement of flux and permeability - flux meter, BH curve and permeability measurement - hysteresis measurement	2	08
4.2	Ballistic galvanometer – principle- determination of BH curve - hysteresis loop. Lloyd Fisher square - measurement of iron losses.	2	
4.3	Measurement luminous intensity-Photoconductive Transducers-Photovoltaic cells	2	
4.4	Temperature sensors-Resistance temperature detectors-negative temperature coefficient Thermistors-thermocouples-silicon temperature sensors.	2	
5	**Transducers and Digital instruments including modern recording and displaying instruments**		
5.1	Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge.	2	09
5.2	Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques.	3	
5.3	Digital voltmeters and frequency meters using electronic counters, DMM, Clamp on meters.	2	
5.4	Phasor Measurement Unit (PMU) (description only). Introduction to Virtual Instrumentation systems-Simulation software's (description only)	2	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET205	**ANALOG ELECTRONICS**	PCC	3	1	0	4

Prerequisite: Fundamentals of Electronics and semiconductor devices

CO 1	Design biasing scheme for transistor circuits.
CO 2	Model BJT and FET amplifier circuits.
CO 3	Identify a power amplifier with appropriate specifications for electronic circuit applications.
CO 4	Describe the operation of oscillator circuits using BJT.
CO 5	Explain the basic concepts of Operational amplifier(OPAMP)
CO 6	Design and developvarious OPAMP application circuits.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2	2									
CO 2	2	2	2									
CO 3			1	2								
CO 4	2	2	2									
CO 5			1	2								
CO 6	2	2	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	50
Apply	20	20	40
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the different types of biasing methods.(K1,K2)
2. Comment on the effect of Bandwidth and slew rate in Op-amp performance.
3. Draw the Small signal equivalent of differential amplifier and derive the equations for Input resistance, Voltage gain, CMRR.

Course Outcome 2 (CO2):

1. Analyse JFET and MOSFET characteristics.
2. Choose a power amplifier with appropriate specifications for electronic circuit applications.
3. List the features of Instrumentation amplifier.
4. What are the various op-amp feedback configurations? Explain each.
5. Explain the following op-amp circuits with neat sketches also find the output voltage equations
   - **a.** Summing amplifiers
   - **b.** Scaling amplifiers
   - **c.** Averaging amplifiers

Course Outcome 3(CO3):

1. Discuss the different feedback topologies.
2. Analyse the properties of an ideal op-amp.
3. Describe the working of Voltage to current converter using op-amp.
4. Draw the circuit diagrams for Log and antilog amplifier and obtain its output equations.
5. With necessary waveforms and neat diagram explain the working of Schmitt Trigger.
6. Design a Wein Bridge oscillator for a gain of 3 and oscillating frequency of 2kHz.

Course Outcome 4 (CO4):

1. Draw the Small signal equivalent of differential amplifier and derive the equations for Input resistance, Voltage gain, CMRR. (K1, K2)
2. Design various basic op-amp circuits. (K2)
3. Explain the following op-amp circuits with neat sketches also find the output voltage equations
   - **a.** Summing amplifiers
   - **b.** Scaling amplifiers(K2,K3)

Course Outcome 5 (CO5):

1. Generate different desired waveforms using op-amp.(K2,K3)
2. Draw the internal block diagram of 555 Timer IC and explain.(K1)
3. Realise multivibrators using 555 IC. (K2,K3)

Course Outcome 6 (CO6):

1. Design and set up an opamp integrator circuit and plot the input and output waveforms.(K3)
2. Explain the working of a ramp generator circuit using opamp.(K2)

Model Question paper

PAGES: 2

Reg No.:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITYTHIRD SEMESTER
B.TECH DEGREE EXAMINATION,

MONTH AND YEAR

Course Code: EET205

Course Name: ANALOG ELECTRONICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks

1. With neat diagrams explain DC load lines in transistor. What is the significance of Q point?
2. Draw and explain the h parameter small signal low frequency model for BJT.
3. Explain the construction and operation of Enhancement type metal oxide semiconductor FET with neat diagrams.
4. Explain the drain characteristics of JFET and mark the pinch-off voltage
5. Discuss the advantages of negative feedback amplifier.
6. State and explain Barkhausen's criterion of oscillation.
7. Compare the Ideal and Practical characteristics of an op-amp
8. Design a three input summing amplifier using op-amp having gains 2, 3and 5 respectively for each input
9. Show the circuit diagram of an Ideal Differentiator using op-amp with corresponding input and output waveform.
10. Explain the operation of a square wave generator using op-amp.

PART B

Answeranyonefullquestionfromeachmodule.Eachquestioncarries14 Marks

Module1

11. Design a voltage divider bias circuit to operate from a 18V supply in which bias conditions are to be $V_{CE}=V_E=6V$ and $I_C=1.5mA$. β=90. Also calculate the stability factor S. **(14)**

12. A CE amplifier has the h-parameters given by h_{ie}= 1000Ω, h_{re} = $2*10^{-4}$, h_{fe}=50, h_{0e}= 25µΩ. If both the load and source resistances are 1kΩ, determine the a) current gain and b) voltage gain. **(14)**

Module 2

13. (a) Sketch the frequency response curve of RC coupled amplifier and discuss methods to improve gain bandwidth product **(7)**

    (b) List the four parameters of JFET. Also obtain the mathematical expression for transconductance. **(7)**

14. (a) How a JFET common drain amplifier is designed using voltage divider biasing? **(5)**

    (b)Which are the internal capacitances of a BJT? How these are incorporated in the high frequency hybid pi model of BJT? **(9)**

Module 3

15. Define conversion efficiency of power amplifier. Prove that the maximum conversion efficiency of a series fed class A amplifier is 25%. **(14)**

16. With neat circuit diagrams, explain the working of a two-stage RC coupled amplifier and derive the output relation of each stage. **(14)**

Module 4

17. How do the open-loop voltage gain and closed loop voltage gain of an op-amp differ? What is the limiting value of output voltage of op amp circuit? **(14)**

18. (a) An input of 3V is fed to the non inverting terminal of an op-amp. The amplifier has R_1=10kΩ and R_f=10kΩ.Find the output voltage. **(7)**

    (b) Explain briefly about the following (i) CMRR (ii) Slew Rate **(7)**

Module 5

19. (a) What is the significance of UTP and LTP in Schmitt trigger circuits? **(7)**

    (b) What is a zero crossing detector? **(7)**

20. (a) Explain the functional block diagram of Timer IC555. **(7)**

    (b) Design an astablemultivibrator using 555 Timer for an output wave of 65% duty ratio at 1kHz frequency. **(7)**

Syllabus

Module 1

Bipolar Junction Transistors: Review of BJT characteristics- Operating point of BJT – Factors affecting stability of Q point. DC Biasing–Biasing circuits: fixed bias, collector to base bias, voltage divider bias, role of emitter resistance in bias stabilisation. Stability factor (Derivation of stability factors for Voltage Divider Biasing only).Numerical problems. Bias compensation using diode and thermistor.

BJT Model- h-parameter model of BJT in CE configuration. Small signal low frequency ac equivalent circuit of CE amplifier –Role of coupling capacitors and emitter bypass capacitor. Calculation of amplifier gains and impedances using h parameter equivalent circuit.

Module 2

Field Effect Transistors: Review of JFET and MOSFET(enhancement mode only) construction, working and characteristics- JFET common drain amplifier-Design using voltage divider biasing.

Frequency response of Amplifiers: Internal Capacitances at high frequency operations of BJT- Hybrid Pi model of BJT. Low and high frequency response of Common Emitter amplifier. Frequency response of CE amplifier, Gain bandwidth product.

Module 3

Multistage amplifiers: Direct, RC, transformer coupled Amplifiers, Applications.

Power amplifiers using BJT: Class A, Class B, Class AB, Class C and Class D. Conversion efficiency – derivation(Class A and Class B). Distortion in power amplifiers. Feedback in Amplifiers-Effect of positive and negative feedbacks.
Oscillators:Barkhausen'scriterion–RCoscillators(RCPhaseshiftoscillatorandWeinBridgeoscillator) –LC oscillators(Hartley and Colpitt's)– Derivation of frequency of oscillation- Crystal oscillator.

Module 4

Operational Amplifiers: Fundamental differential amplifier- Modes of operation.

Properties of ideal and practical Op-amp - Gain, CMRR and Slew rate. Parameters of a typical Op-amp IC 741.

Open loop and Closed loop Configurations-Concept of virtual short. Negative feedback in Op-amps. Inverting and non- inverting amplifier circuits. Summing and difference amplifiers, Instrumentation amplifier.

Module 5

OP-AMP Circuits: Differentiator and Integrator circuits-practical circuits – Design –

Comparators: Zero crossing and voltage level detectors, Schmitt trigger. Comparator IC: LM311.

Wave form generation using Op-Amps: Square, triangular and ramp generator circuits using Op-Amp- Effect of slew rate on waveform generation.

Timer 555IC: Internal diagram of 555IC–Astable and Monostable multi-vibrators using 555 IC.

Text Books

1. Bell D. A., Electronic Devices and Circuits, Prentice Hall ofIndia, 2007.
2. Malvino A. and D. J. Bates, Electronic Principles7/e, Tata McGraw Hill, 2010.
3. Boylestad R. L. and L. Nashelsky,Electronic Devices and CircuitTheory, 10/e, PearsonEducation India, 2009.
4. Choudhury R.,LinearIntegrated Circuits, New AgeInternational Publishers. 2008.

Reference Books

3. Floyd T.L., Fundamentals of Analog Circuits,, Pearson Education, 2012.
4. Robert T. Paynter and John Clemons, Paynter's Introductory electronic devices & circuits, Prentice Hall Career & Technology, New Jersey.
5. Millman J. and C. C. Halkias,Integrated Electronics: Analog and Digital Circuits andSystems, Tata McGraw-Hill, 2010.
6. Streetman B. G. and S. Banerjee,Solid State Electronic Devices, Pearson Education Asia,2006.
7. Gayakward R. A., Op-Amps and LinearIntegrated Circuits, PHILearning Pvt.Ltd., 2012.

Course Contents and Lecture Schedule

No	**Topic**	**No. of Lectures**
1		**10**
1.1	Bipolar Junction Transistors: Review of BJT characteristics	1
1.2	Operating point of BJT – Factors affecting stability of Q point.	1
1.3	Biasing circuits: fixed bias, collector to base bias, voltage divider bias, role of emitter resistance in bias stabilisation. Stability factor (Derivation of stability factors for Voltage Divider Biasing only). Numerical problems.	4
1.4	Bias compensation using diode and thermistor.	1
1.5	BJT Model- h-parameter model of BJT in CE configuration. Small signal low frequency ac equivalent circuit of CE amplifier	1
1.6	Role of coupling capacitors and emitter bypass capacitor.	1
1.7	Calculation of amplifier gains and impedances using h parameter equivalent circuit.	1
2		**8**
2.1	Field Effect Transistors: Review of JFET and MOSFET (enhancement mode)-construction, working and characteristics	2
2.2	JFET common drain amplifier-Design using voltage divider biasing.	1
2.3	FET as switch and voltage controlled resistance.	1
2.4	Frequency response of Amplifiers: Internal Capacitances at high frequency operations of BJT- Hybrid Pi model of BJT. Low and high frequency response of Common Emitter amplifier	3
2.5	Frequency response of CE amplifier, Gain bandwidth product	1
3		**9**
3.1	Multistage amplifiers: Direct, RC, Applications.	1
3.2	Transformer coupled Amplifiers, Applications.	1
3.3	Derivation of conversion efficiency of Class A and Class B amplifiers.	2

3.4	Class AB, Class C and Class D amplifiers. Distortion in power amplifiers(Class A, Class B, Class AB, Class C and Class D)	2
3.5	Oscillators: Barkhausen's criterion–RC oscillators (RC Phase shift oscillator and Wein Bridge oscillator) Derivation of frequency of oscillation	2
3.6	LC oscillators (Hartley and Colpitt's) – Derivation of frequency of oscillation- Crystal oscillator.	1
4		**10**
4.1	Operational Amplifiers: Fundamental differential amplifier- Modes of operation.	2
4.2	Properties of ideal and practical Op-amp - Gain, CMRR and Slew rate. Parameters of a typical Op-amp IC 741.	3
4.3	Open loop and Closed loop Configurations-Concept of virtual short.	2
4.4	Negative feedback in Op-amps.	1
4.5	Inverting and non- inverting amplifier circuits	1
4.6	Summing and difference amplifiers, Instrumentation amplifier.	1
5		**8**
5.1	OP-AMP Circuits: Differentiator and Integrator circuits-practical circuits - Design	1
5.2	Comparators: Zero crossing and voltage level detectors, Schmitt trigger. Comparator IC: LM311.	2
5.3	Wave form generation using Op-Amps: Square, triangular and ramp generator circuits using Op-Amp- Effect of slew rate on waveform generation.	2
5.4	Timer 555IC: Internal diagram of 555IC–Astable and Monostable multi-vibrators using 555 IC.	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EEL201	**CIRCUITS AND MEASUREMENTS LAB**	**PCC**	**0**	**0**	**3**	**2**

Preamble : This laboratory course is designed to train the students to familiarize and practice various measuring instruments and different transducers for measurement of physical parameters. Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing basic instrumentation systems.

Prerequisite : Basic Electrical Engineering

Course Outcomes : After the completion of the course the student will be able to

CO 1	Analyse voltage current relations of RLC circuits
CO 2	Verify DC network theorems by setting up various electric circuits
CO 3	Measure power in a single and three phase circuits by various methods
CO 4	Calibrate various meters used in electrical systems
CO 5	Determine magnetic characteristics of different electrical devices
CO 6	Analyse the characteristics of various types of transducer systems
CO 7	Determine electrical parameters using various bridges
CO 8	Analyse the performance of various electronic devices for an instrumentation systems and, to develop the team management and documentation capabilities.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2						2			3
CO 2	3	3	-	-	-	-	-	-	2	-	-	3
CO 3	3	3	-	-	-	-	-	-	2	-	-	3
CO 4	3	3	2	-	-	-	-	-	2	-	-	3
CO 5	3	3	-	-	-	-	-	-	2	-	-	3
CO 6	3	3	2	-	-	-	-	-	2	-	-	3
CO 7	3	3	-	-	-	-	-	-	2	-	-	3
CO 8	3	3	3	3	2	-	-	-	3	3	3	3

ASSESSMENT PATTERN:

Mark distribution:

Total Marks	CIE marks	ESE marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	Regular Lab work	Internal Test	Course Project	Total
15	30	25	5	**75**

Internal Test Evaluation (Immediately before the second series test)

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

General instructions : Practical examination is to be conducted immediately after the second series test after conducting 12 experiments from the list of experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS:

(12 experiments are mandatory)

1. Verification of Superposition theorem and Thevenin's theorem.
2. Determination of impedance, admittance and power factor in RLC series/ parallel circuits.
3. 3-phase power measurement using one wattmeter and two-wattmeter methods, and determination of reactive/apparent power drawn.
4. Resistance measurement using Kelvin's Double Bridge and Wheatstone's Bridge and extension of range of voltmeters and ammeters.
5. Extension of instrument range by using Instrument transformers(CT and PT)
6. Calibration of ammeter, voltmeter, wattmeter using Potentiometers
7. Calibration of 1-phase Energy meter at various power factors (minimum 4 conditions)
8. Calibration of 3-phase Energy meter using standard wattmeter
9. Determination of B-H curve, μ-H curve and μ-B curve of a magnetic specimen
10. Measurement of Self inductance, Mutual inductance and Coupling coefficient of a 1-phase transformer
11. a. Measurement of Capacitance using AC bridge

    b. Setup an instrumentation amplifier using Opamps.
12. Determination of characteristics of LVDT, Strain gauge and Load-cell.
13. Determination of characteristics of Thermistor, Thermocouple and RTD
14. Verification of loading effect in ammeters and voltmeters with current measurement using Clamp on meter.

15. Demo Experiments/Simulation study:

(a) Measurement of energy using TOD meter

(b) Measurement of electrical variables using DSO

(c) Harmonic analysers

(d) Simulation of Circuits using software platform

(e) Computer interfaced measurements of circuit parameters.

Mandatory Group Project Work : Students have to do a mandatory micro project (group size not more than 5 students) to realise a functional instrumentation system. A report also is to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Example projects (Instrumentation system with sensors, alarm, display units etc)

1. Temperature Monitoring System.
2. Gas / Fire smoke Detection Systems.
3. Simulation using LabVIEW, PLC or Similar Softwares.

Reference Books:

1. A. K. Sawhney: A course in Electrical and Electronic Measurements & Instrumentation, Dhanpat Rai Publishers
2. J. B. Gupta: A course in Electrical & Electronic Measurement & Instrumentation., S. K. Kataria & Sons Publishers
3. Kalsi H. S.: Electronic Instrumentation, 3/e, Tata McGraw Hill, New Delhi.

CODE EEL203	ANALOG ELECTRONICSLAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

CO 1	Use the various electronic instruments and for conducting experiments.
CO 2	Design and develop various electronic circuits using diodes and Zener diodes.
CO 3	Design and implement amplifier and oscillator circuits using BJT and JFET.
CO 4	Design and implement basic circuits using IC (OPAMP and 555 timers).
CO 5	Simulate electronic circuits using any circuit simulation software.
CO 6	Use PCB layout software for circuit design

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	2								2			
CO 2	2	2	2						2			
CO 3	2	2	2						2			
CO 4	2	2	2						2			
CO 5	1	1			3				3			
CO 6	1				3				3			

LIST OF EXPERIMENTS

1. Measurement of current, voltage, frequencyand phase shift of signal in a RC network using oscilloscope.
2. Clipping circuits usingdiodes.
3. Clamping circuits usingdiodes.
4. Design and testing ofsimpleZener voltage regulator.
5. RC coupled amplifier using BJT in CE configuration-Measurement of gain, BW and plotting of frequencyresponse.
6. JFETamplifier-Measurement of gain, BW and plotting of frequencyresponse.
7. Op-amp circuits – Design and set up of invertingand non-inverting amplifier, scale changer, adder, integrator, and differentiator.
8. Op-amps circuits – Scale changer, adder, integrator, and differentiator.
9. Precision rectifierusingOp-amps.
10. Phase shift oscillator usingOp-amps.
11. Wein’sBridgeoscillator using Op-amps.
12. Waveform generation– Square, triangular andsaw tooth waveformgeneration usingOPAMPs.
13. Basic comparator and Schmitt triggercircuits using Op-amp (Use comparator ICs such as LM311).
14. Design and testing of series voltage regulator using Zenerdiode.
15. Astable and Monostable circuit using555IC.
16. RC phase shift oscillator using Op-amp.
17. Introductionto circuit simulation using any circuit simulation software.
18. Introduction to PCB layout software.

Text Books

1. Bell D. A., Electronic Devices and Circuits, Prentice Hall of India, 2007.
2. Malvino A. and D. J. Bates, Electronic Principles7/e, Tata McGraw Hill, 2010.
3. Boylestad R. L. and L. Nashelsky, Electronic Devices and Circuit Theory, 10/e, Pearson Education India, 2009.
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2. Robert T. Paynter and John Clemons, Paynter's Introductory electronic devices & circuits, Prentice Hall Career & Technology, New Jersey.
3. Millman J. and C. C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, Tata McGraw-Hill, 2010.
4. Gayakward R. A., Op-Amps and Linear Integrated Circuits, PHI Learning Pvt. Ltd., 2012.

Course Project: Students have to do a mandatory course project (group size not more than 4 students) using to realise a functional analog circuit on PCB. A maximum of 5 marks shall be awarded for this project (to be evaluated along with the final internal test). Report to be submitted.

Example projects:

1. Audio amplifier.
2. Electronic Pest Repellent Circuit.
3. Electronic Siren.

Assessment Pattern :

Mark distribution :

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	Regular Lab work	Internal Test	Course Project	Total
15	30	25	5	75

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

General instructions : Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

SEMESTER -3
MINOR

Syllabus

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET281	ELECTRIC CIRCUITS	MINOR	3	1	0	4

Preamble : This course deals with circuit theorems applied to dc and ac electric circuits. Steady and transient state response of electric circuits is discussed. Network analysis is introduced with network parameters and transfer functions. This course serves as the most important prerequisite of all many advanced courses in electrical engineering.

Prerequisite : **Basics of Electrical Engineering / Introduction to Electrical Engineering**

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Apply circuit theorems to simplify and solve DC and AC electric networks.
CO 2	Analyse dynamic DC circuitsand develop the complete response.
CO 3	Analyse coupled circuits in S-domain
CO 4	Analyse three-phase networks in Y and Δ configurations.
CO 5	Develop the representation of two-port networks using Z and Y parameter.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2
CO 5	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State and explain network theorems (K1)
2. Problems on solving circuits using network theorems. (K2, K3)

Course Outcome 2 (CO2):

1. Distinguish between the natural response and forced response. (K2, K3)
2. Problems on steady state and transient analysis of RL, RC and RLC series circuits with DC excitation and initial conditions. (K2, K3)

Course Outcome 3 (CO3):

1. Problems on mesh analysis,analysis of transformed circuits in s-domain (K2, K3).
2. Problems on nodal analysis,analysis of transformed circuits in s-domain (K2, K3).

Course Outcome 4 (CO4):

1. Problems on analysis of balanced Y and Δ configurations. (K2, K3)
2. Problems on analysis of unbalanced Y and Δ configurations. (K2, K3)

Course Outcome 5 (CO5):

1. Problems on finding Z and Y parameters of simple two port networks. (K2).
2. Derive the expression for Z parameters in terms of Y parameters. (K1).

Model Question paper

QP CODE: PAGES: 3

Reg. No:______________

Name:________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET281
Course Name: ELECTRIC CIRCUITS

Max. Marks: 100 **Duration: 3 Hours**

PART A
Answer all Questions. Each question carries 3 Marks

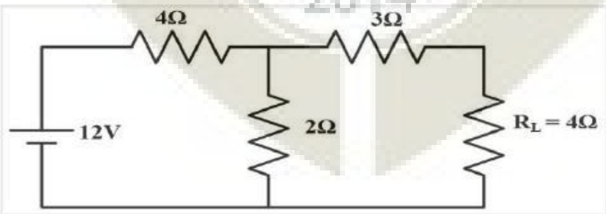
1. Compare the analogy between Nodal and Mesh analysis method.
2. State and explain superposition theorem with suitable examples.
3. Differentiate between transient and steady state analysis.
4. Explain Initial value and final value theorem.
5. Define Self-inductance, Mutual inductance and coupling coefficient.
6. Explain dot rule used in magnetically coupled circuits with the help of a neat figure.
7. Define the terms, real power, reactive power and apparent power.
8. Draw the circuit of a four-wire star connected three phase circuit and mark the lineand phase Voltage.
9. Differentiate driving point and transfer functions with respect to a two port network.
10. Draw the equivalent circuit representation in terms of Z-parameters. **(10 x 3=30)**

PART B

Answer any one full question from each module. Each question carries 14 Marks

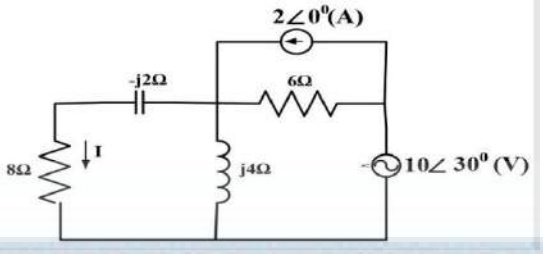
Module-1

11. (a) Draw the Thevenin's equivalent circuit and hence find the power dissipated across R_L **(8)**



(b)Compare the difference between dependent and independent sources. **(6)**

12. (a) Determine the power dissipated across 8Ω for the circuit shown by applying superpositiontheorem. **(10)**



(b) State and explain Thevenin'stheorem with suitable examples. **(4)**

Module-2

13. (a) The current through 5Ω resistor is **I(S) =(5S+3)/(S^2+5S+6).** Find the power dissipated across 5Ω resistor. **(7)**

(b) Derive the equation for the transient current flow through series RL circuit with DCsource and zero initial condition. **(7)**

14. (a) Derive the equation for the transient current flow through series RC circuit with DC source and zero initial condition. **(7)**

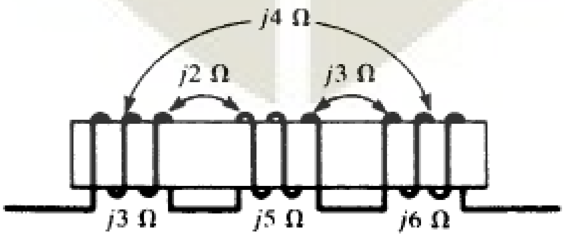
(b) Explain the term time constant with respect to series RL circuit with suitable figures. **(7)**

Module-3

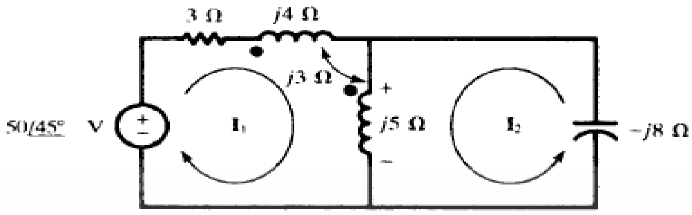
15. (a) In a series aiding connection, two coupled coils have an equivalent inductance LAand in a series opposing connection, the equivalent inductance is LB. Obtain an expression for M in terms of LA and LB. **(7)**

(b) Two coupled coils, L1 = 0.8 H and L2 = 0.2 H, have a coefficient of coupling k = 0:90. Find the mutual inductance M and the turns ratio N1/N2. **(7)**

16. (a) Obtain the dotted equivalent for the circuit shown and use the equivalent to find theequivalent inductive reactance. **(7)**



(b) In the circuit shown in figure, find the voltage across the 5 Ω reactance with the polarity shown. **(7)**



Module-4

17. (a) Explain two watt-meter method to measure the three phase power with the help of suitable equations. **(7)**

(b) Derive the relationship between the line and phase voltage in a three phase starconnected circuit. **(7)**

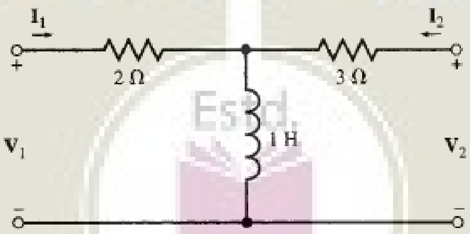
18. (a) A three-phase, three-wire, balanced, delta-connected load yields wattmeter readings of 154W and 557W. Obtain the load impedance, if the line voltage is 141.4 V. **(7)**

(b) Derive the relationship between the line and phase current of a three phase deltaconnected circuit. **(7)**

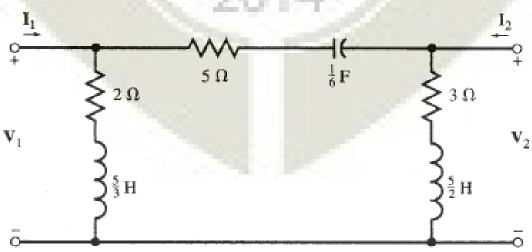
Module-5

19. (a) Derive the relationship between Z and Y parameters. **(6)**

(b) Find the Z-parameters of the two-port circuit. **(8)**



20. (a) Find the Y-parameters of the circuit. **(10)**



(b) Explain the condition for symmetry and reciprocity with respect to Z-parameters. **(4)**

Syllabus

Module 1

Circuit theorems: Review of Nodal and Mesh analysis method. DC and ACcircuits analysis with dependent and independent sources applying Network theorems – Superposition theorem, Thevenin’s theorem.

Module 2

Steady state and transient response:Review of Laplace Transforms. DCresponseof RL, RC and RLC series circuitswith initial conditions and complete solution using Laplace Transforms- Time constant.

Module 3

Transformed circuits and analysis – Mutual inductance, coupling coefficient, dot rule. Analysis of coupled coils -– mesh analysis and node analysis of transformed circuits in S-domain.

Module 4

Three phase networks: Three phase power in sinusoidal steady state-complex power, apparent power and power triangle. Steady state analysis of three-phase three-wire and four-wire balanced and unbalanced Y circuits, Balanced and unbalanced Delta circuit. Three phase power measurement and two-wattmeter method.

Module 5

Two port networks: Driving point and transfer functions – Z and Y parameters.- Conditions for symmetry & reciprocity – Z and Y parameters. Relationshipbetween Z and Y parameters.

Text Books

1. Joseph A. Edminister and MahmoodNahvi, "Theory and Problems in Electric circuits", McGraw Hill, 5th Edition, 2010.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

References:

21. Hayt and Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, New Delhi, 8th Ed, 2013.
2. Van Valkenberg, "Network Analysis", Prentice Hall India Learning Pvt. Ltd., 3 edition, 1980.
3. K. S. Suresh Kumar, “Electric Circuit Analysis”, Pearson Publications, 2013.
4. Chakrabarti, "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018
5. R. Gupta, "Network Analysis and Synthesis", S. Chand & Company Ltd, 2010.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Circuit theorems(12 hours)**	
1.1	Review of Nodal analysis method.	2
1.2	Review of Mesh analysis method.	2
1.3	Dependent and independent current and voltage sources	2
1.4	Superposition theorem - Application to the analysis of DCand AC circuits with dependent and independent sources.	3
1.5	Thevenin’s theorem - Application to the analysis of DC and AC circuits with dependent and independent sources.	3
2	**Steady state and transient response. (9 hours)**	
2.1	Review of Laplace Transforms – Formulae of Laplace Transforms of common functions/signals, Initial value theorem and final value theorem, Inverse Laplace Transforms – partial fraction method.	3
2.2	DC response of RL series with initial conditions and complete solution using Laplace Transforms- Time constant	2
2.3	DC response of RC series with initial conditions and complete solution using Laplace Transforms- Time constant	2
2.4	DC response of RLC series with initial conditions and complete solution using Laplace Transforms- Time constant	2
3	**Transformed circuits and analysis (8 Hours)**	
3.1	Mutual inductance and Coupling Coefficient	2

3.2	Dot rule and polarity convention	1
3.3	Mesh analysis of transformed circuits in s-domain.	3
3.5	Nodalanalysis of transformed circuits in s-domain.	2
4	**Three phase networks. (9 Hours)**	
4.1	Three phase power in sinusoidal steady state-complex power, apparent power and power triangle.	2
4.2	Steady state analysis of three-phase three-wire and four-wire balanced and unbalanced Y circuits	3
4.3	Steady state analysis of three-phase three-wire and four-wire balanced and unbalanced Delta circuits.	2
4.4	Three phase power measurement and two-wattmeter method.	2
5	**Two port networks (7 Hours)**	
5.1	Two port networks: Terminals and Ports, Driving point and transfer functions.	2
5.2	Z –parameters. Equivalent circuit representation.	1
5.3	Y parameters. Equivalent circuit representation.	1
5.6	Conditions for symmetry & reciprocity- Z and Y-parameters	2
5.7	Relationship between Z and Yparameters.	1

Syllabus

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET 283	**INTRODUCTION TO POWER ENGINEERING**	**Minor**	**3**	**1**	**0**	**4**

Preamble : This course introduces various conventional energy sources. This course also introduces the design of transmission system and distributions system. It also introduces the economics of power generation.

Prerequisite : EST 130Basics of Electrical & Electronics Engineering

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Illustrate various conventional sources of energy generation
CO 2	Analyse the economics of power generation
CO 3	Analyse the economics of power factor improvement
CO 4	Design mechanical parameters of a transmission system.
CO 5	Design electrical parameters of a transmission system.
CO 6	Classify different types of ac and dc distribution systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2
CO 5	3	3										2
CO 6	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Schematic and equipment of Conventional Power generation schemes (K1)
2. Comparison of various turbines associated with conventional generation (K2, K3)

Course Outcome 2 (CO2):

1. Definition and Calculation of various terms associated with power generation (K1, K2)
2. Problems on economics of power generation. (K2, K3)

Course Outcome 3 (CO3):

1. Problems on calculation of size of capacitors for power factor improvement (K2, K3).
2. Problems on economics of power factor placement (K2, K3).

Course Outcome 4 (CO4):

1. Derivation of various mechanical parameters associated with transmission line (K2, K3)
2. Derivation and problems of corona and insulators. (K2, K3).

Course Outcome 5 (CO5):

1. Derivation of various electrical parameters associated with transmission line (K2, K3).
2. Definition on transposition of line and changes in electrical parameters (K1,K2)

Course Outcome 6 (CO6):

1. Problems on AC and DC distribution systems (K2,K3).
2. Architecture and technologies in smart grid (K2,K3)

Model Question paper

QPCODE: PAGES:3

Reg.No:____________

Name :______________

APJABDULKALAMTECHNOLOGICALUNIVERSITY

FIRSTSEMESTERB.TECHDEGREEEXAMINATION, MONTH &YEAR

Course Code: EET 283
Course Name: Introduction to Power Engineering

Max.Marks:100 **Duration: 3Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. What are the main differences between nuclear and thermal power plants?
2. How are turbines classified? How is a turbine selected for a site?
3. Explain the significance of Load factor and Load curve.
4. Discuss the disadvantages of low power factor in power system.
5. What is corona? Explain the factors have an influence on corona loss
6. High voltage is preferred for transmission. Discuss the merits and demerits of high voltage transmission.
7. Draw and explain the equivalent models of a medium transmission line.
8. What is transposition of lines? Comment on its necessity in the system.
9. Discuss the requirements of a distribution system.
10. Discuss the main features of an interconnected distribution system.

(10x3=30)

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Explain thegeneral arrangement of gas turbine power plant. **(8)**

(b) Discuss the importance of small hydro power generation along with their advantages and disadvantages. **(6)**

12. (a) Explain various elements of a elements of diesel power plant **(8)**

(b) Explain the general layout of a nuclear power plant. **(6)**

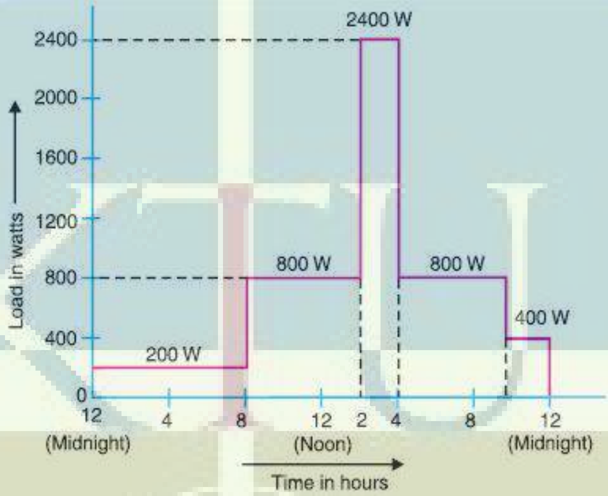
Module 2

13. (a)A generating station has a maximum demand of 150000 kW. The annual load factor is 50% and plant capacity factor is 40%. Determine the reserve capacity of the

plant. **(6)**

(b) The power factor in a three-phase plant with supply voltage of 400 V and absorbing an average power of 300 kW is 0.8. Determine the kVAr of the capacitor required to improve the power factor to 0.93. Determine the reduction in current drawn from the supply after installation of the capacitors. **(8)**

14. (a) Determine average demand and load factor of the load curve shown below **(7)**



(b) Explain any two methods of power factor improvement. **(7)**

Module 3

15. (a) Derive the equation for Sag in transmission lines, when the support is at equaland unequal heights. **(10)**

(b) Discuss the difference between disruptive critical corona and visual critical corona **(4)**

16. (a) In a 33 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 11% of self-capacitance of each insulator, find (i) the distribution of voltage over 3 insulators and (ii) string efficiency. **(9)**

(b) Discuss various types of conductors used in power system. **(5)**

Module 4

17. (a) A 3 phase 70km long Transmission line has its conductors of 1 cm diameter spaced at the corners of the equilateral triangle of 100cm side. Find the inductance per phase of the system. **(6)**

    (b) Derive loop inductance of a single phase two wire line. **(8)**

18. (a) The three conductors of a 3-phase line are arranged at the corners of a triangleof sides 2 m, 2·5 m and 4·5 m. Calculate the inductance per km of the line when the conductors areregularly transposed. The diameter of each conductor is 1·24 cm. **(6)**

    (b)A single-phase transmission line has two parallel conductors 3 m apart,radius of each conductor being 1 cm. Calculate the capacitance of the line per km. **(8)**

Module 5

19. (a) Compare radial and ring main distribution system with the help of appropriate schematics. **(6)**

    (b) A two conductor main, AB, 500m in length is fed from both ends at 250 V. Loads of 50A, 60A, 40A and 30A are tapped at distances of 100m, 250m, 350m and 400m from end A respectively. If the cross section of conductor is 1 cm^2 and specific resistance of the material is 1.7 μΩcm, determine the minimum consumer voltage. **(8)**

20. (a) A 2-wire dc distributor cable AB is 2 km long and supplies loads of 100A, 150A,200A and 50A situated 500 m, 1000 m, 1600 m and 2000 m from the feeding point A. Each conductor has a resistance of 0·01 Ω per 1000 m. Calculate the p.d. at each load point if a p.d. of 300 V is maintained at point A. **(7)**

    (b) Explain the architecture of smart grid with the help of a schematic **(7)**

(14x5=70)

Syllabus

Module 1

Generation of power

Conventional sources**:** Hydroelectric Power Plants- Selection of site. General arrangement of hydel plant, Components of the plant, Classification of the hydel plants -Water turbines: Pelton wheel, Francis, Kaplan and propeller turbines, Small hydro generation.

Steam Power Plants: Working of steam plant, Power plant equipment and layout, Steam turbines

Diesel Power Plant: Elements of diesel power plant, applications

Gas Turbine Power Plant: Introduction Merits and demerits, selection site, fuels for gas turbines, General arrangement of simple gas turbine power plant, comparison of gas power plant with steam power plants

Nuclear Power Plants:Nuclear reaction, nuclear fission process, nuclear plant layout, Classification of reactors

Module 2

Economics of power generation

Types of loads, Load curve, terms and factors, peak load and base load

Cost of electrical energy – numerical problems

Power factor improvement – causes of low power factor, disadvantages - methods of power factor improvement, calculations of power factor correction, economics of power factor improvement

Module 3

Transmission system

Different types of transmission system - High voltage transmission - advantages

Mechanical design of overhead transmission line: Main components of overhead lines – types of conductors, line supports

Insulators–Types-String efficiency – methods of improving string efficiency

Corona – Critical disruptive voltage - Visual Critical Voltage – corona loss - Factors affecting corona, advantages and disadvantages, methods of reducing corona

Sag - calculation

Module 4

Electrical design of transmission line

Constants of transmission line – Resistance, inductance and capacitance

Inductance and capacitance of a single phase transmission line

Inductance and capacitance of a three phase transmission line with symmetrical and unsymmetrical spacing – transposition of lines

Module 5

Distribution system
Types of distribution systems
Types of DC distributors – calculations – distributor fed at one end and at both ends
Types of AC distributors – calculations

Smart Grid

Smart Grid – Introduction - challenges and benefits — architecture of smart grid introduction to IEC 61850 and smart substation

Text Books

Text Books:

1. D P Kothari and I Nagrath, "Power System Engineering," 2/e Tata McGraw Hills, 2008.
2. Wadhwa, “Electrical Power system”, Wiley Eastern Ltd. 2005.

References:

1. A.Chakrabarti, ML.Soni, P.V.Gupta, V .S.Bhatnagar, “A text book of Power system Engineering” DhanpatRai, 2000.
2. Grainer J.J, Stevenson W.D, “Power system Analysis”, McGraw Hill.
3. I.J.Nagarath& D.P. Kothari, “Power System Engineering”, TMH Publication.
4. A Stuart Borlase, “Smart Grids, Infrastructure, Technology and Solutions”, CRC Press, 2013.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Conventional energy sources (9 hours)**	
1.1	Introduction and history ofpower generation	1
1.2	Hydel power plant- Schematic, components and turbines	2
1.2	Steam power plant – Schematic, components and turbines	2
1.3	Schematic and various turbines with diesel and GT power generation	3
1.4	Nuclear power generation	1
2	**Economics of power generation and power factor improvement (8 hours)**	
2.1	Important terms associated with power generation such as load factor, load curve, etc	1

2.2	Numerical problems on the economics of generation.	2
2.3	Significance of power factor in power system	1
2.4	Methods of power factor improvement	2
2.5	Numerical problems on capacitor value evaluation and economics of power factor improvement	2
3	**Transmission System (10 Hours)**	
3.1	Introduction to transmission systems	1
3.2	Mechanical design of transmission lines- line supports and conductors	2
3.3	Types of insulators	1
3.4	String Efficiency, Methods of improving string efficiency, Numerical problems	2
3.5	Corona - Critical disruptive voltage : Visual Critical Voltage –corona loss	1
3.6	Factor affecting corona and corona loss, Numerical problems on corona	2
3.7	Sag in transmission lines	1
4	**Electrical parameters of a transmission line (9 Hours)**	
4.1	Introduction to constants of transmission line	1
4.2	Derivation of inductance and capacitance of a single phase transmission line	2
4.3	Derivation of Inductance and capacitance of a three phase transmission line with symmetrical and unsymmetrical spacing, transposition of lines	3
4..4	Numerical problems on inductance, capacitance of transmission lines	3
5	**Distribution systems (9 Hours)**	
5.1	Introduction to distribution system	1
5.2	DC distribution system – various types	2
5.3	Numerical Examples of DC distribution system	1
5.4	AC distribution system – various types	2
5.5	Numerical Examples of DC distribution system	2
5.6	Introduction to smart grid	1

Syllabus

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET 285	**DYNAMIC CIRCUITS AND SYSTEMS**	**Minor**	**3**	**1**	**0**	**4**

Preamble : This course introduces the application of circuit analysis techniques to dc and ac electric circuits. Analysis of electric circuits both in steady state and dynamic conditions are discussed. Network analysis using network parameters and transfer functions is also included .

Prerequisite : **Basics of Electrical Engineering / Introduction to Electrical Engineering**

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Apply circuit theorems to simplify and solve complex DC and AC electric networks.
CO 2	Analyse dynamic DC and AC circuits and develop the complete response to excitations.
CO 3	Solve dynamic circuits by applying transformation to s-domain.
CO 4	Solve series /parallel resonant circuits.
CO 5	Develop the representation of two-port networks using network parameters and analyse the network.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2
CO 5	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO 1):

1. State and explain network theorems (K1)
2. Problems on solving circuits using network theorems. (K2, K3)

Course Outcome 2 (CO 2):

1. Distinguish between the natural response and forced response. (K2, K3)
2. Problems related to steady state and transient analysis of RL, RC and RLC series circuits with DC excitation and initial conditions. (K2, K3)
3. Problems related to steady state and transient analysis of RL, RC and RLC series circuits with sinusoidal excitation. (K2, K3)

Course Outcome 3 (CO 3):

1. Problems related to mesh analysis and node analysis of transformed circuits in s-domain (K2, K3).
2. Problems related to solution of transformed circuits including mutually coupled circuits in s-domain (K2, K3).

Course Outcome 4 (CO 4):

1. Define Bandwidth, and draw the frequency dependence of impedance of an RLC network. (K1).
2. Develop the impedance/admittance Vs frequency plot for the given RLC network. (K2).
3. Evalutate the parameters such as quality factor, bandwidth,

Course Outcome 5 (CO 5):

1. Problems to find Z, Y, h and T parameters of simple two port networks. (K2).
2. Derive the expression for Z parameters in terms of T parameters. (K1).
3. Show that the overall transmission parameter matrix for cascaded 2 port network is simply the matrix product of transmission parameters for each individual 2 port network in cascade. (K1).

Model Question paper

QP CODE:

PAGES:2

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: EET 285
Course Name: DYNAMIC CIRCUITS AND SYSTEMS

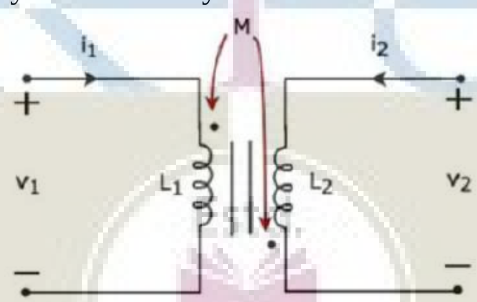
Max. Marks: 100

Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

1. What is the condition for transferring maximum power to load in an ac network? How is it obtained?
2. State and explain the reciprocity theorem.
3. Derive an expression for calculating the steady state current when an ac is applied to a series RL circuit.
4. A voltage of $v(t) = 10\cos(1000t + 60^0)$ is applied to a series RLC circuit in which R=10Ω, L=0.02H and C=10^{-4} F. Find the steady current.
5. Apply KVL in both primary and secondary circuits and write the corresponding equations.



6. Give the transform representation in s-domain of an inductor with initial current and transform representation in s-domain of a capacitor with initial voltage.
7. Compare series and parallel resonance on the basis of resonant frequency, impedance and bandwidth.
8. How is selectivity measured in a parallel resonant circuit? How is selectivity increased?
9. What are the conditions for reciprocity of a two port network in terms of z parameters? What are the similar conditions in terms of y parameters?
10. How do we find equivalent T network of a two port network if z parameters are given?

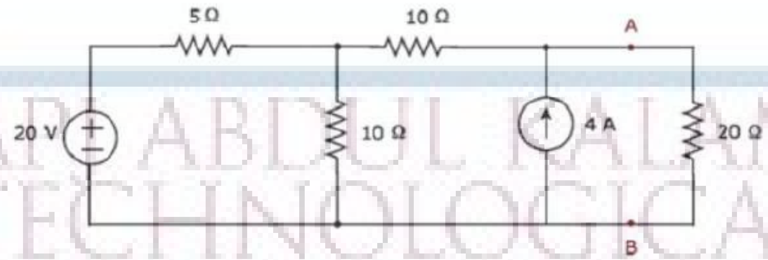
(10 x 3 = 30)

PART B

Answer any one full question, each carries14 marks.

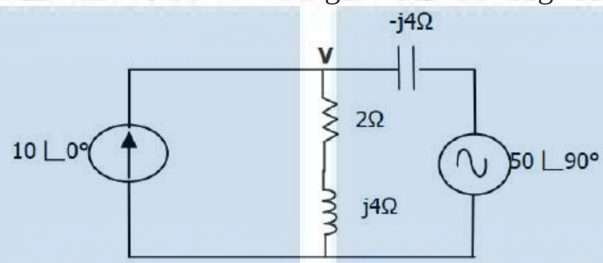
MODULE1

11. a) Find the current through the 20Ω resistor using Norton's theorem. **(6)**



b) State and prove maximum power transfer theorem. **(8)**

12. a) Use superposition theorem to find the voltage V shown in figure. **(8)**



b)State Thevenin's theorem. How is Thevenin equivalent circuit developed? **(6)**

MODULE II

13. a)Write the dynamic equations for analyzing the behavior of step response of a series RLC circuit. **(7)**

b) A sinusoidal voltage 25 sin 10t is applied at time t=0 to a series RL circuit comprising of R=5 Ω, L = 1 H. Using Laplace transformation, find an expression for instantaneous current in the circuit. **(7)**

14. a) A voltage 10 cos (1000t + 60^0) is applied to a series RLC circuit comprising of R=10 Ω, L = 0.02 H, C = 10^{-4} F. Find an expression for the steady state current in the circuit. **(7)**

b) A capacitor C having capacitance of 0.2 F is initially charged to 10 volts and it is connected to an RL series circuit comprising of R=4Ω and L = 1 H, by means of a switch at time t=0. Find the current through the circuit by means of Laplace transformation method. **(7)**

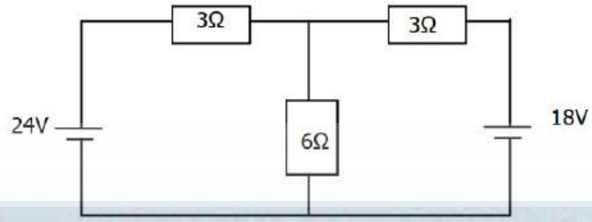
MODULE III

15. a) An LC network comprises of series inductor branches L1 and L2 each of inductance 2 H and parallel capacitor branches C1 and C2 each with capacitance 1 F. Find the transform impedance Z(s). **(6)**

b) What are reciprocal networks? What are the conditions that should be satisfied by a network to be reciprocal? **(8)**

16. a) How is transfer function representation of a network function helpful in analyzing the behavior of the network? Mention the significance of poles and zeros in network functions? **(8)**

b)Using Laplace transformation, find the current in the 6 Ω resistor. **(6)**



MODULE IV

17. a) In a series RLC circuit, for frequencies more than the resonant frequency, what nature of reactance is exhibited? Substantiate the reason for the answer. **(6)**

b) A series RLC circuit consists of R= 25 Ω, L = 0.01 H, C = 0.04 μF. Calculate the resonant frequency. If 10 V is applied to the circuit at resonant frequency, calculate the voltages across L and C. Find the frequencies at which these voltages are maximum. **(8)**

18. a) A coil of resistance 20 ohm and inductance of 200 mH is connected in parallel with a variable capacitor. This combination is connected in series with a resistance of 8000 ohm. Supply voltage is 200 V, 50Hz. Calculate the following

i) The value of C at resonance

ii) The Q of the coil

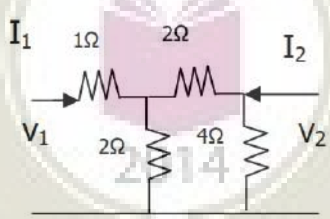
iii) Dynamic resistance of the circuit. **(7)**

b) Derive expressions for selectivity and bandwidth of a parallel tuned circuit. **(7)**

MODULE V

19. a) A two port network has the following z parameters: z_{11}=10 Ω, z_{12}=z_{21}=5 Ω, z_{22} = 12 Ω. Evaluate the y parameters for the network. **(8)**

b)Find the z parameters of the network given. **(6)**



20. a)For the given two-port network equations, draw an equivalent network. $I_1 = 5V_1 - V_2$; $I_2 = -V_2 + V_1$. **(7)**

b) A symmetrical T-network has the following open-circuit and short-circuit impedances:

Z_{oc}= 800Ω (open circuit impedance)

Z_{sc}= 600Ω(short circuit impedance)

Calculate impedance values of the network. **(7)**

Syllabus

Module 1

Circuit theorems: DC and Sinusoidal steady state analysis of circuits with dependent and independent sources applying Superposition principle, Source transformation, Thevenin's, Norton's and Maximum Power Transfer theorems - Reciprocity theorem.

Module 2

Analysis of first and second order dynamic circuits: Formulation of dynamic equations of RL, RC and RLC series and parallel networks with dc excitation and initial conditions and complete solution using Laplace Transforms - Time constant - Complete solution of RL, RC and RLC circuits with sinusoidal excitation using Laplace Transforms – Damping ratio – Over damped, under damped, critically damped and undamped RLC networks.

Module 3

Transformed circuits in s-domain: Transform impedance/admittance of R, L and C - Mesh analysis and node analysis of transformed circuits in s-domain. Transfer Function representation – Poles and zeros.

Analysis of Coupled Circuits: – Dot polarity convention – Sinusoidal steady state analysis of coupled circuits - Linear Transformer as a coupled circuit - Analysis of coupled circuits in s-domain.

Module 4

Resonance in Series and Parallel Circuits:

Resonance in Series and Parallel RLC circuits – Quality factor – Bandwidth – Impedance Vs Frequency, Admittance Vs Frequency, Phase angle Vs frequency for series resonant circuit.

Module 5

Two port networks: Driving point and transfer functions – Z, Y, h and T parameters - Conditions for symmetry & reciprocity – relationship between parameter sets – interconnections of two port networks (series, parallel and cascade) — T-π transformation.

Text Books

1. Joseph A. Edminister and MahmoodNahvi, "Theory and Problems in Electric circuits", McGraw Hill, 5th Edition, 2010.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

References:

1. Hayt and Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, New Delhi, 8th Ed, 2013.
2. Van Valkenberg, "Network Analysis", Prentice Hall India Learning Pvt. Ltd., 3 edition, 1980.
3. K. S. Suresh Kumar, "Electric Circuit Analysis", Pearson Publications, 2013.
4. Chakrabarti, "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018
5. R. Gupta, "Network Analysis and Synthesis", S. Chand & Company Ltd, 2010.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Network theorems - DC and AC steady state analysis (12 hours)**	
1.1	Linearity and Superposition principle - Application to the analysis of DC and AC (sinusoidal excitation) circuits. Application of source transformation in electric circuit analysis.	2
1.2	Thevenin's theorem - Application to the analysis of DC and AC circuits with dependent and independent sources.	3
1.3	Norton's theorem - Application to the analysis of DC and AC circuits with dependent and independent sources.	3
1.4	Maximum power transfer theorem - DC and AC steady state analysis with dependent and independent sources.	2
1.5	Reciprocity Theorem - Application to the analysis of DC and AC Circuits.	2
2	**First order and second order dynamic circuits. (9 hours)**	
2.1	Review of Laplace Transforms – Formulae of Laplace Transforms of common functions/signals, Initial value theorem and final value theorem, Inverse Laplace Transforms – partial fraction method. *(Questions to evaluate the Laplace/inverse transforms of any function / partial fractions method shall not be given in tests/final examination. Problems with application to circuits can be given).*	2
2.2	Formulation of dynamic equations of RL series and parallel networks and solution using Laplace Transforms – with DC excitation and initial conditions. Natural response and forced response. Time constant.	1

2.3	Formulation of dynamic equations of RC series networks and solution using Laplace Transforms – with DC excitation and initial conditions. Natural response and forced response. Time constant.	1
2.4	Formulation of dynamic equations of RLC series networks with DC excitation and initial conditions, and solution using Laplace Transforms – Natural response and forced response. Damping coefficient. Underdamped, Overdamped, critically damped and undamped cases.	1
2.5	Formulation of dynamic equations of RL, RC and RLC series networks and solution with sinusoidal excitation. Complete solution (Solution using Laplace transforms).	2
2.6	Formulation of dynamic equations of RL, RC and RLC parallel networks and solution using Laplace Transforms – with DC and Sinusoidal excitations. Damping ratio.	2
3	**Transformed Circuits in s-domain and Coupled circuits (9 Hours)**	
3.1	Transformed circuits in s-domain: Transformation of elements (R, L, and C) with and without initial conditions.	2
3.2	Mesh analysis of transformed circuits in s-domain.	1
3.3	Node analysis of transformed circuits in s-domain.	1
3.4	Transfer Function representation – Poles and zeros.	1
3.5	Analysis of coupled circuits: mutual inductance – Coupling Coefficient-Dot polarity convention –– Conductively coupled equivalent circuits. Linear Transformer as a coupled circuit.	2
3.6	Analysis of coupled circuits in s-domain.	2
4	**Resonance in Series and Parallel Circuits. (6 Hours)**	
4.1	Resonance in Series and Parallel RLC circuits –Related problems	3
4.2	Quality factor – Bandwidth –	1
4.3	Impedance Vs Frequency, Admittance Vs Frequency and Phase angle Vs frequency for series resonant circuit.	2

5	**Two port networks (9 Hours)**	
5.1	Two port networks: Terminals and Ports, Driving point and transfer functions. Voltage transfer ratio, Current transfer ratio, transfer impedance, transfer admittance, poles and zeros.	2
5.2	Z –parameters. Equivalent circuit representation.	1
5.3	Y parameters. Equivalent circuit representation.	1
5.4	h parameters. Equivalent circuit representation.	1
5.5	T parameters.	1
5.6	Conditions for symmetry & reciprocity, relationship between network parameter sets.	1
5.7	Interconnections of two port networks (series, parallel and cascade).	1
5.8	T-π Transformation.	1

SEMESTER -4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET202	**DC MACHINES AND TRANSFORMERS**	**PCC**	**2**	**2**	**0**	**4**

Preamble : The purpose of the course is to provide the fundamentals of DC generators, DC motors and transformers and giving emphasis to applications in engineering field.

Prerequisite : Basics of Electrical Engineering

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Acquire knowledge about constructional details of DC machines
CO 2	Describe the performance characteristics of DC generators
CO3	Describe the principle of operation of DC motors and select appropriate motor types for different applications
CO 4	Acquire knowledge in testing of DC machines to assess its performance
CO 5	Describe the constructional details and modes of operation of single phase and three phase transformers
CO6	Analyse the performance of transformers under various conditions

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2			2							3
CO 2	3	2				2						3
CO 3	3	2	2			2						3
CO4	3	3				2						3
CO5	3					2						3
CO6	3					2						3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	10	10	30
Apply	10	10	30
Analyse	10	10	20
Evaluate			
Create			

End Semester Examination Pattern

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Part A: 10 Questions x 5 marks=50 marks, **Part B:** 5 Questions x 10 marks =50 marks

Course Level Assessment Questions

CO1:

1. Describe the functions of individual parts of DC machines.
2. Develop simplex lap and wave windings for different pole and slot configurations.
3. Explain in detail why equaliser rings are required in lap windings.

CO2:

1. Describe different types of DC generators.
2. Derive the EMF equation of a DC machine.
3. Draw the open circuit and load characteristics of DC generators.
4. Explain the condition for voltage build up.
5. Explain armature reaction in DC machines and solutions to overcome its effects.
6. Analyse parallel operation of DC generators.

CO3:

1. Derive the torque equation of a DC motor.
2. Why starters are used in DC motors?
3. Explain types of speed control in DC motor.
4. Explain regenerative braking in DC motor.
5. What are the losses associated with DC motor?
6. Select suitable type of DC motor for specific applications.

CO4:

1. Describe the principle of Swinburn’s test for testing of DC motor and perform the calculations.
2. Describe the principle of Hopkinson’s test for testing of DC motor.
3. Describe the principle of retardation test for separation of losses in a DC motor.

CO5:

1. Derive the EMF equation of single-phase transformer.
2. Derive the condition for maximum efficiency in a transformer.
3. Explain the difference between power transformer and distribution transformer.
4. Explain the current rating and kVA rating of auto transformers.
5. Explain in detail no load and on load tap changing.
6. Draw the various three phase transformer connections.
7. Explain the stabilization by tertiary winding.

CO6:

1. Draw the equivalent circuit of single-phase transformer referred to primary side.
2. Explain no load and short circuit test on a single-phase transformer.
3. Explain Sumpner's test on transformers.
4. What are the necessary condition for parallel operation of a single phase and three phase transformers?

Model Question paper

QP CODE:

PAGES: 2

Reg. No:_______________
Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET 202

Course Name: DC MACHINES AND TRANSFORMERS

Max. Marks: 100 **Duration: 3 Hrs**

PART A

Answer all questions. Each Question Carries 3 marks

1. Compare Lap and Wave Windings in DC machines.
2. Explain the need of Dummy Coils in DC machines.
3. What is armature reaction and mention two methods to eliminate it in DC machines.
4. What are the necessary conditions for voltage build up in a DC shunt generator.
5. Explain the significance of Back emf in a DC motor. Write down the voltage equation of a DC shunt motor.
6. Discuss the different types of armature speed control in DC shunt motor.
7. Derive the emf equation for a single phase Transformer.
8. How the rating of a transformer is specified? Justify.
9. Discuss the operation of open delta (V-V) configuration of transformers.
10. Discuss the need and working of on-load tap changers.

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) Discuss the need of Equalizer rings. **(5)**
    b) Obtain the front and back pitch of a progressive simplex double layer wave winding for a 4 pole dc generator with 30 armature conductors. **(9)**
12. Explain the construction of a DC machine with neat diagram. **(14)**

Module 2

13. Explain different types of DC generator with neat circuit diagram and necessary equations. **(14)**
14. Two DC shunt generators with induced emfs of 120V and 115V, armature resistance of 0.05Ω and 0.04Ω and field resistances of 20Ω and 25Ω respectively are in parallel supplying a total load of 25kW. Calculate the load shared by each generator? **(14)**

Module 3

15. Draw the circuit diagram and explain the experimental procedure to conduct Hopkinson test on DC machine. **(14)**
16. A DC machine is rated at 5kW, 250V, 2000rpm and Ra=1Ω. Driven at 2000rpm, the no load power input to the armature is 1.2A at 250V with field winding (Rsh) = 250Ω, excited by Ish =1A. (i) Estimate efficiency as a generator delivering. (ii) Estimate the efficiency as a motor taking 5kW from supply. **(14)**

Module 4

17. a) Derive the condition for maximum efficiency and the load current at which max. Efficiency occurs in a single phase transformer. **(8)**

    b) Discuss the significance of all day efficiency of transformers. **(6)**

18. A 20kVA, 250/2500V single phase transformer gave the following test results.

    OC Test (LV side): 200V, 1.4A, 105W

    SC Test (HV side): 120V, 8A, 320W

    Draw the equivalent circuit of single phase transformer referred to LV side. **(14)**

Module 5

19. Explain Auto transformer with neat diagram and Derive an expression to justify thesaving of copper in auto transformer with respect to an ordinary two winding transformer with same rating. **(14)**
20. Explain Dy11 and Yd1 vector groupings of three phase transformers with phasor and winding connection diagrams. **(14)**

Syllabus

Module 1

Constructional details of dc machines - armature winding- single layer winding, double layer winding- lap and wave, equalizer rings, dummy coils, MMF of a winding, EMF developed, electromagnetic torque - numerical problems.

Module 2

DC generator –principle of operation, EMF equation, excitation,armature reaction– demagnetising and cross magnetising ampere turn,compensating windings, interpoles, commutation,OCC, voltage build upand load characteristics, parallel operation. Power flow diagram– numerical problems.

Module 3

DC motor –back emf, generation of torque,torque equation,performance characteristics – numerical problems.

Starting of dc motors- starters –3point and 4 point starters(principle only).

Speed control of dc motors - field control, armature control. Braking of dc motors. Power flow diagram – losses and efficiency.Testing of dc motors - Swinburne's test,Hopkinson's test, and retardation test.DC motor applications – numerical problems.

Module 4

Single phase transformers –constructional details, principle of operation, EMF equation, ideal transformer,dot convention, magnetising current, transformation ratio, phasor diagram, operation on no load and on load, equivalent circuit, percentage and per unit impedance, voltage regulation. Transformer losses and efficiency, condition for maximum efficiency,kVA rating. Testing of transformers– polarity test, open circuit test, short circuit test, Sumpner's test – separation of losses, all day efficiency.Parallel operation of single-phase transformers– numerical problems

Module 5

Autotransformer – saving of copper –ratingof autotransformers.

Three phase transformer – construction- difference between power transformer and distributiontransformer –Different connections of 3-phase transformers. Y-Y, Δ-Δ,Y-Δ, Δ-Y, V-V. Vector groupings – Yy0, Dd0, Yd1, Yd11, Dy1, Dy11.Parallel operation of three phase transformers.

Three winding transformer – stabilization by tertiary winding. Tap changing transformers - no load tap changing, on load tap changing, dry type transformers.

Text Books

1. Bimbra P. S., Electrical Machinery, 7/e, Khanna Publishers, 2011.
2. Nagrath J. and D. P. Kothari, Theory of AC Machines, Tata McGraw Hill, 2017.

Reference Books

1. Fitzgerald A. E., C. Kingsley and S. Umans, Electric Machinery, 6/e, McGraw Hill, 2003.
2. Langsdorf M. N., Theory of Alternating Current Machinery, Tata McGraw Hill, 2001.
3. Deshpande M. V., Electrical Machines, Prentice Hall India, New Delhi, 2011.
4. B. L. Theraja, Electrical Technology Vol II,S.Chand Publications.
5. A. E. Clayton & N. N. Hancock, The Performance and design of Direct Current Machines,CBS Publishers& Distributors, NewDelhi.

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Hours
1	**Constructional details of dc machines**	**8**
1.1	Constructional details of DC machines	2
1.2	Armature winding- single layer	1
1.3	Armature winding- double layer-wave and lap, equaliser rings, dummy coils.	3
1.4	MMF of a winding, EMF developed, electromagnetic torque.	2
2	**DC Generator**	**9**
2.1	DC generators- principle of operation, EMF equation, methods of excitation –separately and self-excited – shunt, series, compound machines.Numerical problems	3
2.2	Armature reaction – effects of armature reaction, demagnetising and cross magnetising ampere-turns, compensating windings,interpoles. Numerical problems.	3
2.3	Load characteristics, losses and efficiency power flow diagram. Parallel operation – applications of dc generators. Numerical problems.	3
3	**DC Motor**	**10**
3.1	DC motor– principle of operation, back emf, classification– torque equation. Numerical problems.	2

3.2	Starting of DC motors – necessity of starters. Numerical problems. Types of starters – 3 point and 4 point starters(principle only).	2
3.3	Speed control – field control, armature control- Numerical problems. Braking of dc motors (Description only)	2
3.4	Losses and efficiency – power flow diagram. Numerical problems	1
3.5	Swinburne's test - Numerical problems.	1
3.6	Hopkinson's test, separation of losses – retardation test. Applications of dc motors.	2
4	**Single phase Transformer**	**10**
4.1	Transformers – principle of operation, construction, core type and shell type construction.	1
4.2	EMF equation, transformation ratio, ideal transformer,transformer with losses, phasor diagram - no load and on load operation. Numerical problems.	2
4.3	Equivalent circuit, percentage and per unit impedance, voltage regulation. Numerical problems.	2
4.4	Transformer losses and efficiency, Condition for maximum efficiency, all day efficiency – Numerical problems.	2
4.5	Dot convention – polarity test, OC & SC test, Sumpner's test,separation of losses. Numerical problems.	2
4.6	kVA rating of transformers,parallel operation of single phase transformers	1
5	**Autotransformer & Three phase transformer**	8
5.1	Autotransformer – ratings, saving of copper.Numerical problems.	2
5.2	Three phase transformer construction, three phase transformer connections, power transformer and distribution transformer.	2
5.3	Vector groupings Yy0, Dd0, Yd1, Yd11, Dy1, Dy11.	1
5.4	Three winding transformer – tertiary winding. Percentage and per unit impedance. Parallel operation.	2
5.5	On load and off load tap changers, dry type transformers.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET204	**ELECTROMAGNETIC THEORY**	PCC	3	1	0	4

Preamble : The purpose of the course is to familiarize the students with the fundamentals of electrostatics, magnetostatics, time-varying fields and electromagnetic waves.

Prerequisite : Engineering Mathematics,Engineering Physics

Course Outcomes :After the completion of the course the student will be able to:

CO 1	Apply vector analysis and coordinate systems to solve static electric and magneticfield problems.
CO 2	Apply Gauss Law, Coulomb’s law and Poisson's equation to determine electrostatic field parameters
CO 3	Determine magnetic fields from current distributions by applying Biot-Savart's law and Amperes Circulal law.
CO 4	Apply Maxwell Equations for the solution of timevarying fields
CO 5	Analyse electromagnetic wave propagation in different media.

Mapping of course outcomes with programme outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	3										
CO 2	2	3										
CO 3	2	3										
CO 4	2	3										
CO 5	2	3										

Assessment Pattern:

Bloom’s Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand*	20	20	50
Apply*	20	20	30
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

*Numerical problems to test the understanding and application of principles to be asked.

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions:

Course Outcome 1 (CO1):

1. Transform the vector **B**= 5$\mathbf{a}_x$-7$\mathbf{a}_y$ to Cylindrical Co-ordinate System at the point P (r=4, Φ=120^o, z=2).
2. Drawing necessary sketches, obtain the rectangular co-ordinates x,y,z of the point P , in terms of its cylindrical co-ordinates r,Φ,z. Assume the same origin for both co-ordinate systems.
3. Distinguish between Divergence and Gradient. Explain the physical significance of Divergence.
4. State and prove Divergence Theorem.

Course Outcome 2 (CO2):

1. A 2μC positive charge is located in vacuum at P_1(3,-2,4) and 5μC negative charge is at P_2 (1,-4,-2). Determine: (i) the vector force on the negative charge. (ii) the magnitude of the force on the charge at P_1?
2. Apply Gauss's Law to obtain the electric field intensity due to an infinite sheet of charge.
3. Derive an expression for the capacitance of a co-axial cable.

Course Outcome 3(CO3):

1. Derive the magnetic field intensity at a point on a line through the centre and perpendicular to the plane of a circular loop of radius 'r' m carrying current 'I' A. The point is at a distance 'h' m from the centre of the loop.
2. State Ampere's Circuital law. Express it in integral and differential forms.
3. State Biot-Savart's Law and express it in vector form.

Course Outcome 4 (CO4):

1. Formulate the Maxwell's equation in differential form and integral form for time-varying fields.
2. Derive general wave equations from Maxwell's equations.
3. Explain how Ampere's circuital law can be modified for time-varying fields.

Course Outcome 5 (CO5):

1. Define a) intrinsic impedance b) characteristic impedance.
2. Derive wave equations for Uniform plane wave in free space.
3. A 9375 MHz uniform plane wave is propagating in free space. If the amplitude of the electric field intensity is 20 V/m and the material is assumed to be loss less find α, β, λ, intrinsic impedance, propagation constant and amplitude of magnetic field intensity.

Model Question paper

PAGES: 2

QP CODE:

Reg. No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FOURTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET 204

Course Name: ELECTROMAGNETIC THEORY

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. State Strokes Theorem and explain.
2. What do you understand by Curl of a vector? Explain its physical significance?
3. Define electric dipole. What is the electric field intensity due to an electric dipole?
4. Explain the term electric field intensity.
5. State Biot-Savarts Law.
6. What is conduction current and displacement current?
7. Explain group velocity and phase velocity.
8. Which of Maxwell's equation states that the magnetic field is a non-conservational field in both static and dynamic conditions? Comment.
9. Explain electromagnetic interference.
10. What is SWR?

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Transform vector A= 5 a$\hat{r}$ + 2 sinϕa$\hat{\theta}$ +2 cosθ a$\hat{\phi}$ in spherical to Cartesian coordinate system. **(6)**

(b) Evaluate both sides of the Divergence theorem for the region r ≤ 1 and if A= 3r sin^2θ cos^2ϕ a$\hat{r}$. **(8)**

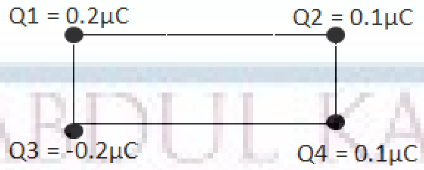
12. (a) Derive co-ordinate transformation between Cartesian and Spherical systems. **(10)**

(b) Explain the physical significance of divergence of a vector field. **(4)**

Module 2

13. (a) State and Prove Gauss's Law. **(4)**

(b) Four point charges are located at the four corners of the rectangle as shown. Length and breadth of rectangle are 5cm and 2 cm respectively. Find the magnitude and direction of the resultant force on Q1. **(10)**



14. (a) Derive the expression of electric field intensity due to infinite line charge having line charge density ρ C/m. **(6)**

(b) Using Gauss's Law derive an expression for the capacitance per unit length between two infinitely long concentric conducting cylinders. The medium between two cylinders is completely filled with air. **(8)**

Module 3

15. (a) State the boundary conditions at the boundary of two magnetic media of permeability µ1 and µ2. **(10)**

(b) Flux lines are received at an iron-air boundary at88^0. If the iron has a relative permeability of 350, determine the angle from the normal with which the flux emerges into air. **(4)**

16. (a) Find the incremental contribution ΔH to magnetic field intensity at the origin caused by a current element in free space, IdL equal to 3π a$\hat{z}$nA, located at (3,-4,0). **(8)**

(b) Derive the magnetic field intensity on the axis of a circular loop carrying current. **(6)**

Module 4

17. (a) A 10GHz plane wave travelling in free space has an amplitude 15V/m. Find velocity of propagation, wavelength, amplitude of H, characteristic impedance of media, propagation constant. **(10)**

(b) What is skin effect and skin depth? (4)

18. (a) Explain about Poynting Theorem. Show that the power flow along a concentric cable is the product of voltage and current using pointing Theorem. **(10)**

(b) What is uniform plane wave? What are its properties? **(4)**

Module 5

19. (a) Explain in detail impedance matching of lines. **(10)**

(b) Explain the term propagation constant and phase velocity as applied to transmission lines. **(4)**

20. (a) Derive the basic transmission line equation. **(9)**

(b) What are the different parameters of transmission lines? **(5)**

Syllabus

Module 1:

Introduction to Co-ordinate Systems – Rectangular, Cylindrical and Spherical Co- ordinate Systems – Co-ordinate transformation; Gradient of a Scalar field, Divergence of a Vector field and Curl of a Vector field- their physical interpretation; Divergence Theorem, Stokes' Theorem;

Module 2:

Coulomb's Law, Electric field intensity, Field due to a line charge, surface charge distribution. Electric Flux and Flux Density; Gauss's law and its application to determine the field due to an infinite line charge, infinite sheet charge; Electric Potential-Potential Gradient, conservative property of electric field, Equipotential surfaces; Electric Dipole; Capacitance - capacitance of co-axial cable, two wire line; Poisson's and Laplace's equations;

Module 3:

Biot-Savart's Law, Magnetic Field intensity due to a finite and infinite wire carrying current; Magnetic field intensity on the axis of a circular and rectangular loop carrying current; Magnetic flux Density; Magnetic Vector Potential; Ampere's circuital law and simple applications; Inductance and mutual inductance. Boundary conditions for electric fields and magnetic fields;

Conduction current and displacement current densities; Continuity equation for current; Maxwell's Equation in Differential and Integral form from Modified form of Ampere's circuital law, Faraday's Law and Gauss's Law.

Module 4:

Wave Equations from Maxwell's Equations; Uniform Plane Waves, Wave equations in Phasor form; Propagation of Uniform Plane waves in free space, loss-less and lossy dielectric medium, Uniform Plane waves in good conductor; Skin effect and skin depth, phase velocity and groupvelocity, Intrinsic Impedance, Attenuation constant and Propagation Constant in all medium;Poynting Vector and Poynting Theorem.

Module 5:

Transmission line: Waves in transmission line, Line parameters, Transmission line equation & solutions, Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation. Standing Wave Ratio(SWR), impedance matching.Solution of problems. Electromagnetic interference.

Text Books

1. Matthew N.O. Sadiku, *Principles of Electromagnetics*, Oxford University Press, 6^{th} Edition.

2 Hayt W. H. and J. A. Buck, *Engineering Electromagnetics*, McGraw-Hill, 8^{th} Edition.

Reference Books

1 Joseph A. Edminister, *Electromagnetics, Schaum's Outline Series*, Tata McGraw-Hill, Revised 2^{nd} Edition.

2 John Kraus and Daniel Fleisch, *Electromagnetics with Applications*, McGraw-Hill, 5^{th}edition

3 Cheng D K,*Fundamentals of Engineering Electromagnetics*, Addison-Wesley.

4 Guru B. S. and H. R.Hizroglu, *Electromagnetic Field Theory Fundamentals*,PWS Publication Company,Boston, 1998.

5 Gangadhar K. A. and P. M. Ramanathan, *Electromagnetic Field Theory*, Khanna Publishers, 2009

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1:**	**9**
1.1	Introduction to coordinate systems – Rectangular, cylindrical and spherical coordinate Systems – Coordinate transformation. Numerical Problems.	3
1.2	Gradient of a scalar field, Divergence of a vector field and curl of a vector field- physical interpretation. Numerical Problems.	3
1.3	Divergence Theorem, Stokes' Theorem.Numerical Problems.	3
2	**Module 2:**	**9**
2.1	Coulomb's Law, Electric field intensity, Field due to a line charge, surface charge distribution. Numerical Problems.	2
2.2	Electric Flux and Flux Density; Gauss's law and its application to determine the field due to an infinite line charge, Infinite sheet charge. Numerical problems.	3

2.3	Electric Potential-Potential Gradient, conservative property of electric field, Equipotential surfaces. Numerical Problems.	2
2.4	Electric Dipole, Capacitance, Poisson’s and Laplace’s equations.Numerical Problems.	2
3	**Module 3:**	**11**
3.1	Biot-Savart’s Law, Magnetic Field intensity due to a finite and infinite wire carrying current.Magnetic field intensity on the axis of a circular and rectangular loop carrying current.Numerical Problems.	3
3.2	Magnetic flux Density; Magnetic Vector Potential; Ampere’s circuital law and simple applications, Numerical Problems.	3
3.3	Boundary conditions for electric fields and magnetic fields. Conduction current and displacement current densities; Continuity equation for current; Electrostatic Energy Density.; Numerical Problems.	3
3.5	Maxwell’s Equation in Differential and Integral form from Modified form of Ampere’s circuital law, Faraday's Law and Gauss’s Law; Numerical Problems.	2
4	**Module 4:**	8
4.1	Wave Equations from Maxwell's Equations; Uniform Plane Waves, Wave equations in Phasor form. Numerical Problems.	3
4.2	Propagation of Uniform Plane waves in free space, loss-less and lossy dielectric medium, Uniform Plane waves in good conductor-properties in different medium.Numerical Problems.	3
4.3	Skin effect and skin depth, Poynting Vector and Poynting Theorem. Numerical Problems.	2
5	**Module 5:**	8
5.1	Transmission line: Waves in transmission line, Line parameters.Numerical Problems.	3
5.2	Transmission line equation &solutions, Physical significance of solutions,Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation.Numerical Problems.	3
5.3	SWR, impedance matching .Solution of problems. Electromagnetic interference Solution of problems.	2

.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET206	**DIGITAL ELECTRONICS**	PCC	3	1	0	4

Preamble : **Nil**

Prerequisite : **Nil**

Course Outcomes :After the completion of the course the student will be able to:

CO 1	Identify various number systems, binary codes and formulate digital functions using Boolean algebra.
CO 2	Design and implement combinational logiccircuits.
CO 3	Design and implement sequential logic circuits.
CO 4	Compare the operation of various analog to digital and digital to analog conversion circuits.
CO 5	Explain the basic concepts of programmable logic devices and VHDL.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1										
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	2	1									
CO 5	3	2	2		2							

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Convert one number system to another form.-Binary, decimal, octal and hexadecimal
2. Arithmetic's using of a 2's complement method?
3. Binary and BCD arithmetic's.
4. Reduce the Boolean expression.
5. Develop logiccircuits using Universal gates.
6. Reduce the Boolean expression using Boolean laws.
7. Describe the logic levels used in TTL logic system.

Course Outcome 2 (CO2):

1. Convert an SOP form to a POS form and vice-versa?
1. Boolean expression simplification using K map.
2. Design full adder using NAND gates alone.
3. Draw and explain the circuit of carry look ahead adder circuit.
4. Discusshow the look ahead carry adder speed up the addition process?
5. Design of i)Half adder ii) Full adder iii) Full subtractor using gates

6. Differentiate priority encoder andordinaryencoder.
7. Explain the use of the enable input in a decoder?
8. Explain odd parity generator and even parity generator.
9. Differentiate between Multiplexers and De- Multiplexers.
10. Design an 8421 to 2421 BCD code converter and draw its logic diagram.

Course Outcome 3(CO3):

1. Explain different types of flip-flops and its application areas.
2. Design various counter circuits.
3. Describe a level triggered flipflopand compare it with an edge triggered flipflop?
4. Discuss master slave flipflop?
5. Design a mod-7 asynchronous counter using J-K flipflop.
6. Distinguish ring counter from Johnson counter.
7. Explain various types of shift register?
8. Differentiate between a counter and a shift register?

Course Outcome 4 (CO4):

1. Determine the number of output voltages that can be produced by an 8 bit ADC.
2. Write the advantage of the R-2R ladder DAC over the weighted resistor type DAC?
3. Which one is the fastest ADC and explain why?
4. Compare PLA and PAL?
5. Describe programmable logic array and differentiate it from ROM?

Course Outcome 5 (CO5):

1. Differentiate between Moore and Mealy machine?
2. Explain the function of mealy machine
3. Code implementation of simple circuits using Verilog
4. Explain FPGA and state its applications?

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

End Semester Examination Pattern :

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Model Question Paper

QP Code: Pages: 2

Reg No: ____________________

Name: ____________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET 206
Course Name: DIGITAL ELECTRONICS

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all Questions. Each question carries 3 Marks

1. Translate the gray code 10110010101 to binary number.
2. Express the decimal number -31 as an 8 bit binary number in sign magnitude form, 1's complement form and 2's complement form.
3. Simplify the Boolean expression $AB + \overline{AC} + A\bar{B}C(AB + C)$.
4. Develop the standard Sum of Products(SOP) for the logic expression $F(A, B, C, D) = AB + \bar{A}B\bar{D} + B\bar{C}D$
5. Differentiate between Multiplexers and De- Multiplexers.
6. Realize a 2-bit comparator.
7. How does a J-K Flip Flop differ from an S-R Flip Flop in its operation?
8. What are PRESET and CLEAR inputs?
9. Draw the schematic of a successive approximation A/D converter.
10. Differentiate PLA and PAL circuits **(10 x 3 = 30)**

PART B
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Why is two's - complement method of representing signed integer numbers preferred overones complement in digital circuits? What is range of numbers that can be represented using two's complement with four bits? **(10)**

(b) Represent the decimal number 3.248×10^4 in single precision IEEE binary format **(4)**

12. (a) Explain the working of a TTL NAND gate with the help of internal diagram. **(10)**

(b) Compare CMOS and TTL performance. **(4)**

Module 2

13. (a) Make use of a 4 variable K map and simplify $F(A,B,C,D) = \sum_m$ *(1,4,9,10,11,12,14) + d(0,8,13)*. Realize the function using NAND gates only. **(10)**

(b) Design a half adder circuit and realize using NAND gates only. **(4)**

14. (a) Realize a look-ahead-carry adder. **(8)**

(b) Construct the truth table for a full adder. Reduce it using K map. Implement it using logic gates. **(6)**

Module 3

15. (a) Explain the even parity method for error detection. **(8)**

(b) Use a 4 x 1 MUX to implement the logic function $F(A,B,C) = \sum_m(1,2,4,7)$. **(6)**

16. (a) What is the purpose of decoder? Explain the functioning of a BCD to Decimal Decoder circuit. **(8)**

(b) Explain the architecture of ALU with the help of a block diagram **(6)**

Module 4

17. (a) Realize an S-R flip flop using a D flipflop. **(10)**

(b) What is the race around condition of a J-K flip flop? How can it be avoided? **(4)**

18. (a) Design a Synchronous Mod-6 Counter using J-K FFs **(8)**

(b) Draw a parallel in -serial out (PISO) register and explain its working. **(6)**

Module 5

19. (a) Differentiate between Moore and Mealy machine? Compare them with the help of logic diagrams. **(10)**

(b) What is the advantage of the R-2R ladder DAC over the weighted resistor type DAC? **(4)**

20. (a) Explain FPGA and state its applications? **(8)**

(b) Design and implement a half adder using Verilog. **(6)**

Syllabus

Module 1

Number Systems and Codes: Binary, Octal and hexadecimal conversions- ASCII code, Excess -3 code, Gray code, BCD, Error detection codes-Parity method.

Signed numbers- representation, addition and subtraction,Fixed point and floating-point representation.

Logic gates, Universal gates, TTL and CMOS logic families-Internal diagram of TTL NAND gate and CMOS NOR gate. Comparison of CMOS and TTL performance.

Module 2

Boolean Laws and theorems, Sum of Products method, Product of Sum method – K map representation and simplification(up to four variables) - Pairs, Quads, Octets, Don't care conditions.

Combinational circuits: Adders -Full adder and half adder, Subtractors- halfsubtractor and fullsubtractor, 4 bit parallel binary adder/subtractor, Carry Look ahead adders.

Module 3

Comparators, Parity generators and checkers, Encoders, Decoders, , BCD to seven segment decoder, Code converters, Multiplexers, Demultiplexers, Architecture of Arithmetic Logic Units (Block schematic only).

Module 4

Flip-Flops, SR, JK, D and T flip-flops, JK Master Slave Flip-flop, Preset and clear inputs, Conversion of flip-flops.

Registers -SISO, SIPO, PISO, PIPO.

Up/Down Counters: Asynchronous Counters – Modulus of a counter – Mod-N counters Ring counter, Johnson Counter

Synchronous counters,Design of Synchronous counters.

Module 5

State Machines: State transition diagram, Moore and Mealy Machines

Digital to Analog converter –Specifications, Weighted resistor type, R-2R Ladder type.Analog to Digital Converter – Specifications, Flash type, Successive approximation type.

Programmable Logic Devices - PAL, PLA, FPGA (Introduction and basic concepts only)
Introduction to Verilog, Implementation of AND, OR, half adder and full adder.
Note: Course assignments may be given in Verilog programming

Text Books

1. Floyd T.L, Digital Fundamentals, 10/e, Pearson Education, 2011.
2. C.H.Roth and L.L.Kimney Fundamentals of Logic Design, 7/e, Cengage Learning, 2013.
3. Mano M.M, Logic and Computer Design Fundamentals, 4/e, Pearson Education.
4. A Anand Kumar, Fundamental of Digital Electronics ,Prentice Hall
5. Roy Chaudari ,Linear Integrated Circuits, New Age International Publications
6. S. Salivahanan , Digital Circuits and Design, Oxford University Press

Reference Books

1. Donald P. Leach, Albert Paul Malvino and GoutamSaha, Digital Principles and Applications, 8/e, by McGraw Hill.
2. Tocci R.J. and N.S.Widmer, Digital Systems, Principles and Applications, 11/e, Pearson Education.
3. John F. Wakerly, Digital Design: Principles and Practices, 4/e, Pearson, 2005.
4. Taub& Schilling: Digital Integrated Electronics, McGraw Hill, 1997.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Number systems and Binary codes10**	
1.1	Introduction, Binary, Octal and hexadecimal conversions	2
1.2	ASCII code, Excess -3 code, Gray code, BCD.	1
1.3	Error detection codes –Parity Codes.	1
1.4	Signed numbersrepresentation, addition and subtraction	1
1.5	Fixed point and floating-point representation	2
1.6	Logic gates and universal gates	1
1.7	TTL and CMOS logic families-Internal diagram of TTL NAND gate and CMOS NOR gate. Comparison of CMOS and TTL performance.	2
2	**Boolean Algebra and Adders9**	
2.1	Boolean Laws and theorems.	1
2.2	Standard forms and canonical forms, Sum of Products method, Product of Sums method.	2
2.3	K-map representation and simplification (upto four variables) -Pairs, Quads, Octets, Don’t care conditions. Realisation using universal gates.	2
2.4	Adders - Full adder and half adder – Subtractors, half subtractor and full subtractor.	2
2.5	4-bit parallel binary adder/subtractor.	1
2.6	Carry Look-ahead adders.	1

3	**Combinational Logic Circuits**	**9**
3.1	2- and 4-bit magnitude comparator.	2
3.2	Parity generators and checkers.	1
3.3	Encoder, Decoder-BCD to decimal and BCD to seven segment decoders.	2
3.4	Realisation of Code converters.	1
3.5	Multiplexers and implementation of functions, Demultiplexers	2
3.6	Architecture of Arithmetic Logic Units (Block schematic only)	1
4	**Sequential circuits10**	
4.1	Flip-Flops, SR, JK, D and T flip-flops, JK Master Slave Flip-flop, Preset and clear inputs	2
4.2	Conversion of flip-flops.	2
4.3	Registers -SISO, SIPO, PISO, PIPO.	1
4.4	Up/Down Counters: Asynchronous Counters – Modulus of a counter – Mod-N counters.	2
4.5	Ring counter, Johnson Counter.	1
4.6	Design of Synchronous counters	2
5	**State Machines, D/A and A/D converters and PLDs7**	
5.1	State Machines: State transition diagram, Moore and Mealy Machines	1
5.2	Digital to Analog converter – R-2R ladder, weighted resistors.	1
5.3	Analog to Digital Converter - Flash ADC, Successive approximation.	1
5.4	Programmable Logic Devices - PAL, PLA-function implementation - FPGA (Introduction and basic concepts only).	2
5.5	Introduction to VHDL, Implementation of AND, OR, half adder and full adder.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EEL202	**ELECTRICAL MACHINES LAB I**	**PCC**	**0**	**0**	**3**	**2**

Preamble : The purpose of this lab is to provide practical experience in operation and testing of DC machines and transformers.

Note : A minimum of **TWELVE** experiments are mandatory out of the fifteen listed.

Prerequisite :

1. Fundamentals of Electrical Engineering
2. D.C Machines and Transformers (Theory)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse the performance of DC motors and DC generators by performing load test.
CO 2	Sketch the Open Circuit Characteristics of a self excited DC shunt generator and check conditions of voltage build up by performing suitable experiment.
CO 3	Develop equivalent circuit and predetermine their regulation and efficiency by performing OC & SC tests on transformer.
CO 4	Analyse the efficiency and regulation of the transformer by performing load test.
CO 5	Analyse the efficiency of a DC machine when working as motor and generator by conducting suitable test.
CO 6	Examine the efficiency by performing Sumpner’s test on two similar transformers.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2	-	-	-	-	3	2	-	3
CO 2	3	3	2	2	-	-	-	-	3	2	-	3
CO 3	3	3	2	2	-	-	-	-	3	2	-	3
CO 4	3	3	2	2	-	-	-	-	3	2	-	3
CO 5	3	3	2	2	-	-	-	-	3	2	-	3
CO 6	3	3	2	2	-	-	-	-	3	2	-	3

Assessment Pattern

Marks distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance:	15 marks
Continuous Assessment:	30 marks
Internal Test (Immediately before the second series test) :	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	15 Marks
(b) Implementing the work/Conducting the experiment	10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting)	25 Marks
(d) Viva voce	20 marks
(e) Record	5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified Laboratory Record. The external examiner shall endorse the record.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1) Conduct a brake test on the given DC series motor and plot its electrical characteristics and speed versus armature current curve.
2) Plot the load characteristics of the given differentially compounded DC generator by conducting suitable experiments.
3) Plot the electrical and mechanical characteristics of the given DC shunt motor by conducting suitable experiments.

Course Outcome 2 (CO2):

1) Predetermine the OCC of the given D.C shunt generator when running at 80% rated speed and also find the critical resistance at rated speed.
2) Plot the OCC of the D.C shunt generator at its rated speed and obtain its critical resistance and critical speed. Also obtain the additional resistance required in the field circuit for generating rated voltage on no load.

Course Outcome 3(CO3):

1) Predetermine the per phase equivalent circuit of the 3 phase transformer referred to low voltage side by conduction suitable experiments. Also compute its KVA corresponding to maximum efficiency.
2) Predetermine the maximum efficiency of the given single phase transformer at upf by conducting suitable experiment. Also compute its full load regulation at upf.

Course Outcome 4 (CO4):

1) Plot the regulation and efficiency curves of the given 1-phase transformer by conducting a suitable experiment.
2) Plot the regulation and efficiency curves of the given 3-phase transformer by conducting a suitable experiment.

Course Outcome 5 (CO5):

1) Conduct a suitable test on the given DC shunt machine and predetermine the efficiency curve of the machine both as motor and as generator

Course Outcome 6 (CO6):

1) Conduct a suitable test on two similar 1-phase transformers and predetermine its efficiency at full load and 0.8 pf lagging.
2) Conduct a suitable test on two similar 1-phase transformers and predetermine its efficiency at half load and UPF.

LIST OF EXPERIMENTS

PART A- DC MACHINES

1. **Open Circuit Characteristics of a DC Shunt Generator**

   Objectives:

   a) Predetermine the OCC at different speeds
   b) Determine the critical field resistance
   c) Obtain maximum voltage built up with given shunt field
   d) Obtain critical speed for a given shunt field resistance

2. **Load Test on a DC Shunt Generator**

   Objectives:

   a) Determine the external & internal characteristics of the given DC Shunt Generator

3. **Brake Test on a DC Shunt Motor**

   Objectives:

   Plot the following characteristics
   a) Performance characteristics
   b) Electrical characteristics
   c) Mechanical characteristics.

4. **Brake Test on a DC Series Motor**

   Objectives:

   Plot the following characteristics
   a) Performance characteristics
   b) Electrical characteristics
   c) Mechanical characteristics.

5. **Load Characteristics of a DC Compound Generator**

   Objectives:

   a) To plot the load characteristics of the given DC Compound generator when cumulatively compounded.
   b) To plot the load characteristics of the given DC Compound generator when differentially compounded

6. Swinburne's Test on a DC Shunt Machine

Objectives:

a) To predetermine the efficiency of a D.C. shunt machine when the machine operates as a motor and as a generator for various load conditions
b) To plot the efficiency curves of the given DC machine.

7. Hopkinson's test on a pair of DC machines

Objectives:

Determination of the efficiency of the given dc shunt machine working as a motor and generator under various load conditions.

8. Retardation test on a DC machine

Objectives:

a) Separation of hysteresis, eddy current, friction &windage losses
b) Find the moment of inertia of the rotating system

9. Separation of losses in a DC shunt motor

Objectives:

a) Separation of hysteresis, eddy current, friction &windage losses
b) Plot the losses vs speed curves

PART B - TRANSFORMERS

10. OC & SC Tests on a Single Phase Transformer

Objectives:

a) To pre-determine the regulation and efficiency of the given single phase transformer at different loads and power factors
b) To obtain the equivalent circuit of the given transformer
c) To plot regulation vs power factor curves
d) To determine the power factors at which regulation is zero

11. DirectLoad Test on a Single Phase Transformer

Objectives:

a) To determine the efficiency of the given transformer at unity power factor at different loads
b) To determine the regulation of the given transformer at unity power factor at different loads
c) To plot the efficiency vs output and regulation vs output curves

12. Separation of Constant losses of a Single Phase Transformer

Objectives:

a) To separate hysteresis and eddy current losses of a single phase transformer, keeping V/f constant.
b) To plot losses vs. frequency curves, by separating the hysteresis and eddy current losses at normal voltage and different frequencies.

13. Sumpner's Test

Objectives:

a) To predetermine efficiency at different loads and power factors
b) To predetermine regulation at different loads and power factors
c) To determine the equivalent circuit

14. Parallel Operation of two dissimilar Single Phase Transformers

Objectives:

a) To determine the load sharing of each transformer by their equivalent impedances.
b) To verify the load sharing by actual measurement.

15. OC & SC Tests on a Three Phase Transformer

Objectives:

a) To predetermine the efficiency at different load conditions and power factors.
b) To predetermine the regulation at different power factors.
c) To develop the per phase equivalent circuit.

Reference Books

1. Bimbra P. S., Electrical Machinery, 7/e, Khanna Publishers, 2011.

2. Theraja B. L., A Textbook of Electrical Technology, S. Chand & Company, New Delhi,

CODE EEL204	DIGITAL ELECTRONICS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Formulate digital functionsusing Boolean Algebra and verify experimentally.
CO 2	Design and implement combinational logic circuits.
CO 3	Design and implement sequential logic circuits.
CO 4	Design and fabricate a digital circuit using the knowledge acquired from the laboratory.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	1	3	3			2	3	3		1
CO 2	3	3	3	3	3			2	3	3		1
CO 3	3	3	3	3	3			2	3	3		1
CO 4	3	2	1	3	2			2	3	3	2	3

LIST OF EXPERIMENTS

Pre-lab assignment :Familiarisation of Logic Gates, Identification of typical logic ICs, Interpreting IC datasheets.

1. Verification & Realisation of De Morgan's theorem.
2. Realisation of SOP & POS functions after K-map reduction.
3. Half adder & Full adder using gates.
4. 4-bit adder/subtractor & BCD adder using IC 7483.
5. Realisation of 2-bit comparator using gates and study of four-bit comparator IC 7485.
6. BCD to decimal decoder and BCD to 7-segment decoder & display.
7. Study of multiplexer IC and realization of combinational circuits using multiplexers.
8. Realization of RS, T, D & JK flip flops using gates.
9. Study of flip flop ICs (7474 & 7476).
10. Realisation of ripple up and down counters and modulo-N counter using flip-flops.
11. Study of counter ICs (7490, 7493).
12. Design of synchronous up, down & modulo-N counters.
13. Realization of 4-bit serial IN serial OUT registers using flip flops.
14. Study of shift register IC 7495, ring counter and Johnsons counter.
15. VHDL implementation of full adder, 4 bit magnitude comparator

Course Project : Students have to do a mandatory course project (group size not more than 4 students) using digital ICs or Programmable Logic Devices (CPLD/FPGA) to realise a functional digital circuit. A maximum of 5 marks shall be awarded for this project (to be evaluated along with the final internal test).

Example of course projects :

1. Realisation of a real-time digital clock with display.
2. Digital Alarms
3. ALU (May be implemented in FPGA)
4. Digital Security Monitoring System
5. Traffic Control

Assessment Pattern :

Mark distribution :

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	Regular Lab work	InternalTest	CourseProject	Total
15	30	25	5	75

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions : Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Reference Books:

1. Floyd T.L, Digital Fundamentals, 10/e, Pearson Education, 2011.
2. C.H.Roth and L.L.Kimney Fundamentals of Logic Design, 7/e, Cengage Learning, 2013.

SEMESTER -4

MINOR

Syllabus

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET282	ELECTRICAL MACHINES	Minor	3	1	0	4

Preamble : This course gives exposure to the students about the concepts of electrical machines including constructional details, principle of operation and performance analysis.

Prerequisite : **Basics of Electrical Engineering**

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Identify the appropriate Electrical machines required for different applications, considering the parameters like input supply voltage, output torque and speed.
CO 2	Evaluate the performance of a single phase transformer based on appropriate test results.
CO 3	Analyse the performance of single phase and permanent magnet motors which can be used for household applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										2
CO 2	2	3										2
CO 3	3	2										2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the types of dc generators based on the method of excitation.(K2)
2. Discuss the applications of dc motors based on their characteristics.(K3)
3. Derive the expression for induced emf of alternator.(K1)
4. Problems on calculating induced emf of alternator. (K2, K3)
5. Why synchronous motor is not self starting? Discuss any two starting methods of synchronous motor? (K1)
6. What are V and Inverted V curves? (K1)
7. Explain the working principle of a three phase induction motor.(K1)
8. Why starting current of induction motor is high? Explain any two starting methods? (K2)

Course Outcome 2 (CO2):

1. Draw the phasor diagram of a single phase transformer. (K1)
2. Problems based on efficiency calculations, all day efficiency.(K2, K3)

Course Outcome 3 (CO3):

1. With the help of a neat diagram explain any two starting methods of single phase induction motor. (K1)
2. Discuss the advantages of permanent magnet rotor compared to the conventional construction. (K2)
3. Explain the principle of operation of a stepper motor.(K1)

Model Question paper

QP CODE:

PAGES:2

Reg. No:______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET 282
Course Name: Electrical Machines

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Derive an expression for emf generated in a dc machine.
2. Explain the principle of operation of a dc motor.
3. Draw the phasor diagram of a single phase transformer working under no load condition.
4. The emf per turn of a single phase 2200/220 V, 50 Hz transformer is approximately 12 V. Calculate (a) the primary and secondary turns (b) the net cross sectional area of the core if the maximum flux density is $1.5 Wb/m^2$.
5. How is voltage regulation of an alternator affected by the load connected to its terminals?
6. Why is synchronous motor not self starting?
7. Explain torque-slip characteristics of a three phase induction motor.
8. A three phase induction motor has 2 poles and is connected to 400 V, 50 Hz supply. Calculate the actual rotor speed and rotor frequency when slip is 4%.
9. Explain the working of a single phase induction motor.
10. List any three applications of PMBLDC motors.

(10 x 3 = 30)

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Briefly explain armature reaction of a dc machine. **(5)**
    (b) Classify dc generators based on their method of excitation with the help of neat diagrams. **(9)**
12. (a) Explain the power stages of a dc motor. **(4)**
    (b) A 75 kW, 250 V dc compound generator has the following data. $R_a = 0.04\Omega$, $R_{se}=0.004\Omega$, $R_f = 100\Omega$, Brush contact drop = 1V/brush. Compare the generated emf when fully loaded for (i) short shunt compound (ii) long shunt compound. **(10)**

Module 2

13. (a) Draw the equivalent circuit of a single phase transformer and explain how the parameters are obtained from the test results. **(10)**

(b) In a 25 kVA, 2000/200 V transformer, the iron and copper losses are 300 W and 400 W respectively. Calculate the efficiency at unity pf at (i) full load (ii) half load. **(4)**

14. (a) What is all day efficiency? Explain its significance. **(4)**

(b) A transformer has its maximum efficiency of 0.98 at 20 kVA at unity pf. During the day it is loaded as follows: 12 hours - 2 kW at pf 0.6, 6 hours – 10 kW at pf 0.8, 6 hours – 20 kW at pf 0.9. Find the all day efficiency of the transformer. **(10)**

Module 3

15. (a) Explain the constructional details of a synchronous machine. **(9)**

(b) A 200 kVA, 3.3 kV, 50 Hz, three phase synchronous generator is star connected. The effective armature resistance is 5Ω/phase and synchronous reactance is 29.2Ω/phase. At full load calculate the voltage regulation for 0.8 lagging and 0.8 leading power factors. **(5)**

16. (a) (i) Explain V curves of a synchronous motor. **(3)**

(ii) What is a synchronous condenser? **(2)**

(b) What is voltage regulation? Explain the method of finding regulation by emf method. **(9)**

Module 4

17. (a) Explain the working principle of a three phase induction motor. **(5)**

(b)Explain the methods of starting of a three phase induction motor. **(9)**

18. (a) The no load and blocked rotor test results conducted on a 30 hp, 835 rpm, 440V, 3 phase, 60 Hz, squirrel cage induction motor are as follows.

No load test: 440V, 14 A, 1470 W

Blocked rotor test: 163V, 60A, 7200W

Resistance measured between two terminals is 0.5Ω. Determine the equivalent circuit parameters. **(10)**

(b) What is a self-excited induction generator? **(4)**

Module 5

19. (a) What are the applications of servomotors? **(4)**

(b) Explain the different types of stepper motors. **(10)**

20. (a) What are universal motors? Explain their working. **(9)**

(b) Write a short note on permanent magnet motors. **(5)**

(14 x 5 = 70)

Syllabus

Module 1

DC Machines-principle of operation of DC generator - emf equation - types of excitations - separately excited, shunt and series excited DC generators, compound generators. General idea of armature reaction, Open circuit and load characteristics-simple numerical problems. Principles of dc motors-torque and speed equations-torque speed characteristics-Characteristics and applications of dc shunt, series and compound motors. Methods of starting, losses and efficiency - simple numerical problems.

Module 2

Transformers –principle of operation –emf equation - phasor diagram - losses and efficiency –OC and SC tests. Equivalent circuits-efficiency calculations - maximum efficiency –all day efficiency –simple numerical problems.

Module 3

Synchronous machines–Parts of synchronous generator – principle of operation–types –emf equation of alternator – regulation of alternator under lagging and leading power factor – determination of regulation by emf method – numerical examples. Principle of operation of synchronous motors - methods of starting - V curves - synchronous condenser.

Module 4

Three phase induction motors-slip ring and squirrel cage types-principle of operation–rotating magnetic field–equivalent circuit, torque slip characteristics-no load and blocked rotor tests. Methods of starting –direct online, star delta, rotor resistance and auto transformer starting.

Induction generator- principle of operation – self excited induction generators.

Module 5

Single phase motors - principle of operation of single phase induction motor –split phase motor – capacitor start motor.

Stepper motor – principle of operation – types. Principle of operation and applications of universal motor and servomotor (dc and ac).

Permanent magnet motors– principle of operation of PMSM and PMBLDC motor, applications.

Text Books

1. Bimbra P.S., "Electrical Machinery", 7/e, Khanna Publishers, 2011.
2. Nagrath J. and D.P. Kothari, "Theory of AC Machines", Tata McGraw Hill, 2006.

Reference Books

1. Fitzgerald A.E., C. Kingsley and S. Umans, “Electric Machinery”, 6/e, McGraw Hill, 2003.
2. Langsdorf M.N., “Theory of Alternating Current Machinery”, Tata McGraw Hill, 2001.
3. Say M.G., “The performance and Design of AC Machines”, CBS Publishers, New Delhi, 2002.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**DC Machines(10 hours)**	
1.1	Principle of operation-emf equation-types of excitations -separately excited, shunt and series excited DC generators, compound generators.	3
1.2	Generalidea of armature reaction, OCCand load characteristics-simple numerical problems.	2
1.3	Principles of dc motors-torque and speed equations-torque speed characteristics	2
1.4	Characteristics and applications of dc shunt, series and compound motors. Principles of starting, losses and efficiency–simple numerical problems.	3
2	**Transformers (8 hours)**	
2.1	Principle of operation –emf equation - phasor diagram.	2
2.2	losses and efficiency –OC and SC tests. Equivalent circuit.	3
2.3	efficiency calculations-maximum efficiency –all day efficiency –simple numerical problems.	3
3	**Synchronous machines (9 hours)**	
3.1	Parts of synchronous generator – principle of operation – types	2
3.2	emf equation of alternator –regulation of alternator under lagging and leading power factor – simple numerical problems.	2
3.3	determination of regulation by emf method – numerical examples.	2
3.4	Principle of operation of synchronous motors-methods of starting.V-curves-synchronous condenser.	3

4	**Three phase induction motors (9 Hours)**	
4.1	Slip ring and squirrel cage types-principle of operation–rotating magnetic field.	2
4.2	Torque-slip characteristics-no load and blocked rotor tests, equivalent circuit - simple numerical problems.	3
4.3	Methods of starting –direct online, star-delta, rotor resistance and autotransformer starting.	2
4.4	Induction generator- principle of operation – self excited induction generators.	1
5	**Single phase motors (9 Hours)**	
5.1	Principle of operation of single phase induction motor –split phase motor –capacitor start motor-	2
5.2	Stepper motor – principle of operation - types	2
5.3	Universal motor, –servomotor – dc and ac servomotors – principle of operation, applications.	3
5.4	Permanent magnet motors – principle of operation of PMSM and PMBLDC motor, applications.	2

Syllabus

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET284	**Energy Systems**	**Minor**	**3**	**1**	**0**	**4**

Preamble : This course introduces various types of renewable energy sources. It discusses various means of generating and storing energy and the importance of renewable energy. Various energy standards and means to improve efficiency of systems are also introduced

Prerequisites : EST 130Basics of Electrical & Electronics Engineering

EET 253 Introduction to Power Engineering

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Illustrate Indian and global energy scenario
CO 2	Elaborate different conventional and non-conventional energy generation schemes and the economics of generation
CO 3	Analyse principle of operation and performance comparison of various energy storage schemes
CO 4	Identify major Global and Indian standards for Energy Management
CO 5	Perform a preliminary Energy Audit
CO 6	Appraise various aspects of energy economics

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2
CO 5	3	3										2
CO 6	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO 1):

1. Discuss Indian and world energy scenario (K1)
2. Describe Indian energy sector reforms (K2)
3. Discuss energy and environment, energy security (K2)
4. Explain the features of Energy Conservation Act (K3)

Course Outcome 2 (CO 2):

1. Describe various sources of non conventional energy (K2)
2. Problems on calculating efficiency of Solar Photovoltaic Systems (K3)
3. Problems on energy availability from wind(K3)
4. Discuss the generation of energy from wave, tide, OTEC and Biomass (K2)

Course Outcome 3 (CO 3):

1. Describe various means of energy storage (K2,)
2. Explain the working of batteries (K2)
3. Calculate the efficiency of fuel cells (K3).

Course Outcome 4 (CO 4):

1. Identify ISO 50001 for Energy Management. (K2)
2. Describe the activities of BEE in India and star rating of equipment (K2).

Course Outcome 5 (CO 5):

1. Give the steps involved in Energy Audit (K1)
2. Calculate the payback period (K3).

Course Outcome 6 (CO 6):

1. Classify different types of tariff (K3)
2. Compare models for demand forecasting (K3)
3. Explain how economic analysis of energy investment is done (K2)

Model Question paper

QPCODE: PAGES: 2

Reg.No:____________

Name:______________

APJABDULKALAMTECHNOLOGICALUNIVERSITY

FOURTH SEMESTERB.TECHDEGREEEXAMINATION, MONTH &YEAR

Course Code: EET 284
Course Name: Energy Systems

Max.Marks:100 **Duration: 3Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Enumerate the important features of Energy Conservation act.
2. Illustrate the concept of green buildings.
3. Find the maximum power and efficiency of a 100 x 100 mm sq. solar cell having an open circuit voltage is 0.611 V, Short circuit current of 3.5 A, Fill factor of 0.7 when input power is 10 W.
4. Draw and explain the block diagram of the ocean thermal energy system.
5. Derive the expression for the power output and efficiency of a fuel cell.
6. Give the relative advantages and disadvantages of battery storage.
7. Discuss the structure of a detailed energy audit report.
8. What is the significance of the energy audit?
9. What is the difference between long term and short forecasting? What is MAED?
10. Differentiate between cost of capital and discount rate.

(10x3=30)

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Compare Energy Scenario of India and the world. **(10)**

    (b) The luminous efficiency of a lamp is 8.8 Lumens/Watt and its luminous intensity is 700 Cd. What is the power of the lamp? **(4)**

12. (a) Compare any four types of lamps. Give their approximate efficiencies as well. **(8)**

(b) Discuss the energy system reforms in India and illustrate their effect. **(6)**

Module 2

13. (a) Explain how energy can be extracted from the heat and light of sun. **(10)**

(b) Determine the power in the wind if the wind speed is 20 m/s and blade length is 50 m and air density = 1.23 kg/m^3. **(4)**

14. (a) Compare the schemes for extraction of energy from waves and tides. **(8)**

(b) Explain with the help of a schematic, extraction of energy from biomass. **(6)**

Module 3

15. (a) Differentiate between primary and secondary cells. **(4)**

(b) Explain the working of any one primary and secondary cell with the help of diagrams **(10)**

16. (a) Give the importance of energy storage. **(4)**

(b)Compare compressed air and fly wheel energy storage systems. **(10)**

Module 4

17. (a) Explain the important features of ISO 50001. **(6)**

(b) Discuss are the functions of Bureau of Energy efficiency. What is the significance of star ratings? **(8)**

18. (a) Explain the types of energy audit and their procedure. **(9)**

(b) Explain various instruments used for energy audit. **(5)**

Module 5

19. (a) Explain LEAP energy planning system with the help of block diagram. **(6)**

(b) A company is planning to install an energy-efficient motor requiring an initial investment of Rs 10.5 lakh. The motor is expected to save 2.5 lakh per year in net cash flows for 7 years. Calculate the payback period. **(8)**

20. (a) Explain one part, two part and three part tariff. **(9)**

(b) A machine can reduce annual cost by Rs 40,000. The cost of the machine is Rs 223,000 and the useful life is 15 years with zero residual value. Calculate the Internal Rate of Return. **(5)**

(14x5=70)

Syllabus

Module 1

Energy Scenario: Indian Energy Scenario, World Energy Scenario, Indian Energy Sector Reforms, Energy and Environment, Energy Security, Energy conservation act

Energy Efficient Systems: Reducing pollution and improving efficiency in buildings, Green Building Standards, Types of lamps and their efficiencies

Module 2

Renewable Energy Resources: Solar Thermal System-Working Principle-Block diagram, Solar Photovoltaic System- Working Principle-Block diagram, Solar cell efficiency calculation, Wind Energy Systems- Working Principle-Block diagram, wind power equation, Energy from Waves and tides- Working Principle-Block diagram, Ocean Thermal Energy System- Working Principle-Block diagram, Energy from Biomass

Module 3

Energy Storage: Importance of Energy Storage- Means of Storing Energy- Principle of operation and performance comparison. Compressed air storage, Fly wheel Energy Storage, Battery Storage-**Battery:** Specification, Charging/Discharging rate, Primary and secondary cells-Dry cell, lead acid, lithium ion, Lithium air, Nickel Cadmium, Nickel Metal Hydride

Fuel Cell: Working Principle, efficiency

Module 4

Energy Standards – International Energy Standards-ISO50001, Bureau of Energy Efficiency, star rating

Energy Management: Significance and general principles of Energy Management, Energy audit-types and procedure, Energy audit report, Instruments for energy auditing

Study of various governmental agencies related to energy conservation and management.

Module 5

Energy Economics: Traditional Types of Rates - Single-Part Rates - Two-Part Rates - Three-Part Rates – Numerical problems

Energy demand forecasting: Introduction –Forecasting using simple indicators- trend analysis- end use method - MAED Model - LEAP Model

Economic Analysis of Energy Investments - calculation of energy efficiency and payback period - Characteristics of Energy Projects - Identification of Costs and Benefits - Valuation of Costs and Benefits - Indicators of Cost-Benefit Comparison:Methods Without Time Value - Net Present Value Based Indicators - Role of Discount Rates - Internal Rate of Return – Numerical Problems

Text Books

1. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN - 978-1-84919-219-4), 2011.
2. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, "Guide to Energy Management", Seventh Edition, The Fairmont Press Inc., 2012.
3. S. Pabla, "Electric Power Systems Planning", Mac Millan India Ltd., 1998

References:

1. K.C. Kothari, D.P.Ranjan, Rakeshsingal "Renewable Energy Sources and Emerging Technology"- PHI; 2nd Revised edition (1 December 2011)
2. M.V.R. Koteswara Rao, Energy Resources: Conventional & Non-Conventional BS Publications/BSP Books (2017)
3. Albert Thumann, Scott Dunning, "EFFICIENT LIGHTING APPLICATIONS & CASE STUDIES"; The Fairmont Press, Inc. (16 April 2013)
4. "Energy Efficiency in Electrical Utilities"-Guide book for National Certificate Examination for Energy Managers and Energy Auditors : Bureau of Energy Efficiency
5. Subhes C. Bhattacharyya, "Energy Economics-Concepts, Issues, Markets and Governance," Springer, 2011
6. ISO50001

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Energy Scenario (9hours)**	
1.1	Indian and world Energy Scenario	2
1.2	Indian Energy Sector reforms	1
1.3	Energy, Environment, Energy Security	1
1.4	Green Building Standards, Industries and electrical Power System	2
1.5	Energy Conservation Act 2001 features	1
1.6	Green Building Standards	1
1.7	Types of lamps and their efficiencies	1
2	**Non-Conventional Energy Sources. (9hours)**	
2.1	Solar Thermal System, Working Principle- Solar cell efficiency Calculation	2
2.2	Solar Photovoltaic System-Working Principle	1
2.3	Wind Energy Systems-Working Principle	2

2.4	Energy From waves and Tides-Block diagram	2
2.5	Energy from Biomass and Ocean Thermal Energy Systems	2
3	**Energy Storage (9 Hours)**	
3.1	Specification, Discharging time calculation	1
3.2	Compressed air storage, Fly wheel Energy Storage, Battery Storage-Advantages	2
3.3	Primary and secondary cells-Dry cell	1
3.4	lead acid, lithium ion, Lithium air, Nickel Cadmium, Nickel Metal Hydride	3
3.5	Fuel Cells, Working Principle, efficiency calculation	2
4	**Energy Management (9 Hours)**	
4.1	International Energy Standards-ISO50001	2
4.2	Bureau of Energy Efficiency, star rating	2
4.3	Significance and general principles of Energy Management, Energy audit-types, procedure, instruments and reports	4
4.4	Study of various governmental agencies related to energy conservation and management.	1
5	**Energy Economics (9 Hours)**	
5.1	Traditional Types of Rates - Single-Part Rates - Two-Part Rates - Three-Part Rates – Numerical problems	3
5.2	Energy demand forecasting: Introduction –Forecasting using simple indicators- trend analysis- end use method - MAED Model - LEAP Model	2
5.3	Economic Analysis of Energy Investments - Characteristics of Energy Projects - Identification of Costs and Benefits - Valuation of Costs and Benefits - Indicators of Cost-Benefit Comparison:Methods Without Time Value - Net Present Value Based Indicators - Role of Discount Rates	3
5.4	Internal Rate of Return – Numerical Problems	1

EET286	PRINCIPLES OF INSTRUMENTATION	CATEGORY	L	T	P	CREDIT
		MINOR	3	1	0	4

Preamble: This course introduces principle of operation and construction of basic instrumentation components, their selection and applications.Familiarization of modern basic digital systems are also included.

Prerequisite: Basics of Electronics and Circuits

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify and analysethe factors affecting performance of instrumentation system
CO 2	Choose appropriate instrumentation system components for the measurement of different parameters
CO 3	Identify different amplifier circuits for instrumentation including selection of Op-amp for linear and Non-linear applications.
CO 4	Identification and selection of basic filters for instrumentation
CO 5	Outline the principles of operation of linear &Non-linear signal processing systems
CO 6	Understand the operating principles of basic building blocks of digital systems, recording and display units

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	-	-	-	-	-	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	1	-	-	-	-	-	-	2
CO 6	3	-	-	-	2	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. What is the loss angle of a capacitor?
2. Explain sensitivity.
3. What is the theoretical relationship between the current through a pn-diode and the voltage across it?

Course Outcome 2 (CO2):

1. What phenomenon is described by the early effect?
2. What is the loss angle of a capacitor?
3. What types of transducers are used for pressure measurements?

Course Outcome 3(CO3):

1. How to design a second order band pass filter using an OPAMP circuit?
2. Explain the working of Schmitt trigger using OPAMP circuit?
3. Show how Analog multipliers can be used for division and square rooting applications?

Course Outcome 4 (CO4):

1. Explain the different types of passive filters.
2. Differentiate between first and second order filters.

Course Outcome 5 (CO5):

1. What is an amplitude modulated signal with a suppressed carrier?
2. Explain phase locked loop (PLL).
3. How to calculate the maximum digital output error for 3-bit cascaded converter?
4. Explain why the pulse frequency is not of importance to the dual slope converter

Course Outcome 6 (CO6):

1. Block diagram of DMM, CRO, DSO
2. Explain the handshake procedure and indicate also what implications this has for data transmission speed?
3. Discuss the main aspects of “virtual instruments”.

MODEL QUESTION PAPER

QP CODE: PAGES:3

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR Course Code: EET 286

Course Name: **PRINCIPLES OF INSTRUMENTATION**

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks

1. What is transducer?
2. What you mean by DC hall effect sensors?
3. How we can find the maximum operating signal frequency of OPAMP?
4. Determine the output voltage of an op-amp for input voltages of V_{i1} = 150 µV, V_{i2} = 140 µV. If it has a differential gain of A_d = 4000 and the value of CMRR is 100
5. Explain voltage-controlled oscillator?
6. What is meant by multiplexing?
7. Draw the block diagram of Dual slope ADC.
8. Calculate the cut-off frequency of a first-order low-pass filter for R_1 =1.2 kΩ and C_1 =0.02 µF.
9. Explain Synchronization and triggering operation in CRO
10. What is use of spectrum and network analysers?

(10x3=30)

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a)To obtain the value of the series resistance $\mathbf{r_s}$ of a diode the voltage is measuredin two different currents: 0.1 mA and 10 mA. The respective results are 600 mVand 735 mV. Find $\mathbf{r_s}$. **(4)**

    b)With neat diagram explain the working of diode peak detector. **(5)**

    c)Give the approximate value of the differential resistance of a pn-diode at 1 mA,at 0.5 mA and at 1 µA. Give also the conductance values. **(5)**

12. a)Explain with neat diagram explain the operation of diode Limiter/clipper. **(7)**

    b) Explain about thermocouples and their practicaluse in instrumentation. **(7)**

Module 2

13. a)What phenomenon is described by the early effect? **(4)**
    b.Explain the working of differential amplifier. **(5)**
    c. State and explain Inverse square law and Lamberts cosine law. **(5)**
14. a) If the input signal has an rms value of 1 V, the op amp input impedance is 1 MΩ and the circuit's load resistance is 1 kΩ. What is the load current? Express the power gain in terms of the input resistance R_i and the load resistance R_L, what is its value in decibels? **(8)**
    b) Derive the expression for noise factor in OPAMP amplifiers **(6)**

Module 3

15. a)Explain the operation of Active voltage limiter and its advantages over diode voltage limiters. **(6)**

    b) With neat diagram explain the operation of Schmitt trigger. Why positive feedback is provided always in the comparator circuit using an OPAMP? Also explain the hysteresis property of Schmitt trigger circuit. **(8)**

16. a)A voltage amplifier is specified as follows: input offset voltage at 20°C is < 0.5 mV, the temperature coefficient of the offset is < 5 μV/K. Calculate the maximum input offset that might occur within a temperature range of 0 to 80 °C. **(6)**

    b) In the integrator circuit given below the component values are C = 1 mF and R = 10 kW. The specifications of the operational amplifier are: $|V_{off}|$ <0.1 mV and $|I_{bias}|$ < 10 nA. The input is supposed to be zero. At t = 0 the output voltage v_o = 0. What is the value of v_o after 10 seconds? **(8)**

Module 4

17. a) Explain why the pulse frequency is not of importance to the dual slope converter. **(4)**

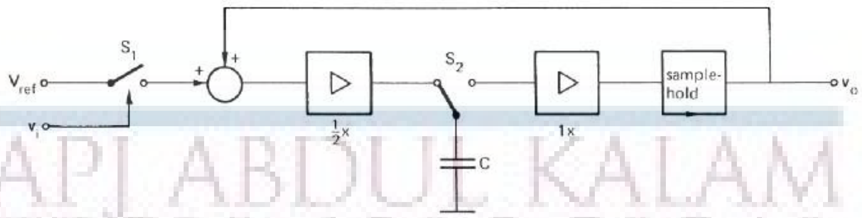
    b) The integration period of an integrating AD-converter is 100 ms ±1 μs.Determine the maximum conversion error caused by a 50 Hz interferencesignal withrms value of 1 V. **(6)**
    c)Explain R-2R ladder digital to analog converter operation. **(4)**

18. a)What is the differential non-linearity of a DA-converter? What is monotony? **(4)**

    b) The clock frequency of a 10-bit successive approximation AD-converter is 200 kHz. Find the (approximated) conversion time for this converter. **(6)**
    c) Explain the term "multiplying DAC" for a DA-converter with external reference. **(4)**

Module 5

19. a) The input signal of the DAC in Figure below is the 3-bit word 101. Make a plot of the relevant output signal versus time. The capacitor is uncharged for $t < 0$.**(10)**



b)The reference voltage of a 10-bit DA-converter is 10 V. Calculate the outputvoltage when the input code is 1111100000 (MSB first). **(4)**

20. a) Explain the operation of Integrating AD-converters with neat diagram. **(6)**

b)Explain the operation of parallel AD-converters with neat diagram. **(8)**

Syllabus

Module 1

Passive electronic components– Resistors- Capacitors- Inductors and transformers

Circuits with pn-diodes - Limiters - Peak detectors - Clamp circuits - DC voltages sources

Sensors– Sensor components - Resistive sensors - Inductive sensors - Capacitive sensors - Thermoelectric sensors - Piezoelectric sensors.

Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge.

Module 2

Circuits with bipolar transistors & field effect transistors - Voltage-to-current converter - voltage amplifier stage with base-current bias - voltage amplifier stage with a base-voltage bias - emitter follower - source follower- differential amplifier

Operational amplifiers - Amplifier circuits with ideal operational amplifiers - Current-to-voltage converters - Inverting voltage amplifiers - Non-inverting voltage amplifiers - Differential amplifiers -Instrumentation amplifiers

Non-ideal operational amplifiers - Selection of operational amplifiers (Specifications)- Input offset voltage - Finite voltage gain

Module 3

Nonlinear signal processing with OPAMP - Voltage comparators - Schmitt-trigger - Voltage limiters - Rectifiers - Nonlinear arithmetic operations - Logarithmic converters - Exponential converters – Multipliers and other arithmetic operators

Electronic switching circuits - Electronic switches - Properties and Components as electronic switches - Circuits with electronic switches - Time multiplexers - Sample-hold circuits - Transient errors

Passive filters - First and second order RC-filters - Low-pass first-order RC-filter – High pass first-order RC-filter - Bandpass filters - Notch filters

Module 4

Modulation and Demodulation - Amplitude modulation and demodulation - Amplitude modulation methods - Demodulation methods. Systems based on synchronous detection - Phase-locked loop - Lock-in amplifiers - Chopper amplifiers

Digital-to-Analogue and Analogue-to-Digital conversion - Parallel converters - Binary signals and codes - Parallel DA-converters - Parallel AD-converters. Special converters - The serial DA-converter - The direct AD converter - Integrating AD-converters

Module 5

Measurement instruments - Stand-alone measurement instruments - Multimeters - Signal generators - Counters, frequency meters and time meters - Spectrum analyzers - Network analyzers - Impedance analyzers

Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques.

Computer-based measurement instruments - Bus structures - Introduction to Virtual Instrumentation systems- Simulation softwares(description only)

Text Books

1. D. Patranabis, ‘Sensors and Transducers’, Prentice Hall of India, 2003
2. Helfrick& Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall of India,5th Edition,2002
3. Sawhney A.K., A course in Electrical and Electronic Measurements & instrumentation, DhanpatRai.
4. Kalsi H. S., Electronic Instrumentation, 3/e, Tata McGraw Hill, New Delhi, 2012
5. S Tumanski, Principles of electrical measurement, Taylor & Francis.
6. David A Bell, Electronic Instrumentation and Measurements,3/e, Oxford

Reference Books

1. Cooper W.D., Modern Electronics Instrumentation, Prentice Hall of India
2. Oliver & Cage, Electronic Measurements & Instrumentation, McGraw Hill
3. E.O Doebelin and D.N Manik, Doebelin’s Measurements Systems, sixth edition, McGraw Hill Education (India) Pvt. Ltd.
4. P.Purkait, B.Biswas, S.Das and C. Koley, Electrical and Electronics Measurements and Instrumentation, McGraw Hill Education (India) Pvt. Ltd.,2013

Course Contents and Lecture Schedule

Module	Topic coverage	No. of Lectures
1	**Basic Instrumentation Circuit Components (9 hours)**	
1.1	Passive electronic components– Resistors- Capacitors- Inductors and transformers. Circuits with pn-diodes - Limiters - Peak detectors - Clamp circuits - DC voltages sources	3
1.2	Sensors– Sensor components - Resistive sensors - Inductive sensors - Capacitive sensors - Thermoelectric sensors - Piezoelectric sensors	3
1.3	Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge.	3
2	**Transistor and amplifier circuits (9 hours)**	
2.1	Circuits with bipolar transistors - Voltage-to-current converter - voltage amplifier stage with base-current bias - voltage amplifier stage with a base-voltage bias - emitter follower - - differential amplifier.	2
2.2	Circuits with field-effect transistors - Voltage-to-current converter - voltage amplifier stage - source follower.	2
2.3	Operational amplifiers - Amplifier circuits with ideal operational amplifiers - Current-to-voltage converters - Inverting voltage amplifiers - Non-inverting voltage amplifiers - Differential amplifiers -Instrumentation amplifiers	3
2.4	Non-ideal operational amplifiers - Selection of operational amplifiers (Specifications)- Input offset voltage - Finite voltage gain	2
3	**Nonlinear signal processing with OPAMP and Filters (9 hours)**	
3.1	Nonlinear transfer functions - Voltage comparators - Schmitt-trigger - Voltage limiters - Rectifiers - Nonlinear arithmetic operations - Logarithmic converters - Exponential converters – Multipliers and other arithmetic operators	3

3.2	Electronic switching circuits - Electronic switches - Properties and Components as electronic switches - Circuits with electronic switches - Time multiplexers - Sample-hold circuits - Transient errors.	3
3.3	Passive filters - First and second order RC-filters - Low-pass first-order RC-filter – High pass first-order RC-filter - Bandpass filters - Notch filters	3
4	**Magnetic ,Lumen and Temperature Measurements (9 hours)**	
4.1	Modulation - Amplitude modulation and demodulation - Amplitude modulation Demodulation- Demodulation methods. Systems based on synchronous detection - The phase-locked loop - Lock-in amplifiers - Chopper amplifiers	4
4.2	Digital-to-Analogue and Analogue-to-Digital conversion - Parallel converters - Binary signals and codes - Parallel DA-converters - Parallel AD-converters	3
4.3	Special converters - The serial DA-converter - The direct AD converter - Integrating AD-converters	2
5	**Measuring instruments including modern recording and displaying instruments (9 hours)**	
5.1	Measurement instruments - Stand-alone measurement instruments - Multimeters - Signal generators - Counters, frequency meters and time meters - Spectrum analyzers - Network analyzers - Impedance analyzers.	4
5.2	Oscilloscopes- Principal of operation of general purpose CRO- basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques.	3
5.3	Computer-based measurement instruments - Bus structures - Introduction to Virtual Instrumentation systems- Simulation software's (description only)	2

SEMESTER -4 HONOURS

Syllabus

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET292	NETWORK ANALYSIS AND SYNTHESIS	Core (Honors)	3	1	0	4

Preamble : This honors course is designed with the objective of expanding the student's knowledge in network analysis beyond the basic topics. It includes advanced topics in network analysis, basics of filter design and network synthesis concepts. This course would help students to explore more advanced concepts in the analysis of complex networks.

Prerequisite : **EET201 Circuits and Networks**

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Apply network topology concepts in the formulation and solution of electric network problems.
CO 2	Apply two-port network analysis in the design and analysis of filter and attenuator networks.
CO 3	Identify the properties and characteristics of network functions, and verify the mathematical constraints for their physical realisation.
CO 4	Synthesize passive one-port networks using standard Foster and Cauer forms.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	15	15	20
Understand (K2)	20	20	50
Apply (K3)	15	15	30
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Model Question Paper

Reg. No.:
Name: **Pages: 4**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: **EET292**

Course Name: Network Analysis and Synthesis

Max. Marks: 100 Time: 3 hrs

Part A
Answer *all* questions. Each question carries 3 marks.

1. Define subgraph, path and a tree, with proper examples.
2. Describe the properties of the complete incidence matrix.
3. What are dual graphs? What is the condition for a network graph to have a dual? Illustrate with an example.
4. Describe a cut-set with an example.
5. Show that the image impedances of a two-port network are given by $Z_{im1} = \sqrt{\dfrac{AB}{CD}}$ and $Z_{im2} = \sqrt{\dfrac{BD}{AC}}$.
6. Draw the frequency response curves for ideal and non-ideal low pass filter, band pass filter, band reject filter, and high pass filter respectively.
7. For the pole-zero plot shown in Fig. 1 below, for a network function, identify the function and find its impulse response.
8. List the properties of positive real functions.
9. What are the properties of LC immittance functions.
10. Draw the Foster and Cauer forms of RC networks. (10 x 3 = 30)

Part B
Answer any one full question from each module.
Each question carries 14 Marks.
Module 1

11. (a) Draw the oriented graph of the given network shown in Fig. 2, and identify one tree and its co-tree. Obtain the incidence matrix. (6)

    (b) Find all voltages and branch currents in the network shown in Fig. 3 by node analysis, and applying network graph principles. (8)

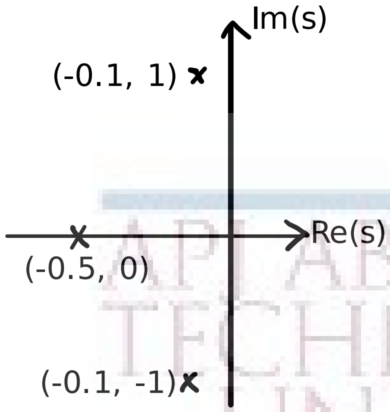


Figure 1: Pole Zero Plot

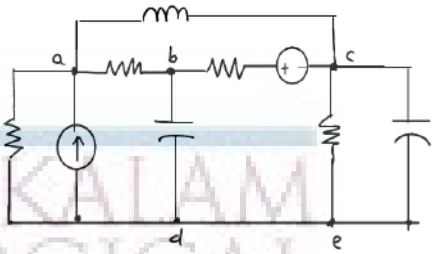


Figure 2: Figure for question 11 (a).

12. (a) The reduced incidence matrix A of an oriented graph is given below. (6)

$$A = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & -1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & -1 & 1 & 0 & -1 \\ 1 & 0 & 1 & 0 & 0 & 0 & -1 & 0 \end{bmatrix}$$

Draw the graph of an electrical network represented by this matrix. The branches constituting the outer loop of are independent current sources branches. All the current sources have their branch current variable at 1 A. Find the currents in all other branches.

(b) Find the total power dissipated in the circuit shown in Fig. 4 by node analysis (graph based). (8)

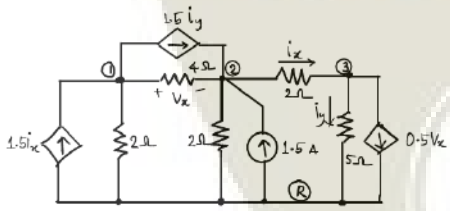


Figure 3: Figure for question 11 (b).

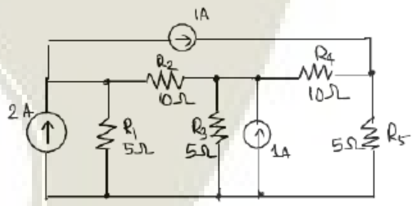


Figure 4: Figure for question 12 (b).

Module 2

13. (a) Find the power delivered by the independent voltage sources in the network shown in Fig. 5 by loop analysis (use graph theory). Prepare the network graph using the reference directions marked in the figure. (8)

(b) A connected network has the fundamental circuit matrix given as, (6)

$$B_f = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & -1 & 0 & 0 & 1 & 0 \\ 1 & -1 & -1 & 0 & 0 & 1 \end{bmatrix}$$

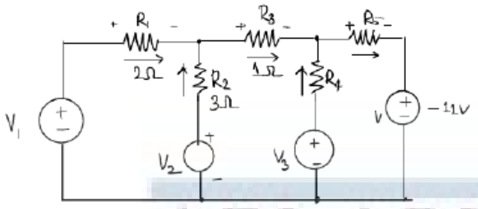


Figure 5: Figure for question 13 (a).

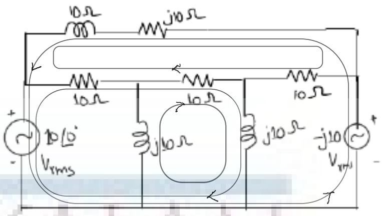


Figure 6: Figure for question 14 (a).

for some choice of tree. Obtain the f-cut-set matrix for the same tree.

14. (a) For the network shown in Fig. 6assign reference directions and draw the network graph. Obtain the connection matrix between branch currents and the loop currents in the three loops shown in the network diagram. Determine the loop impedance matrix of the network. (8)

(b) For the graph shown in Fig. 7, write the cut-set (KCL) equations for the following cut-sets: {1, 6}, {1,2,7,8}, {5, 6, 8, 9} and {2, 5, 7, 9}. Will this set of equations form an independent set of equations? If not why? (6)

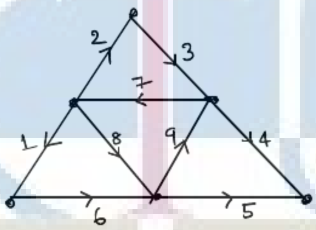


Figure 7: Figure for question 14 (b).

Module 3

15. (a) Design a prototype T-section low-pass filter to cut-off at 100 Hz with a load resistance of 75Ω. Calculate the attenuation in Np and in dB at 200 Hz and 1 kHz. Also find the phase shift suffered by the output signal for 10 Hz and 50 Hz. (7)

(b) Design an m-derived high pass filter having a design impedance of 300 Ω, cut-off frequency of 2000 Hz and infinite attenuation at 1700 Hz. (7)

16. (a) The open-circuit voltage observed across a signal source varies between $\pm 100\ mV$. The voltage across a 60Ω resistance connected across this source is found to vary between $\pm 50\ mV$. Design a T-section attenuator such that the voltage across a 600 Ω load connected across the output of the attenuator varies between $\pm 5\ mV$. (7)

(b) Design the T-section and p-section of a constant K-type BPF that has a pass band from 1500 to 5500 Hz and characteristic resistance of 200 Ω. Further, find resonant frequency of series and shunt arms. (7)

Module 4

17. (a) Test the following polynomials for the Hurwitz property: (6)
    (i). $s^3 + s^2 + 2s + 2$
    (ii). $s^7 + s^5 + s^3 + s$
    (iii). $s^7 + 2s^6 + 2s^5 + s^4 + 4s^3 + 8s^2 + 8s + 4$

    (b) Determine whether the following functions are positive real or not: (8)
    (i). $F(s) = \dfrac{2s^2 + 2s + 4}{(s+1)(s^2+2)}$
    (ii). $F(s) = \dfrac{5s^2 + s}{s^2 + 1}$

18. (a) Find the limits of K so that the polynomial $s^3 + 14s^2 + 56s + K$ may be Hurwitz. (6)

    (b) Find the driving point impedance Z(s) in the form $K\dfrac{N(s)}{D(s)}$ for the network shown in Fig. 8. Verify that Z(s) is positive real and that the polynomial D(s)+KN(s) is Hurwitz. (8)

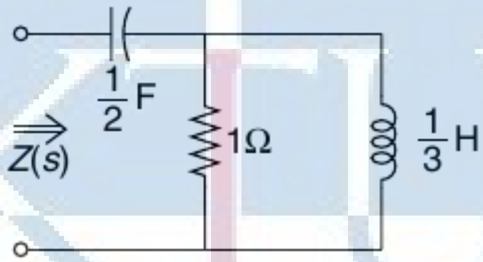


Figure 8: Figure for question 18 (b).

Module 5

19. Realise the impedance $Z(s) = \dfrac{2(s^2+1)(s^2+0)}{s(s^2+4)}$ in three different ways. (14)

20. (a) For the network function $Y(s) = \dfrac{2(s+1)(s+3)}{(s+2)(s+4)}$, synthesise a Foster form and a Cauer form realisations. (10)

    (b) Check whether the driving point impedance $Z(s) = \dfrac{s^4 + s^2 + 1}{s^3 + 2s^2 - 2s + 10}$ represents a passive network or not. (4)

Course Level Assessment Questions

Course Outcome 1 (CO1):

[K1]: Questions on Network topology terminology, definitions.

[K2}: Questions on identification of graphs, paths, sub-paths, etc., Questions on incidence matrix.

[K2, K3] Understand level and application level numerical problems on application of Kirchoff's laws in matrix formulation, nodal analysis.

[K2, K3]. Numerical problems on graph theory based network analysis, cut-set, circuit matrices, nodal and loop analysis.

Course Outcome 2 (CO2): [K1, K2] Questions on definitions and properties of filters.

[K2, K3]. Numerical problems on constant-k and m-derived filter design and analysis.

Course Outcome 3 (CO3): [K1] Questions on the properties of network functions and realizability of passive impedance functions.

[K2, K3]. Numerical problems on the realizability of network functions, testing of positive real functions and Hurwitz polynomials.

Course Outcome 4 (CO4): [K1]. Questions to describe Foster and Cauer forms and the properties of immittance functions.

[K2, K3]. Numerical problems to synthesise networks in Foster and Cauer forms.

Syllabus

Module 1

Network Topology (8 hours)

Linear Oriented Graphs -incidence matrix of a linear oriented graph –Kirchoff’s Laws in incidence matrix formulation –nodal analysis of networks (independent and dependent sources) – Circuit matrix of linear oriented graph –Kirchoff’s laws in fundamental circuit matrix formulation.

Module 2 (8 hours)

Loop analysis of electric networks (with independent and dependent sources) - Planar graphs –Mesh analysis- Duality –Cut set matrix -Fundamental cut set matrix –Relation between circuit, cut set and incidence matrices –Kirchoff’s laws in fundamental cut-set formulation –Node-pair analysis – Analysis using generalized branch model (node, loop and node pair analysis) –Tellegen’s theorem.

Module 3: (12 hours)

Modeling Two-port networks-application examples-amplifiers, transmission lines, passive filters.

Review of network parameter sets for two-port networks (z, y, h, g, T parameters, equivalent circuits and inter-relationship between parameters). (Review may be done using assignments/homeworks).

Image parameter description of a reciprocal two-port network -- Image impedance -Characteristic impedance - propagation constant—derivation of characteristic impedance and propagation constant for T and Pi networks under sinusoidal steady state --Attenuation constant and phase constant.

Filter terminology: Low pass, high pass, band-pass and band-reject filters.

Constant k and m-derived filters -- low pass, high pass, band-pass and band-stop filters --design--effect of cascading multiple sections. Resistive T, Pi and lattice attenuators.

Module 4

Network Functions (10 hours)

Review of Network functions for one port and two port networks: – pole zero location for driving point and transfer functions-Impulse response of Network functions from pole-zero plots- Sinusoidal steady-state frequency response from pole-zero plots.

Hurwitz polynomials –properties - Positive real functions –Properties of positive real functions – passivity-necessary and sufficient conditions for positive real functions-physical realizability.

Module 5

Synthesis of one port networks (8 hours)

Synthesis of reactive one-ports by Foster's and Cauer methods (forms I and II) -Synthesis of LC, RC and RL driving-point functions.

Text Books

1. K. S. Suresh Kumar, "Electric Circuit Analysis", Pearson Publications, 2013.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

References

1. Franklin Kuo, "Network Analysis and Synthesis", 2nd Ed.,Wiley India.
2. Van Valkenburg M.E., "Introduction to Modern Network Synthesis," Wiley Eastern, 1960 (reprint 1986).
3. Van Valkenburg M.E, "Network Analysis," Prentice Hall India, 2014.
4. Charles A. Desoer and Ernest S. Kuh, "Basic Circuit Theory," Tata McGraw Hill Edition.
5. Chakrabarti, A., "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018
6. S. K. Bhattacharya, "Network Analysis and Synthesis," Pearson Education India.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Network Topology (8 hours)**	
1.1	Linear Oriented Graphs - Connected Graph, sub graphs, paths, The incidence matrix of a linear oriented graph – Path matrix, its relation to incidence matrix.	2
1.2	Kirchoff's Laws in incidence matrix formulation – nodal analysis of networks (independent and dependent sources) principle of v-shifting.	2
1.3	Circuit matrix of linear oriented graph – Fundamental Circuit matrix B_f. Relation between All incidence matrix and All Circuit matrix.	2
1.4	Kirchoff's laws in fundamental circuit matrix formulation -	2
2	**(8 hours)**	
2.1	Loop analysis of electric networks (with independent and dependent sources) -- Planar graphs –Mesh analysis- Duality.	2
2.2	Cut set matrix -Fundamental cut set matrix –Relation between circuit, cut set and incidence matrices – Orthogonality relation.	2
2.3	Kirchoff's laws in fundamental cut-set formulation –Node-pair analysis. i-shifting.	2
2.4	Analysis using generalized branch model (node, loop and node pair analysis) –Tellegen's theorem.	2
3	**(13 hours)**	
3.1	Modeling Two-port networks - application examples-amplifiers, transmission lines, passive filters. Review of network parameter sets for two-port networks (z, y, h, g, T parameters, equivalent circuits and inter-relationship between parameters, Standard T- and pi networks. (Review may be done using assignments/homeworks).	2
3.2	Image parameter description of a reciprocal two-port network - Image impedance.	1
3.3	Characteristic impedance - propagation constant—derivation of characteristic impedance and propagation constant for T and Pi networks under sinusoidal steady state -- Attenuation constant and phase constant.	2

3.4	Filter terminology: Low pass, high pass, band-pass and band-reject filters. Gain characteristics. Constant k-derived low pass filter -- Comparison with ideal low-pass filter -- Prototype Low pass filter design.	2
3.5	m-derived low pass filter sections, m-derived half-sections for filter termination. m-derived half-sections for input termination. Half-pi termination for pi section filters.	2
3.6	Constant k- and m-derived high pass filters --Design. Constant k- band-pass filter -- Design of prototype bandpass filter -- Constant-k band-stop filter-effect of cascading multiple sections.	2
3.7	Resistive attenuators-Symmetric T and Pi section attenuators -- Lattice-section attenuator- Symmetrical bridged T-section attenuator -Asymmetrical T-Section and Pi-section attenuator.	2
4	**Network Functions (7 hours)**	
4.1	Review of Network functions for one port and two port networks: – calculation of network functions for ladder and general networks-poles and zeros for network functions-pole zero location for driving point and transfer functions.	2
	Impulse response of Network functions from pole-zero plots- Sinusoidal steady-state frequency response from pole-zero plots.	2
	Hurwitz polynomials – properties - Positive real functions – Properties of positive real functions – passivity-necessary and sufficient conditions for positive real functions - physical realizability.	3
5	**Synthesis of one port networks (9 hours)**	
5.1	Synthesis of reactive one - ports by Foster's and Cauer methods (forms I and II): Synthesis of R–C Network -- Properties of the R–C Impedance or R–L Admittance Function -- Foster Form-I of R–C Network -- Foster Form-II of R–C Network, Cauer Forms of R–C Network.	3
5.2	Synthesis of R–L Network -- Properties of R–L Function/R–C Admittance Function -- Foster Form-I of R–L Network -- Foster Form-II of R–L Network -- Cauer Form-I of R–L Network -- Cauer Form-II R–L Network.	3
5.3	Synthesis of L–C Networks -- Properties of L–C Immittance -- Foster Form-I of L–C Network -- Foster Form-II of L–C Network -- Cauer Form-I of L–C Network -- Cauer Form-II of L–C Network.	3

SEMESTER V

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET301	POWER SYSTEMS I	PCC	3	1	0	4

Preamble: The basic objective of this course is to deliver fundamental concepts in power system components. The basic principle of generation, transmission and distribution of electrical power is comprehensively covered in this course ranging extensively from the conventional ones to the modern discoveries. Deregulated systems in the smart grid and micro-grid with details of grid connected energy storages are also introduced to the students through this course.

Prerequisite : EET 201 Circuits and Networks

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Identify the power generating system appropriate for a given area.
CO 2	Evaluate the electrical performance of any transmission line.
CO 3	Compute various physical characteristics of underground and overhead transmission systems.
CO 4	Select appropriate switchgear for protection schemes.
CO 5	Design a simple electrical distribution system as per the standards.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3					2		2			1	2
CO 2	3	3										
CO 3	3	2				2	2	2				
CO 4	3	1				2		2				1
CO 5	3	1				2	2	2			1	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	30	30	60
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the methods employed for improving the efficiency of thermal power plant? (K1, K2)
2. How does diversity factor decide the capacity of a power station? (K2)
3. What are the limiting factors in tapping the wind and solar potential?(K2)
4. Problem to calculate the specification of ground mounted or rooftop solar plants. (K3)

Course Outcome 2 (CO2):

1. Explain the principle and causes of proximity effect and Ferranti effect using appropriate figures (K2)
2. What is transposition of lines? Comment on its necessity in the system. (K2)
3. Problems in Transmission line modelling and analysis.(K3)

Course Outcome 3 (CO3):

1. What are the critical voltages in the formation of Corona? What is the effect of Corona? (K1, K2).
2. With a neat cross sectional view show the constructional features of an EHT Cable. (K2).
3. Problems due to sag/ corona/insulators. (K3)

Course Outcome 4 (CO4):

1. What are the essential qualities required by any insulating medium used for arc quenching? What are the usual insulating media used? (K2)
2. What is current chopping? What is its effect on the system? (K1,K2).
3. What makes the differential protection very significant in the protection schemes of electrical machines and transformers?(K2)
4. Problems in Arc interruption (K3).

Course Outcome 5 (CO5):

1. Derive the equations for voltage drop and current loss in a two wire ring main distributor supplied by (i) DC and (ii) AC Voltages. (K3).
2. How does power factor affect an HT consumer’s electricity bill? (K2).
3. Problems in power factor improvement (K3).

Model Question paper

QP CODE:

PAGES:4

Reg.No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR

Course Code: EET 301

Course Name: POWER SYSTEMS I

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Draw the block diagram of wind power generation and label each part clearly.
2. Discuss the difference between conventional electric power grid and smart grid
3. Draw the possible configurations for a three phase double circuit transposed line system.
4. Derive the deviation in sag due to ice in a winter climate.
5. What is meant by the term grading associated with insulators? Why is it very significant?
6. Discuss the classification of series and shunt FACTS devices.
7. Derive the peak value of current due to capacitive current chopping.
8. With the help of a schematic, explain the architecture of an IEC61850 enabled substation architecture
9. Write notes on energy markets.
10. Calculate the voltage drop and power loss for a radial load of 120A, 0.8 pf lag supplied by a 6.6kV three phase system with a branch impedance of 2 +j2 ohms.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) A proposed station has the following load cycle:
Time in hours: 6-8 8-11 11-16 16-19 19-22 22-24 24-6
Load in MW: 20 40 50 35 70 40 20
Draw the load curve and select suitable generator units from 10,000, 20,000, 25,000, 30,000 kVA. Prepare the operation schedule for the selected machines and determine the load factor from the curve. **(5)**

b) State Skin Effect and Ferranti Effect and elucidate them with necessary diagrams. **(5)**

c) Enlighten upon the various components and their operation in a hydroelectric power plant for energy production. **(4)**

12. a)A generating station has the following maximum loads: 16000kW, 12000kW, 10000kW, 7000kW and 800kW. The annual load factor is 50%. Calculate the diversity factor and annual energy consumption if the maximum demand on the station is noted as 24000. **(5)**

b)With a neat sketch explain the principle of working of a Thermal Power Station. **(5)**

c)What are the limiting factors in tapping the wind and solar potential? **(4)**

Module 2

13. a)Derive the expression for capacitance in a single phase overhead line under the influence of earth effect. **(5)**

b)Classify transmission lines according to their length and enlist the line models. Derive the ABCD constants for medium lines using nominal π method. **(5)**

c) Following results are obtained by making experiments on three phase, three core metal sheathed cable. (i) Capacitance between all the three bunched conductors and sheath is 1.2 micro Farad. (ii) Capacitance between any one conductor and sheath and the other two being insulated is 0.8 micro Farad. (iii) Calculate the capacitance between any two conductors when the third conductor is connected to the sheath. **(4)**

14. a) An 80 km long transmission line has a series impedance of (0.15+j0.75) ohm per km and a shunt admittance of j5.1 x 10^{-6} ohm per km. Find the A, B, C, D parameters by Nominal π method. **(7)**

b) Derive the inductance of a single phase transmission line with three conductors arranged vertically in Side A and two conductors in Side B. The distance between adjacent conductors in each Side is 6m and that between the sides are 8m. Each conductor is of radius 0.3cm. **(7)**

Module 3

15. a)A transmission line conductor at a river crossing is supported from two towers at a height of 45m and 75m above the water level. The span length is 300m. Weight of the conductor is 0.85kg/mm. Determine the clearance between the conductor and water at a point midway between towers if the tension in the conductor is 2050kg. **(5)**

b) Illustrate the methods used for improving string efficiency of overhead line insulators using appropriate figures and equations. **(5)**

c) Surge impedance loading is a key parameter of any power system. Why? **(4)**

16. a) Explain the advantages and disadvantages of corona. **(4)**

b) (i) A single core, lead sheathed cable is graded by using three dielectrics of permittivity 6, 5 and 4 respectively. The conductor diameter is 2.5cm and overall diameter is 7cm. If the dielectrics are worked at the maximum stress of 38kV/cm, find the safe working voltage of the cable. **(5)**

(ii) What will be the value of safe working voltage for the same core and outside diameter assuming the same maximum stress? (ii) What should be the intersheath voltage, if the taps are provided at the same diameters as in Case (i) with a dielectric of permittivity 5, for the same maximum working stress? **(5)**

Module 4

17. a) With a neat sketch explain the principle of operation of an Vacuum Circuit Breaker **(4)**

b)What are the primary causes of overvoltages? How are the equipments protected from overvoltages? **(5)**

c)Explain the principle of operation of a static overcurrent relay. **(5)**

18. a)In a short circuit test on a 132kV three phase system, the breaker gave the following result: power factor of the fault =0.6, recovery voltage 0.97of full line value; the breaking current is symmetrical and the re-striking transient had a natural frequency of 16kHz. Determine the rate of rise of re-striking voltage. Assume that the fault is grounded. **(5)**

b)Explain the significant features of a Microprocessor based relay. **(5)**

c) What makes the differential protection very significant in the protection schemes of electrical machines and transformers? **(4)**

Module 5

19. a) Derive the equations for voltage drop and current loss in a two wire ring main distributor supplied by (i) DC and (ii) AC Voltages. **(5)**

b)What are the modern practices in distribution system? **(4)**

c)How do you justify the connection of capacitors for the improvement of power factor economically? Explain with a real life example. **(5)**

20. a) State the main types of distribution systems and compare their applications. **(3)**

b) Derivemost economical power factor for constant kW load & constant kVA type loads? **(7)**

c) A 3-phase, 5 kW induction motor has a power factor of 0.85 lagging. A bank of capacitor is connected in delta across the supply terminal and power factor raised to 0.95 lagging. Determine the kVAR rating of the capacitor in each phase? **(4)**

Syllabus

Module I (9 Hours)

Power System evolution–Load curve -Load factor, diversity factor, Load curve (brief description only) - Numerical Problems.
Generation-conventional (block schematic details, special features, environmental and ethical factors, advantages, disadvantages) -hydro, thermal, nuclear –renewable energy(block schematic details, special features, environmental factors, regulations, advantages, disadvantages) –solar and wind –Design of a rooftop/ground mounted solar farm (concepts only) – Energy storage systems as alternative energy sources- grid storage systems- bulk power grids –smart grids – micro grids.

Module II (10 hours)

Power Transmission System(Electrical Model)-Line parameters -resistance- inductanceand capacitance (Derivation of three phase double circuit) - Transmission line modelling- classifications -short line, medium line, long line- transmission line as two port network- parameters- derivation and calculations

Module III (10 hours)

Power Transmission System Calculation of Sag and tension-Insulators –string efficiency- grading–corona-Characteristics of transmission lines-Surge Impedance Loading- Series and shunt compensation.
Underground cables-ratings- classification- Capacitance –grading-testing
Introduction to EHVAC, HVDC and FACTS: Principle, classification and advantages/disadvantages

Module IV (12 hours)

Switchgear: Need for protection-circuit breakers-rating- SF6,VCB – Principle of GIS- protective relays – Demonstration of a typical electromechanical relay - Static, Microprocessor and Numeric types –Principles of overcurrent, directional, distance and differential- Types of protection schemes (Numeric relays) - causes of over voltages–Insulation co-ordination- Communication:PLCC - Fibre Optic-Introduction to IEC61850.

Module V (7 hours)

Power Distribution Systems– Distribution systems- Aerial Bunched Cables -Insulated conductors- Network standards-Earthing- transformer location – balancing of loads.
Methods of power factor improvement using capacitors- Tariff mechanisms– Introduction to energy markets (regulated and deregulated systems) -Distribution Automationsystems

Practical Exposure: Visit to a local Substation or a nearby power generating station, visit to a site of solar installation-Evaluation by a Viva

References:

1. Cotton H. and H. Barber, *Transmission & Distribution of Electrical Energy*, 3/e, Hodder and Stoughton, 1978.
2. Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria& Sons, 2009.
3. Kothari D. P. and I. J. Nagrath, *Power System Engineering*, McGraw Hill, 3rd Edition, 2019
4. Soni, M.L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, DhanpatRai& Sons, New Delhi, 1984.
5. Stevenson W. D., *Elements of Power System Analysis*, 4/e, McGraw Hill, 1982.
6. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
7. Wadhwa C. L., *Electrical Power Systems*, 33/e, New Age International, 2009.
8. Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, *Electric Power System*, John Wiley & Sons, 2012.
9. O. I. Elgerd, *Electric Energy Systems Theory*, McGraw Hill, 1995.
10. John J. Grainger and William D. Stevenson, *Power System Analysis,*McGraw Hill, 1994.
11. IEC 61850 Communication Protocol Manual.
12. IEEE 1547 and 2030 Standards.
13. IEC 61724-1:2017 Performance of Solar Power Plants.
14. Dhirendra Kumar Tyagi, *Design, Installation and Operation of Solar PV Plants,* Published by Walnut Publication, Bhubaneswar, India, January 2019.
15. Souraph Kumar Rajput, *SOLAR ENERGY – Fundamentals, Economic and Energy Analysis,* NITRA Publication, 2017.
16. AS Kapur, *A Practical Guide for Total Engineering of MW capacity Solar PV Power Project*, White Falcon Publishing, 2015.
17. Joshua Eranest, Tore Wizelius, *Wind Power Plants and Project Development,* PHI Learning Pvt. Ltd., 2011.
18. G S Sawhney, *Non-Conventional Resources of Energy*, PHI Learning Pvt. Ltd., 2012
19. Arun G Phadke, James S Thorp, *Computer Relaying for Power Systems*, Wiley Publications, 2009.
20. JanakaEkanayake, KithsiriLiyanageJianzhong Wu, Akihiko Yokoyama and Nick Jenkins, *Smart Grid: Technology and Applications*, Print ISBN:9780470974094 |Online ISBN:9781119968696 |DOI:10.1002/9781119968696, John Wiley & Sons, Ltd, 2012.
21. Badri Ram and D. N. Viswakarma, *Power System Protection and Switchgear*, 2/e, Tata McGraw Hill Publication, 2011.
22. A. S. Pabla, *Electric Power Distribution*, 6/e, Tata McGraw Hill Publication, 2011 (or 5/e 2004).

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Power System evolution and Generation (9 hours)**	
1.1	Power System evolution- Load curve- Economic factors - Numerical Problems.	2
1.2	Hydroelectric -Thermal and Nuclear power plant- (Block schematic details, special features, environmental and ethical factors, advantages, disadvantages)	2
1.3	Nonconventional energy sources-Wind farm –(Block schematic details, special features, environmental factors, regulations, advantages, disadvantages).	1
1.4	Renewable energy sources – Solar–(Block schematic details, special features, environmental factors, regulations, advantages, disadvantages) - Design of a rooftop– Design of a ground mounted solar farm	2
1.5	Energy storage systems as alternate energy sources- Grid Storage systems - Bulk power grids - micro-grids	2
2	**Power Transmission System(Electrical Model)(10 hours)**	
2.1	Line parameters -resistance- inductance and capacitance (Derivation of single phase, three phase, single circuit and double circuit) - Numerical Problems.	5
2.2	Transmission line modelling- classifications -short line, medium line, long line-models- Transmission line as two port network-ABCD parameters- derivation and calculations- Numerical Problems.	5
3	**Power Transmission (Physical Aspects)(10 Hours)**	
3.1	Calculation of Sag and tension- Numerical Problems.	2
3.2	Insulators –string efficiency- grading- Numerical Problems.	2
3.3	Corona- Numerical Problems.	1
3.4	Surge Impedance Loading- Series and shunt compensation- Principle only.	1
3.5	Underground cables-ratings- classification- Capacitance –grading- testing- Numerical Problems.	2
3.6	Introduction to EHVAC, HVDC and FACTS: Principle, classification and advantages/disadvantages	2

4	**Switchgear (12 Hours)**	
4.1	Need for protection-formation of arc-Arc quenching theory- Restriking Voltage-Recovery voltage, RRRV - Interruption of Capacitive currents and current chopping (Numerical Problems) Circuit breakers-rating- SF6,VCB- (Diagram, construction, working, advantages, disadvantages) - Principle of GIS	3
4.2	Protective relays –Demonstration of a typical electromechanical relay - Static-Comparison and duality of Amplitude and Phase comparators-(Circuit Diagram, working, advantages, disadvantages) Microprocessor -(Flow Chart, working, advantages, disadvantages) and Numeric-(Block Diagram, working, advantages, disadvantages) Overcurrent, directional, distance and differential-(Principle, circuit diagram) Types of protection schemes (Using Numeric relays)	6
4.3	Causes of over voltages–Surge Protection	1
4.4	Transmission System -Communication- Fibre Optic - Abstract ideas only)	1
4.5	Introduction to IEC 61850	1
5	**Power Distribution Systems(7 Hours)**	
5.1	Distribution systems- DC and AC distribution: Types of distributors- bus bar arrangement-Numerical problems. Aerial Bunched Cables -Insulated conductors-(Abstract ideas only)	2
5.2	Network-standards -Earthing- transformer location – balancing of loads-(Abstract ideas only)	2
5.3	Tariff – regulated and deregulated systems- Numerical Problems	1
5.4	Methods of power factor improvement using capacitors- Numerical Problems	1
5.5	Distribution Automation systems	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET303	MICROPROCESSORS AND MICROCONTROLLERS	PCC	3	1	0	4

Preamble: This course helps the students to understand 8085 microprocessor and 8051 microcontroller architecture as well as to design hardware interfacing circuit. This also aids to thrive their programming skills to solve real world problems.

Prerequisite: Fundamentals of Digital Electronics, C Programming

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Describe the architecture and timing diagram of 8085 microprocessor.
CO 2	Develop assembly language programs in 8085 microprocessor.
CO 3	Identify the different ways of interfacing memory and I/O with 8085 microprocessor.
CO 4	Understand the architecture of 8051 microcontroller and embedded systems.
CO 5	Develop assembly level and embedded C programs in 8051 microcontroller.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	2	3	2	1							
CO 3	3	2	2	2	2							
CO 4	3	2										
CO 5	3	2	3	2	1	1						1

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	30	30	60

Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.
Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the register organization in 8085 microprocessor.
2. Explain the Stack and subroutine operations.
3. Explain the basic steps involved in accessing memory locations.
4. Draw the timing diagrams of different instructions of 8085 microprocessor.

Course Outcome 2 (CO2):

1. Describe the addressing modes of 8085 microprocessor.
2. Describe the various types of 8085 microprocessor instructions.
3. Explain in detail the instruction set of 8085 microprocessor.
4. Write an ALP for data transfer, arithmetic, logical and branching operations.

Course Outcome 3(CO3):

1. Explain how RAM and ROM memory are interfaced with 8085 microprocessor.
2. Describe address decoding used in I/O interfacing.
3. Explain the architecture of 8255 PPI.
4. Explain the modes of operation of 8255 PPI.

Course Outcome 4 (CO4):

1. Explain the special function registers in 8051 microcontroller.
2. Explain the operating modes of serial port of 8051 microcontroller.
3. Describe the addressing modes and modes of operation of timer of 8051 microcontroller.
4. Explain the embedded C Programming.

Course Outcome 5 (CO5):

1. Explain timer programming in assembly language and embedded C.
2. Explain serial port programming in assembly language and embedded C.
3. How to interface ADC, DAC and sensors with 8051 microcontroller.
4. Explain interrupt programming in assembly language and C.

Model Question Paper

QP Code: Pages: 2

Reg No: ___________________

Name: ____________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR

Course Code: EET303
Course Name: MICROPROCESSORS AND MICROCONTROLLERS

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all Questions. Each question carries 3 Marks

1. Explain the use of ALE signal in Intel 8085 microprocessor.
2. Describe the use of CLK OUT and RESET OUT signals.
3. With the help of an example explain the operation of XTHL instruction.
4. How can we check the status of flags in 8085 microprocessor?
5. Explain software and hardware interrupts.
6. Write the differences between microprocessor and microcontroller.
7. Draw the block diagram of 8051 microcontroller.
8. Explain the bit pattern of TMOD register of 8051 microcontroller.
9. How we can enable and disable interrupts in 8051 microcontroller.
10. Find the bits of TMOD registers to operate as timers in the following modes
    (i) Mode 1 Timer (ii) Mode 2 Timer 0.

PART B
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Explain the functional block diagram of 8085 microprocessor. **(10)**

    (b) Define machine cycle and T state. **(4)**

12. (a) Sketch and explain the timing diagram of LDA 2003H. **(10)**

    (b) Describe the addressing modes of 8085 microprocessor. **(4)**

Module 2

13. (a) Write an ALP to sort an array of 10 numbers stored from memory location 2001H onwards in ascending order. **(10)**

(b) Explain stack related operations in 8085 microprocessor. **(4)**

14. (a) Write a delay program to introduce a delay of 1 second. **(8)**

(b) Explain the operation of DAA instruction in 8085 microprocessor. **(6)**

Module 3

15. (a) Explain the address decoding technique in memory interfacing. **(8)**

(b) Give the control word format for BSR and I/O Mode in 8255. **(6)**

16. (a) Explain the architecture of 8051 microcontroller. **(8)**

(b) Explain hard and soft real time systems. **(6)**

Module 4

17. (a) Explain the different methods to create a time delay in 8051 microcontroller. **(7)**

(b) Explain the different addressing modes of 8051 microcontroller? **(7)**

18. (a) Explain the various types of instructions in 8051 microcontroller? **(6)**

(b) Write a Program in 8051 for the generation of square wave having a duty ratio of 0.5 for a time period of 1ms. **(8)**

Module 5

19. (a) Explain how a DAC can be interfaced to 8051 microcontroller. **(10)**

(b) Explain the role of SBUF and SCON registers used in 8051 microcontroller. **(4)**

20. (a) Describe the generation of time delay using the timer of 8051 microcontroller. **(8)**

(b) Explain the various interrupts in 8051 microcontroller. **(6)**

Syllabus

Module 1

Internal architecture of 8085 microprocessor–Functional block diagram

Instruction set-Addressing modes - Classification of instructions - Status flags.

Machine cycles and T states – Fetch and execute cycles- Timing diagram for instruction and data flow.

Module 2

Introduction to assembly language programming- Data transfer operations, arithmetic operations, logic operations, branching operations, I/O and machine control operations.

Assembly language programmes (ALP) in 8085 microprocessor- Data handling/Data transfer, Arithmetic operations, Code conversion- BCD to Binary - Binary to BCD, Sorting - Ascending and descending including bubble sorting.

Stack and subroutines – Conditional CALL and Return instructions

Time delay subroutines using 8 bit register, 16 bit register pair and Nested loop control.

Module 3

Interrupt & interrupt handling - Hardware and Software interrupts.

I/O and memory interfacing – Address decoding– Interfacing I/O ports -Programmable Peripheral Interface PPI 8255 - Modes of operation- Interfacing of seven segment LED.

Introduction to embedded systems, Current trends and challenges, Applications of embedded systems- Hard and soft real time systems.

Introduction to microcontrollers- Microprocessor Vs Microcontroller- 8051 Microcontrollers – Hardware - Microcontroller architecture and programming model - I/O port structure - Register organization -General purpose RAM - Bit addressable RAM - Special Function Registers (SFRs).

Module 4

Instruction set - Instruction types - Addressing modes of 8051 microcontrollers.

8051 microcontroller data types and directives - Time delay programmes and I/O port programming.

Introduction to embedded C Programming - time delay in C - I/O port programming in embedded C.

Module 5

8051 Timer/counter programming - Serial port programming - Interrupt programming in assembly language and embedded C.

Interfacing –ADC - DAC and temperature sensor

Text Books

1. Ramesh Gaonkar, "Microprocessor Architecture Programming and Applications", Penram International Publishing; Sixth edition, 2014.
2. Mohamed Ali Mazidi, Janice GillispieMazidi, "The 8051 microcontroller and embedded systems using Assembly and C", second edition, Pearson/Prentice hall of India.
3. Kenneth J. Ayala, "The 8051 microcontroller", 3rd edition, Cengage Learning, 2010
4. Lyla B Das, "Embedded Systems - An Integrated Approach", Pearson Education India

Reference Books

1. B Ram, "Fundamentals of Microprocessors and Microcontrollers", 9e, DhanpatRai Publications, 2019.
2. Wadhwa, "Microprocessor 8085 microprocessor: Architecture, Programming and Interfacing", PHI 2010
3. Shibu K V, "Introduction to Embedded systems", TMH

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Architecture and Instruction set of 8085 microprocessor (9 hours)**	
1.1	Internal architecture of 8085 microprocessor– functional block diagram	2
1.2	Instruction set- Addressing modes, Classification of instructions - Status flags.	4
1.3	Machine cycles and T states – Fetch and execute cycles - timing diagram for instruction and data flow.	3
2	**Assembly language programming (9 hours)**	
2.1	Introduction to assembly language programming- data transfer operations, arithmetic operations, logic operations, branching operations, I/O and machine control operations.	2
2.2	Assembly language programmes (ALP) in 8085 microprocessor-Data handling/Data transfer - Arithmetic operations - Code conversion - BCD to Binary - Binary to BCD, Sorting - Ascending and descending including bubble sorting.	4

2.3	Stack and subroutines – Conditional call and return instructions – Stack operations.	2
2.4	Time delay subroutines using 8bit register, 16 bit register pair and Nested loop control.	1
3	**Interfacing circuits for 8085 microprocessor and introduction to 8051 Microcontroller (10 hours)**	
3.1	Interrupt and interrupt handling - Hardware and Software interrupts.	1
3.2	I/O and memory interfacing – Address decoding – Interfacing I/O ports-Programmable peripheral interface PPI 8255 - Modes of operation -Interfacing of seven segment LED.	4
3.3	Introduction to embedded systems - Current trends and challenges - Applications of embedded systems - Hard and Soft real time systems.	1
3.4	Introduction to microcontrollers - Microprocessor Vs Microcontroller - 8051- Microcontrollers - Hardware	1
3.5	Microcontroller Architecture and programming model: I/O Port structure - Register organization - General purpose RAM -Bit Addressable RAM -Special Function Registers (SFRs).	3
4	**Programming of 8051 Microcontroller (9 hours)**	
4.1	Instruction Set - Instruction Types - Addressing modes	3
4.2	8051- Data types and directives -Time delay programmes and I/O port programming.	3
4.3	Introduction to embedded C Programming - Time delay in C - I/O port programming in embedded C.	3
5	**Interfacing circuits of 8051 Microcontroller (9 hours)**	
5.1	Timer/counter programming in assembly language and embedded C	3
5.2	Serial port programming in assembly language and embedded C	2
5.3	Interrupt programming in assembly language and embedded C	2
5.4	Interfacing –ADC - DAC and temperature sensor	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET305	SIGNALS AND SYSTEMS	PCC	3	1	0	4

Preamble : This course introduces the concept of signals and systems. The time domain and frequency domain representation, operations and analysis of both the continuous time and discrete time systems are discussed. The application of Fourier analysis, Laplace Transform and Z-Transforms are included. Stability analysis of continuous time systems and discrete time systems are also introduced.

Prerequisite : **Basics of Circuits and Networks**

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Explain the basic operations on signals and systems.
CO 2	Apply Fourier Series and Fourier Transform concepts for continuous time signals.
CO 3	Analyse the continuous time systems with Laplace Transform.
CO 4	Analyse the discrete time system using Z Transform.
CO 5	Apply Fourier Series and Fourier Transform concepts for Discrete time domain.
CO 6	Describe the concept of stability of continuous time systems and sampled data systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	-	-	2	-	-	-	-	-	-	1
CO 2	3	3	3	-	-	-	-	-	-	-	-	1
CO 3	3	3	3	-	2	-	-	-	-	-	-	2
CO 4	3	3	3	-	2	-	-	-	-	-	-	2
CO 5	3	3	3	-	-	-	-	-	-	-	-	2
CO 6	3	3	-	-	2	-	-	-	-	-	-	1

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	30	30	60
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.
Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions :

Course Outcome 1 (CO1)

1. What are the standard test signals?
2. Problems related to various operations of signals.
3. Problems related to representation of systems in differential equation form.
4. Explain any three differences between linear and nonlinear systems.

Course Outcome 2 (CO2):

1. Problems related to Fourier series of continuous signals.
2. Problems related to Fourier transform of continuous systems.
3. Obtain the frequency response of the given system.

Course Outcome 3(CO3):

1. Derivations of transfer function of a given electrical system to comment on the system behaviour.
2. Problems related to analogous systems.
3. Problems related to block diagram reduction.

Course Outcome 4 (CO4):

1. Problems related ZIT.
2. Problems related to ZTF from difference equation form.
3. Problems related to block diagram development of ZTF of the given sampled system.

Course Outcome 5 (CO5):

1. Problems related to Discrete Fourier series of DT signals.
2. Problems related to Discrete time Fourier transform of DT signals
3. Obtain the frequency response of the given DT system.

Course Outcome 6 (CO6):

1. Problems related to the stability analysis of given continuous time systems using Routh criterion.
2. Problems related to stability analysis of DT systems.
3. Differentiate between asymptotic stability and BIBO stability?

Model Question Paper PAGES: 3

QPCODE:

Reg. No:___________

Name:_____________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code**: EET305**

Course Name: **SIGNALS AND SYSTEMS**

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1 Define unit ramp signal r(t). Sketch the signal r(-t+2).

2 Explain any two peculiar characteristics of nonlinear systems.

3 What are the conditions for the existence of Fourier transform?

4 Why do you use analogous systems? Explain with a suitable example.

5 Determine the unit impulse response for the system with $T(s) = \frac{2}{(s^2 + s - 12)}$

6 Explain the concept of positive real functions.

7 Explain the significance of ZOH circuit in signal reconstruction.

8 Write three properties of discrete convolution.

9 State and prove time reversal property of discrete time Fourier series.

10 Find the Fourier transform of x(n)= n u(n).

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11 a) Check whether the following system is static, causal, linear and time invariant: $y(t) = |x(t)|$ **(8)**

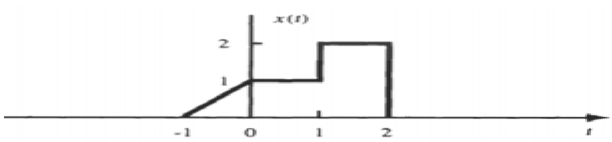
b) Find the convolution of $x_1(t)$ and $x_2(t)$ for the following signals: $x_1(t) = e^{-at}u(t); x_2(t) = e^{-bt}u(t)$ **(6)**

12 a) With suitable examples differentiate between:

i. Odd and even signals,

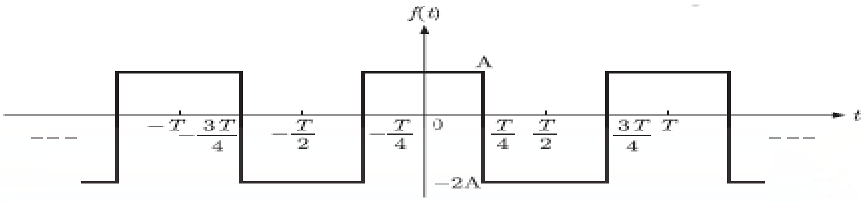
ii. Causal and non causal systems. **(7)**

b) The signal x(t) is given below. Plot x(t-1)+ x(-t+2) **(7)**



Module 2

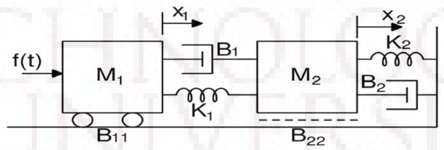
13 a) Find the trigonometric Fourier series for the periodic signal f(t).



(9)

b) State and prove time shifting property of Fourier transform. **(5)**

14 a) Derive the transfer function $X_2(s)/F(s)$ for the mechanical



(7)

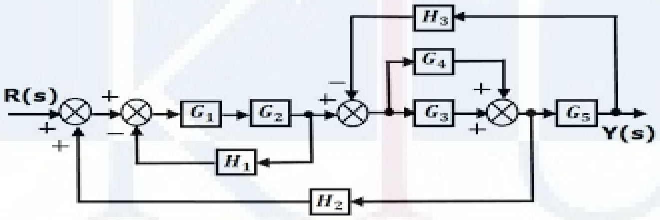
b) A system is described by the following differential equation:

$$\frac{d^2y(t)}{dt^2}+7\frac{dy(t)}{dt}+12y(t)=x(t);\, y(0^-)=-2,\frac{dy}{dt}(0^-)=0$$

Determine the response of the system to a unit step applied at t=0. **(7)**

Module 3

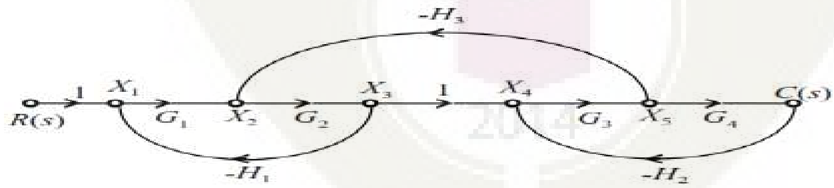
15 a) Determine the overall transfer function Y(s)/R(s) using block diagram reduction.



(8)

b) Check stability of the system represented by the following characteristic equation, using Routh stability criterion: $3s^4+10s^3+5s^2+5s+2=0$ **(6)**

16 a) Determine the transfer function of the system represented by the signal flow graph using Mason's gain formula.



(9)

b) How frequency response can be obtained from poles and zeros? **(5)**

Module 4

17 a) Determine the convolution sum of two sequences x(n)={1,4,3,2} and h(n)={1,3,2,1} using graphical method. **(8)**

b) Determine the z-transform of $x(n)=(1/2)^n u(-n)$. **(6)**

18 a) Explain the aliasing effect in sampled data systems. **(5)**

b) Determine the inverse z-transform of the following functions:

$$i)X(z)=\frac{2z^{-1}}{(1-\frac{1}{4}z^{-1})^2};ROC:|z|>\frac{1}{4}, and, ii)F(z)=\frac{3z^{-1}}{(1-z^{-1})(1-2z^{-1})};ROC:|z|>2$$ **(9)**

Module 5

19 a) Determine the complete solution of the difference equation: y (n) + 2y(n-1) + y(n-2) = x (n) + x(n-1) for the input x(n) = (0.5^n) u(n), initial conditions y(-1) = y(-2) = 1? **(9)**

b) Find the Fourier series coefficients for x(n)=cos(πn/4) **(5)**

20 a) i) Obtain the direct form-I realization for the system described by the difference equation: $y(n)-\frac{5}{6}y(n-1)+\frac{1}{6}y(n-2)=2x(n)$

ii) Also determine the impulse response h(n) for the above system. **(4+5)**

b) Check stability of the system described by the following characteristic equation, using Jury's test: $z^3-0.2z^2-0.25z+0.05=0$ **(5)**

Syllabus

Module 1

Introduction to Signals and Systems (9 hours):

Classification of signals: Elementary signals- Basic operations on continuous time and discrete time signals

Concept of system: Classification of systems- Properties of systems- Time invariance- Linearity -Causality – Memory- Stability-Convolution Integral- Impulse response

Representation of LTI systems: Differential equation representations of LTI systems

Basics of Non linear systems- types and properties

Introduction to random signals and processes (concepts only)

Module 2

Fourier Analysis and Laplace Transform Analysis (10 hours):

Fourier analysis of continuous time signals: Fourier Series- Harmonic analysis of common signals

Fourier transform: Existence- Properties of Continuous time Fourier transform- Energy spectral density and power spectral density

Concept of Frequency response

Laplace transform analysis of system transfer function: Relation between the transfer function and differential equation- Transfer function of LTI systems- Electrical, translational and rotational mechanical systems- Force voltage, Force current and Torque Voltage analogy

Module 3

System Models and Response (8 hours):

Block diagram representation - block diagram reduction

Signal flow graph - Mason's gain formula

Type and Order of the systems- Characteristic equation

Determining the time domain and frequency response from poles and zeros

Concepts of Positive real functions and Hurwitz polynomial- Routh stability criterion.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for mathematical and signal operations (Demo/Assignment only)

Module 4

Sampled Data Systems and Z-Transform (9 hours):

Sampling process-Impulse train sampling-sampling theorem- Aliasing effect

Zero order and First order hold circuits- Signal reconstruction

Discrete convolution and its properties

Z Transform**:** Region of convergence- Properties of Z Transform

Inverse ZT: Methods

Module 5

Analysis of Sampled Data Systems (9 hours):

Difference equation representations of LTI systems - Analysis of difference equation of LTI systems- Z Transfer function- Delay operator and block diagram representation- Direct form, cascade and parallel representations of 2nd order systems

Stability of sampled data system: Basic idea on stability- Jury's test- Use of bilinear transformation

Discrete Fourier series**:** Fourier representation of discrete time signals - Discrete Fourier series– properties.

Discrete Time Fourier Transform: Properties- Frequency response of simple DT systems

Text Books

1. Oppenheim A.V., Willsky A.S. & Nawab S.H., Signals and Systems, 2/e, Prentice Hall
2. Nagrarth I. J, Saran S. N and Ranjan R, Signals and Systems, 2/e, Tata McGraw Hill
3. Haykin S. & Veen B.V., Signals & Systems, 2/e, John Wiley
4. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern
5. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers

Reference Books

1. Bracewell R.N., Fourier Transform & Its Applications, McGraw Hill
2. Farooq Husain, Signals and Systems, Umesh publications.
3. Papoulis A., Fourier Integral & Its Applications, McGraw Hill
4. Taylor F.J., Principles of Signals & Systems, McGraw Hill

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**Introduction to Signals and Systems (9 hours)**	
1.1	Classification of signals - Elementary signals- Basic operations on continuous time and discrete time signals	2
1.2	Concept of systems - Classification of systems- Properties of systems - Time invariance- Linearity -Causality – Memory- Stability.	2
1.3	Convolution Integral- Impulse response-	1
1.4	Representation of LTI systems - Differential equation representations of LTI systems	2
1.5	Basics of Non linear systems- types and properties Introduction to random signals and processes (concepts only)	2
2	**Fourier Analysis and Laplace Transform Analysis (10 hours)**	

2.1	Fourier Analysis of continuous time signals: Fourier Series- Harmonic analysis of common signals	2
2.2	Fourier transform: Existence- Properties of Continuous time Fourier transform- Energy spectral density and power spectral density	2
2.3	Concept of Frequency response- Frequency response of simple LTI systems.	2
2.4	Laplace transform analysis of system transfer function: Relation between the transfer function and differential equation	1
2.5	Transfer function of LTI systems: Electrical, Translational and rotational Mechanical systems	2
2.6	Force Voltage, Force Current and Torque Voltage analogy	1
3	**System Models and Response (8 hours)**	
3.1	Block diagram representation - block diagram reduction	2
3.2	Signal flow graph - Mason's gain formula	1
3.3	Type and Order of the systems- Characteristic equation.	1
3.4	Determining the time domain and frequency response from poles and zeros.	2
3.5	Concepts of Positive real functions and Hurwitz polynomial- Basic idea on Stability- Routh stability criterion	2
3.6	*Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for various mathematical operations (Demo/Assignment only)*	
4	**Sampled Data Systems and Z-Transform (9 hours)**	
4.1	Sampling process-Impulse train sampling-sampling theorem- Aliasing effect	2
4.2	Zero order and First order hold circuits- Signal reconstruction-	2
4.3	Discrete convolution and its properties	1
4.4	Z Transform**:** Region of convergence- Properties of Z Transform	2
4.5	Inverse ZT: Methods	2
5	**Analysis of Sampled Data Systems (9 hours)**	
5.1	Difference equation representations of LTI systems - Analysis of difference equation of LTI systems- Z Transfer function	2
5.2	Delay operator and block diagram representation- Direct form, cascade and parallel representations of 2^{nd} order systems.	2
5.3	Stability of sampled data system: Basic idea on Stability- Jury's test- Use of bilinear transformation.	2
5.4	Discrete Fourier Series**:** Fourier representation of discrete time signals - Discrete Fourier series– properties	2
5.5	Discrete Time Fourier Transform: properties- Frequency response of simple DT systems	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET307	SYNCHRONOUS AND INDUCTION MACHINES	PCC	3	1	0	4

Preamble: Nil

Prerequisite: DC Machines and Transformers

Course Outcomes: After the completion of the course, the student will be able to:

CO 1	Analyse the performance of different types of alternators.
CO 2	Analyse the performance of a synchronous motor.
CO 3	Analyse the performance of different types of induction motors.
CO 4	Describe operating principle of induction machine as generator.
CO 5	Explain the types of single phase induction motors and their working principle.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2	-	-	-	2	-	-	-	-	-	2
CO 2	3	3	2	-	-	2	-	-	-	-	-	2
CO 3	3	3	2	-	-	2	-	-	-	-	-	2
CO 4	3	3	2	-	-	2	-	-	-	-	-	2
CO 5	2	2	-	-	-	2	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	15	15	30
Apply	25	25	50
Analyse			
Evaluate			
Create			

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Part A: 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the principle of operation of alternators.
2. List the advantages of stationary armature type alternators over rotating armature types.
3. Derive emf equation of an alternator.
4. Define coil pitch factor and distribution factor of an alternator.
5. Problems based on emf equation of alternators.
6. Draw the phasor diagram of an alternator operating under lagging/leading/unity power factor and hence derive an expression for the no load induced emf/phase.

Course Outcome 2 (CO2):

1. Why synchronous motors are not self starting?
2. Develop the equivalent circuit and phasor diagram of synchronous motor.
3. Explain the V and Inverted V curves of synchronous motor
4. Explain the power flow diagram of synchronous motor.

Course Outcome 3(CO3):

1. Explain the principle of operation of a three phase induction motor.
2. List the constructional differences between slip ring and squirrel cage induction motors.
3. Problems based on analysing the performance of three phase induction motors using circle diagrams.
4. Problems based on developing the equivalent circuit of a three phase induction motor.
5. Explain the various speed control methods of three phase induction motors.
6. Explain the working of DOL/Star-Delta starter for three phase induction motors.

Course Outcome 4 (CO4):

1. Explain the principle of operation of induction generator.
2. Explain the difference between Grid connected and self excited induction generators
3. Differentiate between induction generator and synchronous generator.
4. Enumerate application of induction generator.

Course Outcome 5 (CO5):

1. Why single phase induction motor is not self starting.
2. Explain double field revolving theory.
3. Draw the torque slip characteristics of single phase induction motor.
4. Develop the equivalent circuit of single phase induction motor.

Model Question paper

QP CODE:

PAGES:3

Reg.No:______________

Name:________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH& YEAR

Course Code: EET307

Course Name: SYNCHRONOUS AND INDUCTION MACHINES

Max. Marks: 100 **Duration: 3 Hrs**

PART A

Answer all questions. Each Question Carries 3 marks

1. List the advantages of stationary armature type alternators over rotating armature types.
2. Define coil pitch factor and distribution factor of an alternator.
3. State and explain Blondel's Two Reaction Theory.
4. What is meant by synchronisation? Lit the conditions to be met while synchronising an alternator to the common bus bars.
5. With the help of neat figures, explain why a synchronous motor is not self-starting.
6. Differentiate between slip ring and squirrel cage induction motors.
7. Explain the phenomenon of crawling and cogging in induction motors.
8. Explain any two braking techniques of induction motors.
9. Differentiate between synchronous and induction generators.
10. What is double field revolving theory?

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) List the causes of harmonics in alternators and suggest ways to mitigate them. **(5)**

    b) A 3-Φ, 10 pole alternator has 2 slots/ pole/ phase on its stator with 10 conductors per slot. The air gap flux is sinusoidally distributed and equals 0.05 Wb. The stator has a double layer winding with a coil span of 1500. If the alternator is running at 600 rpm, calculate the emf generated /phase at no load. **(9)**

12. With the help of neat diagrams, explain the effects of armature reaction in alternators under lagging, leading and unity power factors. **(14)**

Module 2

13. A 220V, 6 pole, 50 Hz, star connected alternator gave the following test results: -

If (A)	0.2	0.4	0.6	0.8	1	1.2	1.4	1.8	2.2	2.6	3	3.4
Voc (line) (V)	29	58	87	116	146	172	194	232	261	284	300	310
Vzpf (line) (V)	-	-	-	-	-	0	29	88	140	177	208	230
Isc (A)	6.6	13.2	20	26.5	32.4	40	46.3	59	-	-	-	-

Find % voltage regulation at full load current of 40A at power factor 0.8 lag by (i) m.m.f method (ii) ZPF method. Ra=0.06 Ω /phase. **(14)**

14. a) Two 3Φ, 6.6 kV star connected alternators supply a load of 3000kW at 0.8 pflag. The synchronous impedance/phase of machine A is 0.5 + j 10 Ω and that of machine B is 0.4+j12 Ω. The excitation of machine A is adjusted so that it delivers 150 A at a lagging power factor and the governors are so set that the load is equally shared between the machines. Determine the current, power factor and induced emf of each machine. **(10)**

b)With the help of a neat circuit diagram, explain how an alternator is synchronised to the bus bars by bright lamp method. **(4)**

Module 3

15. a) With the help of a neat circuit diagram, explain how V and inverted V curves are obtained. **(6)**

b) A 2000V, 3-phase, 4 pole star connected synchronous motor runs at 1500 rpm. The excitation is constant and corresponds to an open circuit voltage of 2000V.The resistance is negligible compared to synchronous reactance of 3Ω per phase. Determine power input, power factor, torque developed for an armature current of 200A. **(8)**

16. a) In rice/flour mills driven by squirrel cage induction motors, the hopper is loaded with the grains only after starting the motor. Similarly, the delivery valve of centrifugal pumps driven by squirrel cage induction motor is opened only after starting the motor. What is the reason behind this? Justify your answer with a relevant performance curve of squirrel cage induction motor. **(4)**

b) A 6-pole, 50 Hz,3-Φ induction motor running on full load develops a useful torque of 150 Nm at a rotor frequency of 1.5 Hz. Calculate the shaft power output. If the mechanical torque lost in friction is 10 Nm, determine a) rotor copper loss b) input to the motor c) the efficiency. The total stator loss is 700W. **(10)**

Module 4

17. For the following test data, calculate (i) line current (ii) power factor (iii) rotor copper loss (iv) slip (v) efficiency (vi) maximum output power (vi) maximum torque and (vii) starting torque:

Induction Motor Details: 3.73kW, 200V, 50Hz, 4pole, 3ϕ star connected
No Load Test: 200V, 350W, 5A
Blocked Rotor Test: 100V, 26A, 1700W
Rotor Copper Loss at standstill is 60% of the total copper loss. **(14)**

18. Explain the methods of speed control in three phase induction motors. **(14)**

Module 5

19. a)Explain the working principle and modes of operation of an Induction Generator. **(8)**

b) With the help of a neat figure, explain the torque-slip characteristics of an induction machine. **(6)**

20. Explain the working of split phase and capacitor start single phase induction motors with the help of neat circuit diagrams and phasor diagrams. Also mention the applications of each. **(14)**

Syllabus

Module 1

Principle of Operation of three phase alternators, Constructional features, Types of Armature Windings(detailed winding diagram not required), EMF equation, Numerical Problems.

Harmonics-causes, suppression, Rating of alternators, Parameters of armature winding, Armature reaction, Equivalent Circuit, Phasor Diagram, Load characteristics, Power Flow Equations.

Module 2

Voltage regulation of three phase Alternators-Direct loading, EMF Method, MMF Method, Potier Method,ASA Method -Numerical Problems.

Blondel's two reaction theory, Phasor Diagram under lagging power factor, Determination of X_d and X_q by slip test, Power developed by a Salient pole machine, Numerical Problems.

Parallel Operation of Alternators- Necessary Conditions, Synchronisation- Synchronising current, Power and Torque, Effect of reactance, Numerical Problems, Methods of Synchronisation.

Module 3

Principle of Synchronous Motor, Equivalent circuit, Phasor diagrams, Power flow diagram and equations, Losses and efficiency -Numerical Problems, Power-angle Characteristics, V Curve and Inverted V Curves.

Three phase Induction motor – Constructional features, Expressions for Power and Torque-Torque- Slip characteristics, Phasor diagram, Equivalent Circuit of Induction motor- Tests on Induction motors for determination of equivalent circuit-Numerical Problems.

Module 4

Performance of three phase Induction motors using Circle diagram, Numerical Problems. Cogging and Crawling in cage motors, Double cage Induction motor-Torque-Slip Characteristics.

Starting of Induction motors – Types of Starters – DOL starter, Autotransformer Starter, Star-Delta starter, Rotor Resistance Starter-Numerical Problems.

Braking of Induction motors – Plugging, Dynamic braking, Regenerative braking, Speed control – Stator Voltage control, V/f control, Rotor Resistance Control.

Module 5

Induction generator – Principle of operation, Grid Connected and Self Excited Operation of Induction Generators, Torque-Slip Characteristics of an Induction machine.

Single phase Induction motors-Double field revolving theory, Equivalent Circuit, Torque-Slip Characteristics, Types of Single Phase Induction motor, Applications.

Selection of AC motors for different applications.

Text Books

1. Bimbra P S, Electric Machines, Khanna Publishers, 2ndedition, 2017.
2. KothariD. P., NagrathI. J., Electric Machines, Tata McGraw Hill, 5thedition.2017.
3. Say M G, The Performance and Design of AC Machines, CBS Publishers, New Delhi, 3rdedition, 2002.
4. Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill,2nd revised edition, 2001.

Reference Books

1. Deshpande M. V., Electrical Machines, Prentice Hall India, New Delhi, Eastern Economy Edition, 2011.
2. Gupta B R, VandanaSinghal, "Fundamentals of Electric Machines", New Age International,.2010.
3. Ashfaq Husain, HaroonAshfaq, Electric Machines, DhanpatRai and Co., 3rd edition,2002.
4. Gupta J B, "Theory and Performance of Electrical Machines", S K Kataria& Sons, 14thedition, 2013.

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Basics of Alternators (10 hours)**	
1.1	Principle of operation and classification of alternators, Synchronous speed.	2
1.2	Construction of synchronous machines. Salient and Cylindrical types, Turbogenerators. Stationary and Rotating armature types.	1
1.3	Armature windings-Types.: Single layer, Double layer, Full pitched winding, Short pitched winding, Concentrated and Distributed winding	1
1.4	EMF Equation, Pitch factor and Distribution factor, Numerical problems	3
1.5	Harmonics in Alternators: Space and slot harmonics, Suppression, Effect of pitch factor on harmonics.	1
1.6	Armature Reaction, Equivalent Circuit and Phasor Diagrams, Power Flow Equations	2
2	**Voltage Regulation and Synchronisation of Alternators (10 hours)**	
2.1	Voltage Regulation of Alternators: EMF, MMF, Potier and ASA Method.	4
2.2	Blondel's Two Reaction Theory, Phasor Diagram under lagging power	3

	factor based on two reaction theory,Slip Test	
2.3	Parallel Operation of Alternators, Necessity of Parallel Operation. Advantages.	1
2.4	Synchronisation of Alternators: Dark Lamp and Bright Lamp Method.	2
3	**Three Phase Synchronous and Induction Motors (10 hours)**	
3.1	Synchronous Motors-Principle, Equivalent Circuit, Phasor Diagrams, Power Flow Diagram, Power and Torque Equations, Numerical Problems	3
3.2	Effects of excitation on armature current and power factor- V and Inverted V Curves, advantages, disadvantages and applications of Synchronous motors.	1
3.3	Three phase Induction Motors-Principle, Constructional details, Slip ring and Cage types.	1
3.4	Slip,frequency and rotor current, Expression for torque and Power-Starting torque, Full load and Pull out torque, Torque- Slip characteristics, Phasor diagram.	3
3.5	Tests on Induction motors for determination of Equivalent circuit, Equivalent Circuit of Induction motor-Numerical Problems.	2
4	**Three Phase Induction Motors Contd. (8 hours)**	
4.1	Circle Diagram, Numerical Problems.	3
4.2	Cogging, Crawling–remedial measures, Double Cage Induction Motor-Principle.	1
4.3	Starters for three phase Induction Motors: DOL, Autotransformer, Star Delta and Rotor Resistance Starters.	2
4.4	Speed Control in Induction Motors	1
4.5	Braking in Induction Motors	1
5	**Induction Generators and Single Phase Induction Motors (7 hours)**	
5.1	Induction Generators: Grid Connected and Self Excited types.	1
5.2	Single phase induction motors-principle, Double field revolving theory, Torque-Slip characteristics, Applications	2
5.3	Types-Split phase, Capacitor Start, Capacitor Start and Run types, Shaded pole motor, Shaded Pole Motor-Principle of operation and applications.	3
5.4	Selection of AC motors for different Applications.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EEL331	MICROPROCESSORS AND MICROCONTROLLERS LAB	PCC	0	0	3	2

Preamble : This laboratory course is designed to train the students to familiarize and program microprocessors and microcontrollers. Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing embedded systems.

Prerequisite : Fundamentals of Digital Electronics and C programming

Course Outcomes : After the completion of the course the student will be able to

CO 1	Develop and execute assembly language programs for solving arithmetic and logical problems using microprocessor/microcontroller.
CO 2	Design and Implement systems with interfacing circuits for various applications.
CO 3	Execute projects as a team using microprocessor/microcontroller for real life applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2	3	-	-	2	2	3	-	2
CO 2	3	3	2	2	3	-	-	2	2	3	-	2
CO 3	3	3	3	3	3	3	3	3	3	3	2	2

ASSESSMENT PATTERN:

Mark distribution:

Total Marks	CIE marks	ESE marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	Regular Lab work	Internal Test	Course Project	Total
15	30	25	5	**75**

Internal Test Evaluation (Immediately before the second series test)

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

General instructions : Practical examination is to be conducted immediately after the second series test after conducting 12 experiments from the list of experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS:

(12 experiments are mandatory)

8085 Microprocessor Programming

1. Data transfer using different addressing modes and block transfer.
2. (a) Arithmetic operations in binary and BCD: addition, subtraction, multiplication and division

   (b) Logical instructions- sorting of arrays in ascending and descending order.

   (c) Binary to BCD conversion and vice versa.

8051 Microcontroller Programming

3. ALP programming for

   (a) Data transfer: Block data movement, exchanging data, sorting, finding largest element in an array.

   (b) Arithmetic operations: Addition, subtraction, multiplication and division. Computation of square and cube of 16-bit numbers.

4. ALP programming for the implementation of counters: HEX up and down counters, BCD up/down counters
5. (a) ALP programming for implementing Boolean and logical instructions: bit manipulation.

   (b) ALP programming for implementing conditional call and return instructions: Toggle the bits of port 1 by sending the values 55H and AAH continuously, Factorial of a number
6. ALP programming for

   (a) Generation of delay

(b) Transmitting characters to a PC HyperTerminal using the serial port and displaying on the serial window

7. C Programs for stepper motor control.

8. C Programs for DC motor direction and speed control using PWM.

9. C Programs for Alphanumerical LCD panel/ keyboard interface.

10. C Programs for ADC interfacing.

11. Demo Experiments using 8085 Microprocessor Programming

(a) Digital I/O using PPI: square wave generation.

(b) Interfacing D/A converter- generation of simple waveforms-triangular, ramp etc.

(c) Interfacing A/D converter.

12. Demo Experiments using 8051 Microcontroller Programming

ALP programming for implementing code conversion– BCD to ASCII, ASCII to BCD, ASCII to decimal, Decimal to ASCII, Hexadecimal to Decimal and Decimal to Hexadecimal.

13. a) Familiarization of Arduino IDE

b) LED blinking with different ON/OFF delay timings with i) inbuilt LED ii) Externally interfaced LED

14. Arduino based voltage measurement of 12V solar PV module/ 12V battery and displaying the measured value using I2C LCD display.

15. Arduino based DC current measurement using Hall-effect current sensor like LEM LA-55P sensor and displaying the value using I2C LCD module.

16. DC motor speed control using MOSFET driven by PWM signal from Arduino module.

17. Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud.

18. Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud.

Mandatory Group Project Work : Students have to do a mandatory micro project (group size not more than 3 students) to realise an embedded system for Industrial Control/ day-to-day life applications. A report also is to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Example projects (Microcontroller based projects)

1. Temperature Monitoring and control System.
2. Home automation system
3. Remote health monitoring and emergency notification system
4. IoT based power monitoring
5. IoT based switching of power devices

Reference Books:

1. Ramesh Gaonkar, Microprocessor Architecture Programming and Applications, Penram International Publishing; Sixth edition, 2014.
2. Mohamed Ali Mazidi, Janice Gillispie Mazidi," The 8051 microcontroller and embedded systems using Assembly and C", second edition, Pearson/Prentice hall of India.
3. Kenneth. J. Ayala, The 8051 microcontroller, 3rd edition, Cengage Learning, 2010
4. Donald P. Leach, Albert Paul Malvino and Goutam Saha, Digital Principles and Applications, 8/e, by McGraw Hill.
5. A. P. Mathur, Introduction to Microprocessors, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Jeeva Jose, Internet of Things, Khanna Publishing House, Delhi
7. Raj Kamal, Internet of Things: Architecture and Design, McGraw Hill

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EEL333	**ELECTRICAL MACHINES LAB II**	**PCC**	**0**	**0**	**3**	**2**

Preamble: The purpose of this lab is to provide practical experience in the operation and testing of synchronous and induction machines.

Prerequisite : Fundamentals of Electrical Engineering

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyse the performance of single phase and three phase induction motors by conducting suitable tests.
CO 2	Analyse the performance of three phase synchronous machine from V and inverted V curves.
CO 3	Analyse the performance of a three phase alternator by conducting suitable tests.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2	-	-	-	-	3	2	-	3
CO 2	3	3	2	2	-	-	-	-	3	2	-	3
CO 3	3	3	2	2	-	-	-	-	3	2	-	3

Assessment Pattern

Marks distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance:	15 marks
Continuous Assessment:	30 marks
Internal Test (Immediately before the second series test) :	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	15 Marks
(b) Implementing the work/Conducting the experiment	10 Marks
(c) Performance, result and inference (usage of equipment and trouble-shooting)	25 Marks
(d) Viva voce	20 marks
(e) Record	5 Marks

General instructions: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified Laboratory Record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS

(A minimum of **TWELVE** experiments are mandatory out of the fifteen listed.)

1. Load test on a three phase Slip Ring Induction Motor

Objectives:

a) Start the motor using auto transformer or rotor resistance starter
b) Plot the performance characteristics

2. No load and block rotor tests on a three phase Squirrel Cage Induction Motor

Objectives:

a) Predetermination of performance parameters from circle diagram
b) Determination of equivalent circuit

3. Starting of a three phase Squirrel Cage Induction Motor using Y-Δ Starter

Objectives:

a) Start the motor using Y-Δ Starter and perform load test
b) Plot the performance characteristics

4. Performance characteristics of a Pole Changing Induction Motor

Objectives:

a) Run the motor in two different pole configurations (example 4 pole and 8 pole)
b) Analyse the performance in the two cases by constructing circle diagrams and compare the results

5. No Load and Blocked Rotor Tests on a single phaseInduction Motor

Objectives:

a) Conduct no load and blocked rotor tests on the motor
b) Predetermine the equivalent circuit

6. Load Test on a single phaseInduction Motor

Objectives:

a) Perform load test on the motor

b) Plot the performance characteristics of the motor

7. Variation of starting torque with rotor resistance in Slip-Ring Induction Motors

Objectives:

a) Plot the variation of starting torque against rotor resistance in a three phase slip ring induction motor

b) Find the external rotor resistance for which maximum starting torque is obtained.

8. V and inverted V curves of a Synchronous Motor

Objectives:

Plot the V and inverted V curves of the Synchronous Motor at no load and full load.

9. Regulation of a three phase Alternator by direct loading

Objectives:

a) Determine the regulation of three phase alternator

b) Plot the regulation versus load curve

10. Regulation of a three phase Alternator by emf and mmf methods

Objectives:

Predetermine the regulation of alternator by emf and mmf methods at 0.8pf lag, upf and 0.8pf lead.

11. Regulation of a three phase alternator by Potier method

Objectives:

a) Synchronize the alternator by dark lamp method

b) Plot ZPF characteristics and determine armature reactance mmf and potier reactance

c) Predetermine the regulation by ZPF method

12. Reactive power control in grid connected Alternators

Objectives:

a) Synchronize the alternator by bright lamp method

b) Control the reactive power and plot the V and inverted V curves for generator operation

13. Slip Test on a three phase Salient Pole Alternator

Objectives:

a) Determine the direct and quadrature axis synchronous reactances

b) Predetermine the regulation at 0.8 lagging power factor

14. V/f control of three phase Squirrel Cage Induction Motor

Objectives:

Perform speed control of the given three phase induction motor by V/f control

15. Performance characteristics of a three phase Induction Generator

Objectives:

Plot the performance characteristics of the generator.

Reference Books

1) Bimbra P S, *Electric Machines*, Khanna Publishers, 2nd edition, 2017.

2). KothariD. P., NagrathI. J., *Electric Machines*, Tata McGraw Hill, 5th edition, 2017.

3) Say M.G, *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd edition, 2002.

4) Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill, 2nd revised edition, 2001.

SEMESTER V

MINOR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET381	SOLID STATE POWER CONVERSION	VAC	3	1	0	4

Preamble: To impart knowledge about the power semiconductor devices, operation and performance of different power converters and its applications.

Prerequisite: Basic knowledge of electric circuits, and basic electronics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the operation of various power semiconductor devices and its characteristics
CO 2	Select appropriate triggering circuit for thyristor
CO 3	Analyse the working of various power converters
CO 4	Describe the principle of operation and voltage control of inverters
CO 5	Compare the features and performance of different dc-dc Converters.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	-	1	-	-	-	-	-	-	-	-
CO 2	3	2	1	2	1	-	-	-	-	-	-	-
CO 3	3	3	-	1	-	-	-	-	-	-	-	-
CO 4	3	3	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	1	2	-	-	-	-	-	-	-	-

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. **Part B** contains 2 questions from each module of which student should answer anyone. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the Working of SCR, power diode, MOSFET, IGBT, TRIAC.
2. Draw the VI characteristics of different power devices
3. Draw and explain the switching characteristics of SCR.
4. Discuss the protection circuits for SCR.
5. Understand the requirements in series & Parallel operation of SCR

Course Outcome 2 (CO2)

1. With waveforms explain R and RC triggering circuits.
2. Explain the need and methods of electrical isolation in triggering circuits for Power Electronics

Course Outcome 3 (CO3):

1. Explain the working of halfwave controlled rectifier.
2. Explain the principle of operation, characteristics and performance of fully controlled and half controlled bridge converters.
3. Problems in finding the average output voltage of rectifier
4. Describe the operation of AC voltage controllers

Course Outcome 4 (CO4):

1. Explain the working of various inverter circuits.
2. Problems in finding the output voltage of inverter.
3. How the output voltage of an inverter can be varied
4. Explain single PWM & multiple PWM technique
5. Explain sinusoidal PWM technique.

Course Outcome 5 (CO5):

1. Explain the working of step down and step up choppers
2. Differentiate between first quadrant, two quadrant and four quadrant operation of choppers.
3. Describe pulse width modulation & current limit control in dc-dc converters
4. Design the value of filter inductor & capacitance in regulators

Model Question paper

Pages: 2

Reg. No:______________

Name:________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET381

Course Name: **SOLID STATE POWER CONVERSION**

Max. Marks: 100 Duration: 3 Hrs

PART A

Answer all questions. Each question carries 3 marks.

1. Draw the circuit for two transistor analogy of silicon controlled rectifier and briefly describe the working.
2. Define holding current and latching current of SCR. Show these currents on the static VI characteristics of SCR.
3. Draw the circuit of an R-Triggering circuit for controlling the thyristor in a half wave-controlled rectifier.
4. Derive the expression for the output voltage of a single phase fully controlled bridge converter with RL load.
5. A three phase half wave converter is operated from 3–phase, 230 V, 50Hz supply with load resistance R= 10Ω. An average output voltage of 50% of the maximum possible output voltage is required. Determine the firing angle.
6. What are the two types of voltage control adopted in ac voltage controllers?
7. With the help of circuit diagram explain the working of current source inverter.
8. What is pulse width modulation? List the various PWM techniques.
9. Draw the circuit of step up chopper and explain its working.
10. A type A chopper has input voltage of 200 V. The current through a load of R=10Ω in series with L=80 mH, varies between 12 A and 16 A. Find the form factor of the output voltage waveform

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) Discuss the condition which must be satisfied for turning on the SCR with agate signal. **(7)**

b) Explain the significance of dv/dt protection in thyristors and describe the method employed for improving the same. **(7)**

12. a) What are the steps to be employed to prevent the difficulties of parallel operation of thyristors? **(6)**

b) Drew the structure of TRIAC and explain its principle of operation. **(8)**

Module 2

13. a) Design an R-triggering circuit for a half wave controlled rectifier circuit for 24 V ac supply. The SCR to be used has the following data.

I_{gmin} = 0.1 mA, I_{gmax} = 12 mA, V_{gmin} = 0.6V, V_{gmax} = 1.5 V **(7)**

b) With the help of circuit diagram explain the operation of single phase semi converter with RL load. Draw the waveform of input voltage, output voltage, load current and voltage across the thyristor. **(7)**

14. a) Draw RC triggering circuit for SCR and explain with relevant wave forms. **(7)**

b) With the help of circuit diagram explain the working of single phase fully controlled converter with RL load. Draw the waveform of output voltage and output current. **(7)**

Module 3

15. a) Sketch the waveform of input voltage, output voltage and output current of a three phase half wave controlled rectifier with R load operating at $\alpha = 30\,°$. **(7)**

b) A three phase half wave converter is operated from 3–phase, 400 V, 50Hz supply with load resistance R = 50 Ω. An average output voltage of 50% of the maximum possible output voltage is required. Determine the firing angle. **(7)**

16. a) Explain the basic working of a single phase dual converter. **(6)**

b) Draw the circuit of a three phase fully controlled bridge converter and draw the waveforms of input voltage, output voltage, output current and input current in any one phase. Assume resistive load and firing angle is 30 degrees. **(8)**

Module 4

17. a) Describe the working of a three phase voltage source inverter with an appropriate circuit diagram. **(7)**

b) Explain with suitable diagram, the principle of voltage control in inverters with single pulse width modulation. **(7)**

18. Explain the 120 degree conduction mode of a three-phase bridge inverter with output voltage waveforms (phase and line), indicating the devices conducting in each state. **(14)**

Module 5

19. a) With the help of circuit diagram and waveform explain the operation of buck converter and derive the equation of output voltage. **(7)**

b) Differentiate between PWM control and current limit control in choppers. **(7)**

20. a) Explain the working of two quadrant (class C) chopper, with relevant waveform. **(8)**

b) A step-up chopper is used to generate 220 V from 100 V dc source. The OFF period of switch is 80μs. Compute the required pulse width. **(6)**

Syllabus

Module 1

Power semiconductor devices, their symbols and static characteristics, specifications of switches, steady state characteristics of Power MOSFET and IGBT.

SCR – Operation, V-I characteristics, steady state and switching characteristics, two transistor model, methods of turn-on, power diodes, operation of TRIAC, series and parallel connection of SCRs.

Module 2

Gate triggering circuits – R and RC triggering circuits – isolation circuits using opto-isolators and pulse transformers.

Controlled rectifiers – half-wave controlled rectifier with R load – single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous conduction) – output voltage equation – single phase half controlled bridge rectifier with R, RL and RLE loads.

Module 3

Three phase half-wave-controlled rectifier with R load – three phase fully controlled & half-controlled converter with RLE load (continuous conduction) – output voltage equation-waveforms for various triggering angles (analysis not required) – single phase and three phase dual converter.

AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R, & RL loads – waveforms – RMS output voltage, sequence control (two stage) with R load.

Module 4

Inverters – voltage source inverters – single phase half-bridge & full bridge inverter with R & RL loads – 3-phase bridge inverter with R load – 120° & 180° conduction mode, current source inverters.

Voltage control in inverters – Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM – modulation index & frequency modulation ratio.

Module 5

DC-DC converters – step down and step up choppers – single-quadrant, two-quadrant & four quadrant chopper – pulse width modulation & current limit control in dc-dc converters. Switching regulators – buck, boost & buck-boost – operation in continuous conduction mode – steady state waveforms – selection of components.

Text Books

1. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education
2. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi

Reference Books

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India
2. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998
3. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India
4. Alok Jain, Power Electronics and its Applications, Penram International Publishing (I) Ltd, 2016
5. Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Power semiconductor devices (9 hours)**	
1.1	Symbols, static characteristics and specifications of semiconductor switches.	2
1.2	Power diodes, power MOSFET and IGBT	3
1.3	SCR - VI Characteristics, Turn on methods	1
1.4	Structure and principle of operation of TRIAC	1
1.5	Series and parallel operation of SCRs	2
2	**Gate triggering circuits & single-phase controlled converters (9 hours)**	
2.1	R and RC triggering circuits	3
2.2	Isolation circuits using opto-isolators and pulse transformers	1
2.3	Half-wave controlled rectifier with R load	1
2.4	Single phase fully controlled bridge rectifier with R, RL and RLE loads	2
2.5	Single phase half controlled bridge rectifier with R, RL and RLE loads	2
3	**Three phase controlled converters & AC voltage regulator (9 hours)**	
3.1	Three phase half-wave-controlled rectifier with R load	1
3.2	Three phase fully controlled & half-controlled converter with RLE load	4
3.3	Single phase and three phase dual converter	2
3.4	AC voltage controllers (ACVC)	1
3.5	Sequence control (two stage) with R load	1
4	**Inverters (9 hours)**	
4.1	Single phase half-bridge & full bridge inverter with R & RL loads	3
4.2	Three phase bridge inverter with R load – 120° & 180° conduction mode	2
4.3	Current source inverters.	1

4.4	Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM	3
5	**DC-DC Converters (9 hours)**	
5.1	Principle of step down and step up choppers	2
5.2	Description of single-quadrant, two-quadrant & four quadrant choppers	1
5.3	Pulse width modulation & current limit control in dc-dc converters	3
5.4	Switching regulators – buck, boost & buck-boost - continuous conduction mode only	2
5.5	Design of filter inductance & capacitance	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET383	SOLAR AND WIND ENERGY CONVERSION SYSTEMS	VAC	3	1	0	4

Preamble: This course introduces about solar and wind energy conversion systems. Design of wind and solar power systems are also discussed.

Prerequisite: Introduction to Power Engineering/ Energy Systems

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Explain the basics of solar energy conversion systems.
CO 2	Design a standalone PV system.
CO 3	Describe different wind energy conversion systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO 1	3	3										2
CO 2	3	3	1									2
CO 3	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern :There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain what do you mean by solar constant (K1)
2. Discuss about the different instruments used for measuring solar radiation and sun shine (K2)

Course Outcome 2 (CO2):

1. Design a standalone PV system. (K3)
2. Design a grid connected PV system. (K3)

Course Outcome 3 (CO3):

1. Compare the performance of different types of wind turbines. (K3).
2. Compare the performance of different types of generators used in wind turbines. (K3).

Model Question paper

QP CODE:

PAGES:2

Reg. No:_______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET383

Course Name: SOLAR AND WIND ENERGY CONVERSION SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain briefly what do you mean by solar azimuth angle and zenith angle.
2. Differentiate between extraterrestrial and terrestrial solar radiation.
3. Write notes on the working of a solar cooker.
4. Discuss what do you mean by a solar green house.
5. Write notes on the different materials used for making solar cells.
6. Discuss the characteristics of a solar cell.
7. Differentiate between lift and drag forces.
8. Explain what do you mean by pitch control of wind turbines.
9. Write notes on the environmental impacts of wind power generation.

10. Discuss about the wind energy program in India

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a. With the help of a neat diagram, explain the working of a pyrheliometer. **(7)**
    b. Explain how monthly average solar radiation on inclined surfaces can be calculated. **(7)**
12. a. State the reasons for variation in the amount of solar energy reaching earth surface. **(4)**
    b. With the help of a neat diagram, explain the working of a sunshine recorder. **(6)**
    c. Explain the difference in the working of pyrheliometer and pyranometer. **(4)**

Module 2

13. a. Explain the different types of solar collectors based on the way they collect solarradiation. **(7)**
    b. Explain in detail, the working of a solar air conditioning system **(7)**

14. a. With the help of a diagram, explain the function of different components of a flat plate solar collector. **(7)**
    b. Design a solar water heater for domestic application. **(7)**

Module 3

15. a. Write notes on the efficiency of a solar cell. **(3)**
    b. Discuss the effect of shadowing on the performance of solar cells. **(3)**
    c. Explain how maximum power point tracking can be done using buck-boostconverter. **(8)**

16. a. Compare the performance of single junction and multijunction PV modules. **(4)**
    b. Write notes on packing factor of a PV module. **(3)**
    c. Explain with a neat sketch, the working principle of a grid connected solar system. **(7)**

Module 4

17. a. Discuss the application of Weibull distribution in wind power generation **(3)**
    b. Explain the characteristics of a wind turbine. **(4)**
    c. Explain the different modes of wind power generation. **(7)**

18. a. Compare the performance of different types of wind turbines **(6)**
    b. Derive an expression for wind turbine power. **(4)**

c. What do you mean by Betz's Law? Why wind turbines are not 100% efficient? **(4)**

Module 5

19. a. With the help of a diagram, explain the working of a wind energy conversion system. **(7)**

b. Compare the performance of different types of generators used in wind mills. **(7)**

20. a. With the help of a diagram, explain the working of a variable speed constant frequency wind energy conversion system. **(7)**

b. Discuss about the different types of converter used in renewable energy systems. **(7)**

Syllabus

Module 1

Introduction - Basic Concept of Energy -Source of Solar Energy -Formation of the Atmosphere - Solar Spectrum. Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer -Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extraterrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors -Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces .

Module 2

Solar Thermal system-Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –performance evaluation. Applications -Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse -Design of solar water heater

Module 3

Solar PV Systems-Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array -Single-Crystal Solar Cell Module, Thin-Film PV Modules, III-V Single Junction and Multijunction PV Modules-Emerging and New PV Systems -Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors.

Module 4

Wind Turbines - Introduction -Origin of Winds- Nature of Winds – Classification of Wind Turbines -Wind Turbine Aerodynamics - Basic principles of wind energy extraction – Extraction of wind turbine power(Numerical problems)- Weibull distribution-Wind power generation curve-Betz's Law-Modes of wind power generation.

Module 5

Wind Energy Conversion Systems-Introduction-Components of WECS - Fixed speed drive scheme- Variable speed drive scheme - Wind–Diesel Hybrid System –Induction generators-Doubly Fed Induction Generator(DFIG)-Squirrel Cage Induction Generator(SCIG)-Power converters in renewable energy system-AC-DC Converters, DC-DC Converters, DC-AC Converters(Block Diagram Only)-Effects of Wind Speed and Grid Condition (System Integration) -Environmental Aspects -Wind Energy Program in India

References:

1. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977
2. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
3. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
4. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002
5. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994.
6. Siraj Ahmed, *Wind Energy- Theory and Practice*, Prentice Hall of India, New Delhi,2010
7. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd Renewable energy systems, Pearson 2017
8. D. P. Kothari, S. Umashankar, Wind Energy Systems and Applications, Narosa publishers,2017
9. G. N. Tiwari,ArvindTiwari,Shyam, Handbook of Solar Energy: Theory, Analysis and Applications, springer,2016.
10. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
11. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009.
12. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
13. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
14. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
15. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
16. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996.
17. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy – Sources for Fuel and Electricity, Earth scan Publications, London, 1993.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Solar energy (8 hours)**	
1.1	Introduction - Basic Concept of Energy -Source of Solar Energy - Formation of the Atmosphere - Solar Spectrum.	2
1.2	Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer – Pyranometer -Sunshine Recorder	2
1.3	Solar Radiation on a Horizontal Surface –Extraterrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors	2
1.4	Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces.	2
2	**Solar Thermal Systems (8 hours)**	
2.1	Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics	1
2.2	Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation.	2
2.3	Applications -Solar heating system, Air conditioning and Refrigeration system	1
2.4	Pumping system, solar cooker, Solar Furnace, Solar Greenhouse	2
2.5	Design of solar water heater	2
3	**Solar PV systems (8 Hours)**	
3.1	Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials	2
3.2	Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III-V Single Junction and Multijunction PV Modules -Emerging and New PV Systems	1
3.3	Packing Factor of the PV Module - Efficiency of the PV Module - Energy Balance Equations for PV Modules	1
3.4	Series and Parallel Combination of PV Modules.- Effect of shadowing-Maximum Power Point Tracker (MPPT) using buck-boost converter.	2
3.5	Solar PV Systems –stand-alone and grid connected -Design steps for a	2

	Stand-Alone system –Storage batteries and Ultra capacitors.	
4	**Wind energy (9 Hours)**	
4.1	Wind Turbines - Introduction -Origin of Winds- Nature of Winds	1
4.2	Classification of Wind Turbines -Wind Turbine Aerodynamics - Basic principles of wind energy extraction	2
4.3	Extraction of wind turbine power(Numerical problems)	2
4.4	Weibull distribution-Wind power generation curve - Betz's Law	2
4.5	Modes of wind power generation.	2
5	Wind energy conversion systems (9)	
5.1	Introduction-Components of WECS - Fixed speed drive scheme-Variable speed drive scheme	2
5.2	Wind–Diesel Hybrid System –Induction generators-Doubly Fed Induction Generator(DFIG)-Squirrel Cage Induction Generator(SCIG)	3
5.3	Power converters in renewable energy system-AC-DC Converters, DC-DC Converters, DC-AC Converters(Block Diagram Only)	2
5.4	Effects of Wind Speed and Grid Condition (System Integration) - Environmental Aspects -Wind Energy Program in India	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET385	CONTROL SYSTEMS	VAC	3	1	0	4

Preamble: This course deals with the fundamental concepts of control systems theory. Modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach are discussed. The state space concept is also introduced.

Prerequisite: Basics of Dynamic Circuits and Systems

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Describe the role of various control blocks and components in feedback systems
CO 2	Analyse the time domain responses of the linear systems
CO 3	Apply Root locus technique to assess the performance of linear systems
CO 4	Analyse the stability of the given LTI systems.
CO 5	Apply state variable concepts to assess the performance of linear systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	-	-	-	-	-	-	-	-	-	3
CO 2	3	3	3	-	-	-	-	-	-	-	-	3
CO 3	3	3	3	-	2	-	-	-	-	-	-	3
CO 4	3	3	3	-	-	-	-	-	-	-	-	3
CO 5	3	3	3	3	-	-	-	-	-	-	-	3

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	30	30	60
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Derive and explain the transfer function of field controlled dc servo motor.
2. With the help of suitable example explain the need for analogous systems.
3. Explain how does the feedback element affect the performance of the closed loop system?

Course Outcome 2 (CO2):

1. Obtain the different time domain specification for a given second order system with impulse input and assess the system dynamics.
2. Determine the value of the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G_p(s) = \frac{K}{s(s+10)}$, which results in a critically damped response.
3. Problems related to static error constant and steady state error for a given input.

Course Outcome 3 (CO3):

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s(s+1)(s+4)}$ is oscillatory, using Root locus.
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s(s^2+3s+2)}$.

   Determine the value of K to achieve a damping factor of 0.5?
3. Problem on root locus for systems with positive feedback.

Course Outcome 4 (CO4):

1. Problems related to application of Routh's stability criterion for analysing the stability of given system.
2. Determine the value of K such that the gain margin for the system with $G(s)H(s) = \frac{K}{s(s+2)(s+5)}$ equals to 10 dB.
3. Problem related to the analysis of given system using Polar plot.

Course Outcome 5 (CO5):

1. Determine the transfer function of the system given by:

   system with state model:

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ -1 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u; \quad y = [0 \quad 1] x.$$

2. Obtain the time response y(t) of the homogeneous system represented by:

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad [y] = [1 \quad 0][X] \text{ with } x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$$

3. Derive and analyse the state model for a field controlled dc servo motor.

Model Question Paper PAGES: 3

QP CODE:

Reg. No:___________

Name:_____________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code**: EET385**

Course Name: **CONTROL SYSTEMS**

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1 Give a comparison between open loop and closed loop control systems with suitable examples.

2 With relevant characteristics explain the operation of a tacho generator as a control device.

3 For a closed loop system with $G(s) = \frac{3}{s\,(s+2)};$ and H(s) = 0.1, calculate the steady state error constants.

4 Check the stability of the system given by the characteristic equation, $G(s) = s^5 + 2s^4 + 4s^3 + 8s^2 + 16s + 32;$ using Routh criterion.

5 With suitable sketches explain how addition of zeroes to the open-loop transfer function affects the root locus plots.

6 Explain Ziegler – Nichol's PID tuning rules.

7 Explain the features of Non-minimum phase systems with a suitable example.

8 How do you determine the gain margin of a system, with the help of Bode plot?

9 A system is represented by $\frac{Y(s)}{U(s)} = \frac{3}{(s+1)(s+2)}$. Derive the Canonical diagonal form of representation in state space.

10 Discuss the advantages of state space analysis.

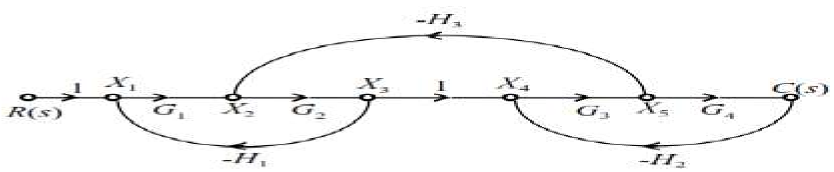
PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

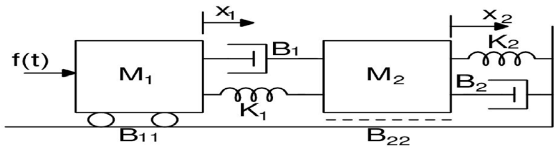
11 a) Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. **(8)**

b) Determine the transfer function of the system represented by the signal flow graph using Mason's gain formula.



(6)

12 a) Derive the transfer function $X_2(s)/F(s)$ for the mechanical system.



(9)

b) Compare the effect of H(s) on the pole-zero plot of the closed loop system with $G(s)=\frac{s+1}{(s^2+5s+6)}$ with: i) derivative feed back H(s)= s; ii) integral feedback H(s)=1/s. **(5)**

Module 2

13 a) Derive an expression for the step response of a critically damped second order system? Explain the dependency of maximum overshoot on damping factor. **(9)**

b) Determine the value of gain K and the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G(s)=\frac{K}{s(s+6)}$, which results in a critically damped response when subjected to a unit impulse input.

Also determine the steady state error for unit velocity input. **(5)**

14 a) A unity feedback system is characterized by an open loop transfer function $G(s)=\frac{4}{(s^2+s+5)}$. Determine the transient response when subjected to a unit step input and sketch the response. Evaluate the rise time and peak time of the system. . **(9)**

b) Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s)=\frac{K}{s(s^2+3s+1)}$ is stable. . **(5)**

Module 3

15 a) Determine the value of K such that the closed loop system with $G(s)H(s)=\frac{K}{s\,(s+2)\,(s+5)}$ is oscillatory, using Root locus.

Also determine the value of K to achieve a damping factor of 0.866. **(10)**

b) Compare between PI and PD controllers. **(4)**

16 a) Sketch the root locus for a system with $G(s)H(s)=\frac{K(s-1)}{s(s+4)}$. Hence determine the range of K for the system stability. **(9)**

b) With help of suitable sketches, explain how does Angle and Magnitude criteria of Root locus method help in control system design. **(5)**

Module 4

17 a) The open-loop transfer function of a unity feedback system is G(s)=$\frac{K}{s(0.5s+1)(0.04s+1)}$.Use asymptotic approach to plot the Bode diagram and determine the value of K for a gain margin of 10 dB. **(10)**

b) Derive and explain the dependence of resonant peak on damping factor. **(4)**

18 a) Draw the polar plot for the system with $G(s)H(s)=\frac{K}{s(s+0.5)(s+2)}$ and determine the value of K such that phase margin equals to 40^o. **(9)**

b) Explain the detrimental effects of transportation lag using Bode plot. **(5)**

Module 5

19 a) Obtain the time response y(t) of the homogeneous system represented by:

$$\left[\dot{X}\right]=\begin{bmatrix}-1 & 1\\ -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}\quad [y]=[1 \quad 0][X] \text{ with } x(0)=\begin{bmatrix}1\\ 0\end{bmatrix}$$ **(6)**

b) Derive and analyse the state model for a field controlled dc servo motor **(8)**

20 a) A system is represented by $\frac{Y(s)}{U(s)}=\frac{4(s+0.5)}{(s+1)(s+2)}$. Derive the phase variable representation in state space. **(5)**

b) Derive the transfer function for the system with

$$\left[\dot{X}\right]=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 2\\ -12 & -7 & -4\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 1\\ 1\end{bmatrix}u;\quad [y]=[1 \quad 0 \quad 0][X]$$

(9)

Syllabus

Module 1

System Modeling (8 hours)

Open loop and closed loop control systems

Transfer function of LTI systems- Electrical, translational and rotational systems – Force voltage and force current analogy

Block diagram representation - block diagram reduction

Signal flow graph - Mason's gain formula

Control system components: Transfer functions of DC and AC servo motors– Control applications of Tacho generator and Stepper motor.

Module 2

Performance Analysis of Control Systems (12 hours)

Characteristic equation of Closed loop systems- Effect of feedback-.

Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of first order and second order systems.

Error analysis: Steady state error analysis - static error coefficients of type 0,1,2 systems.

Stability Analysis: Concept of stability- BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion- analysis - relative stability

Module 3

Root Locus Analysis and Compensators (8 hours)

Root locus technique: General rules for constructing Root loci – stability from root loci - Effect of addition of poles and zeros on Root Locus- Effect of positive feedback systems on Root Locus

Need for controllers: Types- Feedback, cascade and feed forward controllers

PID controllers (basic functions only)- Zieglar Nichols PID tuning methods

Introduction to MATLAB functions and Toolbox for Root locus based analysis (Demo/Assignment only))

Module 4

Frequency Domain Analysis (9 hours)

Frequency domain specifications- correlation between time domain and frequency domain responses

Polar plot: Concepts of gain margin and phase margin- stability analysis

Bode Plot: Construction of Bode plots- Analysis based on Bode plot

Effect of Transportation lag and Non-minimum phase systems

Introduction to MATLAB functions and Toolbox for various frequency domain plots and analysis (Demo/Assignment only).

Module 5

State Space Analysis of Systems (10 hours)

Introduction to state space and state model concepts- state equation of linear continuous time systems, matrix representation- features -Examples of simple electrical circuits, and dc servomotor.

Phase variable forms of state representation- controllable and observable forms- Diagonal Canonical forms - Jordan canonical form

Derivation of transfer function from state equations.

State transition matrix: Properties of state transition matrix- Computation of state transition matrix using Laplace transform- Solution of homogeneous systems

Textbooks

1. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
2. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
3. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
4. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education
5. K R Varmah, Control Systems, Tata McGrawHill, 2010

Reference Books

1. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India
2. Desai M. D., Control System Components, Prentice Hall of India, 2008
3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
4. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016
5. Gopal M., Modern Control System Theory, 2/e, New Age Publishers

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**System Model (8 hours)**	
1.1	Open loop and closed loop control systems	1
1.2	Transfer function of LTI systems- Electrical, translational and rotational systems – Force voltage and force current analogy	2
1.3	Block diagram representation - block diagram reduction	2
1.4	Signal flow graph - Mason's gain formula	1
1.5	Control system components: Transfer functions of DC and AC servo motors –Control applications of Tacho generator and Stepper motor.	2
2	**Performance Analysis of control systems (10 hours)**	
2.1	Characteristic equation of CL systems- Effect of feedback	1

2.2	Time domain analysis of control systems: Time domain specifications of transient and steady state responses, Impulse and Step responses of first order systems, Impulse and Step responses of second order systems.	3
2.3	Error analysis: Steady state error analysis - static error coefficients of type 0, 1, 2 systems.	2
2.4	Stability Analysis: Concept of stability- BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems	2
2.5	Routh criterion: Routh's stability criterion- analysis - relative stability	2
3	**Root locus Analysis and Compensators (8 hours)**	
3.1	Root locus technique: General rules for constructing Root loci - stability from root loci -	3
3.2	Effect of addition of poles and zeros on Root Locus.	1
3.3	Effect of positive feedback on Root Locus	1
3.4	Need for controllers: Types- Feedback, cascade and feed forward controllers	1
3.5	PID controllers**:** PID controllers (basic functions only)- Zieglar Nichols tuning methods	2
3.6	*Introduction to MATLAB functions and Toolbox for Root locus based analysis (Demo/Assignment only)*	
4	**Frequency domain analysis (9 hours)**	
4.1	Frequency domain specifications- correlation between time domain and frequency domain responses	2
4.2	Polar plot: Concepts of gain margin and phase margin- stability analysis	2
4.3	Bode Plot: Construction of Bode plots- Analysis based on Bode plot	4
4.4	Effect of Transportation lag and Non-minimum phase systems	1
4.5	*Introduction to MATLAB functions and Toolbox for various frequency domain plots and analysis (Demo/Assignment only)*	
5	**State space Analysis of systems (10 hours)**	
5.1	Introduction to state space and state model concepts- state equation of linear continuous time systems, matrix representation- features -Examples of simple electrical circuits, and dc servomotor.	3
5.2	Phase variable forms of state representation-controllable and observable forms	2
5.3	Diagonal Canonical forms of state representation- diagonal & Jordan canonical forms	2
5.4	Derivation of transfer function from state equation.	1
5.5	State transition matrix: Properties of state transition matrix- Computation of state transition matrix using Laplace transform- Solution of homogeneous systems	2

SEMESTER V

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET393	DIGITAL SIMULATION	VAC	3	1	0	4

Preamble: Numerical simulation using digital computers is an indispensable tool for electrical engineers. This honours course is designed with the objective of providing a foundation to the theory behind Numerical Simulation of electrical engineering systems and to give an overview of different styles of simulation tools and methodologies. This course would help students to explore and effectively use simulation tools with a clear understanding of their inner engines. This course also prepares students to explore and use the industry-standard tools like MATLAB and SPICE.

Prerequisites : **1. EET201 Circuits and Networks**

2. EET 205: Analog Electronics

3. MAT 204: Probability, Random Processes and Numerical Methods

Course Outcomes: After the successful completion of the course the student will be able to:

CO 1	Formulate circuit analysis matrices for computer solution.
CO 2	Apply numerical methods for transient simulation.
CO 3	Develop circuit files for SPICE simulation of circuits.
CO 4	Develop MATLAB/Simulink programs for simulation of simple dynamic systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3		2	3							2
CO 2	3	3		2	3							2
CO 3	3	3		2	3							2
CO 4	3	3		2	3							2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	15	15	20
Understand (K2)	20	20	50
Apply (K3)	15	15	30

Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

Problems on Circuit Analysis Matrix Formulation for Computer Solution (MNA and Sparse Tableau Approach) - K1 and K2 Level questions to be asked.

Writing code snippets in pseudo codes/Flow - charts for simple circuit formulations - K2, K3 Level.

Course Outcome 2 (CO2):

Explain the features of different numerical algorithms with respect to the requirements of circuit simulation: Questions in K1, K2 and K3 Level.

Compare the features of numerical simulation algorithms. Numerical problems and questions in K1, K2 and K3 levels.

Explain the application-specific features of numerical methods in circuit simulation: Adaptive Step-Size, Artificial Ringing and damping - K1 and K2 level questions.

Course Outcome 3 (CO3):

Write circuit files for simple analogue passive and active circuits using standard SPICE notation. K1, K2 and K3 Level questions.

Course Outcome 4 (CO4):

Develop MATLAB scripts for solution of simple ODEs - K2, K3 level questions.

Develop Simulink signal-flow diagrams for simulation of second order, first-order passive networks. K2, K3 Level question.

Model Question paper

QP CODE: PAGES: 4

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EE393 Course Name: DIGITAL SIMULATION

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Differentiate between DC simulation and Transient Simulation.
2. What is "convergence issue" in circuit simulation?
3. Differentiate between implicit and explicit numerical methods.
4. Define Local Truncation Error.
5. What is a "stiff system"? Give an example.
6. It is required to simulate a circuit with excessively oscillatory response. Out of Euler method and Trapezoidal method, which is suitable for this system, and why?
7. Write the SPICE circuit file to run the transient simulation of an RC circuit excited by a pulse source of amplitude 5 V and frequency 1 kHz. The RC time constant is 0.1 ms (You may choose any R, C values that satisfy this requirement). Use end time of 1 s. Assume any missing information appropriately.
8. Differentiate between ' .lib' and '.inc' SPICE directives?
9. What is the output of the following MATLAB code:?

```
b = [3 8 9 4 7 5];
sum1 = 0;
for k = 1:4
        sum1 = sum1+b(k);
        end
sum1
```

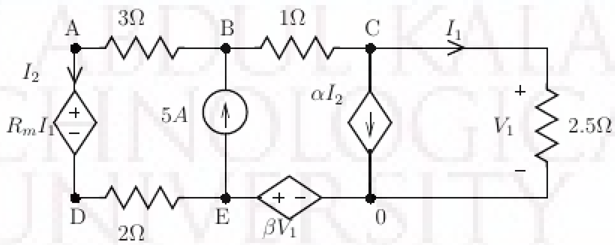
10. Write a MATLAB function to accept the coefficients of a quadratic polynomial and return the evaluated roots.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. (a).Figure 1 shows a network, with α=2, β=0.4 and R_m= 1 Ω. Formulate the Modified Nodal Analysis matrix from fundamental equations. (10)



(b). Explain how 'damping' can be used to improve convergence in nonlinear equation solutions using Newton-Raphson method. (4)

12. (a). For the circuit shown in Fig. 2, formulate the Sparse Tableau Analysis (STA) matrix from the fundamental equations. Take α=0.5. (10)

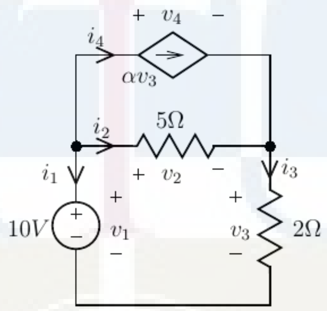


Figure 2: $\alpha = 0.5$

(b). What is Sensitivity Analysis? Explain with an example. (4)

Module 2

13. Solve

$$\frac{dx}{dt} = -\frac{1}{2}x - 6te^{-t/2}$$

, 0 < t < 20, x_0=3, for h = 0.01 and h= 0.05 using Trapezoidal method and forward Euler methods. Compare with the analytical solution $\hat{x}(t) = (2 - 3t^2)e^{-t/2}$. Find the global error at the final value. (14)

14. (a) What is 'Order' of a numerical method? Explain how order and step-size influence the accuracy and computational efficiency of numerical methods. (8)

(b). What are the sources of error in numerical methods? (6)

Module 3

15. Write the MNA equations for the circuit shown in Fig. 3 below: Apply Trapezoidal method on the resulting equations to obtain the corresponding numerical equations.

(14)

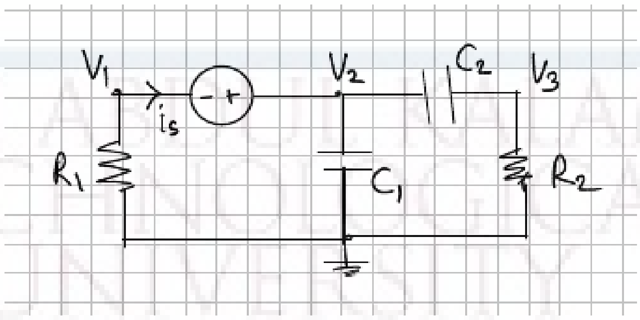


Fig. 3.

16. (a). Explain adaptive step-size in numerical simulation. What methodologies are used for adaptive step-size simulation? (10)

(b). What is 'artificial damping'? Explain with an example.

(4)

Module 4

17. (a). Explain the use of .SUBCKT with an example, where the sub-circuit is an RC integrator circuit to be used in cascade with an RC differentiating circuit. The source is a pulse source of 5 V amplitude and 1 kHz frequency. Assume suitable values for the resistors and capacitors. Use an ideal pulse with no rise time, fall-time, delay time etc. Under what conditions/circumstances do you use a .MODEL instead of a .SUBCKT in a circuit simulation? (8)

(b). Write the circuit file for an RC coupled amplifier with npn transistors. Use suitable values for the circuit parameters. The simulation is to be set up for frequency response analysis. (6).

18. (a). Shown below is a SPICE circuit file/netlist. Inspect the circuit file description and draw the circuit. What kind of simulation is being intended here? Modify this with the source replaced by a single sine wave source of 1kHz and 0.5 mA amplitude, for a transient simulation with end time of 0.1 sec, and a maximum step size of 1 us.

(8)

```
L1 OUT 0 1µ
C1 OUT 0 420p
L2 IN 0 1µ
C2 IN 0 420p
C3 OUT IN {C}
R1 OUT 0 300
I1 0 IN 0 AC 5m
```

R2 IN 0 300
.ac oct 200 5Meg 10Meg
.step param C 50p 150p 50p
.end

(b). Demonstrate the use of the SPICE directives: ".OP, .PARAM, and .IC" with suitable examples. (6).

Module 5

19. (a)Write a MATLAB function to solve an initial value problem given by: $\dot{x} = x - t^2 + 1;\ 0 \leqslant t \leqslant 2;\ x(0) = 0.5$, using the Trapezoidal method. The function should get the initial value, final value and the step through arguments. Modify this code to solve any general function described in another file, named fx.m? (8)

(b). Develop the simulation signal-flow diagram for the simulation of a parallel RLC network excited by a current source, from the fundamental equations. Use standard blocks such as gain, sum/difference, integrators etc. (6)

20. Develop a simulation (signal-flow) diagram for a DC series motor fed from a dc voltage source and connected to a mechanical load. Take k_b as the back-emf constant and k_t as the torque constant of the motor, R_a the armature resistance, L_a the armature inductance, R_f, L_f are the field resistance and inductance respectively, J is the combined moment of inertia, and B is the viscous friction constant. The simulation diagram should show how the armature current i_a and the speed ω are derived. Show all the relevant equations from which the diagram is derived. (14)

Syllabus

Module 1 (9 Hrs)

Introduction to Simulation:

Types of simulation problems - DC Simulation - Transient Simulation - AC Simulation - Digital Circuit Simulation - Sensitivity Analysis - Noise Analysis. Examples.

Problem formulation for circuit simulation:

Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix.

Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language). Formulation Examples.

Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Formulation Examples.

Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time.

Convergence issues -

Practical Limits due to finite precision. Damping.

(Assignments/Course projects may be given for writing code to formulate the Matrix using any high-level language/pseudo code).

Module 2 (7 hours)

Fundamental Theory behind Transient Simulation:

Introduction to transient simulation: Discretization of time, idea of time - step. - Review of backward Euler, forward Euler and trapezoidal methods.

Basic ideas of Accuracy and Stability (Qualitative description only) of methods of transient analysis using numerical techniques.

Basic ideas of Explicit and Implicit methods:

Concept of 'order' of a numerical method, Local Error (LE), Local Truncation Error (LTE) and Global Error. (No detailed derivations needed).

Module 3: (9 hours)

Application to Circuit Simulation:

Application to circuit simulation: Using BE and TRZ methods. - Second order Backward Difference Formula (BDF-2/Gear Formula, no derivation required). Equivalent Circuit Approach- Stiff systems - Features - Simple Examples.

Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only).

Practical aspects in choosing numerical methods: Artificial damping and ringing induced by numerical algorithms - Assessment of accuracy -- The issue of Singular Matrix in initial/start-up condition.

Module 4

Introduction to SPICE: (10 Hrs).

Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences.

Circuit Simulation using SPICE.

Writing SPICE circuit files: SPICE Syntax - SPICE directives (Dot commands: .END, .FUNC, .NET .OPTIONS)

Performing different kinds of simulation and analysis - DC, DC sweep, AC, Transient and noise analyses. (Use of .OP, .PARAM, .TRAN, .DC, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE)

Developing circuit files for simple circuits like CE amplifiers, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes, Transistors).

Developing component models, subcircuits in SPICE. (Use of .MODEL, .SUBCKT, .LIB, .INC, .ENDS directives) - examples (BJTs/MOSFETs).

Simulation Demonstration with simple circuits. Setting-up simulation , and different types of simulation etc. shall be demonstrated by the course instructor.

[LTspice®, a free SPICE version, is chosen here as reference due to wide availability, however, PSpice®, LTspice®, ngSpice, eSim or any available SPICE variants may be used for assignments/demonstrations, based on availability].

Module 5

Introduction to equation solver tools (10 Hrs)

Introduction to scripting using MATLAB®: Language constructs - Basic Arithmetic Operations - Basic Operators and Special Characters Variables and Arrays - Complex numbers -Basic Handling of Arrays (Vectors and Matrices).

Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break -return) - functions.

Numerical Integration - ODE solvers - ode23, ode23t and ode45 - Examples - User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples. (Performance comparison of different solvers may be given as assignments).

Visual Modelling: Introduction to Simulink/Similar Causal modelling tools. Developing causal simulation diagrams using fundamental blocks (Gain, sum/difference, integrators, etc) for simple circuit models - first-order/second-order circuits, Separately excited DC Motor, from the ODE descriptions. Non-linear examples: DC Series Motor, Simple passive networks with switches.

Simulation Demonstration with different integration algorithms /step-sizes. [Only for practice/assignments].

(Instead of MATLAB/Simulink®, Octave and Scilab®/XCos® may be used for assignments/demonstrations).

Text Books

1. M. B. Patil, V. Ramanarayanan and V. T. Ranganathan, "Simulation of Power Electronic Circuits", Narosa Publishing House.
2. Steven C. Chapra and Raymond P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill, New Delhi, 2000.

3. Rudra Pratap, "Getting Started with MATLAB®: A Quick Introduction for Scientists & Engineers", 2010, Oxford University Press.

References

1. LTSpice® [Online] http://www.ltwiki.org
2. MATLAB® [Online] https://in.mathworks.com/help/matlab/
3. Won Y. Yang, Wenwu Cao, Tae-Sang Chung and John Morris, "Applied Numerical Methods Using MATLAB®"

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Introduction to Simulation and Problem Formulation. (9 Hrs).**	
1.1	Types of simulation problems - DC Simulation - Transient Simulation - AC Simulation - Digital Circuit Simulation - Sensitivity Analysis - Noise Analysis. Examples.	2
1.2	Problem formulation for circuit simulation: Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language).	1
1.3	Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language). Examples.	2
1.4	Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Examples.	1
1.5	Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time.	2
1.6	Convergence issues - Limits due to finite precision. Damping.	1
2	**Fundamental Theory behind Transient Simulation: (7 Hrs).**	
2.1	Introduction to transient simulation: Discretization of time, idea of time - step. - Review of backward Euler, forward Euler and trapezoidal	1

	methods.	
2.2	Basic ideas of Accuracy and Stability of methods of transient analysis using numerical techniques.	1
2.3	Basic ideas of Explicit and Implicit methods:	1
2.4	Concept of Order of a numerical method, Local Error (LE), Local Truncation Error (LTE) and Global Error.	4
3.	**Application to Circuit Simulation (9 Hrs)**	
3.1	Application to circuit simulation: Using Backward Euler, Trapezoidal and Second order backward differentiation formula (BDF2 - Gear's formula) methods in circuit simulation: Equivalent Circuit Approach - Equation formulation examples.	4
3.2	Stiff systems - Features - Examples.	1
3.3	Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only).	1
3.4	Practical aspects in choosing numerical methods: Artificial damping and ringing induced by numerical algorithms.	1
3.5	Assessment of accuracy - The issue of Singular Matrix in initial/start-up condition.	2
4	**Introduction to SPICE: (10 Hrs)**	
4.1	Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences.	1
4.2	Circuit Simulation using SPICE. Writing SPICE circuit files: SPICE Syntax - SPICE directives (Dot commands: .end, .FUNC, .NET .OPTIONS)	2
4.3	Performing different kinds of simulation - DC, DC sweep, AC, Transient and noise analyses. (.op, .param, .tran, .dc, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE	2
4.4	Developing simple circuit files for sample circuits like CE amplifier, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes).	2
4.5	Developing component models, sub-circuits in SPICE. (.model, .subckt, .lib, .inc, .ends directives) Example problems. Using datasheets to develop component models - examples (BJTs/MOSFETs) - Exercises.	2

4.6	Simulation Demonstration with simple circuits. Setting-up simulation, and different types of simulation etc., shall be demonstrated by the course instructor. Students shall be given SPICE circuit simulation assignments. [LTspice®, a freeware SPICE version, is chosen here as reference due to wide availability, however, PSpice®, LTspice®, ngSpice or any available SPICE variants may be used for assignments/demonstrations].	1
5.	**Introduction to MATLAB®/Simulink® (10 Hrs)**	
5.1	Introduction to MATLAB® scripting. Language constructs - Basic Arithmetic Operations - Basic Operators and Special Characters - Variables and Arrays - Complex numbers - Basic Handling of Arrays (Vectors and Matrices).	2
5.2	Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break - return) - functions.	2
5.3	Numerical Integration - ODE solvers - ode23, ode23t and ode45 - Examples	1
5.4	User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples. (Performance comparison of different solvers may be given as assignments).	2
5.5	Visual Modelling: Introduction to Simulink. Developing causal simulation diagrams using fundamental blocks for simple circuit models - first-order/second-order circuits, Separately excited DC Motor, from the ODE descriptions.	2
5.6	Demonstration of simulation examples with different integration algorithms /step-sizes. [Only demonstration/practice/assignments]. (Instead of MATLAB®/Simulink®, Octave and Scilab®/XCos® may be used for assignments/demonstrations).	1

SEMESTER VI

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET302	**LINEAR CONTROL SYSTEMS**	**PCC**	**2**	**2**	**0**	**4**

Preamble: This course aims to provide a strong foundation on classical control theory. Modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach will be discussed. The compensator design of linear systems is also introduced.

Prerequisite : Basics of Circuits and Networks, Signals and Systems

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Describe the role of various control blocks and components in feedback systems.
CO 2	Analyse the time domain responses of the linear systems.
CO 3	Apply Root locus technique to assess the performance of linear systems.
CO 4	Analyse the stability of the given LTI systems.
CO 5	Analyse the frequency domain response of the given LTI systems.
CO 6	Design compensators using time domain and frequency domain techniques.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	-	-	-	-	-	-	-	-	-	1
CO 2	3	3	3	-	-	-	-	-	-	-	-	2
CO 3	3	3	3	-	2	-	-	-	-	-	-	2
CO 4	3	3	3	-	-	-	-	-	-	-	-	3
CO 5	3	3	3	-	2	-	-	-	-	-	-	3
CO 6	3	3	3	2	-	-	-	-	-	-	-	3

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	30	30	60
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. **Part B** contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Derive and explain the transfer function of AC servo motor.
2. With the help of suitable sketches explain the need for a lead compensator.
3. Explain how does the feedback element affect the performance of the closed loop system.

Course Outcome 2 (CO2):

1. Obtain the different time domain specifications for a given second order system with impulse input.
2. Determine the value of the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G_p(s) = \frac{K}{s(s+10)}$, which results in a critically damped response. Also analyse the effect of K on damping factor.
3. Problems related to static error constant and steady state error for a given input.

Course Outcome 3(CO3):

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+4)}$ is oscillatory, using Root locus.
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s\,(s^2+2\,s+2)}$? Determine the value of K to achieve a damping factor of 0.5?
3. Problems on root locus for systems with positive feedback.

Course Outcome 4 (CO4):

1. Problems related to application of Routh's stability criterion for analysing the stability of a given system.
2. Problems related to assess the stability of the given system using Bode plot.
3. Problem related to the analysis of given system using Nyquist stability criterion.

Course Outcome 5 (CO5):

1. Determine the value of K such that the gain margin for the system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+5)}$ equals to 2.

2. Determine the phase margin to assess the stability of the system with $G(s)H(s) = \frac{2}{s\,(s+1)\,(s+4)}$
3. Derive and explain the dependence of resonant peak on damping factor.

Course Outcome 6 (CO6):

1. Problems related to the design of lead compensator using Bode plot.
2. Problems related to the design of lag compensator using Root locus technique.
3. Design the parameters of an electrical lag circuit with f_1= 200 Hz and f_2= 1kHz

Model Question Paper

PAGES: 2

QPCODE:

Reg. No:____________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code**: EET302**

Course Name: **LINEAR CONTROL SYSTEMS**

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1 Give a comparison between open loop and closed loop control systems with suitable examples.

2 Derive the dependence of φ_m and α of a lead compensator and hence explain the restrictions on the selection of α?

3 For a closed loop system with $G(s) = \frac{1}{s\,(s+5)}$; and H(s) = 0.05, calculate the steady state error constants.

4 Check the stability of the system given by the characteristic equation, $G(s) = s^5 + 2s^4 + 4s^3 + 8s^2 + 16s + 32$; using Routh criterion.

5 With suitable sketches explain how the addition of poles to the open-loop transfer function affect the root locus plots.

6 Explain Ziegler – Nichol's PID tuning rules.

7 Explain the features of non-minimum phase systems with a suitable example.

8 How do you determine the gain margin of a system, with the help of Bode plot?

9 State and explain Nyquist stability criterion.

10 Discuss the procedure for Lag compensator design using Root locus technique.

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11 a) Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. **(9)**

b) Compare the effect of H(s) on the pole-zero plot of the closed loop system with $G(s) = \frac{s+3}{(s^2+3s+2)}$ with: i) derivative feed back H(s)= s; ii) integral feedback H(s)=1/s. **(5)**

12 a) Why compensation is necessary in feedback control system? What are the factors to be considered for choosing the feedback compensation? **(6)**

b) With relevant characteristics explain the operation of the following control devices. i) Synchro error detector, ii) Tachogenerator. **(8)**

Module 2

13 a) Derive an expression for the step response of a critically damped second order system? Explain the dependency of Mp on damping factor. **(9)**

b) Determine the value of K and the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G(s) = \frac{K}{s(s+10)}$, which results in a critically damped response when subjected to a unit step input.

Also determine the steady state error for unit velocity input. **(5)**

14 a) A unity feedback system is characterized by an open loop transfer function $G(s) = \frac{20}{(s^2+5s+5)}$. Determine the transient response when subjected to a unit step input and sketch the response. Evaluate the maximum overshoot and the corresponding peak time of the system. . **(9)**

b) Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s) = \frac{K}{s(s^2+20s+8)}$ is stable. . **(5)**

Module 3

15 a) Design a lag lead compensator with open loop transfer function $G(s) = \frac{K}{s(s+0.5)}$ to satisfy the following specifications (i) damping ratio of the dominant closed loop poles is 0.5 (ii) Undamped natural frequency of the dominant closed loop poles ω_n = 5 rad/sec iii) Velocity error constant K_v = 80. **(10)**

b) Compare between PI and PD controllers. **(4)**

16 a) Sketch root locus for a system with $G(s)H(s) = \frac{K(s+1)}{s(s+4)}$. Hence determine the range of K for the system stability. . **(9)**

b) With help of suitable sketches, explain how does Angle and Magnitude criteria of Root locus method help in control system design. **(5)**

Module 4

17 a) The open-loop transfer function of a unity feedback system is $G(s)=\frac{K}{s(0.5s+1)(0.04s+1)}$.Use asymptotic approach to plot the Bode diagram and determine the value of K for a gain margin of 10 dB. **(8)**

b) Compare between the polar plots for $G(s)H(s)=\frac{K}{(s+4)}$ and $G(s)H(s)=\frac{K(s-4)}{(s+4)}$. **(6)**

18 a) Draw the polar plot of an open loop transfer function $G(s)=\frac{6}{(s+1)(s+2)}$ and comment on the phase margin and gain margin. **(8)**

b) Explain the detrimental effects of transportation lag, using Bode plot. **(6)**

Module 5

19 a) Draw Nyquist plot for the system whose open loop transfer function is $G(s)H(s)=\frac{K}{s(s+2)(s+10)}$. Determine the range of K for which the closed loop system is stable. **(9)**

b) Write a short note on Nichols chart. . **(5)**

20 a) Design a phase lead compensator for a unity feedback system given by the open loop transfer function $G(s)=\frac{K}{s(S+1)}$ to meet the following specifications (i) phase margin of the system > 45 deg (ii) ess for unit ramp <1/15 (iii) gain crossover frequency must be 7.5 rad/sec. **(11)**

b) Explain the design constrains on the selection of corner frequencies of lag compensator. **(3)**

Syllabus

Module 1

Feedback Control Systems (9 hours)

Open loop and closed loop control systems- Examples of automatic control systems - Transfer function approach to feed back control systems – Effect of feedback

Control system components – Control applications of DC and AC servo motors, Tacho generator, Synchro, Gyroscope and Stepper motor

Controllers- Types of controllers & Compensators - Transfer function and basic characteristics of lag, lead and lag-lead phase compensators.

Module 2

Performance Analysis of Control Systems (9 hours)

Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of first and second order systems- Pole dominance for higher order systems.

Error analysis: Steady state error analysis and error constants -Dynamic error coefficients.

Stability Analysis: Concept of BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion- Relative stability

Module 3

Root Locus Analysis and Compensator Design (11 hours)

Root locus technique: Construction of Root locus- stability analysis- effect of addition of poles and zeroes- Effect of positive feedback systems on Root locus

Design of Compensators: Design of lag, lead and lag-lead compensators using Root locus technique.

PID controllers: PID tuning using Ziegler-Nichols methods.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for Root locus based analysis (Demo/Assignment only)

Module 4

Frequency domain analysis (9 hours)

Frequency domain specifications- correlation between time domain and frequency domain responses

Polar plot: Concepts of gain margin and phase margin- stability analysis

Bode Plot: Construction- Concepts of gain margin and phase margin- stability analysis, Effect of Transportation lag and Non-minimum phase systems.

Module 5

Nyquist stability criterion and Compensator Design using Bode Plot (9 hours)

Nyquist criterion: Nyquist plot- Stability criterion- Analysis

Introduction to Log magnitude vs. phase plot and Nichols chart (concepts only) - Compensator design using Bode plot: Design of lag, lead and lag-lead compensator using Bode plot.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for various frequency domain plots and analysis (Demo/Assignment only).

Textbooks

1. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
2. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
3. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
4. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education

Reference Books

1. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India
2. Desai M. D., Control System Components, Prentice Hall of India, 2008
3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
4. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**Feedback Control Systems (9 hours)**	
1.1	Terminology and basic structure of Open loop and Closed loop control systems- Examples of Automatic control systems (block diagram representations only)	2
1.2	Transfer function approach to feed back control systems- Effect of feedback- Characteristic equation- poles and zeroes- type and order.	2
1.3	Control system components: Transfer functions of DC and AC servo motors –Control applications of Tacho generator, Synchro, Gyroscope and Stepper motor	3
1.4	Need for controllers: Types of controllers – Feedback, Cascade and Feed forward controllers Compensators: Transfer function and basics characteristics of lag, lead, and lag-lead phase compensators	2
2	**Performance Analysis of Control Systems (9 hours)**	
2.1	Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of First order systems- Impulse and Step responses of Second order systems- Pole dominance for higher order systems	3

2.2	Error analysis: Steady state error analysis - static error coefficient of Type 0, 1, 2 systems. Dynamic error coefficients	2
2.3	Stability Analysis: Concept of stability-BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems	2
2.4	Application of Routh's stability criterion to control system analysis- Relative stability	2
3	**Root Locus Analysis and Compensator Design (11 hours)**	
3.1	Root locus technique: General rules for constructing Root loci – stability from root loci -	3
3.2	Effect of addition of poles and zeros on Root locus	1
3.3	Effect of positive feedback systems on Root locus	1
3.4	Design using Root locus: Design of lead compensator using root locus.	2
3.5	Design of lag compensator using root locus.	1
3.6	Design of lag-lead compensator using root locus	1
3.7	PID Controllers: Need for P, PI and PID controllers	1
3.8	Design of P, PI and PID controller using Ziegler-Nichols tuning method.	1
3.9	Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for Root locus based analysis (Demo/Assignment only)	
4	**Frequency domain analysis (9 hours)**	
4.1	Frequency domain specifications- correlation between time domain and frequency domain responses	2
4.2	Polar plot: Concepts of gain margin and phase margin- stability analysis	2
4.3	Bode Plot: Construction of Bode plots- gain margin and phase margin- Stability analysis based on Bode plot	4
4.4	Effect of Transportation lag and Non-minimum phase systems	1
5	**Nyquist stability criterion and Compensator Design using Bode Plot (9 hours)**	
5.1	Nyquist stability criterion: Nyquist plot- Stability criterion- Analysis	3
5.2	Introduction to Log magnitude vs. phase plot and Nichols chart	1
5.3	Design using Bode plot: Design of lead compensator using Bode plot.	2
5.4	Design of Lag compensator using Bode plot.	2
5.5	Design of Lag- lead compensator using Bode plot	1
5.6	Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for various frequency domain plots and analysis (Demo/Assignment only).	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET304	POWER SYSTEMS II	PCC	3	1	0	4

Preamble: The basic objective of this course is to deliver fundamental concepts in power system analysis. The steady state and transient analysis of electrical power system is comprehensively covered in this course ranging extensively using the conventional methods as well as advanced mathematics.

Prerequisite: EET 301 Power Systems I

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Apply the per unit scheme for any power system network and compute the fault levels.
CO 2	Analyse the voltage profile of any given power system network using iterative methods.
CO 3	Analysethe steady state and transient stability of power system networks.
CO 4	Model the control scheme of power systems.
CO 5	Schedule optimal generation scheme.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	3										2
CO 2	3	3	2									2
CO 3	3	3	2									1
CO 4	3	2										
CO 5	3	3	1								3	1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	30	30	60
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Why do we adopt per unit scheme of representation? (K2)
2. Which is the most frequent fault and which is the most severe fault? Substantiate with equation. (K2, K3)

Course Outcome 2 (CO2):

1. How is consistency followed in load flow studies? (K4)
2. How does acceleration factor improve convergence in Gauss Siedel Load flow? (K4)

Course Outcome 3 (CO3):

1. Differentiate between steady state and transient stability? (K1, K2)
2. Derive a swing equation. (K3)

Course Outcome 4 (CO4):

1. What is the significance of Inertia constant? (K3)
2. Draw the schematic representation of AGC. Show the frequency deviation pattern. (K1, K2, K3)

Course Outcome 5 (CO5):

1. What are penalty factors? Explain the significance. (K2, K3)
2. Why do we need Unit commitment? Explain with an example. (K3)

Model Question paper

QP CODE: PAGES:5

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET 304

Course Name: POWER SYSTEMS II

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. The generator neutral grounding impedance appears as 3Zn in the zero-sequence net work. Why?
2. A single-phase transformer is rated at 110/440 V, 3 KVA. Its leakage reactance measured on 110 V side is 0.05 ohm. Determine the leakage impedance referred to 440 V side.
3. What is the need of slack bus in load flow analysis?
4. A power system consists of 300 buses out of which 20 buses are generator buses and 25 buses are provided with reactive power support. All other buses are load buses. Determine the size of the Newton Raphson load flow Jacobian matrix.
5. Explain critical clearing angle and its significance with respect to the stability of a power system.
6. Explain Equal Area criterion and state the assumptions made.
7. Draw the basic block diagram of Automatic Voltage Regulator.
8. Discuss the application of SCADA in power system monitoring
9. Explain unit commitment? List out the constraints on unit commitment.
10. Write the conditions for the optimal power dispatch in a lossless system.

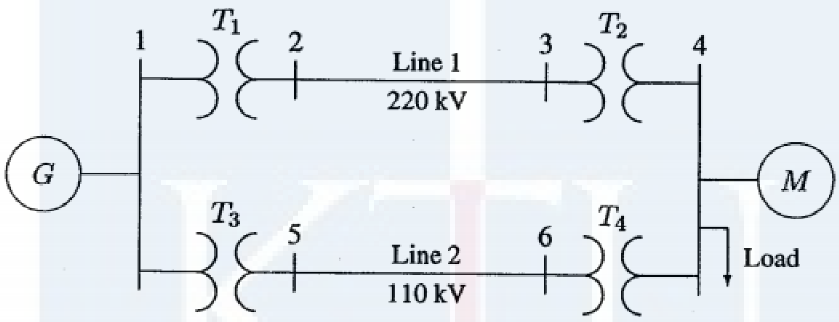
PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module I

1. a)The one-line diagram of a three phase power system is shown in figure below. Select the common base of 100 MVA and 22 kV on the generator side. Draw an impedance diagram with all impedances including the load impedance marked in per unit. The

manufacturer's data for each device is given as follows. The three phase load at bus 4 absorbs 57 MVA, .6 power factor lagging at 10.45 kV. Line1 and Line 2 have reactances of 48.4Ω and 65.43Ω, respectively.

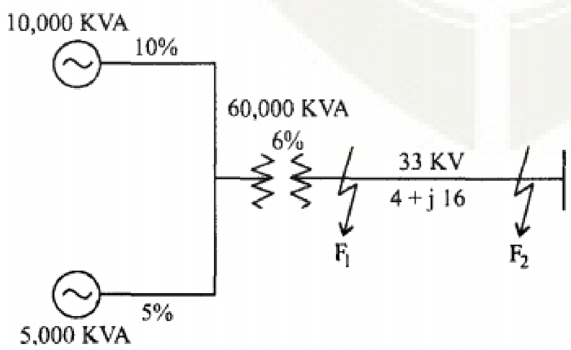
G	90 MVA	22 kV	X=18%
T_1	50 MVA	22/220 kV	X=10%
T_2	40 MVA	220/11 kV	X=6%
T_3	40 MVA	22/110 kV	X=6.4%
T_4	40 MVA	110/11 kV	X=8%
M	66.5 MVA	10.45 kV	X=18.5%



(10)

b) What are the advantages of pu system? Obtain the expression for converting the per unit impedance expressed on one base to another. **(4)**

2. a) A 33 KV line has a resistance of 4 ohm and reactance of 16 ohm respectively. The line is connected to a generating station bus bars through a 6000 KVA step up transformer which has a reactance of 6%. The station has two generators rated 10,000 KVA with 10% reactance and 5000 KVA with 5% reactance. Calculate the fault current and short circuit KVA when a 3-phase fault occurs at the HV terminals of the transformers and at the load end of the line.

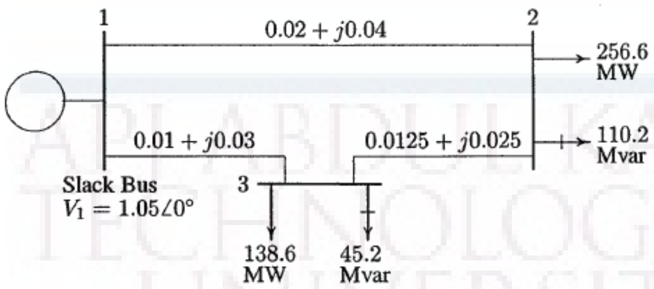


3. **(10)**

b) Explain the different types of current limiting reactors. **(4)**

Module II

4. a)For the system shown in figure obtain the load flow solution at the end of 2 iterations by Gauss Seidel method . The line impedances are marked in per unit on a 100 MVA base.



(10)

b) Explain DC load flow. **(4)**

5. Consider the three bus system shown below. Each of the three lines have aseries impedance of 0.02+j0.08 pu and a total shunt admittance of j0.02 pu. The specified quantities at the buses are tabulated below.

Bus	Real load Demand, P_D	Reactive load demand, Q_D	Real power Generation, P_G	Reactive power Generation, Q_G	Voltage specification
1	2.0	1.0	Unspecified	Unspecified	V_1 = 1.04 +j0
2	0.0	0.0	0.5	1.0	Unspecified
3	1.5	0.6	0.0	Q_{G3} = ?	$\lvert V_3 \rvert$ =1.04

Controllable reactive power source is available at bus 3 with the constraint $0 \leq Q_{G3} \leq 1.5$pu. Find the load flow solution using FDLF method (one iteration).

(14)

Module III

6. a) Starting from first principles, derive swing equation of a synchronous machine. **(6)**

b) Two generators rated at 4-pole, 50 Hz, 50 MW 0.85 p.f (lag) with moment of inertia28,000 kg-m^2 and 2-pole, 50Hz, 75 MW 0.82 p.f (lag) with moment of inertia 5,000 kg-m^2 are connected by a transmission line. Find the inertia constant of each machine and the inertia constant of single equivalent machine connected to infinite bus. Take 100 MVA base. **(8)**

7. a) A 50 Hz generator is delivering 50% of the power that it is capable of delivering through a transmission line to an infinite bus. A fault occurs that increases the reactance between the generator and the infinite bus to 500% of the value before the

fault. When the fault is isolated, the maximum power that can be delivered is 75% of the original maximum value. Determine the critical clearing angle for the condition described. **(10)**

b) Explain Equal Area criterion and state the assumptions made. **(4)**

Module IV

8. a)Two turboalternators rated for 110 MW and 210 MW have governor drop characteristics of 5 per cent from no load to full load. They are connected in parallel to share a load of 250 MW. Determine the load shared by each machine assuming free governor action. **(10)**

b) Enumerate the reasons for keeping strict limits on the system frequency variations. **(4)**

9. a) Develop and explain the block diagram of automatic load frequency control of anisolated power system. **(10)**

b) A 100 MVA synchronous generator operates on full load at a frequency of 50 Hz. Inertia constant is 8 MJ/MVA. The load is suddenly reduced 100 MW. Due to time lag in governor system, the steam valve begins to close after 0.4 seconds. Determine the change in frequency that occurs in this time. **(4)**

Module V

10. a)The fuel inputs per hour of plants 1 and 2 are given as

$F_1 = 0.2 P_1^2 + 40 P_1 + 120$ Rs. per hr

$F_2 = 0.25 P_2^2 + 30 P_2 + 150$Rs. per hr

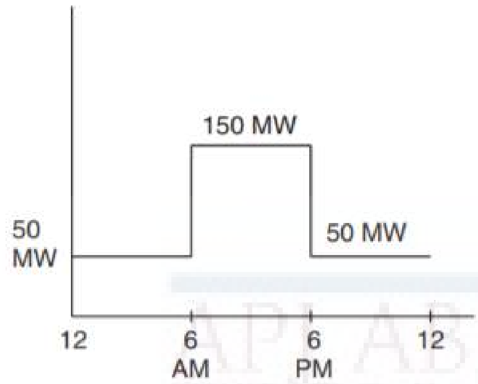
Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading on each unit is 100 MW and 25 MW, the demand is 180 MW, and transmission losses are neglected. If the load is equally shared by both the units, determine the saving obtained by loading the units as per equal incremental productioncost. **(6)**

b) Assume that the fuel input in Btu per hour for units 1 and 2 are given by

$F_1 = (8P_1 + 0.024 P_1^2 + 80)10^6$

$F2 = (6P_2 + 0.04 P_2^2 + 120)10^6$

The maximum and minimum loads on the units are 100 MW and 10 MW respectively. Determine the minimum cost of generation when the following load (as per Figure given below) is supplied. The cost of fuel is Rs. 2 per million Btu.



(8)

11. a) A 2 bus system consist of two power plants connected by a transmission line. The cost curve characteristics of the two plants are
$C_1 = 0.01P_1^2 + 16P_1 + 20$ Rs/hr
$C_2 = 0.02P_2^2 + 20P_2 + 40$ Rs/hr

When a power of 120 MW is transmitted from plant 1 to load (near to plant 2), a loss of 14 MW is occurred. Determine the optimal scheduling of plants and load demand, if cost of received power is 30 Rs./MWhr. **(10)**

b) The incremental fuel cost of two generating units G_1 and G_2 is given by $IC_1 = 25+0.2P_1$, $IC_2 = 32+0.2P_2$, where P_1 and P_2 are real powers generated by the unit. Find the economic allocation for a total load of 250 MW. Neglect the transmission losses. **(4)**

Syllabus

Module I (10 hours)

Per unit quantities-single phase and three phase- Symmetrical components- sequence networks- Fault calculations-symmetrical and unsymmetrical- Fault level of installations- Limiters - Contingency ranking.

Module II (8 hours)

Load flow studies – Introduction-types-network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson (Qualitative analysis only) and Fast Decoupled method (two iterations) - principle of DC load flow - Introduction to distribution flow.

Module III (10 hours)

Power system stability - steady state, dynamic and transient stability-power angle curve- steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Point by Point method - RK method - Equal area criterion application - methods of improving stability limits - Phasor Measurement Units- Wide Area Monitoring Systems

Module IV (10 hours)

Turbines and speed governors-Inertia-Automatic Generation Control: Load frequency control: single area and two area systems - Subsynchronous Resonance - Automatic voltage control -Exciter Control- SCADA systems

Module V (8 hours)

Economic Operation - Distribution of load between units within a plant - transmission loss as a function of plant generation - distribution of load between plants - method of computing penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.

References:

1. Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009.
3. Kundur P., *Power system Stability and Control*, McGraw Hill, 2006
4. Cotton H. and H. Barbera, Transmission & Distribution of Electrical Energy, 3/e, Hodder and Stoughton, 1978.
5. Gupta B. R., *Power System Analysis and Design*, S. Chand, New Delhi, 2006.
6. Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria& Sons, 2009.
7. Soni, M.L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, Dhanpat Rai& Sons, New Delhi, 1984.
8. John J Grainger and William D Stevenson, *Power System Analysis*, 4/e, McGraw Hill, 1994.
9. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
10. Wadhwa C. L., *Electrical Power Systems*, 33/e, New Age International, 2004.
11. Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, *Electric Power System*, John Wiley & Sons, 2012.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Module I(10 hours)**	
1.1	Per unit quantities-single phase and three phase.- -Numerical Problems	2
1.2	Symmetrical components- sequence networks-Numerical Problems	3
1.3	Fault calculations-symmetrical and unsymmetrical-Numerical Problems	3
1.4	Fault level of installations- Limiters-Numerical Problems	2
2	**Module 2(8 Hours)**	

2.1	Load flow studies – Introduction-types	1
2.2	Network model formulation and admittance matrix-Numerical Problems	2
2.3	Gauss-Siedel (two iterations) -Numerical Problems not more than three buses	1
2.4	Newton-Raphson (Qualitative analysis only)	2
2.5	Fast Decoupled method (two iterations) -Numerical Problems not more than three buses	1
2.6	Principle of DC load flow. Introduction to distribution flow.	1
3	**Module 3(10 hours)**	
3.1	Power system stability steady state, dynamic and transient stability--Numerical Problems	2
3.2	power angle curve-steady state stability limit --Numerical Problems	2
3.3	Point by Point method Equal area criterion application-Numerical Problems. RK method-(Abstract idea only)	2
3.4	Methods of improving stability limits-Numerical Problems	2
3.5	Contingency ranking-SSR-(Abstract idea only) – PMUs and Wide area monitoring systems	2
4	**Module IV (10 hours)**	
4.1	Turbines and speed governors-inertia.	2
4.2	Automatic Generation Control: Load frequency control: single area and two area systems-Numerical Problems	3
4.3	Automatic voltage control -Exciter Control.	2
4.4	SCADA systems--(Abstract idea only)	1
4.5	Phasor Measurement Unit- Wide Area Monitoring Systems-(Abstract idea only)	2
5	**Module V (8 hours)**	
5.1	Economic Operation Distribution of load between units within a plant transmission loss as a function of plant generation distribution of load between plants-Numerical Problems	3
5.2	Method of computing penalty factors and loss coefficients-Numerical Problems	2

5.3	Unit commitment: Introduction — Constraints on unit commitments: Spinning reserve, Thermal unit constraints- Hydro constraints- Numerical Problems.	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET306	POWER ELECTRONICS	PCC	3	1	0	4

Preamble: To impart knowledge about the power semiconductor devices, the operation of various power converters and its applications.

Prerequisite: Basics of Electrical Engineering / Introduction to Electrical Engineering/ Basics of Electronics Engineering

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Explain the operation of modern power semiconductor devices and its characteristics.
CO 2	Analyse the working of controlled rectifiers.
CO 3	Explain the working of AC voltage controllers, inverters and PWM techniques.
CO 4	Compare the performance of different dc-dc converters.
CO 5	Describe basic drive schemes for ac and dc motors.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	-	1	-	-	-	-	-	-	-	-
CO 2	3	2	1	2	-	-	-	-	-	-	-	2
CO 3	3	3	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	2	2	-	-	-	-	-	-	-	2
CO 5	3	2	-	-	-	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	20	20	30
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the working and switching characteristics of SCR, MOSFET, IGBT (K1)
2. Give a brief description on wide band-gap power devices (K1)
3. Draw and explain the switching characteristics of SCR (K1, K2)
4. Discuss the protection circuits for SCR (K2)
5. Explain different types of isolation in gate drive for power converter circuits (K1, K2)

Course Outcome 2 (CO2):

1. Describe the working with waveforms of single phase half wave rectifiers for different firing angles. (K1)
2. Describe the working with waveforms of single phase fully controlled rectifiers for different firing angles and loads.(K2)
3. Describe the working with waveforms of single phase half controlled rectifiers for different firing angles and loads.(K2)
4. Describe the working with waveforms of three phase rectifiers fordifferent firing angles and loads. (K2)
5. Problems in finding the average output voltage of rectifier. (K2, K3)

Course Outcome 3 (CO3):

1. Explain the working of ACVC with R and RL loads. (K1)
2. Explain single phase inverter for R and RL loads, problems in finding the output voltage, THD of inverter. (K2, K3)
3. Explain 3 phase mode 120^0 and 180^0 conduction modes. (K4)
4. Explain single phase current source inverter PWM Inverter. (K1)
5. Explain single pulse PWM, multiple pulse,and sinusoidalPWM technique (K1, K2)

Course Outcome 4 (CO4):

1. Explain the working of step up and step down converters. (K1, K2)
2. Problems related to step up and step down converters. (K2, K3)
3. Analyse the working of Buck, Boost & Buck Boost regulators. (K3, K4)
4. Design the value of filter inductor & capacitance in regulators. (K3, K4)
5. Problems in Buck, Boost & Buck Boost regulators. (K2, K3)

Course Outcome 5 (CO5):

1. Explain the block diagram of an electric drive (K1,K2)
2. Explain the working of single phase rectifier fed DC drive (K2, K3)
3. Explain the chopper controller DC drive (K2,K3)
4. Explain the four quadrant operation of a DC drive (K2, K3)
5. Explain the v/f control of Induction motor drive (K3,K4)

Model Question paper

QP CODE:

PAGES:2

Reg.No:_______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET 306

Course Name: POWER ELECTRONICS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain different turn on methods of SCR.
2. Describe the reverse recovery characteristics of a power diode.
3. Draw the input and output voltage waveforms of single phase half controlled rectifier feeding RL load in continuous and discontinuous conduction mode.
4. Explain with neat sketches, the input and output voltage waveforms of 3ø half controlled rectifier with R load for a firing angle of 30^0.
5. Compare voltage source and current source inverters.
6. Explain the terms modulation index and frequency modulation ratio related to pulse width modulation.
7. Explain time ratio control method to vary the output voltage in choppers.
8. Derive the expression for output voltage of a Buck Converter.
9. What are the advantages of electric drives?
10. Explain regenerative braking control in drives.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) Explain the two transistor analogy of SCR. **(6)**

b) Compare the switching characteristics of IGBT. **(8)**

12. a) Explain the structural details of MOSFET. **(8)**

b) Write short note on wideband gap devices. **(6)**

Module 2

13. a) Explain the operation of single phase full wave controlled rectifier without freewheeling diode, when feeding RL load. **(10)**

b) Write short notes on pulse transformer. **(4)**

14. a)The full-wave controlled bridge rectifier has an AC input of 220 V rms at 50 Hz and a 20 ohmload resistor. The delay angle is 40^0. Determine the average current in the load, the power absorbed by the load, and the source volt-amperes. **(7)**

b) Draw the circuit of 3 phase fully controlled rectifier with RLE load and explain the working for $\alpha=60^0$ with necessary waveforms. Derive the expression for output voltage. **(7)**

Module 3

15. a) Explain the 120^0 conduction mode of a three-phase bridge inverter with output voltage waveforms, indicating the devices conducting in each state. **(10)**

b) Write short notes of THD. **(4)**

16. a) Explain sinusoidal PWM technique for varying the magnitude of output voltage in a single-phase inverter . **(6)**

b) Briefly explain current source inverter **(8)**

Module 4

17. a) Explain the working of a Buck-Boost regulator, showing relevant waveforms and derive the expression for its output voltage. **(8)**

b) Design a DC-DC Converter with 12 V input and 200 V output at upto 50 W. The ripple in the output voltage and input current should not exceed +- 5% and +- 20% respectively. Select suitable device and switching frequency. **(6)**

18. a) Describe the working of four quadrant chopper in all the four quadrants with relevant circuit diagrams. **(10)**

b) Briefly explain the current limit control in dc-dc converter **(4)**

Module 5

19. a) Explain the working of a single phase full converter drive **(8)**
b) Explain the working of a four quadrant chopper drive **(6)**

20. a) Explain the stator voltage control for Induction motor drive **(8)**
b) Explain the working of v/f control of Induction motor drive **(6)**

Syllabus

Module 1 - 11 hrs

Introduction to Power Electronics-Scope and applications-power electronics vs signal electronics (1 hr)
Structure and principle of operation ofpower devices- Power diode, Power MOSFET & IGBT – switching characteristics - comparison. Basic principles of wideband gap devices- SiC, GaN (4 hrs)
SCR- Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt& dv/dt protection – Turn-on methods of SCR - Two transistor analogy (5 hr)

Gate triggering circuits – Requirements of isolation and synchronization in gate drive circuits- Opto and pulse transformer based isolation (1hr)

Module 2 - 9 hrs

Controlled Rectifiers (Single Phase) – Half-wave controlled rectifier with R load– Fully controlled and half controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – Output voltage equation- related simple problems(5 hrs)

Controlled Rectifiers (3-Phase) - 3-phase half-wave controlled rectifier with R load – Fully controlled & half-controlled bridge converter with RLE load (continuous conduction, ripple free) – Output voltage equation-Waveforms for various triggering angles (detailed mathematical analysis not required) (4 hrs)

Module 3 - 9 hrs

AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R, & RL loads – Waveforms – RMS output voltage, Input power factor with R load (2 hrs)

Inverters – Voltage Source Inverters– 1-phase half-bridge & full bridge inverter with R and RL loads – THD in output voltage – 3-phase bridge inverter with R load – 120° and 180° conduction modes– Current Source Inverters-1-phase capacitor commutated CSI.(5 hrs)

Voltage control in 1-phase inverters – Pulse width modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM (unipolar & bipolar modulation) – Modulation Index - Frequency modulation ratio.(2 hrs)

Module 4 - 8 hrs

DC-DC converters – Step down and Step up choppers – Single-quadrant, Two-quadrant and Four quadrant chopper – Pulse width modulation & current limit control in dc-dc converters. (4 hrs)
Switching regulators – Buck, Boost & Buck-boost –Operation with continuous conduction mode – Waveforms – Design of Power circuits (switch selection, filter inductance and capacitance) (4 hrs)

Module 5 - 11 hrs

Electric Drive: Introduction to electric drives – Block diagram – advantages of electric drives- types of load – classification of load torque (2 hrs)

DC Drives: Single phase semi converter and single phase fully controlled converter drives. Dual Converters for Speed control of DC motor-1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation. Chopper controlled DC drives- Single quadrant chopper drives- Regenerative braking control- Two quadrant chopper drives- Four quadrant chopper drives(6 hrs)

AC Drives: Three phase induction motor speed control. Stator voltage control – stator frequency control - Stator voltage and frequency control (v/f) (3 hrs)

(It is expected to emphasize the ease of independent control of field flux and armature flux in SEDC motor and relate the same with Induction motor)

Text Books

1. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education
2. Daniel W. Hart, Power Electronics, Tata McGraw-Hill Education
3. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi

References:

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters,

Applications & Design, Wiley-India
2. Fundamentals of Power Electronics, Erickson, Robert W., and Maksimovic, Dragan.
3. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
4. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India
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6. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw-Hill College; International edition ,1995
7. Application notes on SiC and GaN, www.infineon.com. [online]
8. Evolution of wide Band-gap Semi-conductors for power devices expanding field of applications. Technical review, Vol 4, Toshiba Corporation, 2018
9. Milligan, J. W., Sheppard, S., Pribble, W., Wu, Y.-F., Muller, G., &Palmour, J. W. (2007). SiC and GaN Wide Bandgap Device Technology Overview, 2007 IEEE Radar Conference. doi:10.1109/radar.2007.374395.
10. Vedam Subramaniam "Electric drives (concepts and applications)", Tata McGraw-Hill, 2001.
11. G. K. Dubey, Fundamentals of Electric Drives, Narosa publishers, second edition, 2010.

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Power Devices (11 hours)**	
1.1	Introduction to Power Electronics: Scope and applications-power electronics vs signal electronics.	1
1.2	Structure, principle of operation, switching characteristics of Power Devices- Power Diode, Power MOSFET & IGBT – Comparison	3
1.3	Basic principles of wideband gap devices-SiC, GaN	1
1.4	SCR- Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt& dv/dt protection – Turn-on methods of SCR - Two transistor analogy	5
1.5	Requirements of isolation and synchronization in gate drive circuits- Opto and pulse transformer based isolation	1
2	**Single phase and three phase controlled rectifiers (9 hours)**	
2.1	Half-wave controlled rectifier with R load	2
2.2	1-phase fully controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – Output voltage equation	2
2.3	1-phase half controlled bridge rectifier with R, RL and RLE loads	1
2.4	3-phase half-wave controlled rectifier with R load	2
2.5	3-phase fully controlled & half-controlled converter with RLE load (continuous conduction, ripple free) – Output voltage equation.	2

3	**Inverters and Voltage control in single phase inverters (9 Hours)**	
3.1	Applications of AC-AC converters – Single phase full-wave AC voltage controllers with R, & RL loads- Waveforms	1
3.2	RMS output voltage, Input power factor with R load	1
3.3	Voltage Source Inverters– 1-phase Half-bridge & Full bridge inverter with R and RL loads– THD in output voltage	2
3.4	3-phase bridge inverter with R load – 120° and 180° conduction modes	2
3.5	Current Source Inverters-1-phase capacitor commutated CSI.	1
3.6	Pulse Width Modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM (bipolar modulation) – Modulation Index - Frequency modulation ratio.	2
4	**DC-DC converters (8 Hours)**	
4.1	Step down and Step up choppers – Single-quadrant chopper	2
4.2	Two-quadrant and Four-quadrant chopper – Pulse width modulation &current limit control in dc-dc converters.	2
4.3	Buck, Boost & Buck-boost –Operation with continuous conduction mode – Waveforms	3
4.4	Design of Power circuits (switch selection, filter inductance and capacitance)	1
5	**Electric drives (11 Hours)**	
5.1	Electric Drive: Introduction to electric drives – Block diagram – advantages of electric drives- types of load – classification of load torque	2
5.2	DC Drives: Single phase semi converter and single phase fully controlled converter drives. Dual Converters for Speed control of DC motor-1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation.	3
5.3	Chopper controlled DC drives. Single quadrant chopper drives. Regenerative braking control. Two quadrant chopper drives. Four quadrant chopper drives	3
5.4	AC Drives: Three phase induction motor speed control. Stator voltage control – stator frequency control - Stator voltage and frequency control (v/f) (3 hrs)	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET308	COMPREHENSIVE COURSE WORK	PCC	1	0	0	1

Preamble: The objective of this Course work is to ensure the comprehensive knowledge of each student in the most fundamental Program core courses in the curriculum. Five core courses credited from Semesters 3, 4 and 5 are chosen for the detailed study in this course work. This course has an End Semester Objective Test conducted by the University for 50 marks. One hour is assigned per week for this course for conducting mock tests of objective nature in all the listed five courses.

Prerequisite:
1. EET 201 Circuits and Networks
2. EET 202 DC Machines and Transformers
3. EET 206 Digital Electronics
4. EET 301 Power Systems I
5. EET 305 Signals and Systems

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply the knowledge of circuit theorems to solve the problems in electrical networks
CO 2	Evaluate the performance of DC machines and Transformers under different loading conditions
CO 3	Identify appropriate digital components to realise any combinational or sequential logic.
CO 4	Apply the knowledge of Power generation, transmission and distribution to select appropriate components for power system operation.
CO 5	Apply appropriate mathematical concepts to analyse continuous time and discrete time signals and systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3										2
CO2	3	2										2
CO3	3	3	1		1							2
CO4	3	3				1	1	1			1	2
CO5	3	3	1		1							2

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	20
Apply	20
Analyse	
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
50	0	50	1 hour

End Semester Examination Pattern: Objective Questions with multiple choice (Four). Question paper include Fifty Questions of One mark each covering the five identified courses.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A circuit with resistor, inductor and capacitor in series is resonant at f_0 Hz. If all the component values are now doubled, the new resonant frequency is

a) 2 f_0
b) Still f_0
c) f_0 /2
d) f_0 /4

2. The line A to neutral voltage is $10<15^0$ V for a balance three phase star connected load with phase sequence ABC. The voltage of line B with respect to line C is given by

a) $10\sqrt{3}<105^0$ V
b) $10<105^0$ V
c) $10\sqrt{3}<75^0$ V
d) $-10\sqrt{3}<90^0$ V

3. The average power delivered to an impedance (4-j3)Ω by a current $5\cos(100\pi t+100)$A is

a) 44.2 W
b) 50 W
c) 62.5 W
d) 125 W

Course Outcome 2 (CO2)

1. The DC motor which can provide zero speed regulation at full load without any controller is

a) Series
b) Shunt
c) Cumulatively compound
d) Differentially compound

2. For a single phase, two winding transformer, the supply frequency and voltage are both increased by 10%. The percentage changes in the hysteresis and eddy current loss, respectively are

a) 10 and 21
b) -10 and 21
c) 21 and 10
d) -21 and 10

3. Match the following

List I-Performance Variables	List II-Proportional to
A. Armature emf (E)	1. Flux (ϕ), speed (ω), Armature Current(Ia)
B. Developed Torque (T)	2. ϕ and ω only
C. Developed Power (P)	3. ϕ and Ia only
	4. Ia and ω only
	5. Ia only

Choices:

	A	B	C
a)	3	3	1
b)	2	5	4
c)	3	5	4
d)	2	3	1

Course Outcome 3(CO3):

1. The SOP (sum of products) form of a Boolean function is ∑(0, 1, 3, 7, 11), where inputs are A, B, C, D (A is MSB and D is LSB). The equivalent minimized expression of the function is

a) (B'+C)(A'+C)(A'+B')(C'+D)
b) (B'+C)(A'+C)(A'+C')(C'+D)
c) (B'+C)(A'+C)(A'+C')(C'+D')
d) (B'+C)(A+B')(A'+B')(C'+D)

2. A cascade of three identical modulo-5 counters has an overall modulus of

a) 5
b) 25
c) 125
d) 625

3. The octal equivalent of the HEX number AB.CD is

a) 253.314
b) 253.632
c) 526.314
d) 526.632

Course Outcome 4 (CO4):

1. Corona losses are minimized when

a) Conductor size is reduced
b) Smoothness of the conductor is reduced
c) Sharp points are provided in the line hardware
d) Current density in the conductors is reduced

2. Keeping in view the cost and overall effectiveness, the following Circuit Breaker is best suited for capacitor bank switching

a) Vacuum
b) Air Blast
c) SF_6
d) Oil

3. The horizontally placed conductors of a single phase line operating at 50Hz are having outside diameter of 1.6cm and the spacing between centres of the conductors is 6m. The permittivity of free space is 8.854×10^{-12} F/m. The capacitance to ground per kilometre of each line is

a) 4.2×10^{-9} F

b) 4.2×10^{-12} F
c) 8.4×10^{-9} F
d) 8.4×10^{-12} F

Course Outcome 5 (CO5):

1. Consider a continuous time system with input x(t) and output y(t) given by y(t)=x(t)cos(t). This system is

a) Linear and time invariant
b) Non-linear and time invariant
c) Linear and time varying
d) Non-linear time varying

2. Signal Flow Graph is used to obtain

a) Stability of the system
b) Transfer Function of a system
c) Controllability of a system
d) Observability of a system

3. The steady state error due to a step input for Type 1 system is

a) Zero
b) Infinity
c) 1
d) 0.5

Syllabus

Full Syllabus of all Five selected Courses.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Circuits and Networks**	
1.1	Mock Test on Module 1 and Module 2	**1**
1.2	Mock Test on Module 3, Module 4 and Module 5	**1**
1.3	Feedback and Remedial	**1**
2	**DC Machines and Transformers**	
2.1	Mock Test on Module 1, Module 2 and Module 3	**1**
2.2	Mock Test on Module 4 and Module 5	**1**
2.3	Feedback and Remedial	**1**
3	**Digital Electronics**	
3.1	Mock Test on Module 1 and Module 2	**1**
3.2	Mock Test on Module 3, Module 4 and Module 5	**1**

3.3	Feedback and Remedial	**1**
4	**Power Systems I**	
4.1	Mock Test on Module 1, Module 2 and Module 3	**1**
4.2	Mock Test on Module 4 and Module 5	**1**
4.3	Mock Test on Module 1, Module 2 and Module 3	**1**
5	**Signals and Systems**	
5.1	Mock Test on Module 1, Module 2 and Module 3	**1**
5.2	Mock Test on Module 4 and Module 5	**1**
5.3	Feedback and Remedial	**1**

CODE	COURSE	CATEGORY	L	T	P	CREDIT
EEL332	POWER SYSTEMS LAB	PCC	0	0	3	2

Preamble : This Laboratory Course will provide a perfect platform for the students to do hands-on practise with hardware and software in Power Systems. The experiments include simulation of power system analysis in steady state and transient state. The Hardware experiments cover Protective Relaying and High Voltage Testing. Successful completion of this lab will certainly make the students equipped for any Power Industry.

Prerequisite : EET301Power Systems I

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Develop mathematical models and conduct steady state and transient analysis of power system networks using standard software.
CO 2	Develop a frequency domain model of power system networks and conduct the stability analysis.
CO 3	Conduct appropriate tests for any power system component as per standards.
CO 4	Conduct site inspection and evaluate performance ratio of solar power plant.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	3	3			3	2	3		3
CO 2	3	2	1	3	3			1	2	3		2
CO 3	3	1	1	3	3	3	1	3	3	3		3
CO 4	3	1	1	3	3	3	3	3	3	3	2	3

ASSESSMENT PATTERN:

Mark distribution :

Total Marks	CIE	ESE	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	Regular Lab work	Internal Test	Course Project	Total
15	30	25	5	75

Internal Test Evaluation (Immediately before the second series test)

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:

(a) Preliminary work (Type of Test, circuit diagram and diagram for simulation): 15 Marks
(b) Simulation in software and Conducting the experiment (Procedure) : 10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting): 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions : Practical examination to be conducted immediately after the second series test covering the entire syllabus given. Each student has to do both software and hardware parts for the examination. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS:

Part A: POWER SYSTEM SIMULATION EXPERIMENTS

1. Y-Bus Formulation(Basic Programming): Effect of change in topology
2. Transmission Line Modelling (Basic Programming): ABCD constants
3. Load Flow Analysis –Gauss-Siedel Method, Newton-Raphson Method,Fast Decoupled Method – Effect of change in load/generation schedule
4. Load Flow Analysis –Gauss-Siedel Method, Newton-Raphson Method,Fast Decoupled Method – Effect of change in real power/reactive power limits
5. Short Circuit Analysis – Symmetrical Faults and Unsymmetrical Faults
6. Contingency Ranking
7. Transient Stability Analysis
8. Automatic Generation Control – Single Area, Two Area
9. Distribution Systems with Solar PV units
10. Reactive Power Control.
11. Ferranti Effect and Reactive Power Compensation.
12. Plot the IV characteristics of a PV module and determine Maximum Power Point.

Part B: POWER SYSTEM COMPONENT TESTING (Hardware experiments)

1. High voltage testing -Power frequency/Impulse
2. High voltage testing -DC
3. Smart metering
4. Relay Testing - Over current relay /Earth fault(Electromechanical/Static/Numerical)
5. Relay Testing –Voltage relay/ Impedance Relay (Electromechanical/Static/Numerical)
6. Insulation Testing – LT & HT Cable
7. Earth Resistance
8. Testing of CT and PT
9. Testing of transformer oil
10. Testing of dielectric strength of solid insulating materials
11. Testing of dielectric strength of air
12. Power factor improvement

Instructions:

Both software and hardware experiments are included. **At least 12 experiments (4 hardware experiments are mandatory) and one Mini Project.** Any additional experiment can be treated as Beyond the Syllabus. **Students have to do software simulation and a hardware testing for the End semester examination.**

Mandatory Course Project:

Design a solar power plant (rooftop or ground mounted).Conduct site inspection and feasibility study. Design the components to be used and calculate the performance ratio. Prepare a concise project report giving justifications to the choices made and the economic analysis.

Students have to do a mandatory course project (group size not more than 4 students-individual may be preferred).A report isalso to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Reference Books:

1. HadiSaadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. Kothari D. P. and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009
3. M. S. Naidu, V. Kamaraju, *High Voltage Engineering*, Tata McGraw-Hill Education, 2004
4. Wadhwa C. L., *Electrical Power Systems*, 3/e, New Age International, 2009.
5. IEC 61850.
6. IEEE 1547 and 2030 Standards.
7. IS Codes for Testing of Power System components.
8. IEC 61724-1:2017Performance of Solar Power Plants.

CODE	COURSE	CATEGORY	L	T	P	CREDIT
EEL334	POWER ELECTRONICS LAB	PCC	0	0	3	2

Preamble : Impart practical knowledge for the design and setup of different power electronic converters and its application for motor control.

Prerequisite : Power Electronics (EET306)

Course Outcomes : After the completion of the course the student will be able to

CO 1	Determine the characteristics of SCR and design triggering circuits for SCR based circuits.
CO 2	Design, set up and analyse single phase AC voltage controllers.
CO 3	Design, set up and test suitable gate drives for MOSFET/IGBT.
CO 4	Design, set up and test basic inverter topologies.
CO 5	Design and set up dc-dc converters.
CO 6	Develop simulation models of dc-dc converters, rectifiers and inverters using modern simulation tools.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2	2	-	-	-	3	2	-	3
CO 2	3	3	2	2	2	-	-	-	3	2	-	3
CO 3	3	3	2	2	2	-	-	-	3	2	-	3
CO 4	3	3	2	2	2	-	-	-	3	2	-	3
CO 5	3	3	2	2	2	-	-	-	3	2	-	3
CO 6	3	3	2	2	3	-	-	-	3	2	-	3

ASSESSMENT PATTERN:

Mark distribution:

Total Marks	CIE marks	ESE marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	Regular Lab work	Internal Test	Course Project	Total
15	30	25	5	**75**

Internal Test Evaluation (Immediately before the second series test

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding award of marks:

a) Preliminary Work : 15Marks

b) Implementing the work/Conducting the experiment : 10Marks

c) Performance, result and inference (usage of equipments and troubleshooting) : 25Marks

d) Viva voce : 20marks

e) Record : 5Marks

General instructions : Practical examination is to be conducted immediately after the second series test after conducting 12 experiments from the list of experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS:
(12 experiments are mandatory)

HARDWARE EXPERIMENTS: (A minimum of 8 experiments are mandatory)

1. Static characteristics of SCR

Aim: To determine the minimum gate current & gate voltage required to trigger the SCR also to measure the latching current, holding current and to plot the static characteristics of SCR

2. R and RC firing scheme for SCR control

Aim: To design and set up a half wave controlled rectifier with R and RC firing circuits and plot voltage waveform across the load and thyristor for different firing angles.Also determine the minimum and maximum firing angles of this circuit.

3. Line Synchronised Triggering Circuits of SCR

Aim: To design and set-up line synchronized Ramp Trigger and Digital Trigger circuits of SCR and observe the waveforms

4. AC Voltage Controller

Aim: To study the single phase AC voltage controller using TRIAC/SCRs. Set-up a single phase AC voltage controller & observe waveforms across load resistance for different firing angles.

5. Gate Driver Circuits for MOSFET/IGBT

Aim: To design and test a gate driver circuit for triggering half bridge inverter using MOSFET / IGBT using industry-standard MOSFET drive ICs/Circuits. To test the driving of floating and ground-referenced configurations.

6. Single Phase fully Controlled SCR bridge rectifier

Aim: To design and set up a single phase full converter with RL/RLE loads and observethe waveforms with and without freewheeling diode.

7. Design of Inductor/Transformer

Aim: To design and fabricate an inductor/transformer to be used in power electronic circuits.

8. Design and set-up buck/ boost / buck-boost converters

Aim: To design and set up the buck/boost/buck-boost converter and analyse the characteristics of the same.

9. Switching characteristics of MOSFET

Aim: To study and understand the switching characteristics of a power MOSFET.

10. Single-phase half bridge/full bridge inverter using power MOSFET/IGBT

Aim: To design and set up a single phase half-bridge/full-bridge inverter and observe the waveforms across load and firing pulses.

11. Single-phase sine PWM inverter with LC filter

Aim: To design and set up a single phase sine PWM inverter with LC filter using microcontroller

12. Three phase sine PWM Inverter using IGBT

Aim: To set up a 3-phase PWM Inverter with RL load and observe the waveforms

13. Speed control of DC motor using chopper

Aim: To Control the speed of a DC motor using a step-down chopper

14. Speed control of 3-phase induction motor

Aim: To Control the speed of a 3-phase induction motor using V/f control method.

SIMULATION EXPERIMENTS: (A minimum of 4 experiments are mandatory)

15. Simulation of 1-phase fully-controlled and half-controlled rectifier fed separately excited DC motor

Aim: To simulate 1-phase fully-controlled and half-controlled rectifier fed Separately Excited DC motor and observe the speed, torque, armature current, armature voltage, source current waveforms and find the THD in source current and input power factor.

16. Simulation of Dual Converter – 4 quadrant operation of separately excited DC motor

Aim: To simulate a dual converter for a separately excited DC motor and to understand the four quadrant operation

17. Simulation of buck/boost/buck-boost converters

Aim: To simulate a buck, boost and buck boost converter using MATLAB/equivalent or any other simulation platform and analyse the performance under various duty ratio/ switching frequency.

18. Simulation of single phase & three phase sine PWM inverters.

Aim: To simulate a single phase and three phase sine PWM inverter using MATLAB/equivalent

19. Simulation of 3-phase fully-controlled converter with R, RL, RLE loads

Aim: To simulate a 3-phase fully controlled converter with R,RL and RLE loads and observe the waveform in MATLAB simulink/equivalent.

20. Comparative study of PWM and Square wave inverters.

Aim:-To analyse THD, fundamental component of output voltage in PWM and Square wave inverters (single phase) using MATLAB/equivalent.

Mandatory Group Project Work : Students have to do a mandatory micro project (group size not more than 5 students) preferably a simulation work. A report also is to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Reference Books:

1. L. Umanand: Power Electronics – Essentials & Applications, Wiley-India
2. Mohan, Undeland, Robbins: Power Electronics, Converters, Applications & Design, Wiley-India
3. Muhammad H. Rashid: Power Electronics Circuits, Devices and Applications, Pearson Education
4. Ned Mohan A: "First course on power electronics and drives", MNPERE, 2003 Edn.

SEMESTER VI

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET312	BIOMEDICAL INSTRUMENTATION	PEC	2	1	0	3

Preamble :**Nil**

Prerequisite :**Measurements and Instrumentation**

Course Outcomes **:** After the completion of the course, the student will be able to:

CO 1	Explain the basics of anatomy and physiology of human body.
CO 2	Explain different techniques for the measurement of various physiological parameters.
CO 3	Describe modern imaging techniques for medical diagnosis
CO 4	Identify the various therapeutic equipments used in biomedical field
CO 5	Discuss the patient safety measures and recent advancements in medical field.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	-	-	-	-	2	-	-	-	-	-	-
CO 2	2	-	2	-	-	2	-	-	-	-	-	-
CO 3	2	-	2	-	-	2	-	-	-	-	2	-
CO 4	2	2	-	-	-	2	-	-	-	-	2	-
CO 5	2	2	2	-	-	2	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	15	15	30
Understand	20	20	40
Apply	15	15	30
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A**contain 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions.

Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the anatomy of heart and cardiac system.
2. Describe the physiology of respiratory system.
3. Discuss the generation and propagation of action potential with neat sketches.
4. Explain electrode theory and Nernst equation.
5. Draw and explain the equivalent circuit of skin electrode interface.
6. Discuss about surface electrodes.
7. What are the applications of needle electrodes?
8. What are microelectrodes?
9. What are the different bioelectrical potentials generated in human body?

Course Outcome 2 (CO2):

1. What are the problems encountered in measuring living systems?
2. Explain the direct method of blood pressure measurement.
3. Explain the indirect method of blood pressure measurement.
4. Explain the Oscillometric method of blood pressure measurement.
5. Explain the Ultrasonic method of blood pressure measurement.
6. Explain the method of blood flow measurement using electromagnetic blood flowmeter.
7. Explain the method of blood flow measurement using Ultrasonic blood flowmeter.
8. Explain the measurement of Cardiac output.
9. What is phonocardiography?
10. Explain the measurement of respiratory parameters using spirometer.

Course Outcome 3(CO3):

1. Explain ECG with a neat block diagram.
2. What is Einthoven triangle?
3. With neat sketches explain the different electrode placement schemes of ECG.
4. Explain the 10-20 system of EEG electrodes placement.
5. Draw and explain the block diagram of EEG machine.
6. Draw and explain the block diagram of EMG recorder.
7. What are the applications of EEG waveforms?
8. Draw the different EEG waveforms and state its frequency.

Course Outcome 4 (CO4):

1. Explain the generation of X-rays and also mention its applications in biomedical engineering.
2. What are the types of CAT scanning?
3. Explain the principle of MRI scanning.
4. Explain the principle of PET scanning.
5. Explain demand pacemaker with a neat block diagram.
6. Why a dual peak DC defibrillator preferred over DC defibrillator?

7. Explain artificial kidney with neat sketches.
8. Explain shortwave diathermy.
9. Explain microwave diathermy.

Course Outcome 5 (CO5):

1. Discuss the need for ventilators.
2. Draw and explain the block diagram of infant incubator.
3. Explain lithotripsy.
4. What is a heart lung machine?
5. What are the different methods of accident prevention in hospitals?
6. Differentiate between macro shock and micro shock.
7. Explain the physiological effects of electric current.
8. Draw the block diagram of a telemetry system.
9. What are the chemical blood tests carried out in a clinical laboratory?
10. Enumerate the application of robotics in medical field.

Model Question paper
QP CODE:

PAGES: 2

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET312

Course Name: Biomedical Instrumentation

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. What are Microelectrodes?
2. What are the different bioelectrical potentials generated in human body?
3. Explain the measurement of Cardiac output.
4. What is Phonocardiography?
5. What are the applications of EEG waveforms?
6. Explain the 10-20 system of EEG electrodes placement.
7. What are the types of CAT scanning?
8. Explain the principle of MRI scanning.
9. What are the different methods of accident prevention in hospitals?
10. Discuss the need for ventilators.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) Discuss the generation and propagation of action potential with neat sketches. **(8)**

    b) Draw and explain the equivalent circuit of skin electrode interface. **(6)**

12. a) Briefly explain different Bio potential electrodes. **(10)**

    b) Discuss about surface electrodes. **(4)**

Module 2

13. a) Explain the Ultrasonic method of blood pressure measurement. **(7)**

    b) Explain the method of blood flow measurement using electromagnetic blood flow meter **(7)**

14. a) Explain the direct method of blood pressure measurement. **(7)**

    b) Explain the measurement of respiratory parameters using Spirometer **(7)**

Module 3

15. a) Draw and explain the block diagram of EEG machine. **(8)**

    b) Explain the significance of Einthoven triangle. **(6)**

16. a)Draw the different EEG waveforms and state its frequency **(7)**

    b) Explain ECG with a neat block diagram **(7)**

Module 4

17. a)Explain the generation of X-rays and also mention its applications in biomedical engineering. **(14)**

18. a)Explain the principle of CAT scanning **(7)**

    b) Explain the principle of MRI scanning **(7)**

Module 5

19. a) Draw the block diagram of infant incubator and explain **(10)**

    b) Write a note on medical robotics **(4)**

20. a) What are the chemical blood tests carried out in a clinical laboratory **(10)**

    b) Explain artificial kidney with neat sketches **(4)**

Syllabus

Module 1

Human Physiological systems:Brief discussion of Heart andCardio-vascular system- Physiology of Respiratory system - Anatomy of Nervous and Muscular systems-Problems encountered in measuring living systems

Bioelectric potential: Resting and action potential - Generation and propagation - Bioelectric potentials associated with physiology systems (ECG, EEG and EMG).

Bio potential Electrodes: Theory – Surface electrode – Microelectrode-Needle electrodes.

Transducers for biomedical applications: Transducers for the measurement of pressure, temperature and respiration rate.

Module 2

Measurement of blood pressure:Direct and indirect measurement – Oscillometric method – Ultrasonic method-Measurement of blood flow and cardiac output- Plethysmography –Photo electric and Impedance Plethysmographs-Measurement of heart sounds –Phonocardiography.

Cardiac measurements: Electro-conduction system of the heart- Electro-cardiography – Electrodes and leads – Einthoven triangle- ECG read out devices-ECG machine – block diagram

Module 3

Measurements from the nervous system:Neuronal communication-EEG waveforms and features - 10-20 electrode measurement- EEG Block diagram – Brain-Computer interfacing.

Muscle response: Electromyography- Block diagram of EMG recorders – Nerve conduction velocity measurement

Measurements of respiratory parameters: Spiro meter-Pneumograph

Module 4

Modern Imaging Systems: Basic X-ray machines - CAT scanner- Principle of operation - scanning components - Ultrasonic Imaging principle - types of Ultrasound Imaging - MRI and PET scanning(Principle only).

Therapeutic equipment: Cardiac Pacemakers - De-fibrillators - Hemodialysis machines - Artificial kidney – Lithotripsy - Short wave and Micro wave Diathermy machines

Module 5

Ventilators - Heart Lung machine - Infant Incubators

Instruments for clinical laboratory: Test on blood cells – Chemical tests

Electrical safety: Physiological effects of electric current – Shock hazards from electrical equipment – Method of accident prevention.

Introduction to Tele- medicine - Introduction to medical robotics

Text Books

L. Cromwell, F. J. Weibell and L. A. Pfeiffer, "Biomedical Instrumentation Measurements", Pearson education, Delhi, 1990.

J. G. Webster, "Medical Instrumentation, Application and Design", John Wiley and Sons

Reference Books

1. R. S. Khandpur, "Handbook of Biomedical Instrumentation", Tata McGraw Hill
2. J. J. Carr and J. M. Brown, "Introduction to Biomedical Equipment Technology", Pearson Education
3. AchimSchweikard, "Medical Robotics", Springer

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Human Physiology Systems and Transducers (8 hours)**	
1.1	Problems encountered in measuring living systems - Cardio-vascular – Respiratory- nervous and muscular systems of the body.	2
1.2	Electrode theory-Bioelectric potential - Resting and action potential - Generation and propagation.	1
1.3	Bioelectric potentials associated with physiology systems (ECG, EEG and EMG).	1
1.4	Electrodes Theory - Surface electrode - Needle electrode - Microelectrode	2
1.5	Transducers for the measurement of Pressure, temperature and respiration rate.	2
2	**Cardio Vascular System Measurements(8 hours)**	
2.1	Measurement of blood pressure – direct and indirect measurement – Oscillometric measurement –Ultrasonic method	2
2.2	Measurement of blood flow and cardiac output -Plethysmography – Photo electric and Impedance Plethysmographs	3
2.3	Measurement of heart sounds –Phonocardiography.	1

2.4	Electro-conduction system of the heart - Electro Cardiography – Electrodes and leads – Einthoven triangle.	1
2.5	ECG read out devices - ECG machine – Block diagram	1
3	**Nervous System and its Measurements(7 hours)**	
3.1	Neuronal communication - Measurements from the nervous system.	1
3.2	Electroencephalography- Lead system -10-20 Electrode system,	1
3.3	EEG Block diagram - EEG waveforms and features – Brain-Computer interfacing.	2
3.4	Electromyography- Block diagram of EMG recorders - Nerve conduction velocity	2
3.5	Respiratory parameters measurements – Spiro meter - Pneumography.	1
4	**Modern Imaging Systems and Therapeutic Equipment(7 hours)**	
4.1	Basic X-ray machines	1
4.2	CAT Scanner- Principle of operation - Scanning components	1
4.3	Ultrasonic imaging principle - Types of Ultrasound imaging - MRI and PET scanning(Principle only).	2
4.4	Cardiac pace makers - De-fibrillators	1
4.5	Hemo-dialysis machines -Artificial kidney -Lithotripsy	1
4.6	Short wave and Micro wave diathermy machines	1
5	**Instrumentation for Patient Support and Safety(6 hours)**	
5.1	Ventilators - Heart lung machine - Infant incubators	1
5.2	Instruments for clinical laboratory – Test on blood cells – Chemical tests	1
5.3	Electrical safety– Physiological effects of electric current	1
5.4	Shock hazards from electrical equipment - Method of accident prevention	1
5.5	Introduction to tele- medicine	1
5.6	Introduction to medical robotics	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET322	RENEWABLE ENERGY SYSTEMS	PEC	2	1	0	3

Preamble : This course introduces about different new and renewable sources of energy. Design of some of the systems are also discussed

Prerequisite : **Power Systems I**

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Describe the environmental aspects of renewable energy resources.
CO 2	Explain the operation of various renewable energy systems.
CO 3	Design solar PV systems.
CO 4	Explain different emerging energy conversion technologies and storage.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the environmental impacts of wind energy systems. (K1)
2. Explain the limitations of renewable energy systems (K2)

Course Outcome 2 (CO2):

1. With the help of a block diagram, explain the working of a wind energy conversion system. (K2)
2. Explain the working of a small hydro power plant with the help of a diagram. (K2)

Course Outcome 3 (CO3):

1. Design a grid connected solar photovoltaic system. (K3).
2. Design a solar photovoltaic system for a water pumping system. (K3).

Course Outcome 4 (CO4):

1. Explain how energy can be generated from alcohol. (K2)
2. Explain the need for energy storage systems. Discuss how energy can be stored in batteries. (K2).

Model Question paper

QP CODE:

PAGES: 2

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET322

Course Name: RENEWABLE ENERGY SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. What do you mean by global warming? Explain its adverse effects.
2. Write notes on Indian energy scenario.
3. Determine the local apparent time corresponding to 11.30 IST on July 1, at Delhi (280 35' N,770 12'E). The equation of time correction on July 1 is -4 minutes.
4. Draw and explain the V- I characteristics of a solar cell.
5. Define tip speed ratio, cut in speed and cut out speed of a wind turbine.

6. Explain the factors to be considered for the selection of small hydro plants.
7. Discuss the advantages and disadvantages of tidal power plants.
8. Explain the principle of operation of an OTEC plant. What are its advantages?
9. Explain how power can be derived from satellite stations.
10. Explain how energy can be stored using flywheels.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a. Illustrate the relation between energy and sustainable development. **(4)**
    b. Compare the advantages and disadvantages of different conventional sources ofenergy. **(10)**

12. a. Write notes on Kyoto protocol. **(4)**
    b. List out the advantages and disadvantages ofdifferent non-conventional sourcesof energy. **(10)**

Module 2

13. a. With the help of a diagram, explain the working of a pyrheliometer. **(7)**
    b. Explain how a standalone solar PV system can be designed. **(7)**

14. a. With the help of a diagram, explain the working of a flat plate collector. **(7)**
    b. Explain how Maximum Power Point Tracking can be done using a buck boostconverter. **(7)**

Module 3

15. a. Derive an expression for power derived from wind. Explain the characteristic of awind turbine. **(7)**
    b. A propeller wind machine has rotor diameter of 40 m. It is operating at location having wind speed of 35kmph and rotating at 20 rpm. Calculate theoretically the power which the machine can extract from the wind considering both wake rotation and effect of drag. Assume ξ=.012. **(7)**

16. a. With the help of a diagram, explain a wind energy conversion system with variablespeed drive scheme. **(8)**
    b. Explain the different types of turbines used in small hydro plants. **(6)**

Module 4

17. With the help of a diagram, explain the working of different types of tidal powerplants. **(14)**

18. a. With the help of a diagram, explain the working of an OTEC system using hybridcycle. **(10)**
    b. Write notes on the factors to be considered for site selection of OTEC plants. **(4)**

Module 5

19. a. With the help of a diagram, explain biomass gasification based electric powergeneration. **(8)**
    b. Explain the working of a fuel cell with the help of a diagram **(6)**

20. a. With the help of a diagram, explain the working of KVIC model biogas plant. **(10)**
    b. Write notes on pumped storage plants **(4)**

Syllabus

Module 1

Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming-Pollution-Various Pollutants and their Harmful Effects-Green Power-The United Nations Framework Convention On Climate Change (UNFCC)- Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources; Conventional Energy Resources -Availability and their limitations; Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.

Module 2

SOLAR THERMAL SYSTEMS: Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer -Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector)
SOLAR ELECTRIC SYSTEMS: Introduction- Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing-.Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system; Applications –Street lighting, Domestic lighting and Solar Water pumping systems.

Module 3

Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction- Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems)-Wind energy conversion system(WECS) – Fixed–speed drive scheme-Variable speed drive scheme.-Effect of wind speed and grid condition(system integration).
Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection

Module 4

ENERGY FROM OCEAN: Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Advantages and Limitations of TPP.
Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation –Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.

Module 5

BIOMASS ENERGY: Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies, Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model;.
EMERGING TECHNOLOGIES: Fuel Cell, Hydrogen Energy, alcohol energy and power from satellite stations.

ENERGY STORAGE: Necessity Of Energy Storage-Pumped storage-Compressed air storage-Flywheel storage-Batteries storage-Hydrogen storage.

References:

1. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977
2. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their EnvironmentalImpact, Prentice Hall of India, 2001.
3. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, Renewable energy systems,Pearson 2017
4. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996
5. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
6. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
7. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
8. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994
9. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy – Sources for Fuel and Electricity, Earth scan Publications, London, 1993.
10. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
11. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009
12. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
13. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
14. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
15. Tiwari G. N., Solar Energy-Fundamentals, Design, Modelling and Applications, CRC Press, 2002.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Environmental impacts of various energy resources. (7 hours)**	
1.1	Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming	1
1.2	Pollution-Various Pollutants and their Harmful Effects-Green Power -The United Nations Framework Convention On Climate Change (UNFCC)	2
1.3	Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources	1
1.4	Conventional Energy Resources -Availability and their limitations	1
1.5	Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.	2
2	**Solar radiation data, solar thermal and electric systems. (7 hours)**	

2.1	Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer	2
2.2	Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes	1
2.3	Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector)	1
2.4	Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing	1
2.5	Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system	1
2.6	Applications –Street lighting, Domestic lighting and Solar Water pumping systems.	1
3	**Wind energy and small hydro plant (6 Hours)**	
3.1	Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction	1
3.2	-Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems)	1
3.3	Wind energy conversion system(WECS) – Fixed–speed drive scheme-	1
3.4	Variable speed drive scheme.-Effect of wind speed and grid condition(system integration)	1
3.5	Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection	2
4	**Energy from ocean (7 Hours)**	
4.1	Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP)	2
4.2	Classification of Tidal Power Plants, Advantages and Limitations of TPP.	1
4.3	Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation	1
4. 4	Open Cycle (Claude cycle), Closed Cycle (Anderson cycle)	1
4. 5	Hybrid cycle (block diagram description of OTEC)	1
4. 6	Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.	1
5	**Emerging technologies (9 Hours)**	
5.1	Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies	2
5.2	Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model	2

5.3	Types of biogas plants –KVIC and Janata model	1
5.4	Fuel Cell, Hydrogen Energy	1
5.5	Alcohol energy and power from satellite stations.	1
5.6	Necessity Of Energy Storage-Pumped storage-Compressed air storage	1
5.7	Flywheel storage-Batteries storage-Hydrogen storage.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET332	COMPUTER ORGANIZATION	PEC	2	1	0	3

Prerequisite: The basic objective of this course is to lay the foundation of hardware organization of digital computers. The basic organizational concepts of Processor, Control Unit, Memory and I/O units are systematically included in this course. The knowledge on interplay between various building blocks of computer is also covered in this syllabus.

Course Outcomes: After the completion of the course, the student will be able to:

CO 1	Identify the functional units of a digital computer and understand the bus structure to do data transfer.
CO 2	Identify the pros and cons of different types of control unit design for various architectures
CO 3	Explain the principle of operation of ALU for typical arithmetic and logic operations
CO 4	Identify memory organization, Cache memory and virtual memory techniques.
CO 5	Select appropriate interfacing standards for I/O devices.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	1			1							1
CO 2	3	1										1
CO 3	3	1			1							1
CO 4	2											1
CO 5	2											1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	15	15	40
Apply	25	25	40
Analyse			
Evaluate			
Create			

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. The register R1 = 12, and R2= 13. The instruction ADD R1, R2 is in memory location 2000H. After the execution of the instruction, write the value of PC, MAR, IR and R1. Explain the instruction cycle highlighting the sub-cycles.
2. The execution time of a program on machine X is 22 nanoseconds and execution time of the same program on machine Y is 0.1 microsecond. What is the speedup of machine X over machine Y?
3. Differentiate between RISC and CISC systems.

Course Outcome 2 (CO2):

1. Consider a processor having single bus organization of the data path inside a processor. Write the sequence of control steps required for instruction: Add the contents of memory location NUM to register R1.

2. With a neat block diagram, explain in detail about micro programmed control unit and explain its operations.

Course Outcome 3 (CO3):

1. Explain the different methods for representing integers in computer systems.

2. Explain Booth's multiplication algorithm with an example.

Course Outcome 4 (CO4):

1. Show the organization of virtual memory address translation based on fixed length pages

2. Illustrate the implementation of cache memory with any two mapping functions.

Course Outcome 5 (CO5):

1. How vectored interrupts are implemented in processors?

2. Explain DMA method of data transfer in detail with suitable diagrams

Model Question paper

QP CODE:

PAGES:2

Reg.No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET332

Course Name: Computer Organization

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain Von-Neumann architecture
2. Differentiate between direct and indirect addressing modes with suitable examples
3. List the steps of a typical memory read operation.
4. Explain control word and microroutine.
5. Explain floating point representation of an integer.
6. What is the binary representation of decimal number 124.25?
7. What does memory hierarchy mean? What is its significance?
8. Explain the importance of cache memory in computer system.
9. Enlist characteristics of I/O devices
10. What are vectored interrupts?

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a). With the help of a block schematic explain the basic organizational units of a digital computer. **(7)**
    b). What is meant by addressing mode? Explain absolute and indirect addressing modes with suitable examples. **(7)**

12. a). With the help of suitable diagrams explain the single bus and multi bus organization of a computer **(8)**
    b). Differentiate between RISC and CISC systems. **(6)**

Module 2

13. a). Differentiate the design and working of hard wired and micro programmed control unit. **(8)**
    b). Write notes on instruction sequencing. **(6)**

14. a). Consider a 32-bit machine where an instruction (ADD R1, R2) is stored at location 102A (in hexadecimal). How many memory accesses are required to execute this instruction? In addition, what will be the content of PC after the instruction is fetched? Individual instruction is 16-bit. Also write the steps carried out for executing this instruction. **(8)**
    b). Illustrate the load and store cycle with an example? **(6)**

Module 3

15. a).Explain the different methods for representing integers in computer systems. **(6)**
    b). Explain Booth's multiplication algorithm with an example. **(8)**

16. a) Illustrate the methods used for representing a character **(5)**
    b). Explain non-restoring division algorithm with an example **(9)**

Module 4

17. a) Illustrate the implementation of cache memory. **(6)**
    b). Write notes on any two mapping function related to cache memory. **(8)**

18. a). How pipelining is carried out effectively in a computer system. **(8)**
    b). Differentiate various pipeline hazards **(6)**

Module 5

19. a)Explain the different types and characteristics of I/O devices. **(5)**
    b).Explain DMA method of data transfer in detail. **(9)**

20. a). Explain interrupt driven I/O techniques **(9)**
    b). Discuss the advantages and disadvantages of setting interrupt priorities **(5)**

Syllabus

Module 1

Basic Structure of Computers- functional units--Von-Neumann architecture- basic operational concepts, Introduction to buses, Measuring performance: evaluating, comparing and summarizing. Representation of Instructions: Instruction formats -Operands- Addressing modes, Instruction set architectures - CISC and RISC architectures.

Module 2

Processor and Control Unit: Fundamental Concepts, multiple bus organization of CPU, memory read and memory write operations - Data transfer using registers. Execution of a complete instruction -sequencing of control signals. Hardwired Control, Micro programmed Control

Module 3

Data representation: Signed number representation, fixed and floating point representations, character representation. Computer Arithmetic: Integer Addition and Subtraction - Booths Multiplication- Division- non- restoring and restoring techniques.

Module 4

Memory Organization: - Memory cells- Basic Organization. Memory hierarchy - Caches - Cache performance - Virtual memory - Common framework for memory hierarchies Introduction to Pipelining- Pipeline Hazards

Module 5

Input/output organisation- Characteristics of I/O devices, Data transfer schemes - Programmed controlled I/O transfer, Interrupt controlled I/O transfer. Organization of interrupts - vectored interrupts – Servicing of multiple input/output devices – Polling and daisy chaining schemes. Direct memory accessing (DMA).

Text Books

1. Hamacher C., Z. Vranesic and S. Zaky, Computer Organization, 5/e, McGraw Hill, 2011.
2. William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson, 9/e, 2013.
3.

Reference Books

1. Patterson D.A. and J. L. Hennessey, Computer Organization and Design, 5/e, Morgan Kauffmann Publishers, 2013.
2. Heuring V. P. and Jordan H. F., Computer System Design and Architecture, Addison Wesely, 2/e,

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Module 1 (8 hours)**	
1.1	Basic Structure of Computers- functional units-basic operational concepts	1
1.2	Introduction to buses,Performance of computer	2
1.3	Representation of Instructions: Machine instructions-Operands-Addressing modes	2
1.4	Instruction formats, Instruction sets, Instruction set architectures	2
1.5	CISC and RISC architectures.	1
2	**Module 2(8 hours)**	
2.1	Processor and Control Unit : Some Fundamental Concepts	1
2.2	Execution of a Complete Instruction	2
2.3	Multiple Bus Organization	2
2.4	Hardwired Control, Microprogrammed Control	3
3	**Module 3(8 hours)**	
3.1	Computer arithmetic: Signed and unsigned numbers - Addition and subtraction	2
3.2	Booths algorithm,	2
3.3	Division algorithm	2
3.4	Floating point representation	2
4	**Module 4(6 hours)**	
4.1	Memory Organization: - Memory cells- Basic Organization	1
4.2	Memory hierarchy - Caches - Cache performance	2
4.3	Virtual memory	2
4.4	Introduction to pipelining-pipeline Hazards	1
5	**Module 5(6 hours)**	
5.1	Input-Output Organization: Characteristics, data transfer schemes	2
5.2	Organization of interrupts - vectored interrupts	1

5.3	Polling and daisy chaining schemes.	1
5.4	Direct memory accessing (DMA).	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET342	HIGH VOLTAGE ENGINEERING	PEC	2	1	0	3

Preamble: This course introduces basic terms and techniques applicable to high voltage ac and dc networks. Generation of different type of High voltage waveforms, their measurement and analysis including the insulation coordination of different equipments and machinery used in HV applications. It also provides a basic idea of FACTS devices and testing with the help of different testing circuits.

Prerequisite: Basics of Electrical Engineering / Introduction to Electrical Engineering

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Identify different high voltage and current waveform generation circuits.
CO 2	Implement different sensing & measurement techniques for high voltage and current measurement
CO 3	Describe insulation coordination and surge arrestor design
CO 4	Interpret different FACTS devices and their application in HV systems
CO 5	Implement different testing methods for equipments and applications of HV systems

Mapping of course outcomes with programoutcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3					2					2
CO 4	3	3					2					2
CO 5	3	3					2					2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain generation of high voltage AC, DC, impulse voltage and impulse current (K2)
2. Problems on high voltage generator circuits (K2, K3)

Course Outcome 2 (CO2):

1. Explain HV measurement techniques including measurement of peak and rms values (K2)
2. Explain dielectric measurements and partial discharge measurements (K2)
3. Problems on different HV measurement techniques (K2, K3)

Course Outcome 3 (CO3):

1. Explain procedure of insulation coordination (K2)
2. Selection criterion of surge arrester (K2, K3)

Course Outcome 4 (CO4):

1. Describes general principles and main components of HVDC system (K2, K3)
2. Explain FACTS devices used in HV systems (K2)

Course Outcome 5 (CO5):

1. Interpret the testing methods of various components (K2,K3)
2. Explains the applications of HV in various fields (K2)

Model Question paper

QP CODE:

PAGES:2

Reg. .No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET342

Course Name: HIGH VOLTAGE ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain the principle of impulse current generation
2. Explain the working of Cockcroft-Walton voltage multiplier circuit
3. State the different factors affecting the spark over voltage of sphere gap
4. Differentiate between internal and external partial discharges
5. Explain the role of surge arrestors
6. Explain insulation coordination
7. With the help of diagram explain the working of SVC and UPFC
8. State the main components of HVDC links
9. Explain the field testing of HV transformer bushings
10. Explain the objectives of High voltage testing

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a)With the help of diagram explain the generation of rectangular current pulses **(10)**
    b)Explain impulse current generator. **(4)**
12. a) Explain the construction and operation of Marx circuit for multistage impulse generation **(10)**
    b) Discuss the working principle of series resonant circuit used for the generation of high voltage AC **(4)**

Module 2

13. a)Explain how a sphere gap can be used for the measurement of peak voltages **(10)**
    b)Explain the working principle of generating voltmeter. **(4)**

14. a) Explain the operation of Rogowski coil and how it is used for the measurement of high impulse currents. **(10)**
    b) Discuss the disadvantages of sphere gap measurement. **(4)**

Module 3

15. a) Explain how a lightning arrestor location is selected and the rating of the arrestor is selected **(10)**
    b) Differentiate between surge absorber and diverter **(4)**

16. a) An overhead line having surge impedance of 400ohms bifurcates into two lines having surge impedances 400ohm and 40 ohms respectively. Calculate the values of voltage and current for bifurcated lines if a surge voltage of 20kV incidence on the OH line **(10)**
    b) Explain the role of surge arrestor as a shunt protective device. **(4)**

Module 4

17. Elaborate on the main components of HVDC links **(14)**
18. Explain in detail the principle and operation of series compensator andSTATCOM **(14)**

Module 5

19. a) Give a detailed note on insulation systems for impulse voltages **(7)**
    b)Describe in detail electrostatic particle precipitation **(7)**

20. a) Explain any one method of non-disruptive testing for early detection of insulation faults **(4)**
    b)List the various tests performed on high voltage cables **(10)**

Syllabus

Module 1

Generation of High Voltage and Currents

Generation of High DC and AC Voltages- half-wave rectifier circuit- Cockroft-Walton voltage multiplier circuit- Electrostatic generator- Generation of high AC voltages-Cascaded Transformers- Series resonant circuit

Generation of Impulse Voltages and Currents- Impulse voltage- Impulse generator circuits-Multistage impulse generator circuit- Construction of impulse generator- Triggering of impulse generator-Impulse current generation

Module 2

HV measuring techniques

High Voltage Measurement Techniques -Measuring Spark Gaps - Sphere-to-sphere Spark Gap -Rod-to-rod Spark Gap - Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro-optical and Magneto-optical Field Sensors - Voltage Dividers - Instrument Transformers - Measurements of R.M.S. Value, Peak Value and Harmonics - Current Measurement

Dielectric measurements- Dissipation Factor and Capacitance, Insulation Resistance, Conductivity, Dielectric System Response-Partial discharge measuring technique-Requirements on a partial discharge measuring system - Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations

Module 3

Insulation Coordination and surge arresters

Classification of Voltages and Overvoltages-Origin of Overvoltages – Representative Overvoltages- Performance Criterion –Withstand voltage.

Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages-Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages

Determination of Coordination Withstand Voltage (Ucw)-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage (Urw)-Altitude Correction Factor, Safety Factor (Ks)- Selection of Standard Withstand Voltage (Uw)- Surge Arresters- Rated Voltage- Discharge Current- Impulse Current Tests- Residual Voltages-Arrester Durability Requirements

Module 4

HVDC and FACTS

HVDC transmission –General principles-VSC HVDC-Main components of HVDC links-Thyristor valves, Converter transformer, Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies

Converter building - Power electronic support for AC systems- Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC)

Module 5

Testing of HV Systems

High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables
Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors, HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength -Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors)
Lightning Protection- Light and Laser Technology- X-ray Technology-Electrostatic Particle Precipitation, Ionization- Spark plugs

Text Books

1. C L Wadhwa, "High Voltage Engineering", New Age International Publishers, 2011.
2. Andreas Kuchler, " High Voltage Engineering Fundamentals – Technology – Applications", Springer, 2018

References:

1. Naidu M.S. and Kamaraju V., “High voltage Engineering”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004.
2. Farouk A.M. Rizk&Giao N. Trinh, “High Voltage Engineering”, CRC Press, 2014.
3. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India P Ltd, 2005.
4. Hugh M. Ryan, “High-Voltage Engineering and Testing”, IET Power and energy series, 2013.
5. N.G. Hingorani and L.Gyugyi,“Understanding FACTS”,IEEE Press, 2000.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Generation of High Voltage and Currents(7 hours)**	
1.1	Generation of High DC and AC Voltages- half-wave rectifier circuit-Cockcroft-Walton voltage multiplier circuit	2
1.2	Electrostatic generator- Generation of high AC voltages-Cascaded Transformers - Series resonant circuit	2
1.3	Generation of Impulse Voltages and Currents- Impulse voltage- Impulse generator circuits	1
1.4	Multistage impulse generator circuit- Construction of impulse generator-Triggering of impulse generator-Impulse current generation	2
2	**HV measuring techniques (7hours)**	
2.1	High Voltage Measurement Techniques -Measuring Spark Gaps -Sphere-to-sphere Spark Gap -Rod-to-rod Spark Gap	1
2.2	Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro-optical and Magneto-optical Field Sensors	1
2.3	Voltage Dividers - Instrument Transformers - Measurements of R.m.s. Value, Peak Value and Harmonics - Current Measurement	2
2.4	Dielectric measurements- Dissipation Factor and Capacitance, Insulation Resistance, Conductivity,	1
2.5	Dielectric System Response-Partial discharge measuring technique-Requirements on a partial discharge measuring system	1
2.6	Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations	1
3	**Insulation Coordination and surge arresters(8 Hours)**	
3.1	Classification of Voltages and Overvoltages-Origin of Overvoltages – Representative Overvoltages- Performance Criterion –Withstand voltage.	2
3.2	Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages-Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages	2

3.3	Determination of Coordination Withstand Voltage (Ucw)-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage (Urw)-Altitude Correction Factor, Safety Factor (Ks)- Selection of Standard Withstand Voltage (Uw)	2
3.4	Surge Arresters- Rated Voltage- Discharge Current- Impulse Current Tests- Residual Voltages-Arrester Durability Requirements	2
4	**HVDC and FACTS (6 Hours)**	
4.1	HVDC transmission –General principles-VSC HVDC -Main components of HVDC links- Thyristor valves, Converter transformer,	2
4.2	Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies	2
4.3	Converter building - Power electronic support for AC systems- Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC)	2
5	**Testing of HV Systems (8 Hours)**	
5.1	High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables	2
5.2	Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors	2
5.3	HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength-Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors)	2
5.4	Applications-Lightning Protection- Light and Laser Technology- X-ray Technology-Electrostatic Particle Precipitation, Ionization- Spark plugs	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET352	OBJECT ORIENTED PROGRAMMING	PEC	2	1	0	3

Preamble : Nil

Prerequisite : Nil

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Explain object oriented programming concepts and creation of classes for Java applications
CO 2	Develop Java programs using arrays, strings, packages and inheritance concepts
CO 3	Build Java applications using abstract classes, interfaces, run time errors and exceptions
CO 4	Develop Java applets and applications for file I/O operations
CO 5	Apply the concept of multithreading in Java applications.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	2											1
CO 2	2	2			3							2
CO 3	2	2			3							2
CO 4	2	2			3							2
CO 5	2	3			3							2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	20	20	40
Analyse (K4)	10	10	20
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. How does Java achieve platform independence?
2. Compare data hiding and data abstraction in Java.
3. Why main() method is declared as 'static' in Java?

Course Outcome 2 (CO2):

1. Demonstrate how packages are created and used in Java.
2. Compare static binding and dynamic binding
3. Illustrate the use of 'final' keyword in Java.

Course Outcome 3 (CO3):

1. Demonstrate how multiple inheritance is implemented using interfaces.
2. Differentiate abstract classes and interfaces.
3. What are the different ways to handle exceptions in Java?

Course Outcome 4 (CO4):

1. Differentiate between Java applets and Java applications.
2. Explain how parameters can be passed to an applet.
3. Develop a Java program to create a file named "input.txt", write data into the file, read the contents from the file and display on the screen.

Course Outcome 5 (CO5):

1. Illustrate the different ways to create multithreaded programs in java.
2. Give the syntax of SELECT and INSERT SQL commands with example.
3. Explain the architecture of JDBC

Model Question paper

QP CODE:

PAGES:2

Reg.No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR

Course Code: EET 352

Course Name: Object Oriented Programming

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain how data encapsulation and data hiding are implemented in Java.
2. Demonstrate the significance of the 'static' keyword in Java.
3. What are packages? How packages are created and used?
4. Explain the usage of 'final' keyword in Java programs.
5. What are the different ways to handle exceptions?
6. Compare and contrast abstract classes and interfaces.
7. How can parameters be passed into applets? Give examples.
8. What is a stream? Illustrate how the concept of streams is used in java.
9. How thread priority is set in Java? Explain with an example
10. What are different types of JDBC drivers?

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Outline the four access control specifiers in Java and illustrate their use with the help of an example program. **(7)**

    b) What are constructors? Demonstrate the use of different types of constructors in java. **(7)**

12. (a) Discuss the advantages of object oriented paradigm and compare it with procedure oriented programming. **(7)**

(b) Create a Java program to read the details of an employee like name, ID, Basic pay, DA, HRA etc. Find the net salary (Basic pay + DA +HRA) and display the employee details including net salary. Use class Employee to store all the data and use appropriate methods to access the data, calculate net salary and display the details. **(7)**

Module 2

13. (a) Compare and contrast method overloading and method overriding in java with the help of example programs. **(7)**

(b) Explain with examples, the different ways to compare two strings in Java. **(7)**

14. (a) Explain different types of inheritance. How they are implemented in Java? **(8)**

(b) Demonstrate the uses of the keyword "super" in Java. (6)

Module 3

15. (a) Demonstrate how multiple inheritance is implemented in Java with the help of an example program. **(7)**

(b) What is an inner class? Explain different types with examples. **(7)**

16. (a) Differentiate object cloning and copying. How object cloning is implemented in Java? **(7)**

(b) What is reflection? List any 3 methods used to analyse classes during runtime. **(7)**

Module 4

17. (a) "Applets can be used to play audio files". Support this statement with suitable example. **(7)**

(b) Write a program to create a file named "input.txt", write data into the file, read the contents from the file and display on the screen **(7)**

18. (a) What is an applet? Explain the life cycle of an applet with a neat sketch. **(6)**

(b) Distinguish between (i) Input Stream and Reader classes and (ii) Output Stream and Writer classes **(8)**

Module 5

19. (a) What is SQL? Write SQL commands to create, update and delete a table. **(7)**

(b). Explain different methods for creating threads in Java. **(7)**

20. (a) Explain the life cycle of a thread. Which are the different thread properties? **(7)**

(b) Describe the steps for establishing JDBC connection with the help of an example program. **(7)**

Syllabus

Module 1:

Review of object-oriented concepts- Java features – Java Virtual Machine - Objects and classes in Java - defining classes – methods – access specifiers - static members- command line arguments– constructors

Module 2:

Arrays – Strings -Packages - Inheritance – class hierarchy – polymorphism – static binding - dynamic binding – final keyword

Module 3:

Abstract classes – the Object class – Reflection – interfaces – object cloning – inner classes - Exception handling

Module 4:

Applet Basics-

Life cycle - The Applet HTML Tags and Attributes, Creating and running applets – Multimedia support, The Applet Context, JAR Files

File I/O - Concept of Streams - Use of character / byte Streams and stream classes - Writing and Reading characters / bytes

Module 5: –

Multithreaded programming-

Life cycle of a thread -Thread properties – Creating a thread -Interrupting threads –Thread priority- thread synchronization – Synchronized method -Inter thread communication

Database Programming -The Design of JDBC, The Structured Query Language, JDBC Installation, Basic JDBC Programming Concepts, Query Execution

Text Books

1. Herbert Schildt, “Java – The Complete Reference “, 8th Edition, Tata McGraw Hill
2. Cay S. Horstmann and Gary Cornell, “Core Java: Volume I & II– Fundamentals”, Pearson Education, 2008.
3. E Balaguruswamy, “Programming with Java – A primer”, 5th Edition, McGraw Hill

Reference Books

1. P.J.Deitel and H.M.Deitel, “Java: How to Program”, PHI.

2. Programming in Java, S.Malhotra and S.Choudhary, Oxford Univ. Press, 2018
3. K. Arnold and J. Gosling, "The JAVA programming language", Pearson Education
4. Bruce Eckel, Thinking in Java, Pearson Education
5. David H Friedel,Jr. and Anthony Potts, Java Programming Language Handbook, Coriolis Group Books
6. Doug Lowe, Java all-in-one for Dummies, John Wiley & Sons
7. Laura Lemay and Charles L Perkins, Teach yourself Java in 21 days, Sams Publishing

Course Content and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (9 hrs)**	
1.1	Review of Object-Oriented Concepts	1
1.2	Java features - Java Virtual Machine	1
1.3	Objects and classes in Java	1
1.4	defining classes – methods	1
1.5	access specifiers	1
1.6	static variables, static blocks	1
1.7	static methods, static classes	1
1.8	command line arguments	1
1.9	constructors	1
2	**Module 2 (8 hrs)**	
2.1	Arrays – 1D	1
2.2	Arrays – 2D	1
2.3	Strings	1
2.4	Packages	1
2.5	Inheritance – class hierarchy	1
2.6	Polymorphism- static binding	1
2.7	dynamic binding	1
2.8	final keyword	1
3	**Module 3 (7 hrs)**	
3.1	abstract classes	1
3.2	the Object class	1
3.3	Reflection	1
3.4	interfaces	1
3.5	object cloning	1
3.6	inner classes	1

3.7	Exception handling	1
4	**Module 4 (7 hrs)**	
4.1	**Applet Basics**- Life cycle- The Applet HTML Tags and Attributes	1
4.2	Creating and running applets	1
4.3	Multimedia support	1
4.4	The AppletContext - JAR Files	1
4.5	**File I/O** - Concept of Streams	1
4.6	Use of character / byte Streams and stream classes	1
4.7	Writing and Reading characters / bytes	1
5	**Module 5 (5 hrs)**	
5.1	**Multithreaded programming**– Life cycle of a thread -Thread properties	1
5.2	Creating a thread - Interrupting threads –Thread priority	1
5.3	Thread synchronization – Synchronized method -Inter thread communication	1
5.4	**Database Programming** -The Design of JDBC, The Structured Query Language, JDBC Installation	1
5.5	Basic JDBC Programming Concepts, Query Execution	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET362	MATERIAL SCIENCE	PEC	2	1	0	3

Preamble: This course introduces different types of materials used in electrical engineering such as conductors, semiconductors, insulators, solar energy materials, biomaterials, nanomaterials, superconducting materials and magnetic materials. Also, this gives a detailed explanation on dielectrics, polarisation, modern techniques in material science and their applications.

Prerequisite : Basic Electrical Engineering, Basic Electronics Engineering

Course Outcomes : After the completion of the course, the student will be able to:

CO 1	Describe the characteristics of conductor, semiconductor and solar energy materials.
CO 2	Classify different insulating materials and describe polarisation in dielectrics.
CO 3	Explain the mechanisms of breakdown in solids, liquids and gases.
CO 4	Classify and describe magnetic materials and superconducting materials.
CO 5	Explain the recent developments in materials science, modern techniques and their applications in important walks of life.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	-	1	-	-	-	2	-	-	-	-	-
CO 2	3	-	1	-	-	-	-	-	-	-	-	-
CO 3	3	-	1	-	-	-	1	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	2	2	2	-	-	-	-	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	15	15	30
Understand	35	35	70
Apply			
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the dependence of conductivity of conductor materials on temperature and composition.
2. Compare the properties of compound, amorphous and organic semiconductors.
3. Differentiate between intrinsic and extrinsic semiconductors.
4. Derive the expression for conductivity.
5. Write notes on organic solar cell.
6. Explain the different solar selective coatings.
7. What are the different materials used for manufacturing solar cells?

Course Outcome 2 (CO2):

1. Derive Clausius – Mosotti Relation.
2. Explain with examples the different types of polarisation in dielectrics.
3. Classify insulating materials based on their temperature withstanding capability.
4. Explain in detail the properties and applications of SF6 gas.
5. Write short notes on Ferro electricity.
6. Describe the different capacitor materials used in various applications.

Course Outcome 3(CO3):

1. Explain the current voltage characteristics in Townsend's mechanism.
2. Explain the breakdown criteria in Townsend's mechanism.
3. Write notes on streamer mechanism of breakdown in gaseous dielectrics.
4. Explain any one mechanism of breakdown in vacuum insulation.
5. Describe with necessary diagram the treatment of transformer oil.
6. With the help of a circuit diagram, explain the testing of transformer oil.
7. Compare the suspended particle theory and bubble theory mechanisms of breakdown in liquid dielectrics.
8. Write short notes on any one mechanisms of breakdown in solid dielectrics.

Course Outcome 4 (CO4):

1. How are magnetic materials classified?
2. Differentiate between soft and hard magnetic materials.
3. Explain Curie – Weiss law.

4. Write short notes on Ferrites.
5. Define Superconductivity. Explain the characteristics of superconductors.
6. Differentiate between type I and type II superconductors.

Course Outcome 5 (CO5):

1. Compare the top-down and bottom-up growth techniques of nanomaterials.
2. Mention the names of any three non-lithographic growth techniques.Explain any one in detail.
3. Write short notes on Scanning Probe Microscopy.
4. What is a transmission electron microscope?
5. Write a short note on Carbon nanotube.
6. What are the applications of biomaterials?

Model Question paper

QP CODE:

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR

Course Code: EET 362

Course Name: MATERIAL SCIENCE

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. What are the different materials used for manufacturing solar cells?
2. What is an organic solar cell? Explain.
3. Explain the concept of Ferro-electricity.
4. Mention the different types of polarisation in dielectrics.
5. What is treeing and tracking? Explain.
6. Draw the current-voltage characteristics in Townsend's mechanism.
7. How are magnetic materials classified?
8. Why do certain materials exhibit superconductivity?
9. Write a short note on Carbon nanotube.
10. What are the applications of biomaterials?

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) What is the effect of alloying of metals in their conduction? Illustrate with an example. **(5)**

b) Compare the properties of compound, amorphous and organic semiconductors. **(9)**

12. a) Derive the expression for conductivity. Describe the dependence of conductivity of conductor materials on temperature and composition. **(9)**

b) What is intrinsic breakdown? **(5)**

Module 2

13. a)Derive Clausius-Mosotti relation. **(7)**

b)Classify insulating materials based on their temperature withstanding capability. **(7)**

14. a) Explain in detail the properties and applications of SF6 gas. **(4)**

b) Describe the different capacitor materials used in various applications. **(10)**

Module 3

15. a)Compare the suspended particle theory and bubble theory mechanisms of breakdown in liquid dielectrics. **(10)**

b) List out the breakdown criteria in Townsend's mechanism. **(4)**

16. a) What is meant by transformer oil testing? Why is it done? Explain the tests on transformer oil. **(9)**

b) Elucidate any one mechanism of breakdown in vacuum. **(5)**

Module 4

17. a) Discuss the application of magnetic materials used in electrical machines, instruments and relays. Justify with reasons. **(10)**

b) Write short notes on Ferrites. **(4)**

18. a) What do you mean by superconductivity? Explain the characteristics and properties of superconducting materials. **(8)**

b) What are type I and type II superconductors? **(6)**

Module 5

19. a) Compare the top-down and bottom-up growth techniques of nanomaterials. **(8)**

b) Write short notes on Scanning Probe Microscopy. **(6)**

20. a) Mention the names of any three nonlithographic growth techniques. Explain any one in detail. **(8)**

b) What is a transmission electron microscope? **(6)**

Syllabus

Module 1

Conducting Materials: Conductivity- dependence ontemperature and composition – Materials for electricalapplications such as resistance, machines, solders etc.

Semiconductor Materials: Concept, materials and properties– Basic ideas of Compound semiconductors, amorphous andorganic semiconductors- applications.

Solar Energy Materials: Solar selective coatings for enhanced solar thermal energy collection. Solar cells -Silicon, Cadmium sulphide and Gallium arsenic – Organic solar cells.

Module 2

Dielectrics: Introduction to Dielectric polarization andclassification–Clausius-Mosotti relation.

Insulating materials and classification- properties- Common insulating materials used in electrical apparatus-Inorganic, organic, liquid and gaseous insulators- capacitor materials.

Electro-negative gases- properties and applications of SF6 gas and its mixtures with nitrogen
Ferro electricity.

Module 3

Dielectric Breakdown: Mechanism of breakdown in gases, liquids and solids –basic theories including Townsend's criterion, Streamer mechanism.

Mechanism of breakdown in liquids and solids - suspended particle theory, Bubble theory, Stressed oil Volume Theory, intrinsic breakdown, electro-mechanical breakdown, Thermal breakdown, Treeing and Tracking.

Application of vacuum insulation- Breakdown in high vacuum.
Basics of treatment and testing of transformer oil.

Module 4

Magnetic Materials: Classification of magnetic materials -Curie-Weiss law-Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus.

Superconductor Materials:-Basic Concept- types, characteristics- applications.

Module 5

Novel materials: Introduction to Biomaterials, Nano-materials and their significance. Growth techniques of nano-materials – Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes (qualitative study only), Characterisation tools of nanomaterials – SPM, AFM, SEM and TEM (qualitative study only), Special topics in nanotechnology – nanostructures of carbon, nanoelectronics, nanobiometrics(qualitative study only).

Text Books

1. Dekker A.J.: Electrical Engineering Materials, Prentice Hall of India.
2. G.K.Mithal: Electrical Engineering Material Science. Khanna Publishers.
3. K.K. Chattopadhyay, A. N. Banerjee: Introduction to nanoscience and nanotechnology, PHI Learning Pvt. Ltd.

Reference Books

1. Naidu M. S. and V. Kamaraju, *High Voltage Engineering*, Tata McGraw Hill, 2004
2. Indulkar O.S.&Thiruvegadam S., An Introduction to Electrical Engineering Materials, S.Chand.
3. Joon Bu Park, Biomaterials Science and Engineering, Plenum Press, New York, 1984

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Conducting Materials, Dielectrics, Semiconductors (8 hours)**	
1.1	Conducting Materials: Conductivity	1
1.2	Dependence ontemperature and composition – Materials for electricalapplications such as resistance, machines, solders etc	2
1.3	Semiconductor Materials: Concept, materials and properties	2
1.4	Basic ideas of Compound semiconductors, amorphous andorganic semiconductors- applications.	1
1.5	Solar Energy Materials: Solar selective coatings for enhanced solar thermal energy collection.	1
1.6	Solar cells -Silicon, Cadmium sulphide and Gallium arsenic – Organic solar cells.	1
2	**Insulating materials(8 hours)**	
2.1	Dielectrics: Introduction to Dielectric polarization and classification.	1
2.2	Clausius- Mosotti relation.	1

2.3	Insulating materials and classification- properties	2
2.4	Common insulating materials used in electrical apparatus- Inorganic,organic, liquid and gaseous insulators- capacitor materials.	1
2.5	Electro-negative gases- properties and applications of SF6 gas and its mixtures with nitrogen.	2
2.6	Ferro electricity	1
3	**Dielectric Breakdown(8 hours)**	
3.1	Mechanism of breakdown in gases– Townsend's criterion	2
3.2	Streamer theory	1
3.3	Mechanism of breakdown in liquids - suspended particle theory, Bubble theory, Stressed oil Volume Theory.	1
3.4	Mechanism of breakdown in solids - intrinsic breakdown, electro-mechanical breakdown, Thermal breakdown, Treeing and Tracking.	1
3.5	Application of vacuum insulation- Breakdown in high vacuum.	1
3.6	Basics of treatment and testing of transformer oil	2
4	**Magnetic Materials, Superconductors, Solar Energy materials (5 hours)**	
4.1	Magnetic Materials: Classification of magnetic materials –Curie-Weiss law	1
4.2	Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus.	2
4.3	Superconductor Materials:-Basic Concept- types, characteristics-applications.	2
5	**Novel materials(7 hours)**	
5.1	Introduction to biomaterials, nanomaterials and their significance	2
5.2	Growth techniques of nano materials-Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes	2
5.3	Characterisation tools of nanomaterials – SPM, AFM, SEM and TEM	2
5.4	Special topics in nanotechnology – nanostructures of carbon, nanoelectronics, nanobiometrics	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET372	SOFT COMPUTING	PEC	2	1	0	3

Preamble: This course gives an introduction to some new fields in soft computing. It combines the fundamentals of neural network, fuzzy logic, and genetic algorithm which in turn offers the superiority of humanlike problem solving capabilities. This course provides a broad introduction to machine learning, data clustering algorithms and support vector machines.

Prerequisite: Digital Electronics

Course Outcomes: After the completion of the course, the student will be able to:

CO 1	Explain various constituents of soft computing and artificial neural networks.
CO 2	Explain the different learning methods for training of ANNs.
CO 3	Apply fuzzy logic techniques to control a system.
CO 4	Utilize genetic algorithm techniques to find the optimal solution of a given problem.
CO 5	Explain the basics of machine learning, data clustering algorithms and support vector machines.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	-	-	-	-	-	-	-	-	-	-	2
CO 2	3	1	1	1	-	-	-	-	-	-	-	2
CO 3	3	1	1	1	2	-	-	-	-	-	-	2
CO 4	3	1	1	1	-	-	-	-	-	-	-	2
CO 5	3	1	2	1	2	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare Soft and Hard computing.
2. Define ANN. What are the characteristics of ANN?
3. Realize using McCulloch Pitts neuron model (i) a 2-input AND logic and (ii) a 2-input NOR logic considering +1 as the bias value of the neuron.
4. Draw the non-linear model of a neuron and explain the basic elements of the neuronal model.
5. Explain any five types of activation functions used in neural network models.
6. Explain how a biological neuron transmits signals in the human brain with the help of neat diagrams.

Course Outcome 2 (CO2):

1. Describe learning. What are the different learning methods in ANN?
2. Explain the different architectures of neural networks.
3. Explain error correction learning algorithm.
4. What is meant by feed forward network? Compare SLFFN and MLFFN.
5. Compare supervised learning and unsupervised learning methods.
6. Derive the expression for local gradient of an output neuron, in back propagation algorithm.

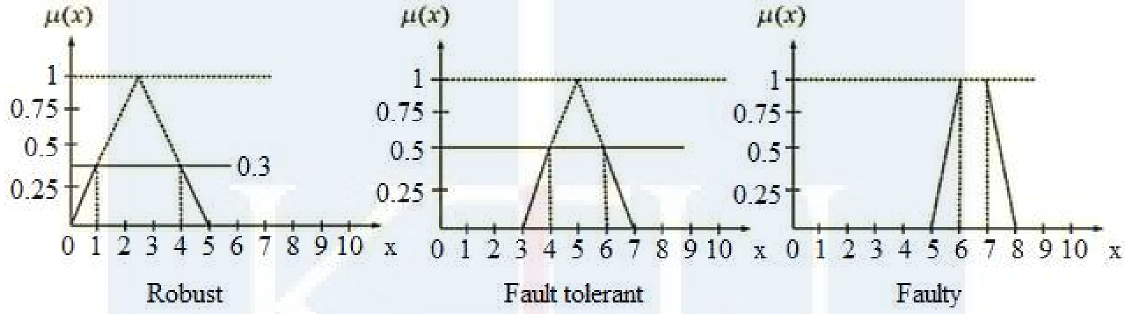
Course Outcome 3(CO3):

1. Define membership function. Also give any three features of a membership function.
2. Define (i) core (ii) support (iii) boundary and crossover points of membership function.
3. Given two fuzzy sets:
   $\tilde{A}$: Mary is efficient, T ($\tilde{A}$) = 0.8
   $\tilde{B}$: Ram is efficient, T ($\tilde{B}$) = 0.65
   Find (i) Mary is not efficient (ii) Mary is efficient and so is Ram (iii) Either Mary or Ram is efficient (iv) If Mary is efficient.
4. P represents a set of four varieties of paddy plants, D represents the four diseases affecting the plants, and S represents the common symptoms of the diseases. $P=\{P_1,P_2,P_3,P_4\},D=\{D_1,D_2,D_3,D_4\},S=\{S_1,S_2,S_3,S_4\}$. R is a relation on $P\times D$ representing which plant is susceptible to which diseases and T is another relation on $D\times S$ and is stated as

$$R = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array}\begin{array}{c} \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{bmatrix} 0.6 & 0.6 & 0.9 & 0.8 \\ 0.1 & 0.2 & 0.9 & 0.8 \\ 0.9 & 0.3 & 0.4 & 0.8 \\ 0.9 & 0.8 & 0.4 & 0.2 \end{bmatrix} \end{array}, \qquad T = \begin{array}{c} \\ D_1 \\ D_2 \\ D_3 \\ D_4 \end{array}\begin{array}{c} \begin{array}{cccc} S_1 & S_2 & S_3 & S_4 \end{array} \\ \begin{bmatrix} 0.1 & 0.2 & 0.7 & 0.9 \\ 1 & 1 & 1 & 0.6 \\ 0 & 0 & 0.5 & 0.9 \\ 0.9 & 1 & 0.8 & 0.2 \end{bmatrix} \end{array}$$

Obtain the association of plants with the different symptoms of the disease using max-min composition.

5. Discuss any two common membership functions used in fuzzy logic.
6. $\tilde{A} = \{(x_1, 0.3), (x_2, 0.5), (x_3, 0.6)\}, \tilde{B} = \{(x_1, 0.2), (x_2, 0.8), (x_3, 0.9)\}$. Find (i) $\tilde{A} \cup \tilde{B}$ (ii) $\tilde{A} \cap \tilde{B}$ (iii) $\tilde{A} - \tilde{B}$ (iv) $\tilde{A} \oplus \tilde{B}$.
7. List out the various operations on Fuzzy sets.
8. Explain simple fuzzy logic controllers.
9. The faulty measure of a circuit is defined fuzzily by three fuzzy sets namely Robust (*R*), Fault tolerant (*FT*) and Faulty (*F*), defined by three membership functions with number of faults occur, as universe of discourse as



Reliability is measured as $r = R \cup FT \cup F$. Determine the crisp value of *r* using centroid method, COS method and weighted average methods of defuzzification.

Course Outcome 4 (CO4):

1. Draw a neat architecture of Adaptive Neuro Fuzzy Inference System (ANFIS)**.**
2. Explain any two types of encoding used in GA.
3. Discuss selection operation in GA. Explain briefly Roulette wheel selection.
4. What is Genetic Algorithm? What are the various methods of selecting chromosomes of parents to crossover?
5. What is crossover? Explain any three types of crossover operators in GA.
6. Define (i) Population (ii) Fitness (iii) Selection (iv) Mutation.

Course Outcome 5 (CO5):

1. What is "Machine Learning"? Give examples of learning machines.
2. Explain different types of machine learning models.
3. Explain different types of Machine Learning Architecture.
4. Explain, K-Means Clustering algorithm. What are its applications?
5. Compare SVM and SVR.
6. ExplainHierarchical clustering technique. What are its limitations?

Model Question paper

QP CODE:

PAGES:2

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION
MONTH & YEAR

Course Code: EET 372

Course Name: SOFT COMPUTING

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks.

1. Compare the structure of a biological neuron with an artificial neuron.
2. What is a perceptron? Explain the training process in perceptron.
3. Describe learning. What are the different learning methods in ANN?
4. Explain the architecture of a Hopfield network.
5. The two fuzzy sets representing an *apple* and an *orange* are:

$$Apple = \left\{ \frac{0.4}{orange} + \frac{0.5}{chair} + \frac{0.8}{table} + \frac{0.9}{apple} + \frac{0.3}{plate} \right\}$$
$$Orange = \left\{ \frac{0.6}{orange} + \frac{0.3}{chair} + \frac{0.4}{table} + \frac{0.5}{apple} + \frac{0.4}{plate} \right\}$$

Find the following:

$i)\ Apple \cup \underline{Orange}\quad ii)\ Apple \cap Orange\quad iii)\ \overline{Apple \cap Orange}$
$iv)\ Apple \cup Apple$

6. With a neat block diagram, explain the fuzzy inference system.
7. Write short notes on any two methods used for selection process in GA.
8. Explain two different types of crossover used in a genetic algorithm.
9. What is a linear learning machine?
10. List out any 4 applications of support vector machines.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks.

Module I

11	a	Realize using McCulloch Pitts neuron model (i) a 2-input AND logic and (ii) a 2-input NOR logic considering +1 as the bias value of the neuron.	**(9)**

	b	Explain any five types of activation functions used in neural network models.	(5)
12	a	Explain the architecture of ADALINE and MADALINE networks.	(9)
	b	Draw the non-linear model of a neuron and explain the basic elements of the neuronal model.	(5)

Module II

13	a	Explain back propagation algorithm with the help of a block diagram and a suitable example.	(9)
	b	Explain radial basis function network.	(5)
14	a	Explain reinforcement learning with the help of a block diagram.	(7)
	b	Explain Kohonen Self organizing map.	(7)

Module III

15 a P represents a set of four varieties of paddy plants, D represents the four diseases affecting the plants, and S represents the common symptoms of the diseases. $P=\{P_1,P_2,P_3,P_4\}, D=\{D_1,D_2,D_3,D_4\}, S=\{S_1,S_2,S_3,S_4\}$. R is a relation on $P\times D$ representing which plant is susceptible to which diseases and T is another relation on $D\times S$ and is stated as **(9)**

$$R = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{array}{c} \begin{matrix} D_1 & D_2 & D_3 & D_4 \end{matrix} \\ \begin{bmatrix} 0.6 & 0.6 & 0.9 & 0.8 \\ 0.1 & 0.2 & 0.9 & 0.8 \\ 0.9 & 0.3 & 0.4 & 0.8 \\ 0.9 & 0.8 & 0.4 & 0.2 \end{bmatrix} \end{array}, \qquad T = \begin{array}{c} \\ D_1 \\ D_2 \\ D_3 \\ D_4 \end{array} \begin{array}{c} \begin{matrix} S_1 & S_2 & S_3 & S_4 \end{matrix} \\ \begin{bmatrix} 0.1 & 0.2 & 0.7 & 0.9 \\ 1 & 1 & 1 & 0.6 \\ 0 & 0 & 0.5 & 0.9 \\ 0.9 & 1 & 0.8 & 0.2 \end{bmatrix} \end{array}$$

Obtain the association of plants with the different symptoms of the disease using max-min composition.

	b	Discuss any two common membership functions used in fuzzy logic.	(5)
16		With the help of an example, explain the working of a fuzzy logic controller.	(14)

Module IV

17	a	Describe the steps involved in solving an optimization problem using Genetic Algorithm. Illustrate the steps with a suitable example	(14)
18	a	Explain Adaptive Neuro-Fuzzy Inference System (ANFIS) with the help of a block diagram.	(9)
	b	What is the role of 'mutation' in GA based optimizationprocess? What is the usual range of probability value given for mutation process**?**	(5)

Module V

19	a	Describe Machine Learning. Write any three applications	(9)
	b	Briefly explain any one clustering algorithm with example.	(5)

20 a Explain support vector regression. List any 2 applications. **(9)**

b What are the common distance measures used in clustering algorithms? **(5)**

Syllabus

Module 1

Introduction: Soft and Hard Computing, Evolution of soft computing, Soft computing constituents.

Artificial Neural Networks: Biological foundations –ANN models - Characteristics of ANN-Types of activation function - McCulloch-Pitts neuron model, Realization of logic gates using McCulloch-Pitts neuron model - simple perceptron, Adaline and Madaline.

Module 2

Neural network architectures - single layer, multilayer, recurrent networks.

Knowledge representation - Learning process - Supervised and unsupervised learning, Learning algorithms–Errorcorrection learning - Hebbian learning – Boltzmann learning - competitive learning- Backpropagation algorithm- Case study-Radial basis function networks - Hopfield network- Kohonen Self organizing maps

Module 3

Fuzzy Logic: Introduction to crisp sets and fuzzy sets, examples, Properties, Basic fuzzy set operations, examples. Fuzzy relations - Cardinality of Fuzzy relations - Operations on Fuzzy relations - Properties of Fuzzy relations. Membership functions - triangular, trapezoidal, bell shaped, Gaussian, sigmoidal.

Fuzzy logic controller (Block Diagram), Fuzzification, rule base, inference engine and defuzzification - Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First and Last of Maxima.

Simple fuzzy logic controllers with examples.

Module 4

Genetic Algorithm: Introduction - basic concepts of Genetic Algorithm, encoding, fitness function, reproduction, cross over, mutation operator, bit-wise operators, generational cycle.

Hybrid Systems: Adaptive Neuro Fuzzy Inference System (ANFIS), Genetic algorithm based back propagation networks, fuzzy back propagation networks.

Module 5

Machine Learning- Machine learning model-Approaches to machine learning- Machine learning architecture- Data Clustering Algorithms -Hierarchical clustering, K-Means Clustering

Support Vector Machines for Learning – Linear Learning Machines – Support Vector Classification – Support Vector Regression - Applications.

Reference Books

1. S.Rajasekharan, G.A.Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
2. S.N.Sivanandam, S.N.Deepa, *Principles of Soft Computing*, Wiley India, 2007.
3. Simon Haykin, *Neural Networks a Comprehensive foundation*, Pearson Education, 1999.
4. Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002
5. Zurada J.M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.
6. Hassoun Mohammed H, *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.J.-S.R.Jang, C.-T.Sun,E.Mizutani, *Neuro-Fuzzy and Soft Computing*, Prentice Hall, 1997.
7. Timothy J Ross, *Fuzzy logic with Engineering Applications*, McGraw Hill, New York.
8. Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
9. Ronald R Yager and Dimitar P Filev, *Essentials of Fuzzy Modelling & Control*, John Wiley & Sons, Inc, 2002.
10. SuranGoonatilake& Sukhdev Khebbal (Eds.), *Intelligent Hybrid Systems*, John Wiley,1995.
11. D.E.Goldberg, *Genetic Algorithms in Search Optimisation and Machine Learning*, Pearson Education, 1989.
12. Tom Mitchell,*Machine Learning*, McGraw Hill, 1997
13. Margaret H. Dunham, *Data Mining- Introductory & Advanced Topics*, Pearson Publication

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	***Introduction to Artificial Neural Networks***	**5 hrs**
1.1	Introduction to soft computing, soft and hard Computing, Soft computing constituents	1
1.2	ANN- Biological foundations - ANN models - Characteristics of ANN - Types of activation function.	1
1.3	McCulloch-Pitts neuron model, Realization of logic gates using McCulloch-Pitts neuron model.	2
1.4	Simple perceptron, Adaline and Madaline.	1
2	***Neural network architectures and Learning***	**7 hrs**
2.1	Neural network architectures - single layer, multilayer, recurrent networks, Knowledge representation.	1
2.2	Learning process: Supervised and unsupervised learning. Learning algorithms- Errorcorrection learning.	1
2.3	Hebbian learning – Boltzmann learning - competitive learning.	1

2.4	Back propagation networks	1
2.5	Radial basis function networks - Hopfield network.	2
2.6	Kohonen Self organizing maps	1
3	***Introduction to Fuzzy Logic***	**11 hrs**
3.1	Introduction to crisp sets and fuzzy sets, examples, Properties.	1
3.2	Basic fuzzy set operations, examples.	1
3.3	Fuzzy relations- Cardinality of Fuzzy relations - Operations on Fuzzy relations - Properties of Fuzzy relations.	2
3.4	Membership functions - triangular, trapezoidal, bell shaped, Gaussian, sigmoidal.	1
3.5	Fuzzy logic controller (Block Diagram), Fuzzification, rule base, inference engine	2
3.6	Defuzzification - Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First and Last of Maxima, Example problems.	2
3.7	Simple fuzzy logic controllers with examples	2
4	***Introduction to Genetic Algorithms and Hybrid Systems***	**7 hrs**
4.1	Basic concepts of Genetic Algorithm – encoding - fitness function – reproduction - cross over - mutation operator - bit-wise operators, generational cycle.	3
4.2	Hybrid Systems: Adaptive Neuro fuzzy Inference System (ANF1S)	2
4.3	Genetic algorithm based back propagation networks	1
4.4	Fuzzy back propagation networks	1
5	***Introduction to Machine Learning***	**6 hrs**
5.1	Machine Learning- Machine learning model- Approaches to machine learning- Machine learning architecture	**2**
5.2	Data Clustering Algorithms - Hierarchical clustering, K-Means Clustering	**2**
5.3	Support Vector Machines for Learning Support Vector Classification – Support Vector Regression - Applications	**2**

SEMESTER VI

MINOR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET 382	POWER SEMICONDUCTOR DRIVES	VAC	3	1	0	4

Preamble: This course is intended to provide fundamental knowledge in dynamics and control of Electric Drives, to justify the selection of Drives for various applications and to familiarize the various semiconductor controlled drives employing various motors

Prerequisite: Basic knowledge of mathematics, basic electronics and analog electronics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain dynamics and control of electric drives.
CO 2	Explain the performance of DC motor drives used in various applications.
CO 3	Explain control strategies for three phase induction motor drives.
CO 4	Explain variable speed synchronous motor drives.
CO5	Choose an appropriate drive system for a specific application.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	-	-	-	-	-	-	-	-	-	1
CO 2	3	2	1	-	-	-	-	-	-	-	-	1
CO 3	3	3	-	-	-	-	-	-	-	-	-	1
CO 4	3	3	-	-	-	-	-	-	-	-	-	1
CO 5	3	2	1	2	2	-	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. **Part B** contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Draw and explain the typical toque speed characteristics of different types of mechanical loads pump, hoist, fan and traction loads. Write the various factors that influence the choice of electric drives?
2. Explain clearly, the four quadrant operation of a motor driving a hoist load.
3. Differentiate between passive and active load torques with example.

Course Outcome 2 (CO2)

1. Explain using suitable diagrams and wave forms, two quadrant operation of single phase full converter fed separately excited dc motor drive for continuous and discontinuous mode of operation and obtain the boundary between two modes. Derive the output voltage equation for both modes.
2. Draw the circuit diagram of a class-C chopper fed DC motor drive. Draw its V/I characteristics.
3. Explain the four quadrant operation of a chopper fed dc motor drive with the help of necessary circuit diagram and waveform

Course Outcome 3 (CO3):

1. Draw and explain the speed torque characteristics of a stator voltage controlled induction motor. Why stator voltage control is not suitable for speed control of induction motor with constant load torque.
2. Explain the static Kramer scheme for the speed control of a slip ring IM. How the slip power is effectively utilised in this drive?
3. Explain v/f control of induction motor. Draw the speed torque characteristics. How the speed of induction motor is controlled using Voltage source inverter?

Course Outcome 4 (CO4):

1. Explain power and torque capability curves of a synchronous motor drive. In variable frequency control of synchronous motor drive, why V/f ratio is maintained constant upto base speed and voltage constant above base speed.
2. Explain the true synchronous mode of operation of synchronous motor drive.
3. How can we control the speed of an ac motor drive using field oriented control? Explain with the help of a block diagram
4. With a suitable block diagram explain variable frequency control of synchronous motor drive in self control mode

Course Outcome 5 (CO5):

1. Differentiate trapezoidal type BLDC motor and sinusoidal type PMBLDC motor
2. With neat sketches explain the operation of a switched reluctance motor drive.
3. Explain the principle of operation of PMBLDC motor for 120^0 commutation with neat circuit diagram.
4. With a block diagram explain the micro controller based PMSM drive

Model Question Paper

QP Code: Pages: 2

Reg No: ___________________

Name: ____________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET382
Course Name: POWER SEMICONDUCTOR DRIVES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks

1. What are the different components of a load torque? Explain each components of load torque.
2. Derive the mathematical condition to obtain the steady state stability of an electric drive.
3. Which are the method of speed control suitable for getting speeds higher than base speed and lower than base speed in a dc motor?
4. Explain the regenerative braking operation of a chopper fed dc motor drive with the help of necessary circuit diagram.
5. Explain the speed control of three phase induction motor by varying stator voltage.
6. Explain v/f control of induction motor. Draw the speed torque characteristics.
7. How to control the speed of synchronous motor by using voltage source inverter?
8. Why the field oriented control of ac motor is superior to other types of speed control?
9. Explain about the classification of PM synchronous motor.
10. Compare the construction and performance of BLDC motor and PMAC motor.

(10 x 3 =30)

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) A motor load system has the following details: Quadrants I and II, T= 400-0.4N, N-m, where N is the speed in rpm. Motor is coupled to a active load torque, Tl= ± 200, N-m. Calculate motor speeds for motoring and braking in forward direction. When operating in quadrants III and IV, T= -400-0.4N, N-m. Calculate the equilibrium speed in quadrant III. **(8)**

(b) What are the speed- torque characteristics of pump, fan and traction loads? **(6)**

12. (a) With the help of a neat sketch explain the multi quadrant operation of a motor driving hoist load **(8)**

(b) Explain the operation of closed loop control scheme? What are the importance of current control and speed control loops **(6)**

Module 2

13. (a) A 220 V, 1500 rpm, 11.6 A separately excited motor is controlled by a l-phase fully controlled rectifier with an ac source voltage of 230 V, 50 Hz. Filter inductance is added to ensure continuous conduction for any torque greater than 25 percent of rated torque, Ra = 2 ohm . What should be the value of the firing angle to get the rated torque at 1000 rpm? Ca1culate the firing angle for the rated braking torque and - 1500 rpm. Also ca1culate the motor speed at the rated torque and $\alpha = 160^{o}$ for the regenerative braking in the second quadrant. **(7)**

(b) Explain the operation of four quadrant chopper fed separately excited DC motor drive with necessary diagrams. **(7)**

14. (a) A 220 V, 1000 rpm and 200 A separately excited dc motor has an armature resistance of 0.02Ω. The motor is fed from chopper which provides both motoring and braking operations. The source has a voltage of 230V. Assume CCM. (i) Calculate duty ratio of chopper for motoring operation at rated torque and 400 rpm. (ii)Calculate duty ratio of chopper for braking operation at rated torque and 400 rpm. **(8)**

(b) Draw the circuit diagram and waveforms of a class-C chopper fed DC motor. Explain. Draw its V/I characteristics. **(6)**

Module 3

15. (a) Explain the static Kramer scheme for the speed control of a slip ring IM. Explain the firing angle control of thyristor bridge with constant motor field. **(8)**

(b) Explain the closed loop static rotor resistance control method for the speed control of a slip ring induction motor. What are the disadvantages of this method? **(6)**

16. (a) What is slip power recovery scheme? Describe static Scherbius drive and show that the slip at which it operates is given by S = - (aT /a) cosα, where a and aT pertain to per phase turns ratio for induction motor and transformer respectively. Why it is always suggested to use a transformer in line side converter for static Scherbius drive? **(10)**

(b) Compare speed control of induction motor using VSI and CSI **(4)**

Module 4

17. (a) Explain the different mode of operation of synchronous motor drive by variable frequency control method. **(10)**

(b) Briefly explain the concept of space vector **(4)**

18. (a) With the help of block diagram explain the closed loop speed control of load commutated inverter fed synchronous motor. **(8)**

(b) Explain the frame transformation from three phase to synchronous reference frame. What is its significance in speed control? **(6)**

Module 5

19. (a) With the help of schematic diagram explain microcontroller based permanent magnet synchronous motor drives **(7)**

(b) With suitable converter circuit diagram discuss the modes of operation of Switched Reluctance motor drive. (7)

20. Explain the principle of operation and control circuit of PMBLDC motor for 120° commutation with neat circuit diagram. **(14)**

Syllabus

Module 1

Introduction to electric drives – Block diagram – advantages of electric drives – Dynamics of motor load system, fundamental equations, and types of load – classification of load torque, four quadrant operation of drives. Steady state stability. Introduction to closed loop control of drives.

Module 2

DC motor drives- constant torque and constant power operation, separately excited dc motor drives using controlled rectifiers, single phase semi converter and single phase fully controlled converter drives. Three phase semi converter and fully controlled converter drives.

Chopper controlled DC drives. Analysis of single quadrant chopper drives. Regenerative braking control. Two quadrant chopper drives. Four quadrant chopper drives.

Module 3

Induction Motor Drives-Three phase induction motor speed control using semiconductor devices. Stator voltage control – stator frequency control – Stator voltage and frequency control (v/f) - Voltage source inverter control - Current source inverter control. Rotor chopper speed control – slip power recovery control schemes – sub synchronous and super synchronous speed variations.

Module 4

Synchronous motor drives – Synchronous motor variable speed drives- variable frequency control- modes of variable frequency control. Closed loop speed control of load commutated inverter fed synchronous motor drive .Concept of space vector – Basic transformation in reference frame theory – field orientation principle.

Module 5

Permanent Magnet and variable reluctance motor drives – different types –Sinusoidal PMAC drives-Brushless DC motor drives- control requirements, converter circuits, modes of operation . Microcontroller based permanent magnet synchronous motor drives (schematic only). Switched Reluctance motor drive- converter circuits- modes of operation.

Text Books

1. Bimal K. Bose "Modern power electronics and AC drives" Pearson Education, Asia 2003
2. Gopal K. Dubey. "Fundamentals of Electric Drives" , second edition, Narosa Publishing house

Reference Books

1. Dewan S.B. , G. R. Slemon, A. Strauvhen, "Power semiconductor drives", John Wiley and sons.
2. Dr. P. S. Bimbra "Power electronics", Khanna publishers.
3. Dubey G. K. "Power semiconductor control drives" Prentice Hall, Englewood Cliffs, New Jersey, 1989.
4. N. K. De, P. K. Sen "Electric drives" Prentice Hall of India 2002.
5. Ned Mohan, Tore m Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons.
6. Pillai S. K. "A first course on electric drives", Wieley Eastern Ltd, New Delhi.
7. Vedam Subrahmanyam, "Electric Drives", MC Graw Hill Education, New Delhi.
8. 8.R. Krishnan , "Electric Motor Drives Modeling, Analysis and Control", Prentice Hall of India 2007.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to electric drives (9 hours)**	
1.1	Block diagram – Parts of Electric Drives. advantages of electric drives	2
1.2	Dynamics of motor load system, fundamental torque equations, equivalent value of drive parameters (both rotational and translational motion)	2
1.3	components of load torque ,types of load and classification of load torque	2
1.4	four quadrant operation of drives	1
1.5	Steady state stability- condition for stability of equilibrium point	1
1.6	Introduction to closed loop control of drives- speed, current, torque and position control	1
2	**DC motor drives (10 hours)**	

2.1	Speed control-constant torque and constant power operation	2
2.2	Separately excited dc motor drives using controlled rectifiers- single phase semi converter and single phase fully controlled converter drives.	3
2.3	Three phase semi converter and fully controlled converter drives.	2
2.4	Chopper controlled DC drives- Analysis of single quadrant chopper drives. Regenerative braking control.	1
2.5	Two quadrant chopper drives. Four quadrant chopper drives	2
3	**Induction Motor Drives (8 hours)**	
3.1	Three phase induction motor speed control using semiconductor devices. Stator voltage control – stator frequency control	2
3.2	Stator voltage and frequency control (v/f)	1
3.3	Voltage source inverter control - Current source inverter control.	2
3.4	Static Rotor resistance speed control using chopper	1
3.5	Slip power recovery control schemes – sub synchronous and super synchronous speed variations.	2
4	**Synchronous motor drives (9 hours)**	
4.1	Synchronous motor variable speed drives- variable frequency control- modes of variable frequency control- true synchronous mode and self control mode	3
4.2	Closed loop speed control of load commutated inverter fed synchronous motor drive	2
4.3	Concept of space vector –Basic transformation in reference frame theory.	2
4.4	Principle of vector control- introduction to field oriented control of ac motor drives	2
5	**Permanent Magnet and variable reluctance motor drives (8 hours)**	
5.1	Different types –Sinusoidal PMAC drives-	2
5.2	Brushless DC motor drives- control requirements, converter circuits, modes of operation.	3
5.3	Microcontroller based permanent magnet synchronous motor drives (schematic only).	1
5.4	Switched Reluctance motor drive- converter circuits- modes of operation.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET384	INSTRUMENTATION AND AUTOMATION OF POWER PLANTS	VAC	3	1	0	4

Preamble: This course introduces measurements and instruments used in power plants. Automation of power plants and Supervisory control and data acquisition are also discussed.

Prerequisite: Introduction to Power Engineering/ Energy Systems

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Analyse different instruments used for measuring parameters in a power plant.
CO 2	Explain various control systems in power plants.
CO 3	Identify different components of SCADA for applications in power plants.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										1
CO 2	3	3										1
CO 3	3	3										1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the working of a digital frequency meter (K2)
2. Explain the working of a radiation detector (K2)

Course Outcome 2 (CO2):

1. Compare the performance of boiler following mode and turbine following mode of operation in power plants. (K4).
2. Explain interlocks in boiler operation (K2).

Course Outcome 3 (CO3):

1. Discuss about the various SCADA architectures. Compare them.(K2, K3)
2. Explain the ladder logic approach of programming in a PLC(K2,).

Model Question paper

QP CODE:

PAGES:2

Reg. No:_______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET384

Course Name: INSTRUMENTATION AND AUTOMATION OF POWER PLANTS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain briefly the working principle of an induction type wattmeter.
2. Discuss the role of dust monitor in power plants.
3. Write notes on temperature measurement techniques used in boilers?
4. Discuss how pedestal vibration is measured in boilers?
5. Explain what do you mean by co-ordinated control in boilers.
6. Discuss the role of distributed control system in a power plant.
7. List out the differences between RTUs and IEDs.

8. State the advantages and disadvantages of PLC.
9. Discuss the operating states of a power system.
10. Explain briefly what do you mean by Energy Management System.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a. With the help of a neat diagram, explain the working of a digital frequency meter. **(7)**
    b. Explain how the flow of feed water is measured in power plants. **(7)**

12. a. With the help of a neat sketch, explain the working of a power factor meter. **(10)**
    b. Explain the working of a radiation detector. **(4)**

Module 2

13. a. Explain how flame monitoring is done in boilers. **(6)**
    b. Discuss the pressure measuring devices in boilers. **(7)**

14. a. Describe with a neat schematic, how shaft vibration can be detected. **(7)**
    b. Explain the working of a non contact type speed measuring device. **(7)**

Module 3

15. a. Explain the control of boiler drum level in power plant operation. **(7)**
    b. Explain how steam temperature can be controlled in boilers. **(7)**

16. a. Compare the performance of boiler following mode and turbine following mode of operation in power plants. **(7)**
    b. Explain interlocks in boiler operation. **(7)**

Module 4

17. a. Describe the basic components of a SCADA system. **(4)**
    b. Describe the components of an IED. **(4)**
    c. Explain the ladder logic approach of programming in a PLC **(6)**

18. a. Explain the objectives of SCADA. **(4)**
    b. Discuss about the various SCADA architectures. Compare them. **(10)**

Module 5

19. a. Discuss the main requirements of an Energy Management System. **(4)**
    b. With the help of a diagram, explain what do you understand by an EMS framework. **(10)**

20. Explain the applications of SCADA in generation operation and management. **(14)**

Syllabus

Module 1

Measurements in power plants: Electrical measurements – current, voltage, power, frequency, power factor etc. – non electrical parameters – flow of feed water, fuel, air and steam with correction factor for temperature – steam pressure and steam temperature – drum level measurement – radiation detector – smoke density measurement – dust monitor.

Module 2

Measurement in boiler and turbine: Metal temperature measurement in boilers, piping. System for pressure measuring devices - smoke and dust monitor - flame monitoring. Introduction to turbine supervising system - pedestal vibration - shaft vibration - eccentricity measurement. Installation of non-contracting transducers for speed measurement.

Module 3

Controls in boilers: Boiler drum level measurement methods - feed water control - soot blowing operation - steam temperature control - Coordinated control - boiler following mode operation - turbine following mode operation - selection between boiler and turbine following modes. Distributed control system in power plants interlocks in boiler operation - Cooling system - Automatic turbine runs up systems.

Module 4

Introduction to SCADA systems: - Elements of a SCADA system - benefits of SCADA system - SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system

SCADA System Components: - Remote Terminal Unit-(RTU), Intelligent Electronic Devices (IED) - PLC: Block diagram, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA.

Module 5

SCADA Applications: Operating states of a power system - Energy management System (EMS) – EMS framework – Generation operation and management – Load forecasting – unit commitment – hydrothermal co-ordination – Real time economic dispatch and reserve monitoring – real time automatic generation control

Text books:

1. P. K. Nag,"Power Plant Engineering" 2nd Edition, Tata McGraw-Hill Education, 2002.
2. R.K.Jain, "Mechanical and Industrial Measurements", 10th Edition, Khanna Publishers, New Delhi, 1995.
3. Sam. G.Dukelow, "The Control of Boilers", 2nd Edition, ISA Press, New York, 1991.
4. Stuart A. Boyer, 'SCADA-Supervisory Control and Data Acquisition', Instrument Society of America Publications,USA,2004.

Reference Books:

1. David Lindsley, "Boiler Control Systems", McGraw Hill, New York, 1991.
2. Jervis M.J, "Power Station Instrumentation", Butterworth Heinemann, Oxford, 1993.

Course Contents and Lecture Schedule:

Sl. No	Topic	No. of Lectures
1	**Measurements in a power plant (8 hours)**	
1.1	Electrical measurements – Current, voltage, power, frequency, power factor etc.	2
1.2	Non electrical parameters – Flow of feed water, fuel, air and steam with correction factor for temperature – Steam pressure and steam temperature	2
1.3	Drum level measurement – Radiation detector	2
1.4	Smoke density measurement – Dust monitor.	2
2	**Monitoring (9 hours)**	
2.1	Measurement in boiler and turbine: Metal temperature measurement in boilers, piping.	2
2.2	System for pressure measuring devices, smoke and dust monitor, flame monitoring.	2
2.3	Introduction to turbine supervising system, pedestal vibration	1
2.4	Shaft vibration, eccentricity measurement.	2
2.5	Installation of non-contracting transducers for speed measurement.	2
3	**Control systems (9 Hours)**	
3.1	Controls in boiler: Boiler drum level measurement methods, feed water control, soot blowing operation, steam temperature control	2
3.2	Coordinated control, boiler following mode operation, turbine following mode operation	1
3.3	Selection between boiler and turbine following modes.	1
3.4	Distributed control system in power plants interlocks in boiler operation.	1
3.5	Cooling system, Automatic turbine runs up systems.	2

4	**SCADA systems (10 Hours)**	
4.1	Introduction to SCADA systems: - Elements of a SCADA system - benefits of SCADA system	1
4.2	SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system	2
4.3	SCADA System Components: - Remote Terminal Unit-(RTU),	3
4.4	Intelligent Electronic Devices (IED) - PLC: Block diagram, Ladder diagram, Functional block diagram	3
4.5	Applications, Interfacing of PLC with SCADA.	1
5	**SCADA applications (9 Hours)**	
5.1	SCADA Applications: Operating states of a power system	2
5.2	Energy management System (EMS) – EMS framework	3
5.3	Generation operation and management – Load forecasting – unit commitment	2
5.4	Hydrothermal co-ordination – Real time economic dispatch and reserve monitoring – real time automatic generation control	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET386	**DIGITAL CONTROL**	**VAC**	**3**	**1**	**0**	**4**

Preamble: This course aims to provide a strong foundation in digital control systems. Modelling, time domain analysis, frequency domain analysis and stability analysis of sampled data control systems based on Pulse Transfer function (conventional) approach and State variable concept are discussed. The design of digital control is also introduced.

Prerequisite: Basics of Circuits, Networks and Control Systems

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Describe the role of various control blocks and components in digital control systems.
CO 2	Analyse the time domain responses of the sampled data systems using Z Transform.
CO 3	Analyse the stability of the given discrete time system.
CO 4	Apply state variable concepts to assess the performance of linear systems
CO 5	Apply Liapunov methods to assess the stability of linear systems
CO 6	Explain control system design strategies in discrete time domain.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		-	-	-	-	-	-	-	-	-	1
CO 2	3	2	-	-	2	-	-	-	-	-	-	1
CO 3	3	2	-	-	-	-	-	-	-	-	-	1
CO 4	3	2	-	-	2	-	-	-	-	-	-	1
CO 5	3	2	-	-	-	-	-	-	-	-	-	1
CO 6	3	2	-	-	-	-	-	-	-	-	-	1

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	15	15	40
Apply (K3)	25	25	40
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Derive the transfer function and obtain the frequency response characteristics of zero order hold circuit.
2. Explain how reconstruction of original signal is achieved from discrete time signals.
3. Explain any three factors to be considered for the choice of sampling frequency for a system.

Course Outcome 2 (CO2):

1. Derive the transfer function and obtain the frequency response characteristics of first order hold.
2. Problems related to steady state error.
3. Problems related to ZTF from difference equation form.

Course Outcome 3(CO3):

1. Problems related to the stability analysis using Jury's test
2. Problems related to the stability analysis using Bilinear Transformation
3. Problems to determine range of K or other TF parameter for stability/ oscillation.

Course Outcome 4 (CO4):

1. Problems related to canonical form representations
2. Problems based on state transition matrix
3. Problems to determine the solution of state equations.

Course Outcome 5 (CO5):

1. Check the stability of the given LTI system using Liapunov method.
2. Explain the physical relevance of Liapunov function.
3. Test the stability of the given nonlinear state model.

Course Outcome 6 (CO6):

1. Design a digital controller using root locus approach to meet the required specifications.
2. Problems on PID tuning and selection.
3. Pole placement problems for LTI systems.

Model Question Paper

PAGES: 3

QP CODE:

Reg.No:____________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION
MONTH & YEAR

Course Code**: EET386**

Course Name: **DIGITAL CONTROL**

Max. Marks: 100 **Duration: 3 Hours**

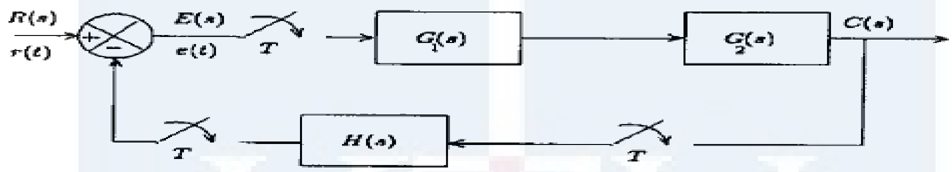
PART A

Answer all Questions. Each question carries 3 Marks

1 Explain any four advantages of sampled data control systems.

2 Determine the z-transform of $x(n)=(1/2)^n u(-n)$.

3 Obtain the pulse transfer function for the given system.



4 Obtain the poles and zeroes of the system governed by the difference equation: $y(n)+\frac{5}{4}y(n-1)+\frac{3}{8}y(n-2)=2x(n)-x(n-1)$

5 Draw and explain the mapping between s- plane to z-plane for the constant frequency loci.

6 Explain how does the P- controller affect the performance of a DT system.

7 Obtain the diagonal canonical form of the system with $G(z)=\frac{z+0.5}{(z^2+1.4z+0.4)}$

8 Determine the state transition matrix for the DT system with state matrix $A=\begin{bmatrix}0 & 1\\ -0.15 & -1\end{bmatrix}$

9 State and explain the Liapunov stability theorem for LTI discrete time systems.

10 Determine the observability of the system with: $A=\begin{bmatrix}-5 & 0\\ -2 & -3\end{bmatrix}; C=\begin{bmatrix}1 & -1\end{bmatrix}$

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11 a) Derive the transfer function of a ZoH circuit. **(5)**

b) Determine the inverse z-transform of the following functions: $i) X(z)=\frac{2z^{-1}}{(1-0.25z^{-1})^2}; ROC: |z|>\frac{1}{4}, and, ii) F(z)=\frac{3z^{-1}}{(1-z^{-1})(1-2z^{-1})}; ROC: |z|>2$ **(9)**

12 a) Determine the Z transform of $H(s)=\frac{3}{s(s+2)^2}$ **(4)**

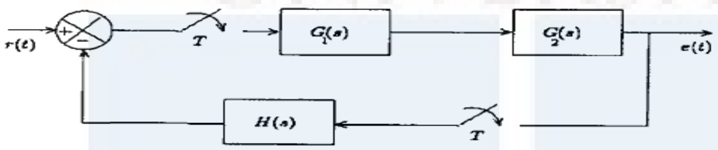
b) Write short notes on:
   i) Aliasing effect
   ii) Importance of First order hold circuit
   iii) Region of convergence for ZT **(10)**

Module 2

13 a) i) Obtain the direct form realization for the system described by the difference equation: $y(n)-\frac{5}{6}y(n-1)+\frac{1}{6}y(n-2)=2x(n)$

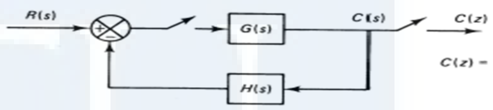
ii) Also determine the impulse response h(n) for the above system. **(3+5)**

b) Obtain the pulse transfer function for the unity feedback system with $G_1(s)=\frac{1}{s}$, $G_2(s)=\frac{1}{(s+2)}$ and assume T=1 second



(6)

14 a) Obtain the unit impulse response C(n) of the following feedback DT system with $G(s)=\frac{1}{(s+3)}, .\, H(s)=\frac{1}{s}$,



Assume ideal sampling and T=1 ms. **(9)**

b) Explain the factors on which the steady state error constants depend on? **(5)**

Module 3

15 a) Check stability of the system described by the following characteristic equation, using Bilinear transformation: $z^3 - 0.2z^2 - 0.25z + 0.05 = 0$ **(7)**

b) With suitable characteristics compare between PI and PD controllers. **(7)**

16 a) For a unity feedback system with $G(z)=\frac{K}{z\,(z^2 - 0.2z - 0.25)}$ determine the range for K for ensuring stability, using Jury's test. **(5)**

b) With help of suitable sketches, explain how can you use root locus technique to design a digital controller. **(9)**

Module 4

17 a) Obtain the phase variable representation for the system with $G(z)=\frac{z+0.5}{(z^3+1.4z^2+0.5\,z+0.2)}$ **(5)**

b) Determine the solution for the homogeneous system x(k+1)= G x(k), where: $G=\begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix}$ and $x(0)=\begin{bmatrix} 1 \\ -1 \end{bmatrix}$ **(9)**

18 a) Determine the pulse transfer function Y(z)/U(z) for the system with:
x(k+1)= G x(k)+ Hu(k) and y(k)= Cx(k)+Du(k),
where $G=\begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix}$, $H=\begin{bmatrix} 1 \\ 1 \end{bmatrix}$ $C=\begin{bmatrix} 1 & 0 \end{bmatrix}$ and D=0 **(9)**

b) Show that for a given pulse transfer function, the states space representation is not unique. **(5)**

a) Determine the stability of the LTI system with state model using Liapunov method: **(9)**

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -5 \end{bmatrix} X$$

b) Determine the controllability of the state model: $\dot{x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 2 \\ 0 & -1 & -7 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$ **(5)**

19 a) Test stability of the nonlinear system given below, using Liapunov method.

$$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3{x_2}^2 & -2 \end{bmatrix} X$$

(4)

b) Design a state feedback controller for the following system such that the closed loop poles are placed at: -1 ± j2 and -10. $\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 2 \\ 0 & -1 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$ **(10)**

Syllabus

Module 1

Digital control system (10 hours)

Basic block diagram of digital control system- Typical examples- Advantages of digital control systems.

Mathematical modelling of sampling process- sampling theorem- Aliasing effect-Impulse train sampling- Zero order and First order hold circuits- Signal reconstruction.

Discrete form of special functions- Discrete convolution and its properties.

Z Transform**:** Region of convergence- Properties of Z transform –- Inverse ZT- methods.

Module 2

Analysis of LTI Discrete time systems (8 hours)

Difference equation representations of LTI systems- Block diagram representation in Direct form

Z-Transfer function- Analysis of difference equation of LTI systems using Z transfer function.

Pulse transfer function: Pulse transfer function of closed loop systems.

Time responses of discrete data systems-Steady state performance-

Static error constants

Module 3

Stability analysis and Digital controllers (9 hours)

Stability analysis: Stability analysis of closed loop systems in the z-plane, Jury's stability test- Use of bilinear transformation for stability analysis.

Digital Controllers: Introduction to Digital Controllers- Root locus based design of digital Controllers.

PID controllers: Digital PID controller and design of PID controllers.

Module 4

State space analysis (8 hours)

State variable model of discrete data systems -Various canonical form representations-controllable, observable forms, Diagonal canonical and Jordan canonical forms

State transition matrix: Properties- Computation of state transition matrix using z-transform method -Solution of homogeneous systems

Determination of transfer function from state space model.

Module 5

Pole placement design and Liapunov stability analysis (10 hours)

Controllability and observability for continuous time systems

Pole placement design using state feedback for continuous time systems

Controllability and observability for discrete time systems- Digital control design using state feedback discrete time systems

Liapunov stability Analysis: Liapunov function- Liapunov methods to stability of linear and nonlinear systems- Liapunov methods to LTI continuous time systems

Liapunov methods to LTI Discrete time systems (Theorem only).

Text Books:

1. Ogata K., Discrete Time Control Systems, 2/e, Pearson Education.
2. Kuo B. C, Digital Control Systems, 2/e, Saunders College Publishing, Philadelphia, 1992.
3. Gopal M, Digital Control and State Variable Methods, 2/e, Tata McGraw Hill
4. Philips C. L., Nagle H. T. and Chakraborthy A,, Digital Control Systems, 4/e, Pearson

References:

1. Constantine H. Houpis and Lamont G. B., Digital Control Systems Theory, Hardware Software, 2/e, McGraw Hill.
2. Isermann R., Digital Control Systems, Fundamentals, Deterministic Control, 2/e, Springer Verlag, 1989.
3. Liegh J. R, Applied Digital Control, 2/e, Dover Publishers.
4. Gopal M, Modern Control System Theory, 2/e, New Age Publishers

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**Digital control system (10 hours)**	
1.1	Basic block diagram of digital control system- Typical examples- Advantages of digital control systems.	1
1.2	Mathematical modelling of sampling process -sampling theorem- Aliasing effect- Impulse train sampling	2
1.3	Zero order and First order hold circuits- Signal reconstruction	2
1.4	Discrete form of special functions- Discrete convolution and its properties	1
1.5	Z Transform: Region of convergence- Properties of the Z transform –	2

1.6	Inverse ZT- methods	2
2	**Analysis of LTI Discrete time systems (8 hours)**	
2.1	Difference equation representations of LTI systems- Delay operator and block diagram representation in Direct form	1
2.2	Z-Transfer function- Analysis of difference equation of LTI systems using ZTF	2
2.3	Pulse transfer function: Pulse transfer function of closed loop systems	2
2.4	Time responses of discrete data systems-Steady state performance-static error constants	3
3	**Stability analysis and Digital controllers (9 hours)**	
3.1	Stability analysis: Stability analysis of closed loop systems in the z-plane, Jury's stability test.	2
3.2	Use of bilinear transformation and extension of Routh-Hurwitz criterion for stability.	2
3.3	Digital Controllers: Introduction to Digital controllers- Root locus based design of Digital controllers.	3
3.4	PID controllers: Digital PID controller and design of PID controllers.	2
4	**State space analysis (8 hours)**	
4.1	State variable model of discrete data systems -Various canonical form representations-controllable and observable forms	2
4.2	Diagonal canonical and Jordan forms	2
4.3	State transition matrix- properties- Computation of state transition matrix using z-transform method	2
4.4	Solution of homogeneous systems	1
4.5	Determination of pulse transfer function from state space model	1
5	**Pole placement design and Liapunov Stability Analysis (10 hours)**	
5.1	Controllability and observability for continuous time systems	2
5.2	Pole placement design using state feedback for continuous time systems	2
5.3	Controllability and observability for discrete time systems- Digital control design using state feedback discrete time systems	3
5.4	Liapunov stability Analysis: Liapunov function- Liapunov methods to stability of linear and nonlinear systems- Liapunov methods to LTI continuous time systems	2
5.5	Liapunov methods to LTI Discrete Time systems (Theorem only).	1

SEMESTER VI

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET394	GENERALIZED MACHINE THEORY	VAC	4	0	0	4

Preamble: Nil

Prerequisite: DC Machines and Transformers. Synchronous and Induction machines

Course Outcomes: After the completion of the course, the student will be able to:

CO 1	Develop the basic two pole model representation of electrical machines using the basic concepts of generalized theory.
CO 2	Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance.
CO 3	Apply linear transformation for the steady state and transient analysis of different types of rotating electrical machines.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2	2	-	-	-	-	-	-	-	-	**2**
CO 2	3	3	2	**2**	-	-	-	-	-	-	-	**2**
CO 3	3	3	3	**2**	-	-	-	-	-	-	-	**2**

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
Remember	5	5	10
Understand	10	10	20
Apply	35	35	70
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions.

Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Part A: 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Kron's Primitive Machine of rotating electrical machines.
2. Describe the essential features of rotating electrical machines.
3. Draw the basic two pole machine diagram of DC Compound Machine.
4. Develop an expression for the electrical torque of the Kron's Primitive Machine.

Course Outcome 2 (CO2):

1. What are the advantages of having power invariance in transformations.
2. Deduce Parks transformations relating three phase currents to its corresponding d- q axis currents.
3. Draw the generalized model of a DC series machine and derive the voltage equation in matrix form.
4. Explain the physical significance of Park's transformations.

Course Outcome 3 (CO3):

1. Explain the steady state analysis of a separately excited DC motor and derive the expression for electromagnetic torque. Also plot the shunt characteristics and speed versus armature voltage characteristics.
2. Obtain the expression for the steady state torque when balanced poly phase supply is impressed on the stator winding of three phase Induction motor
3. Draw the equivalent circuit of a three phase induction motor with the help of its generalized model.
4. Investigate the transient behaviour of a separately excited DC generator under the following operating condition: sudden application of a step field excitation to the field under no load, i_a =0 and for constant no load speed ω_{r0} and explore the variation of armature voltage.

Model Question paper

QP CODE:

PAGES: 2

Reg.No:______________

Name:________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR

Course Code: EET394
Course Name: GENERALIZED MACHINE THEORY

Max. Marks: 100 **Duration: 3 Hrs**

PART A

Answer all questions. Each Question Carries 3 marks

1. Sketch the basic two pole representation of the following machines
   i) DC shunt machine with interpoles ii) DC compound machine
2. Explain linear transformations as used in electrical machines.
3. What is Kron's primitive machine?
4. Enumerate the limitations of generalized theory of electrical machines.
5. Derive an expression for rotational mutual inductance or motional inductance of DC generator
6. Derive the transfer function of separately excited DC motor under on no load operation.
7. Draw the power angle characteristics of salient pole and cylindrical rotor synchronous machine.
8. Draw the torque slip characteristics of three phase Induction motor.
9. Explain equivalent circuit of single phase Induction motor.
10. Compare single phase and poly phase Induction motor.

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) Write the voltage equations for Kron's primitive machine in matrix form. **(9)**
    b) Derive the expression for transformer and speed voltages in the armature along the quadrature axis. **(5)**
12. Derive electrical torque expression of Kron's primitive machine in terms of reluctance and show that no torque is produced by interaction between flux and current on the same axis. **(14**

Module 2

13. Explain Park's transformations to transform currents between a rotating balanced three phase (a, b, c) winding to a pseudo stationary two phase (d, q) winding. Assume equal number of turns on all coils **(14)**

14. a) Explain the physical concept of Park's transformation **(7)**

b) Explain the term invariance of power as applied to electrical machines. Show the power invariance is maintained under this transformation. **(7)**

Module 3

15. a) Derive the voltage and torque equation of a DC series motor from its generalized mathematical model. **(7)**

b) Obtain the steady state analysis of a separately excited DC motor and plot the shunt characteristics. Also derive the expression for torque. **(7)**

16. a) A separately excited DC generator gives a no load output voltage of 240 V at a speed of ωr and a field current of 3 A. Find the generated emf per field ampere, Kg. **(5)**

b) Investigate the transient behaviour of a separately excited DC generator under the following operating condition:

i) Sudden application of a step field excitation to the field under no load, i_a =0 and for constant no load speed ωr0 and explore the variation of armature voltage. **(9)**

Module 4

17) a) Derive the power expression for salient pole synchronous machine in terms of load angle δ and draw the power angle characteristics. **(7)**

b) Derive the voltage equations in matrix form for a three phase synchronous machine with no amortisseurs. **(7)**

18) Derive the equivalent circuit of a poly phase induction motor with the help of its generalized mathematical model. **(14)**

Module 5

19) Derive the electromagnetic torque equations from the primitive machine model of a single phase induction motor by applying cross field theory. **(14)**

20) Explain the double field revolving theory of single phase Induction motor. **(14)**

Syllabus

Module 1

Unified approach to the analysis of electrical machine performance - per unit system - Basic two polemodel of rotating machines- Primitive machine -Conventions -transformer and rotational voltages in the armature voltage and torque equations, resistance, inductance and torque matrix.

Module 2

Transformations-passive linear transformation in machines-invariance of power-transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes-Physical concept of Park's transformation.

Module 3

DC Machines: Application of generalized theory to separately excited DC generator: steady state and transient analysis, Separately excited DC motor- steady state and transient analysis, Transfer function of separately excited DC generator and motor- DC shunt and series motors: Steady state analysis and characteristics.

Module 4

Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves.

Induction Machines: Primitive machine representation. Transformation- Steady state operation-Equivalent circuit. Torque slip characteristics.

Module 5

Single phase induction motor- Revolving Field Theory equivalent circuit- Voltage and Torque equations-Cross field theory-Comparison between single phase and poly phase induction motor.

Text Books

1) Bhimbra P. S., "Generalized Theory of Electrical Machines", Khanna Publishers, 6^{th}edition, Delhi 2017.
2) Charles V. Johnes, "Unified Theory of Electrical Machines". New York, Plenum Press, 1985.
3) Bernad Adkins, Ronald G Harley, "General theory of AC Machines". London, Springer Publications, 2013.

Reference Books

1) Charles Concordia," Synchronous Machines- Theory and Performance", John Wiley and Sons Incorporate, Newyork.1988.
2) Say M. G., "Introduction to Unified Theory of Electrical Machines", Pitman Publishing, 1978.

3) Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill, 2nd revised edition, 2001.

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Two pole Model (10 Hours)**	
1.1	Introduction- Essentials of rotating machines-Electromechanical energy conversion. Conventions.	1
1.2	Idealised machine diagram of DC Compound machine, DC shunt machine, Synchronous motor, Induction motor, Single phase AC motor.	2
1.3	Per unit system, Advantages of per unit system, Expression for self inductance of a machine, Mutual flux linking.	1
1.4	Transformer and speed voltages in the armature, transformer with movable secondary.	2
1.5	Kron's primitive machine, Leakage flux in machines with more than two windings. Fundamental assumptions.	2
1.6	Voltage equations, Stator field coils, Armature coils, Equations of armature voltage in matrix form,	2
2	**Linear Transformations (8 Hours)**	
2.1	Linear transformation in machines- power invariance, Transformations from a displaced brush axis.	2
2.2	Transformations from three phase to two phase (a,b,c) to (α,β,0) transformation matrix.	3
2.3	Transformation from rotating axes (α,β,0) to stationary axes (d,q,0).	2
2.4	Power invariance: problems on transformations	1
3	**DC Machines (10 Hours)**	
3.1	DC machines, Separately excited DC generators, Rotational mutual inductance, Steady state and transient analysis, Armature terminal voltage.	2
3.2	Transfer function of DC machines, Separately excited generator under no load and loaded condition, Numerical Problems.	2
3.3	Steady state analysis and Shunt characteristics of DC machine.	2

3.4	DC series motor, Schematic diagram of Primitive model, Interconnection between armature and field, Torque and speed expression, Different characteristics.	2
3.5	DC shunt motor, Schematic diagram, primitive model, Steady state analysis, Torque-Current and Speed-Current characteristics, Condition for maximum torque.	2
4	**Synchronous and Three Phase Induction Motors(10 Hours)**	
4.1	Poly phase Synchronous machine, Basic structure, Assumptions, Parameters, Synchronous resistance, inductance and mutual inductance between armature and field.	2
4.2	Armature self-inductance, Armature mutual inductance, General synchronous machine parameters, Amplitude of second harmonic component.	2
4.3	Steady state power angle characteristics, reluctance power, Cylindrical rotor machine and salient pole machine, Phasor diagram, Pull out torque, Maximum power.	2
4.4	Polyphase induction machine, Voltage expression, Transformations fromαβ to d-q and vice versa, Expression for electromagnetic torque.	2
4.5	Steady state analysis, Voltage equation in new variables, Connection matrix,	1
4.6	Equivalent circuit of an induction machine, Short circuited and open circuited two winding transformer.	1
5	**Single Phase Induction Motors(7 Hours)**	
5.1	Single phase induction motor, Basic structure, Assumptions, Primitive Machine Model.	2
5.2	Electrical Performance Equations, Voltage Matrix.	2
5.3	Steady state analysis, Equivalent Circuit	2
5.4	Numerical Problems	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET396	ANALYSIS OF POWER ELECTRONIC CIRCUITS	VAC	3	1	0	4

Preamble: To impart knowledge about analysis and design of various power converters.

Prerequisite : Electric circuit theory

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Choose appropriate power semiconductor device along with its driver circuits and protection.
CO 2	Analyse the operation of controlled rectifier circuits and PWM rectifiers.
CO 3	Analyse inverter circuits with different modulation strategies.
CO 4	Analyse the operation of DC-DC converters andAC voltage controllers.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	20	20	40
Apply (K3)	20	20	40
Analyse (K4)			
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Choose appropriate power semiconductor device along with its driver circuits and protection.

1. Compare ideal and real power electronic switches. (K1)
2. Explain the static and dynamic characteristics MOSFET and IGBT. (K2)
3. Choose the appropriate power electronic switch for a converter. (K3)
4. Illustrate the operation of driver and snubber circuits for power electronic switches. (K2)
5. Design a heat sink for a power electronic switch. (K3)

Course Outcome 2 (CO2): Analyse the operation of controlled rectifier circuits and PWM rectifiers.

1. Analyse the operation of full and semi converters for single and three phase applications working with RLE loads. (K2), (K3)
2. Analyse the effect of source inductance in full converters. (K2), (K3)
3. Explain the operation of phase controlled rectifiers in inversion mode.(K2)
4. Explain the different topologies and control of PWM rectifiers. (K2)
5. Mathematically show the effect of single phase rectifiers on neutral currents in three phase four wire systems. (K2), (K3)
6.

Course Outcome 3 (CO3): Analyse inverter circuits with different modulation strategies.

1. Analyse the operation of single and three phase inverters with RL loads. (K2), (K3)
2. Explain unipolar and bipolar sinusoidal pulse width modulation. (K2)
3. Design output filters for inverters. (K3)
4. Describe the types and working of multilevel inverters. (K1), (K2)
5. Explain the various current control methods of voltage source inverter. (K2)

Course Outcome 4 (CO4): Analyse the operation of DC- DC converters and AC voltage controllers.

1. Analyse the operation of single, two and four quadrant dc choppers. (K4)
2. Describe the control methods of dc choppers. (K2)
3. Design input filter for dc choppers. (K4)

4. Explain the working of multiphase choppers. (K2)

5. Analyse the operation of three phase ac voltage controllers with R load. (K4)

Model Question paper

QP CODE:

PAGES: 2

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION
MONTH & YEAR
Course Code: EET396

Course Name: ANALYSIS OF POWER ELECTRONIC CIRCUITS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Draw and explain a snubber circuit for a power MOSFET.
2. Compare the characteristics of ideal and real switches.
3. Why do the triple harmonics dominate in three phase four wire system with balanced rectifier loads?
4. Derive the expression for output voltage of half wave controlled rectifier with resistive load.
5. What is the significance of common mode voltage in inverters.
6. What are the merits of unipolar modulation technique for inverters over bipolar.
7. Derive an expression for average output voltage in terms of input dc voltage andduty cycle for a step down dc chopper.
8. Using a two phase dc chopper, bring out its advantages compared to a single chopper.
9. Develop the expression for power factor for an ac voltage controller using integral cycle control.
10. List the merits and demerits of Hysteresis current controller.

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) A 100 V dc supply is connected to a resistance of 7 Ohms through a series static controlled switch. The ON state forward voltage drop of the switch is 2 V. Its forward leakage current in the OFF state is 2 mA. It is operated with a switching frequency of 1 kHz and a duty cycle of 30%. Neglect the switching transition times

and determine the peak and average power dissipation in the switch. Also find the proportion in which this power dissipation is shared between the ON state dissipation and OFF state dissipation. **(5)**

b) Draw and explain the static and dynamic characteristics of IGBT. **(9)**

12. a) Explain the design of a driver circuit for MOSFET. **(7)**

b) A MOSFET that is used in a dc-dc converter is dissipating 50W. The thermal resistance to conduction from the junction to the case is 0.5 deg K/W and the thermal resistance to conduction from the case to the heat sink is 1.5 deg K/W. If the ambient temperature in the neighbourhood of the heat sink is 50 deg C, then calculate the thermal resistance requirement for the heat sink if the junction temperature does not exceed 100 deg C. **(7)**

Module 2

13. a) Derive the input PF of a single phase controlled rectifier with continuous and ripple-free load current. **(6)**

b) With necessary mathematical analysis, show the effect of source inductance on the output voltage of a single phase controlled bridge rectifier. **(8)**

14. a) Describe the working of 3-phase fully controlled converter with the help of circuit diagram. **(6)**

b) A three phase fully controlled bridge converter is connected to 415 V supply, having a reactance of 0.3 Ohm/phase and resistance of 0.05 Ohm/phase. The converter is working in the inversion mode at a firing advance angle of 35 deg. Compute the average generator voltage. Assume I_d = 60 A and thyristor drop = 1.5 V. **(8)**

Module 3

15. A single phase bridge inverter supplies an R-L load with R=10 Ohms and L=50mH from a 220 V dc supply. If the inverter frequency is 50 Hz, calculate i) rms value of fundamental component of load current ii) THD of load current iii) total power delivered to the load and iv) fundamental power output. **(14)**

16. Three single phase H bridge inverter circuits are available. What is the level of multilevel inverter that can be formed using them? Draw its circuit diagram and the important waveforms. Give a table showing the switch combination to be turned ON to get each level. **(14)**

Module 4

17. With a neat circuit diagram and waveforms, explain how four-quadrant operation is achieved in a Type-E Chopper. **(14)**

18. a) Explain the working of two quadrant type-A chopper with relevant waveforms. **(8)**

b) A step up chopper has input voltage of 120V and output voltage of 360 V. Ifthe conducting time of the thyristor chopper is 100 μs, compute the pulse width of output voltage. **(6)**

Module 5

19. A three phase three wire bidirectional controller supplies a star connected resistive load of R=5 Ohms and the line to line input voltage is 210 V, 50 Hz. The firing angle is π/3. Determine i) the rms output phase voltage ii) the input power factor and iii) the expression for the instantaneous output voltage of phase a. **(14)**

20. (a) What are the challenges faced by the conventional rectifier circuits? Justify. **(5)**

(b) Explain the working of any two PWM rectifier circuits to mitigate these issues. With block diagrams, discuss their control strategy. **(9)**

Syllabus

Module 1 (8 hours)

Overview of solid state devices

Characteristics of Ideal and Real switches - Static and Dynamic Characteristicsfor MOSFET and IGBT, Driver circuit and Snubbers for MOSFET and IGBT – Conduction and Switching loss - Power dissipation and selection of heat sink.

Module 2 (10 hours)

Phase controlled Rectifiers

Single-phase converter - full converter and semi converter - analysis with RLE loads – input PF with continuous and ripple free load current - inversion mode – effect of source inductance – Effect of single phase rectifiers on neutral currents in three phase four wire systems.

Three-phase converter - Full converter & semi converter – analysis with RLE loads – continuous conduction only – inversion mode - effect of source inductance –line notching and distortion.

Module 3 (10 hours)

Inverters

Single phase full Bridge Inverters –Analysis with RL load - Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage; PWM principle - Sinusoidal pulse width modulation- Unipolar and Bipolar modulation, Effect of blanking time on voltage of PWM inverter, output filter design.

Multilevel Inverters

Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters

Module 4 (7 hours)

DC Choppers

Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers, PWM control-Time ratio control – Current limit control, Source filter and its design, multiphase chopper.

Module 5 (6 hours)

AC voltage controllers

Three phase AC Voltage Controllers-Principle, operation and analysis with R loads

Current control of VSI

Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control

PWM rectifiers

Single phase PWM rectifiers –Basic topologies and control

Text Books

1. Joseph Vithayathil, Power Electronics: Principles and Applications, Tata McGraw Hill 2010.
2. Mohan, Undeland, Robbins, Power Electronics; Converters, Applications and Design. -3rd edition, John Wiley and Sons, 2003.
3. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, 2013.

Reference Books

1. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
2. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
3. M H Rashid (Ed), Power Electronics Handbook: Devices, Circuits and Applications,Academic Press 2010.
4. José Rodríguez, *et al,* Multilevel Inverters: A Survey of Topologies, Controls, and Applications, IEEE Transactions on Industrial Electronics, vol. 49, no. 4, August 2002.

Total Lecture Hours: 45

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Overview of solid state devices (8 hours)**	
1.1	Characteristics of Ideal and Real switches	1
1.2	Static and Dynamic Characteristics for MOSFET and IGBT	2
1.3	Driver circuit and Snubbers for MOSFET and IGBT	2
1.4	Conduction and Switching loss	1
1.5	Power dissipation and selection of heat sink	2
2	**Phase controlled Rectifiers (10 hours)**	
2.1	Single-phase converter - full converter and semi converter - analysis with RLE loads	2
2.2	Input PF with continuous and ripple free load current - inversion mode	1
2.3	Effect of source inductance.	1
2.4	Effect of single phase rectifiers on neutral currents in three phase four wire system	1
2.5	Three-phase converter - Full converter & semi converter – analysis with RLE loads - continuous conduction only	2
2.6	Inversion mode - Effect of source inductance	2
2.7	line notching and distortion	1
3	**Inverters (10 Hours)**	
3.1	Single phase full Bridge Inverters – Analysis with RL load	1
3.2	Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage	2
3.3	PWM principle - Sinusoidal pulse width modulation - Unipolar and Bipolar modulation	2
3.4	Effect of blanking time on voltage of PWM inverter, output filter design	2
	Multilevel Inverters	
5.2	Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters	3
4	**DC Choppers (7 Hours)**	
4.1	Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers	3
4.2	PWM control-Time ratio control – Current limit control	2

4.3	Source filter and its design	1
4.4	Multiphase chopper	1
5	**AC voltage controllers (6 Hours)**	
5.1	Three phase AC Voltage Controllers - Principle, operation and analysis with R loads	2
	Current control of VSI	
5.3	Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control	2
	PWM rectifiers	
5.4	Single phase PWM rectifiers –Basic topologies and control	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET398	OPERATION AND CONTROL OF POWER SYSTEMS	VAC	3	1	0	4

Preamble: This course introduces analysis techniques for the operation and control of power systems. Load dispatch and scheduling of energy are discussed. Power system security and state estimation are introduced. This course serves as the most important prerequisite of many advanced courses in power systems.

Prerequisite: Power Systems I

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyse various methods of generation scheduling.
CO 2	Formulate hydro-thermal scheduling problems.
CO 3	Evaluate power exchange in interconnected power systems.
CO 4	Analyse security issues in power system networks.
CO 5	Analyse various state estimation methods.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2								2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3	2	2								2
CO 5	3	3										2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which students should answer any one question. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain economic dispatch and unit commitment (K1)
2. Problems on optimal load dispatch (K2, K3)

Course Outcome 2 (CO2):

1. Distinguish between the long term and short term scheduling. (K2)
2. Explain how scheduling of energy can be done with limited supply. (K2, K3)

Course Outcome 3 (CO3):

1. Discuss the advantages and disadvantages of power pools (K2).
2. Explain what do you mean by interchange evaluation with unit commitment (K2, K3).

Course Outcome 4 (CO4):

1. What is system security? Explain the major factors involved in system security (K2)
2. Explain the effects of generator outages in power systems. (K2, K3).

Course Outcome 5 (CO5):

1. Discuss in detail, what do you mean by network observability.(K1)
2. Explain any one method by which bad measurements can be detected. (K2).

Model Question paper

QP CODE:

PAGES: 2

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: EET398

Course Name: OPERATION AND CONTROL OF POWER SYSTEMS

Max. Marks: 100.Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain what do you mean by economic dispatch.
2. Discuss the different constraints in unit commitment.
3. Differentiate between long range and short term generation scheduling.
4. Write short notes on pumped storage hydro plants
5. Explain what do you mean by power pools.
6. Write short notes on energy banking.
7. Illustrate the importance of power system security
8. What do you mean by contingency analysis?
9. Elaborate on the importance of state estimation in power system.
10. What are the sources of errors in state estimation?

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. What do you mean by optimal load dispatch? Explain any one method by which optimal load dispatch can be done. (14)

12 a. With the help of a flowchart, explain the priority list method of unit commitment. (10)

b. Write notes on security constrained unit commitment. (4)

Module 2

13. a. Explain any one method by which short term hydrothermal co-ordination can be done. (7)

b. Explain how hydroelectric plants are modelled for scheduling problems. (7)

14. a. Explain how scheduling of energy can be done with limited supply. (7)

b. Explain any one method by which hydrothermal scheduling with storage limitation can be done. (7)

Module 3

15. a. Explain the advantages of economy interchange between interconnected utilities. (7)

b. Explain the different types of interchange contracts. (7)

16. a. Discuss the advantages and disadvantages of power pools (7)

b.Explain what do you mean by interchange evaluation with unit commitment. (7)

Module 4

17. With the help of a flowchart, explain contingency analysis using sensitivity factors. (14)

18. a. What is system security? Explain the major factors involved in system security (9)

b. Explain the effects of generator outages in power systems. (5)

Module 5

19. a) Explain how quantities which are not measured can be estimated. (7)

b) Discuss in detail, what do you mean by network observability. (7)

20. a) Explain any one method by which bad measurements can be detected. (10)

b)List out the advantages of state estimation in power systems. (4)

Syllabus

Module 1

Introduction- Optimum load dispatch - First order gradient method base point and participation factors.
Economic dispatch versus unit commitment.
Unit Commitment Solution Methods - Priority-List Methods – SecurityConstrained Unit Commitment.

Module 2

Generation with limited supply-Take or pay fuel supply contract- Introduction to Hydro-thermal coordination-Long range and short range scheduling

Hydro-electric plant models-scheduling energy problems - types of scheduling problems-Scheduling energy - The Hydrothermal Scheduling Problem - Hydro scheduling with storage limitation - Introduction to Pumped storage hydro plants

Module 3

Inter change evaluation and power pools- Interchange contracts – Energy interchange between utilities - Interchange evaluation with unit commitment - Energy banking- power pools.

Module 4

Power system security- Factors Affecting Power System Security - Contingency Analysis: Detection of Network Problems - Generation Outages - Transmission Outages - An Overview of Security Analysis

Module 5

Introduction to State estimation in power system, Maximum Likelihood Weighted Least-Squares Estimation - State Estimation of an AC Network - Sources of Error in State Estimation - Detection and Identification of Bad Measurements - Estimation of Quantities Not Being Measured - Network Observability and Pseudo-measurements - The Use of Phasor Measurement Units (PMUs) - Application of Power Systems State Estimation - Importance of Data Verification and Validation

Text books:

1. Allen J. Wood, Bruce F. Wollenberg&Gerald B. Sheblé, "Power Generation, Operation, and Control", 3rd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey.

2. John Gainger& William Stevenson, "Power System Analysis", McGraw-Hill, Inc, , 1994.

References:

1. Ali Abur,Antonio Gómez Expósito, Power System State Estimation:Theory and Implementation, CRC Press, 2004.

Course Contents and Lecture Schedule:

Sl. No.	Topic	No. of Lectures
1	**Load Dispatch (9 hours)**	
1.1	Review of economic load dispatch	1
1.2	Optimum load dispatch	2
1.3	First order gradient method base point and participation factors.	2
1.4	Economic dispatch versus unit commitment - Unit Commitment Solution Methods - Priority-List Methods	2
1.5	Security-Constrained Unit Commitment	2
2	**Generation Scheduling (9 hours)**	

2.1	Generation with limited supply-Take or pay fuel supply contract	2
2.2	Introduction to Hydro-thermal coordination-Long range and short range scheduling	1
2.3	Hydro-electric plant models	1
2.4	Scheduling energy problems - types of scheduling problems- Scheduling energy	2
2.5	The Hydrothermal Scheduling Problem	2
2.6	Introduction to Pumped storage hydro plants	1
3	**Interchange evaluation and power pools (9 Hours)**	
3.1	Interchange Contracts	2
3.2	Energy Interchange between Utilities	2
3.3	Interchange evaluation with unit commitment	1
3.4	Energy banking	2
3.5	Power pools	2
4	**Power system security (7 Hours)**	
4.1	Factors affecting Power System Security	2
4.2	Contingency Analysis	1
4.3	Detection of Network Problems	1
4. 4	Generation Outages	1
4. 5	Transmission Outages	1
4. 6	An overview of Security Analysis	1
5	**State estimation in power system (9 Hours)**	
5.1	State estimation in power system - Maximum Likelihood Weighted Least-Squares Estimation	2
5.2	State Estimation of an AC Network - Sources of Error in State Estimation	2
5.3	Detection and Identification of Bad Measurements	1
5.4	Estimation of Quantities Not Being Measured	1
5.5	Network Observability and Pseudo-measurements	1
5.6	The Use of Phasor Measurement Units (PMUS)	1
5.7	Application of Power Systems State Estimation - Importance of Data Verification and Validation	1

SEMESTER VII

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET401	ADVANCED CONTROL SYSTEMS	PCC	2	1	0	3

Preamble: This course aims to provide a strong foundation on advanced control methods for modelling, time domain analysis, and stability analysis of linear and nonlinear systems. The course also includes the design of feedback controllers and observers.

Prerequisite: EET 305 Signals and Systems, EET 302 Linear Control Systems

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Develop the state variable representation of physical systems
CO 2	Analyse the performance of linear and nonlinear systems using state variable approach
CO 3	Design state feedback controller for a given system
CO 4	Explain the characteristics of nonlinear systems
CO 5	Apply the tools like describing function approach or phase plane approach for assessing the performance of nonlinear systems
CO 6	Apply Lyapunov method for the stability analysis of physical systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	-	-	-	-	-	-	-	-	-	2
CO 2	3	3	2	-	-	-	-	-	-	-	-	2
CO 3	3	3	3	-	-	-	-	-	-	-	-	2
CO 4	3	2	-	-	-	-	-	-	-	-	-	2
CO 5	3	3	2	-	-	-	-	-	-	-	-	2
CO 6	3	3	2	-	-	-	-	-	-	-	-	2

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	15	15	30
Apply (K3)	25	25	50
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern: There will be two parts; Part A and Part B.

Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Derive the state model of an armature controlled DC servo motor. (K2, PO1)
2. Obtain the phase variable representation for the system with G(s)= $T(s) = \frac{2s^2 + s + 3}{s^3 + 6s^2 + 11s + 6}$ (K3, PO1, PO2)
3. Problems on deriving the state model of a given electrical circuit. (K2, PO1)
4. Problems on the conversion of Phase variable form to Canonical form. (K3, PO1, PO2)

Course Outcome 2 (CO2):

1. Obtain the time response y(t) of the homogeneous system:
   $\dot{X} = \begin{bmatrix} -1 & 1 \\ -2 & -3 \end{bmatrix} x, \quad y = \begin{bmatrix} 1 & 1 \end{bmatrix} x$ and $x(0)^T = \begin{bmatrix} 1 & 0 \end{bmatrix}$ (K3, PO1, PO2)
2. Determine the transfer function for the system with the state model:
   $\dot{X} = \begin{bmatrix} -2 & 1 \\ -3 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u; \quad y = \begin{bmatrix} 1 & 1 \end{bmatrix} x$. (K3, PO1, PO2)
3. Determine the controllability of the following state model:
   $\dot{x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 2 \\ 0 & -1 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$ (K3, PO1, PO2, PO3)

Course Outcome 3(CO3):

1. Design a state feedback controller for the following system such that the closed loop poles are placed at: -1 ± j2 and -12.
   $\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 2 \\ 0 & -1 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$ (K3, PO1, PO2, PO3)
2. Design problems on State observer. (K3, PO1, PO2, PO3)

Course Outcome 4 (CO4):

1. Explain the linearization concept and assumptions made referred to Describing Function analysis. (K1, PO1)
2. With suitable characteristics explain the jump resonance phenomena. (K2, PO1, PO2)
3. Differentiate between linear and nonlinear systems referred to:
   i) frequency response, ii) sustained oscillations. (K2, PO1, PO2)
4. Identify and explain the type of singular points for the following two systems:
   i) $\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & 3 \end{bmatrix} X$ and ii) $\dot{X} = \begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix} X$. (K3, PO1, PO2)

Course Outcome 5 (CO5):

1. Problems related to the derivation of describing function of a common nonlinearity. (K2, PO1, PO2)
2. Problems related to application of describing function for analysing the stability of given closed loop system. (K3, PO1, PO2, PO3)
3. Obtain the phase trajectory of the system with $\ddot{y} + 6\dot{y} + 5y = 0$, for initial point $x(0)^T = [1 \;\; 0.6]$. Use Isocline method. Also, identify the type of singular point. (K3, PO1, PO2, PO3)

Course Outcome 6 (CO6):

1. Use Lyapunov Direct method to determine the value of K such that the given LTI system is stable.

   $$\dot{X} = \begin{bmatrix} 0 & K \\ -2 & -1 \end{bmatrix} X$$. (K3, PO1, PO2, PO3)

2. Determine the stability of the LTI system with state model: $\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -5 \end{bmatrix} X$
   (K3, PO1, PO2, PO3)
3. Test stability of the nonlinear system given below, using Lyapunov method.

   $$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3x_2^{\,2} & -2 \end{bmatrix} X$$ (K3, PO1, PO2, PO3)

Model Question Paper

PAGES: 3

QP CODE:
Reg.No:_____________
Name:______________

APJ ABDULKALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B.TECH DEGREE EXAMINATION
MONTH & YEAR

Course Code: **EET401**

Course Name: **ADVANCED CONTROL SYSTEMS**

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1 Selecting $i_1(t) = x_1(t)$ and $i_2(t) = x_2(t)$ as sate variables obtain state equation and output equation of the network shown.

2 Obtain the diagonal canonical representation for the system with the transfer function:

$$T(s) = \frac{s+2}{s^2 + 0.7s + 0.1}$$

3 Determine the transfer function for the system with state model:

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ 0 & -2 \end{bmatrix} x + \begin{bmatrix} 2 \\ 0 \end{bmatrix} u; \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} x.$$

4 Explain any four properties of state transition matrix.

5 Determine the controllability of the following state model:

$$\dot{x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 1 \\ 0 & -1 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

6 Explain the significance of PBH test for observabilty.

7 With suitable characteristics explain the jump resonance phenomena in nonlinear systems.

8 Obtain the describing function of deadzone non-linearity.

9 Determine given quadratic form is positive definite or not:

$V(x) = 10x_1^{\,2} + 4x_2^{\,2} + x_3^{\,2} + 2x_1 x_2 - 2x_2 x_3 - 4x_1 x_3$

10 Use Lyapunov theorem to determine test stability of the nonlinear system given below.

$$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3x_2^{\,2} & -2 \end{bmatrix} X$$

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11 a) Obtain the phase variable representation for the system with transfer function:

$$T(s) = \frac{2s^2 - 3}{s^3 + 6s^2 + 11s + 6}$$

(7 Marks)

b) Derive the state model of an armature controlled DC servo motor. (7 Marks)

12 a) Determine the diagonal canonical representation for the system:

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ -3 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u ; \quad y = \begin{bmatrix} 1 & -1 \end{bmatrix} x .$$

(9 Marks)

b) Explain any four advantages of state model as compared to transfer function model. (5 Marks)

Module 2

13 a) Obtain the unit step response y(t) of the system

$$\dot{X} = \begin{bmatrix} -1 & 0 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u , \quad y = \begin{bmatrix} 1 & 1 \end{bmatrix} x .$$

(10 Marks)

b) Show that eigen values of state models are unique. (4 Marks)

14 a) Determine the state transition matrix for the system with state model:

$$\dot{X} = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix} x$$

(7 Marks)

b) How do you derive the z transfer function from the state model of a sampled data system? (7 Marks)

Module 3

15 a) Consider a linear system described by the transfer function $\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$ Design a feedback controller with a state feedback so that the closed loop poles are placed at -2, -1±j1. (10 Marks)

b) Write short note on reduced order observer. (4 Marks)

16 a) Consider a linear system described by

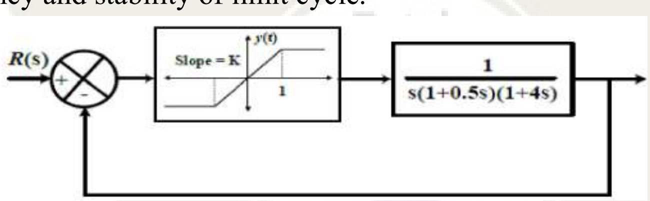
$$\dot{x} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & -5 \end{bmatrix} x + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u$$

Design a state observer so that the closed loop poles are placed at -4, -3±j1. (9 Marks)

b) With suitable example explain the concept of duality referred to controllability. (5 Marks)

Module 4

17 a) Determine the value of K for an occurrence of limit cycle. Also determine the amplitude, frequency and stability of limit cycle.



. (10 Marks)

b) With relevant characteristics explain any three nonlinearities in electrical systems. (4 Marks)

18 a) Obtain the describing function of relay with dead zone nonlinearity. (8 Marks)

b) Explain the linearization concept and assumptions made referred to Describing Function analysis. (6 Marks)

Module 5

19 a) A linear second order system is described by the equation:

$\ddot{e} + 2\delta\omega n\dot{e} + \omega n^2 e=0$, with $\delta = 0.25$, ωn = 1rad/sec, e(0)=1.0, and $\dot{e}(0) = 0$

Determine the singular point and state the stability by constructing the phase trajectory using the method of isoclines. (11 Marks)

b) Identify and explain the type of singular point for the following system:

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & 3 \end{bmatrix} X$$

(3 Marks)

20 a) Differentiate between stable and unstable limit cycles. (5 Marks)

b) Use Lyapunov Direct method to determine the value of K such that the given LTI system is stable.

$$\dot{X} = \begin{bmatrix} 0 & K \\ -2 & -1 \end{bmatrix} X$$

(9 Marks)

Syllabus

Module 1

State Space Representation of Systems (7 hours)

Introduction to state space and state model concepts- State equation of linear continuous time systems, matrix representation- features- Examples of electrical circuits and dc servomotors. Phase variable forms of state representation- Diagonal Canonical forms- Similarity transformations to diagonal canonical form.

Module 2

State Space Analysis (9 hours)

State transition matrix- Properties of state transition matrix- Computation of state transition matrix using Laplace transform and Cayley Hamilton method.

Derivation of transfer functions from state equations.

Solution of time invariant systems: Solution of time response of autonomous systems and forced systems.

State space analysis of Discrete Time control systems: Phase variable form and Diagonal canonical form representations- Pulse transfer function from state matrix- Computation of State Transition Matrix (problems from 2nd order systems only).

Module 3

State Feedback Controller Design (6 hours)

Controllability & observability: Kalman's, Gilbert's and PBH tests.- Duality principle

State feedback controller design: State feed-back design via pole placement technique

State observers for LTI systems- types- Design of full order observer.

Module 4

Nonlinear Systems (7 hours)

Types and characteristics of nonlinear systems- Jump resonance, Limit cycles and Frequency entrainment

Describing function method: Analysis through harmonic linearization- Determination of describing function of nonlinearities.

Application of describing function for stability analysis of autonomous system with single nonlinearity (relay, dead zone and saturation only).

Module 5

Phase Plane and Lyapunov Stability Analysis (8 hours)

Phase plots: Concepts- Singular points – Classification of singular points.

Definition of stability- asymptotic stability and instability.
Construction of phase trajectories using Isocline method for linear and nonlinear systems.
Lyapunov stability analysis: Lyapunov function- Lyapunov methods to stability of nonlinear systems- Lyapunov methods to LTI continuous time systems.

Text Books:

1. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers, 2007
2. Ogata K., Modern Control Engineering, 5/e, Prentice Hall of India, 2010.
3. Gopal M, Modern Control System Theory, 2/e, New Age Publishers, 1984
4. Kuo B.C, Analysis and Synthesis of Sampled Data Systems, Prentice Hall Publications, 2012.

References:

1. Khalil H. K, Nonlinear Systems, 3/e, Prentice Hall, 2002
2. Gibson J.E. Nonlinear Automatic Control, Mc Graw Hill, 1963.
3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill, 2012.
4. Slotine J. E and Weiping Li, Applied Nonlinear Control, Prentice-Hall, 1991,
5. Gopal M, Digital Control and State Variable Methods, 2/e, Tata McGraw Hill, 2003
6. Thomas Kailath, Linear Systems, Prentice-Hall, 1980.
7. Ogata K., Discrete Time Control Systems, 2/e, Pearson Education, Asia, 2015

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**State Space Representation of Systems**	**(7 hours)**
1.1	Introduction to state space and state model concepts- state equation of linear continuous time systems, matrix representation- features -Examples of electrical circuits and dc servomotors	3
1.2	Phase variable forms of state representation- features- controllable and observable companion forms	2
1.3	Diagonal canonical forms of state representation- Diagonal & Jordan forms- features- Similarity transformations to diagonal canonical form	2
2	**State Space Analysis**	**(9 hours)**
2.1	State transition matrix- Properties of state transition matrix- Computation of state transition matrix using Laplace transform- Cayley Hamilton method.	2
2.2	Derivation of transfer functions from state equations.	1
2.3	Solution of time invariant systems: Solution of time response of autonomous systems and forced systems	3
2.4	State space analysis of Discrete Time control systems: Phase variable form and Diagonal canonical form representations	2
2.5	Pulse transfer function from state matrix- Computation of State Transition Matrix- (problems from 2^{nd} order systems only)	1
3	**State Feedback Controller Design**	**(6 hours)**
3.1	Controllability & observability: Kalman's, Gilbert's and PBH tests- Duality property	2
3.2	State feedback controller design: State feed-back design via pole placement technique	2

3.3	State observers for LTI systems- Full order and reduced order observers- Design of full order observer design	2
4	**Nonlinear Systems**	**(7 hours)**
4.1	Types of nonlinear systems- characteristics of nonlinear systems- peculiar features like Jump resonance, Limit cycles and Frequency entrainment	2
4.2	Describing function Method: Analysis through harmonic linearisation	1
4.3	Determination of describing function of nonlinearities	2
4.4	Application of describing function for stability analysis of autonomous system with single nonlinearity (relay, dead zone and saturation only).	2
5	**Phase Plane and Lyapunov Stability Analysis**	**(8 hours)**
5.1	Phase plots: Concepts- Singular points - Classification of singular points.	1
5.2	Construction of phase trajectories using Isocline method for linear and nonlinear systems	2
5.3	Definition of stability- asymptotic stability and instability	1
5.4	Lyapunov stability analysis: Lyapunov function- Lyapunov methods to stability of nonlinear systems	2
5.5	Lyapunov methods to LTI continuous time systems.	2

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EEL411	CONTROL SYSTEMS LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This Laboratory Course provides a platform for modelling and analysis of linear and nonlinear systems with the help of hardware and software tools in the control framework.

Prerequisite: EET302 Linear Control Systems, EET305 Signals and Systems

Course Outcomes: After the completion of the course the student will be able to

CO 1	Demonstrate the knowledge of simulation tools for control system design.
CO 2	Develop the mathematical model of a given physical system by conducting appropriate experiments.
CO 3	Analyse the performance and stability of physical systems using classical and advanced control approaches.
CO 4	Design controllers for physical systems to meet the desired specifications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	3	3			3	3	3		3
CO 2	3	3	3	3	3			3	3	3		3
CO 3	3	3	3	3	3			3	3	3		3
CO 4	3	3	3	3	3			3	3	3		3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration

150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks

Continuous Assessment : 30 marks

Internal Test : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and troubleshooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

General instructions:

Practical examination to be conducted immediately after the second series test after completing 12 experiments out of the 18 experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

Reference Books

1. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Eleventh Edition, Pearson Education 2009.

2. Katsuhiko Ogatta, Modern Control Engineering, Fourth Edition, Pearson Education,2002.

List of Exercises/Experiments: (Lab experiments may be given considering 12 sessions of 3 hours each.)

1. Simulation tools like MATLAB/ SCILAB or equivalent may be used.
2. All experiments done by the students in addition to 12 experiments may be treated as beyond syllabus experiments.

Experiment No.	Name of the experiment
1	**Step response of a second order system.** Objective: Design a second order system (eg: RLC network) to analyse the following: A. The effect of damping factor (ξ: 0, <1,=1,>1) on the unit step response using simulation study (M-File and SIMULINK). B. Verification of the delay time, rise time, peak overshoot and settling time with the theoretical values. C. Performance analysis of hardware setup and comparison with the simulation results.
2	**Performance Analysis using Root-Locus Method.** Objective: Plot the root locus of the given transfer function to analyse the following using simulation: A. Verification of the critical gain, wo with the theoretical values B. The effect of controller gain K on the stability C. The sensitivity analysis by giving small perturbations in given poles and zeros D. The effect of the addition of poles and zeros on the given system.

3	**Stability Analysis by Frequency Response Methods.** Objective: Plot the i) Bode plot and ii) Nyquist plot of the given transfer functions to analyse the following using simulation: A. Determination of Gain Margin and Phase Margin B. Verification of GM and PM with the theoretical values C. The effect of controller gain K on the stability, D. The effect of the addition of poles and zeros on the given system (especially the poles at origin).
4	**Realisation of lead compensator.** Objective: Design, set up and analyse the gain and phase plots of a lead compensator by hardware experimentation using i) passive elements and ii) active components..
5	**Realisation of lag compensator.** Objective: Design, set up and analyse the gain and phase plots of a lag compensator by hardware experimentation using i) passive elements and ii) active components..
6	**Design of compensator in frequency domain and time domain.** Objective: Design a compensator for the given system to satisfy the given specifications A. Time domain specifications using MATLAB B. Frequency domain specifications using MATLAB
7	**State space model for analysis and design** Objective: Study and analysis of state variable model of a given system (eg. DC Motor speed control/ Servo motor/etc) and design a controller by pole-placement technique using MATLAB based tool boxes. A. Determine the open loop stability, controllability and observability B. Analyse the effect of system parameters on eigen values and system performance.

	C. Design a controller by pole-placement technique.
8	**PID Controller Design** Objective: Design and analysis of a PID controller for a given system (eg. DC Motor speed control/ Servo motor/etc) using SIMULINK/ MATLAB based tool boxes A. Design of PID controller to meet the given specifications B. Study the effect of tuning of PID controller on the above system.
9	**Phase plane analysis of nonlinear autonomous systems** Objective: Study and analysis of phase trajectory of a given nonlinear autonomous system using state space model in Simulation tools. A. Determination and verification of the singular points, B. Stability Analysis of the system at various singular points from phase portraits.
10	**Transfer Function of Armature and Field Controlled DC Motor** Objective: Obtain the transfer function of the armature and field controlled DC motor by experiment.
11	**Synchro Transmitter and Receiver.** Objective: Plot and study the different performance characteristics of Synchro transmitter- receiver units in Direct mode and Differential mode.
12	**Transfer function of Separately excited DC Generator.** Objective: Obtain the open loop transfer function of a separately excited DC Generator by experiment.

13	**Transfer function of A.C. Servo motor.** Objective: Obtain the open loop transfer function of AC Servo motor by experiment.
14	**Performance of a typical process control system** Objective: Study of performance characteristics and response analysis of a typical temperature/ Flow/ Level control system.
15	**Closed loop performance of inverted pendulum.** Objective: Study of performance characteristics of inverted pendulum by experiment. A. Determine the various unknown parameters of an inverted pendulum experimentally, B. Obtain and analyse the non-linear and linearised models, C. Design and implement various state feedback controllers to analyse the performance of the system.
16	**Performance analysis of magnetic levitation system.** Objective: Study of performance of magnetic levitation system by experiment. A. Obtain and analyse the dynamics of a magnetic levitation system, B. Design and implement various loop controllers to analyse the performance of this experimental system while tracking in presence/absence of disturbances.
17	**Closed loop performance of Twin rotor system** Objective: Study of performance characteristics of Twin rotor system by experiment.

18	**Mass Spring Damper system** Objective: Study of performance characteristics of Mass-Damper-Spring system by experiment. A. Determine the various unknown parameters of a mass spring damper system experimentally to obtain transfer function/ state space models, B. Design and implement various state feedback controllers to analyse the performance of the system while regulation and tracking

EEQ413	SEMINAR	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	2

Preamble: The course 'Seminar' is intended to enable a B.Tech graduate to read, understand, present and prepare report about an academic document. The learner shall search in the literature including peer reviewed journals, conference, books, project reports etc., and identify an appropriate paper/thesis/report in her/his area of interest, in consultation with her/his seminar guide. This course can help the learner to experience how a presentation can be made about a selected academic document and also empower her/him to prepare a technical report.

Course Objectives:

- To do literature survey in a selected area ofstudy.
- To understand an academic document from the literate and to give a presentation about it.
- To prepare a technical report.

Course Outcomes [COs] : After successful completion of the course, the students will be able to:

CO1	Identify academic documents from the literature which are related to her/his areas of interest (Cognitive knowledge level: **Apply**).
CO2	Read and apprehend an academic document from the literature which is related to her/ his areas of interest (Cognitive knowledge level: **Analyze**).
CO3	Prepare a presentation about an academic document (Cognitive knowledge level: **Create**).
CO4	Give a presentation about an academic document (Cognitive knowledge level: **Apply**).
CO5	Prepare a technical report (Cognitive knowledge level: **Create**).

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1		2	1					3
CO2	3	3	2	3		2	1					3
CO3	3	2			3			1		2		3
CO4	3				2			1		3		3
CO5	3	3	3	3	2	2		2		3		3

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

General Guidelines

- The Department shall form an Internal Evaluation Committee (IEC) for the seminar with academic coordinator for that program as the Chairperson/Chairman and seminar coordinator & seminar guide as members. During the seminar presentation of a student, all members of IEC shall be present.

- Formation of IEC and guide allotment shall be completed within a week after the University examination (or last working day) of the previous semester.

- Guide shall provide required input to their students regarding the selection of topic/ paper.

- Choosing a seminar topic: The topic for a UG seminar should be current and broad based rather than a very specific research work. It's advisable to choose a topic for the Seminar to be closely linked to the final year project area. Every member of the project team could choose or be assigned Seminar topics that covers various aspects linked to the Project area.

- A topic/paper relevant to the discipline shall be selected by the student during the semester break.

- Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.

- The IEC shall approve the selected topic/paper by the second week of the semester.

- Accurate references from genuine peer reviewed published material to be given in the report and to be verified.

Evaluation pattern

Total marks: 100, only CIE, minimum required to pass 50

Seminar Guide: 20 marks (Background Knowledge – 10 (The guide shall give deserving marks for a candidate based on the candidate's background knowledge about the topic selected), Relevance of the paper/topic selected – 10).

Seminar Coordinator: 20 marks (Seminar Diary – 10 (Each student shall maintain a seminar diary and the guide shall monitor the progress of the seminar work on a weekly basis and shall approve the entries in the seminar diary during the weekly meeting with the student), Attendance – 10).

Presentation: 40 marks to be awarded by the IEC (Clarity of presentation – 10, Interactions – 10 (to be based on the candidate's ability to answer questions during the interactive session of her/his presentation), Overall participation – 10 (to be given based on her/his involvement during interactive sessions of presentations by other students), Quality of the slides – 10).

Report: 20 marks to be awarded by the IEC (check for technical content, overall quality, templates followed, adequacy of references etc.).

EED415	PROJECT PHASE I	CATEGORY	L	T	P	CREDIT
		PWS	0	0	6	2

Preamble: The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7^{th} and 8^{th} semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7^{th} semester and two third in 8^{th} semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

Course Objectives

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems.

Course Outcomes [COs] : After successful completion of the course, the students will be able to:

CO1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: **Apply**).
CO2	Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: **Apply**).
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: **Apply**).
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: **Apply**).
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: **Analyze**).
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: **Apply**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	2	2	1	1	1	1	2
CO2	2	2	2		1	3	3	1	1		1	1
CO3									3	2	2	1
CO4					2			3	2	2	3	2
CO5	2	3	3	1	2							1
CO6					2			2	2	3	1	1

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

PROJECT PHASE I

Phase 1 Target

- Literature study/survey of published literature on the assigned topic
- Formulation of objectives
- Formulation of hypothesis/ design/ methodology
- Formulation of work plan and task allocation.
- Block level design documentation
- Seeking project funds from various agencies
- Preliminary Analysis/Modeling/Simulation/Experiment/Design/Feasibility study
- Preparation of Phase 1 report

Evaluation Guidelines & Rubrics

Total: 100 marks (Minimum required to pass: 50 marks).

- Project progress evaluation by guide: 30 Marks.
- Interim evaluation by the Evaluation Committee: 20 Marks.
- Final Evaluation by the Evaluation Committee: 30 Marks.
- Project Phase - I Report (By Evaluation Committee): 20 Marks.

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor).

Evaluation by the Guide

The guide/supervisor shall monitor the progress being carried out by the project groups on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide. Project evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/her group by considering the following aspects:

Topic Selection: innovativeness, social relevance etc. (2)

Problem definition: Identification of the social, environmental and ethical issues of the project problem. (2)

Purpose and need of the project: Detailed and extensive explanation of the purpose and need of the project. (3)

Project Objectives: All objectives of the proposed work are well defined; Steps to be followed to solve the defined problem are clearly specified. (2)

Project Scheduling & Distribution of Work among Team members: Detailed and extensive Scheduling with timelines provided for each phase of project. Work breakdown structure well defined. (3)

Literature survey: Outstanding investigation in all aspects. (4)

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide. (7)

Individual Contribution: The contribution of each student at various stages. (7)

EVALUATION RUBRICS for PROJECT Phase I: Interim Evaluation

No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
1-a	Topic identification, selection, formulation of objectives and/or literature survey. (Group assessment) [CO1]	10	The team has failed to come with a relevant topic in time. Needed full assistance to find a topic from the guide. They do not respond to suggestions from the evaluation committee and/or the guide. No literature review was conducted. The team tried to gather easy information without verifying the authenticity. No objectives formed yet.	The team has identified a topic. The originally selected topic lacks substance and needs to be revised. There were suggestions given to improve the relevance and quality of the project topic. Only a few relevant references were consulted/ studied and there is no clear evidence to show the team's understanding on the same. Some objectives identified, but not clear enough.	Good evidence of the group thinking and brainstorming on what they are going to build. The results of the brainstorming are documented and the selection of topic is relevant. The review of related references was good, but there is scope of improvement. Objectives formed with good clarity, however some objectives are not realistic enough.	The group has brainstormed in an excellent manner on what they were going to build. The topic selected is highly relevant, real world problem and is potentially innovative. The group shows extreme interest in the topic and has conducted extensive literature survey in connection with the topic. The team has come up with clear objectives which are feasible.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-b	Project Planning, Scheduling and Resource/ Tasks Identification and allocation. (Group assessment) [CO4]	10	No evidence of planning or scheduling of the project. The students did not plan what they were going to build or plan on what materials / resources to use in the project. The students do not have any idea on the budget required. The team has not yet decided on who does what. No project journal kept.	Some evidence of a primary plan. There were some ideas on the materials /resources required, but not really thought out. The students have some idea on the finances required, but they have not formalized a budget plan. Schedules were not prepared. The project journal has no details. Some evidence on task allocation among the team members.	Good evidence of planning done. Materials were listed and thought out, but the plan wasn't quite complete. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is not complete in all respect / detailed. There is better task allocation and individual members understand about their tasks. There is room for improvement.	Excellent evidence of enterprising and extensive project planning. Gantt charts were used to depict detailed project scheduling. A project management/version control tool is used to track the project, which shows familiarity with modern tools. All materials / resources were identified and listed and anticipation of procuring time is done. Detailed budgeting is done. All tasks were identified and incorporated in the schedule. A well-kept project journal shows evidence for all the above, in addition to the interaction with the project guide. Each member knows well about their individual tasks.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

Phase 1 Interim Evaluation Total Marks: 20

EVALUATION RUBRICS for PROJECT Phase I: Final Evaluation

Sl. No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
1-c	Formulation of Design and/or Methodology and Progress. (Group assessment) [CO1]	5	None of the team members show any evidence of knowledge about the design and the methodology adopted till now/ to be adopted in the later stages. The team has not progressed from the previous stage of evaluation.	The students have some knowledge on the design procedure to be adopted, and the methodologies. However, the team has not made much progress in the design, and yet to catch up with the project plan.	The students are comfortable with design methods adopted, and they have made some progress as per the plan. The methodologies are understood to a large extent.	Shows clear evidence of having a well- defined design methodology and adherence to it. Excellent knowledge in design procedure and its adaptation. Adherence to project plan is commendable.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
1-d	Individual and Teamwork Leadership (Individual assessment) [CO3]	10	The student does not show any interest in the project activities, and is a passive member.	The student show some interest and participates in some of the activities. However, the activities are mostly easy and superficial in nature.	The student shows very good interest in project, and takes up tasks and attempts to complete them. Shows excellent responsibility and team skills. Supports the other members well.	The student takes a leadership position and supports the other team members and leads the project. Shows clear evidence of leadership.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
1-e	Preliminary Analysis/ Modeling / Simulation/ Experiment / Design/ Feasibility study [CO1]	10	The team has not done any preliminary work with respect to the analysis/modeling/ simulation/experiment/design/feasibility study/ algorithm development.	The team has started doing some preliminary work with respect to the project. The students however are not prepared enough for the work and they need to improve a lot.	There is some evidence to show that the team has done good amount of preliminary investigation and design/ analysis/ modeling etc. They can improve further.	Strong evidence for excellent progress in the project. The team has completed the required preliminary work already and are poised to finish the phase I in an excellent manner. They have shown results to prove their progress.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

1-f	Documentation and presentation. (Individual & group assessment). [CO6]	5	The team did not document the work at all. The project journal/diary is not presented. The presentation was shallow in content and dull in appearance. The individual student has no idea on the presentation of his/her part.	Some documentation is done, but not extensive. Interaction with the guide is minimal. Presentation include some points of interest, but overall quality needs to be improved. Individual performance to be improved.	Most of the project details were documented well enough. There is scope for improvement. The presentation is satisfactory. Individual performance is good.	The project stages are extensively documented in the report. Professional documentation tools like LaTeX were used to document the progress of the project along with the project journal. The documentation structure is well-planned and can easily grow into the project report. The presentation is done professionally and with great clarity. The individual's performance is excellent.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
Total		**30**	**Phase - I Final Evaluation Marks: 30**			

EVALUATION RUBRICS for PROJECT Phase I: Report Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
1-g	Report [CO6]	20	The prepared report is shallow and not as per standard format. It does not follow proper organization. Contains mostly Unacknowledged content. Lack of effort in preparation is evident.	Project report follows the standard format to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly in the report.	Project report shows evidence of systematic documentation. Report is following the standard format and there are only a few issues. Organization of the report is good. Most of references are cited properly.	The report is exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and listed and clearly shown. Language is excellent and follows standard styles.
			(0 - 7 Marks)	(8 - 12 Marks)	(13 - 19 Marks)	(20 Marks)
Phase - I Project Report Marks: 20						

SEMESTER VII

PROGRAM ELECTIVE II

EET413	ELECTRIC DRIVES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To impart knowledge about the DC and AC motor drives and its applications

Prerequisite: EET306 Power Electronics, EET202 DC Machines and Transformers and EET307 Synchronous and Induction Machines.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Describe the transient and steady state aspects electric drives
CO 2	Apply the appropriate configuration of controlled rectifiers for the speed control of DC motors
CO 3	Analyse the operation of chopper-fed DC motor drive in various quadrants
CO 4	Illustrate the various speed control techniques of induction motors
CO 5	Examine the vector control of induction motor drives
CO 6	Distinguish different speed control methods of synchronous motor drives

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	-	-	-	-	-	-	-
CO 2	3	2	-	2		-	-	-	-	-	-	1
CO 3	3	2	-	2		-	-	-	-	-	-	1
CO 4	3	2	-	2		-	-	-	-	-	-	1
CO 5	3	1	-	2		-	-	-	-	-	-	1
CO 6	3	2	-	2		-	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	20	20	40
Apply (K3)	20	20	40
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Derive the condition for steady state stability (K3,K4, PO1, PO4).

2. Draw the speed torque characteristics of traction drive (K1, PO1).

3. Problems based on fundamental torque equations and equivalent values of drive parameters (K3, K4 , PO2, PO4).

Course Outcome 2 (CO2)

1. Numerical problems based on rectifier controlled separately excited dc motor. (K3, K4, PO2, PO4).

2. Describe the function of a three phase inverter driving a dc motor (K2, PO1).

3. Draw the circuit diagram of dual converter and explain the operation (K1, PO1).

Course Outcome 3(CO3):

1. Explain Motoring and braking operation of chopper controlled DC motor (K2,PO1).

2. Numerical problems based on chopper controlled separately excited dc motor. (K3, K4, PO2, PO4).

3. With the block diagram illustrate the closed loop control of SEDC motor (K2, PO4).

Course Outcome 4 (CO4):

1. List different speed control methods for three phase induction motors (K1, PO1)

2. Discuss sine triangle PWM control of three phase induction motor drive (K2, PO4).

3. Numerical problems based on speed control of induction motor drives (K3,K4, PO2, PO4).

Course Outcome 5 (CO5):

1. Draw the block diagram of direct vector control of induction motor drives (K2, PO1).

2. Figure out the differences of scalar and vector control methods of three phase induction motor (K3, PO1).

3. Draw the decoupled diagram and phasor diagram of three phase induction motor (K2, PO1) .

Course Outcome 6 (CO6):

1. Explain v/f control of three phase synchronous motor drive (K2, PO1).

2. Enumerate different speed control methods of synchronous motor drives (K1, PO1).

3. With the diagram of load commutated CSI synchronous motor drive discuss the operation (K2, PO1).

Model Question Paper

PAGES: 3

QPCODE:

Reg. No:____________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B. TECH DEGREE EXAMINATION
MONTH & YEAR

Course Code**: EET413**

Course Name: **ELECTRIC DRIVES**

Max. Marks: 100 **Duration: 3 Hours**

PART A
Answer all Questions.
Each question carries 3 Marks

1	Draw the block diagram of an electric drive.
2	List 3 classifications of load torque with one example for each.
3	For a single phase fully-controlled rectifier fed separately excited DC motor, the armature current is assumed to be continuous and ripple free ($i_a = I_a$). Draw the source current waveform for a firing angle of 45˚.

4 Can a half-controlled rectifier fed separately excited DC drive operated in quadrant IV? Justify your answer.

5 Draw the circuit diagram of a two-quadrant (class C) chopper showing the two quadrants of operation.

6 With the help of the torque – speed characteristics of a DC series motor, explain why it is used for high-starting torque applications?

7 Constant torque loads are not suitable for AC voltage controller fed induction motor drive. Why?

8 Why V/f ratio is kept constant upto base speed and V constant above base speed in variable frequency control of an induction motor?

9 Differentiate between true synchronous mode and self-control mode of operation of a synchronous motor.

10 List any two advantages of vector control of 3-phase induction motors.

PART B

Answer any one full question from each module.

Each question carries 14 Marks

Module 1

11	a)	What are the advantages of electric drives?	(7)
	b)	Explain the multi-quadrant operation of a motor driving a hoist load.	(7)
12	a)	Explain about steady state stability of equilibrium point in electric drive.	(7)
	b)	A drive has following parameters: - $J=10 kg\text{-}m^2$, $T=100-0.1N$ and $T_l=0.05N$ where N is the speed in rpm. Initially the drive is operating in steady state. Now it is to be reversed. For this motor characteristics is changed to $T = -100-0.1N$. Calculate the time of reversal.	(7)

Module 2

13	a)	Explain the working of 3-phase fully-controlled separately excited DC drive with necessary waveforms.	(7)
	b)	A 220V, 1500rpm, 10A separately excited DC motor is fed from a single phase fully controlled rectifier with an ac source voltage of 230V, 50Hz. $R_a=2\Omega$. Conduction can be assumed to be continuous. Calculate the firing angles for rated motor torque and -1000rpm.	(7)
14	a)	Explain the discontinuous conduction mode of operation of a fully controlled rectifier fed separately excited DC motor with necessary waveforms.	(7)
	b)	Explain the working of a dual converter (circulating current type) fed separately excited DC motor.	(7)

Module 3

15	a)	Explain the operation of four quadrant chopper fed DC drives.	(7)
	b)	A chopper used to control the speed of a separately excited DC motor has supply voltage of 230V, $T_{on} = 15ms$, $T_{off} = 5ms$. Assuming continuous conduction of motor current, calculate the average load current when the motor speed is 3000rpm. Assume voltage constant $K_v = 0.5 V/rad/sec$ and $R_a = 4\Omega$.	(7)

16	a)	Explain the chopper control of DC series motor.	(7)
	b)	Using a neat block diagram, explain the closed loop speed control for a separately excited DC motor.	(7)

Module 4

17	a)	Explain V/f control of 3-phase induction motor using necessary speed – torque characteristics.	(7)
	b)	A 440V, 3-phase, 50Hz, 6-pole, 945rpm, delta connected induction motor has following parameters referred to the stator: R_s = 2Ω, R_r' = 2Ω, X_s = 3Ω, X_r' = 4Ω. When driving a fan load at rated voltage it runs at rated speed. The motor speed is controlled by stator voltage control. Determine motor terminal voltage, current and torque at 800rpm.	(7)
18	a)	Explain the working of static rotor resistance control of 3-phase induction motor. Also derive the expression for the total rotor circuit resistance per phase.	(7)
	b)	Explain the static slip power recovery scheme using one uncontrolled bridge rectifier and one controlled bridge rectifier in the rotor circuit.	(7)

Module 5

19	a)	Describe the principle of operation of vector control.	(7)
	b)	Explain the variable frequency control of multiple synchronous motor.	(7)
20	a)	Explain Clerke and Park transformation with necessary equations.	(5)
	b)	Describe the working of a self-controlled synchronous motor drive employing load commutated thyristor inverter.	(9)

Syllabus (36 hours)

Module 1 (6 hours)

Introduction to electric drives – block diagram – advantages of electric drives – dynamics of motor load system, fundamental torque equations, types of load – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters- effect of gearing - steady state stability.

Module 2 (7 hours)

Rectifier control of DC drives- separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives (discontinuous and continuous mode of operation), critical speed - single-phase semi converter fed drives (continuous mode of operation) - three-phase semi converter and fully controlled converter fed drives (continuous mode of operation) - dual converter control of DC motor - circulating current mode.

Module 3 (6 hours)

Chopper control of DC drives - two quadrant and four quadrant chopper drives - motoring and regenerative braking - chopper fed DC series motor drive - closed loop speed control for separately excited dc motor.

Module 4 (10 hours)

Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - below and above base speed – Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM - static rotor resistance speed control employing chopper – static slip power recovery speed control scheme for speed control below synchronous speed.

Module 5 (7 hours)

Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - space vector diagram and block diagram [Ref.1].

Synchronous motor drives – v/f control – open loop control – self-controlled mode – load commutated CSI fed synchronous motor.

Note: Simulation assignments can be given using modern simulation tools like MATLAB, PSIM, PSpice, LTspice etc. from all modules of 2, 3, 4 and 5.

Text Books

1.G. K. Dubey, "Fundamentals of Electric Drives", Narosa publishers, second edition, 2001

Reference Books.

1. Bimal K.Bose, "Power Electronics and and Motor Drives", Academic press, An Imprint of Elsevier, 2006.
2. Vedam Subrahmanyam, "Electric Drives Concepts and Applications", MC Graw Hill Education, second edition, 2011,New Delhi.
3. Dr. P. S. Bimbhra, "Power Electronics", Khanna publishers, fifth edition, 2012.
4. Ned Mohan, Tore M Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons Inc.,3rd edition
5. Muhammad H.Rashid, "Power Electronics, Devices, Circuits and Applications", Pearson, 3rd edition, 2014
6. R Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", Prentice Hall, 2001.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Fundamentals of Electric drives (6 hours)**	
1.1	Introduction to electric drives- block diagram – advantages of electric drives	1
1.2	Dynamics of motor load system, fundamental torque equations,	1
1.3	four quadrant operation of drives	1
1.4	Types of load – classification of load torque	1
1.5	Equivalent values of drive parameters- effect of gearing -	1
1.6	Steady state stability	1
2	**Rectifier Control of DC drives (7 hours)**	
2.1	Rectifier controlled DC drives- separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives discontinuous mode of operation,	2
2.2	continuous mode of operation - critical speed	1
2.3	single-phase semi converter fed drives (continuous mode of operation)	1
2.4	three-phase semi converter controlled converter fed drives (continuous mode of operation)	1
2.5	Three phase fully controlled converter fed drives (continuous mode of operation)	1
2.6	Dual converter control of DC motor - circulating current mode	1
3	**Chopper control of DC drives (6 hours)**	
3.1	Two quadrant chopper DC drives - motoring and regenerative braking	2
3.2	Four quadrant chopper DC drives	1
3.3	Chopper fed DC series motor drive	2
3.4	Closed loop speed control for separately excited dc motor.	1
4	**Three phase induction motor drives (10 hours)**	
4.1	Stator voltage control - Stator frequency control	1
4.2	v/f control - below and above base speed	2
4.3	Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM	2
4.4	Static rotor resistance speed control employing chopper	1
4.5	Static slip power recovery speed control scheme for speed control below synchronous speed.	1
4.6	Auto Sequential Commutated Current source Inverter (CSI) fed induction motor drives	1
4.7	Current regulated VSI using power semiconductor devices, operation and control scheme - comparison of CSI and VSI fed	2

	drives.	
5	**Concept of space vector , Synchronous motor drives (7 hours)**	
5.1	Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - space vector diagram and block diagram.	4
5.2	Synchronous motor drives – v/f control – open loop control	1
5.3	Self-controlled mode – load commutated CSI fed synchronous motor.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET423	DIGITAL CONTROL SYSTEMS	PEC	2	1	0	3

Preamble: This course aims to provide a strong foundation in discrete domain modelling, analysis and design of digital controllers to meet performance requirements.

Prerequisite: EET201 Circuits and Networks, EET305 Signals and Systems, and EET302 Linear Control Systems

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Describe the various control blocks and components of digital control systems.
CO 2	Analyse sampled data systems in z-domain.
CO 3	Design a digital controller/ compensator in frequency domain.
CO 4	Design a digital controller/ compensator in time domain.
CO 5	Apply state variable concepts to design controller for linear discrete time system.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	-	-	-	-	-	-	-	-	2
CO 2	3	3	3	3	-	-	-	-	-	-	-	2
CO 3	3	3	3	3	2	-	-	-	-	-	-	3
CO 4	3	3	3	3	2	-	-	-	-	-	-	3
CO 5	3	3	3	3	-	-	-	-	-	-	-	3

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	15	15	30
Apply (K3)	25	25	50
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Selection of sampling period and elements of discrete time systems (K2) (PO1, PO2).
2. Derivation of the transfer functions of discrete time systems (K3)(PO1, PO2, PO3, PO12).
3. Relations between continuous system poles and that in discrete domain (K2) (PO1, PO2).

Course Outcome 2 (CO2):

1. Derivation of pulse transfer function or response function of various system configurations (K3) (PO1, PO2, PO3, PO4, PO12).
2. Determination of time response of systems, error constant and steady state error (K2) (PO1, PO2).
3. Problems to analyse the response of systems (K3) (PO1, PO2, PO3, PO4, PO12).

Course Outcome 3(CO3):

1. Obtain the frequency response and design controller (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
2. Design suitable compensator in frequency domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
3. Problems related to compensator and controller design in frequency domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).

Course Outcome 4 (CO4):

1. Problems related to design controller from time response (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
2. Design suitable compensator in time domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
3. Problems related compensator and controller design in time domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).

Course Outcome 5 (CO5):

1. Problems related to modelling and analysis (stability, controllability and observability) of system in state space (K2) (PO1, PO2, PO3, PO4).
2. Design a state feedback controller and observer (K3) (PO1, PO2, PO3, PO4).
3. Problems to identify the response and solution of state equation (K2) (PO1, PO2, PO3, PO4).

Model Question Paper PAGES: 2

QP CODE:

Reg.No:____________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code**: EET423**

Course Name: **DIGITAL CONTROL SYSTEMS**

Max. Marks: 100 **Duration: 3 Hours**

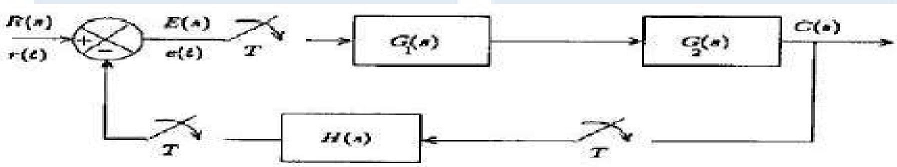
PART A

Answer all Questions. Each question carries 3 Marks

1 Explain any four advantages of sampled data control systems.

2 Identify and justify a suitable sampling frequency for the continuous time system with transfer function $G(s) = \frac{100}{(s+1)(s+10)(s+100)}$

3 Obtain the pulse transfer function for the given system.



4 Distinguish between type and order of a system.

5 Explain the frequency domain specifications.

6 Realize the digital compensator with transfer function $D(z) = \frac{2.3798z-1.9387}{z-0.5589}$

7 Draw and explain the mapping between s- plane to z-plane for the constant frequency loci.

8 What is dead beat response?

9 Identify the discrete equivalent of the continuous time system $\dot{x} = Ax$ when the sampling period is *T*s

10 Define controllability and observability.

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11 a) Derive the transfer function of a FoH circuit. **(6)**

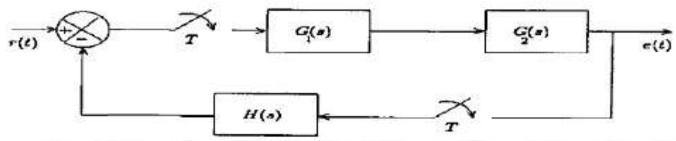
b) Determine the pulse transfer function of the system with transfer function $H(s) = \frac{3}{s(s+2)^2}$ if the sampling period is 0.1s. **(8)**

12 a) Derive the transfer function of a ZoH circuit. **(5)**

b) Realize the digital filter $D(z) = \frac{2z-0.6}{z+0.5}$ by the three methods of direct, standard and ladder programming. **(9)**

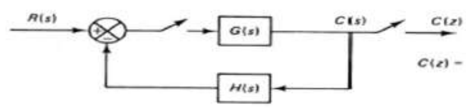
Module 2

13 Obtain the pulse transfer function for the unity feedback system with $G_1(s) = \frac{1}{s}$, $G_2(s) = \frac{1}{(s+2)}$ and assume T=0.1s and hence determine the step response of the system.



(14)

14 a) Obtain the unit impulse response C(n) of the following feedback DT system with $G(s) = \frac{1}{(s+3)}, . H(s) = \frac{1}{s},$



Assume ideal sampling and T=1 ms. **(9)**

b) Explain the factors on which the steady state error constants depend on? **(5)**

Module 3

15 Design a suitable compensator for the unity feedback system with forward transfer function $G(z) = \frac{0.01758\,(z+0.8753)}{(z-1)\,(z-0.6703)}, T = 0.1s$, such that the phase margin of the system be atleast 45° at approximately 2 rad/sec and velocity error constant atleast 100s^{-1}.**(14)**

16 Consider the unity feedback system with forward transfer function $G(z) = \frac{K(0..01873z + 0.01752)}{z^2 - 1.8187z + 0.8187}$. Design a controller for the system such that the *w*-plane phase margin is 50°, gain margin is 10dB, and the static velocity error constant is 2 sec^{-1}. Assume a sampling period of 0.2sec.

(14)

Module 4

17 Design a suitable digital compensator for the unity feedback system with open loop transfer function $G(s) = \frac{1}{s(s+4)}$ to meet the following specifications. Velocity error constant $K_v \geq 40$ sec^{-1}, Damping factor $\zeta = 0.5$, Natural frequency ω_n =4 rad/sec. Assume a sampling period of 0.1s **(14)**

18 Design a controller, by the method of Ragazzini, for the unity feedback system with open loop transfer function $G(z) = \frac{0.018201\,(z+0.905)}{(z-1.105)\,(z-0.6703)}, T = 0.1s$ to meet the following specifications. Damping factor $\zeta = 0.5$, Natural frequency ω_n =2 rad/sec and zero steady state error for unit step input. **(14)**

Module 5

19 Design a suitable controller for the system by selecting suitable poles. $x(k+1) = \begin{bmatrix} 0.9128 & -0.008826 & 0.1574 \\ 0.09194 & 1.114 & -0.1662 \\ 0.07429 & -0.08753 & 0.6855 \end{bmatrix} x(k) + \begin{bmatrix} 0.104 \\ -0.00411 \\ 0.08707 \end{bmatrix} u(k),$
$y(k) = [0 \quad 1 \quad 0]x(k)$ Formulate the control law that can perfectly track a step command. Since the output is directly available for measurement, design a reduced

order observer to realise the controller. **(14)**

20 Compute the unit step response of the system represented by $x(k+1) = \begin{bmatrix} 0.9048 & 0 \\ 0.08611 & 0.8187 \end{bmatrix} x(k) + \begin{bmatrix} 0.09516 \\ 0.09516 \end{bmatrix} u(k),\ y(k) = [1\ \ 1]x(k)$ assume the initial state $x(0) = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$. **(14)**

Syllabus

Module 1

Basics of Digital Control **(6 hours)**

Basic digital control system- Mathematical modelling - sampling and reconstruction - Zero order and First order hold circuits - realisation of digital filters. Relation between transfer function and pulse transfer function - Mapping between s-domain and z-domain.

Module 2

Response Computation **(7 hours)**

Pulse transfer function of different configurations of systems- Modified z-transform-Time Response of discrete time system. Order and Type of a system Steady state error and Static error constants.

Module 3

Design of controller/Compensator in frequency domain **(7 hours)**

Bilinear transformation and sketching of frequency response - Digital P/PI/PID controller design based on frequency response - Digital compensator based on frequency response. Introduction to design and simulation using MATLAB (for demo/ assignment only and not to be included for examination).

Module 4

Design of controller/Compensator based on time response **(7 hours)**

Design of lag, lead and lag-lead compensator using root locus - Design of controllers and compensators by the method of Ragazzini- Dead beat response and deadbeat controller design.

Module 5

Modern control approach to digital control **(10 hours)**

Introduction to state space - state space modelling of discrete time SISO system - Computation of solution of state equation and state transition matrix.

Controllability, observability and stabilizability of discrete time systems- Loss of controllability and observability due to sampling. Digital controller and observer design - state feedback – pole placement - full order observer - reduced order observer.

Text Book:

1. C. L. Philips, H. T. Nagle, Digital Control Systems, Prentice-Hall, Englewood Cliffs, New Jersey, 1995.
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill, 1997
3. Ogata K., Discrete-Time Control Systems, Pearson Education, Asia.

References:

1. Benjamin C. Kuo, Digital Control Systems, 2/e, Saunders College Publishing, Philadelphia, 1992.
2. Constantine H. Houpis and Gary B. Lamont, Digital Control Systems Theory, Hardware Software, McGraw Hill Book Company, 1985.
3. Isermann R., Digital Control Systems, Fundamentals, Deterministic Control, V. I, 2/e, Springer Verlag, 1989.
4. Liegh J. R., Applied Digital Control, Rinchart & Winston Inc., New Delhi.
5. Åström, Karl J., and Björn Wittenmark,. Computer-controlled systems: theory and design. Courier Corporation, 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Basics of Digital Control**	**(6 hours)**
1.1	Basic digital control system- Examples - mathematical model - choice of sampling and reconstruction-ZOH and FOH	2
1.2	Realisation of digital filters.	2
1.3	Relation between s and z - Mapping between s-domain and z-domain	2
2	**Response Computation**	**(7 hours)**
2.1	Pulse transfer function- Different configurations for the design	2
2.2	Time Response of discrete time system.	2
2.3	Steady state performance and error constants.	3
3	**Design of controller/Compensator in frequency domain**	**(7 hours)**
3.1	Digital P/PD/PI controller design	2
3.2	Digital PID controller design	1
3.3	Design of lag and lead compensator,	2
3.4	Design of lag-lead compensator.	1
3.5	Demo with MATLAB	1
4	**Design of controller/Compensator based on time response**	**(7 hours)**
4.1	Design of lag and lead compensator.	2
4.2	Design of lag-lead compensator.	1
4.3	Design based on method of Ragazzini.	2
4.4	Dead beat response design and deadbeat controller design.	2
5	**Modern control approach to digital control**	**(10 hours)**
5.1	Introduction to state space-	1
5.2	Computation of solution of state equation and state transition matrix. (examination questions can be limited to second order systems)	2
5.3	Controllability, Observability, and stabilizability of systems	2
5.4	Loss of controllability and observability due to sampling.	1
5.5	State feedback controller based on pole placement.	2
5.6	Observer design based on pole placement.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET433	MODERN OPERATING SYSTEMS	PEC	2	1	0	3

Preamble: Understanding of concepts of OS, through process/threads, system call interface, inter process communication, deadlock, scheduling, address space , main memory, virtual memory and file systems.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Describe the key concepts of modern operating systems
CO 2	Apply the concepts of scheduling, resource management and process synchronization for process management.
CO 3	Evaluate the implementation of various memory management techniques.
CO 4	Illustrate different file management and directory management methods.
CO 5	Evaluate Disc scheduling algorithms
CO 6	Explain RAID structures

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2											
CO 2	2	2										2
CO 3	2	2										2
CO 4	2											
CO 5	2	2										

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	15	15	30
Understand (K2)	20	20	40
Apply (K3)	15	15	30
Analyse (K4)			
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is an operating system?(K1, PO1)
2. What are operating system services?(k2, PO1)
3. Explain time sharing operating system?(K1, PO1)
4. Explain OS structure?(K2, PO1, PO2)

Course Outcome 2 (CO2):

1. Define the process? (K1, PO1)
2. What is meant by the state of the process?(K1,PO2)
3. What are the types of schedulers?(K1, PO2)
4. Consider the following five processes, with the length of the CPU burst time given in milliseconds. Process Burst time P1 10 P2 29 P3 3 P4 7 P5 12 Consider the First come First serve (FCFS), Non Pre-emptive Shortest Job First (SJF), Round Robin(RR) (quantum=10ms) scheduling algorithms. Illustrate the scheduling using Gantt charts.(K3, PO1,PO2)
5. Define race condition.(K2, PO2)
6. What are the requirements that a solution to the critical section problem must satisfy?(K2, PO1, PO2)

Course Outcome 3 (CO3):

1. Define Swapping(K1,PO2)
2. What is Demand Paging?(K2,PO1,PO2)

3. Explain about the following page replacement algorithms a)FIFO b)OPR, c)LRU
4. Differentiate local and global page replacement algorithms. Differentiate local and global page replacement algorithm(K3, PO1,PO2)

Course Outcome 4 (CO4):

1. What is a File?(K1, PO1)
2. What are the various File Operations?(K1, PO1)
3. What are the different Accessing Methods of a File?(K2, PO2)
4. What are the Allocation Methods of a Disk Space?(K2, PO2)

Course Outcome 5 (CO5):

1. Explain different Disk scheduling algorithms SCAN,CSCAN.CLOOK(K3, PO1,PO2)
2. Explain disk structure in detail(K2, PO1)
3. What are goals for good disk scheduling algorithm(K1, PO1)
4. Define seek time, Rotational latency and disk bandwidth(K1, PO1)

Course Outcome 6 (CO6):

1. What is RAID Technology(K1, PO1)
2. What data is stored on the second hard drive with RAID 1?(K2,PO2
3. Explain RAID level 10(K2, PO1, PO2)

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET433

Course Name:

Max. Marks: 100 **Duration: 3 Hours**

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain the concept of Multiprogramming and Multiprocessing
2. Enlist different kinds of computing environments
3. Compare and contrast user level threads & kernel level threads? Illustrate various multi-threading models.
4. What are the conditions for deadlock?

5. Differentiate between External fragmentation and Internal fragmentation
6. What is thrashing
7. Enlist five file attributes? What you mean by extended file attributes
8. Distinguish between sequential access file & direct access file. Give example on each
9. Define seek time, Rotational latency and disk bandwidth
10. Differentiate between viruses and worms , Give one example for each

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a)Explain the role of OS as Extended Machine (7)

(b) Explain User Operating-System Interface in detail (7)

OR

12. (a)Differentiate between grid computing & Cloud computing. Give examples for each. (6)

(b)What are the functions of the process management module of the OS? What is PCB, Explain its structure (8)

Module 2

13. Consider the following five processes, with the length of the CPU burst time given in milliseconds. Process Burst time P1 10 P2 29 P3 3 P4 7 P5 12 Consider the First come First serve (FCFS), Non Preemptive Shortest Job First (SJF), Round Robin(RR) (quantum=10ms) scheduling algorithms. Illustrate the scheduling using Gantt chart. Also find average waiting time and turnaround time for each algorithm (14)

OR

14. (a) What is race condition? List the condition to be satisfied to ensure mutual exclusion in critical section (7)

(b)Explain semaphores. (7)

Module 3

15. (a)What is contiguous memory allocation? (7)

(b)Explain the different methods and strategies of contiguous memory allocation (7)

OR

16. (a)Explain paging scheme for memory management, discuss the paging hardware and Paging (5)

(b)Explain about the following page replacement algorithms a)FIFO b)OPR, c)LRU (9)

Module 4

17. (a)What are the operations that can be performed on files (7)

(b) Explain Indexed file allocation with proper illustration (7)

OR

18. (a)What is meant by directory structure (6)

(b)what is free space management? Illustrate bit vector free space management technique (8)

Module 5

19. (a)What are goals for good disk scheduling algorithm (4)

(b) Consider a disk with 300 tracks and the queue has random requests from different processes in the order: 60, 39, 23, 90, 170, 150, 38, 194, 295. Initially the arm is at 100. Find the Average Seek length using FIFO, SSTF, SCAN and C- SCAN algorithms (10)

OR

20. (a)Explain different RAID Level in details with proper illustration (8)

(b) Explain programme threats and system threats with proper examples (6)

Syllabus

Module 1: Introduction-Definition– Operating System Structure- Operating System Operations, Process Management- Memory Management- Storage Management- Protection and Security- User and Operating-System Interface-System Calls- Types of System Calls Computing Environments- Open-Source Operating Systems. Process Management- Process Concept- Operations on Processes-Threads Overview- Multithreading Models
Module 2 - CPU Scheduling- Basic Concepts- Scheduling Criteria- Scheduling Algorithms- First come first served scheduling - Shortest job first - Shortest remaining time next- Round robin scheduling - Priority scheduling. **Inter-process communication** - race condition - critical sections -Mutual exclusion with busy waiting - sleep and wakeup - Semaphores, Mutexes

Introduction to Deadlocks
Module 3: Memory Management-Swapping- Contiguous Memory Allocation- Virtual memory - Paging - Page tables – TLBs - Page replacement algorithms - Optimal page replacement algorithm - - First-in first-out algorithm - Second chance page replacement algorithm - Clock algorithm - Least recently used algorithm - the working set page replacement algorithm -Belady's anomaly, local verses global policies
Module 4: File Management- File-System Interface- File Concept- Access Methods - Directory and Disk Structure - File-System Mounting - File Sharing- Protection- File-System Implementation- File-System Structure- - Directory Implementation- Allocation Methods Free-Space Management - Efficiency and Performance
Module 5: Mass Storage Structure- Disk Scheduling- RAID Structure - - Protection and Security- Protection- Goals of Protection- Principles of Protection- Domain of Protection- Access Matrix Implementation of Access Matrix- Access Control- Revocation of Access Rights Security- The Security Problem -Program Threats- System and Network Threats

Text Book

1. Abraham Silberschatz, Greg Gagne, Peter B. GalvinAuthor, Operating System Concepts, 10th Edition "Title", Publisher, 9thth edition, Wiley publishers

Reference Books

1. William Stallings "Operating Systems: Internals and Design Principles, 7th edition, prentice Hall

2. Andrew S. Tanenbaum; Modern Operating systems ,4th edition, Person publications

Course Content and Lecture Schedule

No	Topic	No. of Lectures
	Module 1 (9 hrs)	
1.1	Introduction-Definition– Operating System Structure	1
1.2	Operating System Operations, Process Management and Memory Management	1
1.3	Storage Management- Protection and Security	1
1.4	User and Operating-System Interface	1
1.5	System Calls, Types of System Calls	1
1.6	Computing Environments- Open-Source Operating Systems	1
1.7	Process Management- Process Concept	1
1.8	Operations on Processes	1

1.9	Threads Overview- Multithreading Models	1
	Module 2 (8 hrs)	
2.1	CPU Scheduling- Basic Concepts- Scheduling Criteria	1
2.2	Scheduling Algorithms- First come first served scheduling- problems	1
2.3	Shortest job first - Shortest remaining time next- problems	1
2.4	Round robin scheduling - Priority scheduling.- problems	1
2.5	Inter-process communication - race condition - critical sections	1
2.6	critical sections and Mutual exclusion with busy waiting	1
2.7	Sleep and wakeup Semaphores, Mutexes	1
2.8	Deadlock- introduction only	1
	Module 3 (7 hrs)	
3.1	Memory Management-Swapping- Contiguous Memory Allocation	1
3.2	Virtual memory – Paging	1
3.3	Page tables – TLBs	1
3.4	Page replacement algorithms- Optimal page replacement algorithm - FIFO	1
3.5	Least recently used algorithm	1
3.6	Second chance page replacement algorithm - Clock algorithm	1
3.7	the working set page replacement algorithm -Beladys anomaly, local verses global policies	1
	Module 4 (7 hrs)	
4.1	File Management- File-System Interface- File Concept- Access Methods	1
4.2	Directory and Disk Structure	1
4.3	File-System Mounting - File Sharing- Protection- F	1
4.4	File-System Implementation- File-System Structure-	1
4.5	Directory Implementation-	1
4.6	Allocation Methods Free-Space Management	1
4.7	Efficiency and Performance	1
	Module 5 (5 hrs)	
5.1	Disk Scheduling-	1
5.2	RAID Structure	1
5.3	Protection- Goals of Protection- Principles of Protection- Domain of Protection	1
5.4	Access Matrix Implementation of Access Matrix- Access Control- Revocation of Access Rights Security-	1
5.5	The Security Problem -Program Threats- System and Network Threats	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET443	DATA STRUCTURES	PEC	2	1	0	3

Preamble: This course aims at moulding the learner to understand the various data structures, their organization and operations. The course helps the learners to assess the applicability of different data structures and associated algorithms for solving real world problems efficiently. This course introduces abstract concepts for data organization and manipulation using data structures such as stacks, queues, linked lists, binary trees and graphs for designing their own data structures to solve practical application problems.

Prerequisite: EST 102 Programming in C

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyze the time and space efficiency of the data structure(K3)
CO 2	Describe how arrays, records, linked structures, stacks and queues are used by algorithms (K1)
CO 3	Compare and contrast the benefits of dynamic and static data structures implementations(K3)
CO 4	Explain different memory management techniques and their significance (K3)
CO 5	Develop algorithms incorporating trees and graphs (K3)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	2										
CO 3	3	2										
CO 4	3	2										
CO 5	3	2										
CO 6	3	2										

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	25	25	50
Apply (K3)	15	15	30
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Derive the big O notation for f(n) = n2+2n+5 (K2,PO1)
2. What do you understand by complexity of an algorithm? Write worst case and best case
3. Find complexity of linear search.(K2,PO1)
4. Write an algorithm for matrix multiplication and calculate its time complexity. (K3,PO2)

Course Outcome 2 (CO2)

1. Write an algorithm/pseudo code to add a new element in a particular position of an array(K3,PO2)
2. Explain about the use and representation of header node in linked list (K1,PO1)
3. How a linked list can be used to represent the polynomial 5x4y6+24x3y4-17x2y3+15xy2+45.(K3,P02)
4. What is a circular queue? How it is different from normal queue? (K1,PO1)

Course Outcome 3(CO3):

1. Compare and contrast singly linked list and doubly linked list ((K2,PO1)
2. Write a program that implement stack (its operations) using i) Arrays ii) Linked list(Pointers) and compare performance(K3,PO2)
3. Compare array and linked list implementation of a general list.(K2,P02)
4. What are the disadvantages of representing a linear queue using array? How are they overcome (K1,PO1)

Course Outcome 4 (CO4):

1. Free memory blocks of size 60K, 25K, 12K, 20K, 35K, 45K and 40K are available in this order. Show the memory allocation for a sequence of job requests of size 22K, 10K, 42K, and 31K (in this order) in First Fit, Best Fit and Worst Fit allocation strategies (K3,PO2)
2. Explain how memory de-allocation is done in memory management (K1,PO1)
3. Compare various memory management techniques (K2,PO1)

Course Outcome 5 (CO5):

1. List the properties of a binary search tree. (K1,P01)
2. Create a Binary search Tree with node representing the following sequence 14, 15, 4, 18, 9, 16, 20, 17, 3, 7, 5, 2 and perform inorder, preorder and postorder traversals on the above tree and print the output. .(K3,P02)
3. Develop an algorithm to add an element into a binary search tree (K3,P02)
4. Give any two representations of graph. Give algorithm for DFS. Demonstrate DFS using suitable example. (K2,P01)

Model Question Paper

QP CODE:

PAGES : 3

Reg No: _______________

Name: _________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SEVENTH SEMESTER B.TECH
DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET443

Course Name: DATA STRUCTURES

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Compare Structured Approach and Object Oriented Approach of Programming.

2. Calculate the frequency count of the statement x = x+1; in the following code segment

```
for (i = 0; i< n; i++)
for (j = 0; j< n; j*=2)
x = x + 1;
```

3. Write an Algorithm to reverse a string using Stack.
4. Explain the disadvantages of representing a Linear Queue using Array.
5. Write any three Applications of Linked List.
6. Explain DEQUEUE
7. Write a non recursive algorithm/ Pseudocode for pre-order traversal in a binary tree.

8. What is a binary search tree (BST)? Give an example of a BST with five nodes.

9. Give two different types of representation for graphs.

10. Compare Prim's and Kruskal's Algorithm

PART B

11.a) Explain space complexity and time complexity of an Algorithm. Write an Algorithm/pseudo code for linear search and mention the best case and worst case time complexity of Linear Search algorithm? (10)

b) Explain Modular Programming with Suitable Example (4)

OR

12.a) Explain System Lifecycle in detail. (10)

b) Explain an algorithm? How is its complexity analysed? (4)

13.a) Write algorithms to insert and delete elements from a double ended Queue. Demonstrate with examples (10)

b) Compare and Contrast a Circular Queue with a normal Queue (4)

OR

14.a) Write an Algorithm to evaluate Postfix operation. (8)

b) Convert the following infix expression into prefix expression (A-B/C) * (D*E-F) .Show the stack contents for each step. (6)

15.a) Write algorithms to perform the following operations on a doubly linked list.

(i) Insert a node with data 'y' after a node whose data is 'x'.

(ii) Delete a node whose data is 's' .

(iii) Insert a node with data 'a' as the 1st node of the list. (10)

b) Write an algorithm to count the number of occurrences of a character in a linked list (each node contains only one character). (4)

OR

16.a) Assume that a Stack is represented using Linked List. Write Algorithms for the following operations.

a) PUSH

b) POP (10)

b) Compare a Circular Linked List and a Doubly Linked List. (4)

17. a) Explain how memory de-allocation is done in memory management. (8)

b) Discuss the advantages and Disadvantages of First-fit,Best-fit and Worst-fit Allocation schemes. (6)

OR

18.a) Write an algorithm/Psudocode to perform the following operations on Binary . Search tree.

a) Insert an element k

b) Search for an element k (10)

b) Write an iterative algorithm for in-order traversal of a Binary Tree (4)

19. a) Explain the various ways in which a graph can be represented bringing out the advantages and disadvantages of each representation (10)

b) Write an algorithm to perform bubble sort on a collection of 'n' numbers. (4)

OR

20.a) Give algorithms for DFS and BFS of a graph and explain with examples. (8)

b) How graphs can be represented in a Computer? (6)

Syllabus

Module 1

Basic Concepts of Data Structures

Introduction to programming methodologies – structured approach, object oriented approach, stepwise refinement techniques, Algorithms, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notation, Complexity Calculation of Simple Algorithms

Module 2

Arrays

Introduction to data structures: Stacks, Queues-Circular Queues, Priority Queues, Double Ended Queues, Evaluation of Expressions, Applications of stacks and queues

Module 3

Linked List

Singly Linked List-Operations on Linked List. Doubly Linked List, Circular Linked List, Stacks and Queues using Linked List, Polynomial representation using Linked List

Module 4

Memory Management and Trees

Memory Management - Memory allocation and de-allocation-First-fit, Best-fit and Worst-fit allocation schemes

Trees, Binary Trees-Tree Operations, Binary Tree Representation, Tree Traversals, Binary Search Trees- Binary Search Tree Operations

Module 5

Graphs

Graphs : Definitions, Representation of Graphs, Topological Sort, Depth First Search and Breadth First Search on Graphs, Shortest-path algorithms, Minimum spanning tree, Prim's and Kruskal's algorithms, Applications of graphs

Text Book

1. Fundamentals of Data structures in C, 2nd Edition, E.Horowitz, S.Sahni and Susan Anderson-Freed, University Press (India),2008.

Reference Books

1. Classic Data Structures, Samanta D., Prentice Hall India, 2/e,,2009.
2. Data Structures: A Pseudocode Approach with C, 2/e, Richard F. Gilberg, Behrouz A. Forouzan, Cengage Learning 2005.
3. Data Structures and Algorithms, Aho A. V., J. E. Hopcroft and J. D. Ullman Pearson Publication. 2nd Edition
5. Introduction to Data Structures with Applications, Tremblay J. P. and P. G. Sorenson,Tata McGraw Hill 1995
4. Advanced Data Structures, Peter Brass ,Cambridge University Press,2008
5. Theory and Problems of Data Structures, Lipschuts S., Schaum's Series 1996
6. 8A Structured Approach to Programming, . Hugges J. K. and J. I. Michtm, PHI. 1987

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Introduction**	**5**
1.1	Introduction to programming methodologies – structured approach, object oriented approach, stepwise refinement techniques\	**1**
1.2	Algorithms , Performance Analysis	**1**
1.3	Space Complexity, Time Complexity	**1**
1.4	Asymptotic Notation (Big O Notation)	**1**

1.5	Complexity Calculation of Simple Algorithms	**1**
2	**Arrays**	**7**
2.1	Stacks	**1**
2.2	Queues, Circular Queues	**1**
2.3	Priority Queues	**1**
2.4	Double Ended Queues	**1**
2.5	Conversion and Evaluation of Expressions	**1**
2.6	Applications of stacks and queues	**2**
3	**Linked List**	**8**
3.1	Singly Linked List	**1**
3.2	Doubly Linked List	**1**
3.3	Circular Linked List	**1**
3.4	Stacks using Linked List	**1**
3.5	Queues using Linked List	**1**
3.6	Polynomial representation using Linked List	**2**
4	**Memory Management and Trees**	**8**
4.1	Memory allocation and de-allocation	**1**
4.2	First-fit, Best-fit and Worst-fit allocation schemes	**2**
4.3	Binary Trees- Tree Operations	**1**
4.4	Binary Tree Representation, Tree Traversals	**2**
4.5	Binary Search Trees- Binary Search Tree Operations	**2**
5	**Graphs**	**7**
5.1	Graphs Definitions, Representation of Graphs	**1**
5.2	Topological sort, Depth First Search and Breadth First Search on Graphs,	**2**

5.3	Shortest-path algorithms,	**1**
5.4	Minimum spanning tree	**1**
5.5	Prim’s and Kruskal’s algorithms, Applications of graphs	**2**

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET453	DIGITAL SIGNAL PROCESSING	PEC	2	1	0	3

Preamble: This course introduces the discrete Fourier transform (DFT) and its computation using direct method and fast Fourier transform (FFT). Techniques for designing infinite impulse response (IIR) and finite impulse response (FIR) filters from given specifications are also introduced. Various structures for realization of IIR and FIR filters are discussed. Detailed analysis of finite word-length effects in fixed point DSP systems is included. Architecture of a digital signal processor is also discussed.

Prerequisite : EET305 - Signals and Systems

Course Outcomes: After the completion of the course the student will be able to

CO 1	Compute Discrete Fourier transform and Fast Fourier transform .
CO 2	Discuss the various structures for realization of IIR and FIR discrete-time systems.
CO 3	Design IIR (Butterworth and Chebyshev) digital filters using impulse invariant and bilinear transformation methods.
CO 4	Design FIR filters using frequency sampling method and window function method.
CO 5	Compare fixed point and floating point arithmetic used in digital signal processors and discuss the finite word length effects.
CO 6	Explain the architecture of digital signal processors and the applications of DSP.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	-	2	2	-	-	-	-	-	-	2
CO 2	3	2	-	2	2	-	-	-	-	-	-	2
CO 3	3	2	-	2	2	-	-	-	-	-	-	2
CO 4	3	2	-	2	2	-	-	-	-	-	-	2
CO 5	3	2	-	-	2	-	-	-	-	-	-	2
CO 6	3	-	2	-	2	2	-	-	-	-	-	3

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	10
Understand (K2)	10	10	30
Apply (K3)	30	30	60
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. State and prove various properties of DFT - (K1, PO1,PO2,PO12)
2. Determine the linear convolution using DFT – (K2,PO1,PO2,PO4,PO5,PO12)
3. Determine the linear convolution using overlap-add and overlap-save method – (K3,PO1,PO2,PO4,PO5)
4. Compute DFT using DIT FFT and DIF FFT – (K2,PO1,PO2,PO4,PO5)

Course Outcome 2 (CO2)

1. Determine the structures for direct form, cascade, parallel, transposed and lattice-ladder realisations of IIR systems –(K2,PO1,PO2,PO4,PO5,PO12)
2. Determine the structures for direct form, cascade, lattice ,and linear phase realizations of FIR systems – (K2,PO1,PO2,PO4,PO5)

Course Outcome 3(CO3)

1. Design IIR digital LP/HP/BP/BS filter using Butterworth and Chebyshev methods – (K3,PO1,PO2,PO4,PO5)
2. Transform H(s) to H(z) using impulse invariant technique and bilinear transformation – (K2,PO1,PO2,PO4,PO5,PO12)

Course Outcome 4 (CO4)

1. Design FIR digital LP/HP/BP/BS filter using frequency sampling method – (K3,PO1,PO2,PO4,PO5,PO12)
2. Design FIR digital LP/HP/BP/BS filter using window function – (K3,PO1,PO2,PO4,PO5)

Course Outcome 5 (CO5)

1. Differentiate between fixed-point arithmetic and floating point arithmetic - (K2,PO1,PO2,PO12)
2. Explain various finite word length effects in fixed point DSP processors.- (K2,PO1,PO2)
3. Problems to determine steady state output noise power and round-off noise power – (K3,PO1,PO2)
4. Explain limit cycle oscillations and methods for its elimination - (K2,PO1,PO2)

Course Outcome 6 (CO6)

1. Explain Harvard architecture –(K1,PO1,PO5,PO12)
2. Describe the architecture of a fixed-point DSP processor – (K1,PO1,PO5)
3. List various applications of digital signal processor – (K3,PO1,PO3,PO6)

Model Question Paper PAGES: 3

QPCODE:

Reg. No:____________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B. TECH DEGREE EXAMINATION
MONTH & YEAR

Course Code**: EET453**

Course Name: **DIGITAL SIGNAL PROCESSING**

Max. Marks: 100 **Duration: 3 Hours**

PART A
Answer all Questions.
Each question carries 3 Marks

1 List any 3 properties of DFT.

2 The first 5 points of the 8-point DFT of a real valued sequence are $X(k)=\{0.25, 0.125-j0.3, 0, 0.125-j0.05, 0\}$. Determine the remaining 3 points.

3 Obtain direct form 1 realization for a digital IIR system described by the system function, $H(z)=\dfrac{z+0.2}{z^2+0.5z+1}$.

4 Obtain realization with minimum number of multipliers for the system function $H(z)=\dfrac{1}{2}+z^{-1}+\dfrac{1}{2}z^{-2}$.

5 Explain warping effect in bilinear transformation.

6 Determine the order of a Chebyshev analog lowpass filter with a maximum passband attenuation of 2.5dB at Ω_p = 20 rad/sec and the stopband attenuation of 30dB at Ω_s = 50 rad/sec.

7 What are the desirable characteristics of a window function used for truncating the infinite impulse response?

8 Represent the numbers i) +4.5 and ii) -4.5 in IEEE 754 single-precision floating point format.

9 List any 3 finite-word length effects in a fixed point digital signal processor.

10 Draw the block diagram of a basic Harvard architecture in digital signal processor.

PART B

Answer any one full question from each module.

Each question carries 14 Marks

Module 1

11 a) Find the 4-point DFT of the sequence, $x(n)=\{1,-1,1,-1\}$. Also, using time shift property, find the DFT of the sequence, $y(n)=x((n-2))_4$. (7)

b) Two finite duration sequences are $h(n)=\{1,0,1\}$ and $x(n)=\{-1,2,-1,0,1,3,-2,1,-3,-2,-1,0,-2\}$. Use overlap-save method, to find $y(n)=x(n)*h(n)$. (7)

OR

12 Compute IDFT of the sequence $X(k)=\{7,-0.707-j0.707,-j,0.707-j0.707,1,0.707+j0.707,j,-0.707+j.707\}$ using DIT FFT. (14)

Module 2

13 a) Realize the system function in cascade form $H(z)=\dfrac{1+\frac{1}{3}z^{-1}}{1-\frac{3}{4}z^{-1}+\frac{1}{8}z^{-2}}$. (6)

b) Determine the direct form 2 and transposed direct form structure for the given system $y(n)=\frac{1}{2}y(n-1)-\frac{1}{4}y(n-2)+x(n)+x(n-1)$. (8)

OR

14 a) Obtain the direct form realization of linear phase FIR system given by (7)

$$H(z)=1+\frac{3}{4}z^{-1}+\frac{17}{8}z^{-2}+\frac{3}{4}z^{-3}+z^{-4}$$

b) Determine the coefficients k_m of the lattice filter corresponding to FIR filter described by the system function $H(z)=1+2z^{-1}+\frac{1}{3}z^{-2}$. Also, draw the corresponding second order lattice structure (7)

Module 3

15 a) Find H(z) using impulse invariant transformation. $H(s) = \frac{1}{s^2 + \sqrt{2}s + 1}$; $T = 1\sec$. (7)

b) A Butterworth lowpass filter has to meet the following specifications. (7)

i) Passband gain = -3dB at f_p = 500Hz

ii) Stopband attenuation greater than or equal to 40dB at f_s = 1000Hz

Determine the order of the Butterworth filter to meet the above specifications. Also, find the cut off frequency.

OR

16 Design a Chebyshev digital lowpass filter with a maximum passband attenuation of 2dB at 100Hz and minimum stopband attenuation of 20dB at 500Hz. Sampling rate is 4000 samples/sec. Use bilinear transformation. (14)

Module 4

17 a) Design a linear phase lowpass FIR filter with N = 7 and a cut-off frequency 0.3π radian using the frequency sampling method. (7)

b) A linear phase FIR filter has frequency response $H(\omega) = \cos\frac{\omega}{2} + \frac{1}{2}\cos\frac{3\omega}{2}$ (7)

Determine the impulse response h(n).

OR

18 A band stop filter is to be designed with the following desired frequency response $H_d(e^{j\omega}) = \begin{cases} e^{-j\omega\alpha} & -\omega_{c1} \le \omega \le \omega_{c1} \quad \omega_{c2} \le |\omega| \le \pi \\ 0 & \text{otherwise} \end{cases}$ (14)

Design with N = 7, $\omega_{c1} = \pi/4$ rad/sec, $\omega_{c2} = 3\pi/4$ rad/sec using rectangular window.

Module 5

19 a) Compare between fixed point and floating point digital signal processors. (6)

b) The output of an ADC is applied to a digital filter with system function $H(z) = \frac{0.5z}{(z-0.5)}$. Find the output noise power from digital filter when input signal is quantized to have 8 bits. (8)

OR

20 a) Draw and explain the architecture of any fixed-point DSP processor. (8)

b) Explain the techniques used to prevent overflow in fixed-point DSP operations. (6)

Syllabus

Module 1 - DISCRETE-FOURIER TRANSFORM

Review of signals and systems - Frequency domain sampling - Discrete Fourier transform (DFT) – inverse DFT (IDFT) - properties of DFT – linearity, periodicity, symmetry, time reversal, circular time shift, circular frequency shift, circular convolution, complex conjugate property – Filtering of long data sequences – over-lap save method, over-lap add method – Fast Fourier transform (FFT) – advantages over direct computation of DFT - radix -2 decimation-in-time FFT (DITFFT) algorithm, Radix-2 decimation-in-frequency FFT (DIFFFT) algorithm.

Module 2 - REALIZATION OF IIR AND FIR SYSTEMS

Introduction to FIR and IIR systems - Realization of IIR systems – direct form 1, direct form 2, cascade form, parallel form, lattice structure for all-pole system, lattice-ladder structure – conversion of lattice to direct form and vice-versa - signal flow graphs and transposed structures – Realization of FIR systems – direct form, cascade form, lattice structure, linear phase realization.

Module 3 - IIR FILTER DESIGN

Conversion of analog transfer function to digital transfer function – impulse invarient transformation and bilinear transformation – warping effect

Design of IIR filters – low-pass, high-pass, band-pass, band-stop filters – Butterworth and Chebyshev filter – frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation.

Module 4 - FIR FILTER DESIGN AND REPRESENTATION OF NUMBERS

Impulse response of ideal low pass filter – linear phase FIR filter – frequency response of linear phase FIR filter – Design of FIR filter using window functions (LP, HP, BP, BS filters) – Rectangular, Bartlett, Hanning, Hamming and Blackmann only – FIR filter design based on frequency sampling approach (LP, HP, BP, BS filters)

Representation of numbers – fixed point representation – sign-magnitude, one's complement, two's complement – floating point representation – IEEE 754 32-bit single precision floating point representation

Module 5 - FINITE WORD LENGTH EFFECTS AND DIGITAL SIGNAL PROCESSORS

Finite word length effects in digital Filters – input quantization – quantisation noise power – steady-state output noise power – coefficient quantisation – overflow – techniques to prevent overflow - product quantization error – rounding and truncation – round-off noise power – limit cycle oscillations – zero input limit cycle oscillations – overflow limit cycle oscillations – signal scaling.

Digital signal processor architecture based on Harvard architecture (block diagram) – Harvard architecture, pipelining, dedicated hardware multiplier/accumulator, special instructions dedicated to DSP, replication, on-chip memory cache, extended parallelism

(Reference [2]) - comparison of fixed-point and floating-point processor – applications of DSP

Text Books

1. John G. Proakis & Dimitris G.Manolakis, “Digital Signal Processing Principles, Algorithms & Applications”, Pearson

Reference Books

1. Emmanuel Ifeachor & Barrie W Jervis, “Digital Signal Processing”, Pearson, 13th edition, 2013
2. P. Ramesh Babu, “Digital Signal Processing”, Scitech Publications (India) Pvt Ltd, 2nd edition, 2003
3. Li Tan, “Digital Signal Processing, Fundamentals & Applications”, Academic Press, Ist edition, 2008
4. D. Ganesh Rao & Vineeta P Gejji, “Digital Signal Processing, A Simplified Approach”, Sanguine Technical Publishers, 2nd edition, 2008

Course Contents and Lecture Schedule

Sl. No	Topic	No. of Lectures
1	**DISCRETE-FOURIER TRANSFORM (7 hours)**	
1.1	Review of signals, systems and discrete-time Fourier transform (DTFT), Frequency domain sampling, discrete-Fourier transform (DFT), twiddle factor, inverse DFT, properties of DFT - linearity, periodicity, symmetry, time reversal, circular time shift, circular frequency shift, circular convolution, complex conjugate property	3 hours
1.2	Linear filtering using DFT, linear filtering of long data sequences, overlap-save method, overlap-add method	1 hour
1.3	Fast Fourier transform (FFT) – comparison with direct computation of DFT - radix -2 decimation-in-time FFT (DITFFT) algorithm – bit reversal - Radix-2 decimation-in-frequency FFT (DIFFFT) algorithm	3 hours
2	**REALIZATION OF IIR AND FIR SYSTEMS (7 hours)**	
2.1	Introduction to FIR and IIR systems - comparison - Realization of IIR systems – direct form 1, direct form 2, cascade form, parallel form	3 hours
2.2	Lattice structure for all-pole system - lattice-ladder structure – conversion of lattice to direct form and vice-versa signal flow graphs and transposed structures	2 hours
2.3	Realization of FIR systems – direct form, cascade form, lattice structure, linear phase realization.	2 hours
3	**IIR FILTER DESIGN (7 hours)**	
3.1	Conversion of analog transfer function to digital transfer function – impulse invarient transformation and bilinear transformation – warping effect	2 hours
3.2	Design of IIR filters – characteristics of ideal and practical low-pass, high-pass, band-pass, band-stop filters – design of Butterworth filter –	3 hours

	normalised analog filter - frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation.	
3.3	Design of Chebyshev filter – design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation	2 hours
4	**FIR FILTER DESIGN AND REPRESENTATION OF NUMBERS (7 hours)**	
4.1	Impulse response of ideal low pass filter – linear phase FIR filter – frequency response of linear phase FIR filter – Design of FIR filter using window function (LP, HP, BP, BS filters) – Rectangular, Bartlett, Hanning, Hamming and Blackmann only	3 hours
4.2	FIR filter design based on frequency sampling approach (LP, HP, BP, BS filters)	2 hours
4.3	Representation of numbers – fixed point representation – sign-magnitude, one's complement, two's complement – floating point representation – IEEE 754 32-bit single precision floating point representation	2 hours
5	**FINITE WORD LENGTH EFFECTS AND DIGITAL SIGNAL PROCESSORS (7 hours)**	
5.1	Finite word length effects in digital Filters – input quantization – quantisation noise power – steady-state output noise power	2 hours
5.2	Coefficient quantisation – overflow – techniques to prevent overflow - product quantization error – rounding and truncation – round-off noise power	1 hour
5.3	Limit cycle oscillations – zero input limit cycle oscillations – overflow limit cycle oscillations – signal scaling.	1 hour
5.4	Digital signal processor architecture based on Harvard architecture (block diagram) – Harvard architecture, pipelining, dedicated hardware multiplier/accumulator, special instructions dedicated to DSP, replication, on-chip memory cache, extended parallelism (Reference [1])	2 hours
5.5	Comparison of fixed-point and floating-point processor – applications of digital signal processor	1 hour

Note: Preferable list of computer based assignments

Assignments using signal processing tool of MATLAB/SCILAB etc	
1	Determine 4-point/8-point DFT/IDFT of any sequence by direct computation
2	Compute 4-point/8-point DFT/IDFT using DIT FFT and DIF FFT algorithms.
3	Find the linear convolution and circular convolution of two sequences.
4	Find the linear convolution using overlap-add and overlap-save methods.
5	Determine 2 stage/3 stage lattice ladder coefficients if the system function of IIR direct form is given.
6	Obtain coefficients of IIR direct form from lattice ladder form.
7	Transform an analog filter into digital filter using impulse invariant technique/bilinear transformation.
8	Calculate the order and cut-off frequency of a low pass Butterworth filter
9	Obtain the frequency response and filter coefficients of a LP/HP/BP/BS IIR

	Butterworth filter
10	Obtain the frequency response and filter coefficients of a LP/HP/BP/BS IIR Chebyshev filter
11	Compute LP/HP/BP/BS FIR filter coefficients using rectangular/Bartlett/Hamming/Hanning/Blackmann window

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET463	ILLUMINATION TECHNOLOGY	PEC	2	1	0	3

Preamble: The basic objective of this course is to deliver the fundamental concepts of illumination engineering in the analysis and design of architectural lighting systems.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the fundamental concepts of natural and artificial lighting schemes
CO 2	Design efficient indoor lighting systems
CO 3	Design efficient outdoor lighting systems
CO 4	Describe aesthetic and emergency lighting systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	2	2	3				1					1
CO 3	2	2	3				1					1
CO 4	2	2			3							

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	15	15	30
Understand	15	15	30
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the quality of a good lighting (K2 PO1)
2. Select the factors affecting the quality of artificial lighting (K2 PO2)
3. Define MHCP, MSCP. (K1 PO1)

Course Outcome 2 (CO2)

1. Define Maintenance Factor.(K1 PO1)
2. Problems related to design of indoor lighting systems.(K2 PO2 PO3 PO7)
3. What are the special features that must be taken care of while illuminating staircase. (K2 PO2 PO12)

Course Outcome 3(CO3):

1. Select the main factors for designing street/road lighting? .(K2 PO2 PO3 PO12)
2. Problems related to design of Flood Lighting system?(K2 PO2 PO3 PO7)
3. With a neat diagram give the application of Track Fixtures.(K2 PO2 PO3)

Course Outcome 4 (CO4):

1. Explain at least Five features of monument lighting.(K2 PO1 PO2)
2. What are the different factors to be considered while designing aesthetic illumination of bridges and statues? .(K2 PO1 PO2 PO5)
3. Selection of luminaries for different areas in hospitals? .(K2 PO1 PO2 PO5)

Model Question Paper

QP CODE: PAGES:

Reg No:______________

Name :______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET463
Course Name: ILLUMINATION TECHNOLOGY

Max. Marks: 100 **Duration: 3 Hours**

PART A (10X3=30marks)

Answer all Questions. Each question carries 3 Marks

1. What are the different schemes of artificial lighting?
2. Explain with neat diagram the different types of artificial lighting system used.
3. Explain how photometric bench is used for measuring candle power of a test lamp
4. Explain how illumination can be calculated for Line source and Surface source.
5. Illustrate at least five fixtures used for outdoor lighting?
6. Define Space to Mounting height ratio
7. How are the projectors in flood lighting classified according to the beam?
8. What are different methods available for aiming the lamp in flood lighting?
9. List out the requirements of a good Sport lighting.
10. List out and explain at least five features of auditorium lighting

PART B
Answer any one full question from each module. Each question carries 14 Marks

Module-1

11(a) What is the impact of stroboscopic effect on visual comfort in an artificial lighting scheme? How the effect can be reduced

11(b) Explain with neat diagram the different types of artificial lighting system used.

12(a) Explain Colour rendering and stroboscopic effect

12(b) What is a glare? How it is classified.

Module-2

13(a) Four lamps 15m apart are arranged to illuminate a corridor. Each lamp is mounted at a height of 8m above the floor level. Each lamp gives 450 Cd in all directions below the horizontal. Find the illumination at the midway between 2nd and 3rd lamp

13(b) Illustrate with a neat diagram the concept of polar curve in illumination technology

14(a) State the Laws of Illumination

14(b) Explain with neat figures a.) Inverse square law b.) Lambert's Cosine law

Module-3

15(a) Specify the need of DLOR and ULOR in artificial architectural lighting. List out three factors on which DLOR and ULOR depends

15(b) Illustrate at least five fixtures used for interior lighting?

16(a) Define

1. Coefficient of utilisation
2. Depreciation factor

16(b) A drawing hall in an engineering college is to be illuminated with a lighting installation. The hall is 30m × 20m × 8m (high). The mounting height is 5m and the required level of illumination is 144 lm/m2. Using metal filament lamps, estimate the size and number of single lamp luminaries and draw their spacing layout. Assume: Utilization factor = 0.6, MF = 0.75; Space/Height = 1. Lumens/ Watt for 300-W lamp = 13, Lumens/Watt for 500-W lamp = 16

Module-4

17a) How are the projectors in flood lighting classified according to the beam?

17 b) Describe the area of application of each type of flood light.

18(a) Illustrate at least five fixtures used for outdoor lighting?

18(b) Explain the various types of lamps used in street lighting.

Module-5

19a) What are different factors to be considered while designing aesthetic illumination of bridges and statues?

19 b) What is the importance of modelling and shadows in the case of sports field lighting?

20 a) Describe any five characteristics of statue lighting

20(b) During the Onam week celebration organised by the Dept. of Tourism, it is a customary to illuminate the Kerala Secretariat Building and the arterial road in the capital city in different colours. As an illumination engineer what are the different factors which must be considered for

i) Illuminating the Secretariat building
ii) The roads way aesthetic lighting
iii) A Statue in front of Secretariat building

Syllabus

Module 1

Introduction of Light: Types of illumination, Day lighting, Artificial light sources- artificial lighting and total lighting, Quality of good lighting, Factors affecting the Physical processes- Incandescent and Halogen lamps, Fluorescent lamps, LPSV and HPSV lamps, mercury vapour lamps, metal halide lamps, LED lamps- modern trends. Supplementary lighting- shadow, glare, reflection, Colour rendering and stroboscopic effect, Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localised, Different types of Luminaires

Module 2

Measurement of Light: Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency, Brightness or luminance, Laws of illumination, Inverse square law and Lambert's Cosine law, Illumination at horizontal and vertical plane from point source, Concept of polar curve, Calculation of luminance and illumination in case of linear source, round source and flat source. Measuring apparatus- Goniophotometer, Integrating sphere, lux meter.

Module 3

Design of Interior Lighting: Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilisation and factors affecting it, Illumination required for various work planes, Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance, Selection of utilisation factor, reflection factor and maintenance factor, Determination of Lamp Lumen output taking into account voltage and temperature variations, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building.

Module 4

Design of Outdoor Lighting: Street Lighting - Types of street and their level of illumination required, Terms related to street lighting, Types of fixtures used and their suitable application, Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaire, Calculation of illumination level available on road. Tunnel

Lighting, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.

Flood Lighting: Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, recommended method for aiming of lamp, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.

Module 5

Special Features of Aesthetic Lighting: Monument and statue lighting, Sports lighting, Hospital lighting, Auditorium lighting

General Aspects of emergency lighting. Lighting controllers – dimmers, motion and occupancy sensors, photo sensors and timers. Lighting system design using software (eg: DIALux and Relux).

Note: Case study of indoor and outdoor lighting design using software may be given as assignment.

Text Books

1. D.C. Pritchard Lighting, Routledge, 2016
2. Jack L. Lindsey, Applied Illumination Engineering, PHI, 1991

References:

1. John Matthews Introduction to the Design and Analysis of Building Electrical Systems, Springer, 1993
2. M.A. Cayless, Lamps and Lighting , Routledge, 1996
3. Craig DiLouie, Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications, CRC Press, 2005.
4. Lighting Engineering Applied calculations R. H. Simons and A. R. Bean, Routledge; 1st edition, 2020

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction of Light (7 hours)**	
1.1	Types of illumination, Day lighting.	1
1.2	Artificial light sources-Physical processes- Incandescent and Halogen lamps, Fluorescent lamps, LPSV and HPSV lamps, mercury vapour lamps, metal halide lamps, LED lamps- modern trends.	2
1.3	Supplementary artificial lighting and total lighting, Quality of good lighting, Factors affecting the lighting-shadow, glare, reflection, Colour	2

	rendering and stroboscopic effect.	
1.4	Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localised, Different types of Luminaires.	2
2	**Measurement of Light. (7 hours)**	
2.1	Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency, Brightness or luminance.	2
2.2	Laws of illumination, Inverse square law and Lambert's Cosine law, Illumination at horizontal and vertical plane from point source.	2
2.3	Concept of polar curve, Calculation of luminance and illumination in case of linear source, round source and flat source.	2
2.4	Measuring apparatus- Goniophotometer, Integrating sphere, lux meter.	1
3	**Design of Interior Lighting (8 Hours)**	
3.1	Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilisation and factors affecting it, Illumination required for various work planes.	2
3.2	Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance, Selection of utilisation factor, reflection factor and maintenance factor.	2
3.3	Determination of Lamp Lumen output taking into account voltage and temperature variations, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio.	2
3.4	Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building.	2
4	**Design of Outdoor Lighting (10 Hours)**	
4.1	Street Lighting - Types of street and their level of illumination required, Terms related to street and street lighting, Types of fixtures used and their suitable application.	2
4.2	Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaire, Calculation of illumination level available on road. Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.	2
4.3	Tunnel Lighting, Calculation of their wattage and number and their	2

	arrangement, Calculation of space to mounting height ratio.	
4.4	Flood Lighting: Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, Recommended method for aiming of lamp.	2
4.5	Flood Lighting: Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.	2
5	**Special Features of Aesthetic and Emergency lighting (6 Hours)**	
5.1	Monument and statue lighting, Sports lighting	2
5.2	Hospital lighting, Auditorium lighting	1
5.3	General Aspects of emergency lighting, Lighting controllers – dimmers, motion and occupancy sensors, photo sensors and timers	2
5.4	Lighting system design using software	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET473	DIGITAL PROTECTION OF POWER SYSTEMS	PEC	2	1	0	3

Preamble: The basic objective of this course is to deliver fundamental concepts to design various electronic circuits to implement various relaying functions. The relays such as Static Relays, Microprocessor based protective relays, Digital relay Travelling wave based protection and adaptive relaying is comprehensively covered in this course. It should be also useful to practicing engineers and the research community.

Prerequisite : 1) EET 301 Power Systems I

2) EET 304 Power Systems II

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the relay protection scheme suitable for over current, differential and distance protection.
CO 2	Develop the protection scheme for bus bars, transformers, generators, motors and distribution systems using appropriate protective relays.
CO 3	Illustrate the operation of a numerical relay in his/her own way.
CO 4	Explain signal processing methods and algorithms in digital protection.
CO 5	Infer emerging protection schemes in power systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	-	-	-	-	-	-	-
CO 2	3	3	3	-	-	-	-	-	-	-	-	-
CO 3	3	2	3	-	-	-	-	-	-	-	-	-
CO 4	3	2	3	-	-	-	-	-	-	-	-	-
CO 5	3	3	-	2	-	-	-	-	-	-	-	-

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	30
Understand	20	20	40
Apply	20	20	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss how saturation affects the accuracy of C.T.s. (K2)
2. Why I.D.M.T. relays are widely used for over current protection (K2))
3. Develop a criteria for the selection off distance relays.(K3)

Course Outcome 2 (CO2)

1. In what way distance protection is superior to over current protection for the protection of transmission lines.(K2)
2. Discuss the working principle of frame leakage protection.(K2)
3. Explain the differential scheme for bus zone protection.(K1)

Course Outcome 3(CO3):

1. Explain the principle of operation of numerical relays. (K1)
2. What is the function of the sample and hold circuit.(K2)
3. Explain the sliding window concept.(K2)

Course Outcome 4 (CO4):

1. Explain the concept of Finite Impulse Response filters,(K2)
2. Explain sinusoidal wave based algorithms. (K1)
3. Explain Least squares based algorithm. (K1)

Course Outcome 5 (CO5):

1. Compare the different decision making schemes in protective relays.(K2)

2. Explain the concept of synchronized sampling. (K2)

3. What are the basic components of a phasor measurement unit.(K1)

Model Question Paper

QP CODE: **PAGES:4**

Reg.No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET473

Course Name : DIGITAL PROTECTION OF POWER SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain the basic principle and characteristics of impedance relays.

2. Explain current setting and time setting.

3. Explain the effect of power swings on the performance of distance relays.

4. What are the features of directional protection schemes for distribution system.

5. Give a comparison of numerical relays with static relays.

6. What are the basic components of numerical relays. Explain

7. Why digital filtering is required in a digital relay. Explain.

8. What are the useful properties of finite impulse filter.

9. What are the advantages of adaptive relaying

10. Give the definition of wide-area protection

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11.a) Explain the time current characteristics of inverse, very inverse and extremely inverse over current relays. Discuss their area of applications 7

b) What are the requirements of C.T. s used for protection. 7

12.a) Explain the types of construction used for P.T.s. 7

b) Explain the basic principle and characteristics of reactance and mho relays. 7

Module 2

13.a) With the help of a schematic diagram explain the carrier current protection scheme. 7

b) With the help of a neat diagram explain the working of harmonic restraint relay. 7

14.a) Explain the Phase comparison line protection scheme. 7

b) Explain the loss of excitation protection for a generator. 7

Module 3

15.a) With the help of a block diagram explain the basic components of a digital relay. 8

b) Explain the communication in protective relays (IEC 61850) 6

16.a) Briefly explain the information handling with substation automation system. 7

b) Explain the signal conditioning subsystem in numerical relays. 7

Module 4

17.a) Explain the full cycle window algorithm. 8

b) Give a comparison between infinite impulse filter and finite impulse filter. 6

18.a) Give the basic formulation of sample and first derivative method in sinusoidal wave based algorithm. 8

b) Explain how the impedance to the fault is found by using Least square method. 6

Module 5

19.a) Explain the methods of deterministic decision making and decision making with multiple criteria in protective relays. 8

b) Explain the architectures of wide-area protection 6

20.a) Explain the concept of Adaptive relaying and its applications. 8

b) Explain the Adaptive Differential protective scheme. 6

Syllabus

Module 1 (8 hours)

Introduction: Need for protective systems, Zones of protection, Current transformers and voltage transformers (Electromagnetic and Capacitive voltage transformers), Principle of operation of magneto optic CT/ PT, effect on relaying philosophy.

Relays: Over current relays - time-current characteristics of over current relays: definite time over current relays, inverse Definite Minimum time - directional over current relays, current setting and time setting - Numerical Problems - Differential relays: Operating and restraining characteristics, types of differential relays, Distance relays: impedance relays, reactance relays, mho relays, quadrilateral relays, elliptical relays (basic principles and characteristics only).

Module 2 (8 hours)

Protection of Transmission Line Systems: Schemes of distance protection, Differential line protection, Phase comparison line protection, Use of line carrier and communication links, Effect of power swings on the performance of distance relays.

Protection of Bus-bar, Transformer and Generator & Motor Systems*:* Types of faults, differential protection: High impedance and low impedance differential protection schemes, harmonic restraint relay, Restricted Earth Fault Protection, frame leakage protection, stator and rotor protection against various types of faults.

Pilot relaying schemes: Pilot wire protection, carrier current protection (Basic Principles and schematic).

Protection Scheme for Distribution Systems: Protection criteria for distribution system, Features of directional and non-directional protection schemes for distribution system,

Fundamentals of travelling wave protection scheme.

Module 3 (8 hours)

Introduction to Digital (Numerical) Relays- Basic Components of numerical Relays with block diagram, Processing Unit, Human machine Interface, Principle of operation- Comparison of numerical relays with electromechanical and static relays, Advantages of numerical relays - communication in protective relays (IEC 61850), Information handling with substation automation system (SAS)

Signal Conditioning Subsystems: Surge Protection Circuits, Anti-aliasing filter, Conversion Subsystem, The Sampling Theorem, aliasing, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion, Idea of sliding window concept, Fourier, Discrete and fast Fourier transforms

Module 4 (6 hours)

Signal processing techniques: Sinusoidal wave based algorithms, Fourier Analysis based algorithms (half cycle and full cycle), Least squares based algorithm.

Digital filters – Fundamentals of Infinite Impulse Response Filters, Finite Impulse Response filters, Filters with sine and cosine windows

Module 5 (6 hours)

Decision making in Protective Relays – Deterministic decision making, Statistical Hypothesis testing, Decision making with multiple criteria, Adaptive decision schemes.

Wide Area Protection and Measurement: Phasor Measurement Units, concept of synchronized sampling, Definition of wide-area protection, Architectures of wide-area protection, concept of Adaptive relaying, advantages of adaptive relaying and its application, Adaptive Differential protective scheme.

Assignment - Simulation of protection schemes using SIMULINK

Text/References Books

1. A. T. Johns and S. K. Salman, "Digital Protection for Power Systems," Peter Peregrinus Ltd, UK, 1995.
2. Waldemar Rebizant, Digital Signal Processing in Power System Protection and Control –Springer Publication
3. J. L. Blackburn, "Applied Protective Relaying," Westinghouse Electric Corporation, New York, 1982.
4. A. G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems," Research study press Ltd, John Wiley & Sons, Taunton, UK, 1988.
5. S.P Patra, S.K Bl,lsu and S. Choudhary, "Power System Protection", Oxford IBH Pub.
6. S. Ravindernath and M. Chander, "Power System Protection and Switchgear", Wiley Eastern Ltd.
7. Badri Ram and Vishwakarma, Power System Protection and Switchgear, A McGraw Hill.
8. Digital Signal Processing in Power System Protection and Control by Waldemar Rebizant, Janusz Szafran ,Andrzej Wiszniewski - Springer publication

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Introduction to protective relays (8 hours)**	
1.1	Introduction: Need for protective systems, Zones of protection, Current transformers and voltage transformers (Electromagnetic and Capacitive voltage transformers), Principle of operation of magneto optic CT/ PT, effect on relaying philosophy.	2
1.2	Relays: Over current relays-time-current characteristics of over current	2

	relays: definite time over current relays, inverse Definite Minimum time -directional over current relays, current setting and time setting-Numerical Problems	
1.3	Differential relays: Operating and restraining characteristics, types of differential relays,	1
1.4	Distance relays: impedance relays, reactance relays, mho relays, quadrilateral relays, elliptical relays (basic principles and characteristics only).	3
2	**Protection of Transmission, Distribution, Bus-bar, Transformer, Generator & Motor Systems (8 hours)**	
2.1	**Protection of Transmission Line Systems:** Schemes of distance protection, Differential line protection, Phase comparison line protection, Use of line carrier and communication links, Effect of power swings on the performance of distance relays.	2
2.2	**Protection of Bus-bar, Transformer and Generator & Motor Systems:** Types of faults, differential protection: High impedance and low impedance differential protection schemes, harmonic restraint relay, Restricted Earth Fault Protection, frame leakage protection, stator and rotor protection against various types of faults.	3
2.3	**Pilot relaying schemes:** Pilot wire protection, carrier current protection (Basic Principles and schematic) .	1
2.4	**Protection Scheme for Distribution Systems:** Protection criteria for distribution system, Features of directional and non-directional protection schemes for distribution system, Fundamentals of travelling wave protection scheme.	2
3	**Introduction to Digital (Numerical) Relays (8 hours)**	
3.1	Basic Components of numerical Relays with block diagram, Processing Unit, Human machine Interface, Principle of operation- Comparison of numerical relays with electromechanical and static relays, Advantages of numerical relays	3
3.2	Communication in protective relays (IEC 61850), Information handling with substation automation system (SAS)	1
3.3	Signal Conditioning Subsystems: Surge Protection Circuits, Anti-aliasing filter, Conversion Subsystem, The Sampling Theorem, aliasing, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion	3
3.4	Idea of sliding window concept, Fourier, Discrete and fast Fourier transforms	1

4	**Signal processing techniques (6 hours)**	
4.1	Signal processing techniques: Sinusoidal wave based algorithms, Fourier Analysis based algorithms (half cycle and full cycle), Least squares based algorithm	3
4.2	Digital filters – Fundamentals of Infinite Impulse Response Filters, Finite Impulse Response filters, Filters with sine and cosine windows	3
5	**Decision making in Protective Relays (6 hours)**	
5.1	Decision making in Protective Relays – Deterministic decision making, Statistical Hypothesis testing, Decision making with multiple criteria, Adaptive decision schemes.	2
5.2	Wide Area Protection and Measurement: Phasor Measurement Units, concept of synchronized sampling, Definition of wide-area protection, Architectures of wide-area protection	2
5.3	concept of Adaptive relaying, advantages of adaptive relaying and its application, Adaptive Differential protective scheme.	2

SEMESTER VII

OPEN ELECTIVE

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET415	CONTROL SYSTEMS ENGINEERING	OEC	2	1	0	3

Preamble: Control Engineering is not limited to any engineering discipline, but is equally applicable to mechanical, chemical, electrical, aeronautical engineering. The most characteristic quality of control engineering is the opportunity to control machines, industrial and economic process for the benefit of society. This course aims to provide a strong foundation on classical control theory. In this course modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach will be discussed.

Prerequisite: Knowledge of Laplace transforms.

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Identify the elements of control system.
CO 2	Develop transfer function models of systems.
CO 3	Analyse the relation between pole locations with the transient response of first and second order systems.
CO 4	Determine the stability of LTI systems.
CO 5	Apply the concept of Root locus to assess the performance of linear systems.
CO 6	Determine the frequency domain specifications from Bode plot, Polar plot and Nyquist plot.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	-	-	-	-	-	-	1
CO 2	3	2	-	-	-	-	-	-	-	-	-	1
CO 3	3	2	-	-	2	-	-	-	-	-	-	1
CO 4	3	2	-	-	-	-	-	-	-	-	-	1
CO 5	3	2	-	-	2	-	-	-	-	-	-	1
CO 6	3	2	-		2	-	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Explain with an example how does he feedback element affects the performance of a closed loop system.(K3,PO1, PO2 and PO12)
2. What is the function of controller and sensor in a closed loop system? (K2, PO1)
3. What are the modifications required to convert an open loop system to a closed loop system?(K1, PO1, PO12)

Course Outcome 2 (CO2)

1. Problems related to derivation of transfer function of mechanical systems. (K3,PO1 and PO12)
2. Define transfer function and derive the transfer function of an RC network. (K3, PO1, PO2 and PO12)
3. Write short notes on Force- voltage and Force – current analogy? (K1, PO1, PO12)

Course Outcome 3 (CO3)

1. What is the effect of location of roots on S-plane on the transient response of a system? (K1, PO1, PO12)
2. What is the change in transient response of a second order system due to the addition of poles? Illustrate with an example. (K1, PO1, PO2, PO12)
3. What is the significance of settling time in control system? (K1, PO1, PO12)

Course Outcome 4 (CO4)

1. Problems related to application of Routh's stability criterion for analysing the stability of a given system. (K3, PO1, PO2, PO12)
2. Plot the impulse response of a second order system for different location of poles on S-plane. (K3, PO1, PO2, PO12)

3. How can we relate asymptotic stability to location of roots of characteristic equation? K2, PO1, PO2, PO12)

Course Outcome 5 (CO5)

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+4)}$ is oscillatory, using Root locus. (K3, PO1, PO2, PO12)
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s\,(s^2 + 2s + 2)}$ and determine the value of K to achieve a damping factor of 0.5. (K3, PO1, PO2, PO12)
3. Problems on root locus for systems with positive feedback. (K3, PO1, PO2, PO12)

Course Outcome 6 (CO6)

1. Problems related to assess the stability of the given system using Bode plot. (K3, PO1, PO2, PO3, PO12)
2. Problems related to Polar plot. (K3, PO1, PO2, PO12)
3. Explain Nyquist stability criterion. (K2, PO1, PO2, PO12)

Model Question Paper PAGES: 2

QPCODE:

Reg. No:____________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code**: EET415**

Course Name: **CONTROL SYSTEMS ENGINEERING**

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

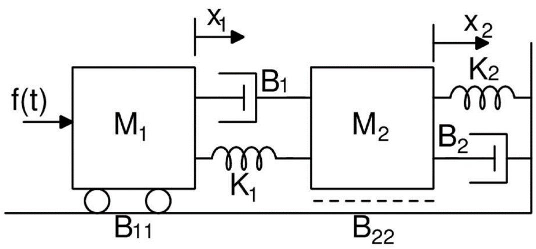
1. Write short notes on Force- voltage and Force – current analogy?
2. Explain Mason's gain formula?
3. Define damping ratio.
4. Derive and sketch the time response of a first order system.
5. What are dynamic error coefficients? What are their merits?
6. Define BIBO Stability. What is the requirement of BIBO Stability?
7. How to determine break away and break in point in root locus plot?
8. What is the significance of dominant pole?
9. Write a short note on the correlation between time and frequency response
10. Explain Nyquist stability criterion

PART B

Answer any one full question from each module. Each question carries 14 Marks

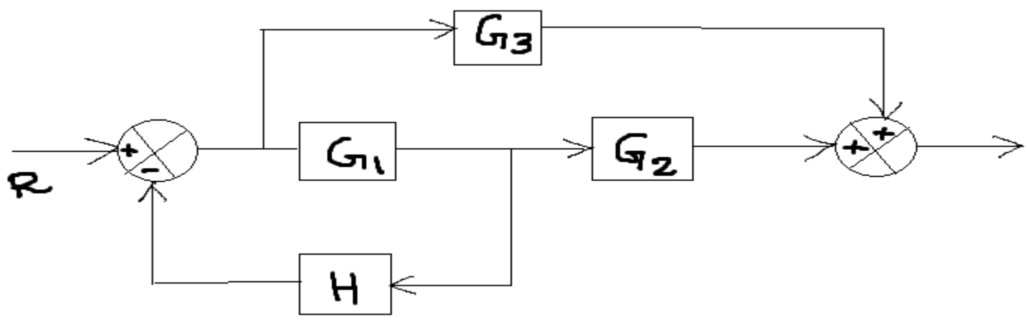
Module 1

9. a. Derive the transfer function for the mechanical system shown in figure. 10



b. Distinguish between open loop system and closed loop system 4

10. a. Reduce the block diagram shown in figure 10



b. Define transfer function and derive the transfer function of an RC network 4

Module 2

11 a. Sketch the time response of a general second order underdamped system and explain the specifications

6

b. The damping ratio of a system is 0.6 and the natural frequency of oscillation is 8 rad/sec. Determine the rise time, peak overshoot and peak time 8

12a. Distinguish between type and order of a system 5

b. The open loop transfer function of a unity feedback system is

$$G(s) = 20/s(s+10)$$

What is the nature of response of closed loop system for unit step input? 9

Module 3

13 a. Plot the impulse response of a second order system for different location of poles on S-plane. 9

b. What is the effect of location of roots on S-plane on the transient response of a system? 5

14 a. A unity feedback system has a open loop transfer function of 7

$$G(s) = 10/(s+1)(s+2)$$

Determine steady state error for unit step input

b. Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s) = \frac{K}{s(s^2 + 20s + 8)}$ is stable. **7**

Module 4

15 a. What is the relation between stability and coefficient of characteristic polynomial? 2

b. Explain the methods to find the crossing points of Root locus in imaginary axis. 4

c. Sketch the root locus for the unity feedback system whose open loop transfer function is given by: 8

$$G(s) = \frac{K}{s(s+4)(S^2+4S+20)}$$

16. Draw the root locus for a unity feedback system having forward path transfer function,

$$G(s) = \frac{K}{s(s+1)(s+5)}$$ 8

(a)Determine value of K which gives continuous oscillations and the frequency of oscillation.

(b)Determine the value of K corresponding to a dominant closed loop pole with damping ratio 0.7 6

Module 5

17. Consider a unity feedback system having an open loop transfer function

$$G(s) = k/s(1+0.2s)(1+0.05s)$$

(a) Sketch the polar plot 8

(b) Determine the value of K so that

(i) Gain margin is 18 db

(ii) Phase margin is 60° 6

18. (a)The open loop transfer function of a system is given by

$$G(s) = k/s(1+0.2s)(1+0.5s)$$

Sketch the Bode plot 8

(b)From the Bode plot determine the value of K so that

(i) Gain margin of the system is 6 db

(ii) Phase margin of the system is 25^o 6

Syllabus

Module 1

Feedback Control Systems (10 hours)

Open loop-and closed loop control systems: Transfer function of LTI systems- Mechanical and Electromechanical systems – Force voltage and force current analogy - block diagram representation - block diagram reduction - signal flow graph - Mason's gain formula - characteristic equation..

Module 2

Performance Analysis of Control Systems (5 hours)

Time domain analysis of control systems: Transient and steady state responses - time domain specifications - first and second order systems - step responses of first and second order systems.

Module 3

Error Analysis and Stability (6 hours)

Error analysis: Steady state error analysis and error constants -Dynamic error coefficients.

Stability Analysis: Concept of BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion-

Module 4

Root Locus Technique (6 hours)

Root locus technique: Construction of Root locus- stability analysis- effect of addition of poles and zeroes.

Module 5

Frequency Domain Analysis (9 hours)

Frequency domain specifications- correlation between time domain and frequency domain responses.

Polar plot: Concepts of gain margin and phase margin- stability analysis

Bode Plot: Construction- Concepts of gain margin and phase margin.

Nyquist stability criterion (criterion only)

Text books

1. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
2. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
3. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
4. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education

Reference Books

1. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India
2. Desai M. D., Control System Components, Prentice Hall of India, 2008
3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
4. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**Feedback Control Systems (10 hours)**	
1.1	Terminology and basic structure of Open loop and Closed loop control systems- Examples of Automatic control systems (block diagram representations only).	2
1.2	Transfer function approach to feed back contr.ol systems- Mechanical and Electromechanical systems	2
1.3	Force –voltage , force –current analogy.	2
1.4	Block Diagram Reduction Techniques.	2
1.5	Signal flow graph- Mason's gain formula, Characteristic Equation.	2
2	**Performance Analysis of Control Systems (5 hours)**	
2.1	Time domain analysis of control systems: Transient and steady state responses- Impulse and Step responses of first and second order systems Time domain specifications.	4
2.2	Time domain specifications.	1
3	**Error analysis and Stability(6 hours)**	
3.1	Error analysis: Steady state error analysis - static error coefficient of Type 0, 1, 2 systems. Dynamic error coefficients.	2
3.2	Stability Analysis: Concept of stability-BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems.	2
3.3	Application of Routh's stability criterion to control system analysis- Relative stability.	2
4	**Root Locus Technique (6 hours)**	
4.1	Root locus technique: General rules for constructing Root loci – stability from root loci -	5
4.2	Effect of addition of poles and zeros on Root locus	1

5	**Frequency domain analysis (9 hours)**	
5.1	Frequency domain specifications- correlation between time domain and frequency domain responses.	2
5.2	Polar plot: Concepts of gain margin and phase margin- stability analysis.	2
5.3	Bode Plot: Construction of Bode plots- gain margin and phase margin- Stability analysis based on Bode plot .	4
5.4	Nyquist stability criterion	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET425	INTRODUCTION TO POWER PROCESSING	OEC	2	1	0	3

Preamble: The recent advances in power electronics has resulted in the development of various industrial and household devices/equipment that employ power processing. It is important for engineering professionals to understand the fundamental principles behind such devices/systems. This course provides an overview of various essential elements of power electronics used for power processing, and their principle of operation. Power electronics deals with the processing and control of 'raw' electrical power from an electrical source. The power levels handled can vary from a few watts to several hundreds of megawatts. It is an enabling technology with a very wide range of applications. The course contents enable the students to understand the principles of power electronics and provide an introduction to various applications such as industrial drives, renewable energy, power supplies and electrical /hybrid vehicles.

Prerequisite: EST 130 Basics of Electrical and Electronics Engineering

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Explain different elements of power electronics.
CO 2	Explain various power electronic converters.
CO 3	Describe the basic principles of ac and dc motor drives.
CO 4	Describe the structure of power processing systems in power supplies, renewable energy conversion and EVs.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2											
CO 2	2											
CO 3	2								2			
CO 4	2						2		2			

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	20	20	40
Understand	30	30	60
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the principle of operation of MOSFET. (K2, PO1)
2. What is the difference between thyristors and controllable switches? (K1, PO1)
3. Why are IGBTs becoming popular in their applications to controlled converters ?
4. Enumerate some applications of IGBTs. (K1, PO1)
5. What are the applications of power electronic systems? (K1, PO1)

Course Outcome 2 (CO2)

1. With a neat circuit and waveforms, explain the working of a boost DC-DC converter.(K2, PO1)
2. With the help of waveform explain sinusoidal pulse width modulation used in single phase inverter. (K2, PO1)
3. Explain the working of a single-phase half bridge square wave inverter with pure R load. Draw the output voltage and output current waveforms.(K2, PO1)
4. Illustrate how a thyristor based 1-phase fully controlled rectifier can be used to convert ac into variable dc. Draw the waveforms of output voltage and output current for both R and RL load at α= 30 degree.(K2, PO1)

Course Outcome 3(CO3):

1. Give the classification of DC motors based on their field winding excitation with neat diagrams.(K2, PO9)
2. What is meant by armature reaction? What are its effects on main field flux? (K1, PO9)
3. Explain V/F control of induction motor drives. (K2, PO9)
4. Explain why we use starters for starting a DC motor. (K2, PO9)

Course Outcome 4 (CO4):

1. Explain a standalone solar PV system with a block diagram. (K2, PO7, PO9)
2. Explain the components of a linear power supply. (K2, PO7, PO9)
3. Distinguish between HEV and PHEV. (K2, PO7, PO9)
4. Explain the powertrain in an EV. (K2, PO7, PO9)

Model Question Paper

QP CODE:

PAGES:

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR Course Code: EET425

Course Name: INTRODUCTION TO POWER PROCESSING

Max. Marks: 100 **Duration: 3 Hours**

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks.

1. Explain the principle of operation of SCR.
2. What are wide bandgap devices? What are its advantages?
3. With a neat circuit explain the working of single phase fully controlled SCR based bridge rectifiers with R load.
4. With neat circuit, explain the working of a boost DC-DC converter
5. Differentiate between voltage source inverter and current source inverter.
6. With the help of waveform explain sinusoidal pulse width modulation used in single phase inverter.
7. What is meant by armature reaction?
8. Explain why we use starters for starting a DC motor.
9. What is the difference between on grid and off grid Solar PV installations?
10. Give three advantages of electric vehicles over the conventional IC engine driven vehicles.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) What are the advantages, disadvantages and applications of power electronic systems? (10)

(b)Compare a diode and a thyristor. (4)

12. (a) Describe the working of IGBT. How does latch-up occur in an IGBT? Why are IGBTs becoming popular in their applications to controlled converters? Enumerate some applications of IGBTs. (10)

(b) With a neat block diagram, explain a typical power electronic system. (4)

Module 2

13. (a) Illustrate how a thyristor based 1-phase fully controlled rectifier can be used to convert ac into variable dc. Draw the waveforms of output voltage and output current for RL load at α= 30 degree. (10)

(b) Discuss the significance of a freewheeling diode. (4)

14 (a) Explain with a circuit diagram and necessary waveforms, the working of a buck regulator for continuous current mode. (10)

(b) Explain the phenomenon of inductive kick. (4)

Module 3

15 (a) Explain the working of a single-phase half bridge square wave inverter with pure R load. Draw the output voltage and output current waveforms. (10)

(b) What is its main drawback? Explain how this drawback is overcome. (4)

16 (a) What is an ac voltage controller? List some of its industrial applications. Enumerate its merits and demerits. (7)

(b) Describe the operation of a single phase ac voltage controller with R load with necessary waveforms. (7)

Module 4

17. (a)With a neat schematic explain the components of an electric drive system (7)

(b)Explain the four-quadrant operation of a dc motor (7)

18 (a) List various control strategies used in induction motor drives (4)

(b) ExplainV/F control of induction motor drives. (10)

Module 5

19. (a) Explain the operation of a grid connected solar PV system with a neat block schematic (7)
    (b) Explain the components of a linear power supply. (7)

20. (a) Distinguish between HEV and PHEV (4)

    (b)Explain different energy storage systems used in Electric Vehicles (10)

Syllabus

Module 1

Introduction to power processing, elements of power electronics, power semiconductor devices. Uncontrolled, Semicontrolled and Fully controlled switches: Diode, SCR, MOSFETs and IGBTs- principle of operation. Advantages of wide bandgap devices-SiC, GaN.

Module 2

Basic power conversion circuits- converter circuits: Controlled rectifiers: Single- phase fully controlled SCR based bridge rectifier with R and RL load (continuous mode only). Principle of operation and waveforms (No analysis required).

DC-DC Converters (Non-isolated) : Buck, Boost and Buck-Boost converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).

Module 3

Single phase half and full bridge Inverter: Square-wave operation with R load. Types of PWM - single pulse, multiple pulse and sinusoidal PWM. Total Harmonic Distortion(THD).

Three phase voltage source inverter with R load- 120 and 180 degree conduction mode - waveforms

Single phase AC voltage controller with R load- waveforms.

Module 4

Applications: 1. *Motor drives*:

Introduction to electric motor drive- Block diagram

4-quadrant operation of a separately excited dc motor (circuit diagram and waveforms only).

Induction motor drives: Principle of operation- v/f control

Module 5

Applications 2: *Renewable energy*- solar PV installations-off grid and on grid systems: Principle of operation - Block diagram.

Applications 3: *Power supplies* - Principle of operation of linear and switched mode power supply- requirements of power supplies- Isolation, protection and regulation.

Applications 4: *Electric vehicles* - Introduction to HEV, PHEV and BEV-Block schematic of power train. Introduction to energy storage in EVs - Li Batteries, Hydrogen Fuel Cell.

Text/Reference Books

1. Ned Mohan, Tore m Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons, 2003.
2. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education, 2009.
3. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 2012.
4. Dubey G. K. "Fundamentals of Electrical drives" Narosa Publishing House, 1995.
5. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, 3rd Edition, Wiley, 2015.
6. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
7. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
8. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
9. Non conventional energy sources, NPTEL lecture by Prof.Prathap Haridoss, IIT Chennai.
10. Abad, Gonzalo, ed. Power electronics and electric drives for traction applications. USA: Wiley, 2017.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Introduction to power processing (6 hours)**	
1.1	Introduction to power electronics and its objectives, Advantages, disadvantages, applications, typical power electronic system	1
1.2	Elements of power electronics, power semiconductor devices.	1
1.3	Symbol and principle of operation of diode and SCR	1
1.4	Symbol and principle of operation of MOSFET	1
1.5	Symbol and principle of operation of IGBT	1
1.6	Advantages of wide bandgap devices- SiC, GaN	1
2	**Basic power conversion circuits (6 hours)**	
2.1	Converter circuits	1
2.2	Single- phase fully controlled SCR based bridge rectifier with R (continuous mode only), Principle of operation and waveforms (No analysis required)	1
2.3	Single- phase fully controlled SCR based bridge rectifier with RL load (continuous mode only), Principle of operation and waveforms (No analysis required)	1
2.4	DC-DC Converters (Non-isolated) : Buck converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).	1
2.5	Boost converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).	1
2.6	Buck-Boost converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).	1
3	**Inverter circuits, AC voltage controllers (6 hours)**	
3.1	Voltage source inverters	1
3.2	Single phase half and full bridge Inverter-Square-wave operation	1

	with R load	
3.3	Types of PWM - single pulse, multiple pulse and sinusoidal PWM Total Harmonic Distortion (THD)	1
3.4	Three phase voltage source inverter with R load- 120 degree conduction mode - waveforms	1
3.5	Three phase voltage source inverter with R load- 180 degree conduction mode - waveforms	1
3.6	Single phase AC voltage controller with R load- waveforms.	1
4	**Applications of power processing in Drives (9 hours)**	
4.1	Introduction to electric drives, components of electric drive, advantages of electric drives.	1
4.2	DC motor – principle of operation – back emf – necessity of motor starter-classification,	2
4.3	Four quadrant operation of separately excited DC Motor	2
	Three phase induction motor-squirrel cage and slip ring induction motor, Working principle-synchronous speed, slip	2
4.4	Induction Motor Drives, V/F control	2
5	**Applications of power processing in renewable energy generation, power supplies and EVs (5 hours)**	
5.1	Solar PV installations-Off grid and On grid	1
5.2	Linear and Switch Mode Power Supplies, Functional Block Diagram and operation	2
5.3	Introduction to Electric Vehicle, Various Types, Types of Energy Storage	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET435	RENEWABLE ENERGY SYSTEMS	OEC	2	1	0	3

Preamble: Objective of this course is to inculcate in students an awareness of new and renewable energy sources.

Prerequisite: Students who have taken EET383 MINOR are not eligible to take this course.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Choose the appropriate energy source depending on the available resources.
CO 2	Explain the concepts of solar thermal and solar electric systems.
CO 3	Illustrate the operating principles of wind, and ocean energy conversion systems.
CO 4	Outline the features of biomass and small hydro energy resources
CO 5	Describe the concepts of fuel cell and hydrogen energy technologies

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2					1	2					
CO 2	3											
CO 3	3					1	1					
CO 4	3					1	1					
CO 5	3											

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	25	25	50
Understand	20	20	40
Apply	5	5	10
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write short notes on the advantages and disadvantages of any three types of non conventional energy sources.(K1, PO1)

2. What are the points to be considered while constructing a house for energy efficiency? (K2, PO1, PO6, PO7)

Course Outcome 2 (CO2)

1. Explain construction of solar flat plate collector with a neat diagram. (K2, PO1)

2. Draw the block diagram of a solar thermal electric plant and explain its working. (K1, PO1)

3. Discuss the effect of temperature and insolation on the characteristics of solar cell. Draw the P-V characteristics of Solar cell under varying temperature and irradiation level. (K3, PO1)

Course Outcome 3 (CO3):

1. Derive the expression for power in the wind turbine. (K1, PO1, PO6, PO7)

2. Classify tidal power plants and brief explain any two of them. (K1, PO1, PO6, PO7)

3. With the help of a block diagram explain the working of a hybrid OTEC. (K2, PO1, PO6, PO7)

Course Outcome 4 (CO4):

1. What are the factors that affect biogas generation? (K1, PO1, PO6, PO7)

2. Compare the construction and performance of floating drum type and fixed dome type biogas plants with the help of neat sketches. (K2, PO1, PO6, PO7)

3. Discuss the selection criteria of turbines for a small hydro project. (K1, PO1, PO6, PO7)

Course Outcome 5 (CO5):

1. What is small hydro power? How is it classified? Obtain an expression for the power that can be generated from a small hydro power station. (K1, PO1)

2. Explain the hydrogen energy system with necessary diagram. (K2, PO1)

3. What do you mean by the conversion efficiency of a fuel cell? (K1, PO1)

Model Question Paper

Total Pages:2

Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code: EET435

Course Name: RENEWABLE ENERGY SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

1 Differentiate between flat plate collectors and solar concentrators.

2 Discuss advantages and limitations of conventional energy sources.

3 With the help of a block diagram explain the working of a hybrid OTEC.

4 List out the advantages and disadvantages of a tidal power plant.

5 Discuss the different types of wind turbine rotors used to extract wind power.

6 The Danish offshore wind farm has a name plate capacity of 209.3 MW. As of January 2017 it has produced 6416 GWh since its commissioning 7.3 years ago. Determine the capacity factor of above wind farm.

7 What are the factors that affect biogas generation

8 Discuss the process of biomass to ethanol conversion

9 What are the components of micro hydel power plant.

10 Enumerate the design and selection of different types of turbines used for small hydro plants

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

9	a)	With the aid of a neat diagram, explain the working of a central tower collector type solar thermal electric plant	(9)
	b)	Define (i) Open Circuit Voltage (ii) Short circuit Current (iii) Fill factor and (iv) Efficiency of the solar cell	(5)
10	a)	Compare the components and working of a standalone and grid connected PV system	(5)
	b)	How energy resources are classified. Compare conventional and non conventional sources of energy resources	(9)

Module 2

11		What are the site selection criteria for OTEC? Draw the block diagram and explain the working of Anderson cycle based OTEC system. Explain how biofouling affects efficiency of energy conversion and how can it be minimised?	(14)
12		Explain the principle of operation of a tidal power plant. How it is classified? Draw the layout of a double basin tidal power plant and label all the components.Explain the function of each component	(14)

Module 3

13	a)	Prove that the maximum wind turbine output can be achieved when $V_d = \frac{1}{3}V_u$ $V_d = \frac{1}{3}V_u$, where V_d V_d and $V_u V_u$ are down-stream and up-stream wind velocity respectively	(10)
	b)	What is pitch control of wind turbine? Explain.	(4)
14	a)	Determine the power output of a wind turbine whose blades are 12m in diameter and when the wind speed is 6m/s, the air density is about 1.2kg/m^3 and the maximum power coefficient of the wind turbine is 0.35.	(5)
	b)	Explain the parts, their function and working of a wind power plant. What are the site selection criteria of a wind power plant?	(9)

Module 4

15 a) With a neat schematic diagram , explain the biomass gasification based electric power generation system (5)

b) Explain the how urban waste is converted into useful energy (9)

16 a) Compare the construction and performance of floating drum type and fixed dome type biogas plants with the help of neat sketches (10)

b) Explain the importance of biomass programme in India (4)

Module 5

15 a) Explain the operation of a phosphoric acid fuel cell with the help of a suitable diagram (7)

b) What are the different methods used for the production and storage of hydrogen (7)

16 a) Draw the layout of a mini hydro project and explain its working (7)

b) Describe the working and constructional features of PEM fuel cell (7)

****

Syllabus

Module 1

Introduction, Classification of Energy Resources- Conventional Energy Resources - Availability and their limitations- Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison.

SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector).

SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, .construction. Solar PV Systems – stand-alone and grid connected- Applications .

Module 2

ENERGY FROM OCEAN- Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system- Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Site-selection criteria- Biofouling- Advantages & Limitations of OTEC.

TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin- double basin types –Limitations -Environmental impacts.

Module 3

WIND ENERGY- Introduction- Basic principles of Wind Energy Conversion Systems (WECS) wind speed measurement-Classification of WECS- types of rotors. wind power equation -Betz limit. Electrical Power Output and Capacity Factor of WECS- Advantages and Disadvantages of WECS -site selection criteria.

Module 4

BIOMASS ENERGY- Introduction- Biomass fuels-Biomass conversion technologies -Urban waste to Energy Conversion- Biomass Gasification- Biomass to Ethanol Production- Biogas production from waste biomass- factors affecting biogas generation-types of biogas plants – KVIC and Janata model-Biomass program in India.

Module 5

SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations.

EMERGING TECHNOLOGIES: Fuel Cell-principle of operation –classification- conversion efficiency and losses - applications .Hydrogen energy -hydrogen production -electrolysis - thermo chemical methods -hydrogen storage and utilization.

Text Books

1. G. D. Rai, " Non Conventional Energy Sources", Khanna Publishers, 2010.
2. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999

Reference Books

1. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
2. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
3. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
4. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
5. Tiwari G. N., Solar Energy- Fundamentals, Design, Modelling and Applications, CRC Press, 2002.
6. A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977
7. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001..
8. Boyle G. (ed.), Renewable Energy - Power for Sustainable Future, Oxford University Press, 1996

9. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
10. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 197
11. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978 62.
12. Khan B.H, Non Conventional Energy resources Tata McGraw Hill, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (35 hours)
1	**INTRODUCTION (7 HOURS)**	
1.1	Classification of Energy Resources- Conventional Energy - Resources - Availability and their limitations	1
1.2	Non-Conventional Energy Resources – Classification, Advantages, Limitations, Comparison.	1
1.3	SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors.	1
1.4	Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector)	1
1.5	SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation	1
1.6	Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction.	1
1.7	Solar PV Systems – stand-alone and grid connected- Applications	1
2	**ENERGY FROM OCEAN (7 hours)**	
2.1	Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system-	1
2.2	Open Cycle (Claude cycle), Closed Cycle (Anderson cycle)	1
2.3	Hybrid cycle. Site-selection criteria	1
2.4	Biofouling- Advantages & Limitations of OTEC	1
2.5	TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)-	1
2.6	Classification-single basin- double basin types –Limitations and environmental impacts	2
3	**WIND ENERGY (7 hours)**	
3.1	Introduction- Basic principles of Wind Energy Conversion Systems (WECS)	1
3.2	Wind speed measurement	1

3.3	Classification of WECS- types of rotors	2
3.4	Wind power equation -Betz limit	1
3.5	Electrical Power Output and Capacity Factor of WECS	1
3.6	Advantages and Disadvantages of WECS -site selection criteria	1
4	**BIOMASS ENERGY (6 hours)**	
4.1	Urban waste to Energy Conversion	1
4.2	Biomass Gasification- Biomass to Ethanol Production	1
4.3	Biogas production from waste biomass	2
4.4	Types of biogas plants – KVIC and Janata model	1
4.5	Biomass program in India.	1
5	**SMALL HYDRO POWER (8 hours)**	
5.1	Classification as micro, mini and small hydro projects	1
5.2	Basic concepts and types of turbines- selection considerations.	2
5.3	EMERGING TECHNOLOGIES: Fuel Cell-principle of operation	1
5.4	Classification- conversion efficiency and losses - applications	1
5.5	Hydrogen energy -hydrogen production	1
5.6	Electrolysis -thermo chemical methods	1
5.7	Hydrogen storage and utilization.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET445	ELECTRIC VEHICLES	OEC	2	1	0	3

Preamble: This course introduces basic knowledge about electric vehicles. Basic knowledge about the drives used in EV and HEV, battery management system , energy sources and communication networks are also discussed.

Prerequisite: NIL.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the basic concept of electric and hybrid electric vehicle
CO 2	Choose proper energy storage systems for vehicle applications
CO 3	Identify various communication protocols and technologies used in vehicle networks

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2					1	1					1
CO 2	2					1	1					1
CO 3	2					1	1					1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	25	25	50
Apply	15	15	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List various vehicle performance indices. (K1, PO1, PO6, PO7)

2. List various hybrid electric vehicle topologies.(K1, PO1)

3. Highlight the importance of control of electric motor drives in electric and hybrid electric vehicle powertrains. (K2, PO1, PO6, PO7)

Course Outcome 2 (CO2)

1. State the different characteristics of the energy storage system used in electric and hybrid electric vehicles .(K2, PO1, PO6, PO7)

2. Describe how the battery size can be reduced in electric and hybrid electric vehicles. (K2, PO1, PO6, PO7)

3. Illustrate the different methods used for increasing the battery life in electric and hybrid electric vehicles. (K2, PO1, PO6, PO7)

Course Outcome 3 (CO3):

1. List the general objectives of energy management strategies employed in electric and hybrid electric vehicles. (K1, PO1, PO6, PO7)

2. Identify various communication protocols used in electric and hybrid electric vehicles. (K1, PO1, PO6)

3. Illustrate how fuel economy is maintained in hybrid electric vehicles. (K2, PO1, PO6, PO7)

Model Question Paper

QP CODE:

PAGES: 3

Reg. No:_______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET455

Course Name: Electric Vehicles

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. List the reasons that led to the evolution of hybrid electric vehicles.

2. List the characteristics of the transmission system in a vehicle.

3. Mention one instance, when the internal combustion engine shall take up extra torque in the drivetrain of a parallel hybrid while being driven.

4. List major components in the drivetrain of an electric vehicle.

5. Discuss the advantage and disadvantage of using DC motors in the drivetrain of electric and hybrid electric vehicles.

6. List any three motors that can be used in the drivetrain of electric and hybrid electric vehicles.

7. Explain the C-rating of a battery

8. Explain the basic fuel cell structure with the help of a neat diagram

9. What are the seven layers of Open System Interconnection (OSI)?

10. What is meant by CAN transfer protocol

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11.	Explain the history of electric and hybrid electric vehicles.	14
12.	Explain the essential characteristics in the power sources intended to be used in electric and hybrid electric vehicles.	14

Module 2

13.	a. Highlight various factors that influence the component sizing in the power trains of hybrid electric vehicles.	7
b.	Illustrate how an internal combustion engine is always operated in its maximum operating efficiency region in a hybrid electric vehicle.	7
14.	a. Highlight the limitations posed by the battery during the power flow control in electric drive-train topologies.	8
b.	Suggest various methods to minimize the battery size and maximize battery life during the power flow control in electric drive-train topologies.	6

Module 3

15.	a. List the desired characteristics of motors used in the drive trains of electric and hybrid electric vehicles.	7
b.	Demonstrate the control of separately excited DC motors in electric vehicles.	7
16.	a. Explain the block diagram of electric drive system used in electric vehicles.	7
b.	Demonstrate the Field Oriented Control of Induction Motors in the powertrain of electric vehicles.	7

Module 4

17.	Explain about Lithium ion batteries with the help of necessary diagram. Write the chemical reactions involved in it.	14

18. What are the various battery parameters? Briefly explain 14

Module 5

19. Compare various energy management strategies in electric vehicles.
14

20. Discuss about a typical CAN layout in a hybrid electric vehicle with the help of block diagram 14

Syllabus

Module 1 (6 hrs)

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance

Module II (8 hrs)

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, Introduction to electric components used in hybrid electric vehicles

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.

Module III (8 hrs)

Block diagram of electric drive system, Introduction to electric motors used in hybrid and electric vehicles: configuration and control of separately excited DC motors, Induction Motors (block diagram representation of FOC).

Module IV (7 hrs)

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, Fuel Cell based energy storage, Hybridization of different energy storage devices, Introduction to Super capacitor and Hydrogen energy storage.

Module V (7 hrs)

Communications, supporting subsystems: In vehicle networks- CAN

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies

Text/References Books

1 Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

2. NPTEL (notes) – Electrical Engineering – Introduction to Hybrid and Electric Vehicles

3 K Sundareswaran, Elementary Concepts of Power Electronic Drives: CRC Press, Taylor & Francis Group

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Hybrid Electric Vehicles (6)**	
1.1	History of hybrid and electric vehicles,	1
1.2	Social and environmental importance of hybrid and electric vehicles	1
1.3	Basics of vehicle performance	1
1.4	Vehicle power source characterization, transmission characteristics	1
1.5	Mathematical models to describe vehicle performance	1
1.6	Dynamics of electric motion	1
2	**Hybrid Electric Drive -trains and Electric drive trains (8)**	
2.1	Basic concept of hybrid traction	1
2.2	Introduction to various hybrid drive-train topologies	1

2.3	Power flow control in hybrid drive-train topologies	2
2.4	Basic concept of electric traction	1
2.5	Introduction to various electric drive-train topologies,	1
2.6	Power flow control in electric drive-train topologies	2
3	**Electric drive system in electric and hybrid electric vehicles (8)**	
3.1	DC motors and induction motors	2
3.2	Introduction to Electric drive system	2
3.3	Separately excited DC motor speed control	1
3.4	V/f control of induction motor drive	1
3.5	Introduction to vector control (block diagram representation only)	2
4	**Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles (7)**	
4.1	Battery based energy storage	**3**
4.2	Fuel Cell based energy storage	**2**
4.3	Hybridization of different energy storage devices	**1**

	Introduction to Super capacitor and Hydrogen energy storage	**1**
5	**Communications, supporting subsystems and energy management strategies (7)**	
5.1	Communications networks	**2**
5.2	Introduction to energy management strategies used in hybrid and electric vehicles	**1**
5.3	Classification of different energy management strategies	**2**
5.4	Comparison of different energy management strategies	**2**

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET455	ENERGY MANAGEMENT	OEC	2	1	0	3

Preamble: This course introduces basic knowledge about energy management and audit. Energy management opportunities in electrical and mechanical systems are discussed. Economic analysis of different energy conservation measures is also described.

Prerequisite: Basics of Mechanical Engineering and Basics of Electrical Engineering.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the significance and procedure for energy management and audit.
CO 2	Discuss the energy efficiency and management of electrical loads.
CO 3	Discuss the energy efficiency in boilers and furnaces.
CO 4	Explain the energy management opportunities in HVAC systems
CO 5	Compute the economic feasibility of the energy conservation measures.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2					1	1		2	1		1
CO 2	2					1	1					
CO 3	2					1	1					
CO 4	2					1	1					
CO 5	2					1	1					1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	25	25	50
Understand	15	15	30
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define energy management. (K1, PO1, PO6, PO7)

2. List the different phases involved in energy management planning.(K1)

3. State the need for energy audit. (K2, PO1, PO9, PO10, PO12)

Course Outcome 2 (CO2)

1. State the different methods which can be adopted to reduce energy consumption in lighting.(K2, PO1, PO6, PO7)

2. Describe how energy consumption can be reduced by energy efficient motors.(K2, PO1, PO6, PO7)

3. Illustrate the different methods used for controlling peak demand.(K2, PO1, PO6, PO7)

Course Outcome 3 (CO3):

1. List the energy conservation opportunities in boiler.(K1, PO1)

2. Define Steam trapping.(K1, PO1)

3. Demonstrate how fuel economy measures can be done in furnaces.(K2, PO1, PO6, PO7)

Course Outcome 4 (CO4):

1. Define Coefficient of performance(K1, PO1)

2. Demonstrate how waste heat recovery can be done.(K2, PO1, PO6, PO7)

3. Describe how energy consumption can be reduced by cogeneration.(K2,PO1, PO6, PO7)

Course Outcome 5 (CO5):

1. State the need for economic analysis of energy projects.(K2, PO6, PO7, PO12)

2. Define payback period.(K1, PO12)

3. Demonstrate how life cycle costing approach can be used for comparing energy projects.(K3, PO6, PO7, PO12)

Model Question Paper

QP CODE:

PAGES: 3

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET455

Course Name: ENERGY MANAGEMENT

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain what do you mean by energy audit report.
2. Write notes on building management system.
3. Compare the efficacy of different light sources.
4. Write notes on types of industrial loads.
5. Discuss any two opportunities for energy savings in steam distribution.
6. Explain how boiler efficiency can be assessed using direct method.
7. Explain the working of a waste heat recovery system.
8. Write notes on computer aided energy management.
9. What are the advantages and disadvantages of pay back period method.
10. What do you mean by time value of money?

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a.	With the help of case studies, explain any four energy management principles.	8
b.	Explain the different phases of energy management planning.	6
12. a.	Explain in detail the different steps involved in a detailed energy audit.	7
b.	Discuss the different instruments used for energy audit.	7

Module 2

13. a.	With the help of case studies, explain any four methods to reduce energy consumption in lighting.	8
b.	Explain how energy efficient motors help in reducing energy consumption.	6
14. a.	With the help of case studies, explain any four methods to reduce energy consumption in motors.	8
b.	Explain the different methods used for peak demand control.	6

Module 3

15. a.	Explain any four energy conservation opportunities in furnaces.	7
b.	What is meant by a steam trap? Explain the operation of the thermostatic steam trap.	7
16. a.	Discuss the different energy conservation opportunities in boilers.	7
b.	Explain in detail, the reasons for low furnace efficiency.	7

Module 4

17. a.	Explain any five energy saving opportunities in heating, ventilating and air conditioning systems.	7
b.	Explain the working of different types of cogeneration systems.	7
18. a.	Explain the impact of evaporator and condenser temperature on the power consumption of a refrigerator.	7
b.	Explain the working of any two waste heat recovery devices.	7

Module 5

19. a. Calculate the energy saving and payback period which can be achieved by replacing a 11 kW, existing motor with an EEM. The capital investment required for EEM is Rs. 40,000/-. Cost of energy/kWh is Rs. 5. The loading is 70% of the rated value for both motors. Efficiency of the existing motor is 81% and that of EEM is 84.7%. 8

b. Compare internal rate of return method with present value method for the selection of energy projects. 6

20. a. Explain how the average rate of return method can be used for the selection of energy projects. 6

b. Compare the following motors based on life cycle costing approach. 8

	Motor A	**Motor B**
Output rating	10 kW	10 kW
Conversion efficiency	80%	90%
Initial cost	Rs. 50000	Rs. 75000
Replacement life	5 yrs	20 yrs
Salvage value	Rs. 2500	Rs. 3000
Annual maintenance and overhead costs	Rs. 1000	Rs. 1000
Electricity cost	Rs. 5 per kWh	
Operating schedule	8 hrs/day, 22 days/ month	

Syllabus

Module 1 (7 hours)

Energy Management - General Principles and Planning:

General principles of energy management and energy management planning

Energy Audit: Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit

Energy conservation in buildings: ECBC code (basic aspects), Building Management System (BMS).

Module 2 (8 hours)

Energy management in Electricity Utilization:

Energy management opportunities in Lighting and Motors, Electrolytic Process and Electric heating.

Types of industrial loads.

Peak demand controls and methodologies

Module 3 (8 hours)

Energy management in boilers and furnaces:

Types of boilers, Combustion in boilers, Performances evaluation, Feed water treatment, Blow down, Energy conservation opportunities in boiler.

Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings.

Classification, General fuel economy measures in furnaces, Excess air, Heat Distribution, Temperature control, Draft control.

Module 4 (6 hours)

Energy management in HVAC systems:

HVAC system: Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioning system performance and savings opportunities.

Classification and Advantages of Waste Heat Recovery system, analysis of waste heat recovery for Energy saving opportunities

Cogeneration-Types and Schemes, Optimal operation of cogeneration plants- Case study.

Computer aided energy management

Module 5 (6 hours)

Energy Economics:

Economic analysis methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, life cycle costing approach, Case studies.

Text/ Reference Books

1. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press, 2003.

2. Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.

3. Craig B. Smith, Energy management principles, Pergamon Press. 4. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press, 2007

5. G.G. Rajan, Optimizing energy efficiencies in industry -, Tata McGraw Hill, Pub. Co., 2001.

6. IEEE recommended practice for energy management in industrial and commercial facilities,

7. IEEE std 739 - 1995 (Bronze book).

8. M Jayaraju and Premlet, Introduction to Energy Conservation and Management, Phasor Books, 2008

9. Paul O'Callaghan, Energy management, McGraw Hill Book Co.

10. Wayne C. Turner, Energy management Hand Book - - The Fairmount Press, Inc., 1997.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Energy Management - General Principles and Planning; Energy audit (7 hours)**	
1.1	Energy management; General principles of energy management	2
1.2	Energy management planning	1
1.3	**Energy audit:** Definition, need, types and methodologies.	2
1.4	Instruments for energy audit, Energy audit report Power quality audit	2
2	**Energy management in Electricity Utilization (8 hours)**	
2.1	Energy management opportunities in Lighting.	2
2.2	Energy management opportunities in Motors.	2
2.3	Electrolytic Process and Electric heating.	2
2.4	Types of Industrial Loads. Peak Demand controls and Methodologies	2
3	**Energy management in boilers and furnaces (8 hours)**	
3.1	Types of boilers, Combustion in boilers, Performances evaluation, Feed water treatment, Blow down, Energy conservation opportunities in boiler.	2
3.2	Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping	2
3.3	Condensate and flash steam recovery system, Identifying opportunities for energy savings.	2
3.4	Classification, General fuel economy measures in furnaces, Excess air, Heat Distribution, Temperature control, Draft control, Waste heat recovery.	2
4	**Energy management in HVAC systems (6 hours)**	
4.1	HVAC system: Coefficient of performance, Capacity	1

4.2	Factors affecting Refrigeration and Air conditioning system performance and savings opportunities.	1
4.3	Classification and Advantages of Waste Heat Recovery system, analysis of waste heat recovery for Energy saving opportunities	2
4.4	Cogeneration-Types and Schemes, Optimal operation of cogeneration plants	2
5	**Energy Economics (6 hours)**	
5.1	Economic analysis methods	1
5.2	Cash flow model, time value of money, evaluation of proposals	1
5.3	Pay-back method, average rate of return method, internal rate of return method	2
5. 4	Present value method, life cycle costing approach, Case studies.	2

SEMESTER VII

MINOR

EED481	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini Project : A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Chemical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

- Survey and study of published literature on the assigned topic;
- Preparing an Action Plan for conducting the investigation, including team work;
- Working out a preliminary Approach to the Problem relating to the assigned topic;
- Block level design documentation
- Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;
- Preparing a Written Report on the Study conducted for presentation to the Department;

CO1	Identify and synthesize problems and propose solutions to them.
CO2	Prepare work plan and liaison with the team in completing as per schedule.
CO3	Validate the above solutions by theoretical calculations and through experimental
CO4	Write technical reports and develop proper communication skills.
CO5	Present the data and defend ideas.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	**20**
2	Project Guide	**30**
3	Final Seminar evaluation by the committee	**30**
4	The report evaluated by the evaluation committee	**20**
	Total	**100**
	Minimum required to pass	**50**

The evaluation committee comprises a panel of HoD or a senior faculty member, Project coordinator and project supervisor.

SEMESTER VII

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET495	OPERATION AND CONTROL OF GENERATORS	VAC	3	1	0	4

Preamble: NIL

Prerequisite: EET307 Synchronous and Induction Machines

EET302 Power Systems II

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify different types of electric generators and prime movers.
CO 2	Develop the model of synchronous generator and excitation system.
CO 3	Explain the basics of speed governor and AGC
CO 4	Acquire knowledge about Reactive power and voltage control.
CO 5	Describe the construction and principle of operation of Self excited synchronous generator, Wound rotor Induction generator and Permanent Magnet Synchronous generator.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	1								
CO 2	3	3	2	1								
CO 3	3	3	2	1								
CO 4	3	3	2	1								
CO 5	3	3	2	1								

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Classify ac generators by principles. (PO1, K1)

2. Explain the principle of operation of any one synchronous generator. (PO2, K2)

3. Why short pitch winding is preferred over full pitch winding in synchronous generator. (PO3, K2)

Course Outcome 2 (CO2)

1. Draw the general block diagram of excitation system of synchronous generator and explain the function of each unit. (PO3, K3)

2. Explain the need of power system stabilizer. (PO2, K2)

3. Develop the transient d -q model of a synchronous generator. (PO4, K3)

Course Outcome 3 (CO3):

1. List the limitations of isochronous speed governor. (PO1, K2)

2. Explain the Speed droop Governor with load reference control. (PO2, K1)

3. Numerical problem based on speed governor. (PO4, K4)

Course Outcome 4 (CO4):

1. Explain the function of shunt capacitor and series capacitor in power system. (PO4, K2)

2. Draw the equivalent circuit of SEIG in per unit frequency and speed. (PO3, K3)

3. Explain the principle of operation of cage rotor induction generator. (PO1, K2)

Course Outcome 5 (CO5):

1. Explain the constructional details of wound rotor induction generator. (PO2, K1)

2. Draw the phase coordinate model of permanent magnet synchronous generator. (PO3, K3)

3. Explain the on grid operation of Wound rotor induction generator. (PO4, K2)

Model Question Paper

QP CODE:

Reg. No: _______________

Name : ________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH& YEAR

Course Code: EET495

Course Name: Operation and Control of Generators

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks

1. Explain the features of Homopolar synchronous generator.
2. Draw the ideal model of hydraulic turbine.
3. Develop the model of a static exciter.
4. Define the static and dynamic stability of synchronous generator.
5. Draw the schematic of isochronous speed governor.
6. Write the features of speed droop governor with load frequency control.
7. Explain static var systems.
8. Explain automatic voltage regulation.
9. Explain the autonomous operation of wound rotor induction generator.
10. Derive the emf equation of permanent magnet synchronous generator.

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) With neat diagram, explain the constructional details of any two types of Synchronous Generators and suggest suitable turbine for them. (9 marks)

    b) Explain the principle of operation of Transverse flux reversal generator. (5 marks)

12. a) Explain the construction and working of linear motion alternator. (6 marks)

    b) Develop the model of steam turbine. (8 marks)

Module 2

13. a) Draw the general block diagram of excitation system of synchronous generator and explain the function of each unit. (8 marks)

    b) Draw and explain the v curve and reactive power capability curve of synchronous generator. (6 marks)

14. a) Explain the solution of instability problem of exciter. (6 marks)

    b) Explain the effect of mechanical transients in synchronous generator. (8 marks)

Module 3

15. a) Two similar alternators operating in parallel have the following data:

    Alternator 1: Capacity 700kW, frequency drops from 50Hz at no load to 48.5 Hz at full load.

    Alternator 2: Capacity 700kW, frequency drops from 50.5Hz at no load to 48 Hz at full load.

    Speed regulation of prime movers is linear in each case.

    i) Calculate how a total load of 1200 kW is shared by each alternator.

    ii) Compute the maximum load that these two units can deliver without over loading either of them. (14 marks)

16. a) Draw the schematic of a primitive speed droop governor and obtain the time response of a generation unit with primitive speed droop governor. Also list its merits. (9 marks)

    b) Explain the operation of AGC in an isolated power system. (5 marks)

Module 4

17. a) Write the physical significance of reactive power. Write the function of shunt

capacitor and shunt reactor in power system. (8 marks)

b) Explain the steady state performance of self-excited induction generator. (6 marks)

18. a) Explain voltage control using synchronous condenser. (6 marks)
b) Explain the principle of cage rotor induction generator. (8 marks)

Module 5

19. a) Obtain the steady state equation and draw the equivalent circuit of wound rotor induction generator. (6 marks)
b) Develop the d-q model of permanent magnet synchronous generator. (8 marks)

20. a) Explain the direct power control of wound rotor induction generator at grid. (6 marks)
b) Explain different practical configurations of permanent magnet synchronous generator and list its characteristics. (8 marks)

Syllabus

Module 1 (7 hours)

Electric Generators: Types of electric generators- Synchronous generators- Permanent magnet synchronous generators, Homopolar synchronous generator. Induction generator- Wound rotor doubly fed Induction generator. Parametric Generators- flux reversal generators, Transverse flux reversal generators and linear motion alternators (Basic principle of working and construction). Generator applications- High power wind generators.

Prime movers- Hydraulic turbines- Basics, ideal model, speed governors. Steam turbines- modelling and speed governors of steam turbine. Wind and gas turbines (basics only).

Module 2 (8 hours)

Excitation system- Brushless Excitation, Exciters- DC, AC and static exciters. Modelling of Exciters: - DC exciter, AC exciter and static exciter.

Compensation of excitation systems- Instability problem of exciter, solution to the instability of exciter, need of the power system stabilizer (PSS).

SG operation at Power Grid- Power/angle characteristics, V-curves, reactive power capability curves, Defining static and dynamic stability of SGs.

SG: Modeling for Transients- d-q model, equivalent circuits. Mechanical transients- response to shaft torque input, forced oscillation. Small disturbance electro mechanical transients (basics only).

Module 3 (7 hours)

Control of Synchronous Generators: General control system, Speed Governing basics- SG with its own load, Isochronous speed governor, The primitive speed -droop governor, load sharing between two SGs with speed- droop governor, speed-droop speed governor with load reference control. Time response of speed governors. Automatic generation control- AGC control of one SG in a two SGs isolated power system, AGC as a multilevel control system.

Module 4 (7 hours)

Reactive power and voltage control- Production and absorption of reactive power. Methods of voltage control: shunt reactors, shunt capacitors, series capacitors, synchronous condensers, static var systems. Automatic voltage regulation concept.

Self-excited induction generators: cage rotor induction machine principle. Self-excitation - Steady state performance of three phase SEIGs, Unbalanced operation of three phase SEIGs

Module 5 (7 hours)

Wound rotor induction generators- construction elements, steady state equations, equivalent circuit, Phasor diagrams. Operation at the grid- stator power versus power angle, rotor power versus power angle and operation at zero slip. Autonomous operation of WRIGs, losses and efficiency, Direct power control of WRIG at grid. Permanent magnet synchronous generator systems. Practical configuration and their characterization-distributed versus concentrated windings. Air gap field distribution, emf and torque. Circuit model- phase coordinate model and d-q model.

Text Books

1. P. Kundur, ‘Power system stability and control’ Mc Graw-Hill, 1994.
2. Ion Boldea, “Synchronous generators”, CRC Press, second edition, 2016.
3. Ion Boldea, “Variable speed generator”, CRC Press, second edition, 2016.
4. P.S. Bhimbra, “Generalized theory of electrical machines”, Khanna Publishers, 2002.
5. Hadi Saddat, “Power System Analysis”, McGraw-Hill, 2002.

Reference Books

1 C. Concordia, “Synchronous Machines”,
2 W.D Stevenson, “Elements of Power system analysis”, 1995.
3 A.E Fitzgerald and Kingsley, “Electric Machinery”, Mc Graw-Hill, Fifth edition, 1990.
4 Edward Wilson Kimbark, “Synchronous Machines”,
5 “Power System Stability”, - Vol 3:

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (7hours)**	
1.1	Types of electric generators- Synchronous generators	1
1.2	Permanent magnet synchronous generators, Homopolar synchronous generator. Induction generator- Wound rotor doubly fed Induction generator.	1
1.3	Parametric Generators- flux reversal generators, Transverse flux reversal generators	1
1.4	Linear motion alternators, Generator applications- High power wind generators.	1
1.5	Hydraulic turbines- Basics, ideal model, speed governors.	1
1.6	Steam turbines-modelling and speed governors of steam turbine.	1
1.7	Wind and gas turbines	
2	**Module 2 (8 Hours)**	
2.1	Brushless Excitation, Exciters- DC, AC and static exciters.	1
2.2	Modelling of Exciters: - DC exciter, AC exciter and static exciter.	1
2.3	Instability problem of exciter, solution to the instability of exciter.	1
2.4	Need of the power system stabilizer (PSS).	1
2.5	SG operation at Power Grid- Power/angle characteristics, V-curves, reactive power capability curves, Defining static and dynamic stability of SGs	1
2.6	SG: Modelling for Transients- d-q model, equivalent circuits.	1
2.7	Mechanical transients- response to shaft torque input, forced oscillation.	1
2.8	Small disturbance electro mechanical transients.	1
3	**Module 3 (7 Hours)**	
3.1	Control of Synchronous Generators: General control system	1
3.2	Speed Governing basics-SG with its own load, Isochronous speed governor.	1
3.3	The primitive speed -droop governor, load sharing between two SGs with speed- droop governor.	1
3.4	Speed-droop speed governor with load reference control.	1
3.5	Time response of speed governors.	1
3.6	Automatic generation control-AGC control of one SG in a two SGs isolated power system.	1
3.7	AGC as a multilevel control system.	1
4	**Module 4 (7 Hours)**	
4.1	Reactive power and voltage control- Production and absorption of reactive power.	1
4.2	Methods of voltage control: shunt reactors, shunt capacitors, series capacitors.	1
4.3	Synchronous condensers, static var systems.	1

4.4	Self-excited induction generators: cage rotor induction machine principle.	1
4.5	Self-excitation -Steady state performance of three phase SEIGs.	2
4.6	Unbalanced operation of three phase SEIGs.	1
5	**Module 5 (7 Hours)**	
5.1	Wound rotor induction generators- construction elements.	1
5.2	Steady state equations, equivalent circuit, phasor diagram.	1
5.3	Operation at the grid-stator power versus power angle, rotor power versus power angle and operation at zero slip.	1
5.4	Autonomous operation of WRIGs, losses and efficiency, Direct power control of WRIG at grid.	1
5.5	Permanent magnet synchronous generator systems- Practical configuration and their characterization-distributed versus concentrated windings.	1
5.6	Air gap field distribution, e.m.f and torque.	1
5.7	Circuit model-phase coordinate model and d-q model.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET497	DYNAMICS OF POWER CONVERTERS	VAC	3	1	0	4

Preamble: The objective of this course is to equip students with the basic tools for analysis and design of controllers for power electronic converters.

Prerequisite: EET306: POWER ELECTRONICS

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse dc-dc converters under steady state.
CO 2	Develop dynamic models of switched power converters using state space averaging and circuit averaging techniques.
CO 3	Derive converter transfer functions.
CO 4	Analyse closed loop controllers for dc-dc power converters.
CO 5	Analyse dc-dc converters operating in discontinuous conduction mode.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	3	3	2	2								
CO 2	3	3	2	2								
CO 3	3	3	2	2								
CO 4	3	3	2	2								
CO 5	3	3	2	2								

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	20%	20%	20
Understand	40%	40%	50

Apply	30%	30%	30
Analyse	10%	10%	
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions (EET497)

Course Outcome 1 (CO1):

1. Analysis of steady state operation with and without loss elements of basic dc-dc converters: (K1, K2, K3).
2. Develop steady state models of buck, boost and buck-boost converters (K2, K3).
3. Evaluate efficiency/duty ratio etc., for the given converters. (K2, K3).
4. Describe the volt-sec balance and amp-sec balance principles and their limitations. (K1, K2)

Course Outcome 2 (CO2)

1. Describe the significance of models with respect to control. (K1, K2).
2. Develop large-signal models from circuit averaging. (K2 K3)
3. Given large signal models, develop small-signal models by perturbation of circuit model. (K2, K3)
4. Procedural steps in deriving the state-space models. (K2)
5. Procedural steps in deriving the circuit averaged/switch averaged models (K2).

6. Given an averaged model of switch network, develop small-signal circuit models by circuit manipulation. (K2, K3).

Course Outcome 3(CO3):

1. Given a small-signal circuit model, develop transfer functions from it. (K2, K3).
2. Given a transfer function, plot Bode plots and get phase margin, Q, etc. (K2, K3).
3. Describe the features of converter transfer functions (K1, K2).
4. Explain experimental measurement of converter transfer functions. (K1, K2)

Course Outcome 4 (CO4):

1. Describe controller requirements for power converters. (K1, K2, K3)
2. Explain the controller structures like PD, PI and PID type compensators. (K2, K3).
3. Given transfer functions of converters, choose appropriate controllers for specified control requirements using Bode plots. (K2, K3)
4. Given transfer functions of compensators, develop op-amp circuits to realise the transfer functions. (K3).

Course Outcome 5 (CO5):

1. Describe the operation of dc-dc converters in DCM. (K2, K3)
2. Develop voltage transformation ratio for buck and boost converters in DCM. (K2, K3).
3. Develop the large-signal and small signal models for buck and boost converters operating in DCM through circuit averaging method. (K2, K3).(Note: From intermediate circuits/equations, full derivations are lengthy).
4. Interpret the model parameters of DCM small-signal, DC and large signal models. (K2, K3).

Model Question Paper:

Code: EET 497 **Pages:5**

Reg No.:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET 497

Course Name: DYNAMICS OF POWER CONVERTERS

Max. Marks: 100 **Duration: 3 hours**

PART A

Answer all questions; each question carries 3 marks.

1. What are the assumptions under which the steady-state analysis of the dc-dc converters is carried out? (3)

2. How are semiconductor conduction losses modelled in the steady-state analysis of dc-dc converters? (3)

3. Compare State-space averaging and circuit averaging techniques. (3)

4. What is the need of small-signal models of dc-dc switched converters? (3)

5. What type of converters have a right-half plane zero in their output-to-control transfer function? (3)

6. What is the significance of 'Q' in the converter transfer functions? How does it affect the converter dynamics? (3)

7. Explain the important controller specifications with respect to design of controllers for dc-dc converters. (3)

8. Show the transfer function of a typical PD type compensator. What are the primary objectives of this type of controller? (3)

9. Develop the voltage transformation ratio of a buck converter operating in discontinuous conduction mode. (3)

10 Explain why discontinuous conduction mode in dc-dc converters is also called complete energy transfer mode? (3)

PART B

Answer any one complete question from each section; each question carries 14 mark

11 (a) A boost converter is operating with an input dc voltage of 100 V. If the operating duty ratio is 0.4 and the operating efficiency is 90%, evaluate the output voltage. (4)

(b) Derive the steady-state equivalent circuit model of a buck-boost converter operating in CCM, assuming the switch has an on-state resistance of R_{on}. Neglect all other losses. (10)

OR

12 (a) A 100 W output buck converter is having a total power loss of 15 W. If the input voltage is 18 V, evaluate the operating duty ratio if the output voltage is 10 V. (4)

(b) Develop the steady-state equivalent circuit model of a buck converter operating in CCM, assuming the switch has an on-state voltage drop of V_T , and the diode has an on-state drop of V_D . Neglect all other losses. (10)

13 (a) Explain the step-by-step procedure to develop the averaged circuit model of dc-dc converters. (4)

(b) A switch network and its small-signal averaged model is shown in the figure 1 below: Plug this model into the ideal boost converter circuit in place of the switch network appropriately and transform into the canonical model. (10)

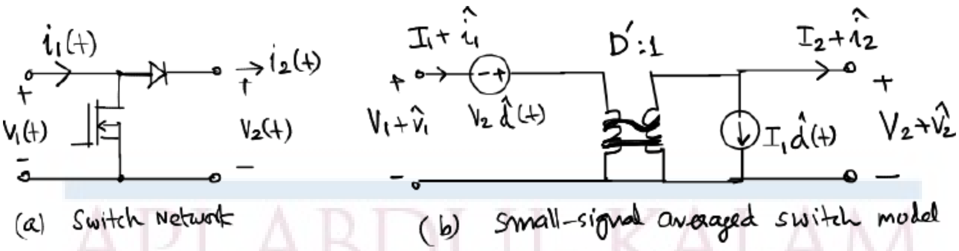


Figure 1.

OR

14 (14)

Identify the switch network in the ideal buck converter such that the relative connections between the switch and the diode are not disturbed. Mark port voltages and currents, identify the port voltage and current waveforms, average them and develop an averaged linear model with transformer representation for this switch network (not the converter).

15 (a) Figure 2 shows the small-signal model of a buck converter. Evaluate the output-to-control transfer function, $G_{vd}(s) = \frac{\hat{v}(s)}{\hat{d}(s)}$ from this equivalent circuit, by applying circuit manipulation techniques. Express the transfer functions in the standard form, where the quality factor Q, resonant frequency ω_0, dc gain G_0etc., are visible. (9)

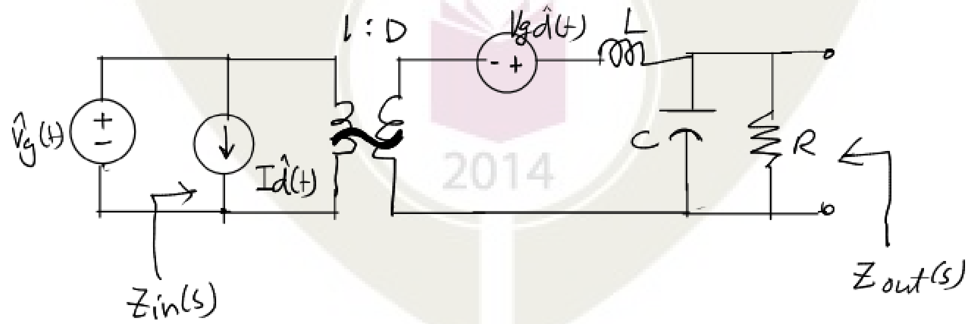


Figure 2.

(b) For the transfer function developed in 15 (a), for a duty ratio D=0.4, L = 100 µH, C= 125 µF and R = 1Ω, evaluate the transfer function. The converter is operated in CCM. Sketch its asymptotic Bode magnitude plot for the frequency range of interest. Comment on the nature of the plot. (5)

OR

16 (a) Describe any one scheme by which the small-signal ac transfer functions of dc-dc power converters can be experimentally measured. (6)

(b) The ideal output-to-control transfer function of a buck-boost converter is given by: (8)

$$G_{vd}(s) = G_{d0}\frac{\left(1-\frac{s}{\omega_z}\right)}{\left(1+\frac{s}{Q\omega_0}+\left(\frac{s}{\omega_0}\right)^2\right)},$$

Where,

$$G_{d0}(s) = \frac{V}{D(1-D)}, \quad \omega_z = \frac{(1-D)^2 R}{DL}, \quad \omega_0 = \frac{(1-D)}{\sqrt{LC}}, \text{ and}$$

$$Q = (1-D)R\sqrt{\frac{C}{L}}$$

For the following specifications, evaluate the transfer function and sketch its asymptotic Bode plots. Label the corner frequencies and the asymptotes appropriately. Vin = 48 V, V =- 24 V; L= 50 µH; C = 220 µF;R= 5Ω.

17 (a) It is desired to design a compensator with the transfer function $H(s)$ for a dc-dc converter given by: (7)

$$H(s) = -20\frac{1+\frac{s}{2\pi 800}}{\frac{s}{2\pi 800}}$$

Design the compensator using the ideal Op-amp. What type of controller is this?

(b) Explain the terms voltage injection and current injection with reference to loop gain measurement in dc-dc converters. Show relevant scheme diagrams. (7)

OR

18 Figure 3 shows the block diagram of a closed-loop controlled converter. (14)

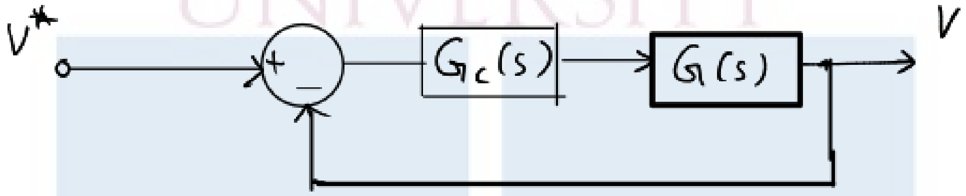


Figure 3.

The converter has a transfer function of

$$G(s) = \frac{40}{1 + \frac{2s}{100\pi} + \frac{s^2}{(100\pi)^2}}$$

The compensator has a transfer function of

$$G_c(s) = \frac{1 + \frac{s}{100\pi}}{1 + \frac{s}{4000\pi}}$$

Sketch the asymptotic gain plots of G(s), H(s) and G(s)H(s), and check whether the closed loop control is stable or not. What is the approximate phase margin of the controller? What is the crossover frequency?

19 (a) The figure following shows the averaged large signal model of a boost converter operating in DCM. What is the significance of the resistor $R_e(D)$, and what does the term P indicate? From this representation, obtain the steady-state expression for voltage transformation ratio in terms of the load resistance R and R_e. (8)

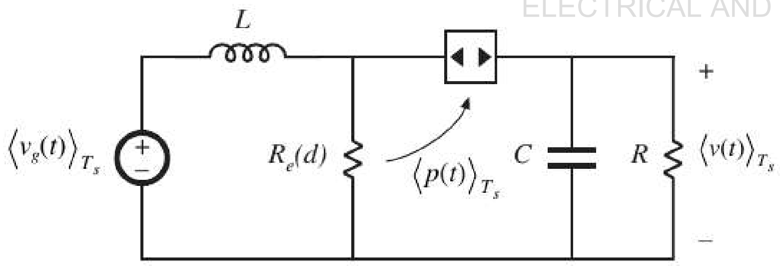
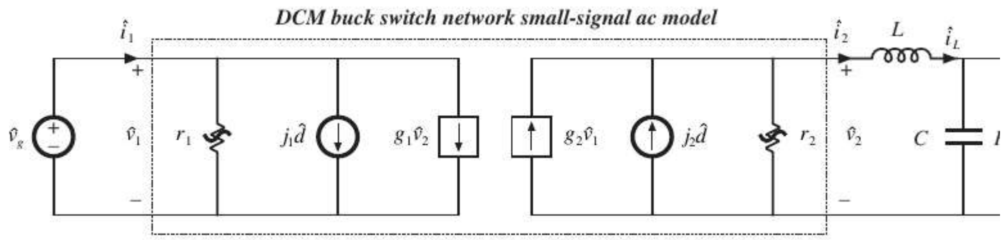


Figure 4.

(b) Write the procedural steps involved in developing the small-signal model for converters operating in DCM. (6)

OR

20 The figure 5 shows the small signal model of a buck converter operated in DCM. Reduce this circuit through circuit analysis techniques and obtain the output-to-line transfer function, Gv(s) = v(s)/v_g(s) in terms of the parameters given in the circuit model. (14)



Syllabus			
Module	**Course Description**	**Hours (45)**	**End Sem exam % Marks**
Module 1	Fundamentals of Steady state converter modelling and analysis applied to basic dc-dc converters: Buck, boost and buck-boost converter - Principle of volt-sec balance, amp-sec balance, and small-ripple approximation - Steady-state (dc) equivalent circuits, losses and efficiency. Inclusion of semiconductor conduction losses in converter model.	**8**	**20**
Module 2	Small-signal AC modelling - Averaging of inductor/capacitor waveforms - perturbation and linearisation. State-Space Averaging-Circuit Averaging and averaged switch modelling- Canonical Circuit Model - Manipulation of dc-dc converters' circuit model into Canonical Form-Modelling the pulse width modulator. *(Treatment may be limited to ideal converters. Questions in the end semester examination may be limited to buck and boost converter).*	**10**	**20**
Module 3	Converter Transfer Functions:- Review of frequency response analysis techniques - Bode plots - Converter transfer functions - graphical construction. Converter transfer functions of ideal buck, boost and buck-boost converters - Measurement of ac transfer functions and impedances.	**8**	**20**
Module 4	Controller Design: Effect of negative feedback on the network transfer functions - loop transfer function- Controller design specifications- PD, PI and PID compensators - applications to the basic dc-dc topologies - Practical methods to measure loop gains: Voltage and current injection.	**10**	**20**
Module 5	Converters in Discontinuous Conduction Mode: AC and DC equivalent circuit modelling of the discontinuous conduction mode-Generalised Switch Averaging-small-signal ac modelling of the DCM switch network. Transfer functions of ideal buck and boost converters in DCM. *(Note: Questions in the end semester examination*	**9**	**20**

	should not demand detailed derivations of transfer functions from scratch, as they're quite lengthy. Instead, intermediate circuits/equations may be provided to ease the time required and test the procedure. Also, form of the transfer functions may be given and asked to interpret/draw bode diagrams).		

Text/Reference Books:

1. Robert Erickson and Dragan Maksimovic, 'Fundamentals of Power Electronics', Springer India, Second Edition.
2. Christophe P. Basso, "Switched Mode Power Supplies: SPICE Simulations and Practical Designs," McGrawhill, Second Edition
3. John. G. Kassakian, M. F. Schlecht, G. C. Verghese, Principles of Power Electronics, PEARSON Education 2010.
4. Ned Mohan, T. M. Undeland, W. P. Robbins, "Power electronics converters, applications and design" 3rd edition, John Wiley and Sons Ltd, 2014.
5. L. Umanand, Power Electronics Essentials and Applications, Wiley publications, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (45)
1	**Steady state Modelling (8)**	
1.1	Fundamentals of Steady state converter modelling and analysis applied to basic dc-dc converters:	2
1.2	Buck, boost and buck-boost converter -	2
1.3	Principle of volt-sec balance, amp-sec balance, and small-ripple approximation -	2
1.4	Steady-state (dc) equivalent circuits, losses and efficiency.	1
1.5	Inclusion of semiconductor conduction losses in converter model.	1
2	**Small-signal AC modelling (10)**	
2.1	Averaging of inductor/capacitor waveforms- perturbation and linearisation.	2
2.2	State-Space Averaging-Circuit Averaging and averaged switch modelling-	2
2.3	Canonical Circuit Model-Manipulation of dc-dc converters' circuit model into Canonical Form-	3

2.4	Modelling the pulse width modulator. (Treatment may be limited to ideal converters. Questions in the examination may be limited to buck and boost converter).	3
3	**Converter Transfer Functions (8)**	
3.1	Review of frequency response analysis techniques-	2
3.2	Bode plots –Converter transfer functions-graphical construction.	2
3.3	Converter transfer functions of ideal buck, boost and buck-boost converters -	2
3.4	Measurement of ac transfer functions and impedances.	2
4	**Controller Design (10) :**	
4.1	Effect of negative feedback on the network transfer functions-	2
4.2	loop transfer function-Controller design specifications-	2
4.3	PD, PI and PID compensators - applications to the basic dc-dc topologies -	3
4.4	Practical methods to measure loop gains: Voltage and current injection.	3
5	**Converters in Discontinuous Conduction Mode (8):**	
5.1	AC and DC equivalent circuit modelling of the discontinuous conduction mode-	2
5.2	Generalised Switch Averaging-small-signal ac modelling of the DCM switch network.	3
5.3	Transfer functions of ideal buck and boost converters in DCM	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET499	CONTROL AND DYNAMICS OF MICROGRIDS	VAC	3	1	0	4

Preamble: The objective of this course is to introduce the fundamental concepts of dynamics and control of microgrid. This course covers different control strategies for microgrid and their analysis.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Illustrate the basic concept of microgrid and its components
CO 2	Choose proper storage systems for microgrid applications
CO 3	Appraise the operating modes, interconnection standards and issues in microgrid
CO 4	Appraise various control strategies for microgrid
CO 5	Model various components of microgrid

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		1									3
CO 2	3	3	3				2					2
CO 3	3	2	2		1	1						2
CO 4	3	3	2		1							2
CO 5	3	3	2		2							2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	30
Understand (K2)	20	20	40
Apply (K3)	20	20	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain a microgrid and its components (K1)

2. Illustrate different microgrid architecture. (K2)

3. Appraise the challenges associated with microgrid development. (K2)

Course Outcome 2 (CO2)

1. Explain the working of various energy storage systems with a schematic diagram. (K2)

2. Outline the scope of thermal energy storage systems for a microgrid. (K2)

3. Select suitable storage system for microgrid applications. (K3)

Course Outcome 3(CO3):

1. Distinguish between the grid-connected and islanded modes of operation of a microgrid. (K2)

2. Illustrate the need for IEEE 1547 interconnection standards. (K2)

3. Explain the fault ride-through capability of a microgrid (K1).

Course Outcome 4 (CO4):

1. Compare centralized control and decentralized control in a microgrid. (K2)

2. Choose suitable control strategies for a microgrid. (K3)

3. Explain frequency regulation, voltage regulation and VAR support. (K1)

Course Outcome 5 (CO5):

1. Explain the dynamic modelling of a microgrid. (K2)

2. What are microgrid stabilizers, and explain their design. (K3)

3. Explain the stability aspects of hybrid AC/DC microgrid. (K2)

Model Question Paper

QP CODE: Pages:

Reg No.: _______________

Name: _________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY ------- SEMESTER

B. TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code:

Course Name: CONTROL AND DYNAMICS OF MICROGRIDS

Max. Marks: 100 **Duration: 3 hours**

PART A

Answer all questions; each question carries 3 marks.

1.	Define a microgrid and list its associated components.	(3)
2.	Explain the technical and economical advantages of a microgrid.	(3)
3.	What is distributed energy storage system?	(3)
4.	What are the key parameters considered for the comparison of energy storage system?	(3)
5.	Explain the integration issues of distributed energy resources in a microgrid	(3)
6.	Explain fault ride-through capability of microgrid	(3)

7. Illustrate droop control of microgrid. (3)

8. What is the benefit of coordinated control in a microgrid ? (3)

9. What are microgrid stabilizers? Explain its necessity. (3)

10. List the advantages of the state-space model of a microgrid. (3)

PART B

Answer any one complete question from each section; each question carries 14 marks

Module 1

11 (a) Compare various microgrid architectures. (6)

(b) Explain the challenges associated with the implementation of a microgrid. (8)

OR

12 (a) Compare the advantages and disadvantages of microgrid deployment. (6)

(b) Explain the operation of a hybrid AC/DC microgrid with a neat diagram. (8)

Module 2

13 (a) Illustrate the working principle of compressed air energy storage system. (7)

(b) Explain flywheel energy storage system with diagram. (7)

OR

14 (a) Identify a suitable energy storage system for momentary support in a microgrid. (8)

(b) Illustrate the working of battery energy storage system. (6)

Module 3

15	(a)	Explain the need for IEEE 1547 standards.	(7)
	(b)	How power management is achieved in a microgrid.	(7)

OR

16	(a)	Illustrate various issues with the integration of distributed energy resources in a microgrid and its possible solutions.	(9)
	(b)	What are the conditions to be met in an AC microgrid for the transition from islanded mode to grid connected mode?	(5)

Module 4

17	(a)	Compare the centralized and decentralized control of a microgrid.	(8)
	(b)	Illustrate the advanced control techniques of a microgrid.	(6)

OR

18	(a)	Explain the hierarchical control of a microgrid.	(8)
	(b)	What are the various droop control techniques employed in a microgrid? Explain any three methods.	(6)

Module 5

19	(a)	Develop the state space model of a DC microgrid.	(10)
	(b)	What are the benefits of hybrid AC/DC microgrid from a stability aspect?	(4)

OR

20	(a)	Develop the state-space model of an AC microgrid.	(10)
	(b)	What is the influence of various parameters on microgrid stability?	(4)

Syllabus

Module 1

Microgrids- Microgrid Concept –Components – Micro sources, loads, power electronic interfaces - Architecture of microgrids (AC/DC/Hybrid AC/DC) – Technical and Economic advantage of microgrids- Challenges and disadvantages of microgrid development.

Module 2

Microgrids and Energy storage systems (ESS)- Different types of Batteries- Advanced lead acid battery, Flow battery, battery performance, storage density, Fuel cell, Flywheel, Supercapacitor, Pumped hydro storage, Superconducting magnetic energy storage, Compressed air energy storage system, Thermal energy storage — Application of energy storage systems in microgrids. PE interface design for energy storage system

Module 3

Operation of microgrid in grid connected and islanded mode – AC microgrid, DC microgrid, Hybrid AC/DC microgrid – Interconnection standards IEEE 1547 series, Integration issues of distributed generation – Power management in microgrids– Fault ride through capability of microgrid

Module 4

Control architectures in microgrid – Master slave with power-based control, Hierarchical control with centralized and distributed control - Basic control strategies – PQ control, V/f control, Droop control – Advanced control techniques- Coordinated control schemes in multi-microgrids, frequency, voltage regulations and volt-VAR support

Module 5

Dynamic modelling of individual components in AC and DC microgrids – Voltage source converter model, DC/DC converter model, line model, load model - state space model analysis and influence of system parameters on the microgrid dynamics - brief concept on the design of microgrid stabilizers to improve stability, Stability of hybrid AC/DC microgrid

Note: It is encouraged to conduct assignments using modern software tools for Module II, Module IV and Module V

Text Books

1. H. Bevrani, B. François, T. Ise, "Microgrid Dynamics and Control", John Wiley & Sons, 1st Edition, 2017.

2. N. D. Hatziargyriou, "Microgrids Architecture and control", IEEE Press Series, John Wiley & Sons Inc, 1st Edition, 2013.

Reference Books

1. S. Chowdhury, S P Chowdhury and P Crossely, "Microgrids and active distribution networks", IET Renewable energy series 6.

2. Suleiman M. Sharkh, Mohammad A. Abusara, "Power electronic converters for microgrid", IEEE Wiley

3. Amirnaser Yezdani, and Reza Iravani, Voltage Source Converters in Power Systems: Modeling, Control and Applications, IEEE John Wiley Publications, 2009.

4. Magdi S. Mahmoud, Microgrid: Advanced Control Methods and Renewable Energy System Integration, Elsevier,2017

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Microgrids**	**(6 hours)**
1.1	Microgrid Concept	2
1.2	Microgrid Concept- Components – Micro sources, loads, power electronic interfaces	1
1.3	Architecture of microgrids (AC/DC/Hybrid AC/DC)	1
1.4	Technical and Economic advantage of microgrids- Challenges and disadvantages of microgrid development.	2
2	**Microgrids and ESS**	**(8 hours)**
2.1	Different types of Batteries- Advanced lead acid battery, Flow battery, battery performance, storage density.	2
2.2	Fuel cell, Flywheel, Supercapacitor	1
2.3	Pumped hydro storage, Superconducting magnetic energy storage, Compressed air energy storage system	1
2.4	Thermal energy storage systems	1
2.5	Application of energy storage systems in microgrids.	1
2.6	PE interface design for energy storage system Assignments using software tool for storage system integrated microgrid	2
3	**Operation of microgrid in grid connected and islanded mode**	**(6 hours)**
3.1	Operation of microgrid in grid connected and islanded mode – AC microgrid, DC microgrid, Hybrid AC/DC microgrid	2
3.2	Interconnection standards IEEE 1547 series, Integration issues of distributed generation	1
3.3	Power management in microgrids	1
3.4	Fault ride through capability of microgrid	2
4	**Control architectures in microgrid**	**(8 hours)**
4.1	Master slave with power-based control	1
4.2	Hierarchical control with centralized and distributed control	1

4.3	Basic control strategies – PQ control, V/f control, Droop control	2
4.4	Advanced control techniques- Coordinated control schemes in multi-microgrids	2
4.5	frequency, voltage regulations and volt-VAR support Assignments using software tool to realize basic control strategies.	2
5	**Dynamic modelling of individual components in AC and DC microgrids (10 hours)**	
5.1	Modelling of voltage source converter, DC/DC converter, line model, load model	3
5.2	State space model analysis and influence of system parameters on the microgrid dynamics	1
5.3	Brief concept on the design of microgrid stabilizers to improve stability	3
5.4	Stability of hybrid AC/DC microgrid Assignments using software tool for stability study.	3

SEMESTER VIII

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET402	ELECTRICAL SYSTEM DESIGN AND ESTIMATION	PCC	2	1	0	3

Preamble: Electrical System Design would provide general awareness on IS Product standards / Codes of Practice, The Electricity Act 2003, CEA Regulations and Rules, NEC etc. related to Domestic, Industrial and Commercial Installations. It will also help in the design of Main and Sub Switchboards and distribution system for a medium class domestic and industrial electrical installations. Design of lighting system and selection of luminaries. Selection of Underground cables, Standby generators, lifts and with all involved auxiliaries. Design and selection of power distribution system with power and motor loads for a medium industry. Electrical system design for High-rise buildings with rising main/ cable distribution to upper floors including fire pumps. Design of indoor and outdoor 11kV substations including selection of switching and protective devices for an HT consumer. Essential safety requirements for the electrical installations for Recreational buildings.

Prerequisite: Basics of electrical power systems, circuit analysis and fault level calculations.

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Explain the rules and regulations in the design of components for medium and high voltage installations.
CO 2	Design lighting schemes for indoor and outdoor applications.
CO 3	Design low/medium voltage domestic and industrial electrical installations.
CO 4	Design, testing and commissioning of 11 kV transformer substation.
CO 5	Design electrical installations in high rise buildings.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1	2	-	-	1	-	2	-	-	-	-
CO 2	3	2	3	-	-	1	1	1	-	-	-	1
CO 3	3	1	3	-	-	1	-	1	-	-	-	1
CO 4	3	1	3	-	-	1	-	1	-	-	1	1
CO 5	3	1	3	-	-	1	1	1	-	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	15	15	30
Apply (K3)	25	25	50
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Case study/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. Mention the Scope of The Electricity Act 2003 (K1, K2, PO1)
2. Precautions to be followed for electric safety against loss of life and materials (K3, PO2, PO3, PO6)
3. Mention the Scope of IS 732 (K2, PO8)

Course Outcome 2 (CO2)
1. How are the luminaries selected based on the area of application? (K2, PO3, PO3, PO6)
2. What is CRI? (K1, PO1)
3. Parameters taken into consideration while designing street lighting and flood lighting (K3, PO2, PO3, PO7, PO8, PO12)

Course Outcome 3 (CO3):
1. Characteristics of MCBs (K1, PO1, PO3)
2. Grading between MCBs (K2, PO2, PO6, PO8)
3. Electrical Schematic and physical layout drawings of switch boards, DBs, lighting fittings, fans etc.(K3, PO2, PO6, PO8, P12)

Course Outcome 4 (CO4):
1. Selection of transformer substation. (K1, K2, PO1, PO3)
2. Protective switchgear selection and design of earthing. (K3, PO2, PO6, PO8, PO11)
3. Pre-commission tests to be conducted (K3, PO6, PO12)

Course Outcome 5 (CO5):
1. Selection of different electrical components/systems for multi-storeyed buildings (K1, K2, PO1)
2. Fire protection in high rise buildings (K1, K2, PO2, PO6, PO8)
3. The energy conservation techniques (K2, K3, PO2, PO6)

4. PV solar system design (K3, PO3, PO6, PO7, PO12)
5. Functioning of AMF system (K2, PO1)

Model Question Paper

PAGES: 3

QP CODE:

Reg. No:____________

Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code**: EET402**

Course Name: **ELECTRICAL SYSTEM DESIGN AND ESTIMATION**

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1	Describe the scope of NEC with regard to electrical system design.
2	What are the 3 phase AC system voltages as per NEC and their permissible limits.
3	Explain the specific design considerations in the design of a good lighting scheme.
4	List the different types of lamps suitable for street lighting and give their merits and demerits.
5	What is load survey and explain its importance in electrical system design.
6	Explain the salient aspects considered for the selection of LV/MV cables.
7	Explain the working principle of MCB/MCCB and compare MCB and MCCB.
8	List out the pre-commissioning tests of 11kV indoor substation of an HT consumer and explain any one method.
9	Explain the terms Continuous, Prime and Standby power ratings as applied to a Diesel Generator set.
10	Explain the principle of operation of an AMF panel in an electrical system. What is its necessity in an industry?

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11	a	What is standardization, how does NEC assist for the electrical system design.	(5)
	b	Explain the relevance of the following IS codes: IS 732, IS 3043.	(5)
	c	Briefly explain the electrical services in buildings.	(4)
12	a	Enumerate any five safety measures incorporated in system design.	(5)
	b)	Draw the standard graphical symbols as given in NEC for: i) circuit breaker ii) star-delta starter iii) fuse disconnector iv) autotransformer v) energy meter	(5)

c Explain the scope of the Electricity Act 2003. (4)

Module 2

13 a) What are the requirements to be satisfied for good road lighting? How are sources selected for road lighting? (7)

b) An office room of size 9X15m is to be illuminated by 2x18W LED luminaire. The lamps are being mounted at a height of 3m from the work plane. The average illumination required is 240 lux. Calculate the number of lamps required to be fitted, assuming a CU of 0.75 and a LLF of 0.8. Assume the ceiling height of the room as 5m. Draw the layout of the luminaire arrangement. The lumen output of 2x18W LED may be taken as 4000 lumens. (7)

14 a Briefly explain the working of an LED lamp with circuit diagram. (7)

b) Design a road way lighting scheme and determine the spacing between the poles using the given lamps. Which alternative you will choose, from the point of energy conservation?

Width of the road way = 12 m
Illumination required = 15lux
Mounting height of poles = 9 m
Arm length = 2m

Types of Lamps	**CU**	**LLF**
HPSV - 150 W, 16000 lumen	0.65	0.7
LPSV - 150 W, 25500 lumen	0.5	0.9

The lamps are placed on one side of the road. Assume any missing data. (7)

Module 3

15 a) List the pre-commissioning tests for domestic installation and with the help of schematic diagram explain any one test in detail. (4)

b) Determine the total connected load, number of sub circuits and type of supply for a domestic building with the following rooms: One-bedroom with attached toilet, hall and kitchen (1BHK). Draw the schematic diagram showing the ratings of MCBs and sub circuits. Design shall be based on the NEC guide lines. Assume all required data. (10)

16 a Briey explain the working of ELCB with a neat connection diagram. (4)

b) A rest house has four air-conditioned bed rooms with attached toilets, dining hall and kitchen. Prepare the room wise list of electrical materials for the installation. Draw the schematic diagram showing the ratings of MCBs and sub circuits. Design is based on the NEC guide lines. Assume all required data. (10)

Module 4

17 a Explain the criteria for the design of bus-bar system of a Motor Control Centre (MCC). (4)

b) An industry consists of the following loads:

a. 7.5 kW, 3 phase cage induction motor – 1 No.
b. 11.2 kW, 3 phase cage induction motor – 2 Nos.
c. 22.5 kW, 3 phase cage induction motor – 1 No.

d. Power sockets – 15Nos.

e. Lighting loads - 40 Nos of 2 x 18 W LED lamps

f. Exhaust fans 100 W - 4 Nos.

Design the electrical system for the industry, if the industry is located in a village, and also determine:

i. Type of industry,

ii. Transformer capacity required and type of substation, and

iii. Draw the single line schematic diagram showing the details of cable size, starters and switch gears. Use a switch board with MCCB/SFU incomer and MCCB/SFU/MCB as outgoing and MCB type distribution board for lighting. (10)

18 a) Explain the design procedures of the MSB of an industry with predominantly motor loads. (4)

b) A factory has the following connected load:

i. Large motor of 150 kW - 1 no.
ii. Machine shop with 7.5 kW motors - 6 nos.
iii. Painting booth of 22.5 kW
iv. 10 kVA welding transformers - 4 nos.
v. Water pumping station load 15 kW
vi. Lighting load 5 kW

Select the transformer rating and design an indoor substation including the schematic diagram showing the details of switchgear and cable sizes. Assume a diversity factor of 1.2. (10)

Module 5

19 a) Draw the schematic diagram of a 400 A rising main arrangement for a five-storied building also give the rating of floor wise feeders and switchgears. (6)

b) Briefly explain the sizing of solar PV system for a domestic installation with a daily usage of 5 units. (8)

20 a) Draw the electric schematic diagram of a 320 kVA standby DG set with an AMF panel. Explain the essential potential and metering arrangements required in the generator control panel. (6)

b) Briefly explain the sizing of the battery bank of an off grid solar PV system to cater 3 kWh per day for a domestic installation. (8)

Syllabus

Module 1

IS Product Standards and Codes of practice, The Electricity Act 2003 and NEC 2011 (6 hours):

General awareness of IS Codes - IS 732 - IS 3043 –IS 2026- IS 3646-part 1&2 - IS 5216 part 1&2 - Electricity supply code-2014 (Relevance of each code in electrical installation applications only).

The Electricity Act 2003- General introduction- Distribution of Electricity (Part VI)- Central Electricity Authority (Part IX)- Regulatory Commissions (Part IX).

National Electric Code (NEC 2011) - Scope – Wiring installation (Section 9)- Short circuit calculations (Section 10).

Graphical symbols and signs as per NEC for electrical installations.

Classification of voltages-standards and specifications, tolerances for voltage and frequency.

Module 2

Lighting Schemes and calculations (6 hours):

Lighting design calculations - Definitions of luminous flux, Lumen, Luminous intensity/illuminance (Lux), Illumination calculations, factors affecting Coefficients of Utilisation (CoU) - and Light Loss Factor (LLF).

Benefits of LED lamps over the yesteryear luminaires – Efficacy of present-day LED lamps- Design of illumination systems – Average lumen method - Space to mounting height ratio- Design of lighting systems for a medium area seminar hall using LED luminaires

Exterior lighting design- point to point method - road lighting and public area lighting- Space to mounting height ratio - selection of luminaires- Metal Halide- High & Low pressure Sodium– LED lamps.

Module 3

Domestic Installation (10 hours)

General aspects as per NEC and IS 732 related to the design of domestic dwellings availing single phase supply (LV) and three phase supply (MV) for a connected load less than 15kW.

Load Survey- common power ratings of domestic gadgets- connected load-diversity factor-selection of number of sub circuits (lighting and power)-selection of MCB distribution boards to provide over load, short circuit and earth leakage protection.

Principle of operation of MCB, MCB Isolator, ELCB/RCCB and RCBO. Selection of CBs for protection and grading between major and minor sections.

Selection of wiring cables, conduits as per NEC and IS 732.

Design of electrical schematic and physical layout drawings for low and medium class domestic installation. Preparation of schedule of works and bill of quantities (cost estimation excluded).

Pre-commissioning tests- Insulation resistance measurement, continuity test, polarity test, and earth resistance measurement as applicable to domestic installations.

Module 4
Industrial Power and Lighting Installations (9 hours):

Industrial installations –classifications- Design of electrical distribution systems with main switch board, sub switch boards and distribution boards with ACBs, MCCBs and MCBs as the case may be, for feeding power (mainly motors) and lighting loads of small and medium industries.

Selection of armoured power cables (AYFY, A2XFY, YWY) – calculation of ampacity, voltage drop, short circuit withstand capacity etc.

Design of MSB & SSB including Motor Control Centre (MCC) for motor controls - selection of bus bars and switchgears.

Selection of 11kV indoor and outdoor transformer substations upto 630kVA - selection of switchgears and protective devices –Preparation of schedule of works and bill of quantities (cost estimation excluded).

Short circuit calculations and earthing design for the HV and LV sides of an 11 kV substation of capacity up to 630 kVA.

Pre-commissioning tests of 11kV indoor/outdoor substation of an HT consumer.

Module 5
High Rise building, Solar PV system, Standby generators and Energy conservation (8 hours):

Electrical installations of high-rise buildings: Distribution systems – rising main, cable system - Installation of lifts, standby generators, fire pumps - electric schematic drawing.

Selection of standby Diesel Generator set (DG set) –power rating - Continuous, Prime and Standby power ratings- installation and essential protections-Introduction to Automatic Mains failure (AMF) systems.

Energy Conservation Techniques in electrical power distribution - Automatic Power Factor Correction (APFC) panel – Principle of operation and advantages.

Introduction to Solar PV Systems, off-grid and on-grid systems, Solar panel efficiencies-design of a PV system for domestic application-Selection of battery for off-grid domestic systems.

Data Book (Use for Examination Hall)

1. Data Book Published by the University

Text/Reference Books

1. National Electrical Code 2011, Bureau of Indian Standards.
2. National Lighting Code 2010, Bureau of Indian Standards.
3. National Building Code of INDIA 2016 - Bureau of Indian Standards.
4. M. K. Giridharan, Electrical Systems Design, I K International Publishers, New Delhi, 2nd edition, 2016.
5. U.A.Bakshi, V.U.Bakshi Electrical Technology, Technical publications, Pune.
6. Narang K.L., A Text Book of Electrical Engineering Drawing, Tech India Publications.
7. J. B. Gupta, A Course in Electrical Installation Estimating and Costing, S.K. Kataria & Sons; Reprint 2013 edition (2013).
8. K. B. Raina, S. K. Bhattacharya, Electrical Design Estimating Costing, NEW AGE; Reprint edition (2010).

Website

1. www.price.kerala.gov.in (Reference for module 3 and 4)

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**IS Codes, Ats, Rules and NEC (6 hours):**	
1.1	General awareness of IS Codes - IS 732 - IS 3043 –IS 2026- IS 3646-part 1&2 - IS 5216 part 1&2 - Electricity supply code-2014 (Relevance of each code in electrical installation applications only). The Electricity Act 2003- General introduction- Distribution of Electricity (Part VI)- Central Electricity Authority (Part IX)- Regulatory Commissions (Part IX).	2
1.2	National Electric Code (NEC 2011) - Scope – Wiring installation (Section 9)- Short circuit calculations (Section 10).	2
1.3	Graphical symbols and signs as per NEC for electrical installations. Classification of voltages-standards and specifications, tolerances for voltage and frequency.	2
2	**Lighting Schemes and calculations (6 hours):**	
2.1	Lighting design calculations - Definitions of luminous flux, Lumen, Luminous intensity/illuminance (Lux), Illumination calculations, factors affecting Coefficients of Utilisation (CoU) - and Light Loss Factor (LLF).	2
2.2	Benefits of LED lamps over the yesteryear luminaires – Efficacy of present-	2

	day LED lamps-Design of illumination systems – Average lumen method - Space to mounting height ratio- Design of lighting systems for a medium area seminar hall using LED luminaires	
2.3	Exterior lighting design- point to point method - road lighting and public area lighting- Space to mounting height ratio - selection of luminaires- Metal Halide- High & Low pressure Sodium– LED lamps.	2
3	**Domestic Installation (10 hours):**	
3.1	General aspects as per NEC and IS 732 related to the design of domestic dwellings availing single phase supply (LV) and three phase supply (MV) for a connected load less than 15kW.	2
3.2	Load Survey- common power ratings of domestic gadgets- connected load-diversity factor-selection of number of sub circuits (lighting and power)-selection of MCB distribution boards to provide over load, short circuit and earth leakage protection.	2
3.3	Principle of operation of MCB, MCB Isolator, ELCB/RCCB and RCBO. Selection of CBs for protection and grading between major and minor sections. Selection of wiring cables, conduits as per NEC and IS 732.	2
3.4	Design of electrical schematic and physical layout drawings for low and medium class domestic installation. Preparation of schedule of works and bill of quantities (cost estimation excluded). Pre-commissioning tests- Insulation resistance measurement, continuity test, polarity test, and earth resistance measurement as applicable to domestic installations.	4
4	**Industrial installations (9 hours):**	
4.1	Industrial installations –classifications- Design of electrical distribution systems with main switch board, sub switch boards and distribution boards with ACBs, MCCBs and MCBs as the case may be, for feeding power (mainly motors) and lighting loads of small and medium industries. Selection of armoured power cables (AYFY, A2XFY, YWY) – calculation of ampacity, voltage drop, short circuit withstand capacity etc.	3
4.2	Design of MSB & SSB including Motor Control Centre (MCC) for motor controls - selection of bus bars and switchgears.	2

4.3	Selection of 11kV indoor and outdoor transformer substations upto 630kVA - selection of switchgears and protective devices –Preparation of schedule of works and bill of quantities (cost estimation excluded). Short circuit calculations and earthing design for the HV and LV sides of an 11 kV substation of capacity up to 630 kVA.	3
4.4	Pre-commissioning tests of 11kV indoor/outdoor substation of an HT consumer.	1
5	**High Rise building, Solar PV system, Standby generators and Energy conservation (8 hours):**	
5.1	Electrical installations of high-rise buildings: Distribution systems – rising main, cable system - Installation of lifts, standby generators, fire pumps - electric schematic drawing.	2
5.2	Selection of standby Diesel Generator set (DG set) –power rating - Continuous, Prime and Standby power ratings- installation and essential protections-Introduction to Automatic Mains failure (AMF) systems.	3
5.3	Energy Conservation Techniques in electrical power distribution - Automatic Power Factor Correction (APFC) panel – Principle of operation and advantages.	1
5.4	Introduction to Solar PV Systems, off-grid and on-grid systems, Solar panel efficiencies-design of a PV system for domestic application-Selection of battery for off-grid domestic systems.	2

EET404	COMPREHENSIVE COURSE VIVA	CATEGORY	L	T	P	CREDIT
		PCC	1	0	0	1

Preamble: The objective of this Course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations.

Guidelines

1. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum.
2. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation. It comprises of Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department.
3. The pass minimum for this course is 25.
4. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
5. Comprehensive Viva should be conducted along with final project evaluation by the three member committee.

Mark Distribution

Total marks: 50, only CIE, minimum required to pass : 25 Marks

EED416	PROJECT PHASE II	CATEGORY	L	T	P	CREDIT
		PWS	0	0	12	4

Preamble: The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

Course Objectives

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems.

Course Outcomes [COs]: After successful completion of the course, the students will be able to:

CO1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: **Apply**).
CO2	Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: **Apply**).
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: **Apply**).
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: **Apply**).
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: **Analyze**).
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: **Apply**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	2	2	1	1	1	1	2
CO2	2	2	2		1	3	3	1	1		1	1
CO3									3	2	2	1
CO4					2			3	2	2	3	2
CO5	2	3	3	1	2							1
CO6					2			2	2	3	1	1

Abstract POs defined by National Board of Accreditation			
PO #	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO0	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

PROJECT PHASE II

Phase 2 Targets

- In depth study of the topic assigned in the light of the report prepared under Phase - I;
- Review and finalization of the approach to the problem relating to the assigned topic.
- Preparing a detailed action plan for conducting the investigation, including teamwork.
- Detailed Analysis/ Modeling / Simulation/ Design/ Problem Solving/Experiment as needed.
- Final development of product/ process, testing, results, conclusions and future directions.
- Preparing a paper for Conference Presentation/ Publication in Journals, if possible.
- Presenting projects in Project Expos conducted by the University at the cluster level and/ or state level as well as others conducted in India and abroad.
- Filing Intellectual Property Rights (IPR) if applicable.
- Preparing a report in the standard format for being evaluated by the Department Assessment Board.
- Final project presentation and viva voce by the assessment board including the external expert.

Evaluation Guidelines & Rubrics

Total: 150 marks (Minimum required to pass: 75 marks).

- Project progress evaluation by guide: 30 Marks.
- Two interim evaluations by the Evaluation Committee: 50 Marks (25 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: 40 Marks
- Quality of the report evaluated by the evaluation committee: 30 Marks

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor. The final evaluation committee comprises of Project coordinator, expert from Industry/research/academic Institute and a senior faculty from a sister department).

Evaluation by the Guide

The guide/supervisor must monitor the progress being carried out by the project groups on regular basis. In case it is found that progress is unsatisfactory it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide. Project evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/her group by considering the following aspects:

Project Scheduling & Distribution of Work among Team members: Detailed and extensive Scheduling with timelines provided for each phase of project. Work breakdown structure well defined. (5)

Literature survey: Outstanding investigation in all aspects. (4)

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide. (7)

Individual Contribution: The contribution of each student at various stages. (9)

Completion of the project: The students should demonstrate the project to their respective guide. The guide shall verify the results and see that the objectives are met. (5)

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation - 1

No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-a	Novelty of idea, and Implementation scope [CO5] [Group Evaluation]	**5**	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea can be implemented. There is still lack of originality in the work done so far by the team. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team . There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable / publishable work.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-b	Effectiveness of task distribution among team members. [CO3] [Group Evaluation]	**5**	No task distribution of any kind. Members are still having no clue on what to do.	Task allocation done, but not effectively, some members do not have any idea of the tasks assigned. Some of the tasks were identified but not followed individually well.	Good evidence of task allocation being done, supported by project journal entries, identification of tasks through discussion etc. However, the task distribution seems to be skewed, and depends a few members heavily than others. Mostly the tasks are being followed by the individual members.	Excellent display of task identification and distribution backed by documentary evidence of team brainstorming, and project journal entries. All members are allocated tasks according to their capabilities, and as much as possible in an equal manner. The individual members are following the tasks in an excellent manner.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-c	Adherence to project schedule. [CO4] [Group Evaluation]	**5**	Little or no evidence of continued planning or scheduling of the project. The students did not stick to the plan what they were going to build nor plan on what materials / resources to use in the project. The students do not have any idea on the budget required even after the end of phase - I. No project journal kept or the journal.	There is some improvement in the primary plan prepared during phase I. There were some ideas on the materials /resources required, but not really thought out. The students have some idea on the finances required, but they have not formalized a budget plan. Schedules were not prepared. The project journal has no useful details on the project.	Good evidence of planning done and being followed up to a good extent after phase I. Materials were listed and thought out, but the plan wasn't followed completely. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is neither complete nor updated regularly.	Excellent evidence of enterprising and extensive project planning and follow-up since phase I. Continued use of project management/version control tool to track the project. Material procurement if applicable is progressing well. Tasks are updated and incorporated in the schedule. A well-kept project journal showed evidence for all the above, in addition to the interaction with the project guide.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

2-d	Interim Results. [CO6] [Group assessment]	**5**	There are no interim results to show.	The team showed some interim results, but they are not complete / consistent to the current stage, Some corrections are needed.	The interim results showed were good and mostly consistent/correct with respect to the current stage. There is room for improvement.	There were significant interim results presented which clearly shows the progress.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-e	Presentation [Individual assessment]	**5**	Very poor presentation and there is no interim results. The student has no idea about the project proposal.	Presentation is average, and the student has only a feeble idea about the team work.	Good presentation. Student has good idea about the team's project. The overall presentation quality is good.	Exceptionally good presentation. Student has excellent grasp of the project. The quality of presentation is outstanding.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 1 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation – 2

No	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-f	Application of engineering knowledge [CO1] [Individual Assessment]	**10**	The student does not show any evidence of applying engineering knowledge on the design and the methodology adopted. The student's contribution in application of engineering knowledge in the project is poor.	The student appears to apply some basic knowledge, but not able to show the design procedure and the methodologies adopted in a comprehensive manner.	The student is able to show some evidence of application of engineering knowledge in the design and development of the project to good extent.	Excellent knowledge in design procedure and its adaptation. The student is able to apply knowledge from engineering domains to the problem and develop solutions.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-g	Involvement of individual members [CO3] [Individual Assessment]	**5**	No evidence of any Individual participation in the project work.	There is evidence for some amount of individual contribution, but is limited to some of the superficial tasks.	The individual contribution is evident. The student has good amount of involvement in core activities of the project.	Evidence available for the student acting as the core technical lead and has excellent contribution to the project.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-h	Results and inferences upon execution [CO5] [Group Assessment]	**5**	None of the expected outcomes are achieved yet. The team is unable to derive any inferences on the failures/ issues observed. Any kind o f observations or studies are not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Documentation and presentation. .[CO6] [Individual assessment]	**5**	The individual student has no idea on the presentation of his/her part. The presentation is of poor quality.	Presentation's overall quality needs to be improved.	The individual's presentation performance is satisfactory.	The individual's presentation is done professionally and with great clarity. The individual's performance is excellent.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 2 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Final Evaluation						
No	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-j	Engineering knowledge. [CO1] [Group Assessment]	10	The team does not show any evidence of applying engineering knowledge on the design and the methodology adopted. (0 – 3 Marks)	The team is able to show some of the design procedure and the methodologies adopted, but not in a comprehensive manner. (4 – 6 Marks)	The team is able to show evidence of application of engineering knowledge in the design and development of the project to good extent. There is scope for improvement. (7 - 9 Marks)	Excellent knowledge in design procedure and its adaptation. The team is able to apply knowledge from engineering domains to the problem and develop an excellent solution. (10 Marks)
2-k	Relevance of the project with respect to societal and/or industrial needs. [Group Assessment] [CO2]	5	The project as a whole do not have any societal / industrial relevance at all. (0 - 1 Marks)	The project has some relevance with respect to social and/or industrial application. The team has however made not much effort to explore further and make it better. (2 - 3 Marks)	The project is relevant to the society and/or industry. The team is mostly successful in translating the problem into an engineering specification and managed to solve much of it. (4 Marks)	The project is exceptionally relevant to society and/or industry. The team has made outstanding contribution while solving the problem in a professional and/ or ethical manner. (5 Marks)
2-i	Innovation / novelty / Creativity [CO5] [Group Assessment]	5	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team. (0 - 1 Marks)	Some of the aspects of the proposed idea appears to be practical. There is still lack of originality in the work done. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/ or improvements. (2 - 3 Marks)	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team. There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity. Could be translated into a product / process if more work is done. (4 Marks)	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable publishable work. (5 Marks)
2-m	Quality of results / conclusions / solutions. [CO1] [Group Assessment]	10	None of the expected outcomes are achieved. The team is unable to derive any inferences on the failures/issues observed. Any kind of observations or studies is not made. (0 – 3 Marks)	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested. (4 – 6 Marks)	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work. (7 - 9 Marks)	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work. (10 Marks)

2-n	Presentation - Part I Preparation of slides. [CO6] [Group Assessment].	5	The presentation slides are shallow and in a clumsy format. It does not follow proper organization.	Presentation slides follow professional style formats to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly, or acknowledged. Presentation slides needs to be more professional.	Presentation slides follow a good style format and there are only a few issues. Organization of the slides is good. Most of references are cited properly. The flow is good and team presentation is neatly organized. Some of the results are not clearly shown. There is room for improvement.	The presentation slides are exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and l i s ted. Results/ inferences clearly highlighted and readable.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
	Presentation - Part II: Individual Communication [CO6] [Individual Assessment].	5	The student is not communicating properly. Poor response to questions.	The student is able to explain some of the content. The student requires a lot of prompts to get to the idea. There are language issues.	Good presentation/ communication by the student. The student is able to explain most of the content very well. There are however, a few areas where the student shows lack of preparation. Language is better.	Clear and concise communication exhibited by the student. The presentation is outstanding. Very confident and tackles all the questions without hesitation. Exceptional traits of communicator.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

Phase-II Final Evaluation, Marks: 40

EVALUATION RUBRICS for PROJECT Phase II: Report Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-o	Report [CO6]	30	The prepared report is shallow and not as per standard format. It does not follow proper organization. Contains mostly unacknowledged content. Lack of effort in preparation is evident. References are not cited. Unprofessional and inconsistent formatting.	Project report follows the standard format to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly in the report. There is lack of formatting consistency.	Project report shows evidence of systematic documentation. Report is mostly following the standard style format and there are only a few issues. Organization of the report is good. Mostly consistently formatted. Most of references/sources are cited/ acknowledged properly.	The report is exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and listed and clearly shown. Language is excellent and follows professional styles. Consistent formatting and exceptional readability.
			(0 - 11 Marks)	(12 - 18 Marks)	(19 - 28 Marks)	(29 - 30 Marks)
Phase - II Project Report Marks: 30						

SEMESTER VIII

PROGRAM ELECTIVE III

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET414	ROBOTICS	PEC	2	1	0	3

Preamble: This course provides an introduction to the robots types, Configurations and application; Coordinate frames and types, Transformations and types; Forward and Inverse Kinematics of manipulator's; all types of robotic sensors; Open loop and closed loop control systems

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the anatomy and specifications of robots for typical application
CO 2	Select the appropriate sensors and actuators for robots
CO 3	Identify robotic configuration and gripper for a particular application
CO 4	Solve forward and inverse kinematics of robotic manipulators
CO 5	Plan trajectories in joint space and Cartesian space
CO 6	Develop the dynamic model of a given robotic manipulator and its control strategy

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1										2
CO 2	2	1										2
CO 3	2	1	2									2
CO 4	3	3	3									2
CO 5	3	3	3									2
CO 6	3	3	3									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the anatomy of a robot which is used for pick and place tasks. (K2, PO1, PO12)
2. What are the specifications of a typical spray painting robot? (DOF, specialties, control method etc.) (K1, PO2, PO12)

3. Which control method is used for a spot welding robot? (Continuous path control or point to point control) (K2, PO2, PO12)

Course Outcome 2 (CO2):

1. Choose a sensor as per robotic application.(K2, PO1, PO12)
2. Describe the functional differences of stepper motors and ac motors.(K1, PO1, PO12)
3. Pneumatic actuators are not suitable for heavy loads under precise control. Justify it.(K2, PO1, PO2, PO12)

Course Outcome 3 (CO3):

1. Explain the features of SCARA, PUMA Robots?(K1, PO1, PO12)
2. What are the different classification of robots based on motion control methods and drive technologies? Explain(K1, PO1, PO2, PO12)
3. What are the factors affecting the selection of grippers?(K1, PO1, PO3, PO12)

Course Outcome 4 (CO4):

1. What do you mean by forward kinematics?(K1, PO1, PO2, PO12)
2. Explain the inverse kinematics of robots.(K1, PO1, PO3, PO12)
3. What are the different coordinate systems used by industrial robots?(K1, PO1, PO3, PO12)

Course Outcome 5 (CO5):

1. Explain about planning the trajectory in Cartesian space and Joint space for robotic manipulators.(K1, PO1, PO2, PO12)
2. Explain about the third order polynomial trajectory planning in Joint space.(K1, PO1, PO2, PO12)
3. A two-degree-of-freedom planar robot is to follow a straight line in Cartesian space between the start (2,6) and the end (12,3) points of the motion segment. Find the joint variables for the robot if the path is divided into 10 segments. Each link is 9 inches long.(K2, PO1, PO3, PO12)

Course Outcome 6 (CO6):

1. Obtain the dynamic model of 1 DOF robot.(K2, PO1, PO2, PO12)
2. Explain the steps to design a PID controller for a single link manipulator.(K2, PO1, PO3, PO12)
3. Write short note on computed torque control.(K1, PO1, PO2, PO12)

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: EET414

Course Name: ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Define reach and stroke of a robotic manipulator.	(3)
2	What are the characteristics of a spot welding robot?	(3)
3	A strain gauge of gauge factor 2 and resistance of the unreformed wire 100 Ω is used to measure the acceleration of an object of mass 3kg. If the strain is 10^{-6}, cross sectional area=10mm^2 and Young's modulus =6.9 x 10^{-10} N/m^2, compute the acceleration of the object.	(3)
4	Compare hydraulic and pneumatic actuators.	(3)
5	Explain the features of a SCARA robot.	(3)
6	What are the advantages and disadvantages of a pneumatic gripper?	(3)
7	If a point $P = [3\ 0\ -1\ 1\ ]^T$, find the new location of the point P, if it is rotated by π about the z-axis of the fixed frame and then translated by 3 units along the y-axis.	(3)
8	How will you compute the end effector position and orientation of a robotic arm?	(3)
9	What is the necessity of dynamic modelling of robotic manipulators?	(3)
10	Is a robotic system linear or nonlinear? Justify your answer.	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11	a)	Explain in detail the specifications of a robotic manipulator.	(10)

b) What is the typical anatomy of a robotic manipulator? (8)

12 a) Explain in detail any two industrial applications of Robots. (10)

b) Compare point to point control and continuous path control. (4)

MODULE II

13 a) How will you choose an appropriate sensor for a robotic application? (8)

b) Mention the applications of vision sensor (6)

14 a) Outline the method of varying position using servo motor and stepper motor. (8)

b) Explain the working of a typical hydraulic actuator. (6)

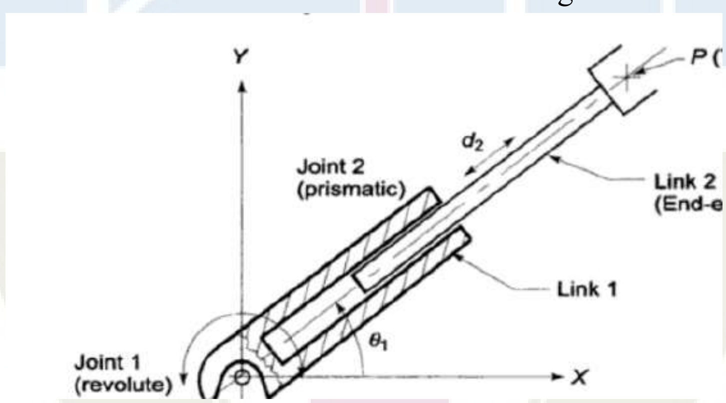
MODULE III

15 a) Explain in detail all robotic configurations. (14)

16 a) Describe the types of end effector & gripper mechanisms with simple sketches (14)

MODULE IV

17 a) Obtain the forward kinematic model of the following robot (14)



18 a) The second joint of a SCARA robot has to move from 15^0 to 45^0 in 3 sec. Find the coefficients of the cubic polynomial to interpolate a smooth trajectory. Also obtain the position, velocity and acceleration profiles (8)

b) How will you plan a straight line trajectory in Cartesian space? (6)

MODULE V

19 a) Obtain the dynamic model of 1 DOF robot operated by electric motor. (8)

b) How will you build a servo controlled robotic arm? (6)

20 a) Describe the schematic of PID controlled robotic manipulator and derive the closed loop transfer function. Explain how gains are computed for the PID controller? (10)

b) Comment on the stability of the above controller (4)

****

SYLLABUS

Module 1

Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot considerations for an application- number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control.

Robot Applications- medical, mining, space, defence, security, domestic, entertainment, Industrial Applications-Material handling, welding, Spray painting, Machining.

Case study- anatomy and specifications of a typical material handling robot

Module 2

Sensors and Actuators

Sensor classification- Touch, force, proximity, vision sensors.

Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, non-contact type; Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors.

Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors; Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages.

Case study- sensors and actuators needed for a differential drive robot which is capable of autonomous navigation, study of sensors and actuators for an autonomous pick and place robot

Module 3

Robotic configurations and end effectors

Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;

Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers.

Case study- typical robotic configuration for a pick and place robot capable picking objects from a moving conveyor

Module 4

Kinematics and Motion Planning

Robot Coordinate Systems- Fundamental and composite rotations, homogeneous coordinates and transformations, Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward and inverse Kinematics of typical robots upto 3 DOF.

Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.

Case study- Obtain the joint profiles of a 2 DOF planar manipulator, if the end effector is moving through an arc.

Module 5

Dynamics and Control of Robots

Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1 DOF robot.

Control Techniques- Transfer function and state space representation, Performance and stability of feedback control, PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control.

Case study: Closed loop PID control a typical 2 DOF planar robotic manipulator

Case Studies/Assignments: Any of the three case studies can be given as assignments.

Text Books

1. Introduction to Robotics by S K Saha, Mc Graw Hill Eduaction
2. Robert. J. Schilling, “Fundamentals of robotics – Analysis and control”, Prentice Hall of India 1996.
3. R K Mittal and I J Nagrath, “Robotics and Control”, Tata McGraw Hill, New Delhi, 2003.
4. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
5. Ashitava Ghosal, “Robotics-Fundamental concepts and analysis”, Oxford University press.
6. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb.
7. Introduction to Robotics, Saeed B. Nikku, Pearson Education, 2001.
8. Rachid Manseur, ‘Robot Modeling and Kinematics’, Lakshmi publications, 2009.

Reference Books

1. D Roy Choudhury and shaail B. jain, ‘Linear Integrated circuits’, New age international Pvt.Ltd 2003
2. Boltans w. ”Mechatronics” Pearson Education , 2009

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction**	
1.1	Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots;	1
1.2	Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom;	1
1.3	Robot considerations for an application- number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control.	1
1.4	Robot Applications- medical, mining, space, defence, security, domestic, entertainment	1
1.5	Industrial Applications-Material handling, welding, Spray painting, Machining.	1

2	**Sensors and Actuators**	
2.1	Sensor classification- touch, force, proximity, vision sensors	1
2.2	Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors;	1
2.3	External sensors-contact type, non-contact type;	1
2.4	Vision-Elements of vision sensor, image acquisition, image processing; Selection of sensors.	1
2.5	Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors;	2
2.6	Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages.	2
3	**Robotic configurations and end effectors**	
3.1	Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots	2
3.2	Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;	2
3.3	Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers.	3
4	**Kinematics and Motion Planning**	
4.1	Robot Coordinate Systems- Fundamental and composite rotations, homogeneous coordinates and transformations.	2
4.2	Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward Kinematic analysis of a typical robots up to 3 DOF.	4
4.3	Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.	2

5	**Dynamics and Control of Robots**	
5.1	Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1 DOF robot	2
5.2	Control Techniques- Transfer function and state space representation, Performance and stability of feedback control.	3
5.3	PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET424	ENERGY MANAGEMENT	PEC	2	1	0	3

Preamble: This course introduces basic knowledge about energy management and audit. Energy management opportunities in electrical and mechanical systems are discussed. Demand side management and ancillary services are explained. Economic analysis of energy conservation measures are also described.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse the significance of energy management and auditing.
CO 2	Discuss the energy efficiency and management of electrical loads.
CO 3	Apply demand side management techniques.
CO 4	Explain the energy management opportunities in industries.
CO 5	Compute the economic feasibility of the energy conservation measures.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7	PO8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**					1	1		1			
CO 2	**2**		1	1		1	1					
CO 3	**2**		1	1		1	1					
CO 4	**2**		1	1		1	1					
CO 5	**2**										2	

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	15	15	30
Understand (K2)	20	20	40
Apply (K3)	15	15	30
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define energy management. (K1, PO1, PO6, PO7)

2. List the different phases involved in energy management planning. (K1, PO1, PO6, PO7)

3. State the need for energy audit. (K2, PO1, PO6, PO7, PO9)

Course Outcome 2 (CO2)

1. State the different methods which can be adopted to reduce energy consumption in lighting. (K2, PO1, PO3, PO4)

2. Describe how energy consumption can be reduced by energy efficient motors. (K2, PO1, PO3, PO4, PO6, PO7)

3. Discuss the maximum efficiency standards for distribution transformers. (K1, PO1, PO3, PO4, PO6, PO7)

Course Outcome 3 (CO3):

1. Discuss the different techniques of DSM. (K2, PO1, PO3, PO4)

2. Illustrate the different techniques used for peak load management. (K2, PO1, PO3, PO4, PO6, PO7)

3. Explain the different types of ancillary services. (K2, PO1, PO3, PO4)

Course Outcome 4 (CO4):

1. Define Coefficient of performance. (K1, PO1)

2. Demonstrate how waste heat recovery can be done. (K2, PO1, PO3, PO4, PO6, PO7)

3. Describe how energy consumption can be reduced by cogeneration. (K3, PO1, PO3, PO4, PO6, PO7)

Course Outcome 5 (CO5):

1. State the need for economic analysis of energy projects. (K2, PO1, PO11)

2. Define pay back period. (K2, PO1, PO11)

3. Demonstrate how life cycle costing approach can be used for comparing energy projects. (K3, PO1, PO11)

Model Question Paper
QP CODE:

PAGES: 3

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET424

Course Name: ENERGY MANAGEMENT

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all questions. Each question carries 3 Marks

1. Explain what you mean by power quality audit.

2. Write notes on building management systems.

3. Compare the efficacy of different light sources.

4. Write notes on design measures for increasing efficiency in transformers.

5. Discuss the benefits of demand side management.

6. Explain the benefits of power factor improvement.

7. Discuss any two opportunities for energy savings in steam distribution.

8. Explain the working of a waste heat recovery system.

9. What are the advantages and disadvantages of the payback period method?

10. Write notes on computer aided energy management systems.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11. a.	With the help of case studies, explain any four energy management principles.	8
b.	Explain the different phases of energy management planning.	6
12. a.	Explain the different steps involved in a detailed energy audit.	7
b.	Discuss the different instruments used for energy audit.	7

Module 2

13. a.	With the help of case studies, explain any four methods to reduce energy consumption in lighting.	8
b.	Explain how energy efficient motors help in reducing energy consumption.	6
14. a.	With the help of case studies, explain any four methods to reduce energy consumption in motors.	8
b.	Define cascade efficiency of an electrical system. How it can be calculated?	6

Module 3

15. a.	Explain the different techniques of demand side management.	6
b.	The load on an installation is 800 kW, 0·8 lagging p.f. which works for 3000hours per annum. The tariff is Rs 100 per kVA plus 20 paise per kWh. If the power factor is improved to 0·9 lagging by means of loss-free capacitors costing Rs 60 per kVAR, calculate the annual saving effected. Allow 10% per annum for interest and depreciation on capacitors.	8
16. a.	Discuss the importance of peak demand control. Explain the different methods used for that.	8

b. Explain the different types of ancillary services. 6

Module 4

17. a. Explain any four energy conservation opportunities in furnaces 7

b. Explain the working of different types of cogeneration systems. 7

18. a. Discuss the different energy conservation opportunities in boiler. 7

b. Explain any five energy saving opportunities in heating, ventilating and air conditioning systems. 7

Module 5

19. a. Calculate the energy saving and payback period which can be achieved by replacing a 11 kW, existing motor with an EEM. The capital investment required for EEM is Rs. 40,000/-. Cost of energy/kWh is Rs. 5. The loading is 70% of the rated value for both motors. Efficiency of the existing motor is 81% and that of EEM is 84.7%. 8

b. Compare internal rate of return method with present value method for the selection of energy projects. 6

20. a. Explain how the life cycle costing approach can be used for the selection of energy projects. 6

b. The cash flow of an energy saving project with a capital investment cost of Rs. 20,000/- is given in the table below. Find the NPV of the project at a discount rate of 10%. Also find the Internal Rate of Return of the project. 8

Year	Cash flow
1	7000
2	7000
3	7000
4	7000
5	7000
6	7000

Syllabus

Module 1 (7 hours)

Energy Management - General Principles and Planning:

General principles of energy management and energy management planning

Energy Audit: Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit

Energy conservation in buildings: ECBC code (basic aspects), Building Management System (BMS).

Module 2 (9 hours)

Energy Efficiency in Electricity Utilization:

Electricity transmission and distribution system, cascade efficiency.

Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.

Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads.

Transformers: Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.

Module 3 (8 hours)

Demand side Management: Introduction to DSM, benefits of DSM, different techniques of DSM –time of day pricing, multi-utility power exchange model, time of day models for planning.

Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.

Power factor improvement, numerical examples.

DSM and Environment.

Ancillary services: Introduction of ancillary services – Types of Ancillary services

Module 4 (6 hours)

Energy Management in Industries and Commercial Establishments:

Boilers: working principle - blow down, energy conservation opportunities in boiler.

Steam: properties of steam, distribution losses, steam trapping. Identifying opportunities for energy savings in steam distribution.

Furnace: General fuel economy measures, energy conservation opportunities in furnaces.

HVAC system: Performance and saving opportunities in Refrigeration and Air conditioning systems.

Heat Recovery Systems:

Waste heat recovery system - Energy saving opportunities.

Cogeneration: Types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.

Module 5 (6 hours)

Energy Economics:

Economic analysis: methods, cash flow model, time value of money, evaluation of proposals, pay-back period, average rate of return method, internal rate of return method, present value method, life cycle costing approach. Computer aided Energy Management Systems (EMS).

Text/Reference Books

1. Energy Conservation Act – 2001 and Related Rules and Standards.
2. Publications of Bureau of Energy Efficiency (BEE).
3. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press, 2003.
4. IEEE recommended practice for energy management in industrial and commercial facilities
5. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press, 2007
6. Operation of restructured power systems Kankar Bhattacharya, Jaap E. Daadler, Math H.J Bollen, Kluwer Academic Pub., 2001.
7. Wayne C. Turner, Energy management Hand Book - the Fairmount Press, Inc., 1997
8. Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.

No	Topic	No. of Lectures
1	**Energy Management - General Principles and Planning; Energy audit (7 hours)**	
1.1	Energy management; General principles of energy management	2
1.2	Energy management planning	1
1.3	**Energy audit:** Definition, need, types and methodologies.	2
1.4	Instruments for energy audit, Energy audit report. Power quality audit	1
1.5	ECBC code (basic aspects), Building Management System (BMS).	1
2	**Energy management in Electricity Utilization (8 hours)**	
2.1	Electricity transmission and distribution system, cascade efficiency.	1
2.2	Energy management opportunities in Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.	2
2.3	Energy management opportunities in Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads.	2
2.4	Transformers: Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.	3
3	**Demand side Management and Ancillary service management:(8 hours)**	
3.1	Introduction to DSM, benefits of DSM, different techniques of DSM, DSM and Environment.	2
3.2	Time of day pricing, multi-utility power exchange model, time of day models for planning.	2

3.3	Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.	2
3.4	Power factor improvement, simple problems.	1
3.5	Introduction of ancillary services – Types of Ancillary services	1
4	**Energy Management in Industries and Commercial Establishments (6 hours):**	
4.1	Boilers: working principle - blow down, energy conservation opportunities in boiler.	1
4.2	Steam: properties of steam, distribution losses, steam trapping. identifying opportunities for energy savings in steam distribution.	1
4.3	Furnace: General fuel economy measures, energy conservation opportunities in furnaces.	1
4.4	Performance and saving opportunities in Refrigeration and Air conditioning systems.	2
4.5	Waste heat recovery system - Energy saving opportunities. Cogeneration: types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.	1
5	**Energy Economics (6 hours)**	
5.1	Economic analysis methods	1
5.2	Cash flow model, time value of money, evaluation of proposals	1
5.3	Pay-back method, average rate of return method, internal rate of return method	2
5. 4	Present value method, life cycle costing approach.	1
5.4	Computer aided Energy Management Systems (EMS).	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET434	SMART GRID TECHNOLOGIES	PEC	2	1	0	3

Preamble: This course introduces various advancements in the area of smart grid. It also introduces distributed energy resources and micro-grid. In addition, cloud computing, cyber security and power quality issues in smart grids are also introduced.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the basic concept of distributed energy resources, micro-grid and smart grid
CO 2	Choose appropriate Information and Communication Technology (ICT) in smart grid
CO 3	Select infrastructure and technologies for consumer domain of smart grid
CO 4	Select infrastructure and technologies for smart substation and distribution automation
CO 5	Formulate cloud computing infrastructure for smart grid considering cyber security
CO 6	Categorize power quality issues and appraise it in smart grid context

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	3	3	3	2							
CO 3	3	3	3	3	2							
CO 4	3	3	3	3								
CO 5	3	3	3	3	3							
CO 6	3	3	3	3	3							

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	30	30	60
Apply (K3)	10	10	20
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Explain the drivers, functions, opportunities, barriers, challenges, technologies and standards of smart grid (K2, PO1)
2. Explain the basic concept of distributed energy resources and their grid integration. (K2, PO1, PO2)
3. Explain the basic concept of microgrid. (K1, PO1)

Course Outcome 2 (CO2)

1. Choose appropriate communication technology for smart grid. (K3, PO1, PO2, PO3, PO4, PO5)

2. Explain the communication protocols and standards in Smart grid. (K2, PO1)

Course Outcome 3 (CO3)

1. Explain the features and merits of Smart Meters, for smart grid implementation. (K2, PO1, PO2, PO3)
2. Explain the role of real time pricing in smart grid. (K3, PO1, PO2, PO3)
3. Describe the concept and role of AMR and AMI in smart grid. (K2, PO1, PO2)
4. Choose various end use devices and explain their role in Home & Building Automation. (K3, PO1, PO2, PO3, PO4, PO5)
5. Explain the various methods for energy management and role of technology for its implementation. (K3, PO1, PO2, PO3, PO4, PO5)

Course Outcome 4 (CO4)

1. Explain the concept of smart substation. (K1, PO1)
2. Describe the functionalities and applications of IED in substation and distribution automation. (K2, PO1, PO2, PO3, PO4)
3. Explain the architecture components and applications of Wide Area Monitoring Systems. (K3, PO1, PO2, PO3)
4. Explain the role of PMU in WAMS. (K2, PO1, PO2,)
5. Explain the role of various application modules in distribution automation. (K2, PO1, PO2, PO3)

Course Outcome 5 (CO5)

1. Classify cloud computing based on its deployment and services. (K2, PO1)
2. Design cloud architecture of smart grid. (K3, PO1, PO2, PO3, PO4, PO5)
3. Explain the challenges and solutions related to cyber security in smart grid. (K2, PO1, PO2, PO3, PO4, PO5)

Course Outcome 6 (CO6)

1. Explain the power quality issues in smart grid. (K2, PO1, PO2)
2. Choose technologies for the mitigation of power quality issues in the smart grid. (K3, PO1, PO2, PO3, PO4, PO5)

Model Question Paper

QP CODE: Pages:

Reg No.:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course code: EET 434

Course Name: SMART GRID TECHNOLOGIES (E)

Max. Marks: 100 **Duration: 3hrs**

PART A

(Answer all questions. Each question carries 3 marks)

1. Define smart grid concept and explain its necessity.
2. Explain the concept of resilient and self-healing grid.
3. Write a note on ZIGBEE.
4. Discuss 61850 standard and its benefits.
5. Explain how automatic meter reading can make the system smarter.
6. What is meant by real time pricing?
7. Describe substation automation.
8. Explain outage management system.
9. Explain the necessity of cyber security in smart grid
10. Write a note on power quality conditioners in smart grid.

PART B

11. (a) With the help of block diagram explain the architecture of smart grid (7)

 (b) What are the challenges of smart grid technology? (7)

OR

12. (a)Explain smart grid drivers (6)

 (b)What are the functions of smart grid components (8)

13. (a) Explain the various communication protocols used in smart grid. (7)

(b) Write a note on Wi-Max based communication in smart grid. (7)

OR

14. (a) Write a note on various mobile communication technologies used in smart grid. (7)

(b) Explain the role of HAN in smart grid. (7)

15. (a) Explain plug in electric vehicles (7)

(b) Explain the role of phasor measurement unit in smart grid (7)

OR

16. (a) What are the advantages of smart meters? (5)

(b) What are IEDs? What are their application in monitoring and protection (9)

17. (a) With the help of block diagram explain the main features of smart substation (10)

(b) Explain GIS (4)

OR

18. (a) Explain demand side ancillary services. (7)

(b) Write a note on smart inverters. (7)

19. (a) Describe cloud architecture of smart grid. (7)

(b) Explain the role of EMC in the smart grid. (7)

OR

20. (a)Why is cyber security of prime importance in smart grid and how can it be achieved? (7)

(b) Describe the power quality issues of grid connected renewable energy source (7)

Syllabus

Module 1 Introduction to Smart Grid: Evolution of electric grid, Definitions, Need for smart grid, Smart grid drivers, Functions of smart grid, Opportunities and barriers of smart grid, Difference between conventional grid and smart grid, Concept of resilient and self- healing grid.

Components and architecture, Inter-operability, Impacts of smart grid on system reliability, Present development and international policies in smart grid, Smart grid standards.

Module 2 Information and Communication Technology in Smart Grid: Wired and wireless communication -radio mesh, ZIGBEE, 3G, 4G and 5G. Digital PLC, DSL, Wi-Max, LAN, NAN, HAN, Wi-Fi, Bluetooth, Bluetooth Low Energy (BLE), Li-Fi.
Communication Protocols in Smart grid, Introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE, Substation model.

Module 3 Smart grid Technologies Part I: Introduction to smart meters, Electricity tariff, Real Time Pricing- Automatic Meter Reading (AMR) - System, Services and Functions, Components of AMR Systems, Advanced Metering Infrastructure (AMI).

Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid (V2G), Grid to Vehicle (G2V), Smart Sensors, Smart energy efficient end use devices, Home & Building Automation.

Intelligent Electronic Devices (IED) and their application for monitoring & protection: Digital Fault Recorder (DFR), Digital Protective Relay (DPR), Circuit Breaker Monitor (CBM), Phasor Measurement Unit (PMU), Standards for PMU. Time synchronization techniques, Wide Area Monitoring System (WAMS), control and protection systems (Architecture, components of WAMS, and applications: Voltage stability assessment, frequency stability assessment, power oscillation assessment, communication needs of WAMS, remedial action scheme).

Module 4 Smart grid Technologies Part II: Smart substations, Substation automation, Feeder automation, Fault detection, Isolation, and Service Restoration (FDISR), Geographic Information System (GIS), Outage Management System (OMS).
Introduction to Smart distributed energy resources and their grid integration, Smart inverters, Concepts of microgrid, Need and application of microgrid – Energy Management- Role of technology in demand response- Demand side management, Demand side Ancillary Services, Dynamic line rating.

Module 5 Cloud computing in smart grid: Private, Public and hybrid cloud. Types of cloud computing services- Software as a Service (SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Data as a service (DaaS), Cloud architecture for smart grid.
Cyber Security - Cyber security challenges and solutions in smart grid**,** Cyber security risk assessment, Security index computation.
Power Quality Management in Smart Grid- Fundamentals, Power Quality (PQ) & Electromagnetic Compatibility (EMC) in smart grid, Power quality conditioners for smart grid.
Case study of smart grid.

Text/Reference Books

1. **Stuart Borlase** "Smart Grid Infrastructure Technology and Solutions", CRC Press; 2nd edition.
2. **James Momoh**, "Smart Grid: Fundamentals of Design and Analysis", Wiley, 2012.
3. **S. Chowdhury**, "Microgrids and Active Distribution Networks." Institution of Engineering and Technology, 2009.
4. **Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins**- "Smart Grids Technology and Applications", Wiley, 2012.
5. **Clark W.Gellings,** "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.
6. **Jean Claude Sabonnadière, Nouredine Hadjsaïd,** "Smart Grids", Wiley Blackwell.
7. **James Larminie, John Lowry**, Electric Vehicle Technology Explained, Wiley, 2003.
8. **Chris Mi, M. AbulMasrur, David WenzhongGao**, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2011, Wiley publication.
9. **Danda B. Rawat; Chandra Bajracharya,** Cyber security for smart grid systems: Status, challenges and perspectives IEEE SoutheastCon 2015, DOI: 10.1109/SECON.2015.7132891.
10. **Pillitteri, V. and Brewer, T. (2014),** Guidelines for Smart Grid Cybersecurity, NIST Interagency/Internal Report (NISTIR), National Institute of Standards and Technology, Gaithersburg, MD, [online], https://doi.org/10.6028/NIST.IR.7628r1.
11. **Barker, Preston, Price, Rudy F.**, "Cybersecurity for the Electric Smart Grid: Elements and Considerations", Nova Science Publishers Inc, 2012.
12. **Eric D. Knapp, Raj Samani, "**Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure", Syngress; 1st edition (26 February 2013).
13. **Richard J. Campbell, "**The Smart Grid and Cybersecurity: Regulatory Policy and Issues", Congressional Research Service, 2011.
14. **Dariusz Kloza, Vagelis Papakonstantinou, Sanjay Goel, Yuan Hong**, "Smart grid security", Springer.
15. **Roger C. Dugan**, "Electrical Power Systems Quality", McGraw-Hill Publication, 3/e.
16. **G.T.Heydt**, "Electric Power Quality", Stars in a Circle Publications, 2/e.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Smart Grid**:	**(7)**
1.1	Evolution of electric grid, definitions need for smart grid, smart grid drivers, functions of smart grid, opportunities and barriers of smart grid, difference between conventional grid and smart grid, concept of resilient and self- healing grid	3
1.2	Components and architecture, inter-operability, impacts of Smart Grid on system reliability	2
1.3	Present development and international policies in smart grid.	2

	smart grid standards.	
2	**Information and Communication Technology in Smart Grid**:	**(8)**
2.1	Wired and wireless communication -radio mesh, ZIGBEE, 3G, 4G and 5G, digital PLC, DSL, Wi-Max, LAN, NAN, HAN, Wi-Fi, bluetooth, Bluetooth Low Energy (BLE), Light-Fi, substation event - GOOSE, IEC 61850 substation model	4
2.2	Communication protocols in smart grid, introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE.	2
2.3	IEC 61850 ,Substation model	2
3	**Smart grid Technologies Part I**	**(7)**
3.1	Introduction to smart meters, electricity tariff, real time pricing-Automatic Meter Reading (AMR) System, services and functions, components of AMR systems, Advanced Metering Infrastructure (AMI)	2
3.2	Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Grid to Vehicle.	1
3.3	Smart sensors, smart energy efficient end use devices, home & building automation, Intelligent Electronic Devices (IED) and their application for monitoring & protection, DFRA, DPRA, CBMA	1
3.4	Phasor Measurement Unit (PMU), standard for PMU. time synchronization techniques, Wide Area Monitoring, control and protection systems - architecture, components of WAMS, and applications: voltage stability assessment, frequency stability assessment, power oscillation assessment, communication needs of WAMS, remedial action scheme.	3
4.	**Smart grid Technologies Part II**	**(7)**
4.1	Smart substations, substation automation, feeder automation, fault detection, isolation, and service restoration, Geographic Information System (GIS), Outage Management System (OMS).	2
4.2	Introduction to smart distributed energy resources and their grid integration, smart inverters.	2
4.3	Concepts of micro grid, need & application of micro grid – Energy Management-Role of technology in demand response-Demand Side Management, Demand Side Ancillary Services, Dynamic Line rating.	3
5	**Cloud computing in smart grid**:	**(8)**
5.1	Public and hybrid cloud, cloud architecture of smart grid, types of cloud computing services- IaaS, SaaS, PaaS, DaaS.	2
5.2	**Cyber Security -** Cyber security challenges and solutions in	2

	smart grid, cyber security risk assessment, security index computation .	
5.3	**Power Quality Management in Smart Grid-** Fundamentals, power quality & EMC in Smart Grid.	2
5.4	Power quality conditioners for smart grid -case study of smart grid	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET444	ELECTRICAL MACHINE DESIGN	PEC	2	1	0	3

Preamble: This course provides an introduction to the design of DC and AC machines and gives a general idea to the computer aided design of electrical machines.

Prerequisite: 1. EET202 DC Machines and Transformers

2. EET307 Synchronous and Induction Machines

Course Outcomes: After the completion of the course the student will be able to:

CO1	Identify the general design considerations of electrical machines.
CO2	Design armature and field system of DC machines.
CO3	Design core, yoke, windings and cooling systems of transformers.
CO4	Design stator and rotor of induction machines.
CO5	Design stator and rotor of synchronous machines.
CO6	Apply software tools in electrical machine design.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	-	-	-	-
CO2	3	2	2	-	-	-	-	-	-	-	-	-
CO3	3	2	2	-	-	-	-	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-	-	-	-	-
CO5	3	2	2	-	-	-	-	-	-	-	-	-
CO6	3	2	1	1	1	-	-	-	-	-	-	-

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand(K2)	10	10	20
Apply (K3)	30	30	60
Analyse (K4)			
Evaluate(K5)			
Create(K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Part A: 10 Questions x 3 marks=30 marks; **Part B:** 5 Questions x 14 marks =70 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. List five types of enclosures used in electrical machines. (K1,PO2)
2. Explain the various insulation classes and the modern insulating materials. (K1,PO1)
3. Problems based on temperature rise calculations. (K2,PO2)

Course Outcome 2 (CO2)

1. Derive the output equation of a DC machine. (K2, PO1)
2. Discuss the factors that influence the choice of number of poles in a DC machine. (K1,PO2)
3. Problems based on the design of main dimensions and armature of a DC machine. (K3,PO3)
4. Problems based on the design of field system of a DC machine. (K3,PO3)

Course Outcome 3 (CO3)

1. Define window space factor in transformer design. (K1,PO2)
2. Derive output equation of transformers. (K2,PO1)
3. Problems based on the dimensions of transformers. (K3,PO3)

Course Outcome 4 (CO4)

1. Derive the expression for end ring current of a squirrel cage induction motor. (K2,PO1)
2. Write a short note on selection of current density in an induction motor in consideration to the insulation system. (K2,PO2)
3. Problems based on the design of an induction motor. (K3,PO3)

Course Outcome 5 (CO5)

1. Briefly explain the factors affecting the choice of specific electric and magnetic loadings in a synchronous machine. (K2,PO2)

2. Problems based on the design of synchronous machines. (K3,PO3)
3. Briefly explain the features of a brushless alternator. (K1,PO1)

Course Outcome 6 (CO6)

1. Explain how the finite element method is used for the analysis of electrical machines. (K2,PO1)
2. Explain various methods for the computer aided design of electrical machines. (K1,PO2)
3. Explain the analysis method with flow chart for computer aided design of electrical machines. (K1,PO2)

Note: *Design, simulation and optimization using electromagnetic field simulation software can be achieved* ***through assignments****. (PO3, PO4 and PO5)*

Model Question Paper

QP CODE:

PAGES: 3

Reg. No: _______________

Name : _______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: EET444
Course Name: ELECTRICAL MACHINE DESIGN

Max. Marks: 100

Duration: 3 Hours

PART A (3 x 10 = 30 Marks)
Answer all questions. Each question carries 3 marks

1. List any four types of enclosures used in electrical machines.
2. Derive the gap contraction factor for slots.
3. Derive the output equation of a DC machine.
4. Explain the importance of proper pole proportions while separating the values of D and L in a DC machine.
5. Derive the output equation of a single phase transformer.
6. Briefly explain the cast resin transformer.
7. Discuss the choice of specific magnetic loading and specific electric loading in induction machines.
8. Derive the expression for end ring current in a squirrel cage induction motor.
9. Explain the synthesis method for computer aided design with a flow chart.
10. Briefly explain the features of a brushless alternator.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) Discuss the thermal and dielectric properties of the following insulating materials used in electrical machines. i) Nomex and ii) Polyamide films. (4 marks)

    b) The temperature rise of a transformer is 25°C after one hour and 37.5°C after 2 hours starting from cold conditions. Calculate its final steady temperature rise and the heating time constant. If its temperature falls from the final steady value to 40°C in 2.5 hours when disconnected, calculate its cooling time constant. The ambient temperature is 30°C. (10 marks)

12. a) What is Carter's coefficient and how does it help in the estimation of mmf of a machine with slotted armature? (6 marks)

    b)Derive the expression for the temperature rise in a machine. Is heating time constant greater than cooling time constant? Justify your answer. (8 marks)

Module 2

13. a) Discuss the factors that influence the choice of number of poles in DC machines. (4 marks)

    b) Find out the main dimensions of a 50kW, 4 pole, 600rpm DC shunt generator to give a square pole face. The full load terminal voltage being 220 V. The maximum gap density is 0.83Wb/m^2 and the ampere conductors per meter is 30000. Assume that full load armature voltage drop is 3 percent of rated terminal voltage and that the field current is 1 percent of rated full load current. Ratio of pole arc to pole pitch is 0.67. (10 marks)

14. a) Explain the design procedure of brushes and commutators for a DC machine. (4 marks)

    b) The following particulars refer to the shunt field coil for a 440V, 6pole, DC generator: mmf per pole = 7000A; depth of winding = 50mm; length of inner turn = 1.1m; length of outer turn = 1.4m; loss radiated from outer surface excluding ends = 1400 W/m2; space factor = 0.62; resistivity = 0.02 Ω/m and mm^2. Calculate a) the diameter of wire b) length of coil c) no. of turns and d) exciting current. Assume a voltage drop of 20% of terminal voltage across the field regulator. (10 marks)

Module 3

15. a) Compare distribution and power transformers. (4 marks)

    b) Determine the dimensions of core and window of a 5kVA, 50 Hz, single phase core type transformer. A rectangular core is used with long side twice as long as short side. The window height is 3 times the width. Voltage per turn is 1.8 V, space factor is 0.2, current density is 1.8A/mm^2 and flux density is 1Wb/m^2. (10 marks)

16. a) Define window space factor in transformer design. (4 marks)
    b) A 300kVA, 11000/400V, 3 phase, core type transformer has a total loss of 5000W at full load. The transformer tank is 1.25m in height and 1m x 0.75 m in plan. Design a suitable design for tubes if average temperature rise is to be limited to 360C. The diameter of the tube is 50mm and is placed 75mm apart. Average height of tubes is 1.05m, specific heat dissipation due to radiation = $6W/m^2$ ^oC and specific heat dissipation due to convection = $6.5W/m^2$ ^oC. Assume that convection is improved by 35 percent due to provision of tubes. (10 marks)

Module 4

17. Find the main dimensions, number of radial ducts, number of stator slots and number of turns per phase of a 3.7kW, 4 pole, 50 Hz, squirrel cage induction motor to be started by star-delta starter. Work out the winding details. The average flux density in the air gap = 0.45 T, ampere conductors per meter = 23000, efficiency = 0.85, power factor = 0.84. Choose main dimensions to achieve cheap design. Winding factor = 0.955, Iron stacking factor = 0.9. (14 marks)
18. a) What is cogging in an induction motor? (4 marks)
    b) Determine approximate values for the stator bore and the effective core length of a 55kW, 415V, 3-phase, star connected, 50Hz, four pole induction motor, Efficiency = 90%, power factor= 0.91, winding factor = 0.955, Assume suitable data wherever necessary with proper justification. (10 marks)

Module 5

19. a) What is short circuit ratio? How does the value of SCR affect the design of a synchronous generator? (4 marks)
    b) Determine the main dimensions of a 2500 kVA, 187.5rpm, 50Hz, 3 phase, 3 kV, salient pole alternator. The generator is to be a vertical, water wheel type. The specific magnetic loading is $0.6Wb/m^2$ and the specific electric loading is 34000A/m. Use circular poles with ratio of core length to pole pitch= 0.65. Specify the type of pole construction used if the run-away speed is about 2 times the normal speed. (10 marks)
20. a) Explain the design procedure for a synchronous generator using finite element software technique. (4 marks)
    b) Determine the diameter, core length, size, no. of conductors and no. of slots for stator of a 15MVA, 11kV, 50Hz, 2 pole, star connected turbo-alternator with 60^0 phase spread. Assume specific magnetic loading = 0.55 Tesla, specific electric loading = 36,000, current density = $5A/mm^2$, peripheral speed = 160m/s. The winding should be arranged to eliminate 5^{th} harmonic. (10 marks)

Syllabus

Module 1 (7 hours)

Principles of electrical machine design: General design considerations, types of enclosures - types of ventilation. Heating - cooling and temperature rise calculation – numerical problems. Continuous, short time and intermittent ratings. Insulation classes – Introduction to modern insulating materials, such as Nomex, Polyamide films and Silicone. Types of cooling in transformers and rotating electrical machines.

Magnetic system - Carter's coefficient – real and apparent flux density. Unbalanced magnetic pull and its practical aspects.

Module 2 (7 hours)

DC Machines: Output equation - main dimensions - choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered - choice of speed and number of poles - design of armature conductors, slots and winding - design problems. Design of air-gap - design of field system – design problems. Fundamental design aspects of interpoles, compensating winding, commutator and brushes.

Module 3 (7 hours)

Transformers: Design of transformers - single phase and three phase transformers - distribution and power transformers - output equation - core design with due consideration to percentage impedance required - window area - window space factor - overall dimensions of core – design problems. Windings - no. of turns - current density in consideration to the insulation scheme - conductor section. Design of cooling tank with tubes – design problems. Essential design features of cast resin dry type transformers. Fundamentals of K-factor rated transformer, ECBC standards for transformers, BEE Star rating of transformers.

Module 4 (7 hours)

Induction machines: Output equation - main dimensions - choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered - design of stator and rotor windings - round conductor or rectangular conductor - design of stator and rotor slots, air-gap of slip ring and squirrel cage motors - calculation of rotor bar and end ring currents in cage rotor - design of slip ring rotor winding - design problems. Design aspects of induction motor for drive applications (basic principles only).

Module 5 (8 hours)

Synchronous Machines: Output equation - salient pole and turbo alternators - main dimensions - choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered - significance of short circuit ratio - choice of speed and number of poles - design of armature conductors, slots and winding - round conductor or rectangular conductor - design of air-gap - design problems.

Fundamental design aspects of the field system and damper winding. Features of brushless alternators.

Introduction to computer aided design: Analysis and synthesis methods - hybrid techniques. Introduction to machine design softwares using Finite Element Method.

Design, simulation and optimization using electromagnetic field simulation software (Assignment only).

Text Books

1. Sawhney A K, A Course in Electrical Machine Design, Dhanpat Rai & Co., 2016.
2. Say M G, The Performance and Design of AC Machines, CBS Publishers, New Delhi, 3rd edition, 2002.
3. Clayton A E & Hancock N N, Performance and Design of DC Machines, ELBS, 1971.

References

1. IS 1180 (Part 1):2014, Bureau of Indian Standards. https://bis.gov.in
2. S.O. No. 4062 (E) for Distribution Transformer dated 16th December, 2016, Bureau of Energy Efficiency, Govt. of India, Ministry of Power. https://www.beestarlabel.com
3. M. V. Deshpande, “Design and Testing of Electrical Machines”, Wheeler Publishing.
4. R. K. Agarwal, “Principles of Electrical Machine Design”, Essakay Publications, Delhi.
5. Ramamoorthy M, “Computer Aided Design of Electrical Equipment”, East-West Press.
6. M. N. O. Sadiku, “Numerical techniques in Electromagnetics”, CRC Press Edition-2001.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Principles of electrical machine design (7 hours)**	
1.1	General design considerations, types of enclosures - types of ventilation.	1
1.2	Heating - cooling and temperature rise calculation – numerical problems.	1
1.3	Continuous, short time and intermittent ratings.	1
1.4	Insulation classes – Introduction to modern insulating materials,	1

	such as Nomex, Polyamide films and Silicone.	
1.5	Types of cooling in transformers and rotating electrical machines.	1
1.6	Magnetic system - Carter's coefficient – real and apparent flux density.	1
1.7	Unbalanced magnetic pull and its practical aspects.	1
2	**Design of DC Machines (7 hours)**	
2.1	Output equation - main dimensions	1
2.2	Choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered	1
2.3	Choice of speed and number of poles	1
2.4	Design of armature conductors, slots and winding	1
2.5	Design problems and design of air-gap	1
2.6	Design of field system – design problems.	1
2.7	Fundamental design aspects of interpoles, compensating winding, commutator and brushes	1
3	**Design of Transformers (7 hours)**	
3.1	Single phase and three phase transformers - distribution and power transformers - output equation	1
3.2	Core design with due consideration to percentage impedance required	1
3.3	Window area - window space factor - overall dimensions of core – design problems.	1
3.4	Windings - no. of turns - current density in consideration to the insulation scheme - conductor section.	1
3.5	Design of cooling tank with tubes – design problems.	1
3.6	Essential design features of cast resin dry type transformers.	1
3.7	Fundamentals of K-factor rated transformer, ECBC standards for transformers, BEE Star rating of transformers.	1
4	**Design of Induction machines (7 hours)**	
4.1	Output equation - main dimensions	1
4.2	Choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered	1
4.3	Design of stator and rotor windings - round conductor or rectangular conductor	1
4.4	Design of stator and rotor slots, air-gap of slip ring and squirrel cage motors - calculation of rotor bar and end ring currents in cage rotor	1
4.5	Design of slip ring rotor winding	1
4.6	Design problems	1
4.7	Design aspects of induction motor for drive applications (basic principles only).	1

5	**Design of Synchronous Machines and Introduction to computer aided design (8 hours)**	
5.1	Output equation - salient pole and turbo alternators - main dimensions	1
5.2	Choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered	1
5.3	Significance of short circuit ratio - choice of speed and number of poles	1
5.4	Design of armature conductors, slots and winding - round conductor or rectangular conductor - design of air-gap	1
5.5	Design problems	1
5.6	Fundamental design aspects of field system and damper winding. Features of brushless alternators.	1
5.7	Analysis and synthesis methods - hybrid techniques.	1
5.8	Introduction to machine design softwares using Finite Element Method. Design, simulation and optimization using electromagnetic field simulation software (Assignment only).	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET454	SWITCHED MODE POWER CONVERTERS	PEC	2	1	0	3

Preamble: This course builds upon the course EET 306: Power Electronics, to give the students a detailed exposure to switched-mode power converter analysis and design. The objectives of this course are:

1. To give a comprehensive exposure to the power converter topologies widely used in the industry for power supply applications.
2. To equip the students with necessary theoretical knowledge to develop practical power converter designs.

Prerequisite: EET306 POWER ELECTRONICS

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop the basic design for non-isolated DC-DC converter topologies.
CO 2	Analyse isolated DC-DC converter topologies.
CO 3	Describe the operation of Switched mode inverters and rectifiers.
CO 4	Distinguish between inverter modulation strategies.
CO 5	Describe the operation of Soft switching resonant converters.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1	1								2
CO 2	3	2	1	1								2
CO 3	3	1	1									2
CO 4	3	1	1									2
CO 5	3	1	1									2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	10	10	50
Apply	20	20	30
Analyse	10	10	
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Design the power circuits of basic dc-dc converters (K2, K3 and K4 level, PO1, PO2, PO3, PO4)
2. Analyse and determine the mode of operation of the given circuit. (K2, K3, K4, PO1, PO2)
3. Design dc-dc non-isolated converters to operate under given conditions/specifications. (K2, K3, K4, PO1, PO2, PO3, PO4)
4. What is the primary difference between switched mode power conversion and linear power conversion? (K1, PO1)

Course Outcome 2 (CO2)

1. Analyse circuits of isolated dc-dc topologies. give relevant waveforms. (K2, K3, K4 levels, PO1, PO2).
2. Explain unidirectional and bidirectional magnetic core excitation.(K1, PO1)
3. Explain double ended forward converter with neat diagram. (K1, PO1)
4. Describe the operation of the push-pull dc-dc converter. Also derive the expression of output voltage. (K1, PO1, PO2)

Course Outcome 3(CO3):

1. Describe the operation of three-phase/single-phase rectifiers (K2, K3, PO1)

2. Explain active wave shaping of input line current through PFC boost converter. (K1, PO1)

3. With a neat circuit diagram, explain the working of the switched mode rectifier. (K1, PO1)

4. Find the Switch utilization factor for single phase full bridge dc-dc converter.(K1, PO1, PO2)

Course Outcome 4 (CO4):

1. Compare PWM schemes and select an appropriate method for given application (K2, K3, K4, PO1)

2. Explain switching times and space vector sequence of space vector modulation. (K1, PO1)

3. With waveform explain hysteresis current control . (K1, PO1)

4. With waveform explain programmed harmonic elimination of single phase inverter. (K1, PO1)

Course Outcome 5 (CO5):

1. Distinguish between hard-switching and soft-switching methods. (K2, PO1)

2. Explain with a neat diagram, series resonant and parallel resonant circuit . Also draw the frequency characteristics . (K1, PO1)

3. Explain significance of Zero voltage and Zero current switching in dc –dc converters. (K1, PO1)

4. Illustrate how switching losses are reduced in ZVS configuration. (K1, PO1, PO2)

Model Question Paper

QP CODE: **Pages:**

Reg No.:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET454

Course Name: SWITCHED MODE POWER CONVERTERS

Max. Marks: 100 **Duration: 3 hours**

PART A

Answer all questions; each question carries 3 marks.

1. What is the primary difference between switched mode power conversion linear power conversion?

2. Draw the circuit diagram of a dc-dc converter that, when operated in continuous conduction mode yields continuous currents in both input and output terminals, and inverted output voltage.

3. Draw the circuit diagram of a two-switch flyback converter and explain why it cannot operate with duty ratios beyond 50%.

4. What are the advantages of a current-fed isolated dc-dc converter?

5. In a single-phase full-bridge PWM inverter operating with Sine PWM and in linear modulation range, what would be the maximum possible rms value of the fundamental voltage that can be obtained at the output if the dc voltage is fixed at 500V?

6. Draw the circuit diagram of the single-phase boost power factor correction rectifier topology. Which signals need to be sensed in order to control this converter?

7. How many space vectors can be produced by a three-phase bridge inverter? Represent them in a table in the given format below:

Sl. No.	Switch states	Space vector magnitude	Location (angle)

8. Differentiate between current controlled voltage source inverter and hysteresis current controlled inverter.

9. Differentiate between PWM hard-switching and Soft-switching.

10 Draw the ZCS switch configuration and explain how the position of the resonant components aid in zero-current switching.

PART B

Answer any one complete question from each section; each question carries 14 mark

11 (a) Derive an expression for the peak-to-peak current ripple in the inductor in a buck converter operating in continuous conduction mode, in terms of the output voltage, operating duty ratio and the value of the inductor. Draw the relevant waveforms used in the derivation. (4)

(b) A photovoltaic panel is rated for an output voltage range between 15 V to 18 V, 36 W peak output power. This panel is to be connected to a dc load that demands a fixed dc voltage of 12 V, with ripple less than 1% of the rated output voltage. Assume the converter is to be operated in discontinuous conduction mode when the load is less than 50% of the rated output power. Select a converter topology suitable for this application, and design it to meet the given specifications. Evaluate the duty ratio D when the input voltage is 18 V and the load is 30% of the rated output power, with the component values selected for the design. (10)

OR

12 (a) A Ćuk converter is supplied with an input voltage that varies between 5V and 10V. The output is required to be regulated at 15V. Find the duty ratio range. Assume the converter is working with continuous conduction mode for the entire range. If the load power is 50W, evaluate the input currents for the minimum and maximum input voltages, assuming an ideal converter. (5)

(b) Develop the voltage transfer ratio of a buck converter operating in Discontinuous Conduction Mode. (9)

13 (a) Compare the features of single-switch and two-switch flyback converter topologies. (4)

(b) It is required to design a power converter with the following features:
(i). Electrical isolation is required.
(ii). Gate drives should be referenced to the same electrical potential.
(iii). The input voltage is 200 V, and the output voltage is 12 V; Power is 250 W.
A junior technician came up with the options: Two-switch Flyback converter, Two-switch forward converter, Push-pull converter, Full-bridge isolated converter and Half-bridge isolated converter. As a design engineer, which out of these options will you choose that can meet the requirements? Develop a basic design of the inductor and capacitor, by assuming a current ripple of 20% of output current and 1% of nominal output voltage as voltage ripple. Evaluate the duty ratio and choose an appropriate turns ratio for the transformer. (10)

OR

14 (a) A flyback converter with 15V input voltage is operating with a duty ratio of 0.4. If the turns ratio of the coupled inductor is 1:0.5, evaluate the output voltage. Assume continuous conduction mode. What is the peak voltage appearing across the switch? Draw the waveforms of the input current, output diode current and voltage across the switch under the given operating conditions and mark the salient features. (6)

(b) For a forward converter with Vd=48V+/-10%; Vo= 5V (regulated); fs=100kHz; Pload=15-50W. If the flux reset winding N3=N1, calculate the turns ratio N2/N1 if this turns ratio is desired to be as small as possible. (8)

15 (a) What are the dominant harmonics in the output line-to-line voltage of a three-phase bridge inverter operating in square-wave mode? Show the line voltage waveform and the harmonic spectrum upto the first 7 dominant harmonics (not upto the 7th). (5)

(b) Describe a single-phase power factor corrected rectification scheme utilising boost converter and its control. Explain how the input current is actively shaped for reduced THD. (9)

OR

16 (a) In a single phase full bridge sine PWM inverter, the input dc voltage varies in a range of 295-325 V. Because of the low distortion required in the output, the inverter is operated in the linear modulation range. What is the highest output fundamental rms voltage that can be obtained from this inverter? If the inverter is to be rated at 2 kVA, calculate the combined switch utilisation ratio of the inverter when it is supplying rated VA. Assume the load current is sinusoidal. (6)

(b) Explain how a single-phase full-bridge topology can be used as a utility interfaced high-power factor rectifier. (8)

17 (a) For a Space Vector PWM based inverter, the dc voltage is 600 V. The switching frequency is 20 kHz. The reference voltage vector is 200□30^{o} Vrms, at a particular sampling interval.
(i). Identify the active vectors to be used during the given sampling interval. Indicate the corresponding switch states.
(ii). The dwell-times of the active vectors and the zero vector during the interval.
(iii). Evaluate the dwell times when the reference vector is at 180^{o} out-of phase with the original location. (8)

(b) What is Selective Harmonic Elimination? Explain with respect to a single-phase inverter. (6)

OR

18 (a) Explain the working of a current controlled voltage source inverter with fixed switching frequency. (6)

(b) Explain how the number of switchings per sampling period are minimised by proper sequencing of the active and zero vectors in Space Vector Modulation. (8)

19 (a) Differentiate between ZCS and ZVS topologies. What are the parasitic elements which are usefully employed in these topologies? (6)

(b) With circuit diagram and relevant waveforms, describe the operation of a series loaded resonant converter operating in discontinuous conduction mode. (8)

OR

20 (a) The ZCS and ZVS resonant switches are dual implementations. Explain why. (6)

(b) Which of the load resonant converters is a voltage-boosting converter? Explain with relevant diagrams/graphs. (8)

Syllabus

Module 1

Switched Mode non-isolated DC-to-DC Converters:

Linear Vs Switching Power Electronics.

Buck, Boost, Buck-boost and Ćuk converters: Principles of steady-state analysis - Inductor volt-seconds balance and capacitor amp-seconds balance – Operation in Continuous Conduction Mode (CCM)- Voltage Gain – design of filter inductance & capacitance - boundary between continuous and discontinuous conduction – critical values of inductance/load resistance - Examples for buck and boost converters.

Discontinuous Conduction Mode (DCM) of buck converter with constant output voltage – Output voltage ripple in DCM. Voltage Gain in DCM for buck converters.

Module 2

DC-DC converters with electrical isolation:

High-frequency transformers for DC-DC converters: unidirectional magnetic core excitation & bidirectional core excitation.

Fly back converter: Operation and waveforms in continuous & discontinuous conduction modes – Voltage gain.

CCM operation of double ended fly-back converter.

Forward converter in CCM: Basic forward converter with ideal transformer – practical forward converter with core reset – double ended forward converter

Push-Pull, Half-Bridge and Full-Bridge converters: Operation in Continuous Conduction Mode (CCM) – Flux-walking in isolated converters.

Current-source DC-DC converter.

Module 3

Switched Mode DC to AC converters:

Review of single-phase bridge inverters - 3-phase Sine-PWM inverter: – Linear Modulation, RMS fundamental line to line voltage & RMS fundamental line-to-line voltage – Overmodulation - Square wave operation in three-phase inverters - Switch utilisation ratio of 1-phase & 3-phase full-bridge inverters.

PWM Rectifiers: Generation of current harmonics in diode bridge rectifiers - Power factor - Improved single-phase utility interface - Active shaping of input line current through PFC boost converter - Single phase Switched mode rectifier.

Module 4

Modulation Schemes:

Space Vector Modulation: Concept of space vector – space vector modulation – reference vector & switching (dwell) times – space vector sequence – comparison of sine PWM & space vector PWM.

Programmed (selective) harmonic elimination switching in single phase inverters (Formulation example with elimination of two harmonics at a time) – current controlled voltage source inverter -

Hysteresis current control.

Module 5

Softswitching and resonant converters:

Hard-switched Vs Soft-switched converters -

Resonant Converters - Basic resonant circuit concepts – series resonant circuit – parallel resonant circuit – series-loaded and parallel loaded resonant converters (Operation in discontinuous conduction mode with $\omega s < 0.5\ \omega r$).

Resonant Switch (Quasi-resonant) Converters: ZCS buck converter - L type - ZVS buck converter – comparison of ZCS & ZVS Resonant Converters.

Note: Assignments may be given to develop simulations of the converter topologies in open-loop and/or closed-loop using appropriate simulation tools. Assignments may also be given to develop design automation scripts/tools using Python, MATLAB, C, Spreadsheets etc.

Text Books

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics: Converters, Applications and Design," Third Edition, John Wiley and Sons, 2003.

Reference Books

1. Joseph Vithayathil, "Power Electronics: Principles and Applications," Tata McGrawhill edition.
2. Robert W. Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics," Second Edition, Springer International Edition (Indian reprint).
3. L. Umanand, "Power Electronics: Elements and Applications," Wiley India, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Non-isolated DC-DC converters:**	**7 Hours**
1.1	Introduction: Linear Vs Switching Power Electronics. Buck and Boost Converters: Topology, principles of low-ripple approximation and inductor volt-sec/capacitor amp-sec balance., Application in developing the voltage transformation ratio in CCM. Evaluation of Inductances and Capacitance for specified current/voltage ripple.	2
1.2	Buck-boost and Cuk Converters: Topology, Application of inductor volt-sec balance/Capacitor amp-sec balance in developing the voltage transformation ratio in CCM. Evaluation of Inductances and Capacitor for specified current/voltage ripple.	2
1.3	Boundary between continuous and discontinuous conduction modes– critical values of inductance/load resistance - Examples for buck and boost converters.	1
1.4	Discontinuous Conduction Mode (DCM) of buck converter with constant output voltage – Output voltage ripple in DCM. Voltage Gain in DCM for buck converters.	2
2	**DC-DC converters with electrical isolation:**	**8 Hours**
2.1	High-frequency transformers for DC-DC converters: unidirectional magnetic core excitation & bidirectional core excitation.	1
2.2	Fly back converter: Operation and waveforms in continuous & discontinuous conduction modes – Voltage gain; CCM operation of double ended fly-back converter.	2

2.3	Forward converter in CCM: Basic forward converter with ideal transformer – practical forward converter with core reset – double ended forward converter.	2
2.4	Push-Pull, Half-Bridge and Full-Bridge converters: Operation in Continuous Conduction Mode (CCM) – Flux-walking in isolated converters.	2
2.5	Current-source DC-DC converter	1
3	**Switched Mode Inverters and Rectifiers**	**6 hours**
3.1	Review of single-phase bridge inverters - 3-phase voltage source inverter: 3-phase Sine-PWM inverter – RMS line to line voltage & RMS fundamental line-to-line voltage – square wave operation - Switch utilisation ratio of 1-phase & 3-phase full-bridge inverters.	2
3.2	**PWM Rectifiers: (Ch. 8 of Ref. 1):** Generation of current harmonics in diode bridge rectifiers - Power factor - Improved single-phase utility interface - Active shaping of input line current through PFC boost converter -Single phase Switched mode rectifier operation and control.	4
4	**Modulation Schemes:**	**7 Hours**
4.1	Concept of space vector; Origin of flux space phasor representation.	1
4.2	Space vector modulation – reference vector & switching times – space vector sequence	2
4.3	Comparison of sine PWM & space vector PWM.	1
4.4	Programmed (selective) harmonic elimination switching in single phase inverters (example with elimination of third and fifth harmonics)	2
4.5	Current controlled voltage source inverter - Hysteresis current control.	1
5	**Softswitching and Resonant Converters:**	**8 hours**
5.1	Softswitching and resonant converters: Hard-switched Vs Soft-switched converters - Switching losses and transition of voltage and current during switching in Hard Switched converters.	1
5.2	Resonant Converters - Basic resonant circuit concepts – series resonant circuit – parallel resonant circuit	2

5.3	Series-loaded (Operation in discontinuous conduction mode with $\omega_{sw} < 0.5\ \omega_r$; ω_{sw}:Switching frequency and ω_r: Resonant frequency)	1
5.4	Parallel loaded resonant converters (Operation in discontinuous conduction mode with $\omega_{sw} < 0.5\ \omega_r$; ω_{sw}:Switching frequency and ω_r: Resonant frequency).	1
5.5	Resonant Switch (Quasi-resonant) Converters: ZCS buck converter - L type.	2
5.6	ZVS buck converter – Comparison of ZCS & ZVS Resonant Converters.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET464	COMPUTER AIDED POWER SYSTEM ANALYSIS	PEC	2	1	0	3

Preamble: The basic objective of this course is to familiarize the efficient computational techniques applied in analyzing the power system.

Prerequisite: Circuits and Networks, Power Systems I, Power Systems II

Course Outcomes: After the completion of the course the student will be able to

CO1	Develop the model of power system networks
CO2	Solve linear systems using computationally efficient methods
CO3	Solve load flow problem to analyse the state of power systems
CO4	Formulate optimal power flow problem in power system networks
CO5	Analyse power system under short circuit conditions and infer the results to design a protective system

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	1	1	-	1	-	-	-	-	-	-	-
CO2	3	2	1	-	1	-	-	-	-	-	-	-
CO3	3	2	2	-	2	-	-	-	-	-	-	-
CO4	3	2	2	-	2	-	-	-	-	-	-	-
CO5	3	3	3	-	2	-	-	-	-	-	-	-

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	20	20	40
Analyse (K4)	10	10	20
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

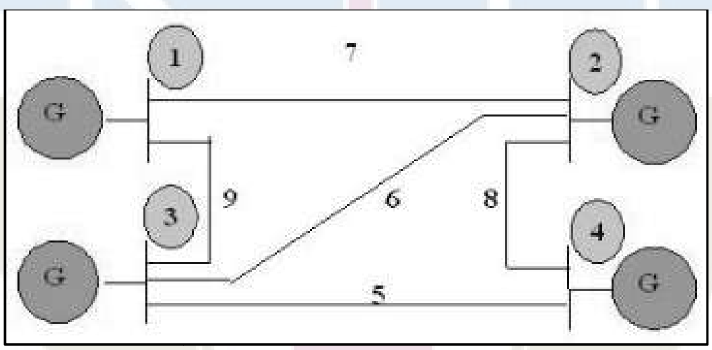
End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

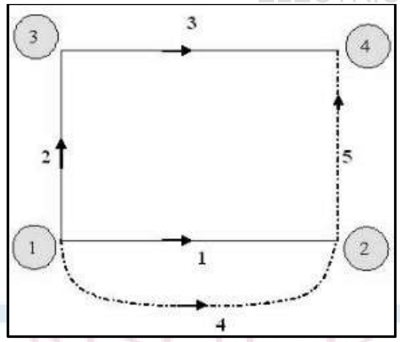
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. For the network shown in Fig. obtain the bus incidence matrix A. (K3)(PO1,PO2,PO3,PO5)



2. For the network in Fig, form the primitive matrices [z] & [y] and obtain the bus admittance matrix by singular transformation. (K2, K3)(PO1,PO2,PO3,PO5)



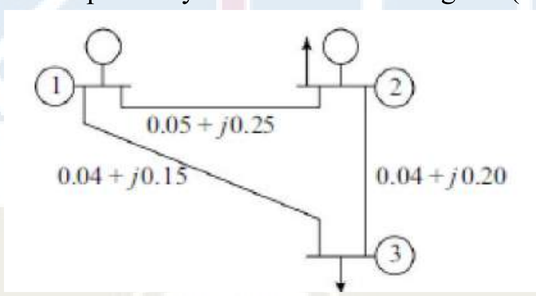
Course Outcome 2 (CO2):

1. Solve Ax=b using Gaussian elimination, given $A=\begin{bmatrix}5 & -2 & -3\\ -3 & 7 & -2\\ -3 & -3 & 8\end{bmatrix}$ $b=\begin{bmatrix}4\\ -10\\ 6\end{bmatrix}$ (K2)(PO1,PO2,PO3,PO5)

2. Enumerate Tinney's optimal ordering schemes. (K2)(PO1,PO2,PO3,PO5)

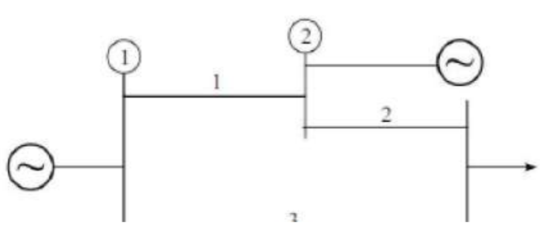
Course Outcome 3 (CO3):

1. Exhibit the structure of fast decoupled load flow equations and DC load flow equations with numerical values for the 3 bus power system shown in the figure. (K3)(PO1,PO2,PO3,PO5)



Load/Gen. Data				
Bus	Gen.		Load	
	MW	MVAR	MW	MVAR
1	0	0	0	0
2	100	50	50	25
3	0	0	75	30
4	0	0	100	50

2. Considering Bus 1 as slack bus, use DC load flow to obtain one iteration of load flow solution for the system shown below. (K2, K3)(PO1,PO2,PO3,PO5)



Line data (all are in p.u)

Line number	***Between buses***	***Line impedance***
1	1-2	0 + j0.1
2	2-3	0 + j0.2
3	1-3	0 + j0.3

Bus data (all are in p.u)

Bus no.	***Type***	***Generator***		***Load***		***Voltage magnitude***	***Reactive power limits***	
		P	***Q***	***P***	***Q***	***lVl***	Q_{min}	Q_{max}
1	Slack	-	-	-	-	1.0	-	-8
2	P-V	5.3217	-	-	-	1.0	0	5.3217
3	P-Q	-	-	3.6392	0.5339	-	-	-

Course Outcome 4 (CO4):

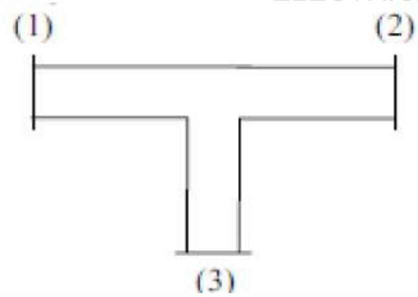
1. Formulate the optimal power flow problem with equality constraints. (K2,K3)(PO1,PO2,PO3,PO5)
2. Discuss the equality and inequality constraints in optimal power flow. (K1)(PO1,PO2,PO3,PO5)
3. Incremental fuel costs in Rs/ mega watthour for a plant consisting of two units are given by

$$\square_1 = \frac{df_1}{dP_1} = 0.008P_1 + 8\lambda_2 = \frac{df_2}{dP_2} = 0.0096P_2 + 6.4$$

   Assume that both units are operating at all times, determine the saving in fuel cost in Rs/hr for the economic distribution of total load of 900 MW between the two units of the plant compared with equal distribution of the same total load. (K3)(PO1,PO2,PO3,PO5)

Course Outcome 5 (CO5):

1. All lines in the network shown in figure have a positive sequence impedance of j0.2 p.u. Generators with transient reactances j0.05 p.u. are connected at buses 1 and 2. Assuming prefault voltage as 1< 0°, for a three-phase to ground fault bus 3, find fault current, fault voltages at buses and currents in all the lines. Determine the fault level at bus 3. (K3, K4)(PO1,PO2,PO3,PO5)



2. A 50-Hz turbo generator is rated 500 MVA, 22 kV. It is Y- connected and solidly grounded and is operating at rated voltage at no load. It is disconnected from the rest of the system. Its reactances are X_d''= X_1= X_2 = 0.15 and X_0 = 0.05 per unit. Determine the ratio of the subtransient line current for a single line to ground fault to the subtransient line current for a symmetrical fault. (K3)(PO1,PO2,PO3,PO5)

Model Question Paper

QP CODE:

PAGES:4

Reg.No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHT SEMESTER
B. TECH. DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET464
Course Name: COMPUTER AIDED POWER SYSTEM ANALYSIS

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all Questions. Each question carry 3 marks

1. Define tree, co-tree, link and branch of a graph.
2. How will the ZBUS matrix be modified, if any line is removed from the previous existing network, or the impedance value of the existing line gets modified.
3. Write short notes on Tinney's optimal ordering.
4. Discuss about triangular factorization of system matrices.
5. Compare NR load flow, decoupled load flow and fast decoupled load flow.
6. What is the principle underlying the decoupled approach in load flow solutions? Narrate its typical solution strategy.
7. Explain the constraints considered in formulating Optimal Power Flow.
8. Explain the concept of economic dispatch problem in the power system.
9. What is the need of performing short circuit analysis in a power system?

10. The Thevenin impedance and voltage at a fault point is $0.576\angle 84^{o}$ p.u. and $1\angle 0^{o}$ p.u. respectively. Determine the short circuit MVA for a base of 30MVA, 11kV.

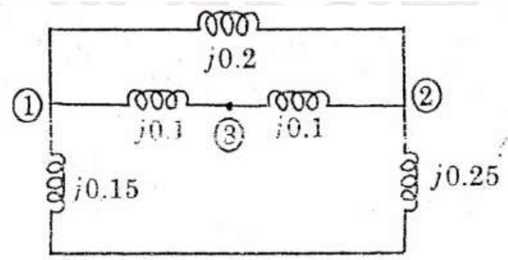
PART B

Answer any one full question from each module. Each full question carry 14 marks

Module-1

11. a) Prove $Y_{Bus}=A^{T}yA$ where A is bus incidence matrix, y is primitive admittance matrix and Y_{Bus} is bus admittance matrix. (7)

b) For the network shown in figure below, obtain Y_{Bus} by singular transformation. All line impedances are in p.u. (7)



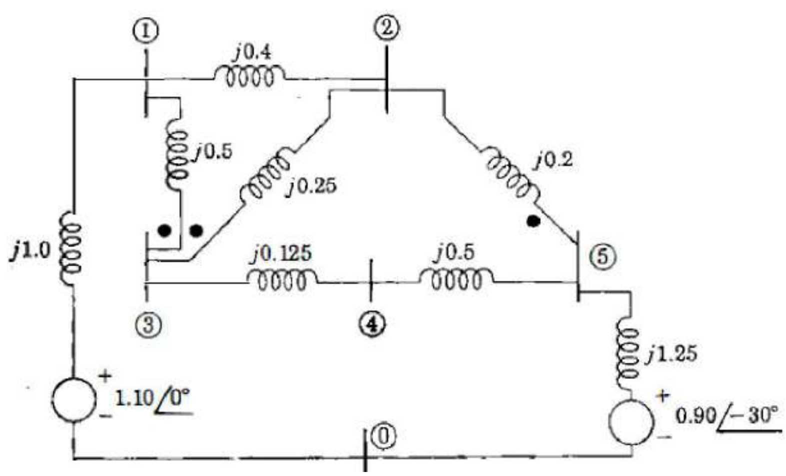
12. For the reactance network shown in figure find Z bus by direct determination (14)

Module-2

13. Find the L and U triangular factors of the symmetric matrix. (14)

$$\mathbf{M} = \begin{bmatrix} 2 & 1 & 3 \\ 1 & 5 & 4 \\ 3 & 4 & 7 \end{bmatrix}$$

14. Using the Guassian elimination find the triangular factors of Y bus for the circuit given (14)



Module-3

15. For the three bus power system shown in figure, carry out one iteration of load flow solution by FDLF method. Line reactances are given in pu. (14)

16. a) Discuss the Newton Raphson algorithm of Load Flow (8)
b) Stating the assumptions, discuss DC Load Flow (6)

Module-4

17. Explain the Optimal Power Flow problem and its solution by gradient method (with equality constraints only) (14)

18. a) Explain the formulation of optimal power flow problem and its solution by Newton method (8)
b) Explain security constrained optimal power flow (6)

Module-5

19. For the system shown in figure a three phase fault occurs in bus 1. Using Z_{Bus} method, find the short circuit current in the fault, currents in line 1-2 and 1-3 and bus voltages. Prefault system is on no load with 1pu voltage and prefault currents are zero. (14)

20. Obtain the sequence network for a LL fault through impedance at the terminals of an unloaded synchronous generator. (14)

Syllabus

Module I (7 hours)

Overview of graph theory - tree, co-tree and bus incidence matrix, development of network matrices Z_{bus} and Y_{bus} from graph theoretic approach (singular transformation only), building algorithm for bus impedance matrix for elements without mutual coupling.

Module II (8 hours)

Review of solution of linear system of equations by Gauss-Jordan method, Gauss elimination, and LDU factorization. Inversion of Y_{bus} for large systems using LDU factors, Tinney's Optimal ordering.

Module III (7 hours)

Review of Load Flow analysis, Newton-Raphson method(only qualitative analysis), Fast Decoupled Load Flow and DC Load Flow (numerical problems upto two iterations).

Module IV (7 hours)

Review of economic load dispatch, formulation of optimal power flow with active power cost minimization, Solution of OPF using Gradient and Newton's methods (Qualitative analysis only), Security Constrained Optimal Power Flow (concept only).

Module V (7 hours)

Network fault calculations using Z_{bus}, algorithm for calculating system conditions after fault – three phase to ground fault.

Text Books:

1. Stagg and E l Abiad, "Computer Methods in Power System Analysis", McGraw Hill, 1968.
2. G. L. Kusic, Computer Aided Power System Analysis, PHI, 1989
3. John J. Grainger, William D. Stevenson, Jr., Power System Analysis, Tata McGraw-Hill Series in Electrical and Computer Engineering.

References:

1. I. J. Nagrath and D. P. Kothari, "Modern Power System Analysis", Tata McGraw Hill, 1980.
2. J. Arriliga and N.R. Watson, Computer Modelling of Electrical Power Systems, 2/e, John Wiley, 2001.
3. L. P. Singh, "Advanced Power System Analysis and Dynamics", 3/e, New Age Intl, 1996.
4. M. A. Pai, Computer Techniques in Power Systems Analysis, Tata McGraw-Hill, Second edition 2005.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis (English) 2nd Edition, Pearson Higher Education
6. Wood, Allen J., Bruce F. Wollenberg, and Gerald B. Sheblé. Power generation, operation, and control. John Wiley & Sons, 2013

Course Content and Lecture Schedule:

Sl. No.	Topic	No. of Lecture Hrs
1	**Module I (7 Hrs)**	
1.1	Introduction, Network Equation, Concept of Linear Graph – tree, cotree	1
1.2	Bus Incidence matrix, A	1
1.3	Formation of Y_{bus} and Z_{bus} by singular transformation, Numerical problem	2
1.4	Z_{bus} building algorithm without mutual coupling(derivation not required), Numerical example	3
2	**Module II (8 Hrs)**	
2.1	Solution of linear system of equations by Gauss Jordan method and Gauss elimination method, Numerical problems	3

2.2	Triangular factorization –LDU factors, Numerical problems	2
2.3	Inversion of the Y_{BUS} matrix for large systems, Numerical problems	2
2.4	Tinney's Optimally Ordering	1
3	**Module III (7 Hrs)**	
3.1	Review of Load Flow	1
3.2	Newton-Raphson method (Qualitative analysis only)	2
3.3	Fast Decoupled Load Flow (Numerical problems up to 2 iterations)	2
3.4	DC Load Flow (Numerical problems up to 2 iterations)	2
4	**Module IV (7 Hrs)**	
4.1	Review of Economic Load Dispatch - Economic dispatch of generation without and with transmission line losses	2
4.2	Concept of optimal power flow – formulation with equality and inequality constraints (with active power cost minimization)	2
4.3	Solution of OPF using Gradient and Newton method (Qualitative analysis only)	2
4.4	Security Constrained Optimal Power Flow (concept only).	1
5	**Module V (7 Hrs)**	
5.1	Symmetrical and Unsymmetrical fault calculations using Z_{BUS} – Numerical Problems (Symmetrical faults up to 3 bus systems)	4
5.2	Algorithm for SC calculations for balanced 3 phase network – three phase to ground fault only –Numerical problem	3
		36 hrs

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET474	MACHINE LEARNING	PEC	2	1	0	3

Preamble:. This course will enable students to:

1) Develop an appreciation for what is involved in learning models from data.
2) Understand a wide variety of learning algorithms.
3) Understand how to evaluate models generated from data.
4) Apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to:

CO1	Understand various basic learning techniques
CO2	Perform dimensionality reduction for multivariate problems
CO3	Implement machine learning solutions to classification, regression, and clustering problems
CO4	Use Perceptron modelling based learning techniques and Support Vector Machines to design solutions
CO5	Design and analyse machine learning experiments for real-life problems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	-	-	-	-	-	-	-	-	-	3
CO 2	3	3	2	-	-	-	-	-	-	-	-	3
CO 3	3	3	3	-	-	-	-	-	-	-	-	3
CO 4	3	3	-	-	-	-	-	-	-	-	-	3
CO 5	3	3	2	-	-	-	-	-	-	-	-	3

Assessment Pattern:

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	20	20	50
Analyse (K4)	10	10	10
Evaluate (K5)			
Create (K6)			

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

End Semester Examination Pattern: There will be two parts; Part A and Part B.
Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.
Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Distinguish between overfitting and underfitting. How it can affect model generalization?

2. Explain bias- variance dilemma.

3. Distinguish between classification and regression with an example.

Course Outcome 2 (CO2)

1. Define VC dimension. Show that an axis aligned rectangle can shatter 4 points in 2 dimensions.

2. Compare Simple Regression, Multiple Regression and Multivariate Regression.

3. Describe any two techniques used for Ensemble Learning.

Course Outcome 3(CO3):

1. Given a linearly separable dataset with one group containing 5 instances and a second group containing 20 instances, is k-means clustering with k =2 guaranteed to find these two clusters? Explain why or why not.

2. Explain Basic decision tree learning algorithm for classification problems

3. Draw the decision tree structure for X1 XOR X2

Course Outcome 4 (CO4):

1. What is kernel trick? Why does the kernel trick allow us to solve SVMs with high dimensional feature spaces, without significantly increasing the running time?

2. Can you represent the following Boolean function with a single binary perceptron? If yes, show the weights. If not, explain why not in 1-2 sentences.

A	B	f(A,B)
1	1	0
0	0	0
1	0	1
0	1	0

3. Formulate the SVM regression problem using insensitive loss.

Course Outcome 5 (CO5):

1) Suppose that the datamining task is to cluster the following seven points (with (x,y) representing location) into two clusters A1(1,1), A2(1.5,2), A3(3,4), A4(5,7), A5(3.5,5), A6(4.5,5), A7(3.5,4.5) The distance function is City block distance. Suppose initially we assign A1,A5 as the centre for each cluster respectively. Using the K-means algorithm to find the three clusters and their centres after two round of execution.
2) Explain the concept of Reinforcement Learning with a practical example.
3) Draw the structure of CNN, and explain the classification process with an example.

Model Question Paper PAGES: 3

QP CODE:

Reg.No:____________

Name:_____________

APJ ABDULKALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE
EXAMINATION MONTH & YEAR

Course Code**: EET474**

Course Name: **MACHINE LEARNING**

Max. Marks: 100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1 Explain false negative, false positive, true negative and true positive with a simple example.

2 While using all features of a data set, if we achieve 100% accuracy on my training set, but ~70% on validation set, discuss whether we might see an underfitting, overfitting or perfect model? Please justify.

3 Differentiate a Perceptron and Logistic Regression?

4 Explain the difference between L1 and L2 regularization.

5 Can we design a neural network without an activation function? Justify your answer.

6 Is Occam's Razor an inductive bias scenario? State reasons with examples.

7 What are the standard use cases for Bayesian belief networks? What is its basic difference with respect to Hidden Markov Models?

8 We have designed an RBF kernel in SVM with high Gamma value. What does this signify?

9 In a binary classification problem, there are 3 models each with 70% accuracy. If we want to ensemble these models using majority voting method, what will be the maximum accuracy we can get?

10 What are the basic elements of reinforcement learning?

PART B

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11 a) Discuss the influence of model complexity on underfitting and overfitting? (7 Marks)

b) How do we measure the power of a classifier? What is the VC dimension for a linear classifier? (7 Marks)

12 a) List out the critical assumptions for applying linear regression, with emphasis to Heteroscedasticity. How can we improve the accuracy of a linear regression model? (9 Marks)

b) Discuss L1 and L2 regularization? (5 Marks)

Module 2

13 a) Explain Naïve Bayes Classifier (10 Marks)

b) Discuss the inconsistencies in Bayesian inference (4 Marks)

14 a) What are the various multivariate learning techniques? Discuss with use cases and applications (7 Marks)

b) Suppose we have 3 cards identical in form except that both sides of the first card are colored red, both sides of the second card are colored black, and one side of the third card is colored red and the other side is colored black. The 3 cards are mixed up in a hat, and 1 card is randomly selected and put down on the ground. If the upper side of the chosen card is colored red, what is the probability that the other side is colored black? (7 Marks)

Module 3

15 a) Consider the following data where x and y are the 2 input variables and Class is the dependent variable. (10 Marks)

x	y	Class
−1	1	−
0	1	+
0	2	−
1	−1	−
1	0	+
1	2	+
2	2	−
2	3	+

Draw the scatter plot for this dataset in a two dimensional space. Assuming a Euclidian distance of in 3-NN, to which class will the new point of x=1 and y=1 belong to?

b) Write four termination conditions for k-means clustering algorithm (4 Marks)

16 a) Describe the expectation-maximization algorithm? (9 Marks)

b) Write short note on Random Forest Decision tree . (5 Marks)

Module 4

17 a) Write the pseudo code for back propagation algorithm and explain? (10 Marks)

b) Differentiate CNN from RNN with respect to its use cases. (4 Marks)

18 a) Discuss the geometric intuition behind SVMs.

Discuss soft margin and hard margin SVMs (10 Marks)

b) When do you apply "Kernel Trick"? (4 Marks)

Module 5

19 a) In an election, N candidates are competing against each other and people are voting for either of the candidates. Voters don't communicate with each other while casting their votes. Which ensemble method works similar to above-discussed election procedure? (11 Marks)

b) Illustrate K-Arm bandit algorithm with an example (3 Marks)

20 a) Discuss problem characteristics in the Reinforcement Learning method (5 Marks)

b) With an example, demonstrate the Q-Function and Q-Learning algorithm, assuming deterministic reward and action. (9 Marks)

Syllabus

Module – 1

Introduction: What Is Machine Learning? Examples of Machine Learning Applications, Learning Associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning

Supervised Learning: Learning a Class from Examples, Vapnik-Chervonenkis (VC) Dimension, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization

Parametric Methods: Maximum Likelihood Estimation, Evaluating an Estimator: Bias and Variance, Parametric Classification, Regression, Tuning Model Complexity and Model Validation: Bias/Variance Dilemma

Module – 2

Bayesian Learning: Introduction to conditional probability and conditional expectations, Bayes theorem, Bayes theorem and concept learning, ML and LS error hypothesis, ML for predicting probabilities, Naive Bayes classifier, Bayesian belief networks,

Multivariate Data, Multivariate Classification, Multivariate Regression

Module – 3

Clustering: Introduction, Mixture Densities, k-Means Clustering, Expectation-Maximization Algorithm, Other methods of clustering.

Nonparametric Methods: Nonparametric Density Estimation, Histogram Estimator, Kernel Estimator, k-Nearest Neighbor Estimator

Decision Tree Based Learning: Decision tree representation, Appropriate problems for decision tree learning, Basic decision tree learning algorithm, hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning

Module – 4

Neural Networks: Neural Networks as a Paradigm for Parallel Processing, Feed Forward Networks, Backpropagation Algorithm, Fundamentals of Deep Learning, Basic Deep Learning Architectures

Local Models: Competitive Learning, Radial Basis Functions, Incorporating Rule-Based Knowledge

Kernel Machines: SVM Formulations, Optimal Separating Hyperplane, The Nonseparable Case: Soft Margin Hyperplane, ν-SVM, Kernel Types, Kernel Machines for Regression

Module – 5

Combining Multiple Learners: Rationale, Generating Diverse Learners, Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging, Boosting

Reinforcement Learning: The State Space Theory, K-Armed Bandit, Elements of Reinforcement Learning, Q Learning

Text Books:

- Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006. [CB-2006]
- Machine Learning. Tom Mitchell, McGraw-hill, 1997

Reference Books:

- Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017. [SS-2017]
- Haykin, Simon. Neural networks and learning machines, 3/E. Pearson Education India, 2010.
- The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009. [TH-2009]
- Foundations of Data Science. Avrim Blum, John Hopcroft and Ravindran Kannan. January 2017. [AB-2017]

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Module 1**	**(7 hours)**
1.1	What Is Machine Learning? Examples of Machine Learning Applications, Learning Associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning	2
1.2	Supervised Learning: Learning a Class from Examples, Vapnik-Chervonenkis (VC) Dimension, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization	2
1.3	Parametric Methods: Maximum Likelihood Estimation, Evaluating an Estimator: Bias and Variance, Parametric Classification, Regression, Tuning Model Complexity and Model Validation: Bias/Variance Dilemma	3
2	**Module 2**	**(7 hours)**
2.1	Bayesian Learning: Introduction to conditional probability and conditional expectations, Bayes theorem, Bayes theorem and concept learning, ML and LS error hypothesis,	3
2.2	ML for predicting probabilities, Naive Bayes classifier, Bayesian belief networks,	2
2.3	Multivariate Data, Multivariate Classification, Multivariate Regression	2
3	**Module 3**	**(7 hours)**
3.1	Clustering: Introduction, Mixture Densities, k-Means Clustering, Expectation-Maximization Algorithm, Other methods of clustering.	2
3.2	Nonparametric Methods: Nonparametric Density Estimation, Histogram Estimator, Kernel Estimator, k-Nearest Neighbor Estimator	2
3.3	Decision Tree Based Learning: Decision tree representation, Appropriate problems for decision tree learning, Basic decision tree learning algorithm, hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning	3
4	**Module 4**	**(7 hours)**
4.1	Neural Networks: Neural Networks as a Paradigm for Parallel Processing, Feed Forward Networks, Backpropagation Algorithm, Fundamentals of Deep Learning, Basic Deep Learning Architectures	2
4.2	Local Models: Competitive Learning, Radial Basis Functions, Incorporating Rule-Based Knowledge	2
4.3	Kernel Machines: SVM Formulations, Optimal Separating Hyperplane, The Nonseparable Case: Soft Margin Hyperplane, ν-SVM, Kernel Types, Kernel Machines for Regression	3
5	**Module 5**	**(7 hours)**
5.1	Combining Multiple Learners: Rationale, Generating Diverse Learners	2
5.2	Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging, Boosting	2
5.3	Reinforcement Learning: The State Space Theory, K-Armed Bandit, Elements of Reinforcement Learning, Q Learning	3

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SEMESTER VIII

PROGRAM ELECTIVE IV

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET416	NONLINEAR SYSTEMS	PEC	2	1	0	3

Preamble: Most of the systems that we come across are nonlinear. Nonlinear systems exhibit interesting oscillatory behaviours and indeed unexpected phenomena like limit cycles, bifurcation, chaos etc. The course aims in understanding the basic phenomena of limit cycles, determine their existence and non-existence in systems using various theorems. This course also aims to investigate the behaviour of nonlinear systems, analyze their stability using the Lyapunov direct/indirect methods, frequency-domain methods and design various control schemes. For understanding the concepts, a basic mathematical foundation is also built throughout the course.The course will provide the basis for designing controllers for various applications such as aerospace, power systems, robotics, electric drives etc.

Prerequisites: EET 302 Linear Control Systems and EET 401 Advanced Control Systems

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyse the qualitative behaviour of nonlinear systems about their equilibrium points.
CO 2	Identify the existence and uniqueness of solutions of nonlinear differential equations, the existence of periodic orbits/limit cycles for nonlinear systems.
CO 3	Analyse the stability of nonlinear systems.
CO 4	Design feedback control systems for nonlinear systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	-	-	-	-	-	-	1
CO 2	3	3	-	-	-	-	-	-	-	-	-	1
CO 3	3	3	-	-	-	-	-	-	-	-	-	1
CO 4	3	2	-	-	-	-	-	-	-	-	-	1

Assessment Pattern:

Total Marks	CIE marks	ESE marks	ESE Duration
150	50	100	03 Hrs

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	15	15	30
Apply (K3)	25	25	50
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern: There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer anyone. Each question carries 14 marks and can have sub-divisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Discuss the characteristics of non-linear systems? (K1, PO1)
2. Model a given nonlinear system. (K2, PO1, PO12)
3. Identify and classify the equilibrium solutions of nonlinear systems. (K2, PO1)
4. Analyse the qualitative behaviour of a given system about its equilibrium points and plot a rough sketch of the phase portrait. (K3, PO2, PO12)
5. What are bifurcations? (K1, PO1)
6. Problems to identify the type of bifurcation. (Saddle-node and Pitchfork only) (K2, PO1)

Course Outcome 2 (CO2):

1. Identify the existence of limit cycles using the Poincare Bendixson theorem. (K3, PO2, PO12)
2. Identify the non-existence of limit cycles using Bendixson's theorem. (K3, PO2, PO12)
3. Problems to check the existence and uniqueness of initial value problems. (K2, PO2)

Course Outcome 3 (CO3):

1. Explain the concept of stability (local and global), instability in the sense of Lyapunov. (K2, PO1)
2. Apply Lyapunov direct/indirect methods to analyze the stability of nonlinear systems. (K3, PO2, PO12)
3. Analyze the stability using LaSalle's invariance theorem. (K3, PO2, PO12)
4. Construct Lyapunov functions using Variable gradient and Krasovskii's method. (K3, PO2)
5. Explain memoryless systems and passivity. (K1, PO1)
6. Examine whether a given system transfer function is positive real or not. (K2, PO1)
7. Explain sector nonlinearity and absolute stability. (K1, PO1)
8. Define KYP Lemma (without proof). (K1, PO1)
9. Examine the stability of the sector nonlinearity using Circle criterion. (K3, PO2)
10. Explain Popov criterion for stability. (K1, PO1)

Course Outcome 4 (CO5):

1. Define feedback control problem - state feedback and output feedback. (K1, PO1)
2. Use state feedback control law for stabilizing a given system. (K2, PO1)
3. Explain the concept of input-state and input-output linearization. (K1, PO1)
4. Examine whether a given system is input-output linearizable. (K3, PO2, PO12)
5. Explain stabilization via integral control. (K1, PO1)

Model Question Paper PAGES: 2
QP CODE:

Reg.No:______________
Name:________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION
MONTH & YEAR

Course Code: **EET416**

Course Name: **NONLINEAR SYSTEMS**

Max. Marks: 100 **Duration: 3 Hours**

PART A
Answer all questions
Each question carries 3 marks

1		Qualitatively analyse the following nonlinear system about the equilibrium point $\dot{y}+0.5\dot{y}+2y+y^2=0$	3
2		What are limit cycles? Give significance and classify them based on stability.	3
3		Define Poincare Index theorem. Check whether there exist periodic orbits for the system defined below using Poincare index theorem. $\dot{y}-y+y^3=0$	3
4		State the conditions for uniqueness and existence of solutions.	3
5		Check the stability of the nonlinear system using Lyapunov direct method. $\dot{x}_1 = x_2$ $\dot{x}_2 = -x_1 - 3x_2$	3
6		What is meant by domain of attraction of a given system?	3
7		What are positive real transfer functions? Check whether G(s)= [s + 2] / [s + 3]	3

		is a positive real transfer function.	
8		Define absolute stability.	3
9		Find the relative degree for the controlled Van der Pol equation with output $y = x_1$ $\dot{x}_1 = x_2$ $\dot{x}_2 = -x_1 + \varepsilon (1 - x_1^2) x_2 + u, \ \epsilon > 0$	3
10		What is the concept of gain scheduling?	3
PART B **(Answer any one full question from each module)**			
Module 1			
11	a)	Find the equilibrium points of the system defined by the system given below and determine the type of each isolated equilibrium point.Also, plot a rough sketch of the qualitative behaviour near the equilibrium points. $\dot{x}_1 = 5x_1 - x_1 x_2$ $\dot{x}_2 = 3x_2 + x_1 x_2 - 3 x_2^2$	7
	b	The nonlinear dynamic equation for a pendulum is given by $ml\ddot{\theta} = -mg\sin(\theta) - kl\dot{\theta}$ where '*l=1*' is the length of the pendulum, '*m*' is the mass of the bob, and θ is the angle subtended by the rod and the vertical axis through the pivot point. '*g*' is the gravitational constant. Choose '*k/m=1*'. Find all the equilibria of the system and determine if the equilibria are stable or not.	7
12	a	What is saddle-node and Pitch fork bifurcation?	6
	b	Obtain the linearized representation of the following system around the origin and check the stability of the linearised system about the origin. $\dot{x}_1 = x_2^2 + x_1 \cos x_2$ $\dot{x}_2 = x_2 + (x_1 + 1)x_1 + x_1 \sin x_2$	8

		Module 2	
13	a	Define a) Bendixson theorem b) Poincare - Bendixson theorem	6
	c	Check whether the following functions are locally Lipchitz. Give reasons for your claim. *(i) f(x,y) =2xy*$^{1/3}$ for (x,y) = [0,0] (ii) *f(t,x) =2tx*^{2} for (x,y) = [0,3]	8
14	a)	Obtain the Lipschitz constant for (i) $f(t,y) = -3y + 2$ (ii) $f(t,y) = 2ty$^2	7
	b	Check whether the system given below has a stable or unstable limit cycle. $((\dot{x}_1) = x_2 - x_1(x_1^2 + x_2^2 - 1))^{\cdot}$ $(\dot{x}_2) = -x_1 - x_2(x_1^2 + x_2^2 - 1)$	7
		Module 3	
15		Explain the concept of the domain of attraction using an example.	5
	c)	Use variable gradient method to find a suitable Lyapunov function for the system given below $(\dot{x}_1) = -2x_1$ $(\dot{x}_1) = -2x_2 + 2x_1 x_2^2$	9
16	a	Define stability in the sense of Lyapunov. What is the difference between asymptotic and exponential stability?	6
	b	State LaSalle's invariance principle. Show that the origin is locally asymptotically stable for the following system using LaSalle's principle. $(\dot{x}_1) = x_2$ $(x_2 = -3x_2)^{\cdot} - x_1^3$	8

		Module 4	
17	a)	What is KYP Lemma?	4
	b	State circle criterion. Determine a stability sector from the Nyquist plot of the system using circle criterion. $$G(s) = 4/((s-1)(s/3+1)(s/5+1))$$	10
18	a)	Using circle criterion, find a sector [a,b] for which the following system is absolutely stable. $$G(s) = 1/((s+1)(s+2)(s+3))$$	8
	b	Describe Popov stability criterion.	6
		Module 5	
19	a)	Define the following terms (i) Diffeomorphism (ii) Lie derivative	6
	b	Check whether the given system can be input-output linearized for output $y = x_1$ $$\dot{x}_1 = x_1$$ $$\dot{x}_2 = x_2 + u$$	8
20	a)	What is input-output linearization?	6
	b	With a suitable feedback control law, linearize the following system $$\dot{x}_1 = a \sin x_2$$ $$\dot{x}_2 = -x_1^2 + u$$	8

Syllabus

Module 1

Introduction and background (7 hours)

Non-linear system characteristics and mathematical modelling of a non-linear system, Classification of equilibrium points, Stability of a nonlinear system based on equilibrium points, Bifurcation (construction not included), Phase plane analysis of nonlinear systems.

Module 2

Nonlinear characteristics (8 hours)

Periodic solution of nonlinear systems and existence of limit cycle, Open sets, closed sets, connected sets, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria, Existence and uniqueness of solutions to nonlinear differential equations (Proofs not required), Lipschitz condition.

Module 3

Stability Analysis (7 hours)

Lyapunov stability theorems (Proofs not required)- local stability - local linearization and stability in the small- region of attraction, the direct method of Lyapunov, Construction of Lyapunov functions - Variable gradient and Krasovskii’s methods, La Salles's invariance principle.

Module 4

Analysis of feedback systems (8 hours)

Passivity and loop transformations, KYP Lemma (Proof not required), Absolute stability, Circle Criterion, Popov Criterion.

Module 5

Nonlinear control systems design (8 hours)

Feedback linearization, Input state linearization method, Input-output linearization method, Stabilization - regulation via integral control- gain scheduling.

Text Book:

1. Khalil H. K., “Nonlinear Systems”, 3/e, Pearson, 2002
2. Gibson J. E., “Nonlinear Automatic Control”, Mc Graw Hill, 1963
3. Slotine J. E. and Weiping Li, “Applied Nonlinear Control”, Prentice-Hall, 1991

References:

1. Alberto Isidori, "Nonlinear Control Systems: An Introduction", Springer-Verlag, 1985.
2. M. Vidyasagar, "Nonlinear Systems Analysis", Prentice-Hall, India, 1991.
3. Shankar Sastry, "Nonlinear System Analysis, Stability and Control", Springer, 1999.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction and background (7 hours)**	
1.1	Non-linear system characteristics and mathematical modelling of a non-linear system.	2
1.2	Classification of equilibrium points, Stability of a nonlinear system based on equilibrium points.	2
1.3	Bifurcation (construction not included), Phase plane analysis of nonlinear systems.	3
2	**Nonlinear characteristics (8 hours)**	
2.1	Periodic solution of nonlinear systems and existence of limit cycles	2
2.2	Open sets, closed sets, connected sets, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria	4
2.3	Existence and uniqueness of solutions to nonlinear differential equations (Proofs not required), Lipschitz condition.	2
3	**Stability Analysis (7 hours)**	
3.1	Lyapunov stability theorems (Proofs not required)- local stability - local linearization and stability in the small- region of attraction	2
3.2	The direct method of Lyapunov	2
3.3	Construction of Lyapunov functions, La Salles's invariance principle.	3
4	**Analysis of feedback systems (8 hours)**	

4.1	Passivity and loop transformations	2
4.2	KYP Lemma (Proof not required), Absolute stability	2
4.3	Circle Criterion	2
4.4	Popov Criterion	2
5	**Nonlinear control systems design (8 hours)**	
5.1	Feedback linearization	2
5.2	Input state linearization method	2
5.3	Input-output linearization method	2
5.4	Stabilization - regulation via integral control- gain scheduling	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET426	SPECIAL ELECTRIC MACHINES	PEC	2	1	0	3

Preamble: This course gives an overview of special electrical machines for control and industrial applications.

Prerequisite: EET202 DC Machines and Transformers

EET307 Synchronous and Induction Machines

Course Outcomes: After the completion of the course, the student will be able to:

CO 1	Analyse the performance of different types of permanent magnet motors.
CO 2	Analyse the performance of a stepper motor.
CO 3	Analyse the performance of different types of reluctance motors.
CO 4	Explain the construction and principle of operation of servo motors, single phase motors and linear motors.
CO 5	Analyse the performance of linear induction motors.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	-	-	-	2	-	-	-	-	-	2
CO 2	3	2	-	-	-	2	-	-	-	-	-	2
CO 3	3	2	-	-	-	2	-	-	-	-	-	2
CO 4	3	2	-	-	-	2	-	-	-	-	-	2
CO 5	3	2	-	-	-	2	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	15	15	30
Understand	25	25	50
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Part A: 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the principle of operation of any motor.[K1, PO1]
2. List the permanent magnets used in motors and explain their magnetization characteristics. [K1, PO1]
3. Problems based on emf and torque of PMBLDC motor and PMSM. [K2, PO2]

Course Outcome 2 (CO2):

1. Explain the working of any type of stepper motor with a neat diagram. [K1, PO1]
2. Explain the different configurations for switching the phases of a stepper motor. [K2, PO1]
3. Numerical problems from stepper motors. [K2, PO2]

Course Outcome 3(CO3):

1. Derive the torque equation of any motor. [K2, PO1]
2. Draw the phasor diagram of a synchronous reluctance motor. [K1, PO1]
3. Explain any two power converter circuits used for the control of SRM. [K1, PO1]

Course Outcome 4 (CO4):

1. Explain the constructional details of any servo motor. [K1, PO1]
2. Discuss the role of servo motors in automation systems. [K2, PO12]
5. Explain the constructional details and working principle of any motor. [K1, PO1]

Course Outcome 5 (CO5):

1. Explain the principle of operation of a LIM. [K1, PO1]
2. What are the different types of Linear motors?. [K1, PO1]
3. Derive the thrust equation of a LIM. [K2, PO1]

Model Question Paper

QP CODE: PAGES:

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER
B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: EET426
Course Name: SPECIAL ELECTRIC MACHINES

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)
Answer all Questions. Each question carries 3 Marks

1. Explain the constructional details of PMBLDC Motor.
2. Explain the sensor less control of PMSM.
3. Define the following terms as applied to stepper motors (i) Holding Torque (ii) Step accuracy (iii) Detent position.
4. What is meant by micro stepping in stepper motors? What are its advantages?
5. Draw the torque -slip characteristics of a Reluctance motor and explain its shape.
6. Explain the drawbacks of a Switched Reluctance motor.
7. What are the applications of servo motors?
8. Draw and explain the performance characteristics of an ac servo motor.
9. Explain the working principle of a hysteresis motor.
10. Derive the expression for linear force in LIM.

PART B (14 x5= 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Explain the principle of operation of the PMBLDC motor with a neat circuit diagram showing the complete drive circuit. (10 marks)
(b) Differentiate trapezoidal and sinusoidal back emf permanent magnet motors. (4 marks)
12. (a) Explain the demagnetisation characteristics and choice of permanent magnets in a Brushless DC motor. (10 marks)
(b) Explain the constructional details and working principle of the permanent magnet dc motor. (4 marks)

Module 2

13. (a) With neat sketches, explain the constructional details and working principle of the variable reluctance stepper motor. (10 marks)
    (b) List any four applications of stepper motors. (4 marks)

14. (a) A permanent magnet stepper motor is driven by a series of pulses of duration 20ms. It has 4 stator poles and 6 rotor poles. How long will it take for the motor to make a complete rotation? (4 marks)
    (b) Compare variable reluctance, permanent magnet and hybrid stepper motors. (6 marks)
    (c) Explain monofilar and bifilar windings. (4 marks)

Module 3

15. (a) With neat sketches explain the construction and operation of 8/6 SRM. (10 marks)
    (b) Draw and explain n+1 switches and diode configuration power converter for the SRM. (4 marks)
16. (a) Derive the torque equation of a synchronous reluctance motor. (8 marks)
    (b) Explain the basic principle of operation of a synchronous reluctance motor. (6 marks)

Module 4

17. (a) With the help of a schematic diagram, explain the working of the field controlled d.c servomotor. (8 marks)
    (b) Explain the working and applications of split field servomotors. (6 marks)
18. (a) Explain the constructional features and working principle of AC Servomotors. (10 marks)
    (b) Explain the characteristic difference between AC and DC servomotors. (4 marks)

Module 5

19. (a) Describe the properties of the materials used for the rotor construction of hysteresis motors. (5 marks)
    (b) Why is compensating winding used in AC series motors? Draw a series motor with different types of compensating windings. (5 marks)
    (c) What are the modifications to be made in the DC series motor to operate it in an AC supply? (4 marks)
20. (a) Develop the equivalent circuit of a LIM and describe the main factors affecting its performance. (10 marks)
    (b) Explain the transverse edge effect in LIM. (4 marks)

Syllabus

Module 1 (8 hours)

Permanent Magnet DC Motors – construction – principle of operation.
PM Brushless DC motor- Brushless DC motor-construction - permanent magnets – different types- demagnetization characteristics – arrangement of permanent magnets – magnetization of permanent magnets – axial and parallel magnetizations- principle of operation – Control of BLDC motor - applications.
Permanent Magnet Synchronous Motors-construction - principle of operation –Control of PMSM - Self control - Sensor less Control– applications - Comparison with BLDC motors.

Module 2 (7 hours)

Stepper motors - Basic principle - different types - variable reluctance, permanent magnet, hybrid type - principle of operation – comparison. Monofilar and bifilar windings - modes of excitation- static and dynamic characteristics- open loop and closed loop control of Stepper Motor-applications.

Module 3 (7 hours)

Synchronous Reluctance Motor - Construction, principle of operation- phasor diagram - torque equation - applications.
Switched reluctance motors - principle of operation - torque equation – characteristics - power converter circuits - control of SRM - rotor position sensors- torque pulsations – sources of noise- noise mitigation techniques - applications.

Module 4 (6 hours)

DC Servo motors – DC servo motors – construction– principle of operation - transfer function of field and armature controlled dc servo motors -permanent magnet armature controlled dc servo motor- series split field dc servo motor- applications.
AC Servo motors -Construction – principle of operation- performance characteristics - damped ac servo motors - Drag cup servo motors- applications.

Module 5 (8 hours)

Single Phase Special Electrical Machines- AC series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor- Construction - principle of operation - applications.

Linear Electric Machines: Linear motors – different types – linear reluctance motor- linear synchronous motors – construction – comparison.

Linear Induction Motor – Construction- Thrust Equation, Transverse edge and end effects- Equivalent Circuit, Thrust-Speed characteristics, Applications.

Text Book:

1. E. G. Janardhanan, '*Special Electrical Machines*' PHI Learning Private Limited.

References:

1. R. Krishnan, '*Permanent magnet synchronous and Brushless DC motor Drives*', CRC Press.
2. T. J. E. Miller, '*Brushless PM and Reluctance Motor Drives*', C. Larendon Press, Oxford.
3. Theodore Wildi, '*Electric Machines, Drives and Power Systems*', Prentice Hall India Ltd.
4. Veinott & Martin,' *Fractional & Sub-fractional hp Electric Motors*', McGraw Hill International Edn.
5. R. Krishnan, '*Switched Reluctance Motor Drives*', CRC Press.
6. K. Venkataratnam, '*Special Electrical Machines*', Universities Press.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Permanent Magnet DC Motors (8 hours)**	
1.1	Permanent Magnet DC Motors – construction – principle of operation.	1
1.2	Brushless DC motor-construction - permanent magnets – different types- demagnetization characteristics	1
1.3	Arrangement of permanent magnets – magnetization of permanent magnets – axial and parallel magnetizations- principle of operation	2
1.4	Control of BLDC motor- applications.	1
1.6	Permanent Magnet Synchronous Motors-construction- principle of operation	1
1.7	Control methods of PMSM-Self control- Sensorless Control -applications- Comparison with BLDC	2
2	**Stepper motors (7 hours)**	
2.1	Stepper motors – construction and principle of operation	1
2.2	different types - variable reluctance , permanent magnet, hybrid type - principle of operation – comparison	2
2.3	Windings - Monofilar and bifilar windings- modes of excitation- Full step on mode, two phase ON mode, Half step mode.	2
2.4	Static and dynamic characteristics	1
2.5	Open loop and closed loop control of Stepper Motor-applications.	1
3	**Reluctance motors (7 Hours)**	
3.1	Synchronous Reluctance Motor - Construction, principle of operation	1
3.2	Phasor diagram - torque equation- torque-slip characteristics- applications	2
3.3	Switched reluctance motors - principle of operation - torque equation- characteristics - power converter circuits .	2
3.4	Control of SRM - rotor position sensors-	1
3.5	Torque pulsations – sources of noise- mitigation techniques -	1

	applications.	
4	**Servo motors (6 Hours)**	
4.1	DC servo motors – construction– principle of operation - transfer function of field and armature controlled DC servomotors	2
4.2	Permanent magnet armature controlled - series split field DC servo motor- applications	2
4.3	**AC Servomotors -**Construction – principle of operation- performance characteristics	1
4.4	Damped AC servo motors - Drag cup servo motors- applications.	1
5	**Single Phase Special Electrical Machines- (8 Hours)**	
5.1	AC series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor- Construction -principle of operation - applications.	3
5.2	**Linear Electric Machines:** Linear motors – different types	1
5.3	Linear reluctance motor , linear synchronous motors – construction – comparison.	1
5.4	Linear Induction Motor – Construction- Thrust Equation, Transverse edge and end effects	2
5.5	Equivalent Circuit, Thrust-Speed characteristics, Applications.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET436	POWER QUALITY	PEC	2	1	0	3

Preamble: The objective of this course is to introduce the fundamental concepts of power quality. This course covers different power quality issues and its mitigation methods.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the sources and effects of power quality problems.
CO 2	Apply Fourier concepts for harmonic analysis.
CO 3	Explain the important aspects of power quality monitoring.
CO 4	Examine power quality mitigation techniques.
CO 5	Discuss power quality issues in grid connected renewable energy systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	2	-	1	-	-	-	2
CO 2	3	3	-	-	-	-	-	-	-	-	-	2
CO 3	3	3	-	-	3	-	-	-	-	-	-	2
CO 4	3	3	2	-	-	-	-	1	-	-	-	2
CO 5	3	2	-	-	-	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	40
Understand	20	20	40
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is meant by Power Quality? (K2, PO1, PO2, PO8)
2. Explain the sources and effects of different power quality problems. (K1, PO1, PO2, PO6, PO12)
3. Discuss the different types of power quality disturbances. (K1, PO1, PO2, PO12)

Course Outcome 2 (CO2)

1. Discuss the important sources of harmonics in the power network. (K1, PO1,PO2, PO12)
2. What are the effects of harmonics in the power system and other networks? (K2, PO1, PO2, PO12)
3. Conduct harmonic analysis using suitable methods. (K3, PO1, PO2)

Course Outcome 3(CO3):

1. Explain the important indices used to quantify harmonics in a power network? (K2, PO1, PO2)
2. Describe the key aspects of different power quality standards. (K2, PO1, PO2, PO12)
3. Discuss the objectives, features and measurement issues of different monitoring instruments. (K2, PO1, PO2, PO5, PO12)

Course Outcome 4 (CO4):

1. Design passive filters for mitigating harmonic distortion. (K3, PO1, PO2, PO3, PO8, PO12)

2. Discuss the important active filters used for harmonic suppression and sag/swell correction. (K2, PO1, PO2, PO12)
3. Explain the operation of a single phase active power factor converter. (K2, PO1, PO2)

Course Outcome 5 (CO5):

1. Discuss the configuration and working of shunt and series-shunt power quality conditioners. (K2, PO1, PO2)
2. Identify the important power quality issues associated with grid connected renewable energy systems. (K2, PO1, PO2, PO12)
3. Explain the operating conflicts in connection with grid connected renewable energy system. (K2, PO1, PO2, PO12)
4. Discuss the problems and its solutions associated with wiring and grounding. (K2, PO1, PO2, PO12)

Model Question Paper

QP CODE:

PAGES:2

Reg.No:_______________
Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH& YEAR
Course Code: EET436
Course Name: POWER QUALITY

Max. Marks: 100 **Duration: 3 Hrs**

PART A

Answer all questions. Each Question Carries 3 marks

1. 'Power Quality is voltage quality'. Comment.
2. Differentiate between impulsive and oscillatory transients.
3. What do you mean by triplen harmonics and what are its effects in the power system?
4. Explain the generation of harmonics in the presence of non-linear loads.
5. Write short note on IEEE 519 standard.
6. Discuss the objectives of power quality monitoring.
7. List the merits and demerits of passive filters to reduce harmonic distortion.
8. Define Telephone Interference Factor.
9. What is meant by islanding? List the problems caused by it.
10. Describe the term Ground Loops. List solutions for mitigating this problem.

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11. a) Explain the sources of voltage sag in a power network. (6)

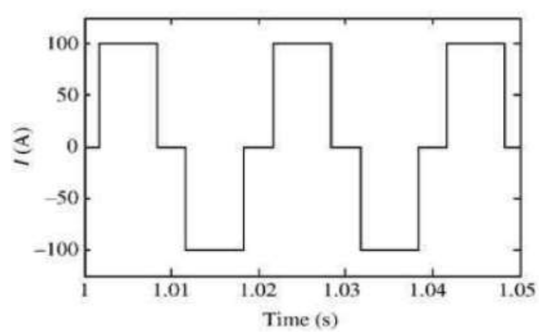
b) Discuss any four effects of power quality problems. (8)

12. What is meant by waveform distortions? Using neat diagrams, explain the five primary types of waveform distortion. (14)

Module 2

13. Explain the effects of power system harmonics on different components of power systems. (14)

14. For a quasi-square wave of (120° pulse width) of current with an amplitude I of 100A (shown in Fig), calculate (a) crest factor (CF), (b) distortion factor (DF), and (c) total harmonic distortion. (14)



Module 3

15. a) Define total harmonic distortion, distortion factor, total demand distortion and telephone influence factor. (8)

b) Derive the relationship between total power factor, distortion factor and displacement factor. (6)

16. a) How is RMS value computed by a power quality monitoring instrument? (7)

b) Describe the functionalities offered by a power quality analyzer. (7)

Module 4

17. a) Explain the working principle of DVR for sag and swell correction. (6)

b) A single-phase fully controlled bridge converter is fed from a supply of 230V at 50 Hz at a thyristor firing angle of 60°. Consider continuous load current of 200 A. Design a shunt passive filter with third, fifth, seventh and a ninth passive tuned filters. (8)

18. Draw the configuration of a unified power quality conditioner and show that it offers a single solution for mitigating multiple power quality problems. (14)

Module 5

19. Explain the operation of a PWM power factor correction circuit. Using a block diagram, explain the control logic of the same. (14)

20. Discuss the important solutions to wiring and grounding problems. (14)

Syllabus

Module 1 **(6 hours)**

Power quality phenomenon - Sources and effects of power quality problems, Need for concern of Power quality, types of power quality disturbances –Transients – classification and origin, Short duration voltage variation – interruption, sag, swell, Long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker

Module 2 **(8 hours)**

Harmonics - mechanism of harmonic generation, Triplen harmonics, Harmonic sources – switching devices, arcing devices and saturable devices, Effects of harmonics on power system equipment and loads – transformers, capacitor banks, motors and telecommunication systems, Effect of triplen harmonics on neutral current, line and phase voltages.

Harmonic analysis using Fourier series and Fourier transforms – simple numerical problems

Module 3 **(6 hours)**

Harmonic indices (CF, DF, THD, TDD, TIF, DIN, C – message weights), Displacement and total power factor

Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000

Power quality Monitoring: Objectives and measurement issues, different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters

Module 4 **(6 hours)**

Mitigation of Power quality problems - Harmonic elimination - Design simple problems and analysis of passive filters to reduce harmonic distortion – demerits of passive filters – description of active filters - shunt, series, hybrid filters, sag and swell correction using DVR

Power quality conditioners - DSTATCOM and UPQC - Configuration and working

Module 5 **(6 hours)**

Power factor correction – Single phase active power factor converter – circuit schematic and control block diagram

Power Quality issues of Grid connected Renewable Energy Systems – operating conflicts

Grounding and wiring– reasons for grounding – wiring and grounding problems - solutions to these problems

Note: It is encouraged to conduct assignments involving case studies to get hands-on experience of use of power quality instruments for power quality monitoring.

Text/Reference Books

1.R. C. Dugan, M. F. Me Granaghen, H. W. Beaty, *'Electrical Power System Quality',* McGraw-Hill, 2012
2. Angelo Baggini (Ed.) *Handbook of Power Quality,* Wiley, 2008
3. C. Sankaran, *'Power Quality',* CRC Press, 2002
4. G. T. Heydt, *'Power Quality',* Stars in circle publication, Indiana, 1991
5. Jose Arillaga, Neville R. Watson, *'Power System Harmonics',* Wiley, 1997
6. Math H. Bollen, 'Understanding Power Quality Problems' Wiley-IEEE Press, 1999
7. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, "Power Quality problems and mitigation techniques", John Wiley and Sons Ltd, 2015.
8. Surajit Chattopadhyay, 'Electric power quality' – Springer, 2011

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (32 Hours)
1	**Power quality phenomenon**	**6**
1.1	Sources and effects of power quality problems	1
1.2	Need for concern of Power quality	1
1.3	Types of power quality disturbances – Transients – classification and origin	1
1.4	Short duration voltage variation – interruption, sag, swell	1
1.5	Long duration voltage variation, voltage unbalance	1
1.6	Waveform distortion - notching, harmonics and voltage flicker	1
2	**Harmonics**	**8**
2.1	Mechanism of harmonic generation	1
2.2	Harmonic sources – switching devices, arcing devices and saturable devices	1
2.3	Effects of harmonics on power system equipment and loads –	2

	transformers, capacitor banks, motors and telecommunication systems	
2.4	Effect of triplen harmonics on neutral current, line and phase voltages.	1
2.5	Harmonic analysis using Fourier series and Fourier transforms simple numerical problems	3
3	**Harmonic indices, PQ standard and monitoring**	**6**
3.1	Harmonic indices - CF, DF, THD, TDD, TIF	1
3.2	Harmonic indices - DIN, C – message weights, Displacement and total power factor	1
3.3	Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000	2
3.4	Power quality Monitoring: Objectives and measurement issues	1
3.5	Different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters	1
4	**Mitigation of Power quality problems and Power factor correction**	**6**
4.1	Harmonic elimination – Design of passive filters simple problems	1
4.2	Analysis of passive filters	1
4.3	Demerits of passive filters –description of active filters - shunt, series, hybrid filters	1
4.4	Sag and swell correction using DVR	1
4.5	DSTATCOM and UPQC - Configuration and working	2
5	**Power quality conditioners, PQ in Grid connected RE systems, Grounding & Wiring**	**6**
5.1	Power factor correction – Single phase active power factor converter – circuit schematic and control block diagram	1
5.2	Power Quality issues of Grid connected Renewable Energy Systems	1
5.3	Operating conflicts	1
5.4	Grounding and wiring– reasons for grounding	1
5.5	Wiring and grounding problems - solutions to these problems	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET446	COMPUTER NETWORKS	PEC	2	1	0	3

Preamble: Nil

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO#	CO
1	Explain the computer networks, layered architecture, protocols and physical media used for setting up a network.
2	Identify the role of Data link layer, role of the MAC sub layer and networking devices in Ethernets and wireless LANs
3	Explain routing algorithms and congestion control algorithms and ways to achieve good quality of service.
4	Illustrate the IP address classes, ICMP protocols and other external routing protocols.
5	Explain the services provided by the transport layer and application layer.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	2	1										
CO3	2	1										
CO4	2											
CO5	2											

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	15	15	30
Understand	25	25	50
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test : 25 marks

Continuous Assessment Assignment : 15 marks

End Semester Examination Pattern:

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course outcome 1 (CO1) :

1. Compare the OSI and TCP/IP reference model (K2, PO1).
2. Distinguish between Connection oriented and connectionless service (K3, PO1).
3. Explain various performance indicators of computer networks. (K2,PO1)

Course outcome 2 (CO2) :

1. Explain the role of the Data link layer in computer networks. (K2, PO1)
2. Discuss the sliding window protocol for error detection and correction (K2, PO1, PO2).
3. Explain the use of Switches, Routers and Gateways (K2,PO1).

Course outcome 3 (CO3) :

1. What is flooding? (K1, PO1)
2. Explain various routing algorithms (Any one algorithm may be asked) (K2, PO1,PO2)
3. Discuss how congestion control is done in computer networks. (K2, PO1, PO2)
4. What is meant by Quality of service? How can it be improved? (K1, PO1)
5. Compare the performance of various routing algorithms (K3,PO1).

Course outcome 4 (CO4) :

1. Describe the format of IPv4/IPv6 datagram with the help of a diagram, highlighting the significance of each field. (any one may be asked only). (K2, PO1)
2. Explain Subnetting with an example. (K2, PO1)
3. What is the advantage of using DHCP? (K1, PO1)
4. Explain Open Shortest Path First (OSPF) Protocol and Border Gateway Protocol (BGP). (Any one may be asked as a part question) (K2,PO1)

Course outcome 5 (CO5) :

1. Explain the UDP/TCP protocol. (K2,PO1)
2. What is RPC? (K1,PO1)
3. What is the use of DNS? (K1,PO1)
4. Explain how message transfer is done using SMTP. (K2,PO1)
5. Discuss the security issues of FTP. How can it be improved? (K2,PO1)

Model Question Paper

QP CODE: **PAGES: ___**

Reg No:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET446

Course Name : Computer Networks

Max Marks: 100 **Duration: 3 Hours**

PART-A

(Answer All Questions. Each question carries 3 marks)

1.	What is a VPN ?	**(10x3= 30 Marks)**
2.	Discuss why fiber optic is preferred over copper wires, when you want to get higher bandwidth in the range of 100Mbps or higher.	
3.	What is the need for framing?	
4.	What is piggybacking ?	
5.	Compare adaptive routing algorithms with the non-adaptive type.	
6.	What is jitter and discuss how it can affect various data transfer applications.	
7.	What is the urgent need for migrating to IPv6 from IPv4?	
8.	Discuss ARP.	
9.	What is the use of DNS?	
10.	What is FTP and discuss its security concerns.	

PART-B

(Answer any one Questions. Each question carries 14 marks)

11.		"Most networks are organized as a stack of layers or levels, each one built upon the one below it". Comment on why a layered approach is adopted with reference to the OSI and TCP/IP reference models.	14
	OR		

12.	a	Distinguish between Connection-Oriented and Connectionless Service	7
	b	Explain the terms Bandwidth, Throughput, Latency, Bandwidth–Delay product.	7
13.		Suppose your organization is spread over 5 buildings in a 100 acre campus, and you are asked to set up an intranet with net connectivity. Discuss how you will set up the network highlighting the use of suitable physical media and various networking devices. A rough architecture diagram is expected.	14
		OR	
14.		Explain CSMA/CD with reference to classic Ethernet LAN,	14
15.		Explain Link state routing.	14
		OR	
16.		Discuss the various means by which congestion control can be achieved.	14
17.		Describe the format of IPv4 datagram with the help of a diagram, highlighting the significance of each field.	14
		OR	
18.		Define Subnetting. What are the advantages of Subnetting? Explain with an example	14
19.		Compare TCP with UDP.	14
		OR	
20.		Explain how message transfer is done using SMTP.	14

Syllabus

Module - 1 (Introduction and Physical Layer)

Introduction – Uses of computer networks, Network hardware, Network software - Protocol hierarchies – Design issues for the layers – Connection oriented versus connectionless service. Reference models – The OSI reference model, The TCP/IP reference model, Comparison of OSI and TCP/IP reference models.

Physical Layer –Transmission media overview – Twisted pair and fiber optics. Performance indicators – Bandwidth, Throughput, Latency, Bandwidth–Delay product.

Module - 2 (Data Link Layer)

Data link layer - Data link layer design issues, Error detection and correction, Sliding window protocols.

Medium Access Control (MAC) sublayer, Channel allocation problem, Multiple access protocols – CSMA, Collision free protocols.

Ethernet – Switched Ethernet, fast Ethernet and gigabit Ethernet.

Wireless LANs - 802.11 – Architecture and protocol stack, Use of Bridges, Repeaters, Hubs, Switches, Routers and Gateways.

Module - 3 (Network Layer)

Network layer design issues. Routing algorithms - The Optimality Principle, Shortest path routing, Flooding, Distance Vector Routing, Link State Routing, Routing for mobile hosts.

Congestion control algorithms – Approaches to congestion control (Details not required).

Quality of Service (QoS) - Requirements, Techniques for achieving good QoS – Traffic shaping, Packet scheduling.

Module - 4 (Network Layer in the Internet)

IPv4 protocol, IP addresses, IPv6, Internet Control Protocols - Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP). Open Shortest Path First (OSPF) Protocol, Border Gateway Protocol (BGP), Internet multicasting.

Module – 5 (Transport Layer and Application Layer)

Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP) – Introduction, Remote procedure call.

Transmission Control Protocol (TCP) – Introduction, TCP service model, TCP protocol, TCP segment header**,** Connection establishment & release.

Application Layer –Domain Name System (DNS) – overview of DNS name space and Name servers, Electronic mail – Architecture and services- SMTP – IMAP - POP3, World Wide Web (WWW) - Architectural overview, HTTP, File Transfer Protocol (FTP).

Text Book

1. Andrew S. Tanenbaum, Computer Networks, 5/e, Pearson Education India.
2. Behrouz A Forouzan, Data Communication and Networking, 5/e, McGraw Hill Education

Reference Books

1. Larry L Peterson and Bruce S Dave, Computer Networks – A Systems Approach, 5/e, Morgan Kaufmann.
2. Fred Halsall, Computer Networking and the Internet, 5/e.
3. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6/e.
4. Keshav, An Engineering Approach to Computer Networks, Addison Wesley, 1998.
5. W. Richard Stevens. TCP/IP Illustrated Volume 1, Addison-Wesley, 2005.
6. William Stallings, Computer Networking with Internet Protocols, Prentice-Hall, 2004.

Course Contents and Lecture Schedule

No	Contents	No of Lecture Hrs
Module – 1 (Introduction and Physical Layer) (7 hrs)		
1.1	Introduction – Uses of computer networks	1
1.2	Uses of computer networks, Network hardware	1
1.3	Network software - Protocol hierarchies – Design issues for the layers – Connection oriented versus connectionless service.	1
1.4	Reference models – The OSI reference model, The TCP/IP reference model	1
1.5	Reference models, Comparison of OSI and TCP/IP reference models.	1
1.6	Physical Layer – Transmission media overview – Twisted pair and fiber optics.	1
1.7	Performance indicators – Bandwidth, Throughput, Latency, Bandwidth–Delay product.	1
Module 2 – (Data Link Layer) (8 hrs)		
2.1	Data link layer - Data link layer design issues	1
2.2	Error detection and correction	1
2.3	Sliding window protocols.	1
2.4	Sliding window protocols, Medium Access Control (MAC) sublayer.	1
2.5	Channel allocation problem, Multiple access protocols – CSMA	1
2.6	Collision free protocols.	1
2.7	Ethernet – Switched Ethernet, fast Ethernet and gigabit Ethernet. Wireless LANs - 802.11 – Architecture and protocol stack	1

2.8	Use of Bridges, Repeaters, Hubs, Switches, Routers and Gateways.	1
Module 3 - (Network Layer) (6 hrs)		
3.1	Network layer design issues.	1
3.2	Routing algorithms, The Optimality Principle, Shortest path routing, Flooding.	1
3.3	Distance Vector Routing.	1
3.4	Link State Routing.	1
3.5	Routing for mobile hosts, Congestion control algorithms – Approaches to congestion control (Details not required).	1
3.6	Quality of Service (QoS) - Requirements, Techniques for achieving good QoS – Traffic shaping, Packet scheduling.	1
Module 4 – (Network Layer in the Internet) (7 hrs)		
4.1	Internet Protocol (IP) - IPv4 protocol	1
4.2	IP addresses.	1
4.3	IP addresses – part 2	1
4.4	IPv6	1
4.5	Internet Control Protocols - Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP).	1
4.6	Open Shortest Path First (OSPF) Protocol.	1
4.7	Border Gateway Protocol (BGP), Internet multicasting.	1
Module 5 - (Transport Layer and Application Layer) (7 hrs)		
5.1	Transport service – Services provided to the upper layers Transport service primitives.	1
5.2	User Datagram Protocol (UDP) – Introduction, Remote procedure call.	1
5.3	Transmission Control Protocol (TCP) – Introduction, TCP	1

	service model, TCP protocol	
5.4	TCP segment header, Connection establishment & release.	1
5.5	Application Layer –Domain Name System (DNS) – overview of DNS name space and Name servers	1
5.6	Electronic mail – Architecture and services- SMTP – IMAP - POP3	1
5.7	World Wide Web (WWW) - Architectural overview, HTTP, File Transfer Protocol (FTP).	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET456	DESIGN OF POWER ELECTRONIC SYSTEMS	PEC	3	0	0	3

Preamble : To impart knowledge about the design and protection of power electronic systems.

Prerequisite : EET306 Power Electronics

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Design gate drive circuits for various power semiconductor switches.
CO 2	Design protection circuits for various semiconductor devices.
CO 3	Select appropriate passive components for power electronic circuits.
CO 4	Design the magnetic components for power electronic circuits.
CO 5	Design signal conditioning circuits and passive filters for converters.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	3	2	-	-	-	-	-	-	-	2
CO 2	3	2	3	2	-	-	-	-	-	-	-	2
CO 3	3	3	-	-	-	-	-	-	-	-	-	2
CO 4	3	3	3	2	-	-	-	-	-	-	-	2
CO 5	3	2	3	2	-	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	20	20	50
Analyse (K4)	10	10	10
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Design a gate/base drive using totem pole arrangement (K1, K3, PO1, PO2, PO4)
2. Design a gate drive using a non-isolated circuit (K1, K3, PO1, PO2, PO4)
3. Design high side and low side switch drives using isolated gate drivers (K1, K3, PO1, PO2, PO4)
4. Explain the boot-strap technique for gate drives using gate drive IC IR 2110 (K1, K2, PO1)

Course Outcome 2 (CO2):

1. Design a turn-off and turn-on snubber circuit for SCR (K1,K3,PO1, PO2, PO4)
2. Design a Snubber circuit for a buck converter (K1, K3, PO1, PO2, PO4)
3. Describe the thermal protection, short-circuit and over-current protection in IGBTs (K1,K2, PO1)
4. Explain the steps for the design of heat sinks (K1,K2, PO1)

Course Outcome 3 (CO3):

1. Explain the different types of inductor and transformer assembly (K1, PO1)
2. Explain the types of capacitors used in power electronic circuits and their selection (K1,K2, PO1)
3. Explain the effect of equivalent series resistance and equivalent series Inductance of capacitors in converter operation (K4, PO1)
4. Explain the filter design for single phase and three phase inverters (K3, PO1, PO2)
5. Describe the various types of power resistors used in power electronic circuits (K1, PO1)

Course Outcome 4 (CO4):

1. Describe the selection of amorphous, ferrite and iron cores used in power electronic circuits(K1,K2)
2. Explain the Inductor design in power electronics circuits (K3)
3. Explain the transformer design in power electronics circuits (K3)
4. Explain the wire selection and skin effect in power electronics circuits (K1,K2)

Course Outcome 5 (CO5):

1. Explain the design of current transformers, resistive shunts, hall-effect based voltage and current sensors for power electronics circuits (K2, K3, PO1)
2. Design input and output filters for single phase and three phase inverters (K3, PO1, PO2, PO4)

3. Explain the corner frequency selection and harmonic filtering performance in inverter circuits (K2,K4, PO1)
4. Explain the various components in an Intelligent Power Module (K1,K2, PO1)

Model Question Paper

QP CODE:

PAGES:2

Reg.No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET456

Course Name: DESIGN OF POWER ELECTRONIC SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. A MOSFET has an input capacitance Ciss = 800 pF. A gate resistance of 250 Ω is used along with a gate drive voltage peak of 12 V. If the threshold gate voltage is Vgs(th) = 4 V, how long will it take this gate signal to turn on the MOSFET?
2. Design a gate drive using non-isolated and isolated circuits.
3. Design a turn-off and turn-on snubber circuit for SCR.
4. Design a Snubber circuit for a buck converter.
5. Explain the different types of inductor and transformer assembly.
6. Explain the types of capacitors used in power electronic circuits and their selection.
7. Describe the selection of amorphous, ferrite and iron cores used in power electronic circuits.
8. Explain the Inductor design in power electronics circuits.
9. Design current transformers, resistive shunts, hall-effect based voltage and current sensors for power electronics applications.
10. Design input and output filters for single phase and three phase inverters.

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) Design high side switch drive using isolated gate drivers. **(6)**

b) Design low side switch drive using isolated gate drivers. **(8)**

12. a) Explain the boot-strap technique for gate drive design using gate drive IC IR 2110 **(8)**

b) Design a gate drive circuit for IGBT **(6)**

Module 2

13. a) Describe the thermal protection in IGBTs. **(10)**
b) Explain the steps for the design of heat sinks. **(4)**

14. a) Describe the short-circuit protection in IGBTs **(7)**
b) Describe the over-current protection in IGBTs **(7)**

Module 3

15. a) Two capacitor values are made by a manufacturer. The two have similar size, and each has an ESL of 20 nH, and tan δ=0.2. One is 1000 μF and the other is 100 μF. Evaluate their ESRs and resonant frequencies. If 10 numbers of 100 μF capacitors are paralleled to make 1000 μF, evaluate the ESR, ESL and the resonant frequency of the paralleled combination. Which (a single 1000 μF or a parallel combination of 10 numbers of 100 μF), is better in terms of operating frequency? (**10)**
b) Explain the filter design for single phase and three phase inverters
(4)

16. a) Describe the various types of power resistors used in power electronic circuits. **(6)**

b) Explain the effect of equivalent series resistance of capacitor **(8)**

Module 4

17. a) Design high frequency transformer in power electronics circuits. **(8)**

b) Explain the wire selection in power electronics circuits. **(6)**

18. a) A 2 mH inductor design for dc applications is as follows, for a maximum current of 0.5A: Core: 26x19; Aw = 40mm2, AC = 90mm2; N=37; aw = 0.29mm2 (23 SWG). For the above core and windings and N, evaluate the peak flux density, peak current density, window space factor (kw), and the inductance value, for air gap values of 0.08mm and 1mm. **(10)**

b) Explain the thermal considerations in power electronic circuits **(4)**

Module 5

19. a) Explain the corner frequency selection in inverter circuits **(8)**
b) Explain the various components in an Intelligent Power Module **(6)**

20. a) Explain the harmonic filtering performance in inverter circuits **(8)**
b) Explain the methods for reducing stray inductance in power electronic circuits **(6)**

Syllabus

Module 1 (8 hrs)

Gate and base drive design: Gate drive requirements and gate/base drive design for SCRs, BJTs, MOSFETs, IGBTs-Gate drive design using discrete components - open collector, totem pole, non-isolated and isolated- optocoupler, pulse transformer based, use of ICs such as DS0026, TLP250- High side and low side switch driving using isolated gate drivers. Boot-strap technique for gate drives using gate drive IC IR 2110.

Major references: Ref.1, Ref.2, Ref.3

Module 2 (7 hrs)

Design of protection elements: Snubber circuits: Function and types of Snubber circuits, design of turn -off and turn-on snubber. Snubber design for step-down converter. Short-circuit and over-current protection in IGBTs, desaturation protection. Thermal protection, cooling, design and selection of heat sinks (natural cooling only).

Major references: Ref.1, Ref.2,

Module 3 (7 hrs)

Passive elements in Power electronics: Inductors: types of inductors and transformer assembly-. Capacitors: types of capacitors used in power electronic circuits, selection of capacitors, dc link capacitors in inverters, filter capacitors in dc-dc and inverter circuits, equivalent series resistance and equivalent series Inductance of capacitors and their effects in converter operation. Design of filters - input and output filters - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance – design constraints. Resistors: power resistors, use in snubbers. Resistors for special purpose: high voltage resistors and current shunts.

Major references: Ref.1, Ref.4,

Module 4 (7 hrs)

Magnetics design: Magnetic materials and cores: amorphous, ferrite and iron cores-Inductor and transformer design based on area-product approach. Magnetic characteristics and selection based on loss performance and size, eddy current and hysteresis loss. Thermal considerations, leakage inductance, comparison of sizes of transformer and inductor, wire selection and skin effect.

Major References: Ref.1,2,3,5,6

Module 5 (7 hrs)

Measurements and signal conditioning: Design of current transformers for power electronic applications, resistive shunts, hall-effect based voltage and current sensors, typical design based on hall-effect sensors, signal conditioning circuits- level shifters, anti-aliasing filters. Minimizing stray inductance in drive circuit, shielding and portioning of drive circuit, reduction of stray inductance in bus bar.Introduction to Intelligent Power Module.

Major References: Ref.6

Assignments/ course projects may be given based on the topic: Demonstrative design of a converter such as Buck converter/ Flyback converter.

Text/Reference Books:

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India, 2002.
2. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
3. V. Ramanarayanan, Course material on 'Switched mode power conversion' 2007.
4. Daniel W. Hart, Power Electronics, Tata McGraw-Hill Education, 2011.
5. Erickson, Robert W., and Maksimovic, Dragan, Fundamentals of Power Electronics, 1997.
6. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
7. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw-Hill College; International edition,1995.
8. Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.
9. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education, 2014.
10. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 1990.

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Design of gate and base drive circuits (8 hours)**	
1.1	Gate drive requirements and gate drive design for SCRs, BJTs, MOSFETs, IGBTs.	3
1.2	Gate drive design using discrete components	3
1.3	High side and low side switch driving using isolated gate drivers	1
1.4	Boot-strap technique for gate drives using gate drive IC IR 2110	1
2	**Design of protection elements (7 hours)**	
2.1	Snubber circuits: Function and types of Snubber circuits, design of turn off and turn-on snubber.	2
2.2	Snubber design for step-down converter.	2
2.3	Short-circuit and over-current protection in IGBTs, desaturation	1

	protection.	
2.4	Thermal protection, cooling, design and selection of heat sink (natural cooling only).	2
3	**Passive elements in Power electronics (7 Hours)**	
3.1	Inductors: types of inductors and transformer assembly	1
3.2	Capacitors: types of capacitors used in power electronic circuits, selection of capacitors	1
3.3	DC link capacitors in inverters, filter capacitors in dc-dc and inverter circuits, equivalent series resistance and equivalent series Inductance of capacitors and their effects in converter operation.	2
3.4	Design of filters: input and output filters - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance – design constraints.	2
3.5	Resistors: power resistors, their use in snubbers. Resistors for special purpose: high voltage resistors and current shunts.	1
4	**Magnetics design (7 Hours)**	
4.1	Magnetic materials and cores: amorphous, ferrite and iron cores	1
4.2	Inductor and transformer design based on area-product approach	3
4.3	Magnetic characteristics and selection based on loss performance and size, eddy current and hysteresis loss	1
4.4	Thermal considerations, leakage inductance, comparison of sizes of transformer and inductor, wire selection and skin effect	2
5	**Measurements and signal conditioning (7 Hours)**	
5.1	Design of current transformers for power electronic applications, resistive shunts	2
5.2	Hall-effect based voltage and current sensors, typical design based on hall-effect sensors	1
5.3	Signal conditioning circuits- level shifters, anti-aliasing filters	2
5.4	Minimizing stray inductance in drive circuit, shielding and portioning of drive circuit, reduction of stray inductance in bus bar	1
5.5	Introduction to Intelligent Power Module	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET466	HVDC AND FACTS	PEC	2	1	0	3

Preamble: This course introduces HVDC concepts and analysis of HVDC systems. It also provides a detailed study of FACTS devices.

Prerequisite : Nil

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Analyse current source and voltage source converters for HVDC systems
CO 2	Describe the control schemes for HVDC systems
CO 3	Explain the need for FACTS devices
CO 4	Classify reactive power compensators in power system
CO 5	Interpret series and shunt connected FACTS devices for power system applications
CO 6	Explain the dynamic interconnection mechanisms of FACTS devices

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3			2							
CO 2	3	3			2							
CO 3	3	3			2							
CO 4	3	3			2							
CO 5	3	3			2							
CO 6	3	3			2							

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	20	20	40
Understand (K2)	20	20	40
Apply (K3)	10	10	20
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the advantages of HVDC over HVAC (K2, PO1)
2. Explain various types of HVDC system (K2, PO1)
3. Explain various converters in HVDC system(K2, PO2)

Course Outcome 2 (CO2):

1. Discuss the control basics of two terminal link (K2, PO1)
2. Explain static V_d-I_d characteristics of a HVDC system (K2, PO1)
3. Derive equivalent circuit of a two terminal HVDC link (K3, PO2)

Course Outcome 3 (CO3):

1. What is meant by voltage regulation? (K1,PO1, PO2)
2. With neat diagrams explain the effect of phase angle compensation (K2,PO1,PO2)

Course Outcome 4 (CO4):

1. Explain the principle of TSC. Also explain the effect of initial charge of the capacitor in TSC. (K2, PO1, PO2)
2. Explain the principle and operation of STATCOM(K2, PO1, PO2)

Course Outcome 5 (CO5):

1. Explain with a neat circuit and necessary waveforms, the operation of IPFC. (K2, PO1,PO2)
2. Explain the applications UPFC (K2, PO1)

Model Question Paper

QP CODE:

PAGES: 2

Reg. .No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET466

Course Name: HVDC AND FACTS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain the advantages of HVDC transmission system over HVAC.
2. What will be the effect on the Short Circuit MVA of a bus if an additional HVDC line is connected to that bus?
3. Enumerate the functions of HVDC control.
4. Discuss any one method for extinction angle control in HVDC.
5. Why are FACTS controllers needed in AC power transmission systems?
6. Explain the effect of series compensation
7. Explain TSR controller with necessary waveforms
8. Explain with neat circuit and necessary waveforms, the operation of TSSC
9. Give the comparisons between UPFC and IPFC
10. Explain the working principle of Thyristor Controlled phase angle Regulator

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) Derive average output voltage of a 6 pulse converter with overlap **(10)**
    b) Compare CSC and VSC. **(4)**

12. a) Explain VSC with AC voltage control with the help of schematic. **(10)**
    b) Discuss the effect of delay angle in the reactive power requirement, in a HVDC system. **(4)**

Module 2

13 a) Derive equivalent circuit of a two terminal HVDC link **(10)**

b) Explain the hierarchy of controls in HVDC system. **(4)**

14 a) Explain static V_d-I_d characteristics of a HVDC system. **(10)**

b) Draw the schematic of current control at the rectifier end. **(4)**

Module 3

15 a) Explain the effect of shunt compensation with neat diagrams **(8)**

b) Give the comparisons between series and shunt compensators **(6)**

16 a) What is meant by power quality and voltage regulation?
Explain its significance in power systems **(10)**

b) List out different types of FACTS controllers. **(4)**

Module 4

17. Explain TCR controller. What are the different methods to eliminate harmonics? **(14)**

18. (a)Explain the principle and operation of SSSC compensation **(4)**

(b)Explain with diagrams, the different modes of TCSC controller **(10)**

Module 5

19.a) With neat diagram, explain the modes of operation of UPFC **(8)**

b)Explain with neat circuit, the operation of IPFC **(6)**

20.a) Explain the working principle of Thyristor Controlled Voltage e Regulator **(4)**

b) Explain the independent reactive power flow control (P&Q) characteristic of UPFC **(10)**

Syllabus

Module 1

Introduction to HVDC System

Comparison of AC and DC Transmission - Types of HVDC system - Current Source Converters - Analysis without and with overlap period. Voltage Source Converters (VSC) - VSC with AC current control and VSC with AC voltage control

Module 2

HVDC Controls - Functions of HVDC Controls - Equivalent circuit for a two terminal DC Link - Control Basics for a two terminal DC Link - Current Margin Control Method - Current Control at the Rectifier - Inverter Extinction Angle Control - Hierarchy of Controls

Module 3

Introduction to FACTS

Power flow in Power Systems – Voltage regulation and reactive power flow control in Power Systems - Power flow control -Constraints of maximum transmission line loading - Needs and emergence of FACTS - Types of FACTS controllers-Advantages and disadvantages

Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control.

Module 4

Shunt and Series Facts Devices

Static shunt Compensator - Objectives of shunt compensations - Variable impedance type VAR Generators -TCR, TSR, TSC, FC-TCR (Principle of operation and schematic) and -STATCOM (Principle of operation and schematic).

Static Series compensator - Objectives of series compensations-Variable impedance type series compensators - GCSC. TCSC, TSSC (Principle of operation and schematic)

Switching converter type Series Compensators-(SSSC) (Principle of operation and schematic)

Module 5

UPFC AND IPFC

Unified Power Flow Controller: Circuit Arrangement, Operation of UPFC- Basic principle of P and Q control- independent real and reactive power flow control- Applications

Introduction to interline power flow controller (IPFC) (Principle of operation and schematic)

Thyristor controlled Voltage and Phase angle Regulators (Principle of operation and schematic)

Note: Simulation assignments may be given in MATLAB, SCILAB, PSAT, ETAP, PSCAD, etc.

Text Books

1. Vijay K Sood, "HVDC and FACTS Controllers", Springer, 2004
2. N.G. Hingorani and L.Gyugyi, "Understanding FACTS", IEEE Press 2000

References:

1. K.R.Padiyar, "High Voltage DC Transmission", Wiley 1993
2. Y.H. Song and A.T.Jones, "Flexible AC Transmission systems (FACTS)", IEEE Press 1999.
3. K.R.Padiyar, "FACTS Controllers in Power Transmission and distribution", New age international Publishers 2007.
4. T.J.E. Miller, "Reactive Power control in Power systems", John Wiley 1982.
5. C.L.Wadhwa, "Electric Power Systems", New Academic Science Limited, 1992

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**HVDC Converters(6 hours)**	
1.1	Comparison of AC and DC Transmission Systems - Costs, Technical considerations and reliability	1
1.2	Types of HVDC Links	1
1.3	Current Source Converters	2
1.4	Voltage Source Converters	2
2	**HVDC Controls (7 hours)**	
2.1	Function of HVDC Controls	1
2.2	Control Basics of two terminal DC Link	2
2.3	Current Margin Control Method	1
2.4	Current Control at the rectifier	1
2.5	Inverter Extinction Angle Control	1
2.6	Hierarchy of Controls	1
3	**Introduction to FACTS (6 hours)**	
3.1	Power flow in Power Systems – Voltage regulation and reactive power flow control in Power Systems - Power flow control -Constraints of maximum transmission line loading	2
3.2	Needs, emergence of FACTS- Types of FACTS controllers-Advantages and disadvantages	2
3.3	Transmission line compensation- Uncompensated line shunt compensation - Series compensation -Phase angle control. (line diagram, vector diagram and expression for P and Q)	2
4	**Shunt and Series Facts Devices (8 Hours)**	
4.1	Static shunt Compensator - Objectives of shunt compensations,	1
4.2	Variable impedance type VAR Generators -TCR , TSR, TSC, FC-TCR (Principle of operation and schematic)	2
4.3	STATCOM- Principle of operation-and schematic	1

4.4	Static Series compensator - Objectives of series compensations	1
4.5	Variable impedance type series compensators - GCSC. TCSC, TSSC - Principle of operation and schematic	2
4.6	Switching converter type Series Compensators-(SSSC)- Principle of operation and schematic	1
5	**UPFC AND IPFC (7 Hours)**	
5.1	Unified Power Flow Controller: Circuit Arrangement, Operation of UPFC-	2
5.2	Basic principle of P and Q control- independent real and reactive power flow control- Applications	2
5.3	Introduction to interline power flow controller (IPFC).	1
5.4	Thyristor controlled Voltage and Phase angle Regulators -Principle of operation	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET476	ADVANCED ELECTRONIC DESIGN	PEC	2	1	0	3

Preamble: This course makes a student capable to design a system that senses a physical quantity, condition the sensed signal and digitally measure it.

Prerequisite: EET205 (Analog Electronics), EET303 (Microprocessors and microcontrollers)

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyse the frequency response characteristics of op-amps along with its circuit properties.
CO 2	Develop advanced op-amp circuits which serve as building blocks to more complex digital and analog circuits.
CO 3	Design active filters as per situational and system demands.
CO 4	Develop sensor circuits for physical quantity measurements.
CO 5	Design the microcontroller interfacing with analog domain for real world applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2		1							
CO 2	3	2	2	1	1							
CO 3	3	2	2	1	1							
CO 4	3	2	2	1	1							
CO 5	3	2	2	1	1							

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	20	20	40

Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the frequency response characteristics of an op-amp. (K1, K2, PO1, PO2)

2. Examine the gain frequency relationships of an op-amp. (K1, K2, PO1, PO2)

3. List the non idealities in frequency response resulting in circuit applications. (K1, K2, PO1, PO4)

Course Outcome 2 (CO2)

1. Design precision rectifier circuit and voltage to current conversion circuit after mentioning the assumptions made with respect to inputs and outputs. (K3, PO1, PO2, PO4)

2. Illustrate the working of a PLL using a block diagram. (K2, PO1)

3. List the criteria you consider for designing a sample and hold circuit. (K2, PO1, PO2, PO4)

Course Outcome 3(CO3):

1. List out the benefits of an active filter over a passive filter. (K2, PO1)

2. List out the factors considered for selecting the filter order. (K2, PO1)

3. List out a set of assumptions and design a Butterworth based on your assumptions for the assumed application. (K2, PO1, PO2, PO4).

Course Outcome 4 (CO4):

1. List out the parameters you may consider for selecting a sensor for a particular application (K2, PO1, PO2, PO4).

2. Design a sensor circuit for pressure measurement with proper assumptions (K3, PO1, PO2, PO4).

3. Hall effect sensor can be termed as an isolated sensor, explain why? (K2, PO1, PO2, PO4)

Course Outcome 5 (CO5):

1. Illustrate how an LM 35 temperature sensor is interfaced with Atmega 32 with a block diagram and required coding. (K3, PO1, PO2, PO3, PO4)

2. Conduct a study on parallel vs serial ADC and list out the pros and cons. (K2, PO1, PO4).

3. Analyse the importance of conversion time of an ADC in an embedded system design. (K2, PO1, PO4).

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH AND YEAR

Course Code: EET476

Course Name: Advanced Electronic Design

Max. Marks: 100 Duration: 3 Hours

Note: Certified IC data sheets of relevant ICs may be permitted inside the examination hall. However, application notes of ICs are NOT permitted.

PART A

Answer all questions, each carries 3 marks. Marks

1	List the effects of Op-amp slew-rate in practical circuits.	(3)
2	Draw the high frequency equivalent circuit of an op-amp.	(3)
3	A randomly varying signal whose peak voltage was expected to be in the range -20 V to 35 V. Draw a peak detector circuit that gives the peak voltage value of the signal. What would be the nominal voltage ratings of the components used? Assume a suitable safety factor.	(3)
4	In a classical sample and hold circuit design explain the relevance of acquisition time.	(3)
5	How will the loading effect be affected if you replace a passive filter with an active filter in a measuring circuit? Give proper reasoning for your answer.	(3)

6 How closely is the roll-off rate requirement associated with the order of an active filter? (3)

7 Mr X has designed a current measurement circuit based on hall effect sensor and the design had transient voltage suppressors for surge protection, active filters for noise separation and an isolation transformer for the purpose of isolating the measuring system from high power circuit. If given an opportunity, what corrections will you suggest without changing the sensor and why? (3)

8 List out the relevance of signal conditioning in a circuit that uses MPX2010 pressure sensor. (3)

9 List out any three characteristics of ADC in Atmega 32. (3)

10 What do you understand by the term conversion time in an ADC? (3)

PART B

Answer any two full questions, each question carries 14 marks.

11 a) Explain the relevance of unity gain bandwidth for an op-amp. (4)

b) Derive the open loop voltage gain of an op-amp as a function of frequency. (10)

OR

12 a) An inverting amplifier with closed loop gain, A_o = -2 V/V is driven with a square wave of peak values $\pm V_m$ and frequency f. With V_m = 2.5 V. It is observed that the output turns from trapezoidal to triangular when f is raised to 250 kHz. With f = 100 kHz, it is found that slew-rate limiting ceases when V_m is lowered to 0.4 V. If the input is changed to a 3.5 V (rms) ac signal, what is the useful bandwidth of the circuit? (8)

b) How does the frequency response of non-compensated Op-amps differ from compensated Op-amps? (6)

13 a) Describe the operation of a frequency-to-voltage converter with circuit diagrams and waveforms. (7)

b) With a block-diagram, explain how a PLL can be used to implement a frequency multiplier. Use a multiplication factor of 2 for the illustration. (7)

OR

14 (a) For a particular application we need to generate multiple copies of a reference current source. Describe an Op-amp circuit that generates mirror images of the current source which can serve the said purpose. (7)

(b) It is required to design an amplifier for the current signal delivered by a photodetector. Use an Op-amp powered from ±15 V power supply to deliver an output voltage in the range -5 V to +5 V for an input current in the range 0 to 1 A. (7)

15 (a) Design a unity gain second-order low-pass Butterworth filter with a -3 dB frequency of 10 kHz. If input, $V_i(t) = 10\cos(4\pi\, 10^4 t - 90°)$ V, find output $V_o(t)$. (8)

(b) Derive an expression to find the cutoff frequency of a second order low pass Sallen-Key filter. (6)

OR

16 a) Explain the relevance of corner frequencies in filter characteristics. (5)

b) Design a second order Sallen-Key high pass filter with a cutoff frequency of 10 kHz and Q of 1. Assume both resistors to be of equal value and both capacitors to be equal. (9)

17 a) Explain a temperature sensor circuit using the sensor AD590. (6)

b) Design a differential pressure measuring circuit using MPX2010 pressure sensor with switching output. The output should switch at 5 kPa pressure difference. Assume zero offset of the sensor. Assume operating voltage of 10 V, temperature of measurement as 25°C and $P_1 > P_2$. *Hint: use a comparator at the output.* (8)

OR

18 a) To calibrate ADXL202E, the accelerometer's measurement axis is pointed directly at the earth. The 1g reading is saved and the sensor is turned 180° to measure -1g. Let A = accelerometer output with axis oriented to +1g = 55% duty cycle and B = accelerometer output with axis oriented to -1g = 32% duty cycle. What is the sensitivity of the accelerometer? (8)

b) When two or more sensors are mounted close to each other, acoustic interference is possible. Describe the ways in which multiple ultrasonic sensors 873P can be connected. Give the connections for both the analog current and the analog voltage outputs. Assume that the sensors (6) are connected away from an amplifier.

19	a)	Differentiate between serial and parallel ADC.	(7)
	b)	What is the relevance of a stable regulated supply voltage in an ADC. List the sampling requirements for successful reproduction in an ADC.	(7)

OR

20		It is required to interface the temperature sensor LM35 with Atmega32 for measuring the temperature of an element that varies in the range 0^o C to 120^oC. Draw the interfacing diagram with proper labelling of the Atmega 32 ports. Write an appropriately commented code for the same.	(14)

****

Syllabus

Module 1: Op-amp Frequency response-compensating networks, frequency response of internally compensated Op-Amps, frequency response of non compensated Op-Amps, High-frequency Op-amp equivalent circuit, open loop voltage gain as a function of frequency, closed loop frequency response, circuit stability, slew rate, slew rate equation, effect of slew rate.

Module 2: Advanced Op-amp applications- Precision rectifier, peak detector and log-converter , antilog amplifier, current mirror, voltage-to-current converters, current-to-voltage converters, voltage-to-frequency and frequency-to-voltage converters, Sample and hold circuit-Basic Circuits, practical sample and hold circuits, performance characteristics. Phase Locked Loop (PLL)- Operating principles, block diagrams, monolithic PLL, IC 565 - PLL applications.

Module 3: Filters- Introduction to basic theory of filters: Filter responses - Active vs passive filters, Low pass, Band-pass, high-pass, band-stop filters and their characteristics - first order vs higher order filters - Realisation of Active filters - Transfer function synthesis, Sallen Key based (VCVS) filters - First order low pass butterworth filter design and frequency scaling, second order low pass butterworth filter design.

Module 4: IC Sensors- IC sensors for different energy forms, thermal energy sensors, mechanical energy sensors, radiant energy sensors, magnetic energy sensors, chemical energy sensors. MEMS-typical IC sensors, temperature energy sensors- LM35 and AD590, pressure sensors-MPX2010, accelerometer-ADXL202E, ultrasonic sensor-873P, infrared thermometer modules-MLX90601 family, Hall effect direction detection sensor-A3422xka

Module 5: ADC, DAC and sensor interfacing to a typical Microcontroller-Review of ADC and ADC characteristics-resolution, conversion time, parallel versus serial ADC with ADC0848 and MAX1112 examples, sampling requirements, ADC programming / interfacing in Atmega 32, interfacing temperature sensor LM35 with Atmega32, DAC 0808 interfacing with Atmega 32

Text Books

1. L. K. Maheswari, M.M.S Anand, "Analog Electronics", Prentice Hall India Learning Private Limited, 2005.

2. Muhammad Ali Mazidi,Sarmad Naimi, Sepehr Naimi, "The AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education India, 1st Edition, 2013

References

1. Ramakant A Gayakwad, "Op-amps and Linear Integrated Circuits", Pearson Education; Fourth edition, 2015

2. D Roy Choudhury, "Linear Integrated Circuits", New Age International Publishers; Fifth edition, 2018

3. Sergio Franco, "Design with operational amplifier and analog circuits" Third Edition, Mc Graw Hill, 2001

4. Elliot Williams,"Make: AVR Programming-Learning to write software for hardware", First edition, Shroff/Maker Media, 2014.

5. Data sheets and application notes of relevant ICs mentioned in the syllabus

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1: Op-amp frequency response (8 hrs)**	
1.1	Compensating networks,frequency response of internally compensated Op-Amps, frequency response of non compensated Op-Amps,	3 hrs
1.2	High-frequency Op-amp equivalent circuit,.	1 hr
1.3	Open loop voltage gain as a function of frequency, closed loop frequency response, circuit stability,	2 hrs
1.4	Slew rate, slew rate equation, effect of slew rate	2 hrs
2	**Module 2: Advanced Op-amp applications (8 hrs)**	
2.1	Precision rectifier, peak detector and log-converter , antilog amplifier, current mirror, voltage-to-current converters, current-to-voltage converters, voltage-to-frequency and frequency-to-voltage converters,	4 hrs
2.2	Sample and hold circuit- Basic Circuits, practical sample and hold circuits, performance characteristics.	2 hrs
2.3	Phase Locked Loop (PLL)- Operating principles, block diagrams, monolithic PLL, IC 565 PLL applications.	2 hrs
3	**Module 3: Filters (6 hrs)**	
3.1	Introduction to basic theory of filters: Filter responses - Active vs passive filters, Low pass, Band-pass, high-pass, band-stop filters and their characteristics - first order vs higher order filters	2 hr
3.2	Realisation of Active filters - Transfer function synthesis, Sallen	2 hr

	Key based (VCVS) filters	
3.3	First order low pass butterworth filter design and frequency scaling, second order low pass butterworth filter design.	2 hrs
4	**Module 4: IC Sensors (7 hrs)**	
4.1	IC sensors for different energy forms, thermal energy sensors, mechanical energy sensors, radiant energy sensors, magnetic energy sensors, chemical energy sensors.	2 hrs
4.2	MEMS-typical IC sensors, temperature energy sensors- LM35 and AD590, pressure sensors-MPX2010, accelerometer-ADXL202E, ultrasonic sensor-873P, infrared thermometer modules-MLX90601 family, Hall effect direction detection sensor-A3422xka	5 hrs
5	**Module 5: ADC, DAC and sensor interfacing to a typical Microcontroller (7 hrs)**	
5.1	Review of ADC and ADC characteristics-resolution, conversion time, parallel versus serial ADC with ADC0848 and MAX1112 examples, Sampling requirements	4 hrs
5.2	ADC programming / interfacing in Atmega 32, interfacing temperature sensor LM35 with Atmega32, DAC 0808 interfacing with Atmega 32	3 hrs

SEMESTER VIII

PROGRAM ELECTIVE V

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET418	ELECTRIC AND HYBRID VEHICLES	PEC	2	1	0	3

Preamble: Electric and Hybrid vehicles are gaining popularity globally. This course introduces the fundamental concepts of electric, hybrid and autonomous vehicles, drive trains, electrical machines used, energy storage devices, charging systems and different communication protocols.

Prerequisite : EET 202 -DC Machines and Transformers, EET 307-Synchronous and Induction machines, EET 302-Power Electronics

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Explain the basic concepts of Conventional, Electric, Hybrid EV and Autonomous Vehicles
CO 2	Describe different configurations of electric and hybrid electric drive trains
CO 3	Discuss the propulsion unit for electric and hybrid vehicles
CO 4	Compare various energy storage and EV charging systems
CO 5	Select drive systems and various communication protocols for EV

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1					2					
CO 2	3	2										
CO 3	3	2										
CO 4	3	3	2									
CO 5	3	1	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	20	20	40
Understand (K2)	20	20	40
Apply (K3)	10	10	20
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Give questions indicating bloom's taxonomy level under each CO

Course Outcome 1 (CO1):

1. Which are the resistive forces that retard the motion of a four wheel vehicle?(PO1,K1)
2. Explain briefly the performance parameters of the vehicle.(PO1, PO2,K1)
3. What are the social and environmental importance of EV.(PO7, K1)

Course Outcome 2 (CO2):

1. Architecture and power flow control of hybrid electric vehicle.(PO2, K2)
2. Subsystems of an electric vehicle.(PO1, K1)

3. What is regenerative braking?(PO1, K1)

Course Outcome 3 (CO3):

1. Electric components of an electric vehicle. (PO1, K1)
2. Control of orthogonal flux and torque in a separately excited DC motor(PO2, K2)
3. FOC control concept in PMSM motors.(PO1, PO2,K2)

Course Outcome 4 (CO4):

1. Battery management supporting system for hybrid vehicle.(PO1, K2)
2. Numerical problems in sizing and selection of batteries (PO3, K3)
3. Pin diagrams and differences of various connectors used for EV charging.(PO2,K2)

Course Outcome 5 (CO5):

1. Torque - speed envelope curves of drive train motors (PO2,K1)
2. Numerical Problems in sizing of drive systems (PO3,K3)
3. Different communication protocols used in EV (PO1, K2)

Model Question Paper

QP CODE: **Pages:**

Reg No.:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHT SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET 418

Course Name: ELECTRIC AND HYBRID VEHICLES

Max. Marks: 100 **Duration: 3 hours**

PART A

Answer all questions; each question carries 3 marks.

1.	Explain rolling resistance and aerodynamic drag in vehicles.	(3)
2.	Write short notes on gradeability of the automobile system	(3)
3.	With the help of a block diagram, explain the major components of an electric vehicle.	(3)
4.	What is axial balancing?	(3)
5.	What are the electric components used in the propulsion unit of EV/HEV?	(3)

6.	List the advantages of PMSM motors over DC and induction motors.	(3)
7.	Explain the terms specific energy and energy density as applied to batteries.	(3)
8.	Explain the V2G concept.	(3)
9.	What is meant by Constant Power Speed Ratio as applied to an electric motor?	(3)
10.	What is the significance of a communication network in electric/hybrid vehicles?	(3)

PART B

Answer any one complete question from each section; each question carries 14 marks

11	(a)	Draw and explain ideal traction power plant characteristics of various power plants and various power source characteristics used in electric and hybrid electric vehicles.	(8)
	(b)	Why is a gear system needed for an ICE? Explain with relevant characteristic curves.	(6)
		OR	
12	(a)	Explain the levels of automation and its significance in autonomous vehicles (5 marks)	
	(b)	What are the resistive forces acting on the vehicle movement? Obtain the dynamic equation of the vehicle movement.	
13	(a)	Draw and explain different classification of electric vehicles based on power source configurations.	(7)
	(b)	Explain the different power flow control modes of a typical parallel hybrid system with the help of block diagrams.	(7)
		OR	
14	(a)	Explain in detail the EV drivetrain alternatives based on drivetrain configurations	(6)
	(b)	Explain the different power flow control modes of a typical ICE dominated series-parallel hybrid system with the help of block diagrams	(8)
15	(a)	Explain the Permanent Magnet Synchronous Motor control for application in EV.	(10)
	(b)	Describe the advantages of independent control of flux and torque in SEDC Motor	(4)
		OR	

16	(a)	Discuss in detail the various electrical components used in HEV.	(10)
	(b)	List the advantages of FOC control.	(4)
17	(a)	What is meant by the C rating of a battery? Explain with an example.	(4)
	(b)	Explain the operation, advantages and disadvantages of Fuel cells used in EV.	(10)
		OR	
18	(a)	Explain briefly the different charging systems used for charging of EV.	(8)
	(b)	With pin diagrams, describe the CCS Type 2 connectors used for EV charging.	(6)
19	(a)	A hybrid electric vehicle has two sources- an ICE with output power of 80kW and battery storage. The battery storage is a 150 Ah, C10 battery at 120V. (i).Calculate the battery energy capacity (ii). Without de-rating the Ahr capacity,what is the maximum power that can be supported by the battery? (iii). What is the electrical motor power output if the total efficiency of power converter and motor combination is 98%? (iv). What is the maximum power that can be transmitted to the wheels if the transmission efficiency is 95%?	(8)
	(b)	Explain briefly the factors to be considered while sizing the electric motor for EV.	(6)
		OR	
20	(a)	What does CP and PP pins denote in connectors and explain its functions	(5)
	(b)	Draw and explain the FLEXRAY communication systems used in EV.	(9)

Syllabus

Module 1 - 8 hrs

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. (2 hrs)

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. (5 hrs)

Autonomous Vehicles: Levels of automation, significance & effects of automation in vehicles (1 hr)

Module 2 - 7 hrs

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. (4 hrs)

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.(3 hrs)

Module 3 - 7 hrs

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles (2 hrs)

DC Drives: Review of Separately excited DC Motor control – Speed and torque equations - Independent control of orthogonal flux and torque - Closed loop control of speed and torque (block diagram only) (2 hrs)

PMSM Drives: PMSM motor basics – Independent control of orthogonal flux and torque (concept only)- Field Oriented Control (FOC) – Sensored and sensorless control (block diagram only) (3 hrs)

Module 4 - 7 hrs

Energy Storage: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems,Battery Management System, Types of battery- Fuel Cell based energy storage systems- Supercapacitors-Hybridization of different energy storage devices (3 hrs)

Overview of Electric Vehicle Battery Chargers - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams – Types of charging stations - AC Level 1 & 2, DC - Level 3 – V2G concept-Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences (4hrs)

Module 5 - 5 hrs

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics (3 hrs)

Vehicle Communication protocols : Need & requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins, Communication Protocols - CAN, LIN, FLEXRAY (Basics only)- Power line communication (PLC) in EV (2 hrs)

Text Books

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. Chris Mi, M A Masrur, D W Gao, " Hybrid Electric Vehicles – Principles and applications with practical perspectives," Wiley, 2011
4. Anderson JM, Nidhi K, Stanley KD, Sorensen P, Samaras C, Oluwatola OA, Autonomous vehicle technology: A guide for policymakers, Rand Corporation,2014

Online Resources:

1. NPTEL courses/Materials (IITG, IITM,IITD) – Electric and Hybrid vehicles
   https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
   https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
   https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2. FOC Control - video lecture by Texas Instruments
   https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3. Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
   https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
   https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4. Electric Vehicle Conductive AC Charging System
   https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf
   Electric Vehicle Conductive AC Charging System

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Introduction to hybrid/electric, conventional & autonomous vehicles (8 hours)**	
1.1	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles	1
1.2	Impact of modern drive-trains on energy supplies	1
1.3	Conventional Vehicles: Basics of vehicle performance	1
1.4	Vehicle power source characterization, transmission characteristics	2
1.6	Mathematical models to describe vehicle performance	2

1.7	Autonomous Vehicles: Levels of automation, significance & effects of automation in vehicles	1
2	**Hybrid & Electric drive-trains (7 hours)**	
2.1	Hybrid Electric Drive-trains: Basic concept of hybrid traction	1
2.2	Introduction to various hybrid drive-train topologies	1
2.3	Power flow control in hybrid drive-train topologies, fuel efficiency analysis.	2
2.4	Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies	1
2.5	Power flow control in electric drive-train topologies, hub motors, fuel efficiency analysis.	2
3	**Electric Propulsion System (7 Hours)**	
3.1	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles	2
3.2	DC Drives: Review of Separately excited DC Motor control – Speed and torque equations - Independent control of orthogonal flux and torque – Closed loop control of speed and torque (block diagram only)	2
3.3	PMSM Drives: PMSM motor basics – Independent control of orthogonal flux and torque (concept only)	2
3.4	Field Oriented Control (FOC) of Permanent Magnet Synchronous Motor – Sensored and sensorless control (block diagram only)	1
4	**Energy Storage (7 Hours)**	
4.1	Energy Storage: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems, Battery Management System	1
4.2	Types of battery-Lithium ion, Lead acid	1
4.3	Fuel Cell based energy storage systems- Supercapacitors-Hybridization of different energy storage devices	1
4.4	Overview of Electric Vehicle Battery Chargers – On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams	2
4.5	Types of charging stations - AC Level 1 & 2, DC - Level 3	1
4.6	V2G concept-Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences	1

5	**Sizing the drive system (5 Hours)**	
5.1	Sizing the drive system **:**Matching the electric machine and the internal combustion engine (ICE)	1
5.2	Sizing the propulsion motor	1
5.3	Sizing the power electronics	1
5.4	Vehicle Communication protocols : Need and requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins	1
5.5	Communication Protocols - CAN, LIN, FLEXRAY(Basics only) –Power Line Communication (PLC) in EV	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET428	INTERNET OF THINGS	PEC	2	1	0	3

Preamble: This elective course is designed for state-of-the-art features to students and enable them to work in the industry where IoT is applied to a great extent**.** Students will also be introduced to the programming of embedded devices used in different levels of IoT application. Moreover, they will get exposed to sensor interfacing and uploading data to cloud services provided by different firms.

Prerequisite: Experience in high level language programming and system design concepts with microcontrollers are required.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the role of computer networks in IoT. (K1)
CO 2	Select the appropriate communication standard for their IoT application. (K2)
CO 3	Use the appropriate sensors and embedded devices to get the data from the "things" and upload to cloud (K2)
CO 4	Develop programs for IoT devices using micropython language. (K3)
CO 5	Utilize the learned information to find an IoT based solution for the problem at hand. (K3)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2											
CO 2	2											
CO 3	2	2			2							
CO 4	2	3	3	1	2				1			1
CO 5	2	3	3	1	2	2	1		1			1
CO 6												

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	25	25	50
Apply	15	15	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Draw and explain the functional block diagram of IoT system.

2. Define the terms a) IP address b) Access point c) Station d) Router e) gateway

3. Explain the enabling technologies of IoT

Course Outcome 2 (CO2)

1. Explain the Wireless Sensor Network (WSN) technology.

2. How the data sensed from things uploaded to cloud?

3. Briefly explain the communication standards in use for connection to cloud service.

Course Outcome 3(CO3):

1. Explain the main features of Raspberry Pi 4 B computer

2. How ESP32 can be used as an embedded device in IoT applications?

3. Briefly explain the use ARM EMBED in IoT application.

Course Outcome 4 (CO4):

1. Prepare a micropython program to enable ESP32 module as an access point.

2. Prepare a micropython program to read analog data using raspberry pi and setup a server.

3. Explain the features of ARM EMBED IoT platform.

Course Outcome 5 (CO5):

1. Explain the application of IoT with suitable block diagram for smart metering of electricty

2. Detail the data sensing and prediction based on IoT applications in smart farming.

3. Detail the features of Industrial IoT with suitable block diagram.

Syllabus

EET 428: INTERNET OF THINGS

Module 1

Introduction: Definition and Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT Protocols, Logical Design of IoT: IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies. Design challenges – power consumption and security issues.

Computer networks: Internet-protocols and standards-OSI model- TCP/IP protocol suite. IP addressing – IPv4 and IPv6, Physical layer components- Switch, Router, Access point, station, Server, Client, Port, Gateway. Sizing of network- LAN, MAN, WAN . **(8 hrs)**

Module 2

IoT and M2M Communications: Introduction, M2M, M2M applications, Differences between M2M and IoT, M2M standards- Bluetooth-LE, Zigbee, NFC, Wifi and LoRaWAN. Data logging and cloud services- CoAP, MQTT and JSON. Big data analytics (concepts only)**(6 hrs)**

Module 3

Sensor technologies for IoT- Wireless sensor network. Voltage, Current, Speed, Temperature and humidity sensors and data acquisition using embedded devices- block diagram. Data logging to cloud services- protocols and programming. **(6 hrs.)**

Module 4

Embedded devices for IoT. Introduction to Python programming and embedded programming using micropython. Sensor interfacing and data acquisition using target boards like Raspberry Pi 4B, ARM EMBED, ESP32, Arduino boards. Programming examples for data logging to cloud using micropython. (Assignments on hardware implementation using these or similar boards may be given.) **(8hrs.)**

Module 5

IoT applications: Energy management and smart grid applications. IoT based home automation, Smart metering for electricity consumers. IoT based weather stations, Agriculture- smart farming, Automobile IoT- Electric vehicles-platform and software, Industrial IoT. **(6 hrs.)**

Text Books

1. Simone Cirani," Internet of things: Architecture, protocols and standards", Wiley, 2019

2. Charles Bell, "MicroPython for the Internet of Things: A Beginner's Guide to Programming with Python on Microcontrollers", Apress, 2017

3. B.K Thripathy, J Anuradha, "Internet of things (IoT) _ technologies, applications, challenges and solutions ", CRC press, 2018

4. Raj Kamal, "Internet of Things: Architecture and Design Principles", McGraw Hill (India) Private Limited.

Reference Books

1. Qusay F. Hassan, " Internet of Things A to Z,: Technologies and applications", IEEE press,2018

2. Gary Smart, "Practical Python Programming for IoT : Build advanced IoT projects using Raspberry Pi 4, MQTT, RESTful APIs, WebSockets, and Python 3, Packt Publishing Ltd, 2020.

3. Gaston C. Hillar , "MQTT Essentials - A Lightweight IoT Protocol" , Packt Publishing Ltd, 2017.

4. Alasdair Gilchrist , "Industry 4.0 The Industrial Internet of Things". Apress, 2016.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I**	
1.1	Introduction to IoT, functional block	2
1.2	IoT communication models,Design challenges	2
1.3	Computer networks related topics	4
2	**Module II**	
2.1	Introduction to M2M communications, standards	2
2.2	Data logging and cloud services, MQTT,json	3
2.3	Big data analytics (concepts only)	1
3	**Module III**	

3.1	Sensors and sensor networks	1
3.2	Voltage ,current, temperature sensors and their interfaces	2
3.3	Data logging to cloud services and protocols	3
4	**Module IV**	
4.1	Introduction to embedded devices like Raspberry Pi, ESP32 etc	2
4.2	Introduction to micropython programming	3
4.3	Micropython programming for data logging to cloud	3
5	**Module V**	
5.1	IoT applications in smart grids	3
5.2	IoT application to other applications	1
5.3	IoT applications in electric vehicles and IIoT	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET438	ENERGY STORAGE SYSTEMS	PEC	2	1	0	3

Preamble: This course aims to introduce the importance and application of energy storage systems and to familiarize with different energy storage technologies.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the role of energy storage in power systems
CO 2	Classify thermal, kinetic and potential storage technologies and their applications
CO 3	Compare Electrochemical, Electrostatic and Electromagnetic storage technologies
CO 4	Illustrate energy storage technology in renewable energy integration
CO 5	Summarise energy storage technology applications for smart grids)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3											
CO 3	3	2	1				1					
CO 4	3	2	1			1	1					1
CO 5	3	1	1			1	1					1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	15	15	30
Understand (K2)	20	20	40
Apply (K3)	15	15	30
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. What are the different parts of a complete energy storage unit? (K1, PO1)
2. Explain the Dynamic Duty of storage plant. (K2, PO1,PO2)
3. What are the different types of central store? (K2, PO1)

Course Outcome 2 (CO2)

1. List the applications of thermal energy storage systems. (K1, PO1)
2. Explain hydrogen-based power utility concept.(K2,PO1)
3. What are the different storage containments of hydrogen? (K1, PO1)

Course Outcome 3(CO3)

1. Explain the working of fuel cell along with schematic diagram. (K2, PO1,PO2,PO7)
2. Write short notes on supercapacitors. (K2, PO1)
3. Explain the arrangement of a control and protection system for Super Conducting Magnetic Energy Storage.(K2 , PO1,PO3)

Course Outcome 4 (CO4)

1. Explain small-scale hydroelectric energy. (K2,PO1,PO3,PO6,PO7,PO12)
2. Write short notes on wave energy and its storage system. (K2, PO1, PO7,PO12)
3. What are the different types of renewable power sources? (K1, PO1, PO7,PO12)

Course Outcome 5 (CO5)

1. Explain distributed energy storage system. (K2, PO1, PO3,PO6,PO7,PO12)
2. What are the characteristics of smart grid system? (K1, PO1, PO6,PO7,PO12)
3. What is demand response? (K1, PO1, PO2)

Model Question Paper

QP CODE: Pages:

Reg No.:_______________

Name:_________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET438

Course Name: ENERGY STORAGE SYSTEMS

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions; each question carries 3 marks.

1. Discuss the power transformation of energy storage system. (3)

2. Explain the different components of energy storage system with schematic structure. (3)

3. Define Flow equation related to thermal energy storage system. (3)

4. Write the difference between hybrid and combined energy storage in power system. (3)

5. Explain the chemical reaction of lead acid batteries. (3)

6. Write down the basic principle of capacitor bank storage system. (3)

7. Classify hydro power plants based on their rated capacity. (3)

8. Briefly discuss small-scale hydroelectric energy system. (3)

9.	What is distributed energy storage system?		(3)
10	List the various layers of smart grid.		(3)

PART B

Answer any one complete question from each section; each question carries 14 marks

11	(a)	Explain static duty of energy storage plant.	(8)
	(b)	With neat diagram explain energy and power balance in a storage unit.	(6)
		OR	
12	(a)	Explain the econometric model of energy storage. Derive the expression for annual cost of the system.	(10)
	(b)	What are the key parameters considered for the comparison of energy storage in power system?	(4)
13	(a)	Discuss the working principle of compressed air energy storage system.	(7)
	(b)	Write short note on flywheel energy storage system.	(7)
		OR	
14	(a)	Write any three industrial methods to produce hydrogen.	(9)
	(b)	Explain 'power to gas' concept.	(5)
15	(a)	Explain the working of Li-ion batteries.	(7)
	(b)	Describe the typical voltage–discharge profile for a battery cell.	(7)
		OR	
16	(a)	Describe basic principle and working of superconducting magnetic energy storage system.	(7)
	(b)	With the help of a block diagram, explain the arrangement of control and	(7)

protection system for superconducting magnetic energy storage system.

17	(a)	What are the main features of renewable energy systems?	(4)
	(b)	Explain the role of storage systems in an integrated power system with grid-connected renewable power sources.	(10)

OR

18	(a)	Explain photovoltaics system.	(4)
	(b)	Discuss the role of storage in an isolated power system with renewable power sources.	(10)
19	(a)	Describe the distributed energy storage system.	(6)
	(b)	"HEV act as a distributed energy generator and storage", justify your answer.	(8)

OR

20	(a)	What is demand response?	(5)
	(b)	Draw and explain the battery SCADA system.	(9)

Syllabus

Module 1

Introduction to energy storage in power systems (6)

Need and role of energy storage systems in power system, General considerations, Energy and power balance in a storage unit, Mathematical model of storage system: modelling of power transformation system (PTS)-Central store (CS) and charge–discharge control system (CDCS), Econometric model of storage system.

Module 2

Overview on Energy storage technologies (7)

Thermal energy: General considerations -Storage media- Containment- Thermal energy storage in a power plant, Potential energy: Pumped hydro-Compressed Air, Kinetic energy: Mechanical- Flywheel , Power to Gas : Hydrogen - Synthetic methane

Module 3

Overview on Energy storage technologies (8)

Electrochemical energy : Batteries- Battery parameters: C-rating -SoC- DoD- Specific Energy-Specific power (numerical examples), Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies.

Module 4

Energy storage and renewable power sources (6)

Types of renewable energy sources: Wave - Wind – Tidal – Hydroelectric - Solar thermal technologies and Photovoltaics, Storage role in isolated power systems with renewable power sources, Storage role in an integrated power system with grid-connected renewable power sources

Module 5

Energy storage Applications (7)

Smart grid, Smart microgrid, Smart house, Mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Management and control hierarchy of storage systems - Aggregating energy storage systems and distributed generation (Virtual Power Plant Energy Management with storage systems), Battery SCADA, Hybrid energy storage systems: configurations and applications.

Text Books

1. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN - 978-1-84919-219-4),2011.

2. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt," Energy Storage in Power Systems" Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016.

Reference Books

1. Electric Power Research Institute (USA), "Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits" (1020676), December 2010.

2. Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, "The Role of Energy Storage with Renewable Electricity Generation", National Renewable Energy Laboratory (NREL) -a National Laboratory of the U.S. Department of Energy.

3. P. Nezamabadi and G. B. Gharehpetian, "Electrical energy management of virtual power plants in distribution networks with renewable energy resources and energy storage systems", IEEE *Power Distribution Conference*, 2011.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to energy storage for power systems: (6)**	
1.1	General considerations- different parts of energy storage unit-static duty of storage plant- dynamic duty of storage plant	2
1.2	Energy and power balance in a storage unit- schematic structure of energy storage	1
1.3	Mathematical model of storage system	1
1.4	Econometric model of storage- capital cost of energy storage-annual cost of storage facility	2
2	**Overview on Energy storage technologies: (7)**	
2.1	Principle of thermal energy storage- sensible heat storage – latent heat storage- containment- thermal energy storage in power plant application	2
2.2	Principle and operation of pumped hydroelectric storage (PHS)-general considerations- schematic diagram	1
2.3	Principle and operation of Compressed Air Energy Storage (CAES)- general considerations- basic principle-industrial application	1
2.4	Principle and operation of Flywheel Energy storage System (FESS)-general considerations -applications	1
2.5	General considerations- synthetic storage media-Hydrogen production-Hydrogen based power utility concept- storage containment for hydrogen-Methods of extraction of methane-	2

	Block diagram Power to gas concept	
3	**Overview on Energy storage technologies (8)**	
3.1	Basic concepts of conventional batteries and flow batteries- Battery parameters- C-rating-SoC- DoD- Specific Energy-Specific power (numerical examples), Fuel cell- Schematic diagram of an electrochemical fuel cell	2
23.2	Super conducting Magnetic Energy Storage (SMES)- basic circuit-principle-advantages	2
3.3	The Supercapacitor Energy Storage System- topology-principle-advantages	2
3.4	Comparative study of different energy storage system based on specific energy, specific power, cycling capability and life in years	2
4	**Energy storage and renewable power sources (6)**	
4.1	Types of renewable power sources- brief description	2
4.2	Storage role in isolated power system with renewable power sources	1
4.3	Storage role in an integrated power system with grid-connected renewable power sources	1
4.4	Small scale hydroelectric energy	1
4.5	Solar thermal technologies and photovoltaics	1
5	**Energy storage Applications (7)**	
5.1	Smart grid-concepts- characteristics- Smart metering	2
5.2	Field of Electromobility- thyristor based battery charger and DC power supply	1
5.3	Vehicle to grid and grid to vehicle charging point topology	1
5.4	Distributed energy storage	1
5.5	Battery SCADA- overview	1
5.6	Hybrid energy storage systems: configurations and applications	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET448	ROBUST AND ADAPTIVE CONTROL	PEC	2	1	0	3

Preamble: This course provides a mathematical introduction to the field of robust and adaptive control. The concepts in this course are considered advanced in the field of modern control theory.

Prerequisite: EET304 Linear Control System, EET401Advanced Control System

Course Outcomes: After the completion of the course the student will be able to

CO 1	Compute the norms of transfer functions and transfer function matrices.
CO 2	Interpret the robustness of the control system using Robust Stability and Robust Performance measures.
CO 3	Explain the synthesis of stabilising controllers in H_2 and H_∞ .
CO 4	Design sliding mode controllers for a system.
CO 5	Design adaptive controllers for a system .

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										3
CO 2	3	3	3									3
CO 3	3	3										3
CO 4	3	3	3									3
CO 5	3	3	3									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define the various norms of a system.(K1,PO1)

2. Compute the various norms of a system.(K2,PO2)

3. Identify the properness, stabilizability and detectability of the given system.(K2,PO2)

Course Outcome 2 (CO2)

1. Define Robust Stability and Performance of a system. (K1,PO1)

2. Apply Robust Stability and Performance measures for a system.(K3,PO3)

3. Use additive and multiplicative uncertainty to model an uncertain system.(K3,PO2,PO3)

Course Outcome 3(CO3):

1. Explain the formulation of H_2 control. (K2,PO2)

2. Explain the formulation of $H\infty$ control. (K2,PO2)

3. Explain the formulation of controller using mu synthesis. (K2,PO2)

Course Outcome 4 (CO4):

1. Differentiate between variable structure control and SMC.(K2,PO2)

2. Explain the formulation of sliding mode control.(K2,PO3)

3. Explain the method of sliding surface design using pole placement method.(K3,PO3)

Course Outcome 5 (CO5):

1. Illustrate the block diagram of any one adaptive scheme.(K2,PO2)

2. Design a MRAC using MIT rule.(K3,PO3)

3. Distinguish adaptive versus conventional feedback system.(K2,PO2)

Model Question Paper

QP CODE:

PAGES:2

Reg.No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET 448

Course Name: ROBUST AND ADAPTIVE CONTROL

Max. Marks: 100 **Duration:3 Hours**

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 marks

1. Calculate the 2-norm and ∞-norm of the given vector $x = [1 \quad -2 \quad -3 \quad 4]^T$.
$x = [1 \quad -2 \quad -3 \quad 4]^T$
2. Define H_2 and H_∞ norm.
3. Define Small gain theorem.
4. Explain the importance of Sensitivity function in robust control.
5. Formulate the standard LQR problem.
6. Explain the lack of Robustness of LQG control.
7. Differentiate between variable structure control and SMC.
8. What is chattering phenomenon in Sliding mode control? How does it affect the system?
9. Justify the statement “Process variations affect the performance of a system” with example.
10. List three applications of Adaptive control.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 marks

Module 1

11. a) What is observability and controllability grammian. **(8)**

b) What is meant by Singular values of a transfer function matrix? What is their significance. **(6)**

12. a). How is H_∞ norm computed for a SISO system? How is H_∞ norm computation done for a MIMO system? **(8)**

b) The system given by

$$\dot{x} = Ax + Bu\,, y = Cx, where\ A = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & -2 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}$$

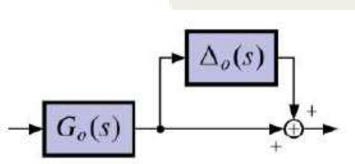
$$\dot{x} = Ax + Bu\,, y = Cx, where\ A = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & -2 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, C = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}$$

Check the stabilizability and detectability of the system. **(6)**

Module 2

13.a) Explain the terms nominal stability, robust stability, nominal performance and robust performance. What are the conditions to be satisfied by a feedback control system for each of the above? **(10)**

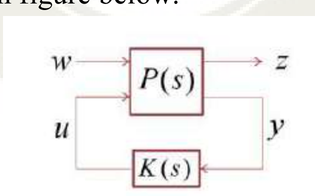
b) Identify the type of uncertainty in the given figure below. Write the mathematical model of the same.



(4)

14. a)Explain the concept of loop shaping in achieving robustness. **(7)**

b) Derive the LFT of the given figure below.



(7)

Module 3

15. a) Determine a LQR controller for the system defined by $\dot{x} = Ax + Bu, where\ A = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ $\dot{x} = Ax + Bu, where\ A = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ such that the performance index $J = \int_0^\infty (x^T x + u^2) dt J = \int_0^\infty (x^T x + u^2) dt$ is minimised. **(8)**

b) Explain the formulation of LQG control. **(6)**

16. a) Explain the formulation of H∞ control. **(6)**

b) What is a structured singular value. Mention the steps in designing a stabilizing controller by mu synthesis. **(8)**

Module 4

17.a) Write down the steps to be followed for designing a sliding mode controller. Also list the main features of sliding mode controllers. **(4)**

b) Design a stabilising variable structure control for a double integrator system **(10)**

18.a) Write two different reaching laws associated with sliding mode control design. Show how they assist the design to satisfy the reachability condition. **(8)**

b) In a sliding mode there exists a finite reaching time $t = t_f$ at which switching function s(t) becomes 0. Derive an expression for t_f in terms of s(0). **(6)**

Module 5

19. a) Explain the design of Self Tuning Regulator by pole placement design. **(8)**

b) Explain the least square estimation for parameter estimation. **(6)**

20. a) Design a MRAC for a first order system using MIT rule. **(8)**

b) Explain with illustration the basic blocks of a MRAS. **(6)**

Syllabus

Module 1: Introduction and mathematical preliminaries(8 hours)

Introduction to robust control

Vector space, linear subspaces, Norm and inner product of real vectors and matrix, Hilbert Spaces , H_2 and H_{inf} Spaces - Computing of H_2 and H_{inf} norms(transfer function and transfer matrices) , Computing of L_2 and L_{inf} Norms, singular value decomposition.

Proper systems, Controllability and Observability Grammians, Concept of Minimal Realisation, Stabilizability and Detectability, Packed form notation- various configurations.

Module 2: Feedback systems and Uncertainty modelling(9 hours)

Single degree and two degree of freedom Robust Control Systems - System Sensitivity, Relation between Sensitivity and disturbance inputs in a feedback system, Sensitivity and Complementary Sensitivity function. Sensitivity and Complementary Sensitivity peak selection- its relation to gain and phase margin - Weighted Sensitivity and weighted complementary sensitivity.

Well-Posedness of Feedback Loop, Internal Stability.

Model Uncertainty - Classification of uncertainties -parametric, structured and unstructured- m-delta configuration- linear fractional transformation-examples.

Nominal Performance, Nominal Stability, Robust Performance and Robust Stability-Small Gain Theorem, Concept of loop shaping.

Module 3: Robust controller design(7 hours)

Introduction to Regulator problem, Standard LQR and LQG problem, control-Lack of Robustness , Introduction to H2 control, Hinf control, mu Synthesis.

Module 4:Design of Sliding mode controllers (7 hours)

Introduction to Variable Structure Systems (VSS) - examples , Introduction to sliding mode control- -sliding surface- examples of dynamical systems with sliding modes, reaching laws-reachability condition, Invariance conditions- chattering-equivalent control, Design of sliding mode controllers using pole placement, LQR method.

Module 5: Introduction to Adaptive Control(7 hours)

Adaptive Control, effects of process variation - Adaptive Schemes - Adaptive Control problem - Applications - RealTime Parameter Estimation: Introduction - Regression Models - Recursive Least Squares, Self Tuning Regulators introduction, pole placement design, Model Reference Adaptive systems (MRAS) - the need for MRAS , MIT rule, MRAS for first order system.

Text Books

1. Sigurd Skogestad and Ian Postewaite, “Muti-variable Feedback Design” (Second Edition), John Wiley, 2005.

2. Kemin Zhou and Doyle J.C, “Essentials of Robust Control”, Prentice-Hall, 1998.

3. C Edwards and Sarah Spurgeon, “ Sliding Mode Control: Theory And Applications”, Taylor and Francis,1998

4. K. J. Astrom and B. Wittenmark, “Adaptive Control”, 2nd Edition, Addison-Wesley, 1995

Reference Books

1. P C Chandrasekharan, “Robust Control of Linear Dynamical Systems”, Academic Press, 1996

2. Richard C. Dorf, Robert H. Bishop, “Modern Control Systems”, Pearson Education, 2008.

3. S. Sastry and M. Bodson, “Adaptive Control”, Prentice-Hall, 1989

3. John C. Doyle, Bruce A. Francis, Allen R. Tannenbaum, “Feedback Control Theory” , Macmillan Pub. Co, 1992

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction and mathematical preliminaries(8 hours)**	
1.1	Introduction to robust control, Vector space, linear subspaces, Norm and inner product of real vectors and matrix,	2
1.2	Hilbert Spaces, H_2 and H_{inf} Spaces - Computing of H_2 and H_{inf} norms(transfer function and transfer matrices) , Computing of L_2 and L_{inf} Norms, singular value decomposition.	3
1.3	Proper systems- various types, Review of Minimal Realisation, Stabilizability and Detectability, Packed form notation- various configuration,	3
2	**Feedback systems and Uncertainty modelling(9 hours)**	
2.1	Single degree and two degree of freedom Robust Control Systems - System Sensitivity, Relation between Sensitivity and disturbance	2

	inputs in a feedback system, Sensitivity and Complementary Sensitivity function.	
2.2	Sensitivity and Complementary Sensitivity peak selection- its relation to gain and phase margin - Weighted Sensitivity and weighted complementary sensitivity. Well-Posedness of Feedback Loop, Internal Stability.	2
2.3	Model Uncertainty - Classification of uncertainties -parametric, structured and unstructured-m-delta configuration- linear fractional transformation-examples.	3
2.4	Nominal Performance, Nominal Stability, Robust Performance and Robust Stability-Small Gain Theorem, Concept of loop shaping.	2
3	**Robust controller design(7 hours)**	
3.1	Introduction to Regulator problem, Standard LQR and LQG problem, control-Lack of Robustness ,	3
3.2	Introduction to H2 control, Hinf control, mu Synthesis.	4
4	**Design of Sliding mode controllers (7 hours)**	
4.1	Introduction to Variable Structure Systems (VSS)- examples , Introduction to sliding mode control- -sliding surface- examples of dynamical systems with sliding modes , reachability condition, Invariance conditions- chattering-equivalent control	5
4.2	Design of sliding mode controllers using pole placement, LQR method.	2
5	**Introduction to Adaptive Control(7 hours)**	
5.1	Adaptive Control, effects of process variation - Adaptive Schemes - Adaptive Control problem - Applications	1
5.2	RealTime Parameter Estimation: Introduction - Regression Models - Recursive Least Squares,	2

5.3	Self Tuning Regulators introduction, pole placement design,	2
5.4	Model Reference Adaptive systems (MRAS) - the need for MRAS , MIT rule, MRAS for first order system.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET458	SOLAR PV SYSTEMS	PEC	2	1	0	3

Preamble: This course introduces solar PV system and its grid integration aspects. It also give insight to basic knowhow for the implementation of Solar PV system utilizing modern simulation software.

Prerequisite : Nil

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Explain the basics of solar energy conversion systems.(K1)
CO 2	Design a standalone PV system. (K3)
CO 3	Demonstrate the operation of a grid interactive PV system and its protection against islanding.(K2)
CO 4	Utilize life cycle cost analysis in the planning of Solar PV System (K3)

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1										1
CO 2	3	3	3									2
CO 3	3	3	2									2
CO 4	3	3	2	1	2						1	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	25	25	50
Apply (K3)	15	15	30
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain what do you mean by solar constant (K1, PO1)
2. Discuss about the different instruments used for measuring solar radiation and sun shine (K2,PO2)

Course Outcome 2 (CO2):

1. Design a stand alone PV system. (K3, PO1, PO2, PO3)
3. Design an off grid PV system to backup 10kW system for 3 hours and draw the block level representation of the final system. (K3, PO1, PO2, PO3)

Course Outcome 3 (CO3):

1. Demonstrate the operation of a grid connected PV system. (K2, PO1, PO2,PO3).
2. Summarize the protection of PV system against islanding and reverse power flow. (K2, PO1, PO2,PO3).

Course Outcome 4 (CO4):

1. The life cycle cost of a system is Rs. 10000/- for a life period of 20 years. The rate of interest is 8% and the inflation rate is 5%. What is the annual life cycle cost for the system? (K3, PO1, PO2,PO3)
2. Design a grid connected PV system utilizing a suitable simulation software. (K3, PO1, PO2,PO3,PO4,PO5)

Model Question Paper

QP CODE:

PAGES:2

Reg. No:_______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE
EXAMINATION, MONTH & YEAR

Course Code: EET458

Course Name: SOLAR PV SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain briefly what do you mean by solar azimuth angle and zenith angle.
2. Differentiate between extraterrestrial and terrestrial solar radiation.

3. Write notes on the working of a solar cooker.
4. Discuss what do you mean by a solar green house.
5. Write notes on the different materials used for making solar cells.
6. Discuss the characteristics of a solar cell.
7. Give a description on of Power Quality related IEEE standards for distributed resource grid integration
8. Differentiate SoC and DoD of storage battery .
9. Write notes on the planned and unplanned islanding .
10. Explain life-cycle cost of renewable energy system.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a.With the help of a neat diagram, explain the working of a pyrheliometer. (7)
    b. Explain how monthly average solar radiation on inclined surfaces can be calculated. (7)
12. a. State the reasons for variation in the amount of solar energy reaching earth surface. (4)
    b.With the help of a neat diagram, explain the working of a sunshine recorder. (6)
    c. Explain the difference in the working of pyrheliometer and pyranometer. (4)

Module 2

13. a. Explain the different types of solar collectors based on the way they collect solar radiation. (7)
    b. Explain in detail, the working of a solar air conditioning system (7)
14. a.With the help of a diagram, explain the function of different components of a flat plate solar collector. (7)
    b. Design a solar water heater for domestic application. (7)

Module 3

15. a. Write notes on the efficiency of a solar cell. (3)
    b. Discuss the effect of shadowing on the performance of solar cells. (3)
    c. Explain how maximum power point tracking can be done using buck-boost converter. (8)
16. a. Compare the performance of single junction and multijunction PV modules. (4)
    b. Write notes on packing factor of a PV module. (3)
    c. Explain the Perturb and Observe MPPT method. Compare with incremental conductance method. (7)

Module 4

17.

a. Design an off grid PV system to backup 10kW system for 3 hours and draw the block level representation of the final system. (7)

b. Explain with a neat sketch, the working principle of a grid connected solar system. (7)

18.

a. In a water pumping system, the water is being pumped from a sump to an overhead tank situated 25m above ground. The sump bottom is 2m below ground. The motor-pump system is located at ground level. The water is being pumped at the rate of 24.6 litres/sec. The pipe inner diameter is 10 cm. The pipe is placed completely vertical with no horizontal part. The friction factor is 0.037. The efficiencies of the pump, motor and dc-dc converter are 70%, 80% and 90% respectively. If the system is being powered by a PV source, what is the output power requirement for the PV panels? (7)

b. Explain the voltage and frequency matching method in grid connected PV system. (7)

Module 5

19.

a. Detail the anti-islanding protection with suitable block diagram. (7)

b. The life cycle cost of a system is Rs. 10000/- for a life period of 20 years. The rate of interest is 8% and the inflation rate is 5%. What is the annual life cycle cost for the system? (7)

20.

a. Draw and explain the line of protection equipment in PV array installation. (6)

b. Suppose the energy-efficiency retrofit of a large building reduces the annual electricity demand for heating and cooling from 2.3 × 106 kWh to 0.8 × 106 kWh and the peak demand for power from by 150 kW. Electricity costs Rs. 5/kWh and demand charges are Rs. 500/kW per month, both of which are projected to rise at an annual rate of 5%. If the project costs Rs. 3,50,00,000, what is the internal rate of return over a project lifetime of 15 years? (8)

Syllabus

Module 1

Introduction - Basic Concept of Energy -Source of Solar Energy -Formation of the Atmosphere - Solar Spectrum. Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer - Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extra-terrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors -Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces .

Module 2

Solar Thermal system-Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation. Applications -Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse - Design of solar water heater

Module 3

Solar PV Systems-Introduction -Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell - Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III–V Single Junction and Multifunction PV Modules-Emerging and New PV Systems -Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-MPPT Techniques-P&O , incremental conductance method-Maximum Power Point Tracker (MPPT) using buck-boost converter.

Module 4

Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system – Storage batteries and Ultra capacitors. Design PV powered DC fan and pump without battery-Design of Standalone System with Battery and AC or DC Load. A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter –Overview of IEEE -2018 Standard for Interconnecting Distributed Resources with Electric Power Systems

Module 5

Protection Against Islanding and Reverse Power Flow – AC Modules Design of EMI Filters. Overcurrent protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications.

Life cycle costing, Growth models, Annual payment and present worth factor, payback period, LCC with examples. Introduction to simulation software for solar PV system design.*(An assignment can be given corresponding to CO2,CO3 and CO4 utilizing the simulation tools)*

Text book:

1. D.P. Kothari, M Jamil. Grid Integration of Solar Photovoltaic Systems, CRC Press 2018

2. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies And Applications 3rd Edition, PHI
3. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002
4. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977

References:

1. Masters, Gilbert M., Renewable and efficient electric power systems, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
2. A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994.
3. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd Renewable energy systems, Pearson 2017
4. G. N. Tiwari,ArvindTiwari,Shyam, Handbook of Solar Energy: Theory, Analysis and Applications, springer,2016.
5. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
6. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
7. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009.
8. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
9. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
10. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
11. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
12. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996.
13. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy – Sources for Fuel and Electricity, Earth scan Publications, London, 1993.
14. Tara Chandra Kandpal, Hari Prakash Garg, Financial evaluation of renewable energy technologies, Mac Millam India Limited.,2003.
15. "IEEE Application Guide for IEEE Std 1547(TM), IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems," in IEEE Std 1547.2-2008 , vol., no., pp.1-217, 15 April 2009, doi: 10.1109/IEEESTD.2008.4816078

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Solar energy (7 hours)**	
1.1	Introduction - Basic Concept of Energy -Source of Solar Energy - Formation of the Atmosphere - Solar Spectrum.	1
1.2	Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer – Pyranometer -Sunshine Recorder	2
1.3	Solar Radiation on a Horizontal Surface –Extra-terrestrial Region.- Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors	2
1.4	Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces.	2
2	**Solar Thermal Systems (6 hours)**	
2.1	Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics	1
2.2	Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation.	2
2.3	Applications -Solar heating system, Air conditioning and Refrigeration system	1
2.4	Pumping system, solar cooker, Solar Furnace, Solar Greenhouse	1
2.5	Design of solar water heater	1
3	**Solar PV systems (7 Hours)**	
3.1	Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials	2
3.2	Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III–V Single Junction and Multijunction PV Modules -Emerging and New PV Systems	1
3.3	Packing Factor of the PV Module - Efficiency of the PV Module - Energy Balance Equations for PV Modules	1
3.4	Series and Parallel Combination of PV Modules.- Effect of shadowing-	1
3.5	MPPT Techniques-P&O , incremental conductance methd-Maximum Power Point Tracker (MPPT) using buck-boost converter.	2

4	**Stand Alone and Grid integrated PV System (9 Hours)**	
4.1	Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors.	2
4.2	Design PV powered DC fan and pump without battery	2
4.3	Design of Standalone System with Battery and AC or DC Load.	2
4.4	A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter	2
4.5	IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems	1
5	**GIPV System Protection and LCC (7)**	
5.1	Protection Against Islanding and Reverse Power Flow	1
5.2	AC Modules Design of EMI Filters. .	1
5.3	Overcurrent protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications	2
5.4	Life cycle costing, Growth models, Annual payment and present worth factor, payback period of solar PV system, LCC with examples.	2
5.5	Introduction to simulation software for solar PV system design like PV syst, PV SOL etc.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET468	INDUSTRIAL INSTRUMENTATION AND AUTOMATION	PEC	2	1	0	3

Preamble: This course introduces basic terms and techniques applicable to instrumentation and various automation activities related to the industry and power sector. It also provides a basic idea of the recent developments in communication techniques and process control in industrial automation.

Prerequisite : Basics of Analog and digital electronics, control systems

Course Outcomes : After the completion of the course, the student will be able to:

CO 1	Identify the sensors/transducers suitable for industrial applications.
CO 2	Design the signal conditioning circuits for industrial instrumentation and automation.
CO 3	Analyze the concepts of data transmission and virtual instrumentation related to automation
CO 4	Develop the logic for the process control applications using PLC programming
CO 5	Describe the fundamental concepts of DCS and SCADA systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	1										2
CO 2	3	1										2
CO 3	3	1										2
CO 4	3	1										2
CO 5	3	1										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	30	30	60
Apply (K3)	10	10	20
Analyse (K4)			
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain different characteristics of transducers (K2)
2. Selection of transducers for various applications (K2, K3)

Course Outcome 2 (CO2):

1. Explain amplifier circuits used for signal conditioning in instrumentation systems (K2)
2. Explain different types of actuators used in instrumentation system (K2)

Course Outcome 3 (CO3):

1. Explain the protocols used in data transmission for instrumentation system (K2)
2. Describe the differences between traditional instruments and virtual instruments (K2)

Course Outcome 4 (CO4):

1. Describe the hardware details of programmable logic controllers (K2)
2. Implement logic gates and simple operations using PLC (K2, K3)

Course Outcome 5 (CO5):

1. Explain the architecture and protocols involved in SCADA systems (K2)
2. Describe the architecture of Distributed Control Systems (K2)

Model Question Paper

QP CODE:

PAGES:2

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER
B. TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET468

Course Name: INDUSTRIAL INSTRUMENTATION AND AUTOMATION

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each Question Carries 3 mark

1. State the factors to be considered while selecting a transducer for a specific application.
2. Explain different modes of operation of hotwire anemometer.
3. How can a log amplifier be used for signal conditioning?
4. Describe the working of electrical actuators
5. Compare Profibus and Fieldbus used in data transmission
6. List the advantages of virtual instrumentation systems
7. Implement basic gate operations using PLC ladder logic
8. Write a PLC program to obtain a delay of 10ms for process control
9. List the main components associated with SCADA Systems.
10. Explain different protocols used in SCADA communication

PART B

Answer any one full question from each module. Each question carries 14 marks.

Module 1

11.	a) With the help of a diagram explain the process control loop.	(10)
	b) Explain second order time response of sensor.	(4)
12.	a) Explain the principal and operation of variable reluctance tachometer	(7)
	b) Discuss the working principle of Capacitive differential pressure measurement	(7)

Module 2

13. a) Explain different types of actuators. (10)
    b) Explain the working principle of charge amplifier. (4)

14. a) Explain the operation of Instrumentation amplifier (7)
    b) How phase sensitive detectors can be employed for phase measurement. (7)

Module 3

15. a) Explain the architecture of Virtual instrumentation system (10)
    b) Describe the concept of graphical programming (4)

16. a) Explain the different types of communication networks used for data collection and control in industrial applications (10)

    b) Explain Field bus. (4)

Module 4

17. Devise a ladder program to switch on a pump for 100 s. It is then to be switched off , and a heater switched on for 50 s. Then the heater is switched off, and another pump is used to empty the water. (14)

18. Draw a block diagram of a PLC showing the main functional items and how buses link them, explaining the functions of each block (14)

Module 5

19. a) With neat diagram explain the architecture of Distributed control system (7)
    b) Describe in detail protocols for SCADA communication (7)

20. a) Explain role of MTU in SCADA communication (4)
    b) With neat diagram explain the architecture of SCADA system (10)

Syllabus		
Module	**Contents**	**Hours**
I	**Sensors and Transducers** Introduction to Process Control - block diagram of the process control loop, definition of elements. Sensor time response - first and second-order responses. Transducers- Characteristics and Choice of the transducer. Applications of Transducers- Displacement measurement using Resistance Potentiometer- Capacitive differential pressure measurement, Flow measurement using Hotwire anemometer, speed measurement- Variable reluctance tachometers, Phase measurement- Analog and digital	7
II	**Signal conditioning circuits and Final control** Electronic amplifiers-Differential Amplifier, Instrumentation Amplifiers, Precision rectifiers, Log amplifiers, Carrier Amplifiers, Lock-In Amplifiers, Isolation Amplifiers, Charge amplifiers, Phase-sensitive detectors. Final control operation- signal conversion- actuators- control elements, Actuators- Electrical – Pneumatic- Hydraulic, Control elements-mechanical- electrical- fluid valves	6
III	**Data transmission and Virtual instrumentation system** Cable transmission of analog and digital data, Fiber optic data transmission, Pneumatic transmission. Process control Network- Functions- General characteristics- Fieldbus and Profibus, radio-wireless communication, WLAN architecture. Virtual instrumentation system: The architecture of virtual instruments – Virtual instruments and traditional instruments – concepts of graphical programming	7
IV	**Programmable logic controllers (PLC)** Programmable logic controllers- Organization- Hardware details- I/O- Power supply- CPU- Standards Programming aspects- Ladder programming- realization of AND, OR logic, the concept of latching, Introduction to Timer/Counters, Exercises based on Timers and Counters.	7
V	**SCADA and DCS systems** **SCADA**: Introduction, SCADA Architecture, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Protocols-IEC 60870-5-101 and DNP3. **DCS:** Introduction, DCS Architecture, Control modes.	5

Text Books

1. Curtis D Johnson , "Process Control Instrumentation Technology", PHI Learning Pvt Ltd New Delhi, 1997
2. Doeblin E.O, "Measurement Systems: Application and Design", Fourth Edition, McGraw Hill, Newyork, 1992
3. DVS. Murty, "Transducers and Instrumentation", Second Edition, PHI Learning Pvt Ltd New Delhi, 2013
4. Jovitha Jerome, "Virtual instrumentation using LabVIEW", Prentice Hall of India, 2010.
5. William Bolton, "Programmable Logic Controllers", Fifth edition, ELSEVIER INDIA Pvt Ltd New Delhi, 2011
6. Stuart A. Boyer, "SCADA: Supervisory Control and Data Acquisition", Fourth edition, International Society of Automation, 2010

References:

1. G.K.McMillan, 'Process/Industrial Instrument and control and hand book' McGraw Hill, New York,1999
2. Michael P .Lucas, 'Distributed Control system', Van Nastrant Reinhold Company, New York
3. Patranabis, D., 'Principles of Industrial Instrumentation', Second Edition Tata McGraw Hill Publishing Co. Ltd. New Delhi
4. Robert B. Northrop, 'Introduction to instrumentation and measurements', CRC, Taylor and Francis 2005

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Sensors and Transducers (07 hours)**	
1.1	Introduction to Process Control - block diagram of the process control loop, definition of elements. Sensor time response - first and second-order responses.	2
1.2	Transducers- Characteristics and Choice of transducer.	1
1.3	Applications of Transducers- Displacement measurement using Resistance Potentiometer- Capacitive differential pressure measurement	2
1.4	Flow measurement using Hotwire anemometer, speed measurement- Variable reluctance tachometers, Phase measurement- Analog and digital	2
2	**Signal conditioning circuits and Final control (06 hours)**	
2.1	Electronic amplifiers-Differential Amplifier, Instrumentation Amplifiers, Precision rectifiers, Log amplifiers, Carrier Amplifiers	2
2.2	Lock-In Amplifiers, Isolation Amplifiers, Charge amplifiers, Phase sensitive detectors	2

2.3	Final control operation- signal conversion- actuators- control elements Actuators- Electrical – Pneumatic- Hydraulic Control elements-mechanical- electrical- fluid valves	2
3	**Data transmission and Virtual instrumentation system(07Hours)**	
3.1	Cable transmission of analog and digital data, Fiber optic data transmission, Pneumatic transmission	2
3.2	Process control Network- Functions- General characteristics- Fieldbus and Profibus, radio and wireless communication and WLAN	2
3.3	Virtual instrumentation system: architecture of virtual instruments – Virtual instruments and traditional instruments – concepts of graphical programming	3
4	**Automation using PLC (07 Hours)**	
4.1	Programmable logic controllers- Introduction	1
4.2	Organisation and Hardware details - I/O- Power supply- CPU etc.	2
4.3	Standards Programming aspects- Ladder programming- realization of AND, OR logic, concept of latching,	2
4.4	Introduction to Timer/Counters, Exercises based on Timers and Counters	2
5	**Automation using SCADA and DCS Systems (05 Hours)**	
5.1	Introduction to SCADA, its Architecture and Common System Components	1
5.2	Supervision and Control, HMI, RTU and Supervisory Stations, Protocols-IEC 60870-5-101 and DNP3.	3
5.3	DCS: Introduction, DCS Architecture, Control modes.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET478	BIG DATA ANALYTICS	PEC	2	1	0	3

Preamble: This course is offered to introduce fundamental algorithmic ideas in processing data. The preliminary concepts of Hadoop and Map Reduce are included as part of this course.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the key concepts of data science.
CO 2	Describe big data and use cases from selected business domains
CO 3	Perform big data analytics using Hadoop and related tools like Pig and Hive.
CO 4	Perform preliminary analytics using R language on simple data sets.
CO 5	Differentiate various learning approaches in machine learning to process data, and to interpret the concepts of supervised and unsupervised learning

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											2
CO 2	3											2
CO 3	3	2	2		3							2
CO 4	3	2			3							2
CO 5	3	2			3							2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	15	15	30
Understand	25	25	50
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the main categories of data that we come across in data science. (K1)
2. Summarize distributed file system with examples. (K1)
3. List the significance of data science. (K2)

Course Outcome 2 (CO2)

1. What are the three characteristics of Big Data, and what are the main considerations in processing Big Data?(K1)
2. Explain Big Data Analytics Lifecycle. (K1)
3. Explain Apache Hadoop ecosystem. (K1)

Course Outcome 3(CO3):

1. Demonstrate the map reduce execution flow to perform word count on data set.(K3)
2. Explain the stages of Map Reduce. (K2)
3. Write short notes on Pig and Hive. (K1)

Course Outcome 4 (CO4):

1. How do you list the preloaded datasets in R? (K2)
2. Use R to find the highest common factor of two numbers. (K3)
3. Why is R useful for data science? (K2)

Course Outcome 5 (CO5):

1. Mention the difference between Data Mining and Machine learning? (K2)
2. What are the different Algorithm techniques in Machine Learning? (K2)
3. Give a popular application of machine learning that you see on day-to-day basis? (K2)

Model Question Paper

QP CODE: **Reg No:______________**

PAGES:3 **Name :______________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER

B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: EET478

Course Name: BIG DATA ANALYTICS

Max. Marks: 100 Duration: 3 Hours

(2019-Scheme)

PART A

(Answer all questions, each question carries 3 marks)

1. List any six Data Science applications.
2. Briefly explain the data transformation step in the process of Data Science.
3. Explain the important characteristics of Bigdata.
4. List the functions of Namenode in HDFS.
5. Identify the need of MapReduce Partitioner in Hadoop.
6. Differentiate between Hadoop MapReduce and Pig.
7. In R how missing values are represented.
8. How you can import Data in R.
9. Discuss any four examples of machine learning applications.
10. Describe the applications of clustering in various domains.

(10x3 = 30 marks)

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11.a) Illustrate with an example different stages of data science project.

b. Categorise the different roles associated with a data analysis project. (10+4 =14 marks)

Or

12. a) Explain the data cleansing subprocess of data science process.

b) Discuss in detail about Exploratory Data analysis. (8+6 =14 marks)

MODULE II

13.a) Explain the core components of Apache Hadoop.

b) Write short note on YARN. (8+6 = 14 marks)

Or

14. a) Explain read and write operations in HDFS.

b) What are Blocks in HDFS Architecture. (10+4 = 14 marks)

MODULE III

15.a) With a neat diagram, explain MapReduce architecture?

b) Describe the stages of MapReduce with an example. (5+9 = 14 marks)

Or

16. a) Write short note on Pig and HIVE.

b) Compare NoSQL & RDBMS (10+4 = 14 marks)

MODULE IV

17.a) Explain data frames in R. Illustrate attach (), detach () and search () functions in R.
b) Explain any three functions in R to visualize a single variable. (8+6 = 14 marks)

Or

18. a) What are the data structures in R that is used to perform statistical analyses and create graphs?
b) Mention how you can produce co-relations and covariances with example?
(9+5 = 14 marks)

MODULE V

19.a) Distinguish between classification and regression with an example.
b) Describe in detail with examples (i) Supervised Learning(ii) Unsupervised Learning (iii) Reinforcement Learning. (5+9 = 14 marks)

Or

20. a) Is regression a supervised learning technique? Justify your answer. Compare regression with classification with examples.?
b) Illustrate K means clustering algorithm with an example.? (8+6 = 14 marks)

Syllabus

Module I-Data science in a big data world: Benefits and uses of data science and big data-Facets of data-the big data ecosystem and data science-Data science process-roles-stages in data science project- Defining research goals-Retrieving data-Cleansing, integrating, and transforming data- Data Exploration-Data modelling - Presentation and automation.

(6 hours)

Module II-Big Data Overview–the five V's of big data-State of the Practice in Analytics-Examples of Big Data Analytics-Apache Hadoop and the Hadoop Ecosystem-HDFS-Design of HDFS, HDFS Concepts-Daemons-Reading and Writing Data-Managing File system Metadata- Map Reduce-The Stages of Map Reduce -Introducing Hadoop Map Reduce-Daemons-YARN (8 hours)

Module III-Analysing the Data with Hadoop using Map and Reduce-Developing a Map Reduce Application-Anatomy of a Map Reduce Job- Scheduling-Shuffle and Sort - Task execution.

Big data Management Tools: PIG- : Introduction to PIG, Execution Modes of Pig,Pig Latin, HIVE: Hive Architecture, HIVEQL, Introduction to NoSQL. (Introduction only)

(7 hours)

Module IV -Review of Basic Analytic methods using R- Introduction to R -Data Import and Export -Attribute and Data Types - ordered and unordered factors-arrays and matrices-lists and data frames -Descriptive Statistics-Exploratory Data Analysis-Dirty Data-Visualizing a Single Variable-Examining Multiple Variables-statistical models in R-Graphical Procedures-High-level plotting commands-Low-level plotting commands.

(7 hours)

Module V -Machine learning -Introduction to Machine Learning, Examples of Machine Learning applications-Supervised Learning- Regression – Single variable, Multi variable-Classification – Logistic Regression- Unsupervised Learning - Clustering: K-means-Reinforcement Learning-Model Selection and validation-k-Fold Cross Validation-Measuring classifier performance- Precision, recall

(7 hours)

Text/ Reference Books

1. Davy Cielen, Arno D. B. Meysman, and Mohamed Ali ,"Introducing Data Science - Big data, machine learning, and more, using Python tools" , Dreamtech Press 2016
2. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses",Wiley,2013
3. EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", Wiley ,January 2015
4. Tom White,"Hadoop: The Definitive Guide", Third Edition, O'Reilley,2012.
5. Eric Sammer,"Hadoop Operations",O'Reilly Media, Inc ,2012
6. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
7. "Programming Pig", Alan Gates, O'Reilley,2011.

8. Ethem Alpaydın, "Introduction to Machine Learning (Adaptive Computation and Machine Learning)", MIT Press, 2004.
9. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014
10. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
11. Matloff, Norman," The art of R programming: A tour of statistical software design". No Starch Press, 2011.
12. Crawley, Michael J. The R book. John Wiley & Sons, 2012.
13. Sourabh Mukherjee, Amit Kumar Das and Sayan Goswami, " Big Data Simplified", Pearson, 1st edition, 2019.
14. Murtaza Haider, "Getting Started with Data Science", Fist Edition, Kindle Edition, IBM Press, 2015.
15. Thomas Erl, Wajid Khattak and Paul Buhler " Big Data Fundamentals:Concepts, Drivers and Techniques", Prentice Hall, Pearson Service, 2016.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module I Data science in a big data world**	**6 hours**
1.1	Data science in a big data world, Benefits and uses of data science and big data-Facets of data	1
1.2	the big data ecosystem and data science-Data science process-roles	1
1.3	Defining research goals-Retrieving data	1
1.4	Cleansing, integrating, and transforming data	1
1.5	Data Exploration	1
1.6	Data modelling - Presentation and automation.	1
2	**Module II -Big Data Overview**	**8 hours**
2.1	the five V's of big data-State of the Practice in Analytics-Examples of Big Data Analytics	1
2.2	Apache Hadoop and the Hadoop Ecosystem- HDFS	2
2.3	Design of HDFS- HDFS Concepts-Daemons-Reading and Writing Data - Managing Filesystem Metadata	2
2.4	Map Reduce-The Stages of MapReduce -Introducing Hadoop MapReduce-Daemons	2
2.5	YARN	1
3	**Module III - Analysing the Data with Hadoop**	**7 hours**
3.1	**Analysing the Data with Hadoop using Map and Reduce-** Developing a Map Reduce Application	1
3.2	Anatomy of a Map Reduce Job- Scheduling-Shuffle and Sort -Task execution	2
3.3	Bigdata Management Tools: PIG- : Introduction to PIG, Execution Modes of Pig,Pig Latin	2
3.4	HIVE: Hive Architecture, HIVEQL,	1

3.5	Introduction to NoSQL	1
4	**Module IV -Review of Basic Analytic methods using R**	**7 hours**
4.1	Introduction to R -Data Import and Export -Attribute and Data Types - ordered and unordered factors-arrays and matrices	2
4.2	lists and data frames -Descriptive Statistics	1
4.3	Exploratory Data Analysis -Dirty Data	1
4.4	Visualizing a Single Variable-Examining Multiple Variables	1
4.5	statistical models in R-.	1
4.6	Graphical Procedures-High-level plotting commands-Low-level plotting commands	1
5	**Module V - Machine learning**	**7 hours**
5.1	Introduction to Machine Learning, Examples of Machine Learning applications	1
5.2	Supervised Learning- Regression – Single variable, Multi variable	2
5.3	Classification – Logistic Regression	1
5.4	Unsupervised Learning - Clustering: K-means	1
5.5	Model Selection and validation-k-Fold Cross Validation	1
5.6	Measuring classifier performance- Precision, recall	1

SEMESTER VIII

MINOR

EED482	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini Project : A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Chemical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

- Survey and study of published literature on the assigned topic;
- Preparing an Action Plan for conducting the investigation, including team work;
- Working out a preliminary Approach to the Problem relating to the assigned topic;
- Block level design documentation
- Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;
- Preparing a Written Report on the Study conducted for presentation to the Department;

CO1	Identify and synthesize problems and propose solutions to them.
CO2	Prepare work plan and liaison with the team in completing as per schedule.
CO3	Validate the above solutions by theoretical calculations and through experimental
CO4	Write technical reports and develop proper communication skills.
CO5	Present the data and defend ideas.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	**20**
2	Project Guide	**30**
3	Final Seminar evaluation by the committee	**30**
4	The report evaluated by the evaluation committee	**20**
	Total	**100**
	Minimum required to pass	**50**

The evaluation committee comprises a panel of HoD or a senior faculty member, Project coordinator and project supervisor.

SEMESTER VIII

HONOURS

EED496	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini Project : A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Chemical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

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- Preparing an Action Plan for conducting the investigation, including team work;
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CO1	Identify and synthesize problems and propose solutions to them.
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Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

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