2017

COURSE HANDOUT S7 EEE

[Type the document subtitle]

[Type the abstract of the document here. The abstract is typically a short summary of the contents of the document. Type the abstract of the document here. The abstract is typically a short summary of the contents of the document.]

ktu
[Type the company name]
6/30/2017

EE 010 701 ELECTRICAL POWER TRANSMISSION

COURSE INFORMATION SHEET

PROGRAMME: **EEE**	DEGREE**: B.Tech**
COURSE: **ELECTRICAL POWER TRANSMISSION**	SEMESTER: **SEVENETH** CREDITS: **4**
COURSE CODE: **EE 010 701** REGULATION: **UG**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **POWER SYSTEM**	CONTACT HOURS: **2+2** (Tutorial) hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY):**Nil**	LAB COURSE NAME: **Nil**

SYLLABUS:

UNIT	DETAILS	HOURS
I	**Transmission line parameters** Inductance of single phase two wire line – inductance of composite conductor lines – inductance of three phase lines – double circuit three phase lines– bundled conductors – resistance – skin effect and proximity effect – magnetic field induction – capacitance of two wire line capacitance of a three phase line with equilateral spacing and unsymmetrical spacing – transposition of lines – effect of earth on capacitance –method of GMD – electrostatic induction	10
II	**Performance analysis of Transmission lines** Short transmission line – generalised circuit constants – medium transmission lines by nominal pi and T methods – long transmission line rigorous solution – equivalent circuit of long lines – Ferranti effect – tuned power lines – power flow through a transmission line – Effects of transformer on the performance of a transmission line reactive power in a line – power transfer capability of transmission lines – compensation of transmission lines – power flow in a long transmission line	11
III	**Insulators for overhead transmission lines:** Ratings – types of insulators – potential distribution over a string of suspension insulators – string efficiency – methods to improve string efficiency – methods of equalising potential – insulation failure – testing of insulators. **Mechanical design of Transmission Lines**: Sag and Tension – Spans of unequal length – equivalent span – effect of ice and wind loading – stringing chart – vibration and vibration dampers. **Underground cables:** types of cables – capacitance of single core cables – grading of cables – power factor and heating of cables – capacitance of three core belted cable – DC cables – location of faults in underground cables (Murray and Varley tests)	12
IV	**Substations:** Types of substations – Bus bar arrangements – substation bus schemes – substation equipments **Grounding Systems:** resistance of grounding systems – neutral grounding – resonant grounding – solid grounding or effective grounding – resistance grounding – reactance grounding – earthing transformer **Corona:** Critical disruptive voltage – conditions affecting corona – corona loss – factors affecting corona loss – radio interference – interference between power and communication lines.	12
V	**HVDC Transmission:** Advantages and disadvantages of HVDC transmission – Types of HVDC links – Interconnection of HVDC into AC systems **FACTS Technology:** Objectives of Flexible AC Transmission – FACTS devices – simple model of STATCOM, static VAR compensator(SVC), thyristor controlled reactor(TCR), thyristor switched reactor(TSR), thyristor switched capacitor(TSC), interline power flow controller(IPFC), thyristor controlled series capacitor(TCSC), thyristor controlled series reactor(TCSR) and unified power flow controller(UPFC)	15
	TOTAL HOURS	60

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
1	Power System Engineering: D P Kothari and I J Nagrath, Tata McGraw Hill

2	Electric Power Generation, Transmission and Distribution: S N Singh, PHI
3	Power System Analysis: Hadi Saadat, Tata McGraw Hill
4	Principles of power system: V.K Mehta , Rohit Mehta
5	FACTS controllers in power transmission and distribution : K.R Padiyar
6	Electrical power Distribution and Transmission: Luces M. Faulkenberry, Walter Coffer, Pearson Education
7	Electrical machines, Drives and Power Systems: Thoedore Wildi, Pearson Ed.
8	Electrical power transmission : Ashfaq Hussain

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EE 010 601	Power Generation and Distribution	Must have idea about various power generating stations and distribution systems and the associated losses in a transmission line.	VI
EN 010 108	Basic Electrical Engineering	Basics of Electrical Engineering	I&II

COURSE OBJECTIVES:

1	To impart knowledge on various transmission line constants (Resistance, Inductance and capacitance).
2	To do the performance analysis of transmission lines and be able to do the mechanical designing of overhead lines and underground cables
3	To impart the knowledge on various compensation techniques in power system and FACTS devices
4	To understand HVDC transmission in power system

COURSE OUTCOMES:

S.NO	DESCRIPTION	BLOOM'S TAXONOMY LEVEL
1	Students will be able to learn about various transmission line constants (Resistance, Inductance and capacitance).	Comprehension [level 2]
2	Students will be able to do the performance analysis of transmission lines	Evaluation[level 6]
3	Students will be able to perform the mechanical designing of overhead lines and underground cables	Evaluation[level 6]
4	Students will be able to reproduce the classification of different types of substation, neutral grounding methods and corona concept.	Analyze [level 4]
5	Students will be able to write about the HVDC transmission and FACTS controllers.	Comprehension [level 2]

MAPPING COURSE OUTCOMES (COs) – PROGRAM OUTCOMES (POs) AND COURSE OUTCOMES (COs) – PROGRAM SPECIFIC OUTCOMES (PSOs)

	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C 504.1	**3**	**3**	**2**		**3**				**2**		**2**		**3**		
C 504. 2	**3**	**3**	**2**		**3**				**2**		**3**		**3**		
C504. 3	**3**	**2**	**2**		**2**				**2**		**2**		**3**		
C504. 4	**3**		**3**						**3**	**3**	**2**		**3**		
C504. 5	**3**	**2**	**3**	**2**			**2**		**1**			**3**	**3**		

EE 504	**2.8**	**2.6**	**2.4**	**2**	**2.75**		**2**		**2**		**2**	**3**	**3**		

Mapping	L/H/M	Justification
C504.1-PO1	**H**	Student will be able to explain about various transmission line constants
C504.1-PO2	**H**	Student will be able to design transmission line (both electrical and mechanical)
C504.1-PO3	**M**	Students will be able to design underground cables and locate faults correctly
C504.1-PO5	**H**	Students will demonstrate an ability to identify, formulate and solve transmission line losses
C504.1-PO9	**M**	Students will be able to acquire new knowledge in the power system design and testing
C504.1-PO11	**L**	Student will be able to use the skills in modern Electrical engineering tools like SIMULINK to know the operational principles of FACTS devices and controllers
C504.2-PO1	**H**	Students will be able to apply the knowledge of mathematics, and engineering Fundamentals for solving power system fault analysis
C504.2-PO2	**H**	Student will be able to anlayze and conduct experiments on power system models
C504.2-PO3	**M**	Students will be able to design power system to meet power quality, reliability and safety
C504.2-PO5	**H**	Students will demonstrate an ability to identify, formulate and solve Electrical and Electronics Engineering problems using the power system techniques
C504.2-PO9	**M**	Students will be able to suggest improvements in the power transmission system for increasing its efficiecy leading to life long learning
C504.2-PO11	**H**	Students can evaluate the performance of the various transmission network models using modern simulation tools
C504.3-PO1	**H**	Students will be able to apply the mathematics and engineering fundamentals for analyzing the merits and demerits of power transmission networks .
C504.3-PO2	**H**	Students will be able to design FACTS devices for compensation.
C504.3-PO3	**H**	Students will demonstrate an ability to identify different methods to improve the transmission efficiency.
C504.3-PO5	**M**	Students will demonstrate an ability to identify, formulate and solve Electrical and Electronics Engineering problems using FACTS techniques.
C504.3-PO9	**H**	Students will be able to suggest improvements in power factor to life long learming
C504.3-PO11	**M**	Students can evaluate the performance of the various models using modern simulation tools
C504.4-PO1	**H**	Students will be able to apply the mathematics and engineering fundamentals for designing HVDC circuits.
C504.4-PO3	**H**	Students will demonstrate an ability to identify different methods to improve the demerits of power system
C504.4-PO9	**H**	Students will demonstrate an ability to identify, Electrical and Electronics Engineering problems
C504.5-PO1	**H**	Students will be able to apply the knowledge of mathematics, and engineering Fundamentals for understanding designing of transmission lines.
C504.5-PO2	**M**	Student will be able to anlayse and conduct experiments on line insulators
C504.5-PO3	**M**	Students will be able to design transmission to meet safety, economic and societal considerations
C504.5-PO5	**H**	Students will demonstrate an ability to identify, formulate and solve Electrical and Electronics Engineering problems for the HVDC system
C504.5-PO9	**M**	Students will be able to suggest improvements in the circuit for increasing it efficiecy leading to life long learming
C504.5-PO11	**M**	Students can evaluate the performance of the circuits using modern simulation tools

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SNO	DESCRIPTION	PROPOSED ACTIONS

1	Power circle diagram not included	NPTEL
2	Simulation of various applications using FACTs devices	MATLAB Tool

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

1	Modeling of FACTS devices
2	Application of various compensation techniques in power system

WEB SOURCE REFERENCES:

1	www.nptel.iitm.ac.in
2	http://ocw.mit.edu/index.htm

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☐☑CHALK & TALK	☐☑ STUD. ASSIGNMENT	☐☑WEB RESOURCES	
☐☑ LCD/SMART BOARDS	☐☑STUD. SEMINARS	☐ ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☐☑ASSIGNMENTS	☐☑ STUD. SEMINARS	☐☑TESTS/MODEL EXAMS	☐☑UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	. STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☐☑STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by **Approved by**

SANTHI.B **(HOD)**

COURSE PLAN

Sl.No	Module	Planned Date	Planned
1	1	17-Jul-17	Introduction to subject and syllabus-current scenario of Indian transmission system.
2	1	17-Jul-17	Brief of Transmission line constants-Resistance-skin effect and proximity effect
3	1	18-Jul-17	Internal and external-flux linkages & Inductance of a single conductor
4	1	18-Jul-17	Inductance of n parallel conductors & Ind of single phase two wire line and problem Ind 3 phase-symmetrical spacing
5	1	19-Jul-17	Inductance of three phase lines-3 phase unsymmetrical spacing-significance of transposition-Ind of transposed conductor
6	1	21-Jul-17	Mutual and Self GMD method-applying for Ind calculation of single & 3 phase systems(single ckt)
7	1	21-Jul-17	Inductance for double circuit three phase lines problem-different configuration(unsymmetrical spacing) with tutorial problem
8	1	24-Jul-17	bundled conductors-Inductance calculation using GMD method-Problem
9	1	25-Jul-17	Tutorial problems-Inductance calculation
10	1	27-Jul-17	fundamental concept of line capacitance -of a single conductor-system of n conductors-capacitance of single phase -2 wire system
11	1	28-Jul-17	capacitance of a three phase line with equilateral spacing and unsymmetrical

			spacing
12	1	31-Jul-17	capacitance of a three phase line with transposition of lines – method of GMD
13	1	2-Aug-17	effect of earth on capacitance - 1 /3 phase- Tutorial Problem
14	2	4-Aug-17	Short transmission line-modeling-problem
15	2	7-Aug-17	Tutorial-problem-short tx. line
16	2	8-Aug-17	medium transmission lines by nominal pi and T methods-basic equations-problem
17	2	9-Aug-17	medium transmission lines by nominal pi and T methods-problem continued
18	2	11-Aug-17	long transmission line rigorous solution-physical interpretation
19	2	14-Aug-17	equivalent circuit of long lines- Tutorial problem
20	2	16-Aug-17	Ferranti effect – tuned power lines
21	2	18-Aug-17	power flow through a transmission line
22	2	21-Aug-17	Effects of transformer on the performance of a transmission line
23	2	22-Aug-17	reactive power in a line – power transfer capability of transmission lines
24	2	23-Aug-17	compensation of transmission lines – power flow in a long transmission line
25	3	8-Sep-17	Insulators for overhead transmission lines: Ratings – types of insulators
26	3	11-Sep-17	potential distribution over a string of suspension insulators – string efficiency
27	3	13-Sep-17	methods to improve string efficiency
28	3	15-Sep-17	methods of equalising potential
29	3	18-Sep-17	Tutorial-problems-string insulators
30	3	19-Sep-17	insulation failure – testing of insulators.
31	3	20-Sep-17	Mechanical design of Transmission Lines: Sag and Tension – Spans of unequal length – equivalent span
32	3	22-Sep-17	effect of ice and wind loading-tutorial-problems in sag calculation
33	3	25-Sep-17	stringing chart – vibration and vibration dampers.
34	3	26-Sep-17	Underground cables: types of cables-capacitance of single core cables
35	3	27-Sep-17	– grading of cables – power factor and heating of cables-capacitance of three core belted cable
36	3	28-Sep-17	DC cables –location of faults in underground cables (Murray and Varley tests)
37	4	3-Oct-17	Substations: Types of substations – Bus bar arrangements –
38	4	4-Oct-17	substation bus schemes –substation equipments
39	4	6-Oct-17	Grounding Systems: resistance of grounding systems – neutral grounding
40	4	9-Oct-17	resonant grounding – solid grounding or effective grounding – resistance grounding-reactance grounding – earthing transformer
41	4	10-Oct-17	Corona: Critical disruptive voltage – conditions affecting corona – corona loss
42	4	11-Oct-17	factors affecting corona loss – problems in corona
43	4	12-Oct-17	radio interference – interference between power and communication lines.
44	5	13-Oct-17	HVDC Transmission: Advantages and disadvantages of HVDC transmission – Types of HVDC links
45	5	16-Oct-17	Interconnection of HVDC into AC systems
46	5	17-Oct-17	FACTS Technology: Objectives of Flexible AC Transmission – FACTS devices – simple model of STATCOM
47	5	19-Oct-17	static VAR compensator(SVC), thyristor controlled reactor(TCR), thyristor switched reactor(TSR), thyristor switched capacitor(TSC)
48	5	19-Oct-17	thyristor controlled series capacitor(TCSC), thyristor controlled series

			reactor(TCSR)
49	5	20-Oct-17	interline power flow controller(IPFC), and unified power flow controller(UPFC)-syllabus overview-university QP discussion

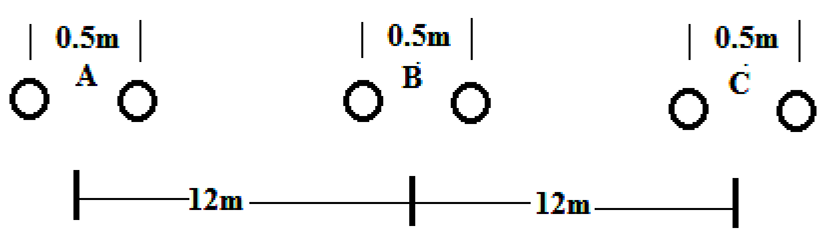
Tutorial Questions

1. Calculate the capacitance of a 100km long 3-phase, 50Hz overhead line consisting of three conductors, each of diameter 2cm and spaced 2.5m at the corners of an equilateral triangle.
2. Two conductors of a single phase line, each of 1cm diameter are arranged in a vertical plane with one conductor mounted 1m above the other. A second identical line is mounted at the same height as the first and spaced horizontally 0.25m apart from it. The two upper and the two lower are connected in parallel. Determine the inductance per km of the resulting double circuit line.
3. Determine the efficiency and regulation of a 3phase, 100 Km, 50 Hz transmission line delivering 20 MW at a power factor of 0.8 lagging and 66 kV to a balanced load. The conductors are of copper, each having resistance 0.1 Ω / Km, 1.5 cm outside dia, spaced equilaterally 2 meters between centres. Use nominal T method.
4. A three phase 5 km long transmission line, having resistance of 0.5 Ω / km and inductance of 1.76 mH / km is delivering power at 0.8 pf lagging. The receiving end voltage is 32kV. If the supply end voltage is 33 kV, 50 Hz, find line current, regulation and efficiency of the transmission line.
5. In a 3-unit insulator, the joint to tower capacitance is 20 % of the capacitance of each unit. By how much should the capacitance of the lowest unit be increased to get a string efficiency of 90 %. The remaining two units are left unchanged.
6. A single core 66 kV cable working on 3-phase system has a conductor diameter of 2cm and sheath of inside diameter 5.3 cm. If two inner sheaths are introduced in such a way that the stress varies between the same maximum and minimum in the three layers find: a) position of inner sheaths b) voltage on the linear sheaths c) maximum and minimum stress.
7. A 3 phase overhead transmission line is being supported by three disc insulators. The potential across top unit (i.e. near the tower) and the middle unit are 8 kV and 11 kV respectively. Calculate, a) The ratio of capacitance between pin and earth to the self capacitance of each unit b) Line Voltage c) String Efficiency

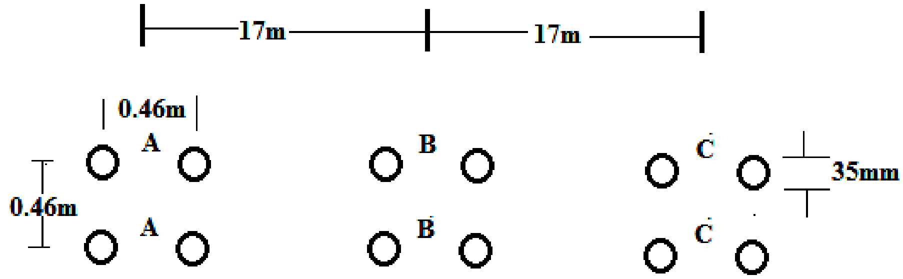
8. A conductor of 1cm diameter passes centrally through porcelain cylinder of internal diameter 2 cms and external diameter 7cms. The cylinder is surrounded by a tightly fitting metal sheath. The permittivity of porcelain is 5 and the peak voltage gradient in air must not exceed 34 kV / cm. Determine the maximum safe working voltage.
9. Calculate the most economical diameter of a single core cable to be used on 132 kV, 3 phase system. Find also the overall diameter of the insulation, if the peak permissible stress does not exceed 60 kV / cm. also derive the formula used here.
10. A string of 4 insulator units has a self capacitance equal to 4 times the pin to earth capacitance. Calculate a) Voltage distribution as a % of total voltage b) String efficiency
11. With a neat diagram, explain the strain and stay insulators. A cable is graded with three dielectrics of permittivity 4, 3 and 2. The maximum permissible potential gradient for all dielectrics is same and equal to 30 kV/cm. The core diameter is 1.5cm and sheath diameter is 5.5 cm. Determine the working voltage.
12. The towers of height 30m and 90m respectively support a transmission line conductor at water crossing. The horizontal distance between the towers is 500m. If the tension in the conductor is 1600kg, find the minimum clearance of the conductor and water and clearance mid-way between the supports. Weight of conductor is 1.5 kg/m. Bases of the towers can be considered to be at water level.
13. An overhead line has a span of 336m. The line is supported at a water crossing from two towers whose heights are 33.6m and 29m above water level. The weight of conductor is 8.33N/m and tension in the conductor is not to exceed $3.34*10^4$N.Find 1) Clearance between lowest point on conductor and water 2) Horizontal distance of this point from lower support.
14. A three phase, 220kV, 50 Hz transmission line consists of 1.5cm radius conductor spaced 2 meters apart in equilateral triangular formation. If the temperature is 40^0C and atmospheric pressure is 76cm, calculate the corona loss per km of the line. Take $m_{o=}$ 0.85.

ASSIGNMENT NO: I –QUESTIONS

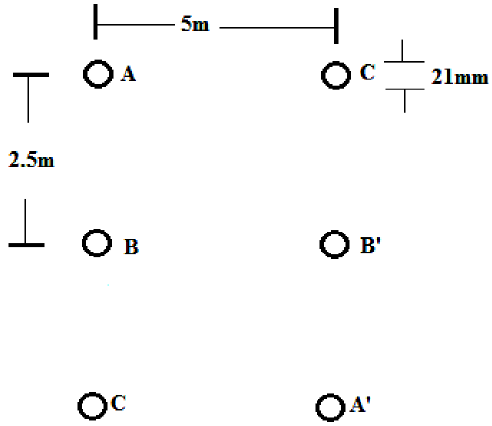
1. A single phase lie has two conductors separated by a distance of 3m. Each conductor has a diameter of 25mm. If the line operates at 10kV, 50Hz, calculate
   (a) Loop inductance/km
   (b) Line capacitance
   (c) Capacitive shunt reactance
   (d) Charging current/km
   (e) Reactive volt amps generated/km
2. A 3phase 110kV, 50Hz transmission line has its conductors arranged in a horizontal plane with 3.5m between middle conductor and each outside conductor. Each conductor has a diameter of 17.8mm. The line is completely transposed. Determine ,
   (a) The inductive reactance/phase/km
   (b) The capacitive reactance to neutral/km
   (c) The charging current/km
   (d) The reactive power/km
3. Figure shows a twin-conductor circuit of a 3phase line with horizontal spacing. The radius of each sub conductor is 10mm. The spacing between sub conductors is 0.5m. If each phase group shares the total current and charge equally and the line adequately transposed, determine
   (a) The line inductance/km
   (b) The line capacitance/km
   (c) The line inductance of the equivalent single conductor system.
   (d) The line capacitance of the equivalent single conductor system.
   (e) The percentage decrease in the inductance due to building.
   (f) The percentage decrease in the capacitance due to building.
   Assume that the area of cross-section of each single conductor is equal to the total area of two sub conductors of a phase.



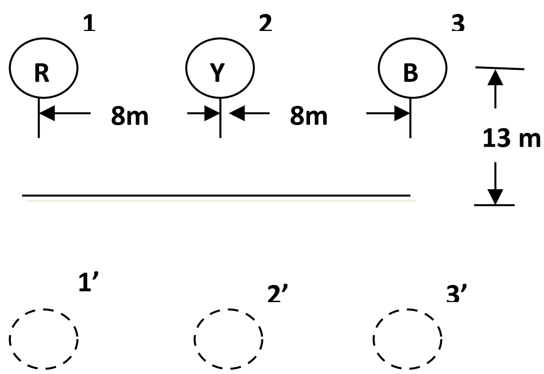
4. A 750kV line has a quadruple-conductor circuit of a 3phase line with horizontal spacing as shown in the figure.
   (a) Calculate the inductive reactance/phase/km at 50 Hz. Each conductor carries 25% of the phase currents and the line is properly transposed.
   (b) Find the size of a hypothetical single conductor line that would have the same inductance as the given line.
   (c) If the line charge/phase divides equally between four sub conductors determine the shunt capacitance/phase of the line.



5. The figure shows a double circuit 3phase overhead line. If the supply currents and charges are equally divided, calculate the effective inductance and effective capacitance of each phase. The phase sequence is A-B-C and diameter of each conductor is 21mm.



6. Find the capacitance per km per phase to neutral of a 3-phase line arranged as shown in Fig. The outside dia of ACSR conductors is 2.60 cm. The line is transposed. Take the effect of ground into account.



ASSIGNMENT NO: II–QUESTIONS

1. Explain with necessary sketches and derivations explain different methods of grading the cables. Also explain briefly the thermal characteristics of cables and power factor in cables.

2. A three phase, 220kV, 50 Hz transmission line consists of 1.5cm radius conductor spaced 2 meters apart in equilateral triangular formation. If the temperature is 40^0C and atmospheric pressure is 76cm, calculate the corona loss per km of the line. Take $m_{o=}$ 0.85.

3. A single core lead sheath is grounded by using three dielectrics of relative permitivitty 5,4 and 3 respectively.The conductor diameter is 2 cm and overall diameter is 8 cm If the three dielectrics are worked at the same maximum stress of 40 kV/cm, find. the safe working voltage of the cable.

4. A single core 66 kV cable working on 3-phase system has a conductor diameter of 2cm and sheath of inside diameter 5.3 cm. If two inner sheaths are introduced in such a way that the stress varies between the same maximum and minimum in the three layers find: a) position of inner sheaths b) voltage on the inner sheaths c) maximum and minimum stress.

5. A 33kV, 3 phase UG cable 4 km long uses singleCore. Each of conductor has a diameter of 2.54 cm and ideal thickness of insulation is 0.5cm determinea) capacitance of cable/phase b) charging current/ph.

EE 010 702 SYNCHRONOUS MACHINES

COURSE INFORMATION SHEET (2016-17)

PROGRAMME: **Electrical & Electronics Engg.**	DEGREE: **BTECH**
COURSE: **Synchronous Machines**	SEMESTER:**7** CREDITS: **4**
COURSE CODE: **EE010 702** REGULATION: **UG**	COURSE TYPE: **Core**
COURSE AREA/DOMAIN: **Electrical & Electronics Engg.**	CONTACT HOURS: **4+1** (Tutorial) hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): **EE 010 806**	LAB COURSE NAME: **Electrical Machines Lab II**

SYLLABUS:

UNIT	DETAILS	HOURS
I	**Synchronous Machines:** Types – selection of alternators – constructional features of cylindrical and salient pole machines. **Armature windings:** different types – phase grouping – single and double layer, integral and fractional slot winding – emf equation – distribution factor – coil span factor – tooth harmonic ripples – skewed slots – harmonics, elimination of	9

	harmonics – revolving magnetic field.	
II	**Armature Reaction** – Synchronous reactance – circuit model of synchronous machine. Regulation – predetermination – emf, mmf and Potier methods, saturated synchronous reactance – Phasor diagrams – short circuit ratio – two-reaction theory – Phasor diagram – slip test – measurement of X_d, X_q, losses and efficiency of synchronous machines.	15
III	**Parallel operation of alternators** – load sharing – synchronizing power and torque – governor characteristics – method of synchronizing – synchroscope. **Synchronous Motor:** Principles of operation – torque and power relationships – Phasor diagram, hunting in synchronous machines – damper winding – starting of synchronous motors.	14
IV	**Synchronous machines connected to infinite bus** – power angle characteristics of cylindrical rotor and salient pole machines – reluctance power – steady state stability limit – V-curves – inverted V-curves – O-curves – synchronous condenser. **Symmetrical short circuit of unloaded alternators** – steady state, transient and sub-transient reactance – current variation during short circuit.	11
V	**Excitation systems:** different types – comparison – exciter ceiling voltage – excitation limits – exciter response – methods of increasing the response of an exciter. **Brushless Alternators:** Principle of operation - constructional features – excitation methods – voltage regulation.	3
	TOTAL HOURS	52

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T	Electrical Machines: P. S. Bhimbra, Khanna Publishers, New Delhi
R	The performance and Design of AC Machines: M.G. Say, CBS Publishers
R	Theory of Alternating Current Machinery: Alexander Langsdorf, Tata Mgraw Hill
R	A course in Electrical Engineering. Vol.2: C.L. Dawes, McGraw- Hill Book Company inc.
R	Power System Stability – Vol. 3: Edward W. Kimbark, IEEE Computer Society Press
R	Electric Machines: D. P. Kothari & I. J. Nagrath, Tata McGraw Hill
R	Chapman S J, Electrical Machine Fundamentals, Mc Graw Hill
R	Theory and performance of Electrical Machines: J.B Gupta, S. K. Kataria & Sons

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EN 010 108	Basic Electrical Engineering	Basics of Electrical Engineering	1 &2
EE 010 402	DC Machines and Transformers	Fundamentals of DC Machines and Static AC Machines	4
EE 010 602	Induction Machines	Fundamentals of AC Machines – Induction Machines	6

COURSE OBJECTIVES:

1	To impart knowledge on • Construction and performance of Salient and Non – salient type Synchronous Machines.

2	To impart knowledge on • Principle of operation and performance of Synchronous Motors.

COURSE OUTCOMES:

Sl. NO:	DESCRIPTION	Blooms' Taxonomy Level
1	Students will be able to **differentiate** the different types of Synchronous machines and types of AC armature windings.	**Comprehension [level 2]**
2	Students will be able to **demonstrate** knowledge on importance of Voltage regulation of Alternators and how to pre-determine the voltage regulation of both Non-Salient and Salient pole machines in laboratory.	**Synthesis [Level 5]**
3	Students will be able to **acquire knowledge** on how Alternators can be paralleled to Infinite bus and how loads can be shared.	**Knowledge [Level 1]**
4	Students will be able to **understand** all about Synchronous Motors and applications of various starting methods.	**Application [Level 3]**
5	Students shall be able to **appreciate and analyse** the different excitation schemes for Synchronous machines and various methods for increasing the response of an exciter.	**Analysis [Level 4]**

MAPPING COURSE OUTCOMES (COs) – PROGRAM OUTCOMES (POs) AND COURSE OUTCOMES (COs) – PROGRAM SPECIFIC OUTCOMES (PSOs)

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
C 702.1	**2**	**2**	**2**							**3**	**2**	**1**	**2**		
C 702. 2	**2**	**2**	**2**	**2**									**3**		
C 702. 3					**1**						**2**	**1**	**2**		
C 702. 4	**2**		**1**		**1**							**1**	**2**		
C 702. 5	**2**				**1**			**1**					**2**		**2**
EE 702	**2**	**1**	**1**	**1**	**1**			**1**		**1**	**1**	**1**	**3**		**1**

JUSTIFATIONS FOR CO-PO MAPPING

Mapping	**L/H/M**	**Justification**
C702.1-PO1	M	Students will be able to apply the knowledge of mathematics, science, Engineering fundamentals while studying different types of Synchronous machines and types of AC armature windings.
C702.1-PO2	M	Students will be able to analyze complex engineering problems using first principles of mathematics, natural sciences, and Engineering sciences.
C702.1-PO3	M	Students will acquire knowledge on the design solutions for complex Engineering problems and design system of Alternators that meet the specified needs with appropriate consideration for the safety and

		environmental considerations.
C702.1-PO10	H	Students will be able to make effective presentation on the given topic.
C702.1-PO11	M	Students will get an initiation on the study and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi disciplinary environments.
C702.1-PO12	L	Students will get an initiation to recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.
C702.2-PO1	M	Students will be able apply the knowledge of mathematics for the solution of issues related to voltage regulation and losses.
C702.2-PO2	M	Students will be able to analyze complex problems related to losses and efficiency.
C702.2-PO3	M	Students will acquire knowledge on the design solutions for complex Engineering problems related to parallel operation of Alternators that meet the specified needs with appropriate consideration for safety and environmental considerations.
C702.2-PO4	M	Students will be able to analyze and interpret data in the area of voltage regulation of both Non-Salient and Salient pole Alterntors.
C702.3-PO5	L	Students will be able to select, and apply appropriate techniques and modern engineering and IT tools for the paralleling operation of Alternators to infinite bus.
C702.3-PO11	M	Students will be able to demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage any issues related to load sharing.
C702.3-PO12	L	Students will be able to recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.
C702.4-PO1	M	Students will be able to apply the knowledge of mathematics, science, Engineering fundamentals while studying different types of Synchronous Motors and different types of starting methods.
C702.4-PO3	L	Student will acquire knowledge on the design solutions for complex Engineering problems and design system of Synchronous Motors that meet the specified needs with appropriate consideration for the safety and environmental considerations.
C702.4-PO5	L	Student will be able to select and apply appropriate techniques and modern engineering and IT tools for the starting operation of Synchronous Motors.
C702.4-PO12	L	Student will be able to recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change in starting methods of Synchronous Motors.
C702.5-PO1	M	Students will be able to apply the knowledge of mathematics, science, Engineering fundamentals while studying different types of excitation schemes for Alternators.
C702.5-PO5	L	Student will be able to select and apply appropriate techniques and modern engineering and IT tools for the excitation of Synchronous Generators.
C702.5-PO8	L	Students will be able to apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

Sl. NO:	DESCRIPTION	PROPOSED ACTIONS
1	Operating limit on Synchronous Machines not included	Students are encouraged to refer standard books, manufacturer's catalogues etc.

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL Etc.

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

1	Saturated Synchronous reactance method of Voltage regulation

WEB SOURCE REFERENCES:

1	http://nptel.iitm.ac.in/courses/IIT-MADRAS/Electrical_Machines_II July 2012
2	http://ocw.mit.edu/index.htm
3	http://www.vlab.co.in

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	
☑ LCD/SMART BOARDS	☑ STUD. SEMINARS	☐ ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☑ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared &
Ms. Jayasri R. Nair

Approved by
Ms. Santhi B.
HOD

COURSE PLAN

	Module I	Sub topics	Hours
1	10/07/2017	Synchronous Machine: Introduction, Types, Rotating Field & Rotating Armature types	1
2	12/072017	Selection of alternators, Constructional features of Cylindrical and Salient pole machines	2
3	13/07/2017	Voltage generation, Expression for frequency, Armature winding - Terms upto Electrical Degree	3
4	14/07/2017	Armature winding – Terms – phase grouping – Single and Double layer, Integral and Fractional slot winding, Coil span factor	4
5	14/07/2017	Distribution factor, Tutorials	5
6	19/07/2017	Winding factor, Armature winding. Features. Lap & Wave winding	6
7	20/07/2017	General principles governing a.c. armature winding, e.m.f equation &. Tutorials.	7
8	21/07/2017	Harmonics in e.m.f wave, design measures.	8
9	21/07/2017	Tooth harmonic ripples – skewed slots, Revolving magnetic field	9

	Module II	Sub topics	Hours
1	26/07/2017	Alternator on no- load, Alternator on load	10
2	27/07/2017	Armature Reaction - upf, lag & lead	11
3	28/07/2017	Synchronous reactance – circuit model of synchronous machine no load, on load, phasor diagram.	12
4	28/07/2017	Load characteristics, Voltage Regulation, Regulation Characteristics – direct method.	13
5	02/08/2017	Indirect test - predetermination – e.m.f. method	14
6	03/08/2017	Tutorials on e.m.f. method	15
7	04/08/2017	Predetermination of regulation – m.m.f.- analytical method & tutorials.	16
8	04/08/2017	Predetermination of regulation – m.m.f. graphical method & tutorials.	17
9	09/08/2017	Predetermination of regulation – Potier method & phasor diagram.	18

10	10/08/2017	Predetermination of regulation – Potier method, zpf curve, other loads & Tutorials on Potier method.	19
11	11/08/2017	Slip test – measurement of X_d, X_q	20
12	11/08/2017	Two-reaction theory	21
13	16/08/2017	Phasor diagram, Tutorials on Slip test, pu system	22
14	17/08/2017	Saturated synchronous reactance & short circuit ratio	23
15	18/08/2017	Losses and efficiency of synchronous machines & Tutorials	24

	Module V	**Sub topics**	**Hours**
1	18/08/2017	Excitation systems: different types – comparison. Exciter ceiling voltage – excitation limits – exciter response	25
2	19/08/2017	Methods of increasing the response of an exciter. Brushless Alternators: Principle of operation, constructional features	26
3	19/08/2017	Excitation methods – Voltage regulation	27

	Module III	**Sub topics**	**Hours**
1	23/08/2017	Parallel operation of Alternators, Methods for synchronization – three dark lamp method	28
2	24/08/2017	Methods for synchronization – two dark & one bright lamp method, Synchroscope	29
3	25/08/2017	Synchronizing current	30
4	25/08/2017	Synchronizing power and torque, Prime mover input - effect	31
5	13/09/2017	Change in excitation in load sharing, Governor characteristics, - Expression for load sharing. tutorials	32
6	14/09/2017	Tutorials on Synchronous Generators.	33
7	20/09/2017	Synchronous Motor: Introduction & Principles of operation	34
8	22/09/2017	Starting of Synchronous motors – using SCIM, Pilot exciter.	35
9	22/09/2017	Starting of Synchronous motors – using damper winding, Hunting in Synchronous machines.	36
10	27/09/2017	Motor on load- Constant excitation, N-T characteristics, Equivalent circuit	37
11	28/09/2017	Phasor diagrams – Cylindrical Motor, Expression for Power & torque	38

12	04/10/2017	Expression for Power P_m, $(P_m)_{max}$	39
13	05/10/2017	Tutorials for Power P_m, $(P_m)_{max}$	40
14	06/10/2017	Tutorials on Synchronous Motor	41

	Module IV	**Sub topics**	**Hours**
1	06/10/2017	Synchronous machines connected to infinite bus, Power angle characteristics of cylindrical rotor, Reluctance power	42
2	07/10/2017	V-curves – inverted V-curves - Alternator	43
3	07/10/2017	Effect of change in driving torque -Alternator.	44
4	11/10/2017	V-curves & inverted V curves – Synchronous Motor	45
5	12/10/2017	Synchronous condenser	46
6	13/10/2017	Tutorials & Symmetrical short circuit of unloaded Alternators	47
7	13/10/2017	O-curves – Constant power varying excitation	48
8	19/10/2017	O-curves – Constant excitation varying power	49
9	20/10/2017	Synchronous condenser, tutorials, Steady state stability	50
10	20/10/2017	Transients & Synchronizing power coefficients	51
11	20/10/2017	Current variation during short circuit & tutorials	52

1. The armature reaction effect in synchronous machines is modeled as an inductive reactance. Justify.
2. Explain the phenomenon of armature reaction in alternator for different load power factors.
3. Explain armature reaction effect in an alternator.
4. What is synchronous impedance of an alternator? Draw its variation with exciting current.
5. State and explain the variation of synchronous impedance with load for a synchronous machine.
6. Explain the effect of armature flux on main field flux when an alternator is operating at (i) Lagging p.f. (ii) Unity p.f. State the reason for accounting the effect of armature reaction as a fictitious reactance in calculations.
7. Explain the effect of armature reaction on the regulation of an alternator.
8. Explain the effect of armature reaction under u.p.f., lag and lead power factors of an alternator.
9. Explain the effect of power factor on generated voltage at (a) u.p.f. (b) lagging p.f. (c) leading p.f.
10. Explain the concept of synchronous reactance and its practical use.
11. Draw the phasor diagram of a loaded alternator at leading p.f.
12. Draw the phasor diagrams of an alternator at u.p.f, lag and lead load conditions.
13. Draw and explain the circuit model of synchronous machines.
14. Draw the equivalent circuit of a synchronous machine and explain the same.

15. What is meant by regulation of alternators? What are the reasons for voltage reduction?
16. What is meant by regulation of alternators? What are the various methods to pre-determine the regulation?
17. What is meant by regulation of alternators? Explain its practical significance.
18. Define voltage regulation of an alternator. Explain how it will vary with load current for various power factors.
19. Explain the various factors which may affect the regulation of an alternator.
20. When the load on the alternator is varied, how the terminal voltage is changed?
21. Define regulation of an alternator and explain the method for determining the voltage regulation by Synchronous impedance method.
22. Explain e.m.f method of finding voltage regulation of a 3 phase alternator. Why it is called as pessimistic method?
23. Give the reason for obtaining high value of voltage regulation in e.m.f. method.
24. Explain m.m.f method of finding voltage regulation of a 3 phase alternator. Why it is called as optimistic method?
25. What is meant by synchronous impedance of an alternator? How will you determine it?
26. What are the short comings of the cylindrical rotor theory for determining the regulation of an alternator? How are they overcome in the two reaction theory?
27. Suggest a method to obtain the regulation of a salient pole machine.
28. Explain the Potier method of pre-determining regulation of an alternator. Why is it considered to be more accurate than methods?
29. Explain e.m.f., m.m.f. and Potier methods of pre-determination of regulation of an alternator.
30. Explain the Potier triangle method of pre-determining regulation of an alternator. Explain clearly how the Potier triangle represents the armature reaction effect and leakage reactance effect.
31. Which are the different methods of finding the voltage regulation of an Alternator.
32. Explain the z.p.f. method for obtaining voltage regulation.
33. Explain the method of predetermining voltage regulation by z.p.f. method.
34. What is the advantage of determination of regulation by the Potier Method?
35. What is meant by regulation of alternators? Explain z.p.f method of finding it.
36. Explain the various factors, which may affect the regulation of an alternator. Draw its variation with exciting current.
37. Define voltage regulation of an alternator. Explain its significance.
38. Define regulation of an alternator and derive the equation for the same.
39. Obtain an expression for the regulation of salient pole alternator.
40. Explain the two-reaction theory of salient pole alternators. Explain the slip test.
41. State and explain the two-reaction concept. Is it applicable to non-salient pole machines?
42. Explain the construction of two reaction phasor diagram.
43. Draw and explain the phasor diagram of Salient pole alternator on the basis of two reaction theory.
44. Explain with phasor diagrams, the two reaction theory of synchronous machine.
45. Explain the slip test for finding X_d and X_q.
46. Describe the slip test method for finding X_d and X_q of Synchronous machines.
47. Explain the two reaction theory of salient pole alternator.
48. With neat circuit diagrams, explain the method to find X_d and X_q of a salient pole machine.
49. Explain how you will perform slip test on a synchronous generator.
50. With suitable diagrams, discuss the two reaction theory.
51. Explain the direct and quadrature axes reactances of synchronous machines. How these reactances can be determined?
52. What is meant by slip test? Explain.
53. Explain slip test for salient pole machine with neat diagrams.
54. Describe slip test in connection with an alternator.
55. Explain the term SCR deriving necessary equations.
56. Explain the meaning and significance of SCR.
57. Explain the losses and efficiency of Synchronous machines.
58. Define Voltage Regulation and what does that mean.

59. Why is the **d axis** reactance larger than **q axis** reactance in a salient pole machine?

RAJAGIRI SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS

EE010 702 SYNCHRONOUS MACHINES (MODULE – II)

TUTORIAL PROBLEMS

1. The magnetization curve of a 400V, 50Hz, star connected non-salient pole alternator is given by the following data.

I_F (A):	2.0	2.5	3.0	3.5	4.0	4.5	5.0
OC Volt (V):	266	344	377	422	450	481	505

The rated current of 100A is obtained on short circuit by a field current of 2A. Calculate the full load regulation at 0.8 p.f lagging. Neglect armature resistance. Use synchronous impedance method.

2. A 3.3kV alternator gave the following test results.

I_F (A):	16	25	37.5	50	70
OC Volt (kV):	1.55	2.45	3.3	3.75	4.15

A field current of 18A is found to cause the FL current to flow through the winding during short circuit. Pre-determine the FL voltage regulation at 0.8p.f lag and lead by m.m.f method.

3. A 3 phase Y connected, 1000kVA, 2000V, 50Hz alternator gave the following test results.

I_F (A):	10	20	30	40	50
OC Volt (V):	800	1500	2000	2350	2600
SC (A)	-	200	300	-	-

The effective armature resistance is 0.4Ω. Estimate the FL voltage regulation at 0.8p.f lag and lead by (i) emf method (ii) ampere-turn method.

4. The no-load excitation of a non-salient pole alternator required to give rated voltage is 90A. In a short circuit test, with full load current flowing in the armature, the field excitation was 70A. Determine the excitation that will be required to give full load current at 0.8 p.f lag at rated voltage.

5. From the following test results, determine the voltage regulation of a 2000V, **1φ** alternator delivering a load current of 100A, at 0.8p.f leading. Test results: An excitation of 2.5A produces a current of 100A in the stator winding on short circuit and an e.m.f of 500V on open circuit. Assume R_a=0.8Ω.

6. A 1000kVA, 11kV, 3 phase Y connected alternator has an effective resistance of 2 Ω per phase. The OCC and z.p.f lag characteristics for FL current are given below. Pre-determine the FL voltage regulation at 0.8p.f lag by z.p.f method.

I_F (A):	20	25	55	70	90
OC Volt (kV):	5.8	7	12.5	13.75	15
V (kV) for zpf:	0	1.5	8.5	10.5	12.5

7. A 3 phase Y connected, 1500kVA, 6.6kV, 50Hz alternator has synchronous impedance of (0.4+j6) Ω per phase. It supplies rated current at 0.8 pf lag and normal rated voltage. Estimate the terminal voltage for the same excitation and load current at 0.8p.f leading.

8. A 500V, 50kVA, 3 phase Y connected alternator has an effective resistance of 0.2 Ω per phase. A field current of 10A produces an armature current of 150A on SC and an e.m.f of 450V on OC. Calculate the voltage regulation at 85% load, 0.8 p.f lag.

9. A 3 phase Y connected, 1000kVA, 2kV, 50Hz alternator gave the following test results at normal speed.

I_F (A):	10	20	25	30	40
OC Volt (V):	800	1500	1760	2000	2350

With armature short circuited, it required a field current of 20A to circulate 200A. R_a=0.755 Ω per phase. Determine the FL voltage regulation at 0.8p.f lag, lead and u.p.f. Use (i) Optimistic (ii) Pessimistic method.

10. A 3 phase Y connected, 2000kVA, 6kV, 50Hz alternator gave the following test results at normal speed.

I_F (A) :	14	18	23	30	43
OC Volt (V) :	4000	5000	6000	7000	8000

With armature short circuited, it required a field current of 16A to circulate FL current. **R_a=1.5Ω across 2 terminals**. Determine the FL voltage regulation at 0.8p.f lag, lead and u.p.f.

11. A 3 phase Y connected, alternator required a field current of 4A to give an OC voltage of 415V. A field current of 3A gives a current of 100A in the armature on SC. Find the field current when the machine supplies a load of 415V, 80A at a lagging p.f of 0.8. Assume both OCC and SCC to be linear through the origin. R_a=0.2Ω per phase.

12. A 5000kVA, 6.6kV, 3 phase Y connected alternator has an effective resistance of 0.075 Ω per phase. Estimate by zpf method the regulation for a load of **500A** at p.f (i) unity (ii) 0.9 leading (iii) 0.71 lagging from the following OCC and zpf FL curves.

I_F (A):	32	50	75	100	140
OC Volt (kV):	3100	4900	6600	7500	8300
V (kV) for zpf:	0	1850	4250	5800	7000

13. A 3 phase Y connected, 6kV, 50Hz alternator gave the following test results at normal speed.

I_F (A) :	14	18	23	30	43
OC Volt (V) :	4000	5000	6000	7000	8000

With armature short circuited, it required a field current of 17 A to circulate FL current and when the m/c is supplying FL 2000kVA at zpf, the field current is 42.5A at rated terminal voltage of 6000V. Determine the FL regulation at u.p.f & 0.8p.f lag.

14. The slip test was performed on a 3 phase, 415V star connected syn. m/c. The armature fluctuates between 4.5A and 7A and the fluctuation in the voltmeter connected across the lines is between 87V and 98V. Estimate the direct axis and quadrature axis reactances. R_a=0.8Ω

15. A 100kVA, 6.6kV, Y connected 3 phase salient pole alternator with X_d=22Ω and X_q=12Ω deliver FL at u.p.f. Calculate the excitation e.m.f.

16. A 3 phase Y connected alternator supplies a current of 10A having phase angle 20^0 lagging at 400V. Find the load angle and components I_d and I_q if X_d =10Ω and X_q=6.5 Ω. Neglect R_a.

17. A 5kVA, 220V, 3 phase Y connected salient pole alternator with X_d=12Ω and X_q=7Ω deliver FL at u.p.f. Calculate the excitation e.m.f. Neglect R_a.

18. A salient pole syn. generator has the following pu parameters. X_d=1.1pu and X_q=0.7pu, R_a=0.04pu. Calculate the excitation e.m.f in pu when the generator delivers rated kVA at 0.8p.f lagging and at rated terminal voltage. Also find the voltage regulation.

19. A 3 phase 1500 rpm, 50Hz alternator has X_d=0.7pu and X_q=0.4pu. For FL and 0.8p.f lag, obtain load angle and no-load pu voltage.

20. A salient pole syn. generator has X_d=1.2pu and X_q=0.8pu and R_a=0.03pu. Calculate percentage voltage regulation on FL and at a p.f. of 0.8 lagging.

21. A 50Hz, 3 phase, 480V delta connected salient pole alternator has X_d=0.1Ω and X_q=0.075Ω. The generator is supplying 1200A at 0.8p.f lagging. Find the excitation e.m.f. Neglect R_a.

22. A 5000kVA, 2 pole, 50Hz alternator has a rated line voltage of 4160V. The open circuit characteristics is

I_f(A):	20	40	60	80	100	120	140	160	180	200
Line Voltage (V):	1250	2500	3650	4450	4950	5150	5300	5440	5530	5600

When the alternator terminals are short circuited, a field current of 84A is required to circulate full-load current. Use m.m.f. and e.m.f. method to find regulation at full load, rated voltage and power factors of (a) unity (b) 0.8 lagging. The alternator is star connected. Neglect armature resistance.

23. The open circuit characteristics of a 6 pole, 440V, 50Hz, 3 phase, star connected alternator is as under:

I_f(A):	2	4	6	7	8	10	12	14
E_0(V):	156	288	396	440	474	530	568	592

A field current of 7A is required to circulate full-load rated armature current of 40A under short circuit conditions. The field current for rated terminal voltage under full-load zero power conditions is 15A. The armature resistance is 0.2 ohms per phase. Find regulation at full load current of 40A at 0.8pf lagging power factor, using Potier method.

24. The open circuit, short circuit and FL zero p.f. tests on a 6 pole 440V, 50 Hz 3 phase Y connected alternator is shown below:

I_f(A):	2	4	6	7	8	10	12	14	16	18
E_0(V):	156	288	396	440	474	530	568	592	-	-
SC line current (A)	11	22	34	40	46	57	69	80	-	-
ZPF terminal Voltage (V)	-	-	-	0	80	206	314	398	460	504

Find the regulation at Full load at 40A at rated voltage and 0.8 p.f. lagging by ZPF method. The effective resistance between any two terminals is 0.3 Ω.

25. A 10 kVA, 380 V, 50 Hz, 3 phase, Y connected Salient pole alternator has direct and quadrature axis reactances of 12 Ω and 8 Ω respectively. The armature has a resistance of 1 Ω per phase. The generator delivers rated load at 0.8 p.f. lag, with terminal voltage being maintained at rated value. If the load angle is 16.15^0, determine the direct axis and quadrature axis component of armature current and excitation voltage.

26. A Salient pole synchronous machine with 4 pole ac winding is charged coupled to a prime mover and excited with a current of 50 Hz frequency. The rotor winding is open. The per phase voltage and current for a phase of machine are 30 V, 25 V, 10 A and 6.5 A. Find X_d and X_q.

27. A 1500 kVA, 6600 V, 3 phase Y connected alternator with a resistance of 0.4 Ω and a reactance of 6 Ω per phase, delivers FL current at 0.8 p.f. lagging, and at normal rated voltage. Estimate the terminal voltage for the same excitation and load current at 0.8.f. leading.

28. A 100 kVA, 2300 V, delta connected polyphase alternator has an effective resistance per phase of 4 Ω and armature reactance per phase of 11 Ω. At rated load, find the generated voltage for (i) u.p.f. (ii) 0.8 leading p.f.

29. A 3 phase, Y connected alternator supplies a load of 10 MW at p.f. of 0.85 lagging and at 11 kV (terminal Voltage). Its resistance is 0.1 Ω per phase and Synchronous reactance 0.66 Ω per phase. Calculate the line value of generated e.m.f.

30. A 10 MVA, 3 phase Y connected 11kV, 2 pole tubo-alternator has a synchronous impedance of (0.0145+j0.05) ohms per phase. The various losses in the generator are as follows:

Open circuit core loss at 11000V = 90 kW

Windage and Friction loss = 50 kW

Short circuit load loss at 525A = 220 kW

Field Winding Resistance = 3 Ohm

Field Current = 175A

Ignoring the change in field current, compute the efficiency at (i) rated load 0.8 p.f. and (ii) half load at 0.9 p.f. lagging

31. A Salient pole synchronous machine with 4 pole a.c winding is charge coupled to a prime mover and excited with a current of 50Hz frequency. The rotor winding is open. The per phase voltage and current for a phase of machine are 30V, 25V, 10A and 6.5A. Calculate X_d and X_q.

32. A three phase, 50 Hz, 100kVA, 3000 V star connected alternator has armature resistance of 0.3 Ω per phase. A field current of 40A produces short circuit current of 200A and a line e.m.f. of 1050 V on open circuit. Calculate the full load voltage regulation at 0.8 p.f. leading and lag.

33. A 3 phase, star connected alternator supplies a current of 10A at a phase angle of 20^0 at 400V. The direct axis and quadrature axis reactance per phase are 10 Ω and 0.5 Ω. Find the components of armature current and voltage regulation neglecting armature resistance. Assume lagging p.f.

34. Following test results are obtained on a 6600 V alternator.

OC Voltage (V):	3100	4900	6600	7500	8300
Field Current (A):	16	25	37.5	50	70

A field current of 20 A is found necessary to circulate FL current on SC of the armature. Calculate % VR at FL, 0.8pf lag using (i) e.m.f. method (ii) m.m.f. method. Neglect armature resistance and leakage reactance. **Take necessary assumptions**.

(Additional Questions)

1. A three phase star connected alternator is rated at 1.6MVA, 13,500V. The armature effective resistance and synchronous reactance are 2 Ω and 30 Ω respectively per phase. Calculate the percentage voltage regulation for a load of 1.28 MW at 0.8 p.f. leading.
2. A 220V, 50 Hz, 6 pole, Y connected alternator with resistance 0.06 Ω per phase gave the following data for open circuit and Short circuit characteristics.

Find the percentage Voltage Regulation at ¾ th Full load, 0.8 p.f. lag. The Full Load current is 40A. Use e.m.f. method.

I_f (A)	0.2	0.4	0.6	0.8	1	1.2	1.4	1.8	2.2	2.6	3
OC (V)	29	58	87	116	146	172	194	232	261.5	284	300
SC (A)	6.6	13.2	20	26.5	32.4	40	46.3	59			

3. An alternator has a direct axis synchronous reactance of 0.8 p.u. and quadrature axis synchronous reactance 0f 0.5 p.u. Draw the phasor diagram for Full Load at lagging p.f. 0.8. Find the p.u. value of open circuit Voltage with full load excitation. Neglect armature resistance and saturation.

4. A 3.5MVA slow speed three phase Synchronous generator rated for 6.6kV has 32 poles. Its direct and quadrature synchronous reactance as measured by slip test are 9.6 Ω and 6 Ω respectively. Neglecting armature resistance, determine the Voltage regulation and excitation e.m.f. needed to maintain 6.6 kV at its terminals when supplying a load of 2.5 MW at 0.8 p.f. lag.

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

I_f (A)	0.2	0.4	0.6	0.8	1	1.2	1.4	1.8	2.2	2.6	3	3.4
OC (V)	29	58	87	116	146	172	194	232	261.5	284	300	310
ZPF test (V)	-	-	-	-	-	0	29	88	140	177	208	230
SC (A)	6.6	13.2	20	26.5	32.4	40	46.3	59				

Find the % voltage regulation at FL of 40 A at power factor of 0.8 lag by (i) m.m.f. method (ii) zpf method. R_a = 0.6 Ω/phase.

6. A 3 phase, 6000 V, star connected alternator has the following OCC at normal speed.

OC Voltage (V): 4000 5000 6000 7000 8000

Field Current (A): 14 18 23 30 43

With armature short circuited, it required a field current of 17 A to circulate FL current and when the m/c is supplying FL 2000kVA at zpf, the field current is 42.5A at rated terminal voltage of 6000V. Determine the field current required when the machine is supplying FL at 0.8 pf lagging.

7. A salient pole alternator has direct & quadrature axis reactances of 80% and 60% respectively. It is having a resistance of 10%. Determine its regulation if the generator delivers (i) FL at rated terminal voltage and 0.8 pf lagging (ii) 3/4th FL and 0.8 pf lagging.

8. A 3 phase star connected alternator is rated at 1600 kVA, 13500 V. The armature effective resistance and synchronous reactance are 1.5 Ω and 30 Ω respectively/ phase. Calculate the

percentage voltage regulation for a load of 1280 kW at power factors of (i) 0.8 leading (ii) 0.8 lagging (iii) unity.

9. A 0.5 MVA, 1.1 kV, 50 Hz, 3 phase Y connected alternator has armature resistance and synchronous reactance per phase as 0.1 Ω and 1.5 Ω respectively. Find the % Voltage regulation at different p.f's of (i) unity (ii) 0.9 pf lag (iii) 0.8 pf lead at FL.
10. A salient pole alternator has direct & quadrature axis reactances of 80% and 60% respectively. It is having a resistance of 10%. Determine its regulation if the generator delivers (i) FL at rated terminal voltage & 0.8pf lag (ii) ¾ FL & at 0.8 pf lag.
11. The magnetization curve of a 3 kVA, 400 V, 4.3 A, 1500 rpm 50 Hz, star connected non-salient pole alternator is given by the following data.

I_F (A):	0.64	0.70	0.76	0.82	0.9	1.08	1.18	1.32	1.52
OC (V):	256	277	294	180	312	371	388	409	433

A rated current of 4.3 A is obtained on short circuit by a field current of 0.8 A. Calculate the Full Load Voltage Regulation at 0.866 p.f lag, 0.866 p.f lead and u.p.f. Given armature resistance per phase as 1.85 Ω. Use pessimistic method.

1. With phasor diagrams and equations, explain the V and inverted V curves of a synchronous generator.
2. Explain the term reluctance power in synchronous machine.
3. With necessary equations, explain the power angle characteristics of a salient pole synchronous machine.
4. Briefly explain 'V' and Inverted 'V'curve.
5. Explain the 'V' curve of synchronous machine. How can you determine the 'V' curve experimentally?
6. What are V curves? Draw and explain the significance of the V curves.
7. Obtain the power angle characteristic of cylindrical and salient pole machine. What is meant by 'reluctance power'?
8. Explain the effect of change in excitation of a synchronous motor on its armature current.
9. Derive an expression for the output power in Cylindrical Rotor machine. Also draw the power angle curve.
10. Obtain the condition for maximum power output of a cylindrical rotor synchronous machine.
11. Obtain the power angle characteristics of a salient pole alternator.
12. Obtain the locus of generated voltage for constant power and variable excitation.
13. Explain an experimental set up to find the 'V' curves of a synchronous motor at constant input.
14. Obtain the locus of the induced e.m.f of an alternator connected to an infinite bus when the excitation is changed assuming constant input.
15. Derive the condition of maximum power developed of a synchronous generator connected to an infinite bus and operating at constant excitation.
16. What are the conditions on which power angle depend on?
17. Explain the origin of reluctance power in a salient pole machine.
18. What is meant by Reluctance power? Explain.
19. Draw and explain the power angle curve of round rotor and salient pole machines.
20. What is meant by Infinite Bus? Draw and explain the power angle characteristics of cylindrical and salient pole machine.
21. Explain V and inverted V-curves of a synchronous motor.
22. Explain with circuit diagram the experimental method to determine the V curve and inverted V curve of a synchronous motor. What is the effect of excitation?
23. Discuss with the aid of phasor diagrams the effect of change the excitation of alternator connected to infinite bus.
24. What is meant by reluctance power? Explain.
25. What is reluctance torque?
26. Derive an equation for reluctance power.

27. Discuss the effect of change of excitation on armature current and power factors for a synchronous motor.
28. Obtain the condition for maximum power output of a cylindrical rotor synchronous machine.
29. Explain O-Curve of a synchronous machine.
30. Differentiate between V curves and O curves.
31. Explain the construction on 'V' and 'O' curves.
32. What are 'V' and inverted 'V' curves? Explain.
33. Explain the construction and significance of 'O' curves.
34. Explain the construction of 'V', inverted 'V' and 'O' curves.
35. Explain the operation of a synchronous motor as a synchronous condenser.
36. What is a synchronous condenser? What are its applications?
37. What is a synchronous condenser? How is this condition achieved?
38. What is meant by synchronous condenser? Explain.
39. Briefly explain Synchronous Condenser.
40. Show that the use of a Synchronous Condenser improves the efficiency and regulation of a system.
41. Explain how a synchronous motor can be used to control the power factor.
42. Explain how a synchronous motor can be operated as a condenser.
43. With a diagram, explain the steady state stability limit of a synchronous machine.
44. Discuss the stability limit of Synchronous machines
45. Discuss in detail the steady state stability limit of a synchronous machine.
46. What is known as steady state stability limit of a synchronous machine? Discuss in detail.
47. Obtain the condition for maximum power output of a salient pole synchronous machine.
48. Derive an expression for the synchronizing power coefficient of a three-phase, salient pole synchronous generator working with constant excitation and show it is stiffer than a cylindrical rotor machine.
49. Explain synchronous power and synchronizing torque torque coefficient and their significance.
50. Explain synchronizing power and torque.
51. Explain the behavior of an unloaded alternator on a symmetrical short circuit. Explain the transient and sub-transient reactances.
52. Describe the operation of an unloaded alternator on a symmetrical short circuit.
53. Explain the current variations in synchronous machine during short circuit.
54. Give a plot of current variations in synchronous machine during short circuit.
55. Draw the waveform of armature current of an alternator on short circuit. Define the different reactances.
56. Explain the term steady-state, transient and sub-transient reactances of a synchronous machine. Explain how the current varies during, a short circuit.
57. Explain the transient, sub-transient and synchronous reactances of an alternator on sudden short circuit. Mention all the assumptions clearly.
58. What are transient and sub-transient reactances? Explain.
59. Explain different reactances of a synchronous machine.
60. Discuss the transient conditions of operation of Alternators.
61. Explain the symmetrical short circuit of alternator during transient and sub-transient periods with relevant waveforms.
62. Explain the steady state limit. How can it be improved for Synchronous Machines?
63. What is an Infinite bus?
64. A synchronous generator operates on constant voltage constant frequency busbars. Show that the maximum power that a synchronous generator can supply with the increase in excitation.

EE 010 702 SYNCHRONOUS MACHINES (MODULE – IV) TUTORIALS

1. A11kV, 3 phase star connected turbo alternator delivers 200A at u.p.f. when running on constant voltage and constant frequency bus-bars. If the induced e.m.f. be raised by 25%, find the current and the p.f. at which the machine now works. Assume a constant steam supply and an unchanged efficiency. R_a = .5 Ω/ phase and X_s = 8 Ω/ phase.
2. A 3-phase synchronous generator having a synchronous impedance of (0.8+j10) Ω per phase delivers 200A at 0.8 p.f. lagging to 11kV, constant frequency bus bars. If the excitation is unchanged and prime mover input is increased to increase the real power delivered by 25%, find the new value of current and p.f.
3. A 3-phase star connected alternator is operating on 10 kV infinite bus. Its synchronous impedance is (0.4+j6) ohm per phase & it is delivering 300 A at 0.8 pf. lagging. If steam input to prime mover is kept constant, find the percentage change in the induced e.m.f to increase p.f. to unity. Ignore all losses.
4. An industrial plant has a load of 700kW at a p.f. of 0.7 lagging. It is desired to purchase a synchronous motor of sufficient capacity to deliver a load of 150kW and also to correct the p.f. of the plant 0.92. Assuming the synchronous motor has an efficiency of 0.93; determine its kVA input and p.f. at which it will operate.
5. A 440V, 50 Hz 3-phase circuit takes 18A at 0.8 p.f. lag. A synchronous motor is used to raise the p.f. to unity. Calculate the kVA input to the motor and its p.f. when driving a mechanical load of 6kW. Assume motor efficiency of 88%.
6. A 400V, 3 phase system supplies a 500kVA load at 0.5 p.f. lagging. A synchronous motor supplying a 100bhp mechanical load and operating at an efficiency of 0.9 is used to improve the p.f. of the system. If the synchronous motor is operating at a p.f. of 0.8 leading, find the overall p.f., total kW, total kVA.
7. A 1500kW, 3 phase, Y connected 3.3kV synchronous motor has reactances of X_d=5Ω and X_q=3 Ω per phase. All losses may be neglected. Calculate the excitation e.m.f. when the motor is supplying rated load at unity p.f. Also calculate the maximum mechanical power that the motor can supply with the excitation held fixed at this value.
8. A 1500kW, 3 phase, Y connected 3.3kV synchronous motor has reactances of X_d=4.01Ω and X_q=2.88Ω per phase. All losses may be neglected. Calculate the excitation e.m.f. when the motor is supplying rated load at unity p.f. Also calculate the maximum mechanical power that the motor can supply with the excitation held fixed at this value.
9. A 10MVA, 3 phase alternator has a reactance of 10Ω and a resistance of 1Ω and operates in parallel with constant voltage 10kV bus-bars. If the steam supply is gradually increased, calculate (i) the maximum external load that the machine can supply before drooping out of step when the machine is excited to give an e.m.f. of 11kV and (ii) the armature current and p.f. corresponding to this maximum load.
10. An 8 pole 50Hz, Y connected synchronous motor has reactances of 11Ω per phase. On no-load, both the excitation and terminal voltages are equal to 3.3kV. Neglect all losses. For a sudden disturbance in shaft torque, the rotor falls back in space by one mechanical degree. Calculate the synchronizing current, synchronizing power and synchronizing torque tending to restore the rotor to its previous position.
11. A 400 kVA, 6.6kV, 3 phase,1500 r.p.m., 50Hz alternator is running in parallel with infinite bus. Its synchronous reactance is 25%. For full load and 0.8 p.f. lag, calculate the synchronizing power and torque per mechanical angle of displacement.
12. A 750kVA, 11kV, 4 pole, 3 phase Y connected alternator has percentage resistance and reactance of 1 and 15 respectively. Calculate the synchronizing power per mechanical angle of displacement at no-load and full load 0.707 p.f. lag.
13. Two 10,000kVA synchronous generators are connected to 50Hz bus-bars having a constant voltage of 1.0 p.u. Generator A has an induced emf of 1.3 22.6 p.u. and reactance of 0.5 p.u. Generator B has an emf of 1.25 36.9 p.u. and a reactance of 0.75 p.u. Find the current, kW and kVAr supplied by each generator.
14. A 3 phase Synchronous motor absorbing 60kW is connected in parallel with a factory load of 240kW having a lagging power factor of 0.8. If the combined load has a p.f. of 0.9, what is the value of the leading kVAr supplied by the motor and its power factor.

15. A 1000kW, 3 phase, Y connected, 3.3kV, 24 pole, 50 Hz Synchronous Motor has a synchronous reactance of 3.24 Ω per phase, the resistance being negligible. The motor is fed from infinite bus bars at 3.3kV. Its field excitation is adjusted to result in unity p.f. operation at rated load. Compute the maximum power and torque that the motor can deliver with its excitation remaining constant at this value.
16. An alternator supplying 500kW at 0.6 p.f. lagging has its power factor raised to unity by means of an overexcited synchronous motor. At a constant armature current, how much input power is required for the synchronous motor? Find the power factor of the synchronous motor?
17. An alternator supplying 500kW at 0.7 p.f. lagging has its power factor raised to unity by means of an overexcited synchronous motor. At a constant armature current, how much input power is required for the synchronous motor? Find the power factor of the synchronous motor?
18. A 3 MVA, 6 pole alternator runs at 1000 r.p.m. on 3.3kV bus bars. The synchronous reactance is 25%. Calculate the synchronizing power and torque per mechanical degree of displacement when the alternator is supplying full load at 0.8 p.f.. lag.
19. A 400V, 3 phase, star connected Synchronous motor with X_d = 6 Ω and X_q = 4 Ω per phase is running in parallel with an infinite bus. Its field current is reduced to zero. Find its maximum reluctance power developed.
20. A 10kVA, 380V, 50 Hz, 3 phase, Y connected Salient pole alternator has direct and quadrature axis reactances of 12 Ω and 8 Ω respectively. The armature has a resistance of 1 Ω per phase. The generator delivers rated load at 0.8 p.f. lagging with terminal voltage maintained at rated value. If the load angle is 16.15^0, determine the direct axis and quadrature axis component of armature current and excitation voltage.
21. A 2000kVA, 3 phase Alternator runs at 750 rpm is parallel with other machines on 6000V bus-bars. Find the Synchronising power per mechanical degree of displacement and the corresponding synchronizing torque. The synchronous reactance is 6 ohms per phase.
22. A 2MVA, 3 phase, 8 pole alternator is connected to 6000V, 50 Hz busbars and has a synchronous reactance of 4 ohm per phase. Calculate the Synchronising power and Synchronising torque per mechanical degree of rotor displacement at no-load.
23. A 10MVA, 5 kV, 3 phase, 4 pole, 50Hz alternator is connected to Infinite bus. The short circuit current 3.5 times the normal FL current and the moment of inertia of the rotating system is 21,000 kg-m^2. Determine its normal speed of operation.
24. A 3 phase Y connected Synchronous Motor takes 48 kW at 693 V, p.f. being 0.8 lag. The induced e.m.f. is increased by 30%, the power taken remaining the same. Find the new current and p.f. The machine has synchronous reactance of 2 Ω /phase and negligible reactance.
25. Compare the different types of excitation systems.
26. Discuss the requirements of excitation system and what is exciter ceiling voltage?
27. Give a brief account of different excitation systems.
28. Explain the different excitation systems in Synchronous machines.
29. Explain the different excitation systems of Alternators.
30. Discuss the various excitation systems for Synchronous machines.
31. Explain and compare the various types of excitation systems.
32. Write a short note on Static excitation system for an alternator.
33. Explain the Static excitation methods used in Synchronous machines.
34. Distinguish between Static excitation and Brushless excitation.
35. Explain the excitation scheme in a large modern generator.
36. Explain the excitation scheme in a large modern water wheel generator.
37. Explain in detail the Brushless excitation of an alternator.
38. Give the methods of increasing the response of an exciter.
39. Which are the methods for increasing the response of an exciter?
40. What is exciter response?
41. Explain the excitation limits of Synchronous machines.
42. What do you mean by exciter ceiling voltage?

43. Describe the exciter ceiling voltage and excitation limits.
44. Explain the constructional features and principle of operation of Brushless alternators.
45. Explain the excitation of Brushless alternators.
46. Give the principle of operation of Brushless alternators.
47. Explain the construction, Principle of operation of Brushless alternators.
48. Describe the constructional features of Brushless alternators. Discuss their applications.
49. Describe the excitation methods and regulation of Brushless Alternators.
50. Draw a diagram and explain the automatic voltage regulation scheme in a modern turbo generator.

ASSIGNMENT1

SET A Class Assignment Test I Max. Marks: 15

(Answer any two from Questions 1-3. Tutorial 4 Compulsory)

1. What are the advantages of Stationary armature and rotating field in an alternator?
2. Explain briefly the constructional features of salient pole alternators.
3. Define Distribution factor and derive an expression for the same.
4. The stator of a 3 phase, 16 pole alternator has 144 slots and there are 4 conductors per slot connected in two layers and the conductors of each phase are connected in series. If the speed of the alternator is 375 rpm, calculate theemf generated per phase. Resultant flux in the air gap is $5x10^{-2}$ Webers / pole sinusoidally distributed. Assume coil span 150^{0}.

EE 010 702 SYNCHRONOUS MACHINES

S_7 EEE (2014 Admission)

SET B Class Assignment Test I Max. Marks: 15

(Answer any two from Questions 1-3. Tutorial 4 Compulsory)

1. Explain the methods for the elimination of harmonics in alternator.
2. Explain briefly the constructional features of non-salient pole alternators.
3. Derive an e.m.f equation for an alternator from fundamentals showing clearly the expression for pitch and distribution factors. Determine, there from, the ratio induced emf of nth harmonic to fundamentals.
4. A 4 pole, 3 phase, 50 Hz, Y connected alternator has 4 slots per pole per phase. There are 6 conductors per slot. The flux per pole is 51 m Wb. Calculate the phase and line voltages.

EE010703 DRIVES AND CONTROL

COURSE INFORMATION SHEET

PROGRAMME: **Electrical and Electronics Engineering**	DEGREE: **BTECH**
COURSE: **Drives and Control**	SEMESTER: **7** CREDITS: **3**
COURSE CODE: **EE010703** REGULATION:**UG**	COURSE TYPE:**Core**
COURSEAREA/DOMAIN: **Electrical and Electronics Engineering/Electrical Drives**	CONTACT HOURS: **2(Lecture)+2 (Tutorial) hours/Week.**
CORRESPONDING LAB COURSE CODE (IF ANY):NIL	LAB COURSE NAME:NIL

SYLLABUS:

UNIT	DETAILS	HOURS
I	Concept of Electric Drives –parts of electrical drives – dynamics of electric drive – torque equation –Four quadrant operation of electric drives– loads with rotational and translational motion – Steady state stability- components of load torques – nature and classification of loadtorques – load equalization. DC motor drive systems: Methods of speed control – single phase half wave controlled drive, half and fully controlled bridge rectifier drives-continuous and discontinuous conduction – speed torque characteristics-motoring and inverter modes of operation- commutation failure source side power factor	15
II	3 Phase fully controlled and half controlled bridge rectifier drives-motoring and inverter	10

	modes of operation. Dual converter fed DC motor drives. Chopper fed drives –single, two and four quadrant operation- motoring and regenerative breaking.	
III	Speed Control of three phase Induction motors**:** Stator voltage control – principle – controller configurations –speed reversal- operation and applications-VSI based induction motor drives – V/f control- Constant torque and constant power operation.	10
IV	Slip speed control: Slip power recovery scheme – principle – Static Kramer's drive – Static Scherbius' drive. CSI fed induction motor drives– operation under fixed frequency – operation under variable frequency – Dynamic and Regenerative Braking of CSI and VSI fed Drives. Basic principle of Vector control.	12
V	Speed control of synchronous motors : Adjustable frequency operation of synchronous motors – principles of synchronous motor control – Voltage Source Inverter Drive with open loop control – self controlled synchronous motor drive using load commutated thyristor inverter. Electric Traction: Important features of traction drives-Conventional DC and AC traction drives– DC & AC traction using PWM VSI SCIM drives	13
	TOTAL HOURS	60

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T	Fundamentals of Electrical Drives*,* G.K. Dubey, Narosa Publishing House, New Delhi, 2005
R	Fundamentals of Electric Drives*,* Mohammad A and E.L Sharkawi, Thomson Learning, 2005
T/R	*Electric Motor Drives – Modeling, Analysis and Control,*R.Krishnan, Prentice-Hall of India, 2003
T	Modern Power Electronics and A.C. Drives, B. K. Bose, PHI, 2002.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EE010504	Power Electronics	Basics of Power Electronics	5
EE 010 402	DC Machines and Transformers	Basics of DC Machines	4
EE010602	Induction Machines	Basics of Induction Machines	6

COURSE OBJECTIVES:

1	To understand different types of electrical drives and control
2	To provide sound knowledge in the control of DC drives, AC Drives , Electric Traction

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
1	Students will be able to **analyse** a drive being applied in 4 different quadrants	analyse [Level 4]
2	Students will be able to **apply** drives being used in real applications	apply [Level 3]
3	Students will be able to **understand** the various speed control techniques used in the control of the machine.	understand [Level 2]
4	Students will be able to to **understand** the concept for DC drive	understand [Level 2]
5	Students will be able to to **understand** the concept of speed control for AC drives	understand [Level 2]

MAPPING COURSE OUTCOMES (COs) – PROGRAM OUTCOMES (POs) AND COURSE OUTCOMES (COs) – PROGRAM SPECIFIC OUTCOMES (PSOs)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C 703.1	3	2				2							3		
C 703.2	3		2	2								2	3		
C 703.3	3	2		2						2		2	3		
C 703.4	3			1									3		
C 703.5	3			2								2	3		
EE 703	3	2	2	2		2				2		2	3		

JUSTIFICATIONS FOR CO-PO MAPPING

Mapping	L/H/M	Justification
C703.1-PO1	H	Students will be able apply the knowledge science & electrical engineering for analyzing the operation of drive in different quadrants.
C703.1-PO2	M	Students will be able to identify and provide solutions to complex problems associated operation of drive in different quadrants.
C703.1-PO6	M	Students will be able to apply the knowledge of quadrant operations deveop products like (hybrid electric vehicles) to assess the societal and safety issues
C703.2-PO1	H	Students will be able apply the knowledge science & electrical engineering to understand and apply suitable drives for various applications.
C703.2-PO3	M	Students will be able apply their ideas to develop applications with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
C703.2-PO4	M	Students will be able to use research based knowledge in real applications of drives.
C703.4-PO12	M	Students will be able to communicate effectively on complex engineering in area of application of drives with the engineering community
C703.3-PO1	H	Students will be able apply the knowledge science & electrical engineering to understand the control techniques of electrical machines
C703.3-PO2	M	Students will be able to identify and provide solutions to complex problems associated with speed control techniques.
C703.3-PO4	M	Students will be able to use research based knowledge to develop advanced speed control techniques.
C703.3-PO10	M	Students can communicate on complex engineering activities with the engineering community on speed control of machines
C703.3-PO12	M	Students will be able to communicate effectively on complex engineering in area of speed control techniques with the engineering community.
C703.4-PO1	H	Students will be able apply the knowledge science & electrical engineering to understand and relate various aspects of DC Drives.
C703.4-PO4	L	Students can get an exposure DC drives and build platform to perform interpretation of data, and synthesis the information.
C703.5-PO1	H	Students will be able apply the knowledge science & electrical engineering to understand and relate various aspects of AC Drives.

C703.5-PO4	L	Students can get an exposure AC drives and build platform to perform interpretation of data, and synthesis the information.
C703.5-PO12	M	Student will get an initiation to study advanced control techniques used in control of induction Motors

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

SNO	DESCRIPTION	PROPOSED ACTIONS
1	Students are not informed about the simulation of electrical drives using software tools	Bridge Course on MATLAB

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

1	Students shall be given basic briefing to actual drives at Drives Lab
2	Students can be introduced to the simulation using MATLAB

WEB SOURCE REFERENCES:

1	Video Lectures onElectric Drives and their Applications by Dr. S. Chatterji [Online] Available https://www.youtube.com/watch?v=SUCwqwBUOKM&t=6s
2	NPTL Lectures [Online Available] http://nptel.ac.in/courses/108102046/
3	NPTL vedio Lecture By Prof. K. Gopakumar , on Industrial Drives- Power Electronics [Online] Available http://nptel.ac.in/courses/108108077/

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑STUD. ASSIGNMENT	☑WEB RESOURCES	
☑ LCD/SMART BOARDS	☐ STUD. SEMINARS	☑ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES	☑ STUDENT FEEDBACK ON FACULTY
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY	☐ OTHERS

EXT. EXPERTS	

Prepared by **Approved by**

COURSE PLAN(2017)

Sl No	Date	Module	No of hours	Course Plan
1	10-Jul	1	1	Concept of Electric Drives
2	11-Jul		2	parts of electrical drives
3	12-Jul		3	parts of electrical drives
4	14-Jul		4	dynamics of electric drive
5	17-Jul		5	torque equation
6	18-Jul		6	Four quadrant operation of electric drives
7	19-Jul		7	loads with rotational and translational motion
8	20-Jul		8	Steady state stability -load equalization.
9	21-Jul		9	components of load torques
10	24-Jul		10	nature and classification of load torques
11	25-Jul		11	DC motor drive Methods of speed control
12	26-Jul		12	phase half wave controlled drive
13	27-Jul		13	half and fully controlled bridge rectifier drives
14	31-Jul		14	speed torque characteristics-motoring and inverter modes of operation
15	2-Aug		15	commutation failure source side power factor
16	4-Aug	2	1	3 phase half controlled bridge rectifier drives
17	7-Aug		2	3 phase half controlled bridge rectifier drives
18	8-Aug		3	Tutorials
19	9-Aug		4	3 Phase fully controlledbridge rectifier drives
20	11-Aug		5	3 Phase fully controlledbridge rectifier drives
21	14-Aug		6	Dual converter fed DC motor drives
22	15-Aug		7	Dual converter fed DC motor drives
23	16-Aug		8	. Chopper fed drives –single, two and four quadrant operation-
24	18-Aug		9	. Chopper fed drives –single, two and four quadrant operation-
25	21-Aug		10	Tutorials
26	22-Aug	3	1	speed control of three phase Induction motor-Stator voltage control
27	23-Aug		2	speed control of three phase Induction motor-Stator voltage control
28	24-Aug		3	speed control of three phase Induction motor-Stator voltage control
29	26-Aug		4	VSI based induction motor drives
30	27-Aug		5	VSI based induction motor drives
31	28-Aug		6	VSI based induction motor drives
32	11-Sep		7	Constant power operation
33	13-Sep		8	Constant torque operation
34	15-Sep		9	Simulation studies

35	18-Sep		10	Simulation studies
36	19-Sep	4	1	Slip speed control: Slip power recovery scheme - principle – Static Kramer's drive
37	20-Sep		2	Static Scherbius' drive
38	22-Sep		3	Static Scherbius' drive
39	25-Sep		4	CSI fed induction motor drives– operation under fixed frequency
40	26-Sep		5	CSI fed induction motor drives– operation under fixed frequency
41	27-Sep		6	CSI fed induction motor drives-operation under variable frequency
42	28-Sep		7	Dynamic Braking of CSI fed Drives
43	3-Oct		8	Regenerative Braking of CSI fed Drives
44	4-Oct		9	Dynamic Braking of VSI fed Drives
45	5-Oct		10	Regenerative Braking of VSI fed Drives
46	6-Oct		11	Vector control
47	7-Oct		12	Vector control
48	8-Oct		1	Speed control of synchronous motors : Adjustable frequency operation of synchronous motors
49	9-Oct	5	2	principles of synchronous motor control
50	10-Oct		3	Voltage Source Inverter Drive with open loop control
51	11-Oct		4	self controlled synchronous motor drive using load commutated thyristor inverter
52	12-Oct		5	self controlled synchronous motor drive using load commutated thyristor inverter
53	13-Oct		6	Electric traction-Introduction
54	14-Oct		7	Conventional DC and AC traction drives
55	15-Oct		8	Conventional DC and AC traction drives
56	16-Oct		9	DC & AC traction using PWM VSI SCIM drives
57	17-Oct		10	DC & AC traction using PWM VSI SCIM drives
58	18-Oct		11	Simulation studies
59	19-Oct		12	Simulation studies
60	20-Oct		13	Tutorials

Tutorials

Q1

A single phase half wave controlled convertor feeds a separately excited DC motor. The convertor is supplied from a 230V, 50Hz supply mains and the field flux is held constant. Armature resistance Ra = 0.6 Ω and motor constant = 0.5 V-sec/rad. The rated load torque is 20 Nm at 1000 rpm. Assume continuous and ripple free current. Determine,

1. A, the delay angle of convertor feeding the armature
2. RMS thyristor and freewheeling diode current
3. Input power factor of armature convertor

Q2

In a separately excited DC motor drive, a single-phase symmetrical semi-convertor with a freewheeling diode is used to feed the load. The speed of motor is 1500rpm. The motor armature has a resistance of 3 ohm and a back emf of 100V. The supply voltage is 230 V, 50Hz. If the load current is continuous and the thyristor-triggering angle is 40® find

a) the average output voltage across the load
b) the average armature current and
c) motor torque

Q3

The load connected to the output of a single-phase full convertor bridge consists of a DC motor load with armature resistance of 1 ohm. The supply voltage is 230 V, 50 Hz. The load current can be assumed to be continuous and ripple free with a magnitude 15 A. Compute the thyristor-triggering angle and the input power factor for (a) E_b = 100 V and (b) E_b = -100 V.

Q4

The armature and field circuit of a separately excited DC motor is fed through a single phase fully controlled convertor connected to a 300 V, 50 Hz single phase source. The field current is held constant at its rated value. The motor drives a rated load torque of 100Nm at 1000 rpm. The armature circuit resistance is 0.2 Ω. The motor constant is 1.2V-sec/rad. Assume that the inductance in the armature circuit is large so that the load current is continuous and free of ripples. Determine

a) Rated armature current
b) Firing angle of armature convertor and rated load

Q5

The input to a three phase semiconvertor is 400 V, 50 Hz. It feeds separately excited DC motor with armature resistance of 1 Ω and a motor constant of 2.5 Nm/A. The convertor triggering angle is 30®. Calculate the speed of the motor when the motor delivers a torque of 60 Nm.

Q6)

With Neat sketch draw the three phase half controlled Rectifier fed DC Drive. Identify the quadrant operation for this drive and justify the answer.

Q7)

With Neat sketch draw the three phase fully controlled Rectifier fed DC Drive. Identify the quadrant operation for this drive and justify the answer.

Q8)

With Neat sketch draw the three phase half controlled Rectifier fed DC Drive in CCM and DCM mode of operation.

Q9)

A separately excited DC motor develops a torque of 60 Nm at 1500 rpm. The armature resistance is 1 Ω. The motor constant is 2.4 V-sec/radians. It is fed through a three phase fully controlled rectifier the input to which is 400 V at 50 Hz. Determine the convertor firing angle.

Q10

A separately excited motor controlled by a D chopper is fed from 220V DC mains. The chopper has an ON time of 15msec and OFF time of 20 msec. Assuming continuous and ripple free motor current, calculate the average load current when the motor speed is 1500 rpm, given that the motor constant is 0.5 V-sec/radian and the armature resistance is 1Ω.

Q11

A step down chopper is fed from a 220V DC source. The chopping frequency is 250 Hz and the ON time of the chopper switch is 1.6 ms. Determine the duty ratio and the average value of the output voltage.

Q12

The chopping frequency of a DC Chopper is 2 KHz and the duty ratio is 60%. The source voltage is 36 V, DC. Determine the ON time and the OFF time of the switch and the average value of the output voltage.

Q13.

The DC source voltage of a chopper is 12 V. The average output voltage is 9.6 If the chopping frequency is 4Khz, find the width of the output pulse.

Q14

For a first quadrant step down chopper, the upper and the lower limits of load currents are 30A and 26A respectively. Assume that the load current is continuous and varies linearly. Determine the ripple current, average and rms values of the load current. If the load consists of a resistance 5Ω and a battery of 36V, find the power delivered to the load.

Q15

The supply voltage to a step down chopper is 220V, DC. The chopping frequency is 800Hz and the ON period of the chopper switch is 1ms. The load consists of a resistance of 10Ω and inductive reactance. The load current is continuos and varies linearly. The average value of the load current is 20A and the ripple current is 3A. Find out the maximum and minimum values of the load current, rms value of load current, the average value of the load voltage, average value of the chopper switch current and the freewheeling current.

Assignment Questions

Assignment No:1

1. Mention the advantages of Electrical Drives.
2. Write short notes on different types of electric drive (1. Group drive 2.Individual drive 3. Multi motor drive).
3. Derive the equivalent values of drive parameters for a load undergoing translational motion

4. Explain the methods for measurement of moment of inertia

Submission Date: 02/08/17

Assignment No:2

1. Explain any one of application of DC motor drive
2. Explain any one of application of Variable Speed Induction Motor Drive
3. Explain any one of application of Synchronous motor Drive

Submission Date: 16/10/17

EE 010 704 MODERN CONTROL THEORY

COURSE INFORMATION SHEET

PROGRAMME: **EEE**	DEGREE: **BTECH**
COURSE: **Modern Control Theory**	SEMESTER: **Seventh** CREDITS: **3**
COURSE CODE: **EE 010 704** REGULATION: **UG**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN:	CONTACT HOURS: **2+1 (Tutorial) hours/Week.**
CORRESPONDING LAB COURSE CODE (IF ANY): **EE 010 708**	LAB COURSE NAME: **Control & Simulation Lab**

SYLLABUS:

UNIT	DETAILS	HOURS
I	*Module 1 :*Design of modern control systems- Concept of Controllability and Observability, Kalman's and Gilbert's tests for controllability and observability. Pole placement design using state variable feed back. Observers- design of full order observer.	9
II	*Module 2:* Non-linear systems – Characteristics – Phase plane analysis – linearization and stability of equilibrium points – Iscoline method – limit cycles of phase plane – stability of limit cycles.	9
III	*Module 3*: Describing function method– Harmonic linearization, describing function of nonlinear systems(On-Off, saturation and dead-zone only)-Analysis of nonlinear systems using describing function. Limit cycles' amplitude and frequency – Stability of non-linear systems – Lyapunov's method for non-linear system – Popov's criterion.	9

IV	*Module 4:* Discrete time systems – Sampling theorem – sample and hold circuits and data reconstruction – Z- transforms – inverse Z transforms – pulse transfer function – state variables – description of discrete time systems – time domain analysis – stability using Jury's tests and Schurcohn method.	9
V	*Module 5:* Computer control of industrial processes(Basic Concepts only) – Control hierarchies for plant level automation – Microprocessor/microcontroller/DSP-based control. Programmable logic controllers –Principle of operation- Architecture. Introduction to PLC programming –symbols used in ladder diagrams- AND,OR,NOR,XOR,Latch operations, Illustrative example of a motor control using PLC. PC-based control – Direct Digital control (Basic concept only). Distributed Digital control (Basic Concept only)	9
	TOTAL HOURS	45

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T.1.	K.P. Mohandas, Modern Control Engineering, Sanguine Technical Publishers.
T.2.	S.Hassan Saeed, Automatic Control Systems. Katson Books
T.3.	M.N. Bandyopadhyay, Control Engineering-Theory and Practice, PHI.
R.1.	**Reference:** Alberto Isidori – Non-linear control systems
R.2.	S. Wiggins – Introduction to applied non-linear dynamical systems and chaos
R.3.	Gene. F. Franklin and David Powel – Digital control of dynamic systems,Pearson.
R.4.	Benjamin .C. Kuo – Digital control systems
R.5.	Digital Control Engineering-Analysis and Design, M.Sami Sadali, Elsevier
R.6.	M. Gopal – Digital control and state variable methods,TMH
R.7.	Stefani,Shahian,Savant and Hostetter, Design of feedback Control Systems, Oxford University Press
R.8.	Krishna Kant , Computer Based Industrial Control ,PHI(Module 5)
R.9.	S.K. Singh, Process Control, Concepts, Dynamics and Applications, PHI.(Module 5)
R.10.	W.Bolton – Instrumentation and control systems, Elsevier(Module-5)

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EE 010 403	**Linear System Analysis**	**Introduction to the concept of state space analysis is required for the**	**Fourth**
EE 010	**Control Engineering**	**Frequency Response Analysis is useful**	**Sixth**

604		**for Describing function method**	

COURSE OBJECTIVES:

1	To provide sound knowledge of advanced control systems
2	To Provide knowledge on non linear systems
3	To develop an overall idea of Discrete time systems, Distributed control systems and PLCs.

COURSE OUTCOMES:

SNO	DESCRIPTION	PO MAPPING
1	Students will be able to **design** controller and observer For linear systems	3
2	Students will be able to **analyze** nonlinear systems	2
3	Students will be able to **recall and explain** the fundamentals of discrete time systems	1
4	Students will be able to acquire fundamental **knowledge** of Plant automation ,distributed control system	1
5	Students will be able to acquire fundamental **knowledge** of PLC	1

SI No	DESCRIPTION	BLOOMS' TAXONOMY LEVEL
1	Students will be able to **design** controller and observer For linear systems	Analysis [Level 4]
2	Students will be able to **analyze** nonlinear systems	Analysis [Level 4]
3	Students will be able to **recall and explain** the fundamentals of discrete time systems.	Comprehension [Level 2]
4	Students will be able to acquire fundamental **knowledge** of Plant automation ,distributed control system	Knowledge[Level 1]
5	Students will be able to acquire fundamental **knowledge** of PLC	Knowledge[Level 1]

MAPPING COURSE OUTCOMES (COs) – PROGRAM OUTCOMES (POs) AND COURSE OUTCOMES (COs) – PROGRAM SPECIFIC OUTCOMES (PSOs):

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
C100.1	1				1										1
C100.2	1	1													1
C100.3	1	1													1
C100.4			1		1										1

C100.5			1									1			1
EE 010 704															

JUSTIFATIONS FOR CO-PO MAPPING:

Mapping	L/H/M	Justification
C100.1-PO1	H	Students will be apply the knowledge of mathematics and science to solve various fundamental problems in design of controllers and observers.
C100.1-PO5	L	Students will be able to use modern tools to find solution for design of controllers and observers
C100.2-PO1	H	Students will be able to apply knowledge in calculus to find the describing function of nonlinear systems
C100.3-PO1	L	Students will be apply the knowledge of mathematics to solve discrete time systems
C100.3-PO2	L	Students will be able to Identify, formulate, review research literature, and analyze complex Engineering problems in discrete time systems
C100.4-PO3	M	Students will be able to Design solutions for complex Engineering problems and design system components or processes that meet the specified needs
C100.4-PO5	L	Students will be able to use modern tools to create Plant automation systems.
C100.5-PO3	L	Students will be able to Create, select, and apply appropriate techniques, resources, to develop PLC related programming.
C100.5-PO12	M	Students will be able to prepare and engage in independent and life-long learning in the broadest context of technological change

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

SNO	DESCRIPTION	Mapping to PO	Mapping to PSO
1	PLC Programming is not included in the syllabus	PO3,PO5	PSO3

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

1	.Description	Mapping to PO	Mapping to PSO
	Ladder programming is taken in detail	PO3,PO5	PSO3

WEB SOURCE REFERENCES:

1	Control system, Robotics and Automation-Vol III-Describing Function method-D P Atherton

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☐ STUD.	☐ WEB RESOURCES	

	ASSIGNMENT		
☑ LCD/SMART BOARDS	☐ STUD. SEMINARS	☐ ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☐ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by
Ms. Zehra S

Approved by
Ms. Santhi B

COURSE PLAN

Hour No.	Date	Module	Topics
1	10-07-2017	1	Introduction
2	11-07-2017	1	Controllability – Definition, conditions
3	13-07-2017	1	Kalman's and Gilbert's tests for controllability

4	14-07-2017	1	Observability –Defintion, conditions
5	17-07-2017	1	Kalman’s and Gilbert’s tests for observability
6	18-07-2017	1	Pole placement design
7	20-07-2017	1	Controller design problems
8	21-07-2017	1	Full-order observer design, problems
9	24-07-2017	1	Tutorial
10	25-07-2017	2	Nonlinear systems - Definition/types
11	27-07-2017	2	Characteristics of nonlinear systems
12	28-07-2017	2	Phase plane analysis – Description, definitions
13	31-07-2017	2	Singular points and their classification
14	01-08-2017	2	Method of isoclines, problems
15	03-08-2017	2	Method of isoclines, problems (contd.)
16	04-08-2017	2	Limit cycles of phase plane, stability of limit cycles
17	07-08-2017	3	Describing function method - Introduction
18	08-08-2017	3	Describing function of ideal relay, saturation, dead zone
19	10-08-2017	3	Describing function of combinations of nonlinearities
Hour No.	**Date**	**Module**	**Topics**
20	11-08-2017	3	Describing function analysis - Problems
21	14-08-2017	3	Describing function analysis – Problems (contd.)
22	17-08-2017	3	Limit cycles amplitude and frequency
23	21-08-2017	3	Stability of nonlinear systems – Lyapunov’s method
24	22-08-2017	3	Popov’s criterion, problems
25	24-08-2017	4	Discrete time systems – Sampling theorem
26	25-08-2017	4	Sample and hold circuits, Data reconstruction
27	29-08-2017	4	z transforms – Properties, problems

28	31-08-2017	4	Inverse z transforms - Problems
29	11-08-2017	4	Pulse transfer function
30	14-09-2017	4	State variable representation of discrete time systems
31	15-09-2017	4	Time domain analysis of discrete time systems
32	22-09-2017	4	Solution of linear difference equations
33	25-09-2017	4	Stability using Jury's test and Schur-cohn test
34	26-09-2017	4	Tutorial
35	28-09-2017	5	Computer control of processes, control hierarchies for plant level automation
36	03-10-2017	5	Differences between microprocessor, microcontroller and dsp-based systems
37	05-10-2017	5	PLCs – Principle of operation, architecture
38	06-10-2017	5	PLC programming using ladder diagrams – AND, OR, NOR, EXOR, NAND, Latching operations ; Illustrative example
39	09-10-2017	5	PC based control – Direct digital control and distributed control
40	10-10-2017	5	Revision

Tutorial – Module 1

1. Check by using Gilbert's and Kalman's tests the complete controllability and observability of the state model,

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} X + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$$

$$y = \begin{bmatrix} 2 & 1 \end{bmatrix} X$$

2. Check for complete controllability and complete observabilitythe system represented by the state model,

$$\dot{X} = \begin{bmatrix} -3 & -1 \\ 2 & 0 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & -1 \end{bmatrix} X$$

3. The state model of a system is given as,

$$\dot{X} = \begin{bmatrix} 2 & -2 & 3 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{bmatrix} X + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u$$

$y = [-3 \quad 5 \quad -2]X$

Check whether the system is completely controllable and completely observable using Kalman'sand Gilbert's tests.

4. The state equation of a system is given by,

$$\dot{X} = \begin{bmatrix} -7 & -2 & 6 \\ 2 & -3 & -2 \\ -2 & -2 & 1 \end{bmatrix} X + \begin{bmatrix} 1 & 1 \\ 1 & -1 \\ 1 & 0 \end{bmatrix} u$$

Check whether the system is completely controllable.

Date: 11-09-2017

Problem

Consider a unity feedback system as shown in the fig. having a saturation amplifier with gain K. Determine the maximum value of K for the system to remain stable. What would be the frequency and nature of the limit cycle for a gain of K=2.5?

Assignment 1

Date of submission:11-08-2017

1. How do the designs of modern control systems differ from traditional systems?
2. Define controllability and observability.
3. Check the controllability of the given system,

$$\dot{X} = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -2 \end{bmatrix} X + \begin{bmatrix} 4 & 2 \\ 0 & 0 \\ 3 & 0 \end{bmatrix} U$$

4. State and explain the principle of duality.
5. Consider a linear system described by the transfer function

$$\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$$

Design a feedback controller with state feedback so that the closed loop poles are placed at $-2, (-1 \pm j1)$.

6. A linear plant is represented by the state model,

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ 0 & -3 \end{bmatrix} X + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u;$$

$$y = [1 \quad 0]X$$

(a) Design a feedback controller gain matrix that places the poles at $s = -1 \pm j2$.

(b) Design a full-order observer with its eigenvalues placed at $s = -5, -10$.

7. The state space model of a system is,

   $$A = \begin{bmatrix} -4 & 1 \\ -4 & 0 \end{bmatrix},\ B = \begin{bmatrix} 2 \\ 1 \end{bmatrix},\ C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

   The system response has a damping ratio of 0.5 and a natural frequency of oscillations of 4 rad/s. Design a full-order observer with its speed of response five times faster than that of the closed loop system. Verify the result using Ackermann's formula.
8. What is a nonlinear system and how does it differ from a linear system. Enumerateand explain the characteristics of nonlinear systems.

Assignment 2

Date of submission:18-10-2017

1. Determine the z-transforms of:
   a) $f(k) = 5^k u(-k-1)$
   b) $f(k) = k a^{k-1}$
   c) $x(n) = cos(n\pi)$
   d) $x(t) = (1 - at)e^{at}$
2. Find $x(0)$ if $x(t) = 1 - e^{-t}$ using initial value theorem.
3. Find $x(\alpha)$ if $x(t) = 1 - e^{-t}$ using final value theorem.
4. Find inverse z-transforms of:
   a) $X(z) = \dfrac{z}{z^2 - z + 1}$
   b) $X(z) = \dfrac{z^2(z+1)}{(z-1)(z^2 - z + 0{,}5)}$
   c) $X(z) = \dfrac{z^2}{(z-1)(z-0.5)^2}$
5. Find the solution of the following difference equation:

   $8y(k+2) - 6y(k+1) + y(k) = x(k)$

Given $y(-1) = 1$, $y(-2) = -1$ and $x(k) = (-1)^k u(k)$

6. Determine the z-domain transfer functions of the following s-domain transfer functions:
   a) $H(s) = \dfrac{1}{s(s+2)^2}$
   b) $H(s) = \dfrac{a}{s^2 - a^2}$
   c) $H(s) = \dfrac{(s+b)}{(s+b)^2 + a^2}$

EE 010 705 COMMUNICATION ENGINEERING

COURSE INFORMATION SHEET

PROGRAMME: **ELECTRICAL AND ELECTRONICS**	DEGREE: **BTECH**
COURSE: **COMMUNICATION ENGINEERING**	SEMESTER:**VII** CREDITS: **IV**
OURSE CODE**: EE010 705** REGULATION**: 2010**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN**: ELECTRONICS**	CONTACT HOURS: **3+1 (Tutorial)** hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): **NIL**	LAB COURSE NAME:**NIL**

SYLLABUS:

UNIT	DETAILS	HOURS
I	Review of AM and FM. AM receiver- Super heterodyne AM receiver- RF amplifier, mixer, detector and AGC circuits. FM Transmitter-Reactance modulator (BJT, FET)-Block schematic of Armstrong FM Modulator. FM receiver-Block Schematic of Super heterodyne FM receiver-FM detector Ratio detector.	**6**
II	**Television:** Composite video signal – synchronizing pulse – blanking pulse equalizing pulse, Video BW, Positive and negative modulation, Vestigial side band transmission, Television standards. **Colour Television:** Compatibility, characteristics of colour transmission and reception, luminance, hue & saturation, colour difference signal, I & Q signals, frequency interleaving, colour sub carrier-block schematic of NTSC,SECAM and PAL transmitters and receivers-comparison.	**9**
III	**Radar:** Basic radar system, radar range equation – performance factors, Pulsed radar, Continuous wave radar – advantages-limitations-applications, CW radar, MTI radar system. Radio navigational aids – ILS – GCA-war & peace application.	**6**
IV	Satellite Communication: Satellite frequency band- orbits & inclination Geostationary orbits-effects of solar eclipse-orbital height-Apogee and Perigee calculation-Satellite subsystem-Altitude & orbit control-Tracking,Telemetry & command-Power System-Transponder-functions-up	**14**

	link/down link converters. HPA-Antenna subsystem-Satellite link Analysis-Path losses-Link budget calculation-C/N & G/T-up link down link modeling-Multiple access techniques TDMA-FDMA-CDMA-DA FDMA-DA TDMA-SPADE-Earth Station Block Schematic.	
V	**Digital Communication:** Digital Coding of Analog Waves: PCM, Differential PCM, Delta Modulation, PAM, Adaptive Digital Coding. Modulation Techniques- Basic principles of Binary and M-Ary modulation. Basic Principles of Binary Amplitude Shift Keying-Binary Phase Shift Keying- Binary Frequency Shift Keying-M-Ary Amplitude Shift Keying- M-Ary Frequency Shift Keying- M-Ary Phase Shift Keying.	**10**
	TOTAL HOURS	**45**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T	Electronic Communication Systems: Wayne Tomasi, Pearson Education, LPE
T	Radio Engineering: M.L.Gupta, Dhanpat Rai Publishing Co (P) Ltd
R	Electronic Communication Systems: George Kennedy, TMH
R	Monochrome and Colour Television: R.R Gulati, Wiley Eastern
R	Satellite Communications: K.N. Raja Rao, PHI
R	Satellite Communication: Manoj Mitra, Khanna Publishers
R	Radio Engineering :Mithal,Khanna Publishers
R	Digital Communications: V.K.Khanna S Chand Publishers.
R	Digital and Analog Communication System: K Sam Shanmugam

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EE010503	Signals and Systems	Understand the signal conventions	**V**
EE 010305	Electronics Circuits	Thorough understanding of the basic concepts of electronic circuits	**III**

COURSE OBJECTIVES:

1	To develop student's basic concepts in communication engineering
2	To expose the students to modern communication systems.

COURSE OUTCOMES:

SNO	DESCRIPTION	PO MAPPING
1	Students will be able to develop basic knowledge in AM/FM and various AM/FM receiver and transmitter circuits	a ,c, f, i
2	Students will be able to develop knowledge in the basics of Monochrome and Colour TV systems	a ,c, f, i
3	Students will be able to develop knowledge about the basics of Radar and its variants	a ,c, f, i
4	Students will be able to develop basic knowledge in satellite communication systems and various multiple access techniques	a ,c, f, i
5	Students will be able to build basic knowledge in digital communication and various digital modulation techniques	a ,c, f, i, k

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

SI NO	DESCRIPTION	PROPOSED ACTIONS
1	Simulation Studies not included	Various Programming examples using Matlab

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

1	Matlab Simulink for communication fundamentals

WEB SOURCE REFERENCES:

1	Surendra Prasad. Introduction to Communication Engineering(NPTEL – Indian Institute of Technology, Madras), http://nptel.iitm.ac.in/video.php?subjectId=117102059 License: Web Studio, IIT Madras.
2	Aderemi A. Atayero, Matthew K. Luka and Adeyemi A. Alatishe, Satellite Link Design: A Tutorial, International Journal of Electrical & Computer Sciences IJECS-IJENS Vol: 11 No: 04, http://www.ijens.org/vol_11_i_04/110904-3232-ijecs-ijens.pdf

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☐ WEB RESOURCES	

☑ LCD/SMART BOARDS	☐ STUD. SEMINARS	☐ ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☑ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by **Approved by**

Dr. Jos Prakash A.V. **Ms.B Santhi**
HOD

COURSE PLAN

1	11/07/2017	Review of AM and FM
2	13/07/2017	AM receiver- Superheterodyne AM receiver- RF amplifier, mixer, detector and AGC circuits.
3	14/07/2017	FM Transmitter-Reactance modulator (BJT, FET)-

4	18/07/2017	Block schematic of Armstrong FM Modulator.
5	20/07/2017	FM receiver-Block Schematic of Superheterodyne FM receiver
6	21/07/2017	FM detector-Ratio detector.
7	25/07/2017	Television Basics:
8	27/07/2017	Composite video signal
9	28/07/2017	synchronizing pulse – blanking pulse
10	03/08/2017	Equalizing pulse, Video BW, Positive and negative modulation, Vestigial side band transmission, Television standards
11	04/08/2017	Colour Television: Compatibility, characteristics of colour transmission and reception, luminance, hue & saturation, colour difference signal, I & Q signals,
12	08/08/2017	frequency interleaving, colour sub carrier-block schematic of NTSC
13	10/08/2017	SECAM and PAL transmitters and receivers-comparison.
14	11/08/2017	Radar: Basic radar system, radar range equation
15	17/08/2017	performance factors, Pulsed radar, Continuous wave radar
16	18/08/2017	advantages-limitations-applications,
17	22/08/2017	CW radar, MTI radar system.
18	24/08/2017	Radio navigational aids – ILS – GCA-war & peace application.
19	14/09/2017	Satellite Communication: Satellite frequency band-orbits & inclination
20	15/09/2017	Geostationary orbits-effects of solar eclipse-orbital height-Apogee and Perigee Calculation
21	19/09/2017	Satellite subsystem-Altitude & orbit control-Tracking ,Telemetry & command-Power System
22	22/09/2017	Transponder-functions-up link/down link converters. HPA-Antenna subsystem
23	26/09/2017	Satellite link Analysis-Path losses-Link budget calculation-C/N & G/T-up link down link modeling-
24	28/09/2017	Multiple access techniques- TDMA-FDMA-CDMA-DA FDMA-DA TDMA-
25	03/10/2017	SPADE-Earth Station Block Schematic.
26	05/10/2017	Digital Communication: Digital Coding of Analog Waves:
27	06/10/2017	PCM, Differential PCM
28	10/10/2017	Delta Modulation, PAM
29	12/10/2017	Adaptive Digital Coding.
30	13/10/2017	Modulation Techniques- Basic principles of Binary and M-Ary modulation.
31	17/10/2017	Basic Principles of Binary Amplitude Shift Keying-Binary Phase Shift Keying-

32	19/10/2017	Binary Frequency Shift Keying-M-Ary Amplitude Shift Keying-
33	20/10/2017	M-Ary Frequency Shift Keying- M-Ary Phase Shift Keying.

ASSIGNMENTS

Assignment – 1

1. State the importance of Intermediate Frequency (IF)?
2. Explain the Frequency Spectrum of FM wave.
3. Give note on Phase Discriminator in the context of FM demodulator (Mathematical Explanation).
4. Block Diagram and Comparison on NTSC, PAL and SECAM Encoder and Decoder.

Assignment – 2

1. What is Companding? State two companding laws.
2. Explain the working of SPADE system with block diagram.
3. Explain ground control approach (GCA)?

EE 010 707 L01 HVDC TRANSMISSION

Course Information Sheet

PROGRAMME: **UG**	DEGREE:**BTECH**
COURSE:**HVDC TRANSMISSION**	SEMESTER: **VII** CREDITS:**4**
COURSE CODE:**EE010 706 L01** REGULATION:**2010**	COURSETYPE:**ELECTIVE**
COURSE AREA/DOMAIN:**POWERSYSTEM**	CONTACTHOURS:**3+1 (Tutorial) hours/Week.**
CORRESPONDINGLABCOURSE CODE (IF ANY):**NIL**	LAB COURSE NAME:**NIL**

SYLLABUS:

UNIT	DETAILS	HOURS
I	Comparison ofAC, DCtransmission–Description ofDCtransmissionsystems– PlanningforHVDC transmission–Thyristordevicecharacteristicsand protection– Pulsenumberofconverters – choiceofconverterconfiguration – Review ofGraetz circuit–Valve rating–Transformerrating– Simplifiedanalysis ofGraetz circuit(withoutoverlapandwith overlap)– Converterbridge characteristics.	13
II	HVDCSystemControl:principlesofDC linkcontrol– convertercontrol characteristics–systemcontrolhierarchy– firinganglecontrol – Currentand extinctionangle control –Higherlevelcontrollers– startingand stoppingofDC link– powercontrol.	10
III	Converterfaults and protection:typesoffaults– commutationfailure–arc through, misfireand currentextinction– protection againstovercurrents– over voltages– surge arresters–protectionagainstovervoltages– smoothingreactors – DCline– transientovervoltages in DCline– Protection ofDC line–DCbreakers	10
IV	Reactive powercontrol:Steadystate reactive powerrequirements– sourcesof reactive power–staticVARsystems– ThyristorControlled Reactor–Thyristor switchedcapacitor –Reactive power controlduringtransients. Harmonicsand filters:Generation ofharmonicsin HVDCsystems– criteria ofdesign forAC filters– typesofACfilters – DCfilters– Carrierfrequencyand radiointerference noise.	12
V	Multi-terminalDCsystems:applications ofMTDCsystems– types– comparison – Controland protection.Modeling:Convertermodel – modelingofDCand AC networks.	15
	TOTAL HOURS	60

TEXT/REFERENCEBOOKS:

T/R	BOOKTITLE/AUTHORS/PUBLICATION

T	HVDCPowerTransmission Systems-Technologyand SystemInteractions:K.RPadiyar, NewAgeInt'l.
R1	DirectCurrentTransmission Vol1:E.WKimbark, Wiley

R2	HVDCand FACTS controllers–VijayKSood–KluwerAcademic Publishers

COURSEPRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EE 010 504	PowerElectronics	Basicconcepts ofThyristoroperation, characteristics, three phasebridge converteroperation	V
EE010 603	Controlsystems	Basicconcepts incontrolsystems-PI controllers,	VI

COURSE OBJECTIVES:

1	Toimpartthe basic concepts ofHVDCTransmission systems and components
2	To provide knowledge in the area ofcontroland protectionofHVDCTransmission systems

COURSEOUTCOMES:

SNO	DESCRIPTI ON	Blooms' Taxonomy Level
1	Students have greaterawarenessregardingthepotentialofDCtransmission from the pointofview ofinteractions with ACsystems	Comprehension [level 2]
2	Students willbeable toinvestigatethoroughlyduringthe design stage ofHVDC controllerstheirprinciple, characteristicsandsolutionsincorporated to overcome the adverseeffects.	Synthesis [Level 5]
3	Students willacquire broad knowledge in HVDCsystemfaults and protection	Knowledge [Level 1]
4	Students willbeable to visualize thescope ofapplication ofHVDCsystems with introduction to multi-terminalsystemoperation	Application [Level3]
5	Students willbeable tousemodelingskillsofconverter, DCand ACnetworks forthefullrealization ofpotentialbenefits ofHVDC transmission.	Analysis [Level 4]

MAPPING COURSEOUTCOMES(COs)–PROGRAM OUTCOMES(POs)AND COURSE OUTCOMES(COs)–PROGRAM SPECIFIC OUTCOMES(PSOs)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
C706.1	3		2		3				2		2		3		
C706. 2				3						3					2
C706. 3		2									2			1	
C706. 4	3		3						3		2			3	
C706. 5	3			2			2		1	2		3	3		2
EE706 L01	2.8	2.6	2.4	2	2.75		2		2		2	3	3		

Mapping	L/	Justification
C706.1-PO1	H	Studentwillbe ableto explain aboutvarious transmission line Losses.
C706.1-PO3	M	Studentwillbe ableto identify parts of transmission line(both electricalandmechanical)
C706.1-PO5	H	Studentswillbe able to design bridge rectifier.
C706.1-PO9	L	Studentswillable to understand SCR and other power electronics devices.
C706.1-PO11	L	Studentswillbe able toacquirenewknowledge in losses in HVDC.
C706.2- PO4	H	Studentwillbe ableto usethe knowledge in designing HVDC system.
C706.2- PO10	H	Studentswillbe able to apply the knowledge ofmathematics,and engineeringFundamentalsforsolving bridge circuit analysis.
C706.3- PO2	M	Studentwillbe ableto anlayse HVDC system.
C706.3- PO11	M	Studentswillbe able to learn 12 pulse transformer.

C706.4- PO1	H	**Studentswilldemonstrate controlmethords in HVDC.**
C706.4- PO3	H	**Studentswillbe able to learnprotection in system.**
C706.4- PO9	H	**Students canevaluatetheperformanceof the various transmission DC, AC networkmodels .**
C706.4- PO11	M	**Studentswillbe able toidentify use of bulk power transmission.**
C706.5- PO1	H	**Studentswillbe able to designMTDCT system.**
C706.5- PO4	M	**Studentswilldemonstratean ability toidentify differentmethodsin connecting HVDC system.**
C706.5- PO7	M	**Studentswilldemonstratean ability toidentify,formulate andsolve Small HVDC problems.**
C706.5- PO9	L	**Studentswillbe able tosuggest improvementsin powerfactortolife longlearming**
C706.5- PO10	M	**Students canevaluatetheperformanceof the various modelsusing modernsimulation tools**
C706.5- PO12	H	**Studentswillbe able to apply the mathimaticsandengineering fundamentalsfor designing HVDCcircuits.**

GAPES IN THESYLLABUS-TOMEETINDUSTRY/PROFESSION REQUIREMENTS:

SNO	DESCRIPTION	PROPOSED ACTIONS
1	Protectionagainstvoltage and currentoscillationsusingdampers	Assignment
2	Ground return	Assignment
3	Syllabusgivesonlyoutlineofbasicconcepts anddesign featuresso void of realtime implementation.	Industry visit for practical understanding

PROPOSED ACTIONS: TOPICS BEYONDSYLLABUS/ASSIGNMENT/INDUSTRYVISIT/GUEST LECTURER/NPTELETC

TOPICSBEYONDSYLLABUS/ADVANCED TOPICS/DESIGN:

1	OperationofDC linkasa partofan ACsystem
2	Simulation ofHVDCsystems

WEBSOURCE REFERENCES:

1	www.nptel.iitm.ac.in–Revived date 2/7/2013

DELIVERY/INSTRUCTIONALMETHODOLOGIES:

☑CHALK&TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	
☑ LCD/SMART BOARDS	☑ STUD. SEMINARS	☐ADD-ON COURSES	

ASSESSMENTMETHODOLOGIES-DIRECT

☑ASSIGNMENTS	☑ STUD. SEMINARS	☑TESTS/MODEL EXAMS	☑UNIV. EXAMINATION
☐STUD. LAB PRACTICES	☐STUD.VIVA	☐MINI/MAJOR PROJECTS	☐CERTIFICATIONS
☐ADD-ON COURSES	☐OTHERS		

ASSESSMENTMETHODOLOGIES-INDIRECT

☑ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENTFEEDBACKONFACULTY (TWICE)
☐ASSESSMENTOFMINI/MAJORPROJECTS BYEXT. EXPERTS	☐OTHERS

Preparedby, **Approved by,**

Unnikrishnan L **(HOD)**

COURSE INFORMATION SHEET

PROGRAMME: **Electrical and Electronics Engineering**	DEGREE: **BTECH**
COURSE: **Electrical CAD**	SEMESTER:**VII** CREDITS: **2**
COURSE CODE: **EE 010 707** REGULATION: **UG**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **Electrical Machines**	CONTACT HOURS: **3 Practical hours/Week.**
CORRESPONDING LAB COURSE CODE (IF ANY): **NIL**	LAB COURSE NAME: **NIL**

SYLLABUS:

UNIT	DETAILS	
1	1. Familiarization of CAD environment - Steps of design procedure, advantages of using CAD S/W in Engineering Design, Basic features of CAD S/W – AutoCAD, ProE, CATIA etc. AutoCAD interface introduction, workspace switching, Co-ord. system's (absolute, relative rectangular, polar), object selection methods – Picking, regular window, crossing window, draft settings – OSNAP, OTRACK, ORTHO. 2. Basic Drawing Commands – Line, Circle, Arc, Ellipse, Rectangle, Polygon, Spline, Polyline, and Construction line, Revision Clouds, Donut, Text. 3. Erase, Move, Copy, Offset, Scale, Stretch, Rotate, Minor, Array, Break, Explode, Trim, Extend, Fillet, Chamfer, Grip Editing, Point, point style, Divide, Measure . 4. Additional Tools for 2 D drawing preparation: Leader, Preparation, PICKADD, Match Properties, Layers, Hatch, Hatch Edit, Dimension Types, Units, Limits. Styles: Text Styles, Dimension styles. 5. Advance Productive Tools: Block, Insert Block, Block Edit, Attributes, Attribute, Edit, Symbol Libraries: Electrical symbol insertion from tool palette and Design Centre.	10
2	6. Drawing examples: Diff. winding drawings: • DC simplex lap & wave winding – sch. Wiring, wires, ladders, wire number, signal arrows. Etc. 7. Electrical Circuits: • Electrical Schematic drawing of an 11kV indoor substation. • Electrical Schematic Drg. Of MSB with supplies, from a TXR and standby DG set, relays, indication lamps, metering etc. 8. Electrical Machine : • Half sectional elevation and end view of	15

	○ Induction motor ○ Synch. Motor ○ DC Machine	
	TOTAL	25

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
R	Auto CAD reference manual (Release 2008 or later)
T	AutoCAD 2007 & AutoCAD LT 2007 Bible – Ellen Finkelstein (Wiley).
R	A text book computer aided machine drawing: S. Trymbaka Murthy
R	CAD/ CAM principle, practice and manufacturing management: Chris McMahon, Jimmie Browne
R	Electrical Machines Design – A. K. Sawhney.
R	Electrical Machine Drawing – S. K. Bhattacharya.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EE010 402	DC machines and Transformers	From the course Students will understand the basic working of a transformer and DC Machines. From the course Students will be capable of analyzing the performance of DC machines and transformers.	IV
EE 010 601	Power generation and Distribution	From the subject the students will understand the basics power generation systems and power distribution systems.	VI

COURSE OBJECTIVES: -

1	To develop skills in computer aided drafting of electrical machines and lay-out of various electrical installations.

COURSE OUTCOMES:

SNO	DESCRIPTION	BLOOMS' TAXONOMY LEVEL
1	Students will be using the fundamental features of AutoCAD to **design** electrical circuits	**Create** Level 6
2	Graduates will be able to use the precision drafting tools in AutoCAD **to sketch and develop** accurate technical drawings.	**Apply** Level 3
3	Students will be able present **labeled**drawings in a detailed and	**Knowledge**

	visually impressive way.	Level 1
4	Graduates will be able to prepare and **analyze** detailed Electrical Drawings of Electrical Installations.	**Analyze** Level 4
5	Graduates will be able to prepare and**explain**Cut section view of electrical machines.	**Understand** Level 2

MAPPING COURSE OUTCOMES (COs) – PROGRAM OUTCOMES (POs) AND COURSE OUTCOMES (COs) – PROGRAM SPECIFIC OUTCOMES (PSOs):

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
C707.1	2	1	3	1	3				1	2	1	1	1		1
C C707.2		2	2		3			1		3	1			1	
C C707.3		2	1		1	1			1	3	1	1	1		
C C707.4	1	1	1	3			1			3	1	1		1	
C C707.5	1	1	1	1	2			1		3	1		1	1	2
EE 101 707	2	2	2	2	2		1	1	1	3					

JUSTIFATIONS FOR CO-PO MAPPING:

Mapping	**L/H/M**	**Justification**
C707.1-PO1	M	Students will be able to explain the fundamentals concepts of electrical engineering through AutoCAD drawings.
C707.1-PO2	L	Students will be able to identify and debug issues related to electronics circuits
C707.1-PO3	H	Students will be able to design and develop solutions for complex engineering problems that meet the specific needs.
C707.1-PO4	L	Students will be able to conduct investigations of complex engineering issue with the aid of research based knowledge.
C707.1-PO5	H	Students will be able to modern drafting tools to design and model complex engineering activities.
C707.1-PO9	L	Students will be able to function effectively as an individual and as a team member
C707.1-PO10	M	Students will be able to communicate effectively, comprehend, and make effective reports and presentations using AutoCAD drafting and annotation tools
C707.1-PO11	L	Students will be able to demonstrate knowledge and understand engineering principles through managing projects in

		multidisciplinary environment.
C707.1-PO12	L	Students will be able to engage in independent and life long learning in the broadest context of technological changes through AutoCAD
C707.2-PO2	M	Students will be able to identify and debug issues related to technical drawings
C707.2-PO3	M	Students will be able to design and develop solutions for complex engineering problems that meet the specific needs through technical drawings.
C707.2-PO5	H	Students will be able to modern drafting tools to design and model complex engineering activities.
C707.2-PO8	L	Students will be able to practice professional ethics.
C707.2-PO10	H	Students will be able to communicate effectively, comprehend, and make effective reports and presentations using AutoCAD drafting and annotation tools
C707.2-PO11	L	Students will be able to demonstrate knowledge and understand engineering principles through managing projects in multidisciplinary environment.
C707.3-PO2	M	Students will be able to identify and debug issues related to engineering drawing.
C707.3-PO3	L	Students will be able to design and develop solutions for complex engineering problems that meet the specific needs.
C707.3-PO5	L	Students will be able to modern drafting tools to design and model complex engineering activities.
C707.3-PO6	L	Students will be able to understand the professional engineering practices
C707.3-PO9	L	Students will be able to function effectively as an individual and as a team member
C707.3-PO10	H	Students will be able to communicate effectively, comprehend, and make effective reports and presentations using AutoCAD drafting and annotation tools
C707.3-PO11	L	Students will be able to demonstrate knowledge and understand engineering principles through managing projects in multidisciplinary environment.
C707.3-PO12	L	Students will be able to engage in independent and life long learning in the broadest context of technological changes.
C707.4-PO1	L	Students will be able to explain the fundamentals concepts of electrical Installations through AutoCAD.
C707.4-PO2	L	Students will be able to identify and debug issues related to engineering drawing.
C707.4-PO3	L	Students will be able to design and develop solutions for complex engineering problems that meet the specific needs.

C707.4-PO4	H	Students will be able to conduct investigations of complex engineering issue with the aid of research based knowledge.
C707.4-PO10	H	Students will be able to communicate effectively, comprehend, and make effective reports and presentations using AutoCAD drafting and annotation tools
C707.5-PO1	L	Students will be able to explain the fundamentals concepts of electrical machines through AutoCAD drawings.
C707.5-PO2	L	Students will be able to identify and debug issues related to electrical connections of machines
C707.5-PO3	L	Students will be able to design and develop solutions for complex engineering problems that meet the specific needs.
C707.5-PO 4	L	Students will be able to conduct investigations of complex engineering issue on electrical machines with the aid of research based knowledge.
C707.5-PO 5	M	Students will be able to modern drafting tools to design and model complex engineering activities.
C707.5-PO8	L	Students will be able to conduct investigations of complex engineering issue with the aid of research based knowledge.
C707.5-PO10	H	Students will be able to communicate effectively, comprehend, and make effective reports and presentations using AutoCAD drafting and annotation tools
C707.5-PO11	L	Students will be able to demonstrate knowledge and understand engineering principles through managing projects in multidisciplinary environment.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

Slno	*Description*	*Proposed Actions*	*Mapping POs*	*Mapping with PSOs*
1	It will be better for students if an overview of a complete Electrical Drawing of a building/ house is analyzed.	Guest Lecture by an expert from this field.	PO2, PO3, PO4, PO10,	PSO1, PSO3

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

Sl no	*Description*	*Mapping with POs*	*Mapping with PSOs*
1	Top view &Cut section of two limb transformer is included.	PO1, PO2, PO3, PO4, PO7, PO10, PO11	PSO1, PSO3

WEB SOURCE REFERENCES:

1	CAD Tutor – [Online] Available : http://www.cadtutor.net/tutorials/autocad/index.php?category_id=1 (Accessed on : July2017)
2.	Autodesk AutoCAD 2013 Essentials Course Available : http://www.vtc.com/products/Autodesk-AutoCAD-2013-Essentials-Tutorials.htm (Accessed on July 2017)
3	CAD Notes – [Online] Available : http://www.cad-notes.com/2010/01/introduction-to-autocad-the-interface (Accessed on June 2017)

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☐ STUD. ASSIGNMENT	☑ WEB RESOURCES	
☑ LCD/SMART BOARDS	☐ STUD. SEMINARS	☐ ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☑ STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☑CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by **Approved by**

Mr. Jebin Francis **Ms. Santhi B**

HOD

COURSE PLAN

Sl.No	Cycle	Planned Date	Planned
1	1	12-Jul-2017	Intro To AutoCAD Electrical .
2	1	17-Jul-2017	BATCH A - AutoCAD Tutotrial -01 & AutoCAD Tutorial - 02
3	1	19-Jul-2017	BATCH B - AutoCAD Tutotrial -01 & AutoCAD Tutorial - 02
4	1	24-Jul-2017	BATCH A - AutoCAD Tutorial - 03
5	1	26-Jul-2017	BATCH B - AutoCAD Tutorial - 03
6	1	31-Jul-2017	BATCH A - AutoCAD Tutorial - 04 - Part A & AutoCAD Tutorial - 04 - Part B
7	1	2-Aug-2017	BATCH B - AutoCAD Tutorial - 04 - Part A & AutoCAD Tutorial - 04 - Part B
8	1	7-Aug-2017	BATCH A - Squirrel Cage Induction Motor - AutoCAD Tutorial - 05
9	1	9-Aug-2017	BATCH B - Squirrel Cage Induction Motor - AutoCAD Tutorial - 05
10	1	14-Aug-2017	BATCH A - Slip Ring Induction Motor - AutoCAD Tutorial - 06 (ii) Sailent Pole Alternator - AutoCAD Tutorial - 07 (iii) Rotating Armature Type Alternator - AutoCAD Tutorial - 08
11	1	16-Aug-2017	BATCH B - Slip Ring Induction Motor - AutoCAD Tutorial - 06 (ii) Sailent Pole Alternator - AutoCAD Tutorial - 07 (iii) Rotating Armature Type Alternator - AutoCAD Tutorial - 08
12	1	21-Aug-2017	BATCH A - Slip Ring Induction Motor - AutoCAD Tutorial - 06 (ii) Sailent Pole Alternator - AutoCAD Tutorial - 07 (iii) Rotating Armature Type Alternator - AutoCAD Tutorial - 08
13	1	11-Sep-2017	BATCH B - Slip Ring Induction Motor - AutoCAD Tutorial - 06 (ii) Sailent Pole Alternator - AutoCAD Tutorial - 07 (iii) Rotating Armature Type Alternator - AutoCAD Tutorial - 08
14	1	13-Sep-2017	BATCH A - Different types of Transformer core - Sectional Plan of One Limb Transformer -Elevation and plan of single and three phase transformer
15	1	18-Sep-2017	BATCH B - Different types of Transformer core - Sectional Plan of One Limb Transformer -Elevation and plan of single and three phase transformer
16	2	20-Sep-2017	BATCH A - Layout of 11kV- 415V Indoor Substation.(ii) Layout of a 66kV outdoor Substation
17	2	25-Sep-2017	BATCH B - Layout of 11kV- 415V Indoor Substation.(ii) Layout of a 66kV outdoor Substation
18	2	27-Sep-2017	BATCH A - DC LAP/WAVE Winding
19	2	4-Oct-2017	BATCH B - DC LAP/WAVE Winding

20	2	9-Oct-2017	BATCH A - DC LAP/WAVE Winding
21	2	11-Oct-2017	BATCH B - DC LAP/WAVE Winding
22	2	16-Oct-2017	BATCH A - DC LAP/WAVE Winding
23	2	18-Oct-2017	BATCH B - DC LAP/WAVE Winding

Lab Cycle

Sl. No	Sheet Title	
Cycle - I		
1	Familiarization of AutoCAD and Basic Commands Used.	
2	AutoCAD Tutorial – 01	
3	AutoCAD Tutorial – 02	
4	AutoCAD Tutorial – 03	
5	AutoCAD Tutorial - 04 - Part A AutoCAD Tutorial - 04 - Part B	
Cycle – I I		
6	Half Sectional Front View (elevation) & Half Sectional End View of a Squirrel Cage Induction Motor.	
7	Half Sectional Front View (elevation) & Half Sectional End View of a Slip Ring Induction Motor.	
8	Half Sectional Front View (elevation) & Half Sectional End View of a Sailent Pole Alternator – Sheet	
9	Half Sectional Front View (elevation) & Half Sectional End View of a Rotating Armature Type Alternator – Sheet	
10	Plan of different types of Transformer core	
11	Sectional Plan of One Limb of a 3Ø Transformer	
12	11kV- 415V Indoor Substation Layout in Electrical CAD.	
13	Layout of a 220kV Substation in Electrical CAD.	
Additional Experiments		
14	Sectional Plan and Elevation of a Single Phase Transformer.	
15	Sectional Plan and Elevation of a Three Phase Transformer.	

Additional Experiments

Aim:
To Draw the sectional plan and elevation for a 500kVA 6600/400V single phase power transformer.
Question :
The detailed dimensions of the parts are listed below:
Core :
Diameter = 33 cm
Width of the largest stamping = 28 cm
Width of the smallest stamping = 17.5cm
Height of core , H = 43 cm
Center to center dist. b/w core = 49 cm
Core laminations are fixed by means of two end plates 3mm thick by a bolt of diameter 1.2 cm.
Yoke :
Construction = Cruciform
Yoke height = 25 cm
Yoke length = 49 + (0.85 x 33) = 77cm
Winding :
LV winding – placed near the core - helical type.
LV winding total turns = 22
No. of turns per limb = 11
LV winding conductor cross section is made from 20 square straps of size 5 x 5 mm
Height of one turn = 28.5 mm
Radial Thickness of one turn = 23 mm
Total Height of the core occupied by LV winding = 36.2 cm
Inside dia. of LV winding = 33.75 cm
Outside dia. of LV winding = 38.35 cm
HV winding – in two layers "Concentric Type".
Inside dia. of H.T 1st layer = 41.5 cm
Outside dia. of HT 1st layer = 43.30 cm
Inside dia. of H.T 2nd layer = 45 cm
Outside dia. of HT 2nd layer = 46.8 cm

Aim:

Draw the sectional plan and elevation for a three phase core type transformer.

Question:
The detailed dimensions of the parts are listed below:
Core :
3 – step core construction
Window height = 47 cm
Overall width = Overall height of core = 98 cm
Winding :
Secondary Winding LT

Inside dia. = 25 cm
Outside dia. = 27.1 cm
Winding in 2 layers
No. of turns per layer = 21
Secondary conductor = 6 strips in parallel each 9.55 mm x 3.2mm

Primary Winding HT

Inside dia. of winding = 32 cm
Outside dia. of winding = 37 cm
No of Turns = 750
8 coils of 83 turns each arranged in 7 layers, height 3.75cm,
2 coils of 43 turns each, height 2.35 cm
Primary Conductor = 2.64 mm dia; 33 mm dia with insulation.

Open Questions

1. For 6 polar D.C machine, armature has 36 numbers of slots.Draw a double layer simplex lap winding.

2. Draw a double layer progressive simplex wavewinding For 4 pole D.C machine, with 24 number of armature slots.

3. Design a 4 pole, simplex lap winding suitable for an armature containing 20 slots. Assume single turn coil with 2 conductors per slot.

4. Design a 4 pole, wave wound armature with 21 slots, having single turn coil and two conductors per slot.

EE 010 708 CONTROL & SIMULATION LABORATORY

COURSE INFORMATION SHEET

PROGRAMME: **Electrical & Electronics Engineering**	DEGREE: **B.TECH**
COURSE: **Control & Simulation Laboratory**	SEMESTER: **VII** CREDITS: **2**
COURSE CODE: **EE 010 708** REGULATION: **UG**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **Control Systems**	CONTACT HOURS: **3 Hours/week**
CORRESPONDING LAB COURSE CODE (IF ANY): **Nil**	

SYLLABUS:

UNIT	DETAILS	HOURS
I	**Determination of Field controlled DC Motor**	
II	**AC Servomotor**	
III	**MATLAB –I** Effect of pole location using MATLAB. Stability Analysis using MATLAB. Time domain and Frequency domain response of second order system.	
IV	**MATLAB –II** Design of P, PI, PID using MATLAB. Simulation of inverted pendulum using MATLAB. Lag and Lead Compensator design.	
V	**MATLAB –III** Introduction of Simulink	
VI	**Temperature controlled Plant**	
VII	**Synchro**	
VIII	**DC Servomotor**	
	TOTAL HOURS	

TEXT/REFERENCE BOOKS:

T/R	**BOOK TITLE/AUTHORS/PUBLICATION**
R	K. Ogatta, Modern Control Engineering Fourth edition- Pearson Education, 2002.
R	Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Pearson Education, 2009.
R	Muhammad H Rashid, Introduction to PSpice using Orcad for Circuits and Electronics, Third Edition PHI 2009.
R	R.K Bansal, A.K Goel, M.K. Sharma, MATLAB and its Application in Engineering, Second Edition ,Pearson 2010.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EE 010 403	Linear System Analysis	Classification of systems, Time domain analysis for linear systems	IV

EE 010 604	Control Engineering	To get the knowledge in the frequency response analysis of LTI systems, To get the knowledge design of controllers and compensators. To get the knowledge of classical methods of system analysis.	VI

COURSE OBJECTIVES:

1	To impart knowledge of control systems through experiments.
2	To impart knowledge in simulation of different systems to study the response.

COURSE OUTCOMES:

SNO	DESCRIPTION	Blooms' Taxonomy Level
1	Students will be able to **explain** and evaluate performance of basic closed loop and open loop systems.	Application [Level 3]
2	Students will be able to **analyze** the system by drawing plots in MATLAB	Analysis [level 4]
3	Students will be able to **Learn and Write** mathematical programming in MATLAB	Knowledge [level 1]
4	Students will be able to **classify** the different type's secondary distribution system.	Comprehension [level 2]
5	Students will be able to **relate** the concepts to design controller to meet the desired specification.	Synthesis [Level 5]

MAPPING COURSE OUTCOMES (COs) – PROGRAM OUTCOMES (POs) AND COURSE OUTCOMES (COs) – PROGRAM SPECIFIC OUTCOMES (PSOs)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
C 708.1	1	1													1
C 708. 2	1				3										1
C708. 3					3										1
C708. 4				2											1
C708. 5				2											1
EE 708	**2**	**2**		**1**		**1**	**1**	**1**		**1**		**1**		**3**	

JUSTIFICATIONS FOR CO-PO MAPPING

Mapping	L/H/M	Justification
C708.1-PO	L	Student will be able to explain the societal issues while considering a site for power plant

C708.1-PO2	L	Student will be able to understand the impact in societal and environment by the professional Engineering solutions while installation and operation of electrical power plant.
C708.2-PO1	L	Student will acquire knowledge in professional ethics and responsibilities for considering site selection operation and maintenance of electrical power plant.
C708.2-PO5	H	Student will be able to make effective presentation on the given topic.
C708.3-PO5	H	Student will get an initiation on the study of different power plant.
C708.4-PO4	M	Student will be able apply the knowledge of mathematics and economic aspects of power generation for the solution of problems related to power generation ,distribution ,power factor improvement and tariff.
C708.5-PO4	M	Student will be able to analyze complex problem related to power generation, distribution, power factor improvement and tariff.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

SNO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1.	Familiarization of digital control system		6 ,7,12	1,2
2	Introduction to PLC	Industrial Visit	1,2,11,12	-

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC**TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:**

SNO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Calculation Cost of electrical energy, Expression for cost electrical energy	Additional class	1,2,12	2
2	Methods of determining depreciation – Straight line method –Diminishing value method-Sinking fund method – Tutorials.	Additional class	1,2,11,12	2

WEB SOURCE REFERENCES:

1	KSEB Profile ,KSEB [online] available:

d) DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	
☑ LCD/SMART BOARDS	☑ STUD. SEMINARS	☐ ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☑ASSIGNMENTS	☑ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

OPEN QUESTIONS

1 . Mathematically model a fourth order system and analyse its stability using MATLAB

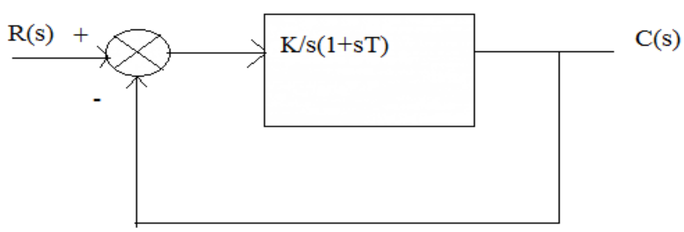
M = 2kg, m= 0.1 kg , l= 0.5m, g = 9.8 m/s^2

2. A system is described by the Transfer Function

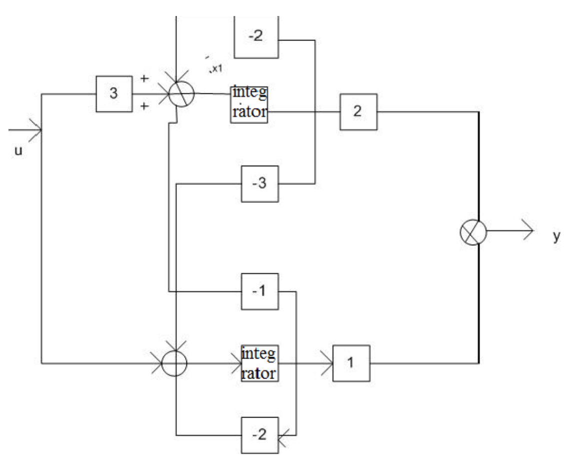
$$G(s) = \frac{s+2}{s^3 + 3s^2 + 2s + 10}$$

Check for Observability and controllability using MATLAB.

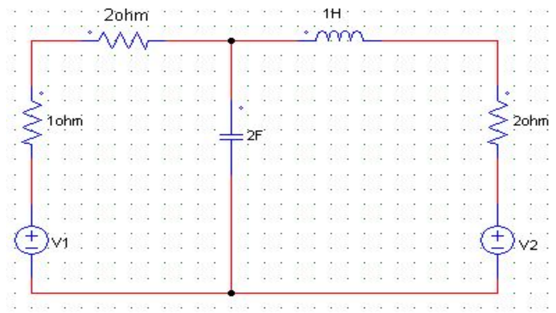
3. For the given system, when subjected to unit step input , the output response is as shown. Find K and T. Also get step response using MATLAB.



4. Obtain the transfer function of the given system and find its response using simulink.



5. Write the state equation for circuit given in the figure.

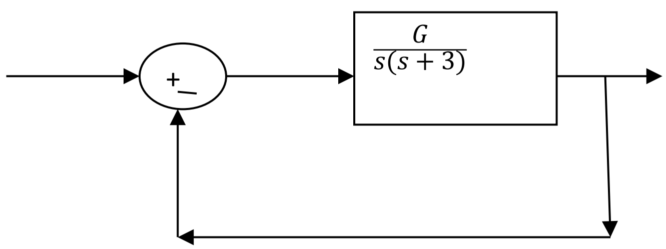


6. A system is described by the Transfer Function

$$G(s) = \frac{s+2}{s^3 + 3s^2 + 2s + 10}$$

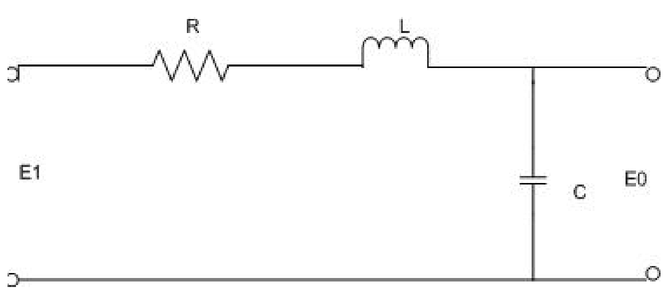
Check for observability and controllability using MATLAB Code.

7. For the block diagram given find the value of G for which system will exhibit an overshoot as shown.



8. Obtain step response of the given network using MATLAB.

Given R= 1Ω, L=0.1H, C=1F



ADVANCED QUESTIONS

1. In Simulink, create a feedback control system which uses a lead controller with transfer function D(s) = $\frac{15(s+10)}{s+100}$
2. Design a PID controller and PI controller for the continuous-time plant $G(s) = \frac{(10)}{s+100}$.
   Plot your results as two subplots with *w* versus t in the upper subplot and u versus t in the lower subplot.
   Comment on the difference in performance.