SEMESTER V

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

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

Prerequisite : EET 201 Circuits and Networks

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

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

Model Question paper

QP CODE:

PAGES:4

Reg.No:______________

Name:______________

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

Course Code: EET 301

Course Name: POWER SYSTEMS I

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

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

PART B (14 x 5 = 70 Marks)

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

Module 1

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

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

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

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

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

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

Module 2

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

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

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

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

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

Module 3

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

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

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

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

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

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

Module 4

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

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

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

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

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

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

Module 5

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

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

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

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

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

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

Syllabus

Module I (9 Hours)

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

Module II (10 hours)

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

Module III (10 hours)

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

Module IV (12 hours)

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

Module V (7 hours)

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

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

References:

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

Course Contents and Lecture Schedule:

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

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

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

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

Prerequisite: Fundamentals of Digital Electronics, C Programming

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

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

Mapping of course outcomes with program outcomes

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

Assessment Pattern:

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3(CO3):

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

Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

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

Model Question Paper

QP Code: Pages: 2

Reg No: ___________________

Name: ____________________

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

Course Code: EET303
Course Name: MICROPROCESSORS AND MICROCONTROLLERS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks

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

PART B

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

Module 1

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

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

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

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

Module 2

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

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

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

    (b) Explain the operation of DAA instruction in 8085 microprocessor. **(6)**

Module 3

15. (a) Explain the address decoding technique in memory interfacing. **(8)**

    (b) Give the control word format for BSR and I/O Mode in 8255. **(6)**

16. (a) Explain the architecture of 8051 microcontroller. **(8)**

    (b) Explain hard and soft real time systems. **(6)**

Module 4

17. (a) Explain the different methods to create a time delay in 8051 microcontroller. **(7)**

    (b) Explain the different addressing modes of 8051 microcontroller? **(7)**

18. (a) Explain the various types of instructions in 8051 microcontroller? **(6)**

    (b) Write a Program in 8051 for the generation of square wave having a duty ratio of 0.5 for a time period of 1ms. **(8)**

Module 5

19. (a) Explain how a DAC can be interfaced to 8051 microcontroller. **(10)**

    (b) Explain the role of SBUF and SCON registers used in 8051 microcontroller. **(4)**

20. (a) Describe the generation of time delay using the timer of 8051 microcontroller. **(8)**

    (b) Explain the various interrupts in 8051 microcontroller. **(6)**

Syllabus

Module 1

Internal architecture of 8085 microprocessor–Functional block diagram

Instruction set-Addressing modes - Classification of instructions - Status flags.

Machine cycles and T states – Fetch and execute cycles- Timing diagram for instruction and data flow.

Module 2

Introduction to assembly language programming- Data transfer operations, arithmetic operations, logic operations, branching operations, I/O and machine control operations.

Assembly language programmes (ALP) in 8085 microprocessor- Data handling/Data transfer, Arithmetic operations, Code conversion- BCD to Binary - Binary to BCD, Sorting - Ascending and descending including bubble sorting.

Stack and subroutines – Conditional CALL and Return instructions

Time delay subroutines using 8 bit register, 16 bit register pair and Nested loop control.

Module 3

Interrupt & interrupt handling - Hardware and Software interrupts.

I/O and memory interfacing – Address decoding– Interfacing I/O ports -Programmable Peripheral Interface PPI 8255 - Modes of operation- Interfacing of seven segment LED.

Introduction to embedded systems, Current trends and challenges, Applications of embedded systems- Hard and soft real time systems.

Introduction to microcontrollers- Microprocessor Vs Microcontroller- 8051 Microcontrollers – Hardware - Microcontroller architecture and programming model - I/O port structure - Register organization -General purpose RAM - Bit addressable RAM - Special Function Registers (SFRs).

Module 4

Instruction set - Instruction types - Addressing modes of 8051 microcontrollers.

8051 microcontroller data types and directives - Time delay programmes and I/O port programming.

Introduction to embedded C Programming - time delay in C - I/O port programming in embedded C.

Module 5

8051 Timer/counter programming - Serial port programming - Interrupt programming in assembly language and embedded C.

Interfacing –ADC - DAC and temperature sensor

Text Books

1. Ramesh Gaonkar, "Microprocessor Architecture Programming and Applications", Penram International Publishing; Sixth edition, 2014.
2. Mohamed Ali Mazidi, Janice GillispieMazidi, "The 8051 microcontroller and embedded systems using Assembly and C", second edition, Pearson/Prentice hall of India.
3. Kenneth J. Ayala, "The 8051 microcontroller", 3rd edition, Cengage Learning, 2010
4. Lyla B Das, "Embedded Systems - An Integrated Approach", Pearson Education India

Reference Books

1. B Ram, "Fundamentals of Microprocessors and Microcontrollers", 9e, DhanpatRai Publications, 2019.
2. Wadhwa, "Microprocessor 8085 microprocessor: Architecture, Programming and Interfacing", PHI 2010
3. Shibu K V, "Introduction to Embedded systems", TMH

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Architecture and Instruction set of 8085 microprocessor (9 hours)**	
1.1	Internal architecture of 8085 microprocessor– functional block diagram	2
1.2	Instruction set- Addressing modes, Classification of instructions - Status flags.	4
1.3	Machine cycles and T states – Fetch and execute cycles - timing diagram for instruction and data flow.	3
2	**Assembly language programming (9 hours)**	
2.1	Introduction to assembly language programming- data transfer operations, arithmetic operations, logic operations, branching operations, I/O and machine control operations.	2
2.2	Assembly language programmes (ALP) in 8085 microprocessor-Data handling/Data transfer - Arithmetic operations - Code conversion - BCD to Binary - Binary to BCD, Sorting - Ascending and descending including bubble sorting.	4

2.3	Stack and subroutines – Conditional call and return instructions – Stack operations.	2
2.4	Time delay subroutines using 8bit register, 16 bit register pair and Nested loop control.	1
3	**Interfacing circuits for 8085 microprocessor and introduction to 8051 Microcontroller (10 hours)**	
3.1	Interrupt and interrupt handling - Hardware and Software interrupts.	1
3.2	I/O and memory interfacing – Address decoding – Interfacing I/O ports-Programmable peripheral interface PPI 8255 - Modes of operation -Interfacing of seven segment LED.	4
3.3	Introduction to embedded systems - Current trends and challenges - Applications of embedded systems - Hard and Soft real time systems.	1
3.4	Introduction to microcontrollers - Microprocessor Vs Microcontroller - 8051- Microcontrollers - Hardware	1
3.5	Microcontroller Architecture and programming model: I/O Port structure - Register organization - General purpose RAM -Bit Addressable RAM -Special Function Registers (SFRs).	3
4	**Programming of 8051 Microcontroller (9 hours)**	
4.1	Instruction Set - Instruction Types - Addressing modes	3
4.2	8051- Data types and directives -Time delay programmes and I/O port programming.	3
4.3	Introduction to embedded C Programming - Time delay in C - I/O port programming in embedded C.	3
5	**Interfacing circuits of 8051 Microcontroller (9 hours)**	
5.1	Timer/counter programming in assembly language and embedded C	3
5.2	Serial port programming in assembly language and embedded C	2
5.3	Interrupt programming in assembly language and embedded C	2
5.4	Interfacing –ADC - DAC and temperature sensor	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET305	SIGNALS AND SYSTEMS	PCC	3	1	0	4

Preamble : This course introduces the concept of signals and systems. The time domain and frequency domain representation, operations and analysis of both the continuous time and discrete time systems are discussed. The application of Fourier analysis, Laplace Transform and Z-Transforms are included. Stability analysis of continuous time systems and discrete time systems are also introduced.

Prerequisite : **Basics of Circuits and Networks**

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

CO 1	Explain the basic operations on signals and systems.
CO 2	Apply Fourier Series and Fourier Transform concepts for continuous time signals.
CO 3	Analyse the continuous time systems with Laplace Transform.
CO 4	Analyse the discrete time system using Z Transform.
CO 5	Apply Fourier Series and Fourier Transform concepts for Discrete time domain.
CO 6	Describe the concept of stability of continuous time systems and sampled data systems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern:

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

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

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

Course Level Assessment Questions :

Course Outcome 1 (CO1)
1. What are the standard test signals?
2. Problems related to various operations of signals.
3. Problems related to representation of systems in differential equation form.
4. Explain any three differences between linear and nonlinear systems.

Course Outcome 2 (CO2):
1. Problems related to Fourier series of continuous signals.
2. Problems related to Fourier transform of continuous systems.
3. Obtain the frequency response of the given system.

Course Outcome 3(CO3):
1. Derivations of transfer function of a given electrical system to comment on the system behaviour.
2. Problems related to analogous systems.
3. Problems related to block diagram reduction.

Course Outcome 4 (CO4):
1. Problems related ZIT.
2. Problems related to ZTF from difference equation form.
3. Problems related to block diagram development of ZTF of the given sampled system.

Course Outcome 5 (CO5):
1. Problems related to Discrete Fourier series of DT signals.
2. Problems related to Discrete time Fourier transform of DT signals
3. Obtain the frequency response of the given DT system.

Course Outcome 6 (CO6):
1. Problems related to the stability analysis of given continuous time systems using Routh criterion.
2. Problems related to stability analysis of DT systems.
3. Differentiate between asymptotic stability and BIBO stability?

Model Question Paper PAGES: 3

QPCODE:

Reg. No:___________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

MONTH & YEAR

Course Code**: EET305**

Course Name: **SIGNALS AND SYSTEMS**

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

PART A

Answer all Questions. Each question carries 3 Marks

1 Define unit ramp signal r(t). Sketch the signal r(-t+2).

2 Explain any two peculiar characteristics of nonlinear systems.

3 What are the conditions for the existence of Fourier transform?

4 Why do you use analogous systems? Explain with a suitable example.

5 Determine the unit impulse response for the system with $T(s) = \frac{2}{(s^2 + s - 12)}$

6 Explain the concept of positive real functions.

7 Explain the significance of ZOH circuit in signal reconstruction.

8 Write three properties of discrete convolution.

9 State and prove time reversal property of discrete time Fourier series.

10 Find the Fourier transform of x(n)= n u(n).

PART B

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

Module 1

11 a) Check whether the following system is static, causal, linear and time invariant: $y(t) = |x(t)|$ **(8)**

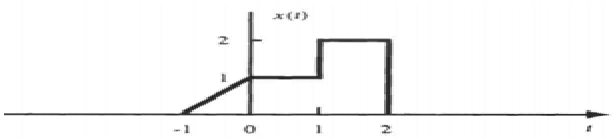
b) Find the convolution of $x_1(t)$ and $x_2(t)$ for the following signals: $x_1(t) = e^{-at}u(t); x_2(t) = e^{-bt}u(t)$ **(6)**

12 a) With suitable examples differentiate between:

i. Odd and even signals,

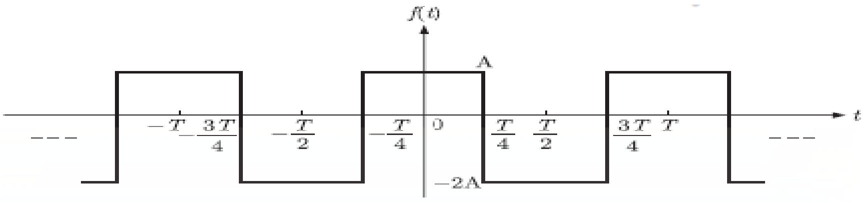
ii. Causal and non causal systems. **(7)**

b) The signal x(t) is given below. Plot x(t-1)+ x(-t+2) **(7)**



Module 2

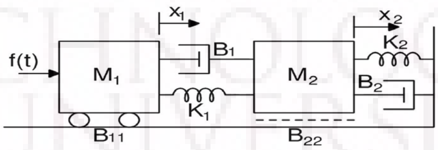
13 a) Find the trigonometric Fourier series for the periodic signal f(t).



(9)

b) State and prove time shifting property of Fourier transform. (5)

14 a) Derive the transfer function $X_2(s)/F(s)$ for the mechanical



(7)

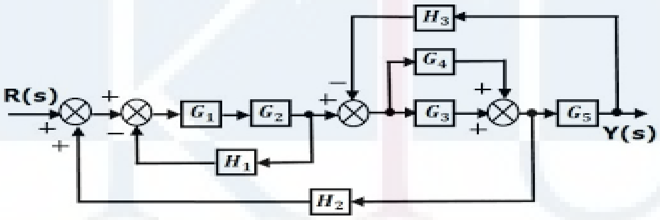
b) A system is described by the following differential equation:

$$\frac{d^2y(t)}{dt^2}+7\frac{dy(t)}{dt}+12y(t)=x(t);\, y(0^-)=-2, \frac{dy}{dt}(0^-)=0$$

Determine the response of the system to a unit step applied at t=0. (7)

Module 3

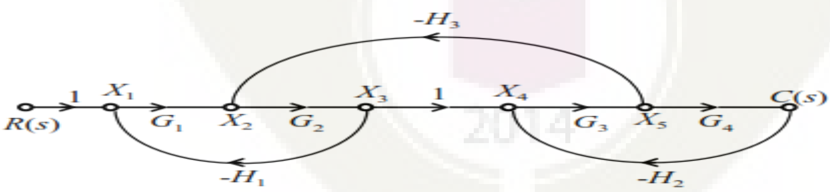
15 a) Determine the overall transfer function Y(s)/R(s) using block diagram reduction.



(8)

b) Check stability of the system represented by the following characteristic equation, using Routh stability criterion: $3s^4+10s^3+5s^2+5s+2=0$ (6)

16 a) Determine the transfer function of the system represented by the signal flow graph using Mason's gain formula.



(9)

b) How frequency response can be obtained from poles and zeros? (5)

Module 4

17 a) Determine the convolution sum of two sequences x(n)={1,4,3,2} and h(n)={1,3,2,1} using graphical method. (8)

b) Determine the z-transform of $x(n)=(1/2)^n u(-n)$. (6)

18 a) Explain the aliasing effect in sampled data systems. (5)

b) Determine the inverse z-transform of the following functions:
$i) X(z)=\frac{2z^{-1}}{(1-\frac{1}{4}z^{-1})^2}; ROC: |z|>\frac{1}{4}, and, ii) F(z)=\frac{3z^{-1}}{(1-z^{-1})(1-2z^{-1})}; ROC: |z|>2$ (9)

Module 5

19 a) Determine the complete solution of the difference equation: y (n) + 2y(n-1) + y(n-2) = x (n) + x(n-1) for the input x(n) = (0.5^n) u(n), initial conditions y(-1) = y(-2) = 1? **(9)**

b) Find the Fourier series coefficients for x(n)=cos(πn/4) **(5)**

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

ii) Also determine the impulse response h(n) for the above system. **(4+5)**

b) Check stability of the system described by the following characteristic equation, using Jury's test: z^3-0.2z^2-0.25z+0.05=0 **(5)**

Syllabus

Module 1

Introduction to Signals and Systems (9 hours):

Classification of signals: Elementary signals- Basic operations on continuous time and discrete time signals

Concept of system: Classification of systems- Properties of systems- Time invariance-Linearity -Causality – Memory- Stability-Convolution Integral- Impulse response

Representation of LTI systems: Differential equation representations of LTI systems

Basics of Non linear systems- types and properties

Introduction to random signals and processes (concepts only)

Module 2

Fourier Analysis and Laplace Transform Analysis (10 hours):

Fourier analysis of continuous time signals: Fourier Series- Harmonic analysis of common signals

Fourier transform: Existence- Properties of Continuous time Fourier transform- Energy spectral density and power spectral density

Concept of Frequency response

Laplace transform analysis of system transfer function: Relation between the transfer function and differential equation- Transfer function of LTI systems- Electrical, translational and rotational mechanical systems- Force voltage, Force current and Torque Voltage analogy

Module 3

System Models and Response (8 hours):

Block diagram representation - block diagram reduction

Signal flow graph - Mason's gain formula

Type and Order of the systems- Characteristic equation

Determining the time domain and frequency response from poles and zeros

Concepts of Positive real functions and Hurwitz polynomial- Routh stability criterion.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for mathematical and signal operations (Demo/Assignment only)

Module 4

Sampled Data Systems and Z-Transform (9 hours):

Sampling process-Impulse train sampling-sampling theorem- Aliasing effect

Zero order and First order hold circuits- Signal reconstruction

Discrete convolution and its properties

Z Transform**:** Region of convergence- Properties of Z Transform

Inverse ZT: Methods

Module 5

Analysis of Sampled Data Systems (9 hours):

Difference equation representations of LTI systems - Analysis of difference equation of LTI systems- Z Transfer function- Delay operator and block diagram representation- Direct form, cascade and parallel representations of 2^{nd} order systems

Stability of sampled data system: Basic idea on stability- Jury's test- Use of bilinear transformation

Discrete Fourier series**:** Fourier representation of discrete time signals - Discrete Fourier series– properties.

Discrete Time Fourier Transform: Properties- Frequency response of simple DT systems

Text Books

1. Oppenheim A.V., Willsky A.S. & Nawab S.H., Signals and Systems, 2/e, Prentice Hall
2. Nagrarth I. J, Saran S. N and Ranjan R, Signals and Systems, 2/e, Tata McGraw Hill
3. Haykin S. & Veen B.V., Signals & Systems, 2/e, John Wiley
4. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern
5. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers

Reference Books

1. Bracewell R.N., Fourier Transform & Its Applications, McGraw Hill
2. Farooq Husain, Signals and Systems, Umesh publications.
3. Papoulis A., Fourier Integral & Its Applications, McGraw Hill
4. Taylor F.J., Principles of Signals & Systems, McGraw Hill

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**Introduction to Signals and Systems (9 hours)**	
1.1	Classification of signals - Elementary signals- Basic operations on continuous time and discrete time signals	2
1.2	Concept of systems - Classification of systems- Properties of systems - Time invariance- Linearity -Causality – Memory- Stability.	2
1.3	Convolution Integral- Impulse response-	1
1.4	Representation of LTI systems - Differential equation representations of LTI systems	2
1.5	Basics of Non linear systems- types and properties Introduction to random signals and processes (concepts only)	2
2	**Fourier Analysis and Laplace Transform Analysis (10 hours)**	

2.1	Fourier Analysis of continuous time signals: Fourier Series- Harmonic analysis of common signals	2
2.2	Fourier transform: Existence- Properties of Continuous time Fourier transform- Energy spectral density and power spectral density	2
2.3	Concept of Frequency response- Frequency response of simple LTI systems.	2
2.4	Laplace transform analysis of system transfer function: Relation between the transfer function and differential equation	1
2.5	Transfer function of LTI systems: Electrical, Translational and rotational Mechanical systems	2
2.6	Force Voltage, Force Current and Torque Voltage analogy	1
3	**System Models and Response (8 hours)**	
3.1	Block diagram representation - block diagram reduction	2
3.2	Signal flow graph - Mason's gain formula	1
3.3	Type and Order of the systems- Characteristic equation.	1
3.4	Determining the time domain and frequency response from poles and zeros.	2
3.5	Concepts of Positive real functions and Hurwitz polynomial- Basic idea on Stability- Routh stability criterion	2
3.6	*Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for various mathematical operations (Demo/Assignment only)*	
4	**Sampled Data Systems and Z-Transform (9 hours)**	
4.1	Sampling process-Impulse train sampling-sampling theorem- Aliasing effect	2
4.2	Zero order and First order hold circuits- Signal reconstruction-	2
4.3	Discrete convolution and its properties	1
4.4	Z Transform**:** Region of convergence- Properties of Z Transform	2
4.5	Inverse ZT: Methods	2
5	**Analysis of Sampled Data Systems (9 hours)**	
5.1	Difference equation representations of LTI systems - Analysis of difference equation of LTI systems- Z Transfer function	2
5.2	Delay operator and block diagram representation- Direct form, cascade and parallel representations of 2nd order systems.	2
5.3	Stability of sampled data system: Basic idea on Stability- Jury's test- Use of bilinear transformation.	2
5.4	Discrete Fourier Series**:** Fourier representation of discrete time signals - Discrete Fourier series– properties	2
5.5	Discrete Time Fourier Transform: properties- Frequency response of simple DT systems	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET307	SYNCHRONOUS AND INDUCTION MACHINES	PCC	3	1	0	4

Preamble: Nil

Prerequisite: DC Machines and Transformers

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

CO 1	Analyse the performance of different types of alternators.
CO 2	Analyse the performance of a synchronous motor.
CO 3	Analyse the performance of different types of induction motors.
CO 4	Describe operating principle of induction machine as generator.
CO 5	Explain the types of single phase induction motors and their working principle.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2	-	-	-	2	-	-	-	-	-	2
CO 2	3	3	2	-	-	2	-	-	-	-	-	2
CO 3	3	3	2	-	-	2	-	-	-	-	-	2
CO 4	3	3	2	-	-	2	-	-	-	-	-	2
CO 5	2	2	-	-	-	2	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	15	15	30
Apply	25	25	50
Analyse			
Evaluate			
Create			

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

Part A: 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the principle of operation of alternators.
2. List the advantages of stationary armature type alternators over rotating armature types.
3. Derive emf equation of an alternator.
4. Define coil pitch factor and distribution factor of an alternator.
5. Problems based on emf equation of alternators.
6. Draw the phasor diagram of an alternator operating under lagging/leading/unity power factor and hence derive an expression for the no load induced emf/phase.

Course Outcome 2 (CO2):

1. Why synchronous motors are not self starting?
2. Develop the equivalent circuit and phasor diagram of synchronous motor.
3. Explain the V and Inverted V curves of synchronous motor
4. Explain the power flow diagram of synchronous motor.

Course Outcome 3(CO3):

1. Explain the principle of operation of a three phase induction motor.
2. List the constructional differences between slip ring and squirrel cage induction motors.
3. Problems based on analysing the performance of three phase induction motors using circle diagrams.
4. Problems based on developing the equivalent circuit of a three phase induction motor.
5. Explain the various speed control methods of three phase induction motors.
6. Explain the working of DOL/Star-Delta starter for three phase induction motors.

Course Outcome 4 (CO4):

1. Explain the principle of operation of induction generator.
2. Explain the difference between Grid connected and self excited induction generators
3. Differentiate between induction generator and synchronous generator.
4. Enumerate application of induction generator.

Course Outcome 5 (CO5):

1. Why single phase induction motor is not self starting.
2. Explain double field revolving theory.
3. Draw the torque slip characteristics of single phase induction motor.
4. Develop the equivalent circuit of single phase induction motor.

Model Question paper

QP CODE:

PAGES:3

Reg.No:______________
Name:________________

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

Course Code: EET307
Course Name: SYNCHRONOUS AND INDUCTION MACHINES

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

PART A

Answer all questions. Each Question Carries 3 marks

1. List the advantages of stationary armature type alternators over rotating armature types.
2. Define coil pitch factor and distribution factor of an alternator.
3. State and explain Blondel's Two Reaction Theory.
4. What is meant by synchronisation? Lit the conditions to be met while synchronising an alternator to the common bus bars.
5. With the help of neat figures, explain why a synchronous motor is not self-starting.
6. Differentiate between slip ring and squirrel cage induction motors.
7. Explain the phenomenon of crawling and cogging in induction motors.
8. Explain any two braking techniques of induction motors.
9. Differentiate between synchronous and induction generators.
10. What is double field revolving theory?

PART B

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

Module 1

11. a) List the causes of harmonics in alternators and suggest ways to mitigate them. **(5)**

b) A 3-Φ, 10 pole alternator has 2 slots/ pole/ phase on its stator with 10 conductors per slot. The air gap flux is sinusoidally distributed and equals 0.05 Wb. The stator has a double layer winding with a coil span of 1500. If the alternator is running at 600 rpm, calculate the emf generated /phase at no load. **(9)**

12. With the help of neat diagrams, explain the effects of armature reaction in alternators under lagging, leading and unity power factors. **(14)**

Module 2

13. A 220V, 6 pole, 50 Hz, star connected alternator gave the following test results: -

If (A)	0.2	0.4	0.6	0.8	1	1.2	1.4	1.8	2.2	2.6	3	3.4
Voc (line) (V)	29	58	87	116	146	172	194	232	261	284	300	310
Vzpf (line) (V)	-	-	-	-	-	0	29	88	140	177	208	230
Isc (A)	6.6	13.2	20	26.5	32.4	40	46.3	59	-	-	-	-

Find % voltage regulation at full load current of 40A at power factor 0.8 lag by (i) m.m.f method (ii) ZPF method. Ra=0.06 Ω /phase. **(14)**

14. a) Two 3Φ, 6.6 kV star connected alternators supply a load of 3000kW at 0.8 pflag. The synchronous impedance/phase of machine A is 0.5 + j 10 Ω and that of machine B is 0.4+j12 Ω. The excitation of machine A is adjusted so that it delivers 150 A at a lagging power factor and the governors are so set that the load is equally shared between the machines. Determine the current, power factor and induced emf of each machine. **(10)**

b)With the help of a neat circuit diagram, explain how an alternator is synchronised to the bus bars by bright lamp method. **(4)**

Module 3

15. a) With the help of a neat circuit diagram, explain how V and inverted V curves are obtained. **(6)**

b) A 2000V, 3-phase, 4 pole star connected synchronous motor runs at 1500 rpm. The excitation is constant and corresponds to an open circuit voltage of 2000V.The resistance is negligible compared to synchronous reactance of 3Ω per phase. Determine power input, power factor, torque developed for an armature current of 200A. **(8)**

16. a) In rice/flour mills driven by squirrel cage induction motors, the hopper is loaded with the grains only after starting the motor. Similarly, the delivery valve of centrifugal pumps driven by squirrel cage induction motor is opened only after starting the motor. What is the reason behind this? Justify your answer with a relevant performance curve of squirrel cage induction motor. **(4)**

b) A 6-pole, 50 Hz,3-Φ induction motor running on full load develops a useful torque of 150 Nm at a rotor frequency of 1.5 Hz. Calculate the shaft power output. If the mechanical torque lost in friction is 10 Nm, determine a) rotor copper loss b) input to the motor c) the efficiency. The total stator loss is 700W. **(10)**

Module 4

17. For the following test data, calculate (i) line current (ii) power factor (iii) rotor copper loss (iv) slip (v) efficiency (vi) maximum output power (vi) maximum torque and (vii) starting torque:

Induction Motor Details: 3.73kW, 200V, 50Hz, 4pole, 3 ϕ star connected
No Load Test: 200V, 350W, 5A
Blocked Rotor Test: 100V, 26A, 1700W
Rotor Copper Loss at standstill is 60% of the total copper loss. **(14)**

18. Explain the methods of speed control in three phase induction motors. **(14)**

Module 5

19. a)Explain the working principle and modes of operation of an Induction Generator. **(8)**

b) With the help of a neat figure, explain the torque-slip characteristics of an induction machine. **(6)**

20. Explain the working of split phase and capacitor start single phase induction motors with the help of neat circuit diagrams and phasor diagrams. Also mention the applications of each. **(14)**

Syllabus

Module 1

Principle of Operation of three phase alternators, Constructional features, Types of Armature Windings(detailed winding diagram not required), EMF equation, Numerical Problems.

Harmonics-causes, suppression, Rating of alternators, Parameters of armature winding, Armature reaction, Equivalent Circuit, Phasor Diagram, Load characteristics, Power Flow Equations.

Module 2

Voltage regulation of three phase Alternators-Direct loading, EMF Method, MMF Method, Potier Method,ASA Method -Numerical Problems.

Blondel's two reaction theory, Phasor Diagram under lagging power factor, Determination of X_d and X_q by slip test, Power developed by a Salient pole machine, Numerical Problems.

Parallel Operation of Alternators- Necessary Conditions, Synchronisation- Synchronising current, Power and Torque, Effect of reactance, Numerical Problems, Methods of Synchronisation.

Module 3

Principle of Synchronous Motor, Equivalent circuit, Phasor diagrams, Power flow diagram and equations, Losses and efficiency -Numerical Problems, Power-angle Characteristics, V Curve and Inverted V Curves.

Three phase Induction motor – Constructional features, Expressions for Power and Torque-Torque- Slip characteristics, Phasor diagram, Equivalent Circuit of Induction motor- Tests on Induction motors for determination of equivalent circuit-Numerical Problems.

Module 4

Performance of three phase Induction motors using Circle diagram, Numerical Problems. Cogging and Crawling in cage motors, Double cage Induction motor-Torque-Slip Characteristics.

Starting of Induction motors – Types of Starters – DOL starter, Autotransformer Starter, Star-Delta starter, Rotor Resistance Starter-Numerical Problems.

Braking of Induction motors – Plugging, Dynamic braking, Regenerative braking, Speed control – Stator Voltage control, V/f control, Rotor Resistance Control.

Module 5

Induction generator – Principle of operation, Grid Connected and Self Excited Operation of Induction Generators, Torque-Slip Characteristics of an Induction machine.

Single phase Induction motors-Double field revolving theory, Equivalent Circuit, Torque-Slip Characteristics, Types of Single Phase Induction motor, Applications.

Selection of AC motors for different applications.

Text Books

1. Bimbra P S, Electric Machines, Khanna Publishers, 2ndedition, 2017.
2. KothariD. P., NagrathI. J., Electric Machines, Tata McGraw Hill, 5thedition.2017.
3. Say M G, The Performance and Design of AC Machines, CBS Publishers, New Delhi, 3rdedition, 2002.
4. Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill,2nd revised edition, 2001.

Reference Books

1. Deshpande M. V., Electrical Machines, Prentice Hall India, New Delhi, Eastern Economy Edition, 2011.
2. Gupta B R, VandanaSinghal, "Fundamentals of Electric Machines", New Age International,.2010.
3. Ashfaq Husain, HaroonAshfaq, Electric Machines, DhanpatRai and Co., 3rd edition,2002.
4. Gupta J B, "Theory and Performance of Electrical Machines", S K Kataria& Sons, 14thedition, 2013.

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Basics of Alternators (10 hours)**	
1.1	Principle of operation and classification of alternators, Synchronous speed.	2
1.2	Construction of synchronous machines. Salient and Cylindrical types, Turbogenerators. Stationary and Rotating armature types.	1
1.3	Armature windings-Types.: Single layer, Double layer, Full pitched winding, Short pitched winding, Concentrated and Distributed winding	1
1.4	EMF Equation, Pitch factor and Distribution factor, Numerical problems	3
1.5	Harmonics in Alternators: Space and slot harmonics, Suppression, Effect of pitch factor on harmonics.	1
1.6	Armature Reaction, Equivalent Circuit and Phasor Diagrams, Power Flow Equations	2
2	**Voltage Regulation and Synchronisation of Alternators (10 hours)**	
2.1	Voltage Regulation of Alternators: EMF, MMF, Potier and ASA Method.	4
2.2	Blondel's Two Reaction Theory, Phasor Diagram under lagging power	3

	factor based on two reaction theory,Slip Test	
2.3	Parallel Operation of Alternators, Necessity of Parallel Operation. Advantages.	1
2.4	Synchronisation of Alternators: Dark Lamp and Bright Lamp Method.	2
3	**Three Phase Synchronous and Induction Motors (10 hours)**	
3.1	Synchronous Motors-Principle, Equivalent Circuit, Phasor Diagrams, Power Flow Diagram, Power and Torque Equations, Numerical Problems	3
3.2	Effects of excitation on armature current and power factor- V and Inverted V Curves, advantages, disadvantages and applications of Synchronous motors.	1
3.3	Three phase Induction Motors-Principle, Constructional details, Slip ring and Cage types.	1
3.4	Slip,frequency and rotor current, Expression for torque and Power- Starting torque, Full load and Pull out torque, Torque- Slip characteristics, Phasor diagram.	3
3.5	Tests on Induction motors for determination of Equivalent circuit, Equivalent Circuit of Induction motor-Numerical Problems.	2
4	**Three Phase Induction Motors Contd. (8 hours)**	
4.1	Circle Diagram, Numerical Problems.	3
4.2	Cogging, Crawling—remedial measures, Double Cage Induction Motor-Principle.	1
4.3	Starters for three phase Induction Motors: DOL, Autotransformer, Star Delta and Rotor Resistance Starters.	2
4.4	Speed Control in Induction Motors	1
4.5	Braking in Induction Motors	1
5	**Induction Generators and Single Phase Induction Motors (7 hours)**	
5.1	Induction Generators: Grid Connected and Self Excited types.	1
5.2	Single phase induction motors-principle, Double field revolving theory, Torque-Slip characteristics, Applications	2
5.3	Types-Split phase, Capacitor Start, Capacitor Start and Run types, Shaded pole motor, Shaded Pole Motor-Principle of operation and applications.	3
5.4	Selection of AC motors for different Applications.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EEL331	MICROPROCESSORS AND MICROCONTROLLERS LAB	PCC	0	0	3	2

Preamble : This laboratory course is designed to train the students to familiarize and program microprocessors and microcontrollers. Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing embedded systems.

Prerequisite : Fundamentals of Digital Electronics and C programming

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

CO 1	Develop and execute assembly language programs for solving arithmetic and logical problems using microprocessor/microcontroller.
CO 2	Design and Implement systems with interfacing circuits for various applications.
CO 3	Execute projects as a team using microprocessor/microcontroller for real life applications.

Mapping of course outcomes with program outcomes

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

ASSESSMENT PATTERN:

Mark distribution:

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

Continuous Internal Evaluation (CIE) Pattern:

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

Internal Test Evaluation (Immediately before the second series test)

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

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

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

(d) Viva voce : 20 marks

(e) Record : 5 Marks

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

LIST OF EXPERIMENTS:

(12 experiments are mandatory)

8085 Microprocessor Programming

1. Data transfer using different addressing modes and block transfer.
2. (a) Arithmetic operations in binary and BCD: addition, subtraction, multiplication and division

   (b) Logical instructions- sorting of arrays in ascending and descending order.

   (c) Binary to BCD conversion and vice versa.

8051 Microcontroller Programming

3. ALP programming for

   (a) Data transfer: Block data movement, exchanging data, sorting, finding largest element in an array.

   (b) Arithmetic operations: Addition, subtraction, multiplication and division. Computation of square and cube of 16-bit numbers.

4. ALP programming for the implementation of counters: HEX up and down counters, BCD up/down counters

5. (a) ALP programming for implementing Boolean and logical instructions: bit manipulation.

   (b) ALP programming for implementing conditional call and return instructions: Toggle the bits of port 1 by sending the values 55H and AAH continuously, Factorial of a number

6. ALP programming for

   (a) Generation of delay

(b) Transmitting characters to a PC HyperTerminal using the serial port and displaying on the serial window

7. C Programs for stepper motor control.

8. C Programs for DC motor direction and speed control using PWM.

9. C Programs for Alphanumerical LCD panel/ keyboard interface.

10. C Programs for ADC interfacing.

11. Demo Experiments using 8085 Microprocessor Programming

    (a) Digital I/O using PPI: square wave generation.

    (b) Interfacing D/A converter- generation of simple waveforms-triangular, ramp etc.

    (c) Interfacing A/D converter.

12. Demo Experiments using 8051 Microcontroller Programming

    ALP programming for implementing code conversion– BCD to ASCII, ASCII to BCD, ASCII to decimal, Decimal to ASCII, Hexadecimal to Decimal and Decimal to Hexadecimal.

13. a) Familiarization of Arduino IDE

    b) LED blinking with different ON/OFF delay timings with i) inbuilt LED ii) Externally

    interfaced LED

14. Arduino based voltage measurement of 12V solar PV module/ 12V battery and displaying the measured value using I2C LCD display.

15. Arduino based DC current measurement using Hall-effect current sensor like LEM LA-55P sensor and displaying the value using I2C LCD module.

16. DC motor speed control using MOSFET driven by PWM signal from Arduino module.

17. Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud.

18. Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud.

Mandatory Group Project Work : Students have to do a mandatory micro project (group size not more than 3 students) to realise an embedded system for Industrial Control/ day-to-day life applications. A report also is to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Example projects (Microcontroller based projects)

1. Temperature Monitoring and control System.
2. Home automation system
3. Remote health monitoring and emergency notification system
4. IoT based power monitoring
5. IoT based switching of power devices

Reference Books:

1. Ramesh Gaonkar, Microprocessor Architecture Programming and Applications, Penram International Publishing; Sixth edition, 2014.
2. Mohamed Ali Mazidi, Janice Gillispie Mazidi," The 8051 microcontroller and embedded systems using Assembly and C", second edition, Pearson/Prentice hall of India.
3. Kenneth. J. Ayala, The 8051 microcontroller, 3rd edition, Cengage Learning, 2010
4. Donald P. Leach, Albert Paul Malvino and Goutam Saha, Digital Principles and Applications, 8/e, by McGraw Hill.
5. A. P. Mathur, Introduction to Microprocessors, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Jeeva Jose, Internet of Things, Khanna Publishing House, Delhi
7. Raj Kamal, Internet of Things: Architecture and Design, McGraw Hill

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EEL333	ELECTRICAL MACHINES LAB II	PCC	0	0	3	2

Preamble: The purpose of this lab is to provide practical experience in the operation and testing of synchronous and induction machines.

Prerequisite : Fundamentals of Electrical Engineering

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

CO 1	Analyse the performance of single phase and three phase induction motors by conducting suitable tests.
CO 2	Analyse the performance of three phase synchronous machine from V and inverted V curves.
CO 3	Analyse the performance of a three phase alternator by conducting suitable tests.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Marks distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

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

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

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

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

LIST OF EXPERIMENTS

(A minimum of **TWELVE** experiments are mandatory out of the fifteen listed.)

1. Load test on a three phase Slip Ring Induction Motor

Objectives:

a) Start the motor using auto transformer or rotor resistance starter
b) Plot the performance characteristics

2. No load and block rotor tests on a three phase Squirrel Cage Induction Motor

Objectives:

a) Predetermination of performance parameters from circle diagram
b) Determination of equivalent circuit

3. Starting of a three phase Squirrel Cage Induction Motor using Y-Δ Starter

Objectives:

a) Start the motor using Y-Δ Starter and perform load test
b) Plot the performance characteristics

4. Performance characteristics of a Pole Changing Induction Motor

Objectives:

a) Run the motor in two different pole configurations (example 4 pole and 8 pole)
b) Analyse the performance in the two cases by constructing circle diagrams and compare the results

5. No Load and Blocked Rotor Tests on a single phaseInduction Motor

Objectives:

a) Conduct no load and blocked rotor tests on the motor
b) Predetermine the equivalent circuit

6. Load Test on a single phaseInduction Motor

Objectives:

a) Perform load test on the motor

b) Plot the performance characteristics of the motor

7. Variation of starting torque with rotor resistance in Slip-Ring Induction Motors

Objectives:

a) Plot the variation of starting torque against rotor resistance in a three phase slip ring induction motor
b) Find the external rotor resistance for which maximum starting torque is obtained.

8. V and inverted V curves of a Synchronous Motor

Objectives:

Plot the V and inverted V curves of the Synchronous Motor at no load and full load.

9. Regulation of a three phase Alternator by direct loading

Objectives:

a) Determine the regulation of three phase alternator
b) Plot the regulation versus load curve

10. Regulation of a three phase Alternator by emf and mmf methods

Objectives:

Predetermine the regulation of alternator by emf and mmf methods at 0.8pf lag, upf and 0.8pf lead.

11. Regulation of a three phase alternator by Potier method

Objectives:

a) Synchronize the alternator by dark lamp method
b) Plot ZPF characteristics and determine armature reactance mmf and potier reactance
c) Predetermine the regulation by ZPF method

12. Reactive power control in grid connected Alternators

Objectives:

a) Synchronize the alternator by bright lamp method
b) Control the reactive power and plot the V and inverted V curves for generator operation

13. Slip Test on a three phase Salient Pole Alternator

Objectives:

a) Determine the direct and quadrature axis synchronous reactances
b) Predetermine the regulation at 0.8 lagging power factor

14. V/f control of three phase Squirrel Cage Induction Motor

Objectives:

Perform speed control of the given three phase induction motor by V/f control

15. Performance characteristics of a three phase Induction Generator

Objectives:

Plot the performance characteristics of the generator.

Reference Books

1) Bimbra P S, *Electric Machines*, Khanna Publishers, 2nd edition, 2017.
2). KothariD. P., NagrathI. J., *Electric Machines*, Tata McGraw Hill, 5th edition, 2017.
3) Say M.G, *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd edition, 2002.
4) Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill, 2nd revised edition, 2001.

SEMESTER V

MINOR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET381	SOLID STATE POWER CONVERSION	VAC	3	1	0	4

Preamble: To impart knowledge about the power semiconductor devices, operation and performance of different power converters and its applications.

Prerequisite: Basic knowledge of electric circuits, and basic electronics.

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

CO 1	Explain the operation of various power semiconductor devices and its characteristics
CO 2	Select appropriate triggering circuit for thyristor
CO 3	Analyse the working of various power converters
CO 4	Describe the principle of operation and voltage control of inverters
CO 5	Compare the features and performance of different dc-dc Converters.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the Working of SCR, power diode, MOSFET, IGBT, TRIAC.
2. Draw the VI characteristics of different power devices
3. Draw and explain the switching characteristics of SCR.
4. Discuss the protection circuits for SCR.
5. Understand the requirements in series & Parallel operation of SCR

Course Outcome 2 (CO2)

1. With waveforms explain R and RC triggering circuits.
2. Explain the need and methods of electrical isolation in triggering circuits for Power Electronics

Course Outcome 3 (CO3):

1. Explain the working of halfwave controlled rectifier.
2. Explain the principle of operation, characteristics and performance of fully controlled and half controlled bridge converters.
3. Problems in finding the average output voltage of rectifier
4. Describe the operation of AC voltage controllers

Course Outcome 4 (CO4):

1. Explain the working of various inverter circuits.
2. Problems in finding the output voltage of inverter.
3. How the output voltage of an inverter can be varied
4. Explain single PWM & multiple PWM technique
5. Explain sinusoidal PWM technique.

Course Outcome 5 (CO5):

1. Explain the working of step down and step up choppers
2. Differentiate between first quadrant, two quadrant and four quadrant operation of choppers.
3. Describe pulse width modulation & current limit control in dc-dc converters
4. Design the value of filter inductor & capacitance in regulators

Model Question paper

Pages: 2

Reg. No:______________

Name:________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EET381

Course Name: **SOLID STATE POWER CONVERSION**

Max. Marks: 100 Duration: 3 Hrs

PART A

Answer all questions. Each question carries 3 marks.

1. Draw the circuit for two transistor analogy of silicon controlled rectifier and briefly describe the working.
2. Define holding current and latching current of SCR. Show these currents on the static VI characteristics of SCR.
3. Draw the circuit of an R-Triggering circuit for controlling the thyristor in a half wave-controlled rectifier.
4. Derive the expression for the output voltage of a single phase fully controlled bridge converter with RL load.
5. A three phase half wave converter is operated from 3–phase, 230 V, 50Hz supply with load resistance R= 10Ω. An average output voltage of 50% of the maximum possible output voltage is required. Determine the firing angle.
6. What are the two types of voltage control adopted in ac voltage controllers?
7. With the help of circuit diagram explain the working of current source inverter.
8. What is pulse width modulation? List the various PWM techniques.
9. Draw the circuit of step up chopper and explain its working.
10. A type A chopper has input voltage of 200 V. The current through a load of R=10Ω in series with L=80 mH, varies between 12 A and 16 A. Find the form factor of the output voltage waveform

PART B

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

Module 1

11. a) Discuss the condition which must be satisfied for turning on the SCR with agate signal. **(7)**

b) Explain the significance of dv/dt protection in thyristors and describe the method employed for improving the same. **(7)**

12. a) What are the steps to be employed to prevent the difficulties of parallel operation of thyristors? **(6)**

b) Drew the structure of TRIAC and explain its principle of operation. **(8)**

Module 2

13. a) Design an R-triggering circuit for a half wave controlled rectifier circuit for 24 V ac supply. The SCR to be used has the following data.

$I_{gmin} = 0.1$ mA, $I_{gmax} = 12$ mA, $V_{gmin} = 0.6$V, $V_{gmax} = 1.5$ V **(7)**

b) With the help of circuit diagram explain the operation of single phase semi converter with RL load. Draw the waveform of input voltage, output voltage, load current and voltage across the thyristor. **(7)**

14. a) Draw RC triggering circuit for SCR and explain with relevant wave forms. **(7)**

b) With the help of circuit diagram explain the working of single phase fully controlled converter with RL load. Draw the waveform of output voltage and output current. **(7)**

Module 3

15. a) Sketch the waveform of input voltage, output voltage and output current of a three phase half wave controlled rectifier with R load operating at $\alpha = 30$ °. **(7)**

b) A three phase half wave converter is operated from 3–phase, 400 V, 50Hz supply with load resistance R = 50 Ω. An average output voltage of 50% of the maximum possible output voltage is required. Determine the firing angle. **(7)**

16. a) Explain the basic working of a single phase dual converter. **(6)**

b) Draw the circuit of a three phase fully controlled bridge converter and draw the waveforms of input voltage, output voltage, output current and input current in any one phase. Assume resistive load and firing angle is 30 degrees. **(8)**

Module 4

17. a) Describe the working of a three phase voltage source inverter with an appropriate circuit diagram. **(7)**

b) Explain with suitable diagram, the principle of voltage control in inverters with single pulse width modulation. **(7)**

18. Explain the 120 degree conduction mode of a three-phase bridge inverter with output voltage waveforms (phase and line), indicating the devices conducting in each state. **(14)**

Module 5

19. a) With the help of circuit diagram and waveform explain the operation of buck converter and derive the equation of output voltage. **(7)**

b) Differentiate between PWM control and current limit control in choppers. **(7)**

20. a) Explain the working of two quadrant (class C) chopper, with relevant waveform. **(8)**

b) A step-up chopper is used to generate 220 V from 100 V dc source. The OFF period of switch is 80μs. Compute the required pulse width. **(6)**

Syllabus

Module 1

Power semiconductor devices, their symbols and static characteristics, specifications of switches, steady state characteristics of Power MOSFET and IGBT.

SCR – Operation, V-I characteristics, steady state and switching characteristics, two transistor model, methods of turn-on, power diodes, operation of TRIAC, series and parallel connection of SCRs.

Module 2

Gate triggering circuits – R and RC triggering circuits – isolation circuits using opto-isolators and pulse transformers.

Controlled rectifiers – half-wave controlled rectifier with R load – single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous conduction) – output voltage equation – single phase half controlled bridge rectifier with R, RL and RLE loads.

Module 3

Three phase half-wave-controlled rectifier with R load – three phase fully controlled & half-controlled converter with RLE load (continuous conduction) – output voltage equation-waveforms for various triggering angles (analysis not required) – single phase and three phase dual converter.

AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R, & RL loads – waveforms – RMS output voltage, sequence control (two stage) with R load.

Module 4

Inverters – voltage source inverters – single phase half-bridge & full bridge inverter with R & RL loads – 3-phase bridge inverter with R load – 120° & 180° conduction mode, current source inverters.

Voltage control in inverters – Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM – modulation index & frequency modulation ratio.

Module 5

DC-DC converters – step down and step up choppers – single-quadrant, two-quadrant & four quadrant chopper – pulse width modulation & current limit control in dc-dc converters. Switching regulators – buck, boost & buck-boost – operation in continuous conduction mode – steady state waveforms – selection of components.

Text Books

1. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education
2. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi

Reference Books

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India
2. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998
3. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India
4. Alok Jain, Power Electronics and its Applications, Penram International Publishing (I) Ltd, 2016
5. Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Power semiconductor devices (9 hours)**	
1.1	Symbols, static characteristics and specifications of semiconductor switches.	2
1.2	Power diodes, power MOSFET and IGBT	3
1.3	SCR - VI Characteristics, Turn on methods	1
1.4	Structure and principle of operation of TRIAC	1
1.5	Series and parallel operation of SCRs	2
2	**Gate triggering circuits & single-phase controlled converters (9 hours)**	
2.1	R and RC triggering circuits	3
2.2	Isolation circuits using opto-isolators and pulse transformers	1
2.3	Half-wave controlled rectifier with R load	1
2.4	Single phase fully controlled bridge rectifier with R, RL and RLE loads	2
2.5	Single phase half controlled bridge rectifier with R, RL and RLE loads	2
3	**Three phase controlled converters & AC voltage regulator (9 hours)**	
3.1	Three phase half-wave-controlled rectifier with R load	1
3.2	Three phase fully controlled & half-controlled converter with RLE load	4
3.3	Single phase and three phase dual converter	2
3.4	AC voltage controllers (ACVC)	1
3.5	Sequence control (two stage) with R load	1
4	**Inverters (9 hours)**	
4.1	Single phase half-bridge & full bridge inverter with R & RL loads	3
4.2	Three phase bridge inverter with R load – 120° & 180° conduction mode	2
4.3	Current source inverters.	1

4.4	Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM	3
5	**DC-DC Converters (9 hours)**	
5.1	Principle of step down and step up choppers	2
5.2	Description of single-quadrant, two-quadrant & four quadrant choppers	1
5.3	Pulse width modulation & current limit control in dc-dc converters	3
5.4	Switching regulators – buck, boost & buck-boost - continuous conduction mode only	2
5.5	Design of filter inductance & capacitance	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET383	SOLAR AND WIND ENERGY CONVERSION SYSTEMS	VAC	3	1	0	4

Preamble: This course introduces about solar and wind energy conversion systems. Design of wind and solar power systems are also discussed.

Prerequisite: Introduction to Power Engineering/ Energy Systems

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

CO 1	Explain the basics of solar energy conversion systems.
CO 2	Design a standalone PV system.
CO 3	Describe different wind energy conversion systems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
CO 1	3	3										2
CO 2	3	3	1									2
CO 3	3	3										2

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain what do you mean by solar constant (K1)
2. Discuss about the different instruments used for measuring solar radiation and sun shine (K2)

Course Outcome 2 (CO2):

1. Design a standalone PV system. (K3)
2. Design a grid connected PV system. (K3)

Course Outcome 3 (CO3):

1. Compare the performance of different types of wind turbines. (K3).
2. Compare the performance of different types of generators used in wind turbines. (K3).

Model Question paper

QP CODE:

PAGES:2

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET383

Course Name: SOLAR AND WIND ENERGY CONVERSION SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain briefly what do you mean by solar azimuth angle and zenith angle.
2. Differentiate between extraterrestrial and terrestrial solar radiation.
3. Write notes on the working of a solar cooker.
4. Discuss what do you mean by a solar green house.
5. Write notes on the different materials used for making solar cells.
6. Discuss the characteristics of a solar cell.
7. Differentiate between lift and drag forces.
8. Explain what do you mean by pitch control of wind turbines.
9. Write notes on the environmental impacts of wind power generation.

10. Discuss about the wind energy program in India

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a. With the help of a neat diagram, explain the working of a pyrheliometer. **(7)**
    b. Explain how monthly average solar radiation on inclined surfaces can be calculated. **(7)**
12. a. State the reasons for variation in the amount of solar energy reaching earth surface. **(4)**
    b. With the help of a neat diagram, explain the working of a sunshine recorder. **(6)**
    c. Explain the difference in the working of pyrheliometer and pyranometer. **(4)**

Module 2

13. a. Explain the different types of solar collectors based on the way they collect solarradiation. **(7)**
    b. Explain in detail, the working of a solar air conditioning system **(7)**

14. a. With the help of a diagram, explain the function of different components of a flat plate solar collector. **(7)**
    b. Design a solar water heater for domestic application. **(7)**

Module 3

15. a. Write notes on the efficiency of a solar cell. **(3)**
    b. Discuss the effect of shadowing on the performance of solar cells. **(3)**
    c. Explain how maximum power point tracking can be done using buck-boostconverter. **(8)**

16. a. Compare the performance of single junction and multijunction PV modules. **(4)**
    b. Write notes on packing factor of a PV module. **(3)**
    c. Explain with a neat sketch, the working principle of a grid connected solar system. **(7)**

Module 4

17. a. Discuss the application of Weibull distribution in wind power generation **(3)**
    b. Explain the characteristics of a wind turbine. **(4)**
    c. Explain the different modes of wind power generation. **(7)**

18. a. Compare the performance of different types of wind turbines **(6)**
    b. Derive an expression for wind turbine power. **(4)**

c. What do you mean by Betz's Law? Why wind turbines are not 100% efficient? **(4)**

Module 5

19. a. With the help of a diagram, explain the working of a wind energy conversion system. **(7)**

b. Compare the performance of different types of generators used in wind mills. **(7)**

20. a. With the help of a diagram, explain the working of a variable speed constant frequency wind energy conversion system. **(7)**

b. Discuss about the different types of converter used in renewable energy systems. **(7)**

Syllabus

Module 1

Introduction - Basic Concept of Energy -Source of Solar Energy -Formation of the Atmosphere - Solar Spectrum. Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer - Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extraterrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors -Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces .

Module 2

Solar Thermal system-Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –performance evaluation. Applications -Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse - Design of solar water heater

Module 3

Solar PV Systems-Introduction -Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell - Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III-V Single Junction and Multijunction PV Modules-Emerging and New PV Systems -Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors.

Module 4

Wind Turbines - Introduction -Origin of Winds- Nature of Winds – Classification of Wind Turbines -Wind Turbine Aerodynamics - Basic principles of wind energy extraction – Extraction of wind turbine power(Numerical problems)- Weibull distribution-Wind power generation curve-Betz's Law-Modes of wind power generation.

Module 5

Wind Energy Conversion Systems-Introduction-Components of WECS - Fixed speed drive scheme- Variable speed drive scheme - Wind–Diesel Hybrid System –Induction generators-Doubly Fed Induction Generator(DFIG)-Squirrel Cage Induction Generator(SCIG)-Power converters in renewable energy system-AC-DC Converters, DC-DC Converters, DC-AC Converters(Block Diagram Only)-Effects of Wind Speed and Grid Condition (System Integration) -Environmental Aspects -Wind Energy Program in India

References:

1. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977
2. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
3. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
4. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002
5. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994.
6. Siraj Ahmed, *Wind Energy- Theory and Practice*, Prentice Hall of India, New Delhi,2010
7. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd Renewable energy systems, Pearson 2017
8. D. P. Kothari, S. Umashankar, Wind Energy Systems and Applications, Narosa publishers,2017
9. G. N. Tiwari,ArvindTiwari,Shyam, Handbook of Solar Energy: Theory, Analysis and Applications, springer,2016.
10. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
11. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009.
12. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
13. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
14. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
15. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
16. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996.
17. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy – Sources for Fuel and Electricity, Earth scan Publications, London, 1993.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Solar energy (8 hours)**	
1.1	Introduction - Basic Concept of Energy -Source of Solar Energy - Formation of the Atmosphere - Solar Spectrum.	2
1.2	Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer – Pyranometer -Sunshine Recorder	2
1.3	Solar Radiation on a Horizontal Surface –Extraterrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors	2
1.4	Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces.	2
2	**Solar Thermal Systems (8 hours)**	
2.1	Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics	1
2.2	Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation.	2
2.3	Applications -Solar heating system, Air conditioning and Refrigeration system	1
2.4	Pumping system, solar cooker, Solar Furnace, Solar Greenhouse	2
2.5	Design of solar water heater	2
3	**Solar PV systems (8 Hours)**	
3.1	Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials	2
3.2	Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III-V Single Junction and Multijunction PV Modules -Emerging and New PV Systems	1
3.3	Packing Factor of the PV Module - Efficiency of the PV Module - Energy Balance Equations for PV Modules	1
3.4	Series and Parallel Combination of PV Modules.- Effect of shadowing- Maximum Power Point Tracker (MPPT) using buck-boost converter.	2
3.5	Solar PV Systems –stand-alone and grid connected -Design steps for a	2

	Stand-Alone system –Storage batteries and Ultra capacitors.	
4	**Wind energy (9 Hours)**	
4.1	Wind Turbines - Introduction -Origin of Winds- Nature of Winds	1
4.2	Classification of Wind Turbines -Wind Turbine Aerodynamics - Basic principles of wind energy extraction	2
4.3	Extraction of wind turbine power(Numerical problems)	2
4.4	Weibull distribution-Wind power generation curve - Betz's Law	2
4.5	Modes of wind power generation.	2
5	Wind energy conversion systems (9)	
5.1	Introduction-Components of WECS - Fixed speed drive scheme-Variable speed drive scheme	2
5.2	Wind–Diesel Hybrid System –Induction generators-Doubly Fed Induction Generator(DFIG)-Squirrel Cage Induction Generator(SCIG)	3
5.3	Power converters in renewable energy system-AC-DC Converters, DC-DC Converters, DC-AC Converters(Block Diagram Only)	2
5.4	Effects of Wind Speed and Grid Condition (System Integration) - Environmental Aspects -Wind Energy Program in India	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET385	CONTROL SYSTEMS	VAC	3	1	0	4

Preamble: This course deals with the fundamental concepts of control systems theory. Modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach are discussed. The state space concept is also introduced.

Prerequisite: Basics of Dynamic Circuits and Systems

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

CO 1	Describe the role of various control blocks and components in feedback systems
CO 2	Analyse the time domain responses of the linear systems
CO 3	Apply Root locus technique to assess the performance of linear systems
CO 4	Analyse the stability of the given LTI systems.
CO 5	Apply state variable concepts to assess the performance of linear systems

Mapping of course outcomes with program outcomes

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

Assessment Pattern:

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

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

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

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Derive and explain the transfer function of field controlled dc servo motor.
2. With the help of suitable example explain the need for analogous systems.
3. Explain how does the feedback element affect the performance of the closed loop system?

Course Outcome 2 (CO2):

1. Obtain the different time domain specification for a given second order system with impulse input and assess the system dynamics.
2. Determine the value of the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G_p(s) = \frac{K}{s(s+10)}$, which results in a critically damped response.
3. Problems related to static error constant and steady state error for a given input.

Course Outcome 3 (CO3):

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\ (s+1)\ (s+4)}$ is oscillatory, using Root locus.
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s\ (s^2 + 3s + 2)}$.
   Determine the value of K to achieve a damping factor of 0.5?
3. Problem on root locus for systems with positive feedback.

Course Outcome 4 (CO4):

1. Problems related to application of Routh's stability criterion for analysing the stability of given system.
2. Determine the value of K such that the gain margin for the system with $G(s)H(s) = \frac{K}{s\ (s+2)\ (s+5)}$ equals to 10 dB.
3. Problem related to the analysis of given system using Polar plot.

Course Outcome 5 (CO5):

1. Determine the transfer function of the system given by:

system with state model:

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ -1 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u; \quad y = [0 \quad 1] x.$$

2. Obtain the time response y(t) of the homogeneous system represented by:

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad [y] = [1 \quad 0][X] \text{ with } x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$$

3. Derive and analyse the state model for a field controlled dc servo motor.

Model Question Paper PAGES: 3

QP CODE:

Reg. No:____________

Name:______________

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

Course Code: **EET385**

Course Name: **CONTROL SYSTEMS**

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

PART A

Answer all Questions. Each question carries 3 Marks

1 Give a comparison between open loop and closed loop control systems with suitable examples.

2 With relevant characteristics explain the operation of a tacho generator as a control device.

3 For a closed loop system with $G(s) = \frac{3}{s\,(s+2)}$; and H(s) = 0.1, calculate the steady state error constants.

4 Check the stability of the system given by the characteristic equation, $G(s) = s^5 + 2s^4 + 4s^3 + 8s^2 + 16s + 32;$ using Routh criterion.

5 With suitable sketches explain how addition of zeroes to the open-loop transfer function affects the root locus plots.

6 Explain Ziegler – Nichol's PID tuning rules.

7 Explain the features of Non-minimum phase systems with a suitable example.

8 How do you determine the gain margin of a system, with the help of Bode plot?

9 A system is represented by $\frac{Y(s)}{U(s)} = \frac{3}{(s+1)(s+2)}$. Derive the Canonical diagonal form of representation in state space.

10 Discuss the advantages of state space analysis.

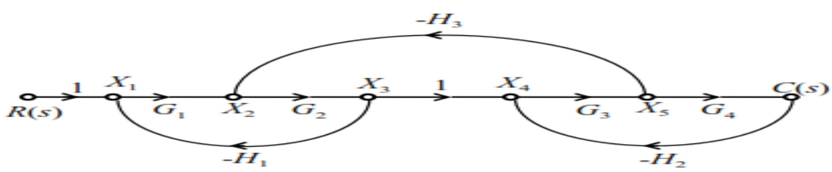
PART B

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

Module 1

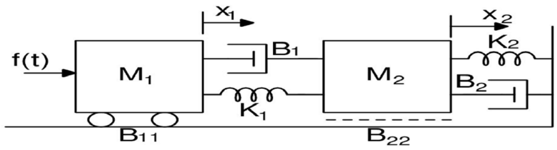
11 a) Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. **(8)**

b) Determine the transfer function of the system represented by the signal flow graph using Mason's gain formula.



(6)

12 a) Derive the transfer function $X_2(s)/F(s)$ for the mechanical system.



(9)

b) Compare the effect of H(s) on the pole-zero plot of the closed loop system with $G(s) = \frac{s+1}{(s^2+5s+6)}$ with: i) derivative feed back H(s)= s; ii) integral feedback H(s)=1/s. **(5)**

Module 2

13 a) Derive an expression for the step response of a critically damped second order system? Explain the dependency of maximum overshoot on damping factor. **(9)**

b) Determine the value of gain K and the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G(s) = \frac{K}{s(s+6)}$, which results in a critically damped response when subjected to a unit impulse input.

Also determine the steady state error for unit velocity input. **(5)**

14 a) A unity feedback system is characterized by an open loop transfer function $G(s) = \frac{4}{(s^2+s+5)}$. Determine the transient response when subjected to a unit step input and sketch the response. Evaluate the rise time and peak time of the system. . **(9)**

b) Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s) = \frac{K}{s(s^2+3s+1)}$ is stable. . **(5)**

Module 3

15 a) Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\,(s+2)\,(s+5)}$ is oscillatory, using Root locus.

Also determine the value of K to achieve a damping factor of 0.866. **(10)**

b) Compare between PI and PD controllers. **(4)**

16 a) Sketch the root locus for a system with $G(s)H(s) = \frac{K(s-1)}{s(s+4)}$. Hence determine the range of K for the system stability. **(9)**

b) With help of suitable sketches, explain how does Angle and Magnitude criteria of Root locus method help in control system design. **(5)**

Module 4

17 a) The open-loop transfer function of a unity feedback system is G(s)=$\frac{K}{s(0.5s+1)(0.04s+1)}$.Use asymptotic approach to plot the Bode diagram and determine the value of K for a gain margin of 10 dB. **(10)**

b) Derive and explain the dependence of resonant peak on damping factor. **(4)**

18 a) Draw the polar plot for the system with $G(s)H(s) = \frac{K}{s(s+0.5)(s+2)}$ and determine the value of K such that phase margin equals to 40°. **(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

SEMESTER V

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET393	DIGITAL SIMULATION	VAC	3	1	0	4

Preamble: Numerical simulation using digital computers is an indispensable tool for electrical engineers. This honours course is designed with the objective of providing a foundation to the theory behind Numerical Simulation of electrical engineering systems and to give an overview of different styles of simulation tools and methodologies. This course would help students to explore and effectively use simulation tools with a clear understanding of their inner engines. This course also prepares students to explore and use the industry-standard tools like MATLAB and SPICE.

Prerequisites : **1. EET201 Circuits and Networks**

2. EET 205: Analog Electronics

3. MAT 204: Probability, Random Processes and Numerical Methods

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

CO 1	Formulate circuit analysis matrices for computer solution.
CO 2	Apply numerical methods for transient simulation.
CO 3	Develop circuit files for SPICE simulation of circuits.
CO 4	Develop MATLAB/Simulink programs for simulation of simple dynamic systems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	15	15	20
Understand (K2)	20	20	50
Apply (K3)	15	15	30

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

Problems on Circuit Analysis Matrix Formulation for Computer Solution (MNA and Sparse Tableau Approach) - K1 and K2 Level questions to be asked.

Writing code snippets in pseudo codes/Flow - charts for simple circuit formulations - K2, K3 Level.

Course Outcome 2 (CO2):

Explain the features of different numerical algorithms with respect to the requirements of circuit simulation: Questions in K1, K2 and K3 Level.

Compare the features of numerical simulation algorithms. Numerical problems and questions in K1, K2 and K3 levels.

Explain the application-specific features of numerical methods in circuit simulation: Adaptive Step-Size, Artificial Ringing and damping - K1 and K2 level questions.

Course Outcome 3 (CO3):

Write circuit files for simple analogue passive and active circuits using standard SPICE notation. K1, K2 and K3 Level questions.

Course Outcome 4 (CO4):

Develop MATLAB scripts for solution of simple ODEs - K2, K3 level questions.

Develop Simulink signal-flow diagrams for simulation of second order, first-order passive networks. K2, K3 Level question.

Model Question paper

QP CODE: PAGES: 4

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: EE393 Course Name: DIGITAL SIMULATION

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Differentiate between DC simulation and Transient Simulation.
2. What is “convergence issue” in circuit simulation?
3. Differentiate between implicit and explicit numerical methods.
4. Define Local Truncation Error.
5. What is a “stiff system”? Give an example.
6. It is required to simulate a circuit with excessively oscillatory response. Out of Euler method and Trapezoidal method, which is suitable for this system, and why?
7. Write the SPICE circuit file to run the transient simulation of an RC circuit excited by a pulse source of amplitude 5 V and frequency 1 kHz. The RC time constant is 0.1 ms (You may choose any R, C values that satisfy this requirement). Use end time of 1 s. Assume any missing information appropriately.
8. Differentiate between ‘ .lib’ and ‘.inc' SPICE directives?
9. What is the output of the following MATLAB code:?

```
b = [3 8 9 4 7 5];

sum1 = 0;

for k = 1:4

        sum1 = sum1+b(k);

        end

sum1
```

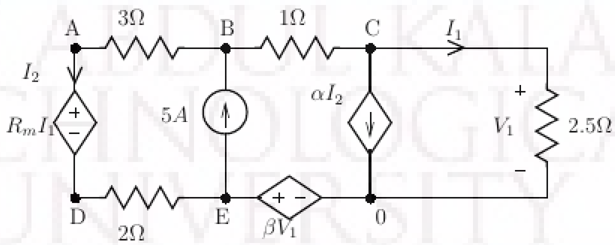
10. Write a MATLAB function to accept the coefficients of a quadratic polynomial and return the evaluated roots.

PART B (14 x 5 = 70 Marks)

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

Module 1

11. (a).Figure 1 shows a network, with α=2, β=0.4 and R_m= 1 Ω. Formulate the Modified Nodal Analysis matrix from fundamental equations. (10)



(b). Explain how 'damping' can be used to improve convergence in nonlinear equation solutions using Newton-Raphson method. (4)

12. (a). For the circuit shown in Fig. 2, formulate the Sparse Tableau Analysis (STA) matrix from the fundamental equations. Take α=0.5. (10)

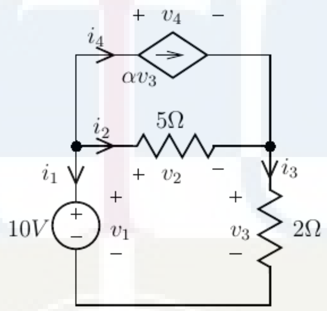


Figure 2: $\alpha = 0.5$

(b). What is Sensitivity Analysis? Explain with an example. (4)

Module 2

13. Solve

$\frac{dx}{dt} = -\frac{1}{2}x - 6te^{-t/2}$, 0 < t < 20, x_0=3, for h = 0.01 and h= 0.05 using Trapezoidal method and forward Euler methods. Compare with the analytical solution $\hat{x}(t) = (2 - 3t^2)e^{-t/2}$. Find the global error at the final value. (14)

14. (a) What is 'Order' of a numerical method? Explain how order and step-size influence the accuracy and computational efficiency of numerical methods. (8)

(b). What are the sources of error in numerical methods? (6)

Module 3

15. Write the MNA equations for the circuit shown in Fig. 3 below: Apply Trapezoidal method on the resulting equations to obtain the corresponding numerical equations.

(14)

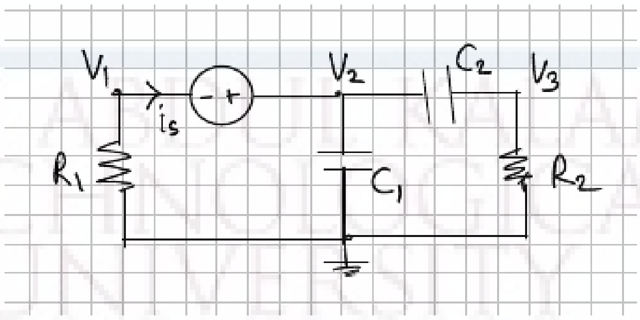


Fig. 3.

16. (a). Explain adaptive step-size in numerical simulation. What methodologies are used for adaptive step-size simulation? (10)

(b). What is 'artificial damping'? Explain with an example.

(4)

Module 4

17. (a). Explain the use of .SUBCKT with an example, where the sub-circuit is an RC integrator circuit to be used in cascade with an RC differentiating circuit. The source is a pulse source of 5 V amplitude and 1 kHz frequency. Assume suitable values for the resistors and capacitors. Use an ideal pulse with no rise time, fall-time, delay time etc. Under what conditions/circumstances do you use a .MODEL instead of a .SUBCKT in a circuit simulation? (8)

(b). Write the circuit file for an RC coupled amplifier with npn transistors. Use suitable values for the circuit parameters. The simulation is to be set up for frequency response analysis. (6).

18. (a). Shown below is a SPICE circuit file/netlist. Inspect the circuit file description and draw the circuit. What kind of simulation is being intended here? Modify this with the source replaced by a single sine wave source of 1kHz and 0.5 mA amplitude, for a transient simulation with end time of 0.1 sec, and a maximum step size of 1 us.

(8)

```
L1 OUT 0 1µ
C1 OUT 0 420p
L2 IN 0 1µ
C2 IN 0 420p
C3 OUT IN {C}
R1 OUT 0 300
I1 0 IN 0 AC 5m
```

```
R2 IN 0 300
.ac oct 200 5Meg 10Meg
.step param C 50p 150p 50p
.end
```

(b). Demonstrate the use of the SPICE directives: ".OP, .PARAM, and .IC" with suitable examples. (6).

Module 5

19. (a)Write a MATLAB function to solve an initial value problem given by: $\dot{x} = x - t^2 + 1;\ 0 \leqslant t \leqslant 2;\ x(0) = 0.5$, using the Trapezoidal method. The function should get the initial value, final value and the step through arguments. Modify this code to solve any general function described in another file, named fx.m? (8)

(b). Develop the simulation signal-flow diagram for the simulation of a parallel RLC network excited by a current source, from the fundamental equations. Use standard blocks such as gain, sum/difference, integrators etc. (6)

20. Develop a simulation (signal-flow) diagram for a DC series motor fed from a dc voltage source and connected to a mechanical load. Take k_b as the back-emf constant and k_t as the torque constant of the motor, R_a the armature resistance, L_a the armature inductance, R_f, L_f are the field resistance and inductance respectively, J is the combined moment of inertia, and B is the viscous friction constant. The simulation diagram should show how the armature current i_a and the speed ω are derived. Show all the relevant equations from which the diagram is derived. (14)

Syllabus

Module 1 (9 Hrs)

Introduction to Simulation:

Types of simulation problems - DC Simulation - Transient Simulation - AC Simulation - Digital Circuit Simulation - Sensitivity Analysis - Noise Analysis. Examples.

Problem formulation for circuit simulation:

Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix.

Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language). Formulation Examples.

Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Formulation Examples.

Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time.

Convergence issues -

Practical Limits due to finite precision. Damping.

(Assignments/Course projects may be given for writing code to formulate the Matrix using any high-level language/pseudo code).

Module 2 (7 hours)

Fundamental Theory behind Transient Simulation:

Introduction to transient simulation: Discretization of time, idea of time - step. - Review of backward Euler, forward Euler and trapezoidal methods.

Basic ideas of Accuracy and Stability (Qualitative description only) of methods of transient analysis using numerical techniques.

Basic ideas of Explicit and Implicit methods:

Concept of 'order' of a numerical method, Local Error (LE), Local Truncation Error (LTE) and Global Error. (No detailed derivations needed).

Module 3: (9 hours)

Application to Circuit Simulation:

Application to circuit simulation: Using BE and TRZ methods. - Second order Backward Difference Formula (BDF-2/Gear Formula, no derivation required). Equivalent Circuit Approach- Stiff systems - Features - Simple Examples.

Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only).

Practical aspects in choosing numerical methods: Artificial damping and ringing induced by numerical algorithms - Assessment of accuracy -- The issue of Singular Matrix in initial/start-up condition.

Module 4

Introduction to SPICE: (10 Hrs).

Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences.

Circuit Simulation using SPICE.

Writing SPICE circuit files: SPICE Syntax - SPICE directives (Dot commands: .END, .FUNC, .NET .OPTIONS)

Performing different kinds of simulation and analysis - DC, DC sweep, AC, Transient and noise analyses. (Use of .OP, .PARAM, .TRAN, .DC, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE)

Developing circuit files for simple circuits like CE amplifiers, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes, Transistors).

Developing component models, subcircuits in SPICE. (Use of .MODEL, .SUBCKT, .LIB, .INC, .ENDS directives) - examples (BJTs/MOSFETs).

Simulation Demonstration with simple circuits. Setting-up simulation , and different types of simulation etc. shall be demonstrated by the course instructor.

[LTspice®, a free SPICE version, is chosen here as reference due to wide availability, however, PSpice®, LTspice®, ngSpice, eSim or any available SPICE variants may be used for assignments/demonstrations, based on availability].

Module 5

Introduction to equation solver tools (10 Hrs)

Introduction to scripting using MATLAB®: Language constructs - Basic Arithmetic Operations - Basic Operators and Special Characters Variables and Arrays - Complex numbers -Basic Handling of Arrays (Vectors and Matrices).

Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break -return) - functions.

Numerical Integration - ODE solvers - ode23, ode23t and ode45 - Examples - User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples. (Performance comparison of different solvers may be given as assignments).

Visual Modelling: Introduction to Simulink/Similar Causal modelling tools. Developing causal simulation diagrams using fundamental blocks (Gain, sum/difference, integrators, etc) for simple circuit models - first-order/second-order circuits, Separately excited DC Motor, from the ODE descriptions. Non-linear examples: DC Series Motor, Simple passive networks with switches.

Simulation Demonstration with different integration algorithms /step-sizes. [Only for practice/assignments].

(Instead of MATLAB/Simulink®, Octave and Scilab®/XCos® may be used for assignments/demonstrations).

Text Books

1. M. B. Patil, V. Ramanarayanan and V. T. Ranganathan, “Simulation of Power Electronic Circuits”, Narosa Publishing House.
2. Steven C. Chapra and Raymond P. Canale, “Numerical Methods for Engineers”, Tata-McGraw Hill, New Delhi, 2000.

3. Rudra Pratap, "Getting Started with MATLAB®: A Quick Introduction for Scientists & Engineers", 2010, Oxford University Press.

References

1. LTSpice® [Online] http://www.ltwiki.org
2. MATLAB® [Online] https://in.mathworks.com/help/matlab/
3. Won Y. Yang, Wenwu Cao, Tae-Sang Chung and John Morris, "Applied Numerical Methods Using MATLAB®"

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Introduction to Simulation and Problem Formulation. (9 Hrs).**	
1.1	Types of simulation problems - DC Simulation - Transient Simulation - AC Simulation - Digital Circuit Simulation - Sensitivity Analysis - Noise Analysis. Examples.	2
1.2	Problem formulation for circuit simulation: Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language).	1
1.3	Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language). Examples.	2
1.4	Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Examples.	1
1.5	Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time.	2
1.6	Convergence issues - Limits due to finite precision. Damping.	1
2	**Fundamental Theory behind Transient Simulation: (7 Hrs).**	
2.1	Introduction to transient simulation: Discretization of time, idea of time - step. - Review of backward Euler, forward Euler and trapezoidal	1

	methods.	
2.2	Basic ideas of Accuracy and Stability of methods of transient analysis using numerical techniques.	1
2.3	Basic ideas of Explicit and Implicit methods:	1
2.4	Concept of Order of a numerical method, Local Error (LE), Local Truncation Error (LTE) and Global Error.	4
3.	**Application to Circuit Simulation (9 Hrs)**	
3.1	Application to circuit simulation: Using Backward Euler, Trapezoidal and Second order backward differentiation formula (BDF2 - Gear's formula) methods in circuit simulation: Equivalent Circuit Approach - Equation formulation examples.	4
3.2	Stiff systems - Features - Examples.	1
3.3	Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only).	1
3.4	Practical aspects in choosing numerical methods: Artificial damping and ringing induced by numerical algorithms.	1
3.5	Assessment of accuracy - The issue of Singular Matrix in initial/start-up condition.	2
4	**Introduction to SPICE: (10 Hrs)**	
4.1	Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences.	1
4.2	Circuit Simulation using SPICE. Writing SPICE circuit files: SPICE Syntax - SPICE directives (Dot commands: .end, .FUNC, .NET .OPTIONS)	2
4.3	Performing different kinds of simulation - DC, DC sweep, AC, Transient and noise analyses. (.op, .param, .tran, .dc, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE	2
4.4	Developing simple circuit files for sample circuits like CE amplifier, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes).	2
4.5	Developing component models, sub-circuits in SPICE. (.model, .subckt, .lib, .inc, .ends directives) Example problems. Using datasheets to develop component models - examples (BJTs/MOSFETs) - Exercises.	2

4.6	Simulation Demonstration with simple circuits. Setting-up simulation, and different types of simulation etc., shall be demonstrated by the course instructor. Students shall be given SPICE circuit simulation assignments. [LTspice®, a freeware SPICE version, is chosen here as reference due to wide availability, however, PSpice®, LTspice®, ngSpice or any available SPICE variants may be used for assignments/demonstrations].	1
5.	**Introduction to MATLAB®/Simulink® (10 Hrs)**	
5.1	Introduction to MATLAB® scripting. Language constructs - Basic Arithmetic Operations - Basic Operators and Special Characters - Variables and Arrays - Complex numbers - Basic Handling of Arrays (Vectors and Matrices).	2
5.2	Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break - return) - functions.	2
5.3	Numerical Integration - ODE solvers - ode23, ode23t and ode45 - Examples	1
5.4	User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples. (Performance comparison of different solvers may be given as assignments).	2
5.5	Visual Modelling: Introduction to Simulink. Developing causal simulation diagrams using fundamental blocks for simple circuit models - first-order/second-order circuits, Separately excited DC Motor, from the ODE descriptions.	2
5.6	Demonstration of simulation examples with different integration algorithms /step-sizes. [Only demonstration/practice/assignments]. (Instead of MATLAB®/Simulink®, Octave and Scilab®/XCos® may be used for assignments/demonstrations).	1

SEMESTER VI

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET302	**LINEAR CONTROL SYSTEMS**	**PCC**	**2**	**2**	**0**	**4**

Preamble: This course aims to provide a strong foundation on classical control theory. Modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach will be discussed. The compensator design of linear systems is also introduced.

Prerequisite : Basics of Circuits and Networks, Signals and Systems

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

CO 1	Describe the role of various control blocks and components in feedback systems.
CO 2	Analyse the time domain responses of the linear systems.
CO 3	Apply Root locus technique to assess the performance of linear systems.
CO 4	Analyse the stability of the given LTI systems.
CO 5	Analyse the frequency domain response of the given LTI systems.
CO 6	Design compensators using time domain and frequency domain techniques.

Mapping of course outcomes with program outcomes

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

Assessment Pattern:

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

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

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

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Derive and explain the transfer function of AC servo motor.
2. With the help of suitable sketches explain the need for a lead compensator.
3. Explain how does the feedback element affect the performance of the closed loop system.

Course Outcome 2 (CO2):

1. Obtain the different time domain specifications for a given second order system with impulse input.
2. Determine the value of the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G_p(s) = \frac{K}{s(s+10)}$, which results in a critically damped response. Also analyse the effect of K on damping factor.
3. Problems related to static error constant and steady state error for a given input.

Course Outcome 3(CO3):

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+4)}$ is oscillatory, using Root locus.
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s\,(s^2+2\,s+2)}$? Determine the value of K to achieve a damping factor of 0.5?
3. Problems on root locus for systems with positive feedback.

Course Outcome 4 (CO4):

1. Problems related to application of Routh's stability criterion for analysing the stability of a given system.
2. Problems related to assess the stability of the given system using Bode plot.
3. Problem related to the analysis of given system using Nyquist stability criterion.

Course Outcome 5 (CO5):

1. Determine the value of K such that the gain margin for the system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+5)}$ equals to 2.

2. Determine the phase margin to assess the stability of the system with $G(s)H(s) = \frac{2}{s\,(s+1)\,(s+4)}$
3. Derive and explain the dependence of resonant peak on damping factor.

Course Outcome 6 (CO6):

1. Problems related to the design of lead compensator using Bode plot.
2. Problems related to the design of lag compensator using Root locus technique.
3. Design the parameters of an electrical lag circuit with f_1= 200 Hz and f_2= 1kHz

Model Question Paper

PAGES: 2

QPCODE:

Reg. No:____________

Name:______________

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

Course Code**: EET302**

Course Name: **LINEAR CONTROL SYSTEMS**

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

PART A

Answer all Questions. Each question carries 3 Marks

1 Give a comparison between open loop and closed loop control systems with suitable examples.

2 Derive the dependence of φ_m and α of a lead compensator and hence explain the restrictions on the selection of α?

3 For a closed loop system with $G(s) = \frac{1}{s\,(s+5)}$; and H(s) = 0.05, calculate the steady state error constants.

4 Check the stability of the system given by the characteristic equation, $G(s) = s^5 + 2s^4 + 4s^3 + 8s^2 + 16s + 32$; using Routh criterion.

5 With suitable sketches explain how the addition of poles to the open-loop transfer function affect the root locus plots.

6 Explain Ziegler – Nichol's PID tuning rules.

7 Explain the features of non-minimum phase systems with a suitable example.

8 How do you determine the gain margin of a system, with the help of Bode plot?

9 State and explain Nyquist stability criterion.

10 Discuss the procedure for Lag compensator design using Root locus technique.

PART B

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

Module 1

11 a) Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. **(9)**

b) Compare the effect of H(s) on the pole-zero plot of the closed loop system with $G(s)=\frac{s+3}{(s^2+3s+2)}$ with: i) derivative feed back H(s)= s; ii) integral feedback H(s)=1/s. **(5)**

12 a) Why compensation is necessary in feedback control system? What are the factors to be considered for choosing the feedback compensation? **(6)**

b) With relevant characteristics explain the operation of the following control devices. i) Synchro error detector, ii) Tachogenerator. **(8)**

Module 2

13 a) Derive an expression for the step response of a critically damped second order system? Explain the dependency of Mp on damping factor. **(9)**

b) Determine the value of K and the natural frequency of oscillation ω_n for the unity feedback system with forward transfer function $G(s)=\frac{K}{s(s+10)}$, which results in a critically damped response when subjected to a unit step input.

Also determine the steady state error for unit velocity input. **(5)**

14 a) A unity feedback system is characterized by an open loop transfer function $G(s)=\frac{20}{(s^2+5s+5)}$. Determine the transient response when subjected to a unit step input and sketch the response. Evaluate the maximum overshoot and the corresponding peak time of the system. . **(9)**

b) Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s)=\frac{K}{s(s^2+20s+8)}$ is stable. . **(5)**

Module 3

15 a) Design a lag lead compensator with open loop transfer function $G(s) = \frac{K}{s(s+0.5)}$ to satisfy the following specifications (i) damping ratio of the dominant closed loop poles is 0.5 (ii) Undamped natural frequency of the dominant closed loop poles ω_n = 5 rad/sec iii) Velocity error constant K_v = 80. **(10)**

b) Compare between PI and PD controllers. **(4)**

16 a) Sketch root locus for a system with $G(s)H(s)=\frac{K(s+1)}{s(s+4)}$. Hence determine the range of K for the system stability. . **(9)**

b) With help of suitable sketches, explain how does Angle and Magnitude criteria of Root locus method help in control system design. **(5)**

Module 4

17 a) The open-loop transfer function of a unity feedback system is $G(s)=\frac{K}{s(0.5s+1)(0.04s+1)}$.Use asymptotic approach to plot the Bode diagram and determine the value of K for a gain margin of 10 dB. **(8)**

b) Compare between the polar plots for $G(s)H(s)=\frac{K}{(s+4)}$ and $G(s)H(s)=\frac{K(s-4)}{(s+4)}$. **(6)**

18 a) Draw the polar plot of an open loop transfer function G(s)= $\frac{6}{(s+1)(s+2)}$ and comment on the phase margin and gain margin. **(8)**

b) Explain the detrimental effects of transportation lag, using Bode plot. **(6)**

Module 5

19 a) Draw Nyquist plot for the system whose open loop transfer function is $G(s)H(s)=\frac{K}{s(s+2)(s+10)}$. Determine the range of K for which the closed loop system is stable. **(9)**

b) Write a short note on Nichols chart. . **(5)**

20 a) Design a phase lead compensator for a unity feedback system given by the open loop transfer function $G(s)=\frac{K}{s(S+1)}$ to meet the following specifications (i) phase margin of the system > 45 deg (ii) ess for unit ramp <1/15 (iii) gain crossover frequency must be 7.5 rad/sec. **(11)**

b) Explain the design constrains on the selection of corner frequencies of lag compensator. **(3)**

Syllabus

Module 1

Feedback Control Systems (9 hours)

Open loop and closed loop control systems- Examples of automatic control systems - Transfer function approach to feed back control systems – Effect of feedback

Control system components – Control applications of DC and AC servo motors, Tacho generator, Synchro, Gyroscope and Stepper motor

Controllers- Types of controllers & Compensators - Transfer function and basic characteristics of lag, lead and lag-lead phase compensators.

Module 2

Performance Analysis of Control Systems (9 hours)

Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of first and second order systems- Pole dominance for higher order systems.

Error analysis: Steady state error analysis and error constants -Dynamic error coefficients.

Stability Analysis: Concept of BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion- Relative stability

Module 3

Root Locus Analysis and Compensator Design (11 hours)

Root locus technique: Construction of Root locus- stability analysis- effect of addition of poles and zeroes- Effect of positive feedback systems on Root locus

Design of Compensators: Design of lag, lead and lag-lead compensators using Root locus technique.

PID controllers: PID tuning using Ziegler-Nichols methods.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for Root locus based analysis (Demo/Assignment only)

Module 4

Frequency domain analysis (9 hours)

Frequency domain specifications- correlation between time domain and frequency domain responses

Polar plot: Concepts of gain margin and phase margin- stability analysis

Bode Plot: Construction- Concepts of gain margin and phase margin- stability analysis, Effect of Transportation lag and Non-minimum phase systems.

Module 5

Nyquist stability criterion and Compensator Design using Bode Plot (9 hours)

Nyquist criterion: Nyquist plot- Stability criterion- Analysis

Introduction to Log magnitude vs. phase plot and Nichols chart (concepts only) - Compensator design using Bode plot: Design of lag, lead and lag-lead compensator using Bode plot.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for various frequency domain plots and analysis (Demo/Assignment only).

Textbooks

1. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
2. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
3. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
4. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education

Reference Books

1. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India
2. Desai M. D., Control System Components, Prentice Hall of India, 2008
3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
4. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016

Course Contents and Lecture Schedule:

Module	Topic coverage	No. of Lectures
1	**Feedback Control Systems (9 hours)**	
1.1	Terminology and basic structure of Open loop and Closed loop control systems- Examples of Automatic control systems (block diagram representations only)	2
1.2	Transfer function approach to feed back control systems- Effect of feedback- Characteristic equation- poles and zeroes- type and order.	2
1.3	Control system components: Transfer functions of DC and AC servo motors –Control applications of Tacho generator, Synchro, Gyroscope and Stepper motor	3
1.4	Need for controllers: Types of controllers – Feedback, Cascade and Feed forward controllers Compensators: Transfer function and basics characteristics of lag, lead, and lag-lead phase compensators	2
2	**Performance Analysis of Control Systems (9 hours)**	
2.1	Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of First order systems- Impulse and Step responses of Second order systems- Pole dominance for higher order systems	3

2.2	Error analysis: Steady state error analysis - static error coefficient of Type 0, 1, 2 systems. Dynamic error coefficients	2
2.3	Stability Analysis: Concept of stability-BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems	2
2.4	Application of Routh's stability criterion to control system analysis- Relative stability	2
3	**Root Locus Analysis and Compensator Design (11 hours)**	
3.1	Root locus technique: General rules for constructing Root loci – stability from root loci -	3
3.2	Effect of addition of poles and zeros on Root locus	1
3.3	Effect of positive feedback systems on Root locus	1
3.4	Design using Root locus: Design of lead compensator using root locus.	2
3.5	Design of lag compensator using root locus.	1
3.6	Design of lag-lead compensator using root locus	1
3.7	PID Controllers: Need for P, PI and PID controllers	1
3.8	Design of P, PI and PID controller using Ziegler-Nichols tuning method.	1
3.9	Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for Root locus based analysis (Demo/Assignment only)	
4	**Frequency domain analysis (9 hours)**	
4.1	Frequency domain specifications- correlation between time domain and frequency domain responses	2
4.2	Polar plot: Concepts of gain margin and phase margin- stability analysis	2
4.3	Bode Plot: Construction of Bode plots- gain margin and phase margin- Stability analysis based on Bode plot	4
4.4	Effect of Transportation lag and Non-minimum phase systems	1
5	**Nyquist stability criterion and Compensator Design using Bode Plot (9 hours)**	
5.1	Nyquist stability criterion: Nyquist plot- Stability criterion- Analysis	3
5.2	Introduction to Log magnitude vs. phase plot and Nichols chart	1
5.3	Design using Bode plot: Design of lead compensator using Bode plot.	2
5.4	Design of Lag compensator using Bode plot.	2
5.5	Design of Lag- lead compensator using Bode plot	1
5.6	Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for various frequency domain plots and analysis (Demo/Assignment only).	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET304	POWER SYSTEMS II	PCC	3	1	0	4

Preamble: The basic objective of this course is to deliver fundamental concepts in power system analysis. The steady state and transient analysis of electrical power system is comprehensively covered in this course ranging extensively using the conventional methods as well as advanced mathematics.

Prerequisite: EET 301 Power Systems I

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

CO 1	Apply the per unit scheme for any power system network and compute the fault levels.
CO 2	Analyse the voltage profile of any given power system network using iterative methods.
CO 3	Analysethe steady state and transient stability of power system networks.
CO 4	Model the control scheme of power systems.
CO 5	Schedule optimal generation scheme.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Why do we adopt per unit scheme of representation? (K2)
2. Which is the most frequent fault and which is the most severe fault? Substantiate with equation. (K2, K3)

Course Outcome 2 (CO2):

1. How is consistency followed in load flow studies? (K4)
2. How does acceleration factor improve convergence in Gauss Siedel Load flow? (K4)

Course Outcome 3 (CO3):

1. Differentiate between steady state and transient stability? (K1, K2)
2. Derive a swing equation. (K3)

Course Outcome 4 (CO4):

1. What is the significance of Inertia constant? (K3)
2. Draw the schematic representation of AGC. Show the frequency deviation pattern. (K1, K2, K3)

Course Outcome 5 (CO5):

1. What are penalty factors? Explain the significance. (K2, K3)
2. Why do we need Unit commitment? Explain with an example. (K3)

Model Question paper

QP CODE: PAGES:5

Reg. No:______________

Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: EET 304

Course Name: POWER SYSTEMS II

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. The generator neutral grounding impedance appears as 3Zn in the zero-sequence net work. Why?
2. A single-phase transformer is rated at 110/440 V, 3 KVA. Its leakage reactance measured on 110 V side is 0.05 ohm. Determine the leakage impedance referred to 440 V side.
3. What is the need of slack bus in load flow analysis?
4. A power system consists of 300 buses out of which 20 buses are generator buses and 25 buses are provided with reactive power support. All other buses are load buses. Determine the size of the Newton Raphson load flow Jacobian matrix.
5. Explain critical clearing angle and its significance with respect to the stability of a power system.
6. Explain Equal Area criterion and state the assumptions made.
7. Draw the basic block diagram of Automatic Voltage Regulator.
8. Discuss the application of SCADA in power system monitoring
9. Explain unit commitment? List out the constraints on unit commitment.
10. Write the conditions for the optimal power dispatch in a lossless system.

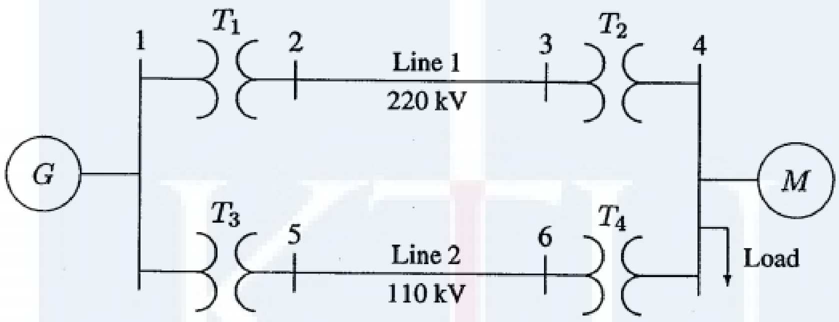
PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module I

1. a)The one-line diagram of a three phase power system is shown in figure below. Select the common base of 100 MVA and 22 kV on the generator side. Draw an impedance diagram with all impedances including the load impedance marked in per unit. The

manufacturer's data for each device is given as follows. The three phase load at bus 4 absorbs 57 MVA, .6 power factor lagging at 10.45 kV. Line1 and Line 2 have reactances of 48.4Ω and 65.43Ω, respectively.

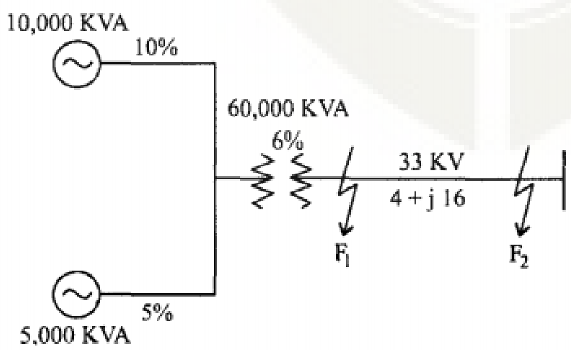
G	90 MVA	22 kV	X=18%
T_1	50 MVA	22/220 kV	X=10%
T_2	40 MVA	220/11 kV	X=6%
T_3	40 MVA	22/110 kV	X=6.4%
T_4	40 MVA	110/11 kV	X=8%
M	66.5 MVA	10.45 kV	X=18.5%



(10)

b) What are the advantages of pu system? Obtain the expression for converting the per unit impedance expressed on one base to another. **(4)**

2. a) A 33 KV line has a resistance of 4 ohm and reactance of 16 ohm respectively. The line is connected to a generating station bus bars through a 6000 KVA step up transformer which has a reactance of 6%. The station has two generators rated 10,000 KVA with 10% reactance and 5000 KVA with 5% reactance. Calculate the fault current and short circuit KVA when a 3-phase fault occurs at the HV terminals of the transformers and at the load end of the line.

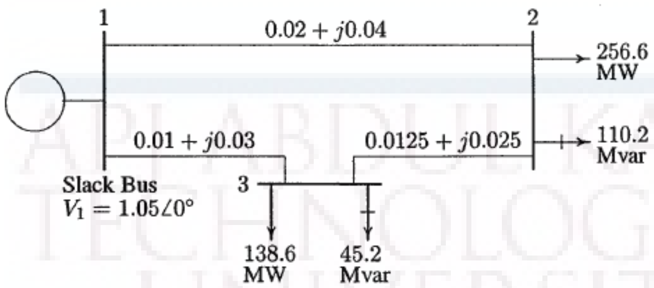


3. **(10)**

b) Explain the different types of current limiting reactors. **(4)**

Module II

4. a)For the system shown in figure obtain the load flow solution at the end of 2 iterations by Gauss Seidel method . The line impedances are marked in per unit on a 100 MVA base.



(10)

b) Explain DC load flow. **(4)**

5. Consider the three bus system shown below. Each of the three lines have aseries impedance of 0.02+j0.08 pu and a total shunt admittance of j0.02 pu. The specified quantities at the buses are tabulated below.

Bus	Real load Demand, P_D	Reactive load demand, Q_D	Real power Generation, P_G	Reactive power Generation, Q_G	Voltage specification
1	2.0	1.0	Unspecified	Unspecified	V_1 = 1.04 +j0
2	0.0	0.0	0.5	1.0	Unspecified
3	1.5	0.6	0.0	$Q_{G3} =$?	$\vert V_3 \vert$ =1.04

Controllable reactive power source is available at bus 3 with the constraint $0 \leq Q_{G3} \leq 1.5$pu. Find the load flow solution using FDLF method (one iteration).

(14)

Module III

6. a) Starting from first principles, derive swing equation of a synchronous machine. **(6)**

b) Two generators rated at 4-pole, 50 Hz, 50 MW 0.85 p.f (lag) with moment of inertia28,000 kg-m^2 and 2-pole, 50Hz, 75 MW 0.82 p.f (lag) with moment of inertia 5,000 kg-m^2 are connected by a transmission line. Find the inertia constant of each machine and the inertia constant of single equivalent machine connected to infinite bus. Take 100 MVA base. **(8)**

7. a) A 50 Hz generator is delivering 50% of the power that it is capable of delivering through a transmission line to an infinite bus. A fault occurs that increases the reactance between the generator and the infinite bus to 500% of the value before the

fault. When the fault is isolated, the maximum power that can be delivered is 75% of the original maximum value. Determine the critical clearing angle for the condition described. **(10)**

b) Explain Equal Area criterion and state the assumptions made. **(4)**

Module IV

8. a)Two turboalternators rated for 110 MW and 210 MW have governor drop characteristics of 5 per cent from no load to full load. They are connected in parallel to share a load of 250 MW. Determine the load shared by each machine assuming free governor action. **(10)**

b) Enumerate the reasons for keeping strict limits on the system frequency variations. **(4)**

9. a) Develop and explain the block diagram of automatic load frequency control of anisolated power system. **(10)**

b) A 100 MVA synchronous generator operates on full load at a frequency of 50 Hz. Inertia constant is 8 MJ/MVA. The load is suddenly reduced 100 MW. Due to time lag in governor system, the steam valve begins to close after 0.4 seconds. Determine the change in frequency that occurs in this time. **(4)**

Module V

10. a)The fuel inputs per hour of plants 1 and 2 are given as

$F_1 = 0.2\ P_1{}^2 + 40\ P_1 + 120$ Rs. per hr

$F_2 = 0.25\ P_2{}^2 + 30\ P_2 + 150$Rs. per hr

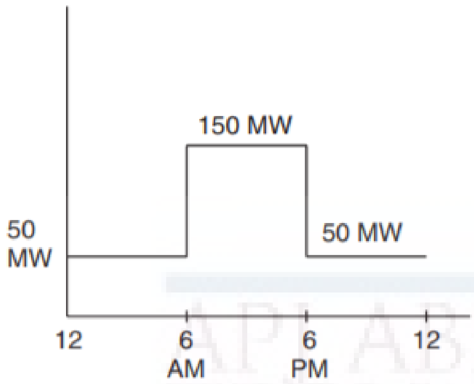
Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading on each unit is 100 MW and 25 MW, the demand is 180 MW, and transmission losses are neglected. If the load is equally shared by both the units, determine the saving obtained by loading the units as per equal incremental productioncost. **(6)**

b) Assume that the fuel input in Btu per hour for units 1 and 2 are given by

$F_1 = (8P_1 + 0.024\ P_1{}^2 + 80)10^6$

$F2 = (6P_2 + 0.04\ P_2{}^2 + 120)10^6$

The maximum and minimum loads on the units are 100 MW and 10 MW respectively. Determine the minimum cost of generation when the following load (as per Figure given below) is supplied. The cost of fuel is Rs. 2 per million Btu.



(8)

11. a) A 2 bus system consist of two power plants connected by a transmission line. The cost curve characteristics of the two plants are
$C_1 = 0.01P_1^2 + 16P_1 + 20$ Rs/hr
$C_2 = 0.02P_2^2 + 20P_2 + 40$ Rs/hr

When a power of 120 MW is transmitted from plant 1 to load (near to plant 2), a loss of 14 MW is occurred. Determine the optimal scheduling of plants and load demand, if cost of received power is 30 Rs./MWhr. **(10)**

b) The incremental fuel cost of two generating units G_1 and G_2 is given by $IC_1 = 25+0.2P_1$, $IC_2 = 32+0.2P_2$, where P_1 and P_2 are real powers generated by the unit. Find the economic allocation for a total load of 250 MW. Neglect the transmission losses. **(4)**

Syllabus

Module I (10 hours)

Per unit quantities-single phase and three phase- Symmetrical components- sequence networks- Fault calculations-symmetrical and unsymmetrical- Fault level of installations- Limiters - Contingency ranking.

Module II (8 hours)

Load flow studies – Introduction-types-network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson (Qualitative analysis only) and Fast Decoupled method (two iterations) - principle of DC load flow - Introduction to distribution flow.

Module III (10 hours)

Power system stability - steady state, dynamic and transient stability-power angle curve-steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Point by Point method - RK method - Equal area criterion application - methods of improving stability limits - Phasor Measurement Units- Wide Area Monitoring Systems

Module IV (10 hours)

Turbines and speed governors-Inertia-Automatic Generation Control: Load frequency control: single area and two area systems - Subsynchronous Resonance - Automatic voltage control -Exciter Control- SCADA systems

Module V (8 hours)

Economic Operation - Distribution of load between units within a plant - transmission loss as a function of plant generation - distribution of load between plants - method of computing penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.

References:

1. Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009.
3. Kundur P., *Power system Stability and Control*, McGraw Hill, 2006
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5. Gupta B. R., *Power System Analysis and Design*, S. Chand, New Delhi, 2006.
6. Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria& Sons, 2009.
7. Soni, M.L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, Dhanpat Rai& Sons, New Delhi, 1984.
8. John J Grainger and William D Stevenson, *Power System Analysis*, 4/e, McGraw Hill, 1994.
9. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
10. Wadhwa C. L., *Electrical Power Systems*, 33/e, New Age International, 2004.
11. Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, *Electric Power System*, John Wiley & Sons, 2012.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Module I(10 hours)**	
1.1	Per unit quantities-single phase and three phase.- -Numerical Problems	2
1.2	Symmetrical components- sequence networks-Numerical Problems	3
1.3	Fault calculations-symmetrical and unsymmetrical-Numerical Problems	3
1.4	Fault level of installations- Limiters-Numerical Problems	2
2	**Module 2(8 Hours)**	

2.1	Load flow studies – Introduction-types	1
2.2	Network model formulation and admittance matrix-Numerical Problems	2
2.3	Gauss-Siedel (two iterations) -Numerical Problems not more than three buses	1
2.4	Newton-Raphson (Qualitative analysis only)	2
2.5	Fast Decoupled method (two iterations) -Numerical Problems not more than three buses	1
2.6	Principle of DC load flow. Introduction to distribution flow.	1
3	**Module 3(10 hours)**	
3.1	Power system stability steady state, dynamic and transient stability--Numerical Problems	2
3.2	power angle curve-steady state stability limit --Numerical Problems	2
3.3	Point by Point method Equal area criterion application-Numerical Problems. RK method-(Abstract idea only)	2
3.4	Methods of improving stability limits-Numerical Problems	2
3.5	Contingency ranking-SSR-(Abstract idea only) – PMUs and Wide area monitoring systems	2
4	**Module IV (10 hours)**	
4.1	Turbines and speed governors-inertia.	2
4.2	Automatic Generation Control: Load frequency control: single area and two area systems-Numerical Problems	3
4.3	Automatic voltage control -Exciter Control.	2
4.4	SCADA systems--(Abstract idea only)	1
4.5	Phasor Measurement Unit- Wide Area Monitoring Systems-(Abstract idea only)	2
5	**Module V (8 hours)**	
5.1	Economic Operation Distribution of load between units within a plant transmission loss as a function of plant generation distribution of load between plants-Numerical Problems	3
5.2	Method of computing penalty factors and loss coefficients-Numerical Problems	2

5.3	Unit commitment: Introduction — Constraints on unit commitments: Spinning reserve, Thermal unit constraints- Hydro constraints- Numerical Problems.	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET306	POWER ELECTRONICS	PCC	3	1	0	4

Preamble: To impart knowledge about the power semiconductor devices, the operation of various power converters and its applications.

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

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

CO 1	Explain the operation of modern power semiconductor devices and its characteristics.
CO 2	Analyse the working of controlled rectifiers.
CO 3	Explain the working of AC voltage controllers, inverters and PWM techniques.
CO 4	Compare the performance of different dc-dc converters.
CO 5	Describe basic drive schemes for ac and dc motors.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember (K1)	10	10	20
Understand (K2)	20	20	30
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the working and switching characteristics of SCR, MOSFET, IGBT (K1)
2. Give a brief description on wide band-gap power devices (K1)
3. Draw and explain the switching characteristics of SCR (K1, K2)
4. Discuss the protection circuits for SCR (K2)
5. Explain different types of isolation in gate drive for power converter circuits (K1, K2)

Course Outcome 2 (CO2):

1. Describe the working with waveforms of single phase half wave rectifiers for different firing angles. (K1)
2. Describe the working with waveforms of single phase fully controlled rectifiers for different firing angles and loads.(K2)
3. Describe the working with waveforms of single phase half controlled rectifiers for different firing angles and loads.(K2)
4. Describe the working with waveforms of three phase rectifiers fordifferent firing angles and loads. (K2)
5. Problems in finding the average output voltage of rectifier. (K2, K3)

Course Outcome 3 (CO3):

1. Explain the working of ACVC with R and RL loads. (K1)
2. Explain single phase inverter for R and RL loads, problems in finding the output voltage, THD of inverter. (K2, K3)
3. Explain 3 phase mode 120^0 and 180^0 conduction modes. (K4)
4. Explain single phase current source inverter PWM Inverter. (K1)
5. Explain single pulse PWM, multiple pulse,and sinusoidalPWM technique (K1, K2)

Course Outcome 4 (CO4):

1. Explain the working of step up and step down converters. (K1, K2)
2. Problems related to step up and step down converters. (K2, K3)
3. Analyse the working of Buck, Boost & Buck Boost regulators. (K3, K4)
4. Design the value of filter inductor & capacitance in regulators. (K3, K4)
5. Problems in Buck, Boost & Buck Boost regulators. (K2, K3)

Course Outcome 5 (CO5):

1. Explain the block diagram of an electric drive (K1,K2)
2. Explain the working of single phase rectifier fed DC drive (K2, K3)
3. Explain the chopper controller DC drive (K2,K3)
4. Explain the four quadrant operation of a DC drive (K2, K3)
5. Explain the v/f control of Induction motor drive (K3,K4)

Model Question paper

QP CODE:

PAGES:2

Reg.No:_______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: EET 306

Course Name: POWER ELECTRONICS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain different turn on methods of SCR.
2. Describe the reverse recovery characteristics of a power diode.
3. Draw the input and output voltage waveforms of single phase half controlled rectifier feeding RL load in continuous and discontinuous conduction mode.
4. Explain with neat sketches, the input and output voltage waveforms of 3ø half controlled rectifier with R load for a firing angle of 30^0.
5. Compare voltage source and current source inverters.
6. Explain the terms modulation index and frequency modulation ratio related to pulse width modulation.
7. Explain time ratio control method to vary the output voltage in choppers.
8. Derive the expression for output voltage of a Buck Converter.
9. What are the advantages of electric drives?
10. Explain regenerative braking control in drives.

PART B (14 x 5 = 70 Marks)

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

Module 1

11. a) Explain the two transistor analogy of SCR. **(6)**

b) Compare the switching characteristics of IGBT. **(8)**

12. a) Explain the structural details of MOSFET. **(8)**

b) Write short note on wideband gap devices. **(6)**

Module 2

13. a) Explain the operation of single phase full wave controlled rectifier without freewheeling diode, when feeding RL load. **(10)**

b) Write short notes on pulse transformer. **(4)**

14. a)The full-wave controlled bridge rectifier has an AC input of 220 V rms at 50 Hz and a 20 ohmload resistor. The delay angle is 40^0. Determine the average current in the load, the power absorbed by the load, and the source volt-amperes. **(7)**

b) Draw the circuit of 3 phase fully controlled rectifier with RLE load and explain the working for $\alpha=60^0$ with necessary waveforms. Derive the expression for output voltage. **(7)**

Module 3

15. a) Explain the 120^0 conduction mode of a three-phase bridge inverter with output voltage waveforms, indicating the devices conducting in each state. **(10)**

b) Write short notes of THD. **(4)**

16. a) Explain sinusoidal PWM technique for varying the magnitude of output voltage in a single-phase inverter . **(6)**

b) Briefly explain current source inverter **(8)**

Module 4

17. a) Explain the working of a Buck-Boost regulator, showing relevant waveforms and derive the expression for its output voltage. **(8)**

b) Design a DC-DC Converter with 12 V input and 200 V output at upto 50 W. The ripple in the output voltage and input current should not exceed +- 5% and +- 20% respectively. Select suitable device and switching frequency. **(6)**

18. a) Describe the working of four quadrant chopper in all the four quadrants with relevant circuit diagrams. **(10)**

b) Briefly explain the current limit control in dc-dc converter **(4)**

Module 5

19. a) Explain the working of a single phase full converter drive **(8)**
b) Explain the working of a four quadrant chopper drive **(6)**

20. a) Explain the stator voltage control for Induction motor drive **(8)**
b) Explain the working of v/f control of Induction motor drive **(6)**

Syllabus

Module 1 - 11 hrs

Introduction to Power Electronics-Scope and applications-power electronics vs signal electronics (1 hr)
Structure and principle of operation ofpower devices- Power diode, Power MOSFET & IGBT – switching characteristics - comparison. Basic principles of wideband gap devices-SiC, GaN (4 hrs)
SCR- Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt& dv/dt protection – Turn-on methods of SCR - Two transistor analogy (5 hr)

Gate triggering circuits – Requirements of isolation and synchronization in gate drive circuits- Opto and pulse transformer based isolation (1hr)

Module 2 - 9 hrs

Controlled Rectifiers (Single Phase) – Half-wave controlled rectifier with R load– Fully controlled and half controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – Output voltage equation- related simple problems(5 hrs)

Controlled Rectifiers (3-Phase) - 3-phase half-wave controlled rectifier with R load – Fully controlled & half-controlled bridge converter with RLE load (continuous conduction, ripple free) – Output voltage equation-Waveforms for various triggering angles (detailed mathematical analysis not required) (4 hrs)

Module 3 - 9 hrs

AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R, & RL loads – Waveforms – RMS output voltage, Input power factor with R load (2 hrs)

Inverters – Voltage Source Inverters– 1-phase half-bridge & full bridge inverter with R and RL loads – THD in output voltage – 3-phase bridge inverter with R load – 120° and 180° conduction modes– Current Source Inverters-1-phase capacitor commutated CSI.(5 hrs)

Voltage control in 1-phase inverters – Pulse width modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM (unipolar & bipolar modulation) – Modulation Index - Frequency modulation ratio.(2 hrs)

Module 4 - 8 hrs

DC-DC converters – Step down and Step up choppers – Single-quadrant, Two-quadrant and Four quadrant chopper – Pulse width modulation & current limit control in dc-dc converters. (4 hrs)
Switching regulators – Buck, Boost & Buck-boost –Operation with continuous conduction mode – Waveforms – Design of Power circuits (switch selection, filter inductance and capacitance) (4 hrs)

Module 5 - 11 hrs

Electric Drive: Introduction to electric drives – Block diagram – advantages of electric drives- types of load – classification of load torque (2 hrs)

DC Drives: Single phase semi converter and single phase fully controlled converter drives. Dual Converters for Speed control of DC motor-1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation. Chopper controlled DC drives- Single quadrant chopper drives- Regenerative braking control- Two quadrant chopper drives- Four quadrant chopper drives(6 hrs)

AC Drives: Three phase induction motor speed control. Stator voltage control – stator frequency control - Stator voltage and frequency control (v/f) (3 hrs)

(It is expected to emphasize the ease of independent control of field flux and armature flux in SEDC motor and relate the same with Induction motor)

Text Books

1. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education
2. Daniel W. Hart, Power Electronics, Tata McGraw-Hill Education
3. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi

References:

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters,

Applications & Design, Wiley-India
2. Fundamentals of Power Electronics, Erickson, Robert W., and Maksimovic, Dragan.
3. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
4. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India
5. Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.
6. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw-Hill College; International edition ,1995
7. Application notes on SiC and GaN, www.infineon.com. [online]
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9. Milligan, J. W., Sheppard, S., Pribble, W., Wu, Y.-F., Muller, G., &Palmour, J. W. (2007). SiC and GaN Wide Bandgap Device Technology Overview, 2007 IEEE Radar Conference. doi:10.1109/radar.2007.374395.
10. Vedam Subramaniam "Electric drives (concepts and applications)", Tata McGraw-Hill, 2001.
11. G. K. Dubey, Fundamentals of Electric Drives, Narosa publishers, second edition, 2010.

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Power Devices (11 hours)**	
1.1	Introduction to Power Electronics: Scope and applications-power electronics vs signal electronics.	1
1.2	Structure, principle of operation, switching characteristics of Power Devices- Power Diode, Power MOSFET & IGBT – Comparison	3
1.3	Basic principles of wideband gap devices-SiC, GaN	1
1.4	SCR- Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt& dv/dt protection – Turn-on methods of SCR - Two transistor analogy	5
1.5	Requirements of isolation and synchronization in gate drive circuits-Opto and pulse transformer based isolation	1
2	**Single phase and three phase controlled rectifiers (9 hours)**	
2.1	Half-wave controlled rectifier with R load	2
2.2	1-phase fully controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – Output voltage equation	2
2.3	1-phase half controlled bridge rectifier with R, RL and RLE loads	1
2.4	3-phase half-wave controlled rectifier with R load	2
2.5	3-phase fully controlled & half-controlled converter with RLE load (continuous conduction, ripple free) – Output voltage equation.	2

3	**Inverters and Voltage control in single phase inverters (9 Hours)**	
3.1	Applications of AC-AC converters – Single phase full-wave AC voltage controllers with R, & RL loads- Waveforms	1
3.2	RMS output voltage, Input power factor with R load	1
3.3	Voltage Source Inverters– 1-phase Half-bridge & Full bridge inverter with R and RL loads– THD in output voltage	2
3.4	3-phase bridge inverter with R load – 120° and 180° conduction modes	2
3.5	Current Source Inverters-1-phase capacitor commutated CSI.	1
3.6	Pulse Width Modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM (bipolar modulation) – Modulation Index - Frequency modulation ratio.	2
4	**DC-DC converters (8 Hours)**	
4.1	Step down and Step up choppers – Single-quadrant chopper	2
4.2	Two-quadrant and Four-quadrant chopper – Pulse width modulation &current limit control in dc-dc converters.	2
4.3	Buck, Boost & Buck-boost –Operation with continuous conduction mode – Waveforms	3
4.4	Design of Power circuits (switch selection, filter inductance and capacitance)	1
5	**Electric drives (11 Hours)**	
5.1	Electric Drive: Introduction to electric drives – Block diagram – advantages of electric drives- types of load – classification of load torque	2
5.2	DC Drives: Single phase semi converter and single phase fully controlled converter drives. Dual Converters for Speed control of DC motor-1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation.	3
5.3	Chopper controlled DC drives. Single quadrant chopper drives. Regenerative braking control. Two quadrant chopper drives. Four quadrant chopper drives	3
5.4	AC Drives: Three phase induction motor speed control. Stator voltage control – stator frequency control - Stator voltage and frequency control (v/f) (3 hrs)	3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET308	COMPREHENSIVE COURSE WORK	PCC	1	0	0	1

Preamble: The objective of this Course work is to ensure the comprehensive knowledge of each student in the most fundamental Program core courses in the curriculum. Five core courses credited from Semesters 3, 4 and 5 are chosen for the detailed study in this course work. This course has an End Semester Objective Test conducted by the University for 50 marks. One hour is assigned per week for this course for conducting mock tests of objective nature in all the listed five courses.

Prerequisite:
1. EET 201 Circuits and Networks
2. EET 202 DC Machines and Transformers
3. EET 206 Digital Electronics
4. EET 301 Power Systems I
5. EET 305 Signals and Systems

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

CO 1	Apply the knowledge of circuit theorems to solve the problems in electrical networks
CO 2	Evaluate the performance of DC machines and Transformers under different loading conditions
CO 3	Identify appropriate digital components to realise any combinational or sequential logic.
CO 4	Apply the knowledge of Power generation, transmission and distribution to select appropriate components for power system operation.
CO 5	Apply appropriate mathematical concepts to analyse continuous time and discrete time signals and systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3										2
CO2	3	2										2
CO3	3	3	1		1							2
CO4	3	3				1	1	1			1	2
CO5	3	3	1		1							2

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	20
Apply	20
Analyse	
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
50	0	50	1 hour

End Semester Examination Pattern: Objective Questions with multiple choice (Four). Question paper include Fifty Questions of One mark each covering the five identified courses.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A circuit with resistor, inductor and capacitor in series is resonant at f_0 Hz. If all the component values are now doubled, the new resonant frequency is

a) 2 f_0
b) Still f_0
c) f_0 /2
d) f_0 /4

2. The line A to neutral voltage is $10<15^0$ V for a balance three phase star connected load with phase sequence ABC. The voltage of line B with respect to line C is given by

a) $10\sqrt{3}<105^0$ V
b) $10<105^0$ V
c) $10\sqrt{3}<75^0$ V
d) $-10\sqrt{3}<90^0$ V

3. The average power delivered to an impedance (4-j3)Ω by a current $5\cos(100\pi t+100)$A is

a) 44.2 W
b) 50 W
c) 62.5 W
d) 125 W

Course Outcome 2 (CO2)

1. The DC motor which can provide zero speed regulation at full load without any controller is

a) Series
b) Shunt
c) Cumulatively compound
d) Differentially compound

2. For a single phase, two winding transformer, the supply frequency and voltage are both increased by 10%. The percentage changes in the hysteresis and eddy current loss, respectively are

a) 10 and 21
b) -10 and 21
c) 21 and 10
d) -21 and 10

3. Match the following

List I-Performance Variables	List II-Proportional to
A. Armature emf (E)	1. Flux (ϕ), speed (ω), Armature Current(Ia)
B. Developed Torque (T)	2. ϕ and ω only
C. Developed Power (P)	3. ϕ and Ia only
	4. Ia and ω only
	5. Ia only

Choices:

	A	B	C
a)	3	3	1
b)	2	5	4
c)	3	5	4
d)	2	3	1

Course Outcome 3(CO3):

1. The SOP (sum of products) form of a Boolean function is ∑(0, 1, 3, 7, 11), where inputs are A, B, C, D (A is MSB and D is LSB). The equivalent minimized expression of the function is

a) (B'+C)(A'+C)(A'+B')(C'+D)
b) (B'+C)(A'+C)(A'+C')(C'+D)
c) (B'+C)(A'+C)(A'+C')(C'+D')
d) (B'+C)(A+B')(A'+B')(C'+D)

2. A cascade of three identical modulo-5 counters has an overall modulus of

a) 5
b) 25
c) 125
d) 625

3. The octal equivalent of the HEX number AB.CD is

a) 253.314
b) 253.632
c) 526.314
d) 526.632

Course Outcome 4 (CO4):

1. Corona losses are minimized when

a) Conductor size is reduced
b) Smoothness of the conductor is reduced
c) Sharp points are provided in the line hardware
d) Current density in the conductors is reduced

2. Keeping in view the cost and overall effectiveness, the following Circuit Breaker is best suited for capacitor bank switching

a) Vacuum
b) Air Blast
c) SF_6
d) Oil

3. The horizontally placed conductors of a single phase line operating at 50Hz are having outside diameter of 1.6cm and the spacing between centres of the conductors is 6m. The permittivity of free space is 8.854×10^{-12} F/m. The capacitance to ground per kilometre of each line is

a) 4.2×10^{-9} F

b) 4.2×10^{-12} F
c) 8.4×10^{-9} F
d) 8.4×10^{-12} F

Course Outcome 5 (CO5):

1. Consider a continuous time system with input x(t) and output y(t) given by y(t)=x(t)cos(t). This system is

a) Linear and time invariant
b) Non-linear and time invariant
c) Linear and time varying
d) Non-linear time varying

2. Signal Flow Graph is used to obtain

a) Stability of the system
b) Transfer Function of a system
c) Controllability of a system
d) Observability of a system

3. The steady state error due to a step input for Type 1 system is

a) Zero
b) Infinity
c) 1
d) 0.5

Syllabus

Full Syllabus of all Five selected Courses.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Circuits and Networks**	
1.1	Mock Test on Module 1 and Module 2	**1**
1.2	Mock Test on Module 3, Module 4 and Module 5	**1**
1.3	Feedback and Remedial	**1**
2	**DC Machines and Transformers**	
2.1	Mock Test on Module 1, Module 2 and Module 3	**1**
2.2	Mock Test on Module 4 and Module 5	**1**
2.3	Feedback and Remedial	**1**
3	**Digital Electronics**	
3.1	Mock Test on Module 1 and Module 2	**1**
3.2	Mock Test on Module 3, Module 4 and Module 5	**1**

3.3	Feedback and Remedial	**1**
4	**Power Systems I**	
4.1	Mock Test on Module 1, Module 2 and Module 3	**1**
4.2	Mock Test on Module 4 and Module 5	**1**
4.3	Mock Test on Module 1, Module 2 and Module 3	**1**
5	**Signals and Systems**	
5.1	Mock Test on Module 1, Module 2 and Module 3	**1**
5.2	Mock Test on Module 4 and Module 5	**1**
5.3	Feedback and Remedial	**1**

CODE	COURSE	CATEGORY	L	T	P	CREDIT
EEL332	POWER SYSTEMS LAB	PCC	0	0	3	2

Preamble : This Laboratory Course will provide a perfect platform for the students to do hands-on practise with hardware and software in Power Systems. The experiments include simulation of power system analysis in steady state and transient state. The Hardware experiments cover Protective Relaying and High Voltage Testing. Successful completion of this lab will certainly make the students equipped for any Power Industry.

Prerequisite : EET301Power Systems I

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

CO 1	Develop mathematical models and conduct steady state and transient analysis of power system networks using standard software.
CO 2	Develop a frequency domain model of power system networks and conduct the stability analysis.
CO 3	Conduct appropriate tests for any power system component as per standards.
CO 4	Conduct site inspection and evaluate performance ratio of solar power plant.

Mapping of course outcomes with program outcomes

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

ASSESSMENT PATTERN:

Mark distribution :

Total Marks	CIE	ESE	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation (CIE) Pattern:

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

Internal Test Evaluation (Immediately before the second series test)

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:

(a) Preliminary work (Type of Test, circuit diagram and diagram for simulation): 15 Marks
(b) Simulation in software and Conducting the experiment (Procedure) : 10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting): 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

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

LIST OF EXPERIMENTS:

Part A: POWER SYSTEM SIMULATION EXPERIMENTS

1. Y-Bus Formulation(Basic Programming): Effect of change in topology
2. Transmission Line Modelling (Basic Programming): ABCD constants
3. Load Flow Analysis –Gauss-Siedel Method, Newton-Raphson Method,Fast Decoupled Method – Effect of change in load/generation schedule
4. Load Flow Analysis –Gauss-Siedel Method, Newton-Raphson Method,Fast Decoupled Method – Effect of change in real power/reactive power limits
5. Short Circuit Analysis – Symmetrical Faults and Unsymmetrical Faults
6. Contingency Ranking
7. Transient Stability Analysis
8. Automatic Generation Control – Single Area, Two Area
9. Distribution Systems with Solar PV units
10. Reactive Power Control.
11. Ferranti Effect and Reactive Power Compensation.
12. Plot the IV characteristics of a PV module and determine Maximum Power Point.

Part B: POWER SYSTEM COMPONENT TESTING (Hardware experiments)

1. High voltage testing -Power frequency/Impulse
2. High voltage testing -DC
3. Smart metering
4. Relay Testing - Over current relay /Earth fault(Electromechanical/Static/Numerical)
5. Relay Testing –Voltage relay/ Impedance Relay (Electromechanical/Static/Numerical)
6. Insulation Testing – LT & HT Cable
7. Earth Resistance
8. Testing of CT and PT
9. Testing of transformer oil
10. Testing of dielectric strength of solid insulating materials
11. Testing of dielectric strength of air
12. Power factor improvement

Instructions:

Both software and hardware experiments are included. **At least 12 experiments (4 hardware experiments are mandatory) and one Mini Project.** Any additional experiment can be treated as Beyond the Syllabus. **Students have to do software simulation and a hardware testing for the End semester examination.**

Mandatory Course Project:

Design a solar power plant (rooftop or ground mounted).Conduct site inspection and feasibility study. Design the components to be used and calculate the performance ratio. Prepare a concise project report giving justifications to the choices made and the economic analysis.

Students have to do a mandatory course project (group size not more than 4 students- individual may be preferred).A report isalso to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Reference Books:

1. HadiSaadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. Kothari D. P. and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009
3. M. S. Naidu, V. Kamaraju, *High Voltage Engineering*, Tata McGraw-Hill Education, 2004
4. Wadhwa C. L., *Electrical Power Systems*, 3/e, New Age International, 2009.
5. IEC 61850.
6. IEEE 1547 and 2030 Standards.
7. IS Codes for Testing of Power System components.
8. IEC 61724-1:2017Performance of Solar Power Plants.

CODE	COURSE	CATEGORY	L	T	P	CREDIT
EEL334	POWER ELECTRONICS LAB	PCC	0	0	3	2

Preamble : Impart practical knowledge for the design and setup of different power electronic converters and its application for motor control.

Prerequisite : Power Electronics (EET306)

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

CO 1	Determine the characteristics of SCR and design triggering circuits for SCR based circuits.
CO 2	Design, set up and analyse single phase AC voltage controllers.
CO 3	Design, set up and test suitable gate drives for MOSFET/IGBT.
CO 4	Design, set up and test basic inverter topologies.
CO 5	Design and set up dc-dc converters.
CO 6	Develop simulation models of dc-dc converters, rectifiers and inverters using modern simulation tools.

Mapping of course outcomes with program outcomes

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

ASSESSMENT PATTERN:

Mark distribution:

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

Continuous Internal Evaluation (CIE) Pattern:

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

Internal Test Evaluation (Immediately before the second series test

End Semester Examination (ESE) Pattern:

The following guidelines should be followed regarding award of marks:

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

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

LIST OF EXPERIMENTS:
(12 experiments are mandatory)

HARDWARE EXPERIMENTS: (A minimum of 8 experiments are mandatory)

1. Static characteristics of SCR

Aim: To determine the minimum gate current & gate voltage required to trigger the SCR also to measure the latching current, holding current and to plot the static characteristics of SCR

2. R and RC firing scheme for SCR control

Aim: To design and set up a half wave controlled rectifier with R and RC firing circuits and plot voltage waveform across the load and thyristor for different firing angles.Also determine the minimum and maximum firing angles of this circuit.

3. Line Synchronised Triggering Circuits of SCR

Aim: To design and set-up line synchronized Ramp Trigger and Digital Trigger circuits of SCR and observe the waveforms

4. AC Voltage Controller

Aim: To study the single phase AC voltage controller using TRIAC/SCRs. Set-up a single phase AC voltage controller & observe waveforms across load resistance for different firing angles.

5. Gate Driver Circuits for MOSFET/IGBT

Aim: To design and test a gate driver circuit for triggering half bridge inverter using MOSFET / IGBT using industry-standard MOSFET drive ICs/Circuits. To test the driving of floating and ground-referenced configurations.

6. Single Phase fully Controlled SCR bridge rectifier

Aim: To design and set up a single phase full converter with RL/RLE loads and observethe waveforms with and without freewheeling diode.

7. Design of Inductor/Transformer

Aim: To design and fabricate an inductor/transformer to be used in power electronic circuits.

8. Design and set-up buck/ boost / buck-boost converters

Aim: To design and set up the buck/boost/buck-boost converter and analyse the characteristics of the same.

9. Switching characteristics of MOSFET

Aim: To study and understand the switching characteristics of a power MOSFET.

10. Single-phase half bridge/full bridge inverter using power MOSFET/IGBT

Aim: To design and set up a single phase half-bridge/full-bridge inverter and observe the waveforms across load and firing pulses.

11. Single-phase sine PWM inverter with LC filter

Aim: To design and set up a single phase sine PWM inverter with LC filter using microcontroller

12. Three phase sine PWM Inverter using IGBT

Aim: To set up a 3-phase PWM Inverter with RL load and observe the waveforms

13. Speed control of DC motor using chopper

Aim: To Control the speed of a DC motor using a step-down chopper

14. Speed control of 3-phase induction motor

Aim: To Control the speed of a 3-phase induction motor using V/f control method.

SIMULATION EXPERIMENTS: (A minimum of 4 experiments are mandatory)

15. Simulation of 1-phase fully-controlled and half-controlled rectifier fed separately excited DC motor

Aim: To simulate 1-phase fully-controlled and half-controlled rectifier fed Separately Excited DC motor and observe the speed, torque, armature current, armature voltage, source current waveforms and find the THD in source current and input power factor.

16. Simulation of Dual Converter – 4 quadrant operation of separately excited DC motor

Aim: To simulate a dual converter for a separately excited DC motor and to understand the four quadrant operation

17. Simulation of buck/boost/buck-boost converters

Aim: To simulate a buck, boost and buck boost converter using MATLAB/equivalent or any other simulation platform and analyse the performance under various duty ratio/ switching frequency.

18. Simulation of single phase & three phase sine PWM inverters.

Aim: To simulate a single phase and three phase sine PWM inverter using MATLAB/equivalent

19. Simulation of 3-phase fully-controlled converter with R, RL, RLE loads

Aim: To simulate a 3-phase fully controlled converter with R,RL and RLE loads and observe the waveform in MATLAB simulink/equivalent.

20. Comparative study of PWM and Square wave inverters.

Aim:-To analyse THD, fundamental component of output voltage in PWM and Square wave inverters (single phase) using MATLAB/equivalent.

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

Reference Books:

1. L. Umanand: Power Electronics – Essentials & Applications, Wiley-India
2. Mohan, Undeland, Robbins: Power Electronics, Converters, Applications & Design, Wiley-India
3. Muhammad H. Rashid: Power Electronics Circuits, Devices and Applications, Pearson Education
4. Ned Mohan A: "First course on power electronics and drives", MNPERE, 2003 Edn.

SEMESTER VI

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET312	BIOMEDICAL INSTRUMENTATION	PEC	2	1	0	3

Preamble :**Nil**

Prerequisite :**Measurements and Instrumentation**

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

CO 1	Explain the basics of anatomy and physiology of human body.
CO 2	Explain different techniques for the measurement of various physiological parameters.
CO 3	Describe modern imaging techniques for medical diagnosis
CO 4	Identify the various therapeutic equipments used in biomedical field
CO 5	Discuss the patient safety measures and recent advancements in medical field.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	-	-	-	-	2	-	-	-	-	-	-
CO 2	2	-	2	-	-	2	-	-	-	-	-	-
CO 3	2	-	2	-	-	2	-	-	-	-	2	-
CO 4	2	2	-	-	-	2	-	-	-	-	2	-
CO 5	2	2	2	-	-	2	-	-	-	-	-	1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	15	15	30
Understand	20	20	40
Apply	15	15	30
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A**contain 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions.

Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the anatomy of heart and cardiac system.
2. Describe the physiology of respiratory system.
3. Discuss the generation and propagation of action potential with neat sketches.
4. Explain electrode theory and Nernst equation.
5. Draw and explain the equivalent circuit of skin electrode interface.
6. Discuss about surface electrodes.
7. What are the applications of needle electrodes?
8. What are microelectrodes?
9. What are the different bioelectrical potentials generated in human body?

Course Outcome 2 (CO2):

1. What are the problems encountered in measuring living systems?
2. Explain the direct method of blood pressure measurement.
3. Explain the indirect method of blood pressure measurement.
4. Explain the Oscillometric method of blood pressure measurement.
5. Explain the Ultrasonic method of blood pressure measurement.
6. Explain the method of blood flow measurement using electromagnetic blood flowmeter.
7. Explain the method of blood flow measurement using Ultrasonic blood flowmeter.
8. Explain the measurement of Cardiac output.
9. What is phonocardiography?
10. Explain the measurement of respiratory parameters using spirometer.

Course Outcome 3(CO3):

1. Explain ECG with a neat block diagram.
2. What is Einthoven triangle?
3. With neat sketches explain the different electrode placement schemes of ECG.
4. Explain the 10-20 system of EEG electrodes placement.
5. Draw and explain the block diagram of EEG machine.
6. Draw and explain the block diagram of EMG recorder.
7. What are the applications of EEG waveforms?
8. Draw the different EEG waveforms and state its frequency.

Course Outcome 4 (CO4):

1. Explain the generation of X-rays and also mention its applications in biomedical engineering.
2. What are the types of CAT scanning?
3. Explain the principle of MRI scanning.
4. Explain the principle of PET scanning.
5. Explain demand pacemaker with a neat block diagram.
6. Why a dual peak DC defibrillator preferred over DC defibrillator?

7. Explain artificial kidney with neat sketches.
8. Explain shortwave diathermy.
9. Explain microwave diathermy.

Course Outcome 5 (CO5):

1. Discuss the need for ventilators.
2. Draw and explain the block diagram of infant incubator.
3. Explain lithotripsy.
4. What is a heart lung machine?
5. What are the different methods of accident prevention in hospitals?
6. Differentiate between macro shock and micro shock.
7. Explain the physiological effects of electric current.
8. Draw the block diagram of a telemetry system.
9. What are the chemical blood tests carried out in a clinical laboratory?
10. Enumerate the application of robotics in medical field.

Model Question paper
QP CODE:

PAGES: 2

Reg. No:_______________
Name:_______________

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

Course Code: EET312

Course Name: Biomedical Instrumentation

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. What are Microelectrodes?
2. What are the different bioelectrical potentials generated in human body?
3. Explain the measurement of Cardiac output.
4. What is Phonocardiography?
5. What are the applications of EEG waveforms?
6. Explain the 10-20 system of EEG electrodes placement.
7. What are the types of CAT scanning?
8. Explain the principle of MRI scanning.
9. What are the different methods of accident prevention in hospitals?
10. Discuss the need for ventilators.

PART B (14 x 5 = 70 Marks)

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

Module 1

11. a) Discuss the generation and propagation of action potential with neat sketches. **(8)**

    b) Draw and explain the equivalent circuit of skin electrode interface. **(6)**

12. a) Briefly explain different Bio potential electrodes. **(10)**

    b) Discuss about surface electrodes. **(4)**

Module 2

13. a) Explain the Ultrasonic method of blood pressure measurement. **(7)**

    b) Explain the method of blood flow measurement using electromagnetic blood flow meter **(7)**

14. a) Explain the direct method of blood pressure measurement. **(7)**

    b) Explain the measurement of respiratory parameters using Spirometer **(7)**

Module 3

15. a) Draw and explain the block diagram of EEG machine. **(8)**

    b) Explain the significance of Einthoven triangle. **(6)**

16. a)Draw the different EEG waveforms and state its frequency **(7)**

    b) Explain ECG with a neat block diagram **(7)**

Module 4

17. a)Explain the generation of X-rays and also mention its applications in biomedical engineering. **(14)**

18. a)Explain the principle of CAT scanning **(7)**

    b) Explain the principle of MRI scanning **(7)**

Module 5

19. a) Draw the block diagram of infant incubator and explain **(10)**

    b) Write a note on medical robotics **(4)**

20. a) What are the chemical blood tests carried out in a clinical laboratory **(10)**

    b) Explain artificial kidney with neat sketches **(4)**

Syllabus

Module 1

Human Physiological systems:Brief discussion of Heart andCardio-vascular system- Physiology of Respiratory system - Anatomy of Nervous and Muscular systems-Problems encountered in measuring living systems

Bioelectric potential: Resting and action potential - Generation and propagation - Bioelectric potentials associated with physiology systems (ECG, EEG and EMG).

Bio potential Electrodes: Theory – Surface electrode – Microelectrode-Needle electrodes.

Transducers for biomedical applications: Transducers for the measurement of pressure, temperature and respiration rate.

Module 2

Measurement of blood pressure:Direct and indirect measurement – Oscillometric method – Ultrasonic method-Measurement of blood flow and cardiac output- Plethysmography –Photo electric and Impedance Plethysmographs-Measurement of heart sounds –Phonocardiography.

Cardiac measurements: Electro-conduction system of the heart- Electro-cardiography – Electrodes and leads – Einthoven triangle- ECG read out devices-ECG machine – block diagram

Module 3

Measurements from the nervous system:Neuronal communication-EEG waveforms and features - 10-20 electrode measurement- EEG Block diagram – Brain-Computer interfacing.

Muscle response: Electromyography- Block diagram of EMG recorders – Nerve conduction velocity measurement

Measurements of respiratory parameters: Spiro meter-Pneumograph

Module 4

Modern Imaging Systems: Basic X-ray machines - CAT scanner- Principle of operation - scanning components - Ultrasonic Imaging principle - types of Ultrasound Imaging - MRI and PET scanning(Principle only).

Therapeutic equipment: Cardiac Pacemakers - De-fibrillators - Hemodialysis machines - Artificial kidney – Lithotripsy - Short wave and Micro wave Diathermy machines

Module 5

Ventilators - Heart Lung machine - Infant Incubators

Instruments for clinical laboratory: Test on blood cells – Chemical tests

Electrical safety: Physiological effects of electric current – Shock hazards from electrical equipment – Method of accident prevention.

Introduction to Tele- medicine - Introduction to medical robotics

Text Books

L. Cromwell, F. J. Weibell and L. A. Pfeiffer, "Biomedical Instrumentation Measurements", Pearson education, Delhi, 1990.

J. G. Webster, "Medical Instrumentation, Application and Design", John Wiley and Sons

Reference Books

1. R. S. Khandpur, "Handbook of Biomedical Instrumentation", Tata McGraw Hill
2. J. J. Carr and J. M. Brown, "Introduction to Biomedical Equipment Technology", Pearson Education
3. AchimSchweikard, "Medical Robotics", Springer

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Human Physiology Systems and Transducers (8 hours)**	
1.1	Problems encountered in measuring living systems - Cardio-vascular – Respiratory- nervous and muscular systems of the body.	2
1.2	Electrode theory-Bioelectric potential - Resting and action potential - Generation and propagation.	1
1.3	Bioelectric potentials associated with physiology systems (ECG, EEG and EMG).	1
1.4	Electrodes Theory - Surface electrode - Needle electrode - Microelectrode	2
1.5	Transducers for the measurement of Pressure, temperature and respiration rate.	2
2	**Cardio Vascular System Measurements(8 hours)**	
2.1	Measurement of blood pressure – direct and indirect measurement – Oscillometric measurement –Ultrasonic method	2
2.2	Measurement of blood flow and cardiac output -Plethysmography – Photo electric and Impedance Plethysmographs	3
2.3	Measurement of heart sounds –Phonocardiography.	1

2.4	Electro-conduction system of the heart - Electro Cardiography – Electrodes and leads – Einthoven triangle.	1
2.5	ECG read out devices - ECG machine – Block diagram	1
3	**Nervous System and its Measurements(7 hours)**	
3.1	Neuronal communication - Measurements from the nervous system.	1
3.2	Electroencephalography- Lead system -10-20 Electrode system,	1
3.3	EEG Block diagram - EEG waveforms and features – Brain-Computer interfacing.	2
3.4	Electromyography- Block diagram of EMG recorders - Nerve conduction velocity	2
3.5	Respiratory parameters measurements – Spiro meter - Pneumography.	1
4	**Modern Imaging Systems and Therapeutic Equipment(7 hours)**	
4.1	Basic X-ray machines	1
4.2	CAT Scanner- Principle of operation - Scanning components	1
4.3	Ultrasonic imaging principle - Types of Ultrasound imaging - MRI and PET scanning(Principle only).	2
4.4	Cardiac pace makers - De-fibrillators	1
4.5	Hemo-dialysis machines -Artificial kidney -Lithotripsy	1
4.6	Short wave and Micro wave diathermy machines	1
5	**Instrumentation for Patient Support and Safety(6 hours)**	
5.1	Ventilators - Heart lung machine - Infant incubators	1
5.2	Instruments for clinical laboratory – Test on blood cells – Chemical tests	1
5.3	Electrical safety– Physiological effects of electric current	1
5.4	Shock hazards from electrical equipment - Method of accident prevention	1
5.5	Introduction to tele- medicine	1
5.6	Introduction to medical robotics	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET322	RENEWABLE ENERGY SYSTEMS	PEC	2	1	0	3

Preamble : This course introduces about different new and renewable sources of energy. Design of some of the systems are also discussed

Prerequisite : **Power Systems I**

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

CO 1	Describe the environmental aspects of renewable energy resources.
CO 2	Explain the operation of various renewable energy systems.
CO 3	Design solar PV systems.
CO 4	Explain different emerging energy conversion technologies and storage.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the environmental impacts of wind energy systems. (K1)
2. Explain the limitations of renewable energy systems (K2)

Course Outcome 2 (CO2):

1. With the help of a block diagram, explain the working of a wind energy conversion system. (K2)
2. Explain the working of a small hydro power plant with the help of a diagram. (K2)

Course Outcome 3 (CO3):

1. Design a grid connected solar photovoltaic system. (K3).
2. Design a solar photovoltaic system for a water pumping system. (K3).

Course Outcome 4 (CO4):

1. Explain how energy can be generated from alcohol. (K2)
2. Explain the need for energy storage systems. Discuss how energy can be stored in batteries. (K2).

Model Question paper

QP CODE:

PAGES: 2

Reg. No:_______________
Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET322

Course Name: RENEWABLE ENERGY SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. What do you mean by global warming? Explain its adverse effects.
2. Write notes on Indian energy scenario.
3. Determine the local apparent time corresponding to 11.30 IST on July 1, at Delhi (280 35’ N,770 12’E). The equation of time correction on July 1 is -4 minutes.
4. Draw and explain the V- I characteristics of a solar cell.
5. Define tip speed ratio, cut in speed and cut out speed of a wind turbine.

6. Explain the factors to be considered for the selection of small hydro plants.
7. Discuss the advantages and disadvantages of tidal power plants.
8. Explain the principle of operation of an OTEC plant. What are its advantages?
9. Explain how power can be derived from satellite stations.
10. Explain how energy can be stored using flywheels.

PART B (14 x 5 = 70 Marks)

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

Module 1

11. a. Illustrate the relation between energy and sustainable development. **(4)**
    b. Compare the advantages and disadvantages of different conventional sources ofenergy. **(10)**

12. a. Write notes on Kyoto protocol. **(4)**
    b. List out the advantages and disadvantages ofdifferent non-conventional sourcesof energy. **(10)**

Module 2

13. a. With the help of a diagram, explain the working of a pyrheliometer. **(7)**
    b. Explain how a standalone solar PV system can be designed. **(7)**

14. a. With the help of a diagram, explain the working of a flat plate collector. **(7)**
    b. Explain how Maximum Power Point Tracking can be done using a buck boostconverter. **(7)**

Module 3

15. a. Derive an expression for power derived from wind. Explain the characteristic of awind turbine. **(7)**
    b. A propeller wind machine has rotor diameter of 40 m. It is operating at location having wind speed of 35kmph and rotating at 20 rpm. Calculate theoretically the power which the machine can extract from the wind considering both wake rotation and effect of drag. Assume ξ=.012. **(7)**

16. a. With the help of a diagram, explain a wind energy conversion system with variablespeed drive scheme. **(8)**
    b. Explain the different types of turbines used in small hydro plants. **(6)**

Module 4

17. With the help of a diagram, explain the working of different types of tidal powerplants. **(14)**

18. a. With the help of a diagram, explain the working of an OTEC system using hybridcycle. **(10)**
    b. Write notes on the factors to be considered for site selection of OTEC plants. **(4)**

Module 5

19. a. With the help of a diagram, explain biomass gasification based electric powergeneration. **(8)**
    b. Explain the working of a fuel cell with the help of a diagram **(6)**

20. a. With the help of a diagram, explain the working of KVIC model biogas plant. **(10)**
    b. Write notes on pumped storage plants **(4)**

Syllabus

Module 1

Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming-Pollution-Various Pollutants and their Harmful Effects-Green Power-The United Nations Framework Convention On Climate Change (UNFCC)- Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources; Conventional Energy Resources -Availability and their limitations; Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.

Module 2

SOLAR THERMAL SYSTEMS: Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer -Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector)
SOLAR ELECTRIC SYSTEMS: Introduction- Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing-.Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system; Applications –Street lighting, Domestic lighting and Solar Water pumping systems.

Module 3

Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction- Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems)-Wind energy conversion system(WECS) – Fixed–speed drive scheme-Variable speed drive scheme.-Effect of wind speed and grid condition(system integration).
Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection

Module 4

ENERGY FROM OCEAN: Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Advantages and Limitations of TPP.
Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation –Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.

Module 5

BIOMASS ENERGY: Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies, Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model;.
EMERGING TECHNOLOGIES: Fuel Cell, Hydrogen Energy, alcohol energy and power from satellite stations.

ENERGY STORAGE: Necessity Of Energy Storage-Pumped storage-Compressed air storage-Flywheel storage-Batteries storage-Hydrogen storage.

References:

1. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977
2. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their EnvironmentalImpact, Prentice Hall of India, 2001.
3. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, Renewable energy systems,Pearson 2017
4. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996
5. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
6. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
7. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
8. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994
9. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy – Sources for Fuel and Electricity, Earth scan Publications, London, 1993.
10. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
11. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009
12. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
13. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
14. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
15. Tiwari G. N., Solar Energy-Fundamentals, Design, Modelling and Applications, CRC Press, 2002.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Environmental impacts of various energy resources. (7 hours)**	
1.1	Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming	1
1.2	Pollution-Various Pollutants and their Harmful Effects-Green Power -The United Nations Framework Convention On Climate Change (UNFCC)	2
1.3	Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources	1
1.4	Conventional Energy Resources -Availability and their limitations	1
1.5	Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.	2
2	**Solar radiation data, solar thermal and electric systems. (7 hours)**	

2.1	Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer	2
2.2	Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes	1
2.3	Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector)	1
2.4	Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing	1
2.5	Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system	1
2.6	Applications –Street lighting, Domestic lighting and Solar Water pumping systems.	1
3	**Wind energy and small hydro plant (6 Hours)**	
3.1	Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction	1
3.2	-Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems)	1
3.3	Wind energy conversion system(WECS) – Fixed–speed drive scheme-	1
3.4	Variable speed drive scheme.-Effect of wind speed and grid condition(system integration)	1
3.5	Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection	2
4	**Energy from ocean (7 Hours)**	
4.1	Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP)	2
4.2	Classification of Tidal Power Plants, Advantages and Limitations of TPP.	1
4.3	Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation	1
4. 4	Open Cycle (Claude cycle), Closed Cycle (Anderson cycle)	1
4. 5	Hybrid cycle (block diagram description of OTEC)	1
4. 6	Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.	1
5	**Emerging technologies (9 Hours)**	
5.1	Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies	2
5.2	Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model	2

5.3	Types of biogas plants –KVIC and Janata model	1
5.4	Fuel Cell, Hydrogen Energy	1
5.5	Alcohol energy and power from satellite stations.	1
5.6	Necessity Of Energy Storage-Pumped storage-Compressed air storage	1
5.7	Flywheel storage-Batteries storage-Hydrogen storage.	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET332	COMPUTER ORGANIZATION	PEC	2	1	0	3

Prerequisite: The basic objective of this course is to lay the foundation of hardware organization of digital computers. The basic organizational concepts of Processor, Control Unit, Memory and I/O units are systematically included in this course. The knowledge on interplay between various building blocks of computer is also covered in this syllabus.

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

CO 1	Identify the functional units of a digital computer and understand the bus structure to do data transfer.
CO 2	Identify the pros and cons of different types of control unit design for various architectures
CO 3	Explain the principle of operation of ALU for typical arithmetic and logic operations
CO 4	Identify memory organization, Cache memory and virtual memory techniques.
CO 5	Select appropriate interfacing standards for I/O devices.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	1			1							1
CO 2	3	1										1
CO 3	3	1			1							1
CO 4	2											1
CO 5	2											1

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	20
Understand	15	15	40
Apply	25	25	40
Analyse			
Evaluate			
Create			

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. The register R1 = 12, and R2= 13. The instruction ADD R1, R2 is in memory location 2000H. After the execution of the instruction, write the value of PC, MAR, IR and R1. Explain the instruction cycle highlighting the sub-cycles.
2. The execution time of a program on machine X is 22 nanoseconds and execution time of the same program on machine Y is 0.1 microsecond. What is the speedup of machine X over machine Y?
3. Differentiate between RISC and CISC systems.

Course Outcome 2 (CO2):

1. Consider a processor having single bus organization of the data path inside a processor. Write the sequence of control steps required for instruction: Add the contents of memory location NUM to register R1.

2. With a neat block diagram, explain in detail about micro programmed control unit and explain its operations.

Course Outcome 3 (CO3):

1. Explain the different methods for representing integers in computer systems.

2. Explain Booth's multiplication algorithm with an example.

Course Outcome 4 (CO4):

1. Show the organization of virtual memory address translation based on fixed length pages

2. Illustrate the implementation of cache memory with any two mapping functions.

Course Outcome 5 (CO5):

1. How vectored interrupts are implemented in processors?

2. Explain DMA method of data transfer in detail with suitable diagrams

Model Question paper

QP CODE:

PAGES:2

Reg.No:______________

Name:______________

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

Course Code: EET332

Course Name: Computer Organization

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain Von-Neumann architecture
2. Differentiate between direct and indirect addressing modes with suitable examples
3. List the steps of a typical memory read operation.
4. Explain control word and microroutine.
5. Explain floating point representation of an integer.
6. What is the binary representation of decimal number 124.25?
7. What does memory hierarchy mean? What is its significance?
8. Explain the importance of cache memory in computer system.
9. Enlist characteristics of I/O devices
10. What are vectored interrupts?

PART B (14 x 5 = 70 Marks)

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

Module 1

11. a). With the help of a block schematic explain the basic organizational units of a digital computer. **(7)**

    b). What is meant by addressing mode? Explain absolute and indirect addressing modes with suitable examples. **(7)**

12. a). With the help of suitable diagrams explain the single bus and multi bus organization of a computer **(8)**

    b). Differentiate between RISC and CISC systems. **(6)**

Module 2

13. a). Differentiate the design and working of hard wired and micro programmed control unit. **(8)**
    b). Write notes on instruction sequencing. **(6)**

14. a). Consider a 32-bit machine where an instruction (ADD R1, R2) is stored at location 102A (in hexadecimal). How many memory accesses are required to execute this instruction? In addition, what will be the content of PC after the instruction is fetched? Individual instruction is 16-bit. Also write the steps carried out for executing this instruction. **(8)**
    b). Illustrate the load and store cycle with an example? **(6)**

Module 3

15. a).Explain the different methods for representing integers in computer systems. **(6)**
    b). Explain Booth's multiplication algorithm with an example. **(8)**

16. a) Illustrate the methods used for representing a character **(5)**
    b). Explain non-restoring division algorithm with an example **(9)**

Module 4

17. a) Illustrate the implementation of cache memory. **(6)**
    b). Write notes on any two mapping function related to cache memory. **(8)**

18. a). How pipelining is carried out effectively in a computer system. **(8)**
    b). Differentiate various pipeline hazards **(6)**

Module 5

19. a)Explain the different types and characteristics of I/O devices. **(5)**
    b).Explain DMA method of data transfer in detail. **(9)**

20. a). Explain interrupt driven I/O techniques **(9)**
    b). Discuss the advantages and disadvantages of setting interrupt priorities **(5)**

Syllabus

Module 1

Basic Structure of Computers- functional units--Von-Neumann architecture- basic operational concepts, Introduction to buses, Measuring performance: evaluating, comparing and summarizing. Representation of Instructions: Instruction formats -Operands- Addressing modes, Instruction set architectures - CISC and RISC architectures.

Module 2

Processor and Control Unit: Fundamental Concepts, multiple bus organization of CPU, memory read and memory write operations - Data transfer using registers. Execution of a complete instruction -sequencing of control signals. Hardwired Control, Micro programmed Control

Module 3

Data representation: Signed number representation, fixed and floating point representations, character representation. Computer Arithmetic: Integer Addition and Subtraction - Booths Multiplication- Division- non- restoring and restoring techniques.

Module 4

Memory Organization: - Memory cells- Basic Organization. Memory hierarchy - Caches - Cache performance - Virtual memory - Common framework for memory hierarchies Introduction to Pipelining- Pipeline Hazards

Module 5

Input/output organisation- Characteristics of I/O devices, Data transfer schemes - Programmed controlled I/O transfer, Interrupt controlled I/O transfer. Organization of interrupts - vectored interrupts – Servicing of multiple input/output devices – Polling and daisy chaining schemes. Direct memory accessing (DMA).

Text Books

1. Hamacher C., Z. Vranesic and S. Zaky, Computer Organization, 5/e, McGraw Hill, 2011.
2. William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson, 9/e, 2013.
3.

Reference Books

1. Patterson D.A. and J. L. Hennessey, Computer Organization and Design, 5/e, Morgan Kauffmann Publishers, 2013.
2. Heuring V. P. and Jordan H. F., Computer System Design and Architecture, Addison Wesely, 2/e,

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Module 1 (8 hours)**	
1.1	Basic Structure of Computers- functional units-basic operational concepts	1
1.2	Introduction to buses,Performance of computer	2
1.3	Representation of Instructions: Machine instructions-Operands-Addressing modes	2
1.4	Instruction formats, Instruction sets, Instruction set architectures	2
1.5	CISC and RISC architectures.	1
2	**Module 2(8 hours)**	
2.1	Processor and Control Unit : Some Fundamental Concepts	1
2.2	Execution of a Complete Instruction	2
2.3	Multiple Bus Organization	2
2.4	Hardwired Control, Microprogrammed Control	3
3	**Module 3(8 hours)**	
3.1	Computer arithmetic: Signed and unsigned numbers - Addition and subtraction	2
3.2	Booths algorithm,	2
3.3	Division algorithm	2
3.4	Floating point representation	2
4	**Module 4(6 hours)**	
4.1	Memory Organization: - Memory cells- Basic Organization	1
4.2	Memory hierarchy - Caches - Cache performance	2
4.3	Virtual memory	2
4.4	Introduction to pipelining-pipeline Hazards	1
5	**Module 5(6 hours)**	
5.1	Input-Output Organization: Characteristics, data transfer schemes	2
5.2	Organization of interrupts - vectored interrupts	1

5.3	Polling and daisy chaining schemes.	1
5.4	Direct memory accessing (DMA).	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET342	HIGH VOLTAGE ENGINEERING	PEC	2	1	0	3

Preamble: This course introduces basic terms and techniques applicable to high voltage ac and dc networks. Generation of different type of High voltage waveforms, their measurement and analysis including the insulation coordination of different equipments and machinery used in HV applications. It also provides a basic idea of FACTS devices and testing with the help of different testing circuits.

Prerequisite: Basics of Electrical Engineering / Introduction to Electrical Engineering

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

CO 1	Identify different high voltage and current waveform generation circuits.
CO 2	Implement different sensing & measurement techniques for high voltage and current measurement
CO 3	Describe insulation coordination and surge arrestor design
CO 4	Interpret different FACTS devices and their application in HV systems
CO 5	Implement different testing methods for equipments and applications of HV systems

Mapping of course outcomes with programoutcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain generation of high voltage AC, DC, impulse voltage and impulse current (K2)
2. Problems on high voltage generator circuits (K2, K3)

Course Outcome 2 (CO2):

1. Explain HV measurement techniques including measurement of peak and rms values (K2)
2. Explain dielectric measurements and partial discharge measurements (K2)
3. Problems on different HV measurement techniques (K2, K3)

Course Outcome 3 (CO3):

1. Explain procedure of insulation coordination (K2)
2. Selection criterion of surge arrester (K2, K3)

Course Outcome 4 (CO4):

1. Describes general principles and main components of HVDC system (K2, K3)
2. Explain FACTS devices used in HV systems (K2)

Course Outcome 5 (CO5):

1. Interpret the testing methods of various components (K2,K3)
2. Explains the applications of HV in various fields (K2)

Model Question paper

QP CODE:

PAGES:2

Reg. .No:______________
Name:______________

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

Course Code: EET342

Course Name: HIGH VOLTAGE ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain the principle of impulse current generation
2. Explain the working of Cockcroft-Walton voltage multiplier circuit
3. State the different factors affecting the spark over voltage of sphere gap
4. Differentiate between internal and external partial discharges
5. Explain the role of surge arrestors
6. Explain insulation coordination
7. With the help of diagram explain the working of SVC and UPFC
8. State the main components of HVDC links
9. Explain the field testing of HV transformer bushings
10. Explain the objectives of High voltage testing

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a)With the help of diagram explain the generation of rectangular current pulses **(10)**
    b)Explain impulse current generator. **(4)**
12. a) Explain the construction and operation of Marx circuit for multistage impulse generation **(10)**
    b) Discuss the working principle of series resonant circuit used for the generation of high voltage AC **(4)**

Module 2

13. a)Explain how a sphere gap can be used for the measurement of peak voltages **(10)**

    b)Explain the working principle of generating voltmeter. **(4)**

14. a) Explain the operation of Rogowski coil and how it is used for the measurement of high impulse currents. **(10)**

    b) Discuss the disadvantages of sphere gap measurement. **(4)**

Module 3

15. a) Explain how a lightning arrestor location is selected and the rating of the arrestor is selected **(10)**

    b) Differentiate between surge absorber and diverter **(4)**

16. a) An overhead line having surge impedance of 400ohms bifurcates into two lines having surge impedances 400ohm and 40 ohms respectively. Calculate the values of voltage and current for bifurcated lines if a surge voltage of 20kV incidence on the OH line **(10)**

    b) Explain the role of surge arrestor as a shunt protective device. **(4)**

Module 4

17. Elaborate on the main components of HVDC links **(14)**
18. Explain in detail the principle and operation of series compensator andSTATCOM **(14)**

Module 5

19. a) Give a detailed note on insulation systems for impulse voltages **(7)**

    b)Describe in detail electrostatic particle precipitation **(7)**

20. a) Explain any one method of non-disruptive testing for early detection of insulation faults **(4)**

    b)List the various tests performed on high voltage cables **(10)**

Syllabus

Module 1

Generation of High Voltage and Currents

Generation of High DC and AC Voltages- half-wave rectifier circuit- Cockroft-Walton voltage multiplier circuit- Electrostatic generator- Generation of high AC voltages-Cascaded Transformers- Series resonant circuit

Generation of Impulse Voltages and Currents- Impulse voltage- Impulse generator circuits- Multistage impulse generator circuit- Construction of impulse generator- Triggering of impulse generator-Impulse current generation

Module 2

HV measuring techniques

High Voltage Measurement Techniques -Measuring Spark Gaps - Sphere-to-sphere Spark Gap -Rod-to-rod Spark Gap - Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro-optical and Magneto-optical Field Sensors - Voltage Dividers - Instrument Transformers - Measurements of R.M.S. Value, Peak Value and Harmonics - Current Measurement

Dielectric measurements- Dissipation Factor and Capacitance, Insulation Resistance, Conductivity, Dielectric System Response-Partial discharge measuring technique- Requirements on a partial discharge measuring system - Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations

Module 3

Insulation Coordination and surge arresters

Classification of Voltages and Overvoltages-Origin of Overvoltages – Representative Overvoltages- Performance Criterion –Withstand voltage.

Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages-Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages

Determination of Coordination Withstand Voltage (Ucw)-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage (Urw)-Altitude Correction Factor, Safety Factor (Ks)- Selection of Standard Withstand Voltage (Uw)- Surge Arresters- Rated Voltage- Discharge Current- Impulse Current Tests- Residual Voltages- Arrester Durability Requirements

Module 4

HVDC and FACTS

HVDC transmission –General principles-VSC HVDC-Main components of HVDC links-Thyristor valves, Converter transformer, Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies

Converter building - Power electronic support for AC systems- Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC)

Module 5

Testing of HV Systems

High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables
Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors, HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength -Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors)
Lightning Protection- Light and Laser Technology- X-ray Technology-Electrostatic Particle Precipitation, Ionization- Spark plugs

Text Books

1. C L Wadhwa, "High Voltage Engineering", New Age International Publishers, 2011.
2. Andreas Kuchler, " High Voltage Engineering Fundamentals – Technology – Applications", Springer, 2018

References:

1. Naidu M.S. and Kamaraju V., “High voltage Engineering”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004.
2. Farouk A.M. Rizk&Giao N. Trinh, “High Voltage Engineering”, CRC Press, 2014.
3. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India P Ltd, 2005.
4. Hugh M. Ryan, “High-Voltage Engineering and Testing”, IET Power and energy series, 2013.
5. N.G. Hingorani and L.Gyugyi,“Understanding FACTS”,IEEE Press, 2000.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Generation of High Voltage and Currents(7 hours)**	
1.1	Generation of High DC and AC Voltages- half-wave rectifier circuit-Cockcroft-Walton voltage multiplier circuit	2
1.2	Electrostatic generator- Generation of high AC voltages-Cascaded Transformers - Series resonant circuit	2
1.3	Generation of Impulse Voltages and Currents- Impulse voltage- Impulse generator circuits	1
1.4	Multistage impulse generator circuit- Construction of impulse generator-Triggering of impulse generator-Impulse current generation	2
2	**HV measuring techniques (7hours)**	
2.1	High Voltage Measurement Techniques -Measuring Spark Gaps -Sphere-to-sphere Spark Gap -Rod-to-rod Spark Gap	1
2.2	Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro-optical and Magneto-optical Field Sensors	1
2.3	Voltage Dividers - Instrument Transformers - Measurements of R.m.s. Value, Peak Value and Harmonics - Current Measurement	2
2.4	Dielectric measurements- Dissipation Factor and Capacitance, Insulation Resistance, Conductivity,	1
2.5	Dielectric System Response-Partial discharge measuring technique-Requirements on a partial discharge measuring system	1
2.6	Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations	1
3	**Insulation Coordination and surge arresters(8 Hours)**	
3.1	Classification of Voltages and Overvoltages-Origin of Overvoltages – Representative Overvoltages- Performance Criterion –Withstand voltage.	2
3.2	Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages-Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages	2

3.3	Determination of Coordination Withstand Voltage (Ucw)-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage (Urw)-Altitude Correction Factor, Safety Factor (Ks)- Selection of Standard Withstand Voltage (Uw)	2
3.4	Surge Arresters- Rated Voltage- Discharge Current- Impulse Current Tests- Residual Voltages-Arrester Durability Requirements	2
4	**HVDC and FACTS (6 Hours)**	
4.1	HVDC transmission –General principles-VSC HVDC -Main components of HVDC links- Thyristor valves, Converter transformer,	2
4.2	Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies	2
4.3	Converter building - Power electronic support for AC systems- Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC)	2
5	**Testing of HV Systems (8 Hours)**	
5.1	High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables	2
5.2	Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors	2
5.3	HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength-Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors)	2
5.4	Applications-Lightning Protection- Light and Laser Technology- X-ray Technology-Electrostatic Particle Precipitation, Ionization- Spark plugs	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET352	OBJECT ORIENTED PROGRAMMING	PEC	2	1	0	3

Preamble : Nil

Prerequisite : Nil

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

CO 1	Explain object oriented programming concepts and creation of classes for Java applications
CO 2	Develop Java programs using arrays, strings, packages and inheritance concepts
CO 3	Build Java applications using abstract classes, interfaces, run time errors and exceptions
CO 4	Develop Java applets and applications for file I/O operations
CO 5	Apply the concept of multithreading in Java applications.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. How does Java achieve platform independence?
2. Compare data hiding and data abstraction in Java.
3. Why main() method is declared as 'static' in Java?

Course Outcome 2 (CO2):

1. Demonstrate how packages are created and used in Java.
2. Compare static binding and dynamic binding
3. Illustrate the use of 'final' keyword in Java.

Course Outcome 3 (CO3):

1. Demonstrate how multiple inheritance is implemented using interfaces.
2. Differentiate abstract classes and interfaces.
3. What are the different ways to handle exceptions in Java?

Course Outcome 4 (CO4):

1. Differentiate between Java applets and Java applications.
2. Explain how parameters can be passed to an applet.
3. Develop a Java program to create a file named "input.txt", write data into the file, read the contents from the file and display on the screen.

Course Outcome 5 (CO5):

1. Illustrate the different ways to create multithreaded programs in java.
2. Give the syntax of SELECT and INSERT SQL commands with example.
3. Explain the architecture of JDBC

Model Question paper

QP CODE:

PAGES:2

Reg.No:_______________
Name:_______________

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

Course Code: EET 352

Course Name: Object Oriented Programming

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain how data encapsulation and data hiding are implemented in Java.
2. Demonstrate the significance of the ‘static’ keyword in Java.
3. What are packages? How packages are created and used?
4. Explain the usage of ‘final’ keyword in Java programs.
5. What are the different ways to handle exceptions?
6. Compare and contrast abstract classes and interfaces.
7. How can parameters be passed into applets? Give examples.
8. What is a stream? Illustrate how the concept of streams is used in java.
9. How thread priority is set in Java? Explain with an example
10. What are different types of JDBC drivers?

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Outline the four access control specifiers in Java and illustrate their use with the help of an example program. **(7)**

    b) What are constructors? Demonstrate the use of different types of constructors in java. **(7)**

12. (a) Discuss the advantages of object oriented paradigm and compare it with procedure oriented programming. **(7)**

(b) Create a Java program to read the details of an employee like name, ID, Basic pay, DA, HRA etc. Find the net salary (Basic pay + DA +HRA) and display the employee details including net salary. Use class Employee to store all the data and use appropriate methods to access the data, calculate net salary and display the details. **(7)**

Module 2

13. (a) Compare and contrast method overloading and method overriding in java with the help of example programs. **(7)**

(b) Explain with examples, the different ways to compare two strings in Java. **(7)**

14. (a) Explain different types of inheritance. How they are implemented in Java? **(8)**

(b) Demonstrate the uses of the keyword "super" in Java. (6)

Module 3

15. (a) Demonstrate how multiple inheritance is implemented in Java with the help of an example program. **(7)**

(b) What is an inner class? Explain different types with examples. **(7)**

16. (a) Differentiate object cloning and copying. How object cloning is implemented in Java? **(7)**

(b) What is reflection? List any 3 methods used to analyse classes during runtime. **(7)**

Module 4

17. (a) "Applets can be used to play audio files". Support this statement with suitable example. **(7)**

(b) Write a program to create a file named "input.txt", write data into the file, read the contents from the file and display on the screen **(7)**

18. (a) What is an applet? Explain the life cycle of an applet with a neat sketch. **(6)**

(b) Distinguish between (i) Input Stream and Reader classes and (ii) Output Stream and Writer classes **(8)**

Module 5

19. (a) What is SQL? Write SQL commands to create, update and delete a table. **(7)**

(b). Explain different methods for creating threads in Java. **(7)**

20. (a) Explain the life cycle of a thread. Which are the different thread properties? **(7)**

(b) Describe the steps for establishing JDBC connection with the help of an example program. **(7)**

Syllabus

Module 1:

Review of object-oriented concepts- Java features – Java Virtual Machine - Objects and classes in Java - defining classes – methods – access specifiers - static members- command line arguments– constructors

Module 2:

Arrays – Strings -Packages - Inheritance – class hierarchy – polymorphism – static binding - dynamic binding – final keyword

Module 3:

Abstract classes – the Object class – Reflection – interfaces – object cloning – inner classes - Exception handling

Module 4:

Applet Basics-

Life cycle - The Applet HTML Tags and Attributes, Creating and running applets – Multimedia support, The Applet Context, JAR Files

File I/O - Concept of Streams - Use of character / byte Streams and stream classes - Writing and Reading characters / bytes

Module 5: –

Multithreaded programming-

Life cycle of a thread -Thread properties – Creating a thread -Interrupting threads –Thread priority- thread synchronization – Synchronized method -Inter thread communication

Database Programming -The Design of JDBC, The Structured Query Language, JDBC Installation, Basic JDBC Programming Concepts, Query Execution

Text Books

1. Herbert Schildt, "Java – The Complete Reference ", 8th Edition, Tata McGraw Hill
2. Cay S. Horstmann and Gary Cornell, "Core Java: Volume I & II– Fundamentals", Pearson Education, 2008.
3. E Balaguruswamy, "Programming with Java – A primer", 5th Edition, McGraw Hill

Reference Books

1. P.J.Deitel and H.M.Deitel, "Java: How to Program", PHI.

2. Programming in Java, S.Malhotra and S.Choudhary, Oxford Univ. Press, 2018
3. K. Arnold and J. Gosling, "The JAVA programming language", Pearson Education
4. Bruce Eckel, Thinking in Java, Pearson Education
5. David H Friedel,Jr. and Anthony Potts, Java Programming Language Handbook, Coriolis Group Books
6. Doug Lowe, Java all-in-one for Dummies, John Wiley & Sons
7. Laura Lemay and Charles L Perkins, Teach yourself Java in 21 days, Sams Publishing

Course Content and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1 (9 hrs)**	
1.1	Review of Object-Oriented Concepts	1
1.2	Java features - Java Virtual Machine	1
1.3	Objects and classes in Java	1
1.4	defining classes – methods	1
1.5	access specifiers	1
1.6	static variables, static blocks	1
1.7	static methods, static classes	1
1.8	command line arguments	1
1.9	constructors	1
2	**Module 2 (8 hrs)**	
2.1	Arrays – 1D	1
2.2	Arrays – 2D	1
2.3	Strings	1
2.4	Packages	1
2.5	Inheritance – class hierarchy	1
2.6	Polymorphism- static binding	1
2.7	dynamic binding	1
2.8	final keyword	1
3	**Module 3 (7 hrs)**	
3.1	abstract classes	1
3.2	the Object class	1
3.3	Reflection	1
3.4	interfaces	1
3.5	object cloning	1
3.6	inner classes	1

3.7	Exception handling	1
4	**Module 4 (7 hrs)**	
4.1	**Applet Basics**- Life cycle- The Applet HTML Tags and Attributes	1
4.2	Creating and running applets	1
4.3	Multimedia support	1
4.4	The AppletContext - JAR Files	1
4.5	**File I/O** - Concept of Streams	1
4.6	Use of character / byte Streams and stream classes	1
4.7	Writing and Reading characters / bytes	1
5	**Module 5 (5 hrs)**	
5.1	**Multithreaded programming**– Life cycle of a thread -Thread properties	1
5.2	Creating a thread - Interrupting threads –Thread priority	1
5.3	Thread synchronization – Synchronized method -Inter thread communication	1
5.4	**Database Programming** -The Design of JDBC, The Structured Query Language, JDBC Installation	1
5.5	Basic JDBC Programming Concepts, Query Execution	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET362	MATERIAL SCIENCE	PEC	2	1	0	3

Preamble: This course introduces different types of materials used in electrical engineering such as conductors, semiconductors, insulators, solar energy materials, biomaterials, nanomaterials, superconducting materials and magnetic materials. Also, this gives a detailed explanation on dielectrics, polarisation, modern techniques in material science and their applications.

Prerequisite : Basic Electrical Engineering, Basic Electronics Engineering

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

CO 1	Describe the characteristics of conductor, semiconductor and solar energy materials.
CO 2	Classify different insulating materials and describe polarisation in dielectrics.
CO 3	Explain the mechanisms of breakdown in solids, liquids and gases.
CO 4	Classify and describe magnetic materials and superconducting materials.
CO 5	Explain the recent developments in materials science, modern techniques and their applications in important walks of life.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	-	1	-	-	-	2	-	-	-	-	-
CO 2	3	-	1	-	-	-	-	-	-	-	-	-
CO 3	3	-	1	-	-	-	1	-	-	-	-	-
CO 4	3	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	-	-	-	2	2	2	-	-	-	-	2

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	15	15	30
Understand	35	35	70
Apply			
Analyse			
Evaluate			
Create			

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the dependence of conductivity of conductor materials on temperature and composition.
2. Compare the properties of compound, amorphous and organic semiconductors.
3. Differentiate between intrinsic and extrinsic semiconductors.
4. Derive the expression for conductivity.
5. Write notes on organic solar cell.
6. Explain the different solar selective coatings.
7. What are the different materials used for manufacturing solar cells?

Course Outcome 2 (CO2):

1. Derive Clausius – Mosotti Relation.
2. Explain with examples the different types of polarisation in dielectrics.
3. Classify insulating materials based on their temperature withstanding capability.
4. Explain in detail the properties and applications of SF6 gas.
5. Write short notes on Ferro electricity.
6. Describe the different capacitor materials used in various applications.

Course Outcome 3(CO3):

1. Explain the current voltage characteristics in Townsend's mechanism.
2. Explain the breakdown criteria in Townsend's mechanism.
3. Write notes on streamer mechanism of breakdown in gaseous dielectrics.
4. Explain any one mechanism of breakdown in vacuum insulation.
5. Describe with necessary diagram the treatment of transformer oil.
6. With the help of a circuit diagram, explain the testing of transformer oil.
7. Compare the suspended particle theory and bubble theory mechanisms of breakdown in liquid dielectrics.
8. Write short notes on any one mechanisms of breakdown in solid dielectrics.

Course Outcome 4 (CO4):

1. How are magnetic materials classified?
2. Differentiate between soft and hard magnetic materials.
3. Explain Curie – Weiss law.

4. Write short notes on Ferrites.
5. Define Superconductivity. Explain the characteristics of superconductors.
6. Differentiate between type I and type II superconductors.

Course Outcome 5 (CO5):

1. Compare the top-down and bottom-up growth techniques of nanomaterials.
2. Mention the names of any three non-lithographic growth techniques.Explain any one in detail.
3. Write short notes on Scanning Probe Microscopy.
4. What is a transmission electron microscope?
5. Write a short note on Carbon nanotube.
6. What are the applications of biomaterials?

Model Question paper

QP CODE:

PAGES:2

Reg. No:______________
Name:______________

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

Course Code: EET 362

Course Name: MATERIAL SCIENCE

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. What are the different materials used for manufacturing solar cells?
2. What is an organic solar cell? Explain.
3. Explain the concept of Ferro-electricity.
4. Mention the different types of polarisation in dielectrics.
5. What is treeing and tracking? Explain.
6. Draw the current-voltage characteristics in Townsend's mechanism.
7. How are magnetic materials classified?
8. Why do certain materials exhibit superconductivity?
9. Write a short note on Carbon nanotube.
10. What are the applications of biomaterials?

PART B (14 x 5 = 70 Marks)

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

Module 1

11. a) What is the effect of alloying of metals in their conduction? Illustrate with an example. **(5)**

    b) Compare the properties of compound, amorphous and organic semiconductors. **(9)**

12. a) Derive the expression for conductivity. Describe the dependence of conductivity of conductor materials on temperature and composition. **(9)**

    b) What is intrinsic breakdown? **(5)**

Module 2

13. a)Derive Clausius-Mosotti relation. **(7)**

    b)Classify insulating materials based on their temperature withstanding capability. **(7)**

14. a) Explain in detail the properties and applications of SF6 gas. **(4)**

    b) Describe the different capacitor materials used in various applications. **(10)**

Module 3

15. a)Compare the suspended particle theory and bubble theory mechanisms of breakdown in liquid dielectrics. **(10)**

    b) List out the breakdown criteria in Townsend's mechanism. **(4)**

16. a) What is meant by transformer oil testing? Why is it done? Explain the tests on transformer oil. **(9)**

    b) Elucidate any one mechanism of breakdown in vacuum. **(5)**

Module 4

17. a) Discuss the application of magnetic materials used in electrical machines, instruments and relays. Justify with reasons. **(10)**

    b) Write short notes on Ferrites. **(4)**

18. a) What do you mean by superconductivity? Explain the characteristics and properties of superconducting materials. **(8)**

    b) What are type I and type II superconductors? **(6)**

Module 5

19. a) Compare the top-down and bottom-up growth techniques of nanomaterials. **(8)**

    b) Write short notes on Scanning Probe Microscopy. **(6)**

20. a) Mention the names of any three nonlithographic growth techniques. Explain any one in detail. **(8)**

b) What is a transmission electron microscope? **(6)**

Syllabus

Module 1

Conducting Materials: Conductivity- dependence ontemperature and composition – Materials for electricalapplications such as resistance, machines, solders etc.

Semiconductor Materials: Concept, materials and properties– Basic ideas of Compound semiconductors, amorphous andorganic semiconductors- applications.

Solar Energy Materials: Solar selective coatings for enhanced solar thermal energy collection. Solar cells -Silicon, Cadmium sulphide and Gallium arsenic – Organic solar cells.

Module 2

Dielectrics: Introduction to Dielectric polarization andclassification–Clausius-Mosotti relation.

Insulating materials and classification- properties- Common insulating materials used in electrical apparatus-Inorganic, organic, liquid and gaseous insulators- capacitor materials.

Electro-negative gases- properties and applications of SF6 gas and its mixtures with nitrogen
Ferro electricity.

Module 3

Dielectric Breakdown: Mechanism of breakdown in gases, liquids and solids –basic theories including Townsend's criterion, Streamer mechanism.

Mechanism of breakdown in liquids and solids - suspended particle theory, Bubble theory, Stressed oil Volume Theory, intrinsic breakdown, electro-mechanical breakdown, Thermal breakdown, Treeing and Tracking.

Application of vacuum insulation- Breakdown in high vacuum.
Basics of treatment and testing of transformer oil.

Module 4

Magnetic Materials: Classification of magnetic materials -Curie-Weiss law-Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus.

Superconductor Materials:-Basic Concept- types, characteristics- applications.

Module 5

Novel materials: Introduction to Biomaterials, Nano-materials and their significance. Growth techniques of nano-materials – Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes (qualitative study only), Characterisation tools of nanomaterials – SPM, AFM, SEM and TEM (qualitative study only), Special topics in nanotechnology – nanostructures of carbon, nanoelectronics, nanobiometrics(qualitative study only).

Text Books

1. Dekker A.J.: Electrical Engineering Materials, Prentice Hall of India.
2. G.K.Mithal: Electrical Engineering Material Science. Khanna Publishers.
3. K.K. Chattopadhyay, A. N. Banerjee: Introduction to nanoscience and nanotechnology, PHI Learning Pvt. Ltd.

Reference Books

1. Naidu M. S. and V. Kamaraju, *High Voltage Engineering*, Tata McGraw Hill, 2004
2. Indulkar O.S.&Thiruvegadam S., An Introduction to Electrical Engineering Materials, S.Chand.
3. Joon Bu Park, Biomaterials Science and Engineering, Plenum Press, New York, 1984

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Conducting Materials, Dielectrics, Semiconductors (8 hours)**	
1.1	Conducting Materials: Conductivity	1
1.2	Dependence ontemperature and composition – Materials for electricalapplications such as resistance, machines, solders etc	2
1.3	Semiconductor Materials: Concept, materials and properties	2
1.4	Basic ideas of Compound semiconductors, amorphous andorganic semiconductors- applications.	1
1.5	Solar Energy Materials: Solar selective coatings for enhanced solar thermal energy collection.	1
1.6	Solar cells -Silicon, Cadmium sulphide and Gallium arsenic – Organic solar cells.	1
2	**Insulating materials(8 hours)**	
2.1	Dielectrics: Introduction to Dielectric polarization and classification.	1
2.2	Clausius- Mosotti relation.	1

2.3	Insulating materials and classification- properties	2
2.4	Common insulating materials used in electrical apparatus- Inorganic,organic, liquid and gaseous insulators- capacitor materials.	1
2.5	Electro-negative gases- properties and applications of SF6 gas and its mixtures with nitrogen.	2
2.6	Ferro electricity	1
3	**Dielectric Breakdown(8 hours)**	
3.1	Mechanism of breakdown in gases– Townsend's criterion	2
3.2	Streamer theory	1
3.3	Mechanism of breakdown in liquids - suspended particle theory, Bubble theory, Stressed oil Volume Theory.	1
3.4	Mechanism of breakdown in solids - intrinsic breakdown, electro-mechanical breakdown, Thermal breakdown, Treeing and Tracking.	1
3.5	Application of vacuum insulation- Breakdown in high vacuum.	1
3.6	Basics of treatment and testing of transformer oil	2
4	**Magnetic Materials, Superconductors, Solar Energy materials (5 hours)**	
4.1	Magnetic Materials: Classification of magnetic materials –Curie-Weiss law	1
4.2	Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus.	2
4.3	Superconductor Materials:-Basic Concept- types, characteristics-applications.	2
5	**Novel materials(7 hours)**	
5.1	Introduction to biomaterials, nanomaterials and their significance	2
5.2	Growth techniques of nano materials-Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes	2
5.3	Characterisation tools of nanomaterials – SPM, AFM, SEM and TEM	2
5.4	Special topics in nanotechnology – nanostructures of carbon, nanoelectronics, nanobiometrics	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET372	SOFT COMPUTING	PEC	2	1	0	3

Preamble: This course gives an introduction to some new fields in soft computing. It combines the fundamentals of neural network, fuzzy logic, and genetic algorithm which in turn offers the superiority of humanlike problem solving capabilities. This course provides a broad introduction to machine learning, data clustering algorithms and support vector machines.

Prerequisite: Digital Electronics

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

CO 1	Explain various constituents of soft computing and artificial neural networks.
CO 2	Explain the different learning methods for training of ANNs.
CO 3	Apply fuzzy logic techniques to control a system.
CO 4	Utilize genetic algorithm techniques to find the optimal solution of a given problem.
CO 5	Explain the basics of machine learning, data clustering algorithms and support vector machines.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	-	-	-	-	-	-	-	-	-	-	2
CO 2	3	1	1	1	-	-	-	-	-	-	-	2
CO 3	3	1	1	1	2	-	-	-	-	-	-	2
CO 4	3	1	1	1	-	-	-	-	-	-	-	2
CO 5	3	1	2	1	2	-	-	-	-	-	-	2

Assessment Pattern

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

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare Soft and Hard computing.
2. Define ANN. What are the characteristics of ANN?
3. Realize using McCulloch Pitts neuron model (i) a 2-input AND logic and (ii) a 2-input NOR logic considering +1 as the bias value of the neuron.
4. Draw the non-linear model of a neuron and explain the basic elements of the neuronal model.
5. Explain any five types of activation functions used in neural network models.
6. Explain how a biological neuron transmits signals in the human brain with the help of neat diagrams.

Course Outcome 2 (CO2):

1. Describe learning. What are the different learning methods in ANN?
2. Explain the different architectures of neural networks.
3. Explain error correction learning algorithm.
4. What is meant by feed forward network? Compare SLFFN and MLFFN.
5. Compare supervised learning and unsupervised learning methods.
6. Derive the expression for local gradient of an output neuron, in back propagation algorithm.

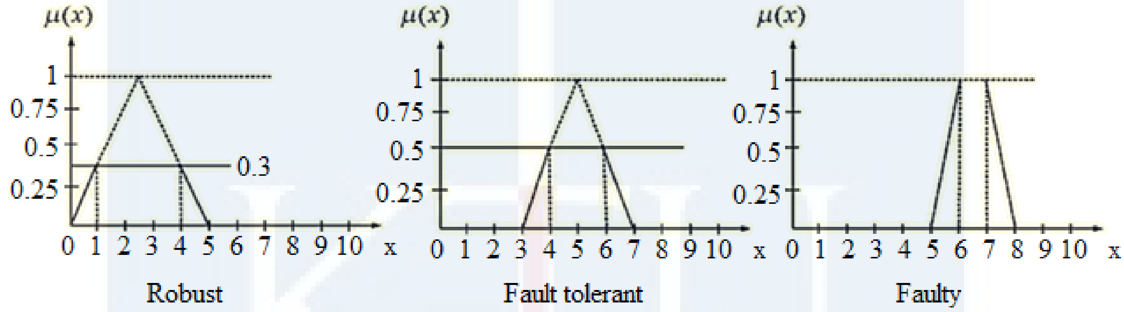
Course Outcome 3(CO3):

1. Define membership function. Also give any three features of a membership function.
2. Define (i) core (ii) support (iii) boundary and crossover points of membership function.
3. Given two fuzzy sets:
   $\tilde{A}$: Mary is efficient, T ($\tilde{A}$) = 0.8
   $\tilde{B}$: Ram is efficient, T ($\tilde{B}$) = 0.65
   Find (i) Mary is not efficient (ii) Mary is efficient and so is Ram (iii) Either Mary or Ram is efficient (iv) If Mary is efficient.
4. P represents a set of four varieties of paddy plants, D represents the four diseases affecting the plants, and S represents the common symptoms of the diseases. $P = \{P_1, P_2, P_3, P_4\}, D = \{D_1, D_2, D_3, D_4\}, S = \{S_1, S_2, S_3, S_4\}$. R is a relation on $P \times D$ representing which plant is susceptible to which diseases and T is another relation on $D \times S$ and is stated as

$$R = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{array}{c} \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{bmatrix} 0.6 & 0.6 & 0.9 & 0.8 \\ 0.1 & 0.2 & 0.9 & 0.8 \\ 0.9 & 0.3 & 0.4 & 0.8 \\ 0.9 & 0.8 & 0.4 & 0.2 \end{bmatrix} \end{array}, \qquad T = \begin{array}{c} \\ D_1 \\ D_2 \\ D_3 \\ D_4 \end{array} \begin{array}{c} \begin{array}{cccc} S_1 & S_2 & S_3 & S_4 \end{array} \\ \begin{bmatrix} 0.1 & 0.2 & 0.7 & 0.9 \\ 1 & 1 & 1 & 0.6 \\ 0 & 0 & 0.5 & 0.9 \\ 0.9 & 1 & 0.8 & 0.2 \end{bmatrix} \end{array}$$

Obtain the association of plants with the different symptoms of the disease using max-min composition.

5. Discuss any two common membership functions used in fuzzy logic.
6. $\tilde{A} = \{(x_1, 0.3), (x_2, 0.5), (x_3, 0.6)\}, \tilde{B} = \{(x_1, 0.2), (x_2, 0.8), (x_3, 0.9)\}$. Find (i) $\tilde{A} \cup \tilde{B}$ (ii) $\tilde{A} \cap \tilde{B}$ (iii) $\tilde{A} - \tilde{B}$ (iv) $\tilde{A} \oplus \tilde{B}$.
7. List out the various operations on Fuzzy sets.
8. Explain simple fuzzy logic controllers.
9. The faulty measure of a circuit is defined fuzzily by three fuzzy sets namely Robust (*R*), Fault tolerant (*FT*) and Faulty (*F*), defined by three membership functions with number of faults occur, as universe of discourse as



Reliability is measured as $r = R \cup FT \cup F$. Determine the crisp value of *r* using centroid method, COS method and weighted average methods of defuzzification.

Course Outcome 4 (CO4):

1. Draw a neat architecture of Adaptive Neuro Fuzzy Inference System (ANFIS)**.**
2. Explain any two types of encoding used in GA.
3. Discuss selection operation in GA. Explain briefly Roulette wheel selection.
4. What is Genetic Algorithm? What are the various methods of selecting chromosomes of parents to crossover?
5. What is crossover? Explain any three types of crossover operators in GA.
6. Define (i) Population (ii) Fitness (iii) Selection (iv) Mutation.

Course Outcome 5 (CO5):

1. What is "Machine Learning"? Give examples of learning machines.
2. Explain different types of machine learning models.
3. Explain different types of Machine Learning Architecture.
4. Explain, K-Means Clustering algorithm. What are its applications?
5. Compare SVM and SVR.
6. ExplainHierarchical clustering technique. What are its limitations?

Model Question paper

QP CODE:

PAGES:2

Reg. No:______________

Name:______________

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

Course Code: EET 372

Course Name: SOFT COMPUTING

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks.

1. Compare the structure of a biological neuron with an artificial neuron.
2. What is a perceptron? Explain the training process in perceptron.
3. Describe learning. What are the different learning methods in ANN?
4. Explain the architecture of a Hopfield network.
5. The two fuzzy sets representing an *apple* and an *orange* are:

$$Apple = \left\{ \frac{0.4}{orange} + \frac{0.5}{chair} + \frac{0.8}{table} + \frac{0.9}{apple} + \frac{0.3}{plate} \right\}$$
$$Orange = \left\{ \frac{0.6}{orange} + \frac{0.3}{chair} + \frac{0.4}{table} + \frac{0.5}{apple} + \frac{0.4}{plate} \right\}$$

Find the following:

$i)\, Apple \cup Orange \quad ii)\, Apple \cap Orange \quad iii)\, \overline{Apple \cap Orange}$
$iv)\, Apple \cup \overline{Apple}$

6. With a neat block diagram, explain the fuzzy inference system.
7. Write short notes on any two methods used for selection process in GA.
8. Explain two different types of crossover used in a genetic algorithm.
9. What is a linear learning machine?
10. List out any 4 applications of support vector machines.

PART B (14 x 5 = 70 Marks)

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

Module I

11 a Realize using McCulloch Pitts neuron model (i) a 2-input AND logic and (ii) a 2-input NOR logic considering +1 as the bias value of the neuron. **(9)**

b Explain any five types of activation functions used in neural network models. **(5)**

12 a Explain the architecture of ADALINE and MADALINE networks. **(9)**

b Draw the non-linear model of a neuron and explain the basic elements of the neuronal model. **(5)**

Module II

13 a Explain back propagation algorithm with the help of a block diagram and a suitable example. **(9)**

b Explain radial basis function network. **(5)**

14 a Explain reinforcement learning with the help of a block diagram. **(7)**

b Explain Kohonen Self organizing map. **(7)**

Module III

15 a P represents a set of four varieties of paddy plants, D represents the four diseases affecting the plants, and S represents the common symptoms of the diseases. $P=\{P_1,P_2,P_3,P_4\}, D=\{D_1,D_2,D_3,D_4\}, S=\{S_1,S_2,S_3,S_4\}$. R is a relation on $P\times D$ representing which plant is susceptible to which diseases and T is another relation on $D\times S$ and is stated as **(9)**

$$R = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{array}{c} \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{bmatrix} 0.6 & 0.6 & 0.9 & 0.8 \\ 0.1 & 0.2 & 0.9 & 0.8 \\ 0.9 & 0.3 & 0.4 & 0.8 \\ 0.9 & 0.8 & 0.4 & 0.2 \end{bmatrix} \end{array}, \qquad T = \begin{array}{c} \\ D_1 \\ D_2 \\ D_3 \\ D_4 \end{array} \begin{array}{c} \begin{array}{cccc} S_1 & S_2 & S_3 & S_4 \end{array} \\ \begin{bmatrix} 0.1 & 0.2 & 0.7 & 0.9 \\ 1 & 1 & 1 & 0.6 \\ 0 & 0 & 0.5 & 0.9 \\ 0.9 & 1 & 0.8 & 0.2 \end{bmatrix} \end{array}$$

Obtain the association of plants with the different symptoms of the disease using max-min composition.

b Discuss any two common membership functions used in fuzzy logic. **(5)**

16 With the help of an example, explain the working of a fuzzy logic controller. **(14)**

Module IV

17 a Describe the steps involved in solving an optimization problem using Genetic Algorithm. Illustrate the steps with a suitable example **(14)**

18 a Explain Adaptive Neuro-Fuzzy Inference System (ANFIS) with the help of a block diagram. **(9)**

b What is the role of 'mutation' in GA based optimizationprocess? What is the usual range of probability value given for mutation process**?** **(5)**

Module V

19 a Describe Machine Learning. Write any three applications **(9)**

b Briefly explain any one clustering algorithm with example. **(5)**

20 a Explain support vector regression. List any 2 applications. **(9)**

b What are the common distance measures used in clustering algorithms? **(5)**

Syllabus

Module 1

Introduction: Soft and Hard Computing, Evolution of soft computing, Soft computing constituents.

Artificial Neural Networks: Biological foundations –ANN models - Characteristics of ANN- Types of activation function - McCulloch-Pitts neuron model, Realization of logic gates using McCulloch-Pitts neuron model - simple perceptron, Adaline and Madaline.

Module 2

Neural network architectures - single layer, multilayer, recurrent networks.

Knowledge representation - Learning process - Supervised and unsupervised learning, Learning algorithms–Errorcorrection learning - Hebbian learning – Boltzmann learning - competitive learning- Backpropagation algorithm- Case study-Radial basis function networks - Hopfield network- Kohonen Self organizing maps

Module 3

Fuzzy Logic: Introduction to crisp sets and fuzzy sets, examples, Properties, Basic fuzzy set operations, examples. Fuzzy relations - Cardinality of Fuzzy relations - Operations on Fuzzy relations - Properties of Fuzzy relations. Membership functions - triangular, trapezoidal, bell shaped, Gaussian, sigmoidal.

Fuzzy logic controller (Block Diagram), Fuzzification, rule base, inference engine and defuzzification - Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First and Last of Maxima.

Simple fuzzy logic controllers with examples.

Module 4

Genetic Algorithm: Introduction - basic concepts of Genetic Algorithm, encoding, fitness function, reproduction, cross over, mutation operator, bit-wise operators, generational cycle.

Hybrid Systems: Adaptive Neuro Fuzzy Inference System (ANFIS), Genetic algorithm based back propagation networks, fuzzy back propagation networks.

Module 5

Machine Learning- Machine learning model-Approaches to machine learning- Machine learning architecture- Data Clustering Algorithms -Hierarchical clustering, K-Means Clustering

Support Vector Machines for Learning – Linear Learning Machines – Support Vector Classification – Support Vector Regression - Applications.

Reference Books

1. S.Rajasekharan, G.A.Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
2. S.N.Sivanandam, S.N.Deepa, *Principles of Soft Computing*, Wiley India, 2007.
3. Simon Haykin, *Neural Networks a Comprehensive foundation*, Pearson Education, 1999.
4. Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002
5. Zurada J.M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.
6. Hassoun Mohammed H, *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.J.-S.R.Jang, C.-T.Sun,E.Mizutani, *Neuro-Fuzzy and Soft Computing*, Prentice Hall, 1997.
7. Timothy J Ross, *Fuzzy logic with Engineering Applications*, McGraw Hill, New York.
8. Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
9. Ronald R Yager and Dimitar P Filev, *Essentials of Fuzzy Modelling & Control*, John Wiley & Sons, Inc, 2002.
10. SuranGoonatilake& Sukhdev Khebbal (Eds.), *Intelligent Hybrid Systems*, John Wiley,1995.
11. D.E.Goldberg, *Genetic Algorithms in Search Optimisation and Machine Learning*, Pearson Education, 1989.
12. Tom Mitchell,*Machine Learning*, McGraw Hill, 1997
13. Margaret H. Dunham, *Data Mining- Introductory & Advanced Topics*, Pearson Publication

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	***Introduction to Artificial Neural Networks***	**5 hrs**
1.1	Introduction to soft computing, soft and hard Computing, Soft computing constituents	1
1.2	ANN- Biological foundations - ANN models - Characteristics of ANN - Types of activation function.	1
1.3	McCulloch-Pitts neuron model, Realization of logic gates using McCulloch-Pitts neuron model.	2
1.4	Simple perceptron, Adaline and Madaline.	1
2	***Neural network architectures and Learning***	**7 hrs**
2.1	Neural network architectures - single layer, multilayer, recurrent networks, Knowledge representation.	1
2.2	Learning process: Supervised and unsupervised learning. Learning algorithms- Errorcorrection learning.	1
2.3	Hebbian learning – Boltzmann learning - competitive learning.	1

2.4	Back propagation networks	1
2.5	Radial basis function networks - Hopfield network.	2
2.6	Kohonen Self organizing maps	1
3	***Introduction to Fuzzy Logic***	**11 hrs**
3.1	Introduction to crisp sets and fuzzy sets, examples, Properties.	1
3.2	Basic fuzzy set operations, examples.	1
3.3	Fuzzy relations- Cardinality of Fuzzy relations - Operations on Fuzzy relations - Properties of Fuzzy relations.	2
3.4	Membership functions - triangular, trapezoidal, bell shaped, Gaussian, sigmoidal.	1
3.5	Fuzzy logic controller (Block Diagram), Fuzzification, rule base, inference engine	2
3.6	Defuzzification - Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First and Last of Maxima, Example problems.	2
3.7	Simple fuzzy logic controllers with examples	2
4	***Introduction to Genetic Algorithms and Hybrid Systems***	**7 hrs**
4.1	Basic concepts of Genetic Algorithm – encoding - fitness function – reproduction - cross over - mutation operator - bit-wise operators, generational cycle.	3
4.2	Hybrid Systems: Adaptive Neuro fuzzy Inference System (ANF1S)	2
4.3	Genetic algorithm based back propagation networks	1
4.4	Fuzzy back propagation networks	1
5	***Introduction to Machine Learning***	**6 hrs**
5.1	Machine Learning- Machine learning model- Approaches to machine learning- Machine learning architecture	**2**
5.2	Data Clustering Algorithms - Hierarchical clustering, K-Means Clustering	**2**
5.3	Support Vector Machines for Learning Support Vector Classification – Support Vector Regression - Applications	**2**

SEMESTER VI

MINOR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET 382	POWER SEMICONDUCTOR DRIVES	VAC	3	1	0	4

Preamble: This course is intended to provide fundamental knowledge in dynamics and control of Electric Drives, to justify the selection of Drives for various applications and to familiarize the various semiconductor controlled drives employing various motors

Prerequisite: Basic knowledge of mathematics, basic electronics and analog electronics.

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

CO 1	Explain dynamics and control of electric drives.
CO 2	Explain the performance of DC motor drives used in various applications.
CO 3	Explain control strategies for three phase induction motor drives.
CO 4	Explain variable speed synchronous motor drives.
CO5	Choose an appropriate drive system for a specific application.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Draw and explain the typical toque speed characteristics of different types of mechanical loads pump, hoist, fan and traction loads. Write the various factors that influence the choice of electric drives?
2. Explain clearly, the four quadrant operation of a motor driving a hoist load.
3. Differentiate between passive and active load torques with example.

Course Outcome 2 (CO2)

1. Explain using suitable diagrams and wave forms, two quadrant operation of single phase full converter fed separately excited dc motor drive for continuous and discontinuous mode of operation and obtain the boundary between two modes. Derive the output voltage equation for both modes.
2. Draw the circuit diagram of a class-C chopper fed DC motor drive. Draw its V/I characteristics.
3. Explain the four quadrant operation of a chopper fed dc motor drive with the help of necessary circuit diagram and waveform

Course Outcome 3 (CO3):

1. Draw and explain the speed torque characteristics of a stator voltage controlled induction motor. Why stator voltage control is not suitable for speed control of induction motor with constant load torque.
2. Explain the static Kramer scheme for the speed control of a slip ring IM. How the slip power is effectively utilised in this drive?
3. Explain v/f control of induction motor. Draw the speed torque characteristics. How the speed of induction motor is controlled using Voltage source inverter?

Course Outcome 4 (CO4):

1. Explain power and torque capability curves of a synchronous motor drive. In variable frequency control of synchronous motor drive, why V/f ratio is maintained constant upto base speed and voltage constant above base speed.
2. Explain the true synchronous mode of operation of synchronous motor drive.
3. How can we control the speed of an ac motor drive using field oriented control? Explain with the help of a block diagram
4. With a suitable block diagram explain variable frequency control of synchronous motor drive in self control mode

Course Outcome 5 (CO5):

1. Differentiate trapezoidal type BLDC motor and sinusoidal type PMBLDC motor
2. With neat sketches explain the operation of a switched reluctance motor drive.
3. Explain the principle of operation of PMBLDC motor for 120^0 commutation with neat circuit diagram.
4. With a block diagram explain the micro controller based PMSM drive

Model Question Paper

QP Code: Pages: 2

Reg No: ___________________

Name: ____________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET382
Course Name: POWER SEMICONDUCTOR DRIVES

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all Questions. Each question carries 3 Marks

1. What are the different components of a load torque? Explain each components of load torque.
2. Derive the mathematical condition to obtain the steady state stability of an electric drive.
3. Which are the method of speed control suitable for getting speeds higher than base speed and lower than base speed in a dc motor?
4. Explain the regenerative braking operation of a chopper fed dc motor drive with the help of necessary circuit diagram.
5. Explain the speed control of three phase induction motor by varying stator voltage.
6. Explain v/f control of induction motor. Draw the speed torque characteristics.
7. How to control the speed of synchronous motor by using voltage source inverter?
8. Why the field oriented control of ac motor is superior to other types of speed control?
9. Explain about the classification of PM synchronous motor.
10. Compare the construction and performance of BLDC motor and PMAC motor.

(10 x 3 =30)

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

Module 1

11. (a) A motor load system has the following details: Quadrants I and II, T= 400-0.4N, N-m, where N is the speed in rpm. Motor is coupled to a active load torque, Tl= ± 200, N-m. Calculate motor speeds for motoring and braking in forward direction. When operating in quadrants III and IV, T= -400-0.4N, N-m. Calculate the equilibrium speed in quadrant III. **(8)**

    (b) What are the speed- torque characteristics of pump, fan and traction loads? **(6)**

12. (a) With the help of a neat sketch explain the multi quadrant operation of a motor driving hoist load **(8)**

(b) Explain the operation of closed loop control scheme? What are the importance of current control and speed control loops **(6)**

Module 2

13. (a) A 220 V, 1500 rpm, 11.6 A separately excited motor is controlled by a l-phase fully controlled rectifier with an ac source voltage of 230 V, 50 Hz. Filter inductance is added to ensure continuous conduction for any torque greater than 25 percent of rated torque, Ra = 2 ohm . What should be the value of the firing angle to get the rated torque at 1000 rpm? Ca1culate the firing angle for the rated braking torque and - 1500 rpm. Also ca1culate the motor speed at the rated torque and $\alpha = 160^{o}$ for the regenerative braking in the second quadrant. **(7)**

(b) Explain the operation of four quadrant chopper fed separately excited DC motor drive with necessary diagrams. **(7)**

14. (a) A 220 V, 1000 rpm and 200 A separately excited dc motor has an armature resistance of 0.02Ω. The motor is fed from chopper which provides both motoring and braking operations. The source has a voltage of 230V. Assume CCM. (i) Calculate duty ratio of chopper for motoring operation at rated torque and 400 rpm. (ii)Calculate duty ratio of chopper for braking operation at rated torque and 400 rpm. **(8)**

(b) Draw the circuit diagram and waveforms of a class-C chopper fed DC motor. Explain. Draw its V/I characteristics. **(6)**

Module 3

15. (a) Explain the static Kramer scheme for the speed control of a slip ring IM. Explain the firing angle control of thyristor bridge with constant motor field. **(8)**

(b) Explain the closed loop static rotor resistance control method for the speed control of a slip ring induction motor. What are the disadvantages of this method? **(6)**

16. (a) What is slip power recovery scheme? Describe static Scherbius drive and show that the slip at which it operates is given by $S = -(aT/a)\cos\alpha$, where a and aT pertain to per phase turns ratio for induction motor and transformer respectively. Why it is always suggested to use a transformer in line side converter for static Scherbius drive? **(10)**

(b) Compare speed control of induction motor using VSI and CSI **(4)**

Module 4

17. (a) Explain the different mode of operation of synchronous motor drive by variable frequency control method**.** **(10)**

(b) Briefly explain the concept of space vector **(4)**

18. (a) With the help of block diagram explain the closed loop speed control of load commutated inverter fed synchronous motor. **(8)**

    (b) Explain the frame transformation from three phase to synchronous reference frame. What is its significance in speed control? **(6)**

Module 5

19. (a) With the help of schematic diagram explain microcontroller based permanent magnet synchronous motor drives **(7)**

    (b) With suitable converter circuit diagram discuss the modes of operation of Switched Reluctance motor drive. **(7)**

20. Explain the principle of operation and control circuit of PMBLDC motor for 120° commutation with neat circuit diagram. **(14)**

Syllabus

Module 1

Introduction to electric drives – Block diagram – advantages of electric drives – Dynamics of motor load system, fundamental equations, and types of load – classification of load torque, four quadrant operation of drives. Steady state stability. Introduction to closed loop control of drives.

Module 2

DC motor drives- constant torque and constant power operation, separately excited dc motor drives using controlled rectifiers, single phase semi converter and single phase fully controlled converter drives. Three phase semi converter and fully controlled converter drives.

Chopper controlled DC drives. Analysis of single quadrant chopper drives. Regenerative braking control. Two quadrant chopper drives. Four quadrant chopper drives.

Module 3

Induction Motor Drives-Three phase induction motor speed control using semiconductor devices. Stator voltage control – stator frequency control – Stator voltage and frequency control (v/f) - Voltage source inverter control - Current source inverter control. Rotor chopper speed control – slip power recovery control schemes – sub synchronous and super synchronous speed variations.

Module 4

Synchronous motor drives – Synchronous motor variable speed drives- variable frequency control- modes of variable frequency control. Closed loop speed control of load commutated inverter fed synchronous motor drive .Concept of space vector – Basic transformation in reference frame theory – field orientation principle.

Module 5

Permanent Magnet and variable reluctance motor drives – different types –Sinusoidal PMAC drives-Brushless DC motor drives- control requirements, converter circuits, modes of operation . Microcontroller based permanent magnet synchronous motor drives (schematic only). Switched Reluctance motor drive- converter circuits- modes of operation.

Text Books

1. Bimal K. Bose "Modern power electronics and AC drives" Pearson Education, Asia 2003
2. Gopal K. Dubey. "Fundamentals of Electric Drives" , second edition, Narosa Publishing house

Reference Books

1. Dewan S.B. , G. R. Slemon, A. Strauvhen, "Power semiconductor drives", John Wiley and sons.
2. Dr. P. S. Bimbra "Power electronics", Khanna publishers.
3. Dubey G. K. "Power semiconductor control drives" Prentice Hall, Englewood Cliffs, New Jersey, 1989.
4. N. K. De, P. K. Sen "Electric drives" Prentice Hall of India 2002.
5. Ned Mohan, Tore m Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons.
6. Pillai S. K. "A first course on electric drives", Wieley Eastern Ltd, New Delhi.
7. Vedam Subrahmanyam, "Electric Drives", MC Graw Hill Education, New Delhi.
8. 8.R. Krishnan , "Electric Motor Drives Modeling, Analysis and Control", Prentice Hall of India 2007.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to electric drives (9 hours)**	
1.1	Block diagram – Parts of Electric Drives. advantages of electric drives	2
1.2	Dynamics of motor load system, fundamental torque equations, equivalent value of drive parameters (both rotational and translational motion)	2
1.3	components of load torque ,types of load and classification of load torque	2
1.4	four quadrant operation of drives	1
1.5	Steady state stability- condition for stability of equilibrium point	1
1.6	Introduction to closed loop control of drives- speed, current, torque and position control	1
2	**DC motor drives (10 hours)**	

2.1	Speed control-constant torque and constant power operation	2
2.2	Separately excited dc motor drives using controlled rectifiers- single phase semi converter and single phase fully controlled converter drives.	3
2.3	Three phase semi converter and fully controlled converter drives.	2
2.4	Chopper controlled DC drives- Analysis of single quadrant chopper drives. Regenerative braking control.	1
2.5	Two quadrant chopper drives. Four quadrant chopper drives	2
3	**Induction Motor Drives (8 hours)**	
3.1	Three phase induction motor speed control using semiconductor devices. Stator voltage control – stator frequency control	2
3.2	Stator voltage and frequency control (v/f)	1
3.3	Voltage source inverter control - Current source inverter control.	2
3.4	Static Rotor resistance speed control using chopper	1
3.5	Slip power recovery control schemes – sub synchronous and super synchronous speed variations.	2
4	**Synchronous motor drives (9 hours)**	
4.1	Synchronous motor variable speed drives- variable frequency control- modes of variable frequency control- true synchronous mode and self control mode	3
4.2	Closed loop speed control of load commutated inverter fed synchronous motor drive	2
4.3	Concept of space vector –Basic transformation in reference frame theory.	2
4.4	Principle of vector control- introduction to field oriented control of ac motor drives	2
5	**Permanent Magnet and variable reluctance motor drives (8 hours)**	
5.1	Different types –Sinusoidal PMAC drives-	2
5.2	Brushless DC motor drives- control requirements, converter circuits, modes of operation.	3
5.3	Microcontroller based permanent magnet synchronous motor drives (schematic only).	1
5.4	Switched Reluctance motor drive- converter circuits- modes of operation.	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET384	INSTRUMENTATION AND AUTOMATION OF POWER PLANTS	VAC	3	1	0	4

Preamble: This course introduces measurements and instruments used in power plants. Automation of power plants and Supervisory control and data acquisition are also discussed.

Prerequisite: Introduction to Power Engineering/ Energy Systems

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

CO 1	Analyse different instruments used for measuring parameters in a power plant.
CO 2	Explain various control systems in power plants.
CO 3	Identify different components of SCADA for applications in power plants.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the working of a digital frequency meter (K2)
2. Explain the working of a radiation detector (K2)

Course Outcome 2 (CO2):

1. Compare the performance of boiler following mode and turbine following mode of operation in power plants. (K4).
2. Explain interlocks in boiler operation (K2).

Course Outcome 3 (CO3):

1. Discuss about the various SCADA architectures. Compare them.(K2, K3)
2. Explain the ladder logic approach of programming in a PLC(K2,).

Model Question paper

QP CODE:

PAGES:2

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET384

Course Name: INSTRUMENTATION AND AUTOMATION OF POWER PLANTS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain briefly the working principle of an induction type wattmeter.
2. Discuss the role of dust monitor in power plants.
3. Write notes on temperature measurement techniques used in boilers?
4. Discuss how pedestal vibration is measured in boilers?
5. Explain what do you mean by co-ordinated control in boilers.
6. Discuss the role of distributed control system in a power plant.
7. List out the differences between RTUs and IEDs.

8. State the advantages and disadvantages of PLC.
9. Discuss the operating states of a power system.
10. Explain briefly what do you mean by Energy Management System.

PART B (14 x 5 = 70 Marks)

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

Module 1

11. a. With the help of a neat diagram, explain the working of a digital frequency meter. **(7)**
    b. Explain how the flow of feed water is measured in power plants. **(7)**

12. a. With the help of a neat sketch, explain the working of a power factor meter. **(10)**
    b. Explain the working of a radiation detector. **(4)**

Module 2

13. a. Explain how flame monitoring is done in boilers. **(6)**
    b. Discuss the pressure measuring devices in boilers. **(7)**

14. a. Describe with a neat schematic, how shaft vibration can be detected. **(7)**
    b. Explain the working of a non contact type speed measuring device. **(7)**

Module 3

15. a. Explain the control of boiler drum level in power plant operation. **(7)**
    b. Explain how steam temperature can be controlled in boilers. **(7)**

16. a. Compare the performance of boiler following mode and turbine following mode of operation in power plants. **(7)**
    b. Explain interlocks in boiler operation. **(7)**

Module 4

17. a. Describe the basic components of a SCADA system. **(4)**
    b. Describe the components of an IED. **(4)**
    c. Explain the ladder logic approach of programming in a PLC **(6)**
18. a. Explain the objectives of SCADA. **(4)**
    b. Discuss about the various SCADA architectures. Compare them. **(10)**

Module 5

19. a. Discuss the main requirements of an Energy Management System. **(4)**
    b. With the help of a diagram, explain what do you understand by an EMS framework. **(10)**
20. Explain the applications of SCADA in generation operation and management. **(14)**

Syllabus

Module 1

Measurements in power plants: Electrical measurements – current, voltage, power, frequency, power factor etc. – non electrical parameters – flow of feed water, fuel, air and steam with correction factor for temperature – steam pressure and steam temperature – drum level measurement – radiation detector – smoke density measurement – dust monitor.

Module 2

Measurement in boiler and turbine: Metal temperature measurement in boilers, piping. System for pressure measuring devices - smoke and dust monitor - flame monitoring. Introduction to turbine supervising system - pedestal vibration - shaft vibration - eccentricity measurement. Installation of non-contracting transducers for speed measurement.

Module 3

Controls in boilers: Boiler drum level measurement methods - feed water control - soot blowing operation - steam temperature control - Coordinated control - boiler following mode operation - turbine following mode operation - selection between boiler and turbine following modes. Distributed control system in power plants interlocks in boiler operation - Cooling system - Automatic turbine runs up systems.

Module 4

Introduction to SCADA systems: - Elements of a SCADA system - benefits of SCADA system - SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system

SCADA System Components: - Remote Terminal Unit-(RTU), Intelligent Electronic Devices (IED) - PLC: Block diagram, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA.

Module 5

SCADA Applications: Operating states of a power system - Energy management System (EMS) – EMS framework – Generation operation and management – Load forecasting – unit commitment – hydrothermal co-ordination – Real time economic dispatch and reserve monitoring – real time automatic generation control

Text books:

1. P. K. Nag,”Power Plant Engineering” 2nd Edition, Tata McGraw-Hill Education, 2002.
2. R.K.Jain, “Mechanical and Industrial Measurements”, 10th Edition, Khanna Publishers, New Delhi, 1995.
3. Sam. G.Dukelow, “The Control of Boilers”, 2nd Edition, ISA Press, New York, 1991.
4. Stuart A. Boyer, ‘SCADA-Supervisory Control and Data Acquisition’, Instrument Society of America Publications,USA,2004.

Reference Books:

1. David Lindsley, "Boiler Control Systems", McGraw Hill, New York, 1991.
2. Jervis M.J, "Power Station Instrumentation", Butterworth Heinemann, Oxford, 1993.

Course Contents and Lecture Schedule:

Sl. No	Topic	No. of Lectures
1	**Measurements in a power plant (8 hours)**	
1.1	Electrical measurements – Current, voltage, power, frequency, power factor etc.	2
1.2	Non electrical parameters – Flow of feed water, fuel, air and steam with correction factor for temperature – Steam pressure and steam temperature	2
1.3	Drum level measurement – Radiation detector	2
1.4	Smoke density measurement – Dust monitor.	2
2	**Monitoring (9 hours)**	
2.1	Measurement in boiler and turbine: Metal temperature measurement in boilers, piping.	2
2.2	System for pressure measuring devices, smoke and dust monitor, flame monitoring.	2
2.3	Introduction to turbine supervising system, pedestal vibration	1
2.4	Shaft vibration, eccentricity measurement.	2
2.5	Installation of non-contracting transducers for speed measurement.	2
3	**Control systems (9 Hours)**	
3.1	Controls in boiler: Boiler drum level measurement methods, feed water control, soot blowing operation, steam temperature control	2
3.2	Coordinated control, boiler following mode operation, turbine following mode operation	1
3.3	Selection between boiler and turbine following modes.	1
3.4	Distributed control system in power plants interlocks in boiler operation.	1
3.5	Cooling system, Automatic turbine runs up systems.	2

4	**SCADA systems (10 Hours)**	
4.1	Introduction to SCADA systems: - Elements of a SCADA system - benefits of SCADA system	1
4.2	SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system	2
4.3	SCADA System Components: - Remote Terminal Unit-(RTU),	3
4.4	Intelligent Electronic Devices (IED) - PLC: Block diagram, Ladder diagram, Functional block diagram	3
4.5	Applications, Interfacing of PLC with SCADA.	1
5	**SCADA applications (9 Hours)**	
5.1	SCADA Applications: Operating states of a power system	2
5.2	Energy management System (EMS) – EMS framework	3
5.3	Generation operation and management – Load forecasting – unit commitment	2
5.4	Hydrothermal co-ordination – Real time economic dispatch and reserve monitoring – real time automatic generation control	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET386	DIGITAL CONTROL	VAC	3	1	0	4

Preamble: This course aims to provide a strong foundation in digital control systems. Modelling, time domain analysis, frequency domain analysis and stability analysis of sampled data control systems based on Pulse Transfer function (conventional) approach and State variable concept are discussed. The design of digital control is also introduced.

Prerequisite: Basics of Circuits, Networks and Control Systems

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

CO 1	Describe the role of various control blocks and components in digital control systems.
CO 2	Analyse the time domain responses of the sampled data systems using Z Transform.
CO 3	Analyse the stability of the given discrete time system.
CO 4	Apply state variable concepts to assess the performance of linear systems
CO 5	Apply Liapunov methods to assess the stability of linear systems
CO 6	Explain control system design strategies in discrete time domain.

Mapping of course outcomes with program outcomes

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

Assessment Pattern:

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

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	15	15	40
Apply (K3)	25	25	40
Analyse (K4)			
Evaluate (K5)			
Create (K6)			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

Course Level Assessment Questions:

Course Outcome 1 (CO1)

1. Derive the transfer function and obtain the frequency response characteristics of zero order hold circuit.
2. Explain how reconstruction of original signal is achieved from discrete time signals.
3. Explain any three factors to be considered for the choice of sampling frequency for a system.

Course Outcome 2 (CO2):

1. Derive the transfer function and obtain the frequency response characteristics of first order hold.
2. Problems related to steady state error.
3. Problems related to ZTF from difference equation form.

Course Outcome 3(CO3):

1. Problems related to the stability analysis using Jury's test
2. Problems related to the stability analysis using Bilinear Transformation
3. Problems to determine range of K or other TF parameter for stability/ oscillation.

Course Outcome 4 (CO4):

1. Problems related to canonical form representations
2. Problems based on state transition matrix
3. Problems to determine the solution of state equations.

Course Outcome 5 (CO5):

1. Check the stability of the given LTI system using Liapunov method.
2. Explain the physical relevance of Liapunov function.
3. Test the stability of the given nonlinear state model.

Course Outcome 6 (CO6):

1. Design a digital controller using root locus approach to meet the required specifications.
2. Problems on PID tuning and selection.
3. Pole placement problems for LTI systems.

Model Question Paper

PAGES: 3

QP CODE:

Reg.No:____________

Name:______________

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

Course Code**: EET386**

Course Name: **DIGITAL CONTROL**

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

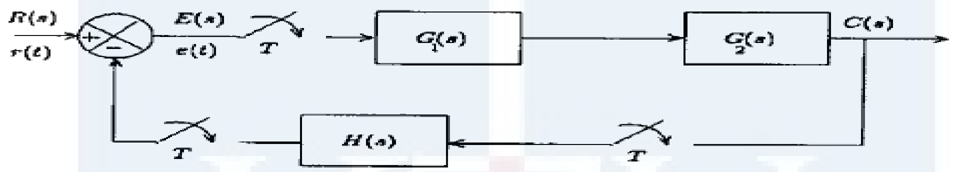
PART A

Answer all Questions. Each question carries 3 Marks

1 Explain any four advantages of sampled data control systems.

2 Determine the z-transform of $x(n)=(1/2)^n u(-n)$.

3 Obtain the pulse transfer function for the given system.



4 Obtain the poles and zeroes of the system governed by the difference equation: $y(n)+\frac{5}{4}y(n-1)+\frac{3}{8}y(n-2)=2x(n)-x(n-1)$

5 Draw and explain the mapping between s- plane to z-plane for the constant frequency loci.

6 Explain how does the P- controller affect the performance of a DT system.

7 Obtain the diagonal canonical form of the system with $G(z)=\dfrac{z+0.5}{(z^2+1.4z+0.4)}$

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: $i) X(z)=\dfrac{2z^{-1}}{(1-0.25z^{-1})^2}; ROC:|z|>\dfrac{1}{4}, and, ii) F(z)=\dfrac{3z^{-1}}{(1-z^{-1})(1-2z^{-1})}; ROC:|z|>2$ **(9)**

12 a) Determine the Z transform of $H(s)=\dfrac{3}{s(s+2)^2}$ **(4)**

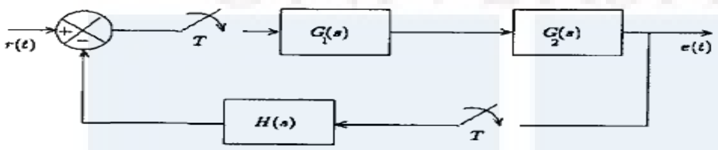
b) Write short notes on:
   i) Aliasing effect
   ii) Importance of First order hold circuit
   iii) Region of convergence for ZT **(10)**

Module 2

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

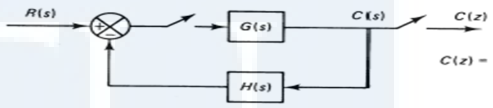
ii) Also determine the impulse response h(n) for the above system. **(3+5)**

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

SEMESTER VI

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET394	GENERALIZED MACHINE THEORY	VAC	4	0	0	4

Preamble: Nil

Prerequisite: DC Machines and Transformers. Synchronous and Induction machines

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

CO 1	Develop the basic two pole model representation of electrical machines using the basic concepts of generalized theory.
CO 2	Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance.
CO 3	Apply linear transformation for the steady state and transient analysis of different types of rotating electrical machines.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	2	2	-	-	-	-	-	-	-	-	**2**
CO 2	3	3	2	**2**	-	-	-	-	-	-	-	**2**
CO 3	3	3	3	**2**	-	-	-	-	-	-	-	**2**

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
Remember	5	5	10
Understand	10	10	20
Apply	35	35	70
Analyse			
Evaluate			
Create			

End Semester Examination Pattern : There will be two parts; Part A and Part B. **Part A** contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions.

Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Part A: 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Kron's Primitive Machine of rotating electrical machines.
2. Describe the essential features of rotating electrical machines.
3. Draw the basic two pole machine diagram of DC Compound Machine.
4. Develop an expression for the electrical torque of the Kron's Primitive Machine.

Course Outcome 2 (CO2):

1. What are the advantages of having power invariance in transformations.
2. Deduce Parks transformations relating three phase currents to its corresponding d- q axis currents.
3. Draw the generalized model of a DC series machine and derive the voltage equation in matrix form.
4. Explain the physical significance of Park's transformations.

Course Outcome 3 (CO3):

1. Explain the steady state analysis of a separately excited DC motor and derive the expression for electromagnetic torque. Also plot the shunt characteristics and speed versus armature voltage characteristics.
2. Obtain the expression for the steady state torque when balanced poly phase supply is impressed on the stator winding of three phase Induction motor
3. Draw the equivalent circuit of a three phase induction motor with the help of its generalized model.
4. Investigate the transient behaviour of a separately excited DC generator under the following operating condition: sudden application of a step field excitation to the field under no load, i_a =0 and for constant no load speed ω_{r0} and explore the variation of armature voltage.

Model Question paper

QP CODE:

PAGES: 2

Reg.No:______________
Name:________________

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

Course Code: EET394
Course Name: GENERALIZED MACHINE THEORY

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

PART A

Answer all questions. Each Question Carries 3 marks

1. Sketch the basic two pole representation of the following machines
   i) DC shunt machine with interpoles ii) DC compound machine
2. Explain linear transformations as used in electrical machines.
3. What is Kron's primitive machine?
4. Enumerate the limitations of generalized theory of electrical machines.
5. Derive an expression for rotational mutual inductance or motional inductance of DC generator
6. Derive the transfer function of separately excited DC motor under on no load operation.
7. Draw the power angle characteristics of salient pole and cylindrical rotor synchronous machine.
8. Draw the torque slip characteristics of three phase Induction motor.
9. Explain equivalent circuit of single phase Induction motor.
10. Compare single phase and poly phase Induction motor.

PART B

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

Module 1

11. a) Write the voltage equations for Kron's primitive machine in matrix form. **(9)**
    b) Derive the expression for transformer and speed voltages in the armature along the quadrature axis. **(5)**
12. Derive electrical torque expression of Kron's primitive machine in terms of reluctance and show that no torque is produced by interaction between flux and current on the same axis. **(14**

Module 2

13. Explain Park's transformations to transform currents between a rotating balanced three phase (a, b, c) winding to a pseudo stationary two phase (d, q) winding. Assume equal number of turns on all coils **(14)**

14. a) Explain the physical concept of Park's transformation **(7)**

b) Explain the term invariance of power as applied to electrical machines. Show the power invariance is maintained under this transformation. **(7)**

Module 3

15. a) Derive the voltage and torque equation of a DC series motor from its generalized mathematical model. **(7)**

b) Obtain the steady state analysis of a separately excited DC motor and plot the shunt characteristics. Also derive the expression for torque. **(7)**

16. a) A separately excited DC generator gives a no load output voltage of 240 V at a speed of ωr and a field current of 3 A. Find the generated emf per field ampere, Kg. **(5)**

b) Investigate the transient behaviour of a separately excited DC generator under the following operating condition:

i) Sudden application of a step field excitation to the field under no load, i_a =0 and for constant no load speed ωr0 and explore the variation of armature voltage. **(9)**

Module 4

17) a) Derive the power expression for salient pole synchronous machine in terms of load angle δ and draw the power angle characteristics. **(7)**

b) Derive the voltage equations in matrix form for a three phase synchronous machine with no amortisseurs. **(7)**

18) Derive the equivalent circuit of a poly phase induction motor with the help of its generalized mathematical model. **(14)**

Module 5

19) Derive the electromagnetic torque equations from the primitive machine model of a single phase induction motor by applying cross field theory. **(14)**

20) Explain the double field revolving theory of single phase Induction motor. **(14)**

Syllabus

Module 1

Unified approach to the analysis of electrical machine performance - per unit system - Basic two polemodel of rotating machines- Primitive machine -Conventions -transformer and rotational voltages in the armature voltage and torque equations, resistance, inductance and torque matrix.

Module 2

Transformations-passive linear transformation in machines-invariance of power-transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes-Physical concept of Park's transformation.

Module 3

DC Machines: Application of generalized theory to separately excited DC generator: steady state and transient analysis, Separately excited DC motor- steady state and transient analysis, Transfer function of separately excited DC generator and motor- DC shunt and series motors: Steady state analysis and characteristics.

Module 4

Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves.

Induction Machines: Primitive machine representation. Transformation- Steady state operation-Equivalent circuit. Torque slip characteristics.

Module 5

Single phase induction motor- Revolving Field Theory equivalent circuit- Voltage and Torque equations-Cross field theory-Comparison between single phase and poly phase induction motor.

Text Books

1) Bhimbra P. S., “Generalized Theory of Electrical Machines”, Khanna Publishers, 6th edition, Delhi 2017.
2) Charles V. Johnes, “Unified Theory of Electrical Machines”. New York, Plenum Press, 1985.
3) Bernad Adkins, Ronald G Harley, “General theory of AC Machines”. London, Springer Publications, 2013.

Reference Books

1) Charles Concordia,” Synchronous Machines- Theory and Performance”, John Wiley and Sons Incorporate, Newyork.1988.
2) Say M. G., “Introduction to Unified Theory of Electrical Machines”, Pitman Publishing, 1978.

3) Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill, 2nd revised edition, 2001.

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1	**Two pole Model (10 Hours)**	
1.1	Introduction- Essentials of rotating machines-Electromechanical energy conversion. Conventions.	1
1.2	Idealised machine diagram of DC Compound machine, DC shunt machine, Synchronous motor, Induction motor, Single phase AC motor.	2
1.3	Per unit system, Advantages of per unit system, Expression for self inductance of a machine, Mutual flux linking.	1
1.4	Transformer and speed voltages in the armature, transformer with movable secondary.	2
1.5	Kron's primitive machine, Leakage flux in machines with more than two windings. Fundamental assumptions.	2
1.6	Voltage equations, Stator field coils, Armature coils, Equations of armature voltage in matrix form,	2
2	**Linear Transformations (8 Hours)**	
2.1	Linear transformation in machines- power invariance, Transformations from a displaced brush axis.	2
2.2	Transformations from three phase to two phase (a,b,c) to (α,β,0) transformation matrix.	3
2.3	Transformation from rotating axes (α,β,0) to stationary axes (d,q,0).	2
2.4	Power invariance: problems on transformations	1
3	**DC Machines (10 Hours)**	
3.1	DC machines, Separately excited DC generators, Rotational mutual inductance, Steady state and transient analysis, Armature terminal voltage.	2
3.2	Transfer function of DC machines, Separately excited generator under no load and loaded condition, Numerical Problems.	2
3.3	Steady state analysis and Shunt characteristics of DC machine.	2

3.4	DC series motor, Schematic diagram of Primitive model, Interconnection between armature and field, Torque and speed expression, Different characteristics.	2
3.5	DC shunt motor, Schematic diagram, primitive model, Steady state analysis, Torque-Current and Speed-Current characteristics, Condition for maximum torque.	2
4	**Synchronous and Three Phase Induction Motors(10 Hours)**	
4.1	Poly phase Synchronous machine, Basic structure, Assumptions, Parameters, Synchronous resistance, inductance and mutual inductance between armature and field.	2
4.2	Armature self-inductance, Armature mutual inductance, General synchronous machine parameters, Amplitude of second harmonic component.	2
4.3	Steady state power angle characteristics, reluctance power, Cylindrical rotor machine and salient pole machine, Phasor diagram, Pull out torque, Maximum power.	2
4.4	Polyphase induction machine, Voltage expression, Transformations fromαβ to d-q and vice versa, Expression for electromagnetic torque.	2
4.5	Steady state analysis, Voltage equation in new variables, Connection matrix,	1
4.6	Equivalent circuit of an induction machine, Short circuited and open circuited two winding transformer.	1
5	**Single Phase Induction Motors(7 Hours)**	
5.1	Single phase induction motor, Basic structure, Assumptions, Primitive Machine Model.	2
5.2	Electrical Performance Equations, Voltage Matrix.	2
5.3	Steady state analysis, Equivalent Circuit	2
5.4	Numerical Problems	1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET396	ANALYSIS OF POWER ELECTRONIC CIRCUITS	VAC	3	1	0	4

Preamble: To impart knowledge about analysis and design of various power converters.

**Prerequisite : ** Electric circuit theory

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

CO 1	Choose appropriate power semiconductor device along with its driver circuits and protection.
CO 2	Analyse the operation of controlled rectifier circuits and PWM rectifiers.
CO 3	Analyse inverter circuits with different modulation strategies.
CO 4	Analyse the operation of DC-DC converters andAC voltage controllers.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1): Choose appropriate power semiconductor device along with its driver circuits and protection.

1. Compare ideal and real power electronic switches. (K1)
2. Explain the static and dynamic characteristics MOSFET and IGBT. (K2)
3. Choose the appropriate power electronic switch for a converter. (K3)
4. Illustrate the operation of driver and snubber circuits for power electronic switches. (K2)
5. Design a heat sink for a power electronic switch. (K3)

Course Outcome 2 (CO2): Analyse the operation of controlled rectifier circuits and PWM rectifiers.

1. Analyse the operation of full and semi converters for single and three phase applications working with RLE loads. (K2), (K3)
2. Analyse the effect of source inductance in full converters. (K2), (K3)
3. Explain the operation of phase controlled rectifiers in inversion mode.(K2)
4. Explain the different topologies and control of PWM rectifiers. (K2)
5. Mathematically show the effect of single phase rectifiers on neutral currents in three phase four wire systems. (K2), (K3)
6.

Course Outcome 3 (CO3): Analyse inverter circuits with different modulation strategies.

1. Analyse the operation of single and three phase inverters with RL loads. (K2), (K3)
2. Explain unipolar and bipolar sinusoidal pulse width modulation. (K2)
3. Design output filters for inverters. (K3)
4. Describe the types and working of multilevel inverters. (K1), (K2)
5. Explain the various current control methods of voltage source inverter. (K2)

Course Outcome 4 (CO4): Analyse the operation of DC- DC converters and AC voltage controllers.

1. Analyse the operation of single, two and four quadrant dc choppers. (K4)
2. Describe the control methods of dc choppers. (K2)
3. Design input filter for dc choppers. (K4)

4. Explain the working of multiphase choppers. (K2)

5. Analyse the operation of three phase ac voltage controllers with R load. (K4)

Model Question paper

QP CODE:

PAGES: 2

Reg. No:______________

Name:_______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION
MONTH & YEAR
Course Code: EET396

Course Name: ANALYSIS OF POWER ELECTRONIC CIRCUITS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Draw and explain a snubber circuit for a power MOSFET.
2. Compare the characteristics of ideal and real switches.
3. Why do the triple harmonics dominate in three phase four wire system with balanced rectifier loads?
4. Derive the expression for output voltage of half wave controlled rectifier with resistive load.
5. What is the significance of common mode voltage in inverters.
6. What are the merits of unipolar modulation technique for inverters over bipolar.
7. Derive an expression for average output voltage in terms of input dc voltage andduty cycle for a step down dc chopper.
8. Using a two phase dc chopper, bring out its advantages compared to a single chopper.
9. Develop the expression for power factor for an ac voltage controller using integral cycle control.
10. List the merits and demerits of Hysteresis current controller.

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) A 100 V dc supply is connected to a resistance of 7 Ohms through a series static controlled switch. The ON state forward voltage drop of the switch is 2 V. Its forward leakage current in the OFF state is 2 mA. It is operated with a switching frequency of 1 kHz and a duty cycle of 30%. Neglect the switching transition times

and determine the peak and average power dissipation in the switch. Also find the proportion in which this power dissipation is shared between the ON state dissipation and OFF state dissipation. **(5)**

b) Draw and explain the static and dynamic characteristics of IGBT. **(9)**

12. a) Explain the design of a driver circuit for MOSFET. **(7)**

b) A MOSFET that is used in a dc-dc converter is dissipating 50W. The thermal resistance to conduction from the junction to the case is 0.5 deg K/W and the thermal resistance to conduction from the case to the heat sink is 1.5 deg K/W. If the ambient temperature in the neighbourhood of the heat sink is 50 deg C, then calculate the thermal resistance requirement for the heat sink if the junction temperature does not exceed 100 deg C. **(7)**

Module 2

13. a) Derive the input PF of a single phase controlled rectifier with continuous and ripple-free load current. **(6)**

b) With necessary mathematical analysis, show the effect of source inductance on the output voltage of a single phase controlled bridge rectifier. **(8)**

14. a) Describe the working of 3-phase fully controlled converter with the help of circuit diagram. **(6)**

b) A three phase fully controlled bridge converter is connected to 415 V supply, having a reactance of 0.3 Ohm/phase and resistance of 0.05 Ohm/phase. The converter is working in the inversion mode at a firing advance angle of 35 deg. Compute the average generator voltage. Assume I_d = 60 A and thyristor drop = 1.5 V. **(8)**

Module 3

15. A single phase bridge inverter supplies an R-L load with R=10 Ohms and L=50mH from a 220 V dc supply. If the inverter frequency is 50 Hz, calculate i) rms value of fundamental component of load current ii) THD of load current iii) total power delivered to the load and iv) fundamental power output. **(14)**

16. Three single phase H bridge inverter circuits are available. What is the level of multilevel inverter that can be formed using them? Draw its circuit diagram and the important waveforms. Give a table showing the switch combination to be turned ON to get each level. **(14)**

Module 4

17. With a neat circuit diagram and waveforms, explain how four-quadrant operation is achieved in a Type-E Chopper. **(14)**

18. a) Explain the working of two quadrant type-A chopper with relevant waveforms. **(8)**

b) A step up chopper has input voltage of 120V and output voltage of 360 V. Ifthe conducting time of the thyristor chopper is 100 μs, compute the pulse width of output voltage. **(6)**

Module 5

19. A three phase three wire bidirectional controller supplies a star connected resistive load of R=5 Ohms and the line to line input voltage is 210 V, 50 Hz. The firing angle is $\pi/3$. Determine i) the rms output phase voltage ii) the input power factor and iii) the expression for the instantaneous output voltage of phase a. **(14)**

20. (a) What are the challenges faced by the conventional rectifier circuits? Justify. **(5)**

(b) Explain the working of any two PWM rectifier circuits to mitigate these issues. With block diagrams, discuss their control strategy. **(9)**

Syllabus

Module 1 (8 hours)

Overview of solid state devices

Characteristics of Ideal and Real switches - Static and Dynamic Characteristicsfor MOSFET and IGBT, Driver circuit and Snubbers for MOSFET and IGBT – Conduction and Switching loss - Power dissipation and selection of heat sink.

Module 2 (10 hours)

Phase controlled Rectifiers

Single-phase converter - full converter and semi converter - analysis with RLE loads – input PF with continuous and ripple free load current - inversion mode – effect of source inductance – Effect of single phase rectifiers on neutral currents in three phase four wire systems.

Three-phase converter - Full converter & semi converter – analysis with RLE loads – continuous conduction only – inversion mode - effect of source inductance –line notching and distortion.

Module 3 (10 hours)

Inverters

Single phase full Bridge Inverters –Analysis with RL load - Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage; PWM principle - Sinusoidal pulse width modulation- Unipolar and Bipolar modulation, Effect of blanking time on voltage of PWM inverter, output filter design.

Multilevel Inverters

Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters

Module 4 (7 hours)

DC Choppers

Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers, PWM control-Time ratio control – Current limit control, Source filter and its design, multiphase chopper.

Module 5 (6 hours)

AC voltage controllers

Three phase AC Voltage Controllers-Principle, operation and analysis with R loads

Current control of VSI

Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control

PWM rectifiers

Single phase PWM rectifiers –Basic topologies and control

Text Books

1. Joseph Vithayathil, Power Electronics: Principles and Applications, Tata McGraw Hill 2010.
2. Mohan, Undeland, Robbins, Power Electronics; Converters, Applications and Design. -3rd edition, John Wiley and Sons, 2003.
3. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, 2013.

Reference Books

1. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
2. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
3. M H Rashid (Ed), Power Electronics Handbook: Devices, Circuits and Applications,Academic Press 2010.
4. José Rodríguez, *et al,* Multilevel Inverters: A Survey of Topologies, Controls, and Applications, IEEE Transactions on Industrial Electronics, vol. 49, no. 4, August 2002.

Total Lecture Hours: 45

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Overview of solid state devices (8 hours)**	
1.1	Characteristics of Ideal and Real switches	1
1.2	Static and Dynamic Characteristics for MOSFET and IGBT	2
1.3	Driver circuit and Snubbers for MOSFET and IGBT	2
1.4	Conduction and Switching loss	1
1.5	Power dissipation and selection of heat sink	2
2	**Phase controlled Rectifiers (10 hours)**	
2.1	Single-phase converter - full converter and semi converter - analysis with RLE loads	2
2.2	Input PF with continuous and ripple free load current - inversion mode	1
2.3	Effect of source inductance.	1
2.4	Effect of single phase rectifiers on neutral currents in three phase four wire system	1
2.5	Three-phase converter - Full converter & semi converter – analysis with RLE loads - continuous conduction only	2
2.6	Inversion mode - Effect of source inductance	2
2.7	line notching and distortion	1
3	**Inverters (10 Hours)**	
3.1	Single phase full Bridge Inverters – Analysis with RL load	1
3.2	Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage	2
3.3	PWM principle - Sinusoidal pulse width modulation - Unipolar and Bipolar modulation	2
3.4	Effect of blanking time on voltage of PWM inverter, output filter design	2
	Multilevel Inverters	
5.2	Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters	3
4	**DC Choppers (7 Hours)**	
4.1	Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers	3
4.2	PWM control-Time ratio control – Current limit control	2

4.3	Source filter and its design	1
4.4	Multiphase chopper	1
5	**AC voltage controllers (6 Hours)**	
5.1	Three phase AC Voltage Controllers - Principle, operation and analysis with R loads	2
	Current control of VSI	
5.3	Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control	2
	PWM rectifiers	
5.4	Single phase PWM rectifiers –Basic topologies and control	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET398	OPERATION AND CONTROL OF POWER SYSTEMS	VAC	3	1	0	4

Preamble: This course introduces analysis techniques for the operation and control of power systems. Load dispatch and scheduling of energy are discussed. Power system security and state estimation are introduced. This course serves as the most important prerequisite of many advanced courses in power systems.

Prerequisite: Power Systems I

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

CO 1	Analyse various methods of generation scheduling.
CO 2	Formulate hydro-thermal scheduling problems.
CO 3	Evaluate power exchange in interconnected power systems.
CO 4	Analyse security issues in power system networks.
CO 5	Analyse various state estimation methods.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain economic dispatch and unit commitment (K1)
2. Problems on optimal load dispatch (K2, K3)

Course Outcome 2 (CO2):

1. Distinguish between the long term and short term scheduling. (K2)
2. Explain how scheduling of energy can be done with limited supply. (K2, K3)

Course Outcome 3 (CO3):

1. Discuss the advantages and disadvantages of power pools (K2).
2. Explain what do you mean by interchange evaluation with unit commitment (K2, K3).

Course Outcome 4 (CO4):

1. What is system security? Explain the major factors involved in system security (K2)
2. Explain the effects of generator outages in power systems. (K2, K3).

Course Outcome 5 (CO5):

1. Discuss in detail, what do you mean by network observability.(K1)
2. Explain any one method by which bad measurements can be detected. (K2).

Model Question paper

QP CODE:

PAGES: 2

Reg. No:______________
Name:______________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET398

Course Name: OPERATION AND CONTROL OF POWER SYSTEMS

Max. Marks: 100.Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Explain what do you mean by economic dispatch.
2. Discuss the different constraints in unit commitment.
3. Differentiate between long range and short term generation scheduling.
4. Write short notes on pumped storage hydro plants
5. Explain what do you mean by power pools.
6. Write short notes on energy banking.
7. Illustrate the importance of power system security
8. What do you mean by contingency analysis?
9. Elaborate on the importance of state estimation in power system.
10. What are the sources of errors in state estimation?

PART B (14 x 5 = 70 Marks)

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

Module 1

11. What do you mean by optimal load dispatch? Explain any one method by which optimal load dispatch can be done. (14)

12 a. With the help of a flowchart, explain the priority list method of unit commitment. (10)

b. Write notes on security constrained unit commitment. (4)

Module 2

13. a. Explain any one method by which short term hydrothermal co-ordination can be done. (7)

b. Explain how hydroelectric plants are modelled for scheduling problems. (7)

14. a. Explain how scheduling of energy can be done with limited supply. (7)

b. Explain any one method by which hydrothermal scheduling with storage limitation can be done. (7)

Module 3

15. a. Explain the advantages of economy interchange between interconnected utilities. (7)

b. Explain the different types of interchange contracts. (7)

16. a. Discuss the advantages and disadvantages of power pools (7)

b.Explain what do you mean by interchange evaluation with unit commitment. (7)

Module 4

17. With the help of a flowchart, explain contingency analysis using sensitivity factors. (14)

18. a. What is system security? Explain the major factors involved in system security (9)

b. Explain the effects of generator outages in power systems. (5)

Module 5

19. a) Explain how quantities which are not measured can be estimated. (7)

b) Discuss in detail, what do you mean by network observability. (7)

20. a) Explain any one method by which bad measurements can be detected. (10)

b)List out the advantages of state estimation in power systems. (4)

Syllabus

Module 1

Introduction- Optimum load dispatch - First order gradient method base point and participation factors.
Economic dispatch versus unit commitment.
Unit Commitment Solution Methods - Priority-List Methods – SecurityConstrained Unit Commitment.

Module 2

Generation with limited supply-Take or pay fuel supply contract- Introduction to Hydro-thermal coordination-Long range and short range scheduling

Hydro-electric plant models-scheduling energy problems - types of scheduling problems-Scheduling energy - The Hydrothermal Scheduling Problem - Hydro scheduling with storage limitation - Introduction to Pumped storage hydro plants

Module 3

Inter change evaluation and power pools- Interchange contracts – Energy interchange between utilities - Interchange evaluation with unit commitment - Energy banking- power pools.

Module 4

Power system security- Factors Affecting Power System Security - Contingency Analysis: Detection of Network Problems - Generation Outages - Transmission Outages - An Overview of Security Analysis

Module 5

Introduction to State estimation in power system, Maximum Likelihood Weighted Least-Squares Estimation - State Estimation of an AC Network - Sources of Error in State Estimation - Detection and Identification of Bad Measurements - Estimation of Quantities Not Being Measured - Network Observability and Pseudo-measurements - The Use of Phasor Measurement Units (PMUs) - Application of Power Systems State Estimation - Importance of Data Verification and Validation

Text books:

1. Allen J. Wood, Bruce F. Wollenberg&Gerald B. Sheblé, “Power Generation, Operation, and Control”, 3rd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey.

2. John Gainger& William Stevenson, “Power System Analysis”, McGraw-Hill, Inc, , 1994.

References:

1. Ali Abur,Antonio Gómez Expósito, Power System State Estimation:Theory and Implementation, CRC Press, 2004.

Course Contents and Lecture Schedule:

Sl. No.	Topic	No. of Lectures
1	**Load Dispatch (9 hours)**	
1.1	Review of economic load dispatch	1
1.2	Optimum load dispatch	2
1.3	First order gradient method base point and participation factors.	2
1.4	Economic dispatch versus unit commitment - Unit Commitment Solution Methods - Priority-List Methods	2
1.5	Security-Constrained Unit Commitment	2
2	**Generation Scheduling (9 hours)**	

2.1	Generation with limited supply-Take or pay fuel supply contract	2
2.2	Introduction to Hydro-thermal coordination-Long range and short range scheduling	1
2.3	Hydro-electric plant models	1
2.4	Scheduling energy problems - types of scheduling problems- Scheduling energy	2
2.5	The Hydrothermal Scheduling Problem	2
2.6	Introduction to Pumped storage hydro plants	1
3	**Interchange evaluation and power pools (9 Hours)**	
3.1	Interchange Contracts	2
3.2	Energy Interchange between Utilities	2
3.3	Interchange evaluation with unit commitment	1
3.4	Energy banking	2
3.5	Power pools	2
4	**Power system security (7 Hours)**	
4.1	Factors affecting Power System Security	2
4.2	Contingency Analysis	1
4.3	Detection of Network Problems	1
4. 4	Generation Outages	1
4. 5	Transmission Outages	1
4. 6	An overview of Security Analysis	1
5	**State estimation in power system (9 Hours)**	
5.1	State estimation in power system - Maximum Likelihood Weighted Least-Squares Estimation	2
5.2	State Estimation of an AC Network - Sources of Error in State Estimation	2
5.3	Detection and Identification of Bad Measurements	1
5.4	Estimation of Quantities Not Being Measured	1
5.5	Network Observability and Pseudo-measurements	1
5.6	The Use of Phasor Measurement Units (PMUS)	1
5.7	Application of Power Systems State Estimation - Importance of Data Verification and Validation	1