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

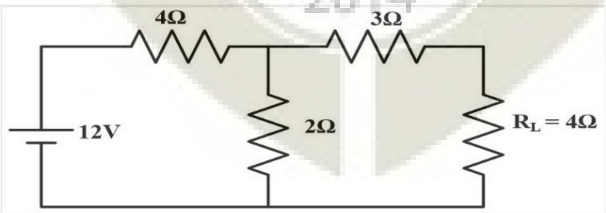
1. Compare the analogy between Nodal and Mesh analysis method.
2. State and explain superposition theorem with suitable examples.
3. Differentiate between transient and steady state analysis.
4. Explain Initial value and final value theorem.
5. Define Self-inductance, Mutual inductance and coupling coefficient.
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

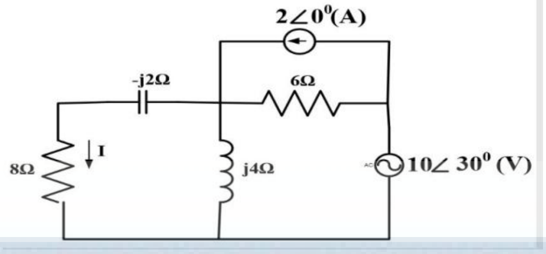
Module-1

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)**

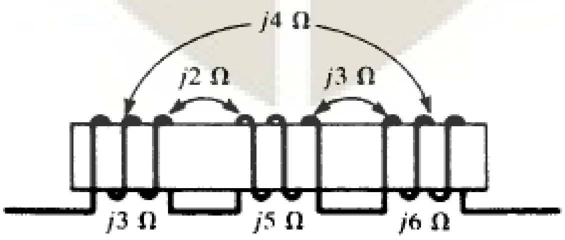
(b) Explain the term time constant with respect to series RL circuit with suitable figures. **(7)**

Module-3

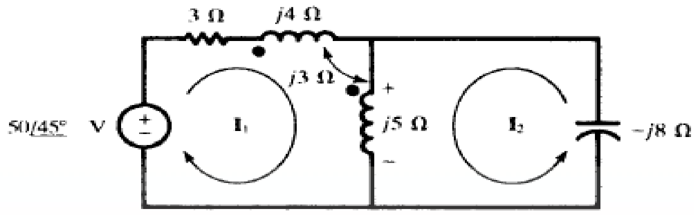
15. (a) In a series aiding connection, two coupled coils have an equivalent inductance LAand in a series opposing connection, the equivalent inductance is LB. Obtain an expression for M in terms of LA and LB. **(7)**

(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)**

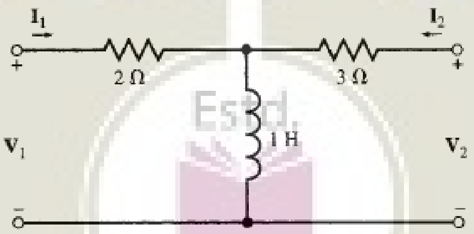
18. (a) A three-phase, three-wire, balanced, delta-connected load yields wattmeter readings of 154W and 557W. Obtain the load impedance, if the line voltage is 141.4 V. **(7)**

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

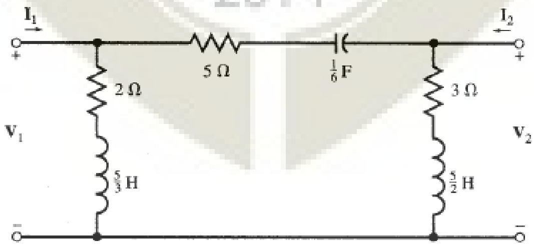
Module-5

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
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
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)**

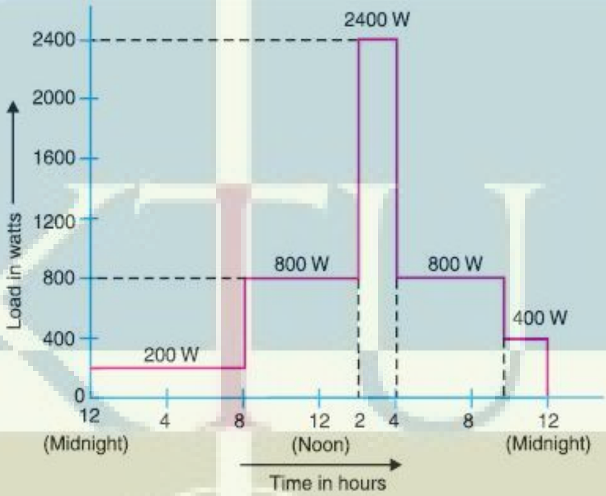
(b) Explain the general layout of a nuclear power plant. **(6)**

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
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

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

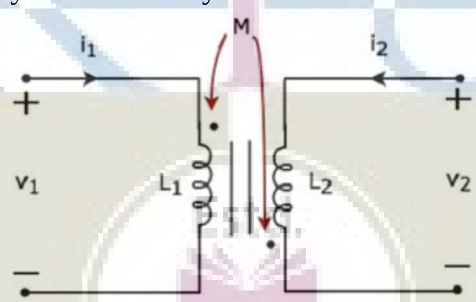
Max. Marks: 100

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?

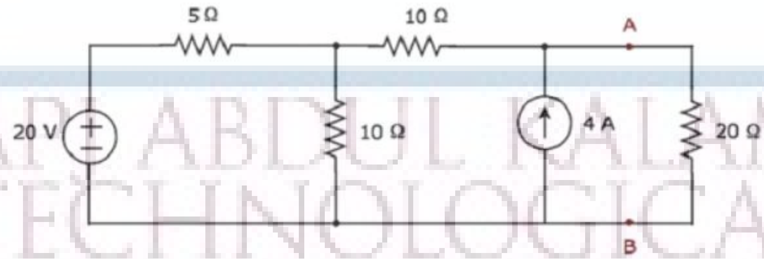
(10 x 3 = 30)

PART B

Answer any one full question, each carries14 marks.

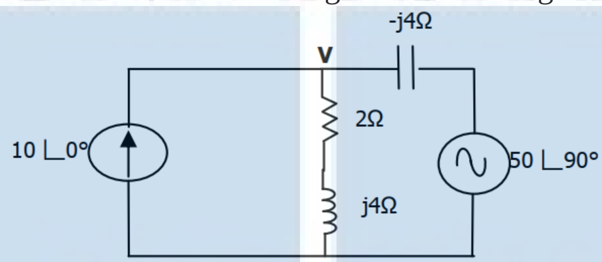
MODULE1

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)**

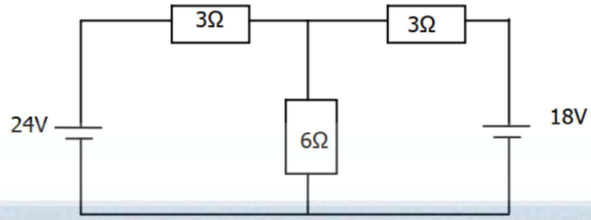
MODULE III

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

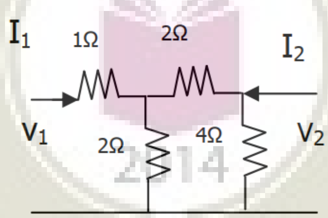
iii) Dynamic resistance of the circuit. **(7)**

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

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)**

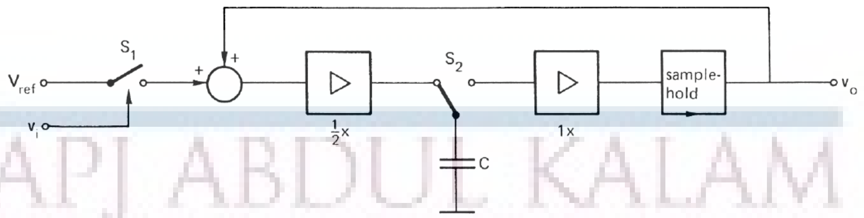
    b) The integration period of an integrating AD-converter is 100 ms ±1 μs.Determine the maximum conversion error caused by a 50 Hz interferencesignal withrms value of 1 V. **(6)**
    c)Explain R-2R ladder digital to analog converter operation. **(4)**

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

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	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
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	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
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.

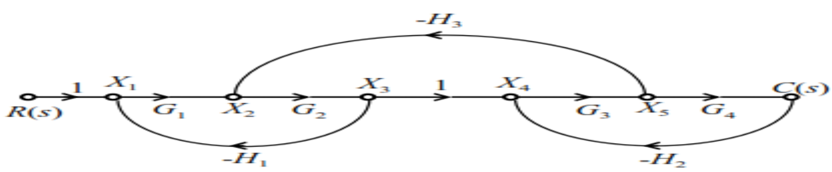
PART B

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

Module 1

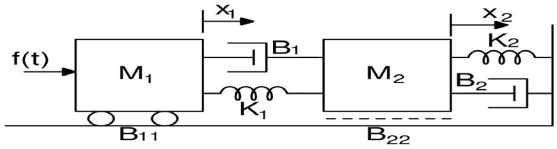
11 a) Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. **(8)**

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:

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad [y] = [1 \quad 0][X] \text{ with } x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$ **(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

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 2 \\ -12 & -7 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u; \quad [y] = [1 \quad 0 \quad 0][X]$$

(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

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**

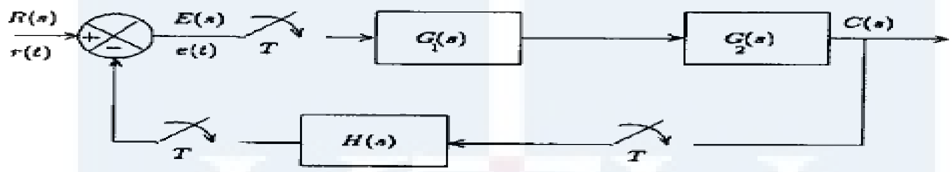
PART A

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)**

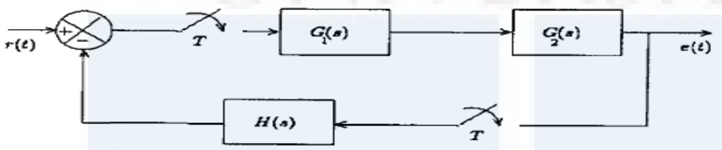
b) Write short notes on:
   i) Aliasing effect
   ii) Importance of First order hold circuit
   iii) Region of convergence for ZT **(10)**

Module 2

13 a) i) Obtain the direct form realization for the system described by the difference equation: $y(n)-\frac{5}{6}y(n-1)+\frac{1}{6}y(n-2)=2x(n)$

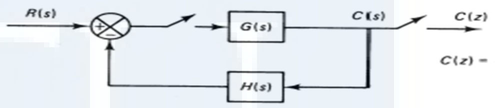
ii) Also determine the impulse response h(n) for the above system. **(3+5)**

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.

$$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3x_2^{\,2} & -2 \end{bmatrix} X$$

(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

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.

EED482	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

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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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