REVISED CURRICULUM AND DETAILED SYLLABI

FOR

B.E. DEGREE (Electrical and Electronics) PROGRAM

SECOND SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2008-2009 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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Department of Electrical and Electronics Engineering

Graduating Students of BE program of EEE will be able to

1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power
2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015
Department of Electrical and Electronics
Scheduling of Courses

Semester	**Theory Courses**						**Practical / Project**		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					E88 Project 0:12	
7th (22)	E71 Mgmt. The. & Practice 3:0	E72 Protection & Switchgear 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		Computer Aided Engineering Lab 0:1	E78 Project 0:6	
6th (21)	E61 Accounting & Finance 3:0	E62 Power System Analysis 3:0	E63 Electric Drives 3:0	E64 Design with FPGAs 3:1	Elective 1 3:0	Elective 2 3:0	E67 Power System Simulation Lab 0:1	E68 Power Electronic & Drives Lab 0:1	
5th (23)	E51 Engineering Mathematics – 5 4:0	E52 Generation, Transmission & Distribution 3:0	E53 Power Electronics 3:0	E54 Embedded Systems 3:1	E55 Mixed Signal Circuits and Interfacing 3:0	E56 Electrical Machine Design 3:0	E57 Digital Signal Processing Lab 0:1	E58 Embedded Systems Lab 0:1	E59 Instrumentation and Control Lab 0:1
4th (25)	E41 Engineering Mathematics – 4 4:0	E42 AC Machines 3:1	E43 Microprocessors & Microcontrollers 4:0	E44 Thermal Engineering 3:0	E45 Digital Signal Processing 3:0	E46 Instrumentation 3:0	E47 AC Machines Lab. 0:1	E48 Microprocessors & Microcontrollers Lab. 0:1	E49 Professional Communications 1:1
3rd (24)	E31 Engineering Mathematics – 3 4:0	E32 Electromagnetics 3:1	E33 DC Machines & Transformers 3:1	E34 Digital Systems 3:0	E35 Data Structures 3:0	E36 Control Systems 3:1	E37 Digital Systems Lab 0:1	E38 DC Machines & Transformers Lab 0:1	
2nd (23)	E21 Engineering Mathematics – 2 4:0	E22 Electric Circuit Analysis 4:0	E23 Analog Circuits & Systems 4:0	E24 Computers and Programming 3:0	E25 Materials Science 3:0	E26 Ecology 2:0	E27 Analog Circuits and Systems Lab 0:1	E28 Computer Programming Lab 0:1	E29 Workshop 0:1
1st (25)	H11 Engineering Mathematics – 1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of M & CE 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab 0:1	H18 Chemistry Lab 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics) Program

SUBJECTS OF STUDY

(For the candidates admitted from 2008-2009 onwards)

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
E 21	Engineering Mathematics II	BS	4	-	-	4
E 22	Electric Circuit Analysis	DC	4		-	4
E 23	Analog circuits and systems	DC	4	-	-	4
E 24	Computers and Programming	ES	3	-	-	3
E 25	Materials Science	ES	3	-	-	3
E 26	Ecology	HSS	2	-	-	2
PRACTICAL						
E 27	Analog Circuits and systems Lab.	DC	-	-	2	1
E 28	Computer Programming Lab.	ES	-	-	2	1
E 29	Workshop	ES	-	-	2	1
	Total		**20**	**-**	**6**	**23**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2008-2009 onwards)

SECOND SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	E21	Engineering Mathematics II	3	50	50	100	25	50
2	E22	Electric circuit Analysis	3	50	50	100	25	50
3	E23	Analog Circuits and systems	3	50	50	100	25	50
4	E24	Computers and Programming	3	50	50	100	25	50
5	E25	Materials Science	3	50	50	100	25	50
6	E26	Ecology	3	50	50	100	25	50
PRACTICAL								
7	E27	Analog Circuits and systems Lab.	3	50	50	100	25	50
8	E28	Computer Programming Lab.	3	50	50	100	25	50
9	E29	Workshop	3	50	50	100	25	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

Sub Code	Lectures	Tutorial	Practical	Credit
E 21	4	0	-	4

E21 Engineering Mathematics II

(Common to all branches of Engineering B21, C21, D21, E21, G21, T21)

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

b. An ability to identify, formulate and solve engineering problems

c. An ability to engage in life-long learning

Competencies: At the end of the course the students should be able to

1. Formulate and solve problems of engineering dynamics using different differential operators.
2. Formulate the problem of computing areas and volumes through vector integration, and determine them by applying Green, Stokes and Divergence theorems
3. Determine maxima and minima of functions of several variables using analytical and Lagrangian multipliers methods
4. Determine the values of multiple integrals directly or by changing the order of integration or by making transformation with Jacobians.
5. Determine areas and volumes of geometrical figures using multiple integrals, beta and gamma functions.
6. Analyze functions of complex variable in terms of continuity, differentiability and analyticity.
7. Apply Cauchy-Riemann equations and harmonic functions to problems of fluid mechanics, thermodynamics and electro-magnetic fields.
8. Find singularities of complex functions and determine the values of integrals using residues.
9. Geometrically interpret conformal and bilinear transformations

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define total differentiation
2. Describe change of order of integration
3. Identify the value of λ, so that $\bar{F}$= $(2x-5y)\bar{i}+(x+\lambda y)\bar{j}+(3x-z)\bar{k}$ is solenoidal
4. If C is a simple closed curve and $\bar{r}=x\bar{i}+y\bar{j}+z\bar{k}$ show that $\int_c c.dr = 0$
5. Define "harmonic" and "conjugate harmonic" functions.

6. Show by an example that there exist harmonic functions u(x,y) and v(x,y), such that u+iv is not analytic.
7. State Cauchy's integral theorem or Cauchy's fundamental theorem.
8. State the extension of Cauchy's integral theorem.
9. State Cauchy's Integral formula.
10. State Cauchy's integral formula for the derivatives of an analytic function.

Understand

1. Elevation of land above sea level H, depends on two map coordinates x, y in the following way H(x,y) $= e^{-0.01(x^2+y^2)}$. A car travels through this terrain, so it's coordinates depend on time in the following way x(t) = -7 + 10 cos(10t), y(t) = 4 + 10 sin(10 t). Find the speed with which the altitude of the car is increasing or decreasing at t = 0.
2. Prove that the rectangular solid of maximum volume which can be inscribed in a sphere is a cube.
3. Interpret the integral $\iint xy(x+y)dxdy$ over the area between $y=x^2$ and y=x.
4. Change the order of integration and hence predict $\int_0^{\frac{a}{\sqrt{2}}} \int_0^{\sqrt{x^2-y^2}} \log(x^2+y^2)dxdy$ (a>0)
5. Change the order of integration and hence predict $\int_0^a \int_{\sqrt{ax}}^a \frac{y^2}{\sqrt{y^4-a^2x^2}} dydx$

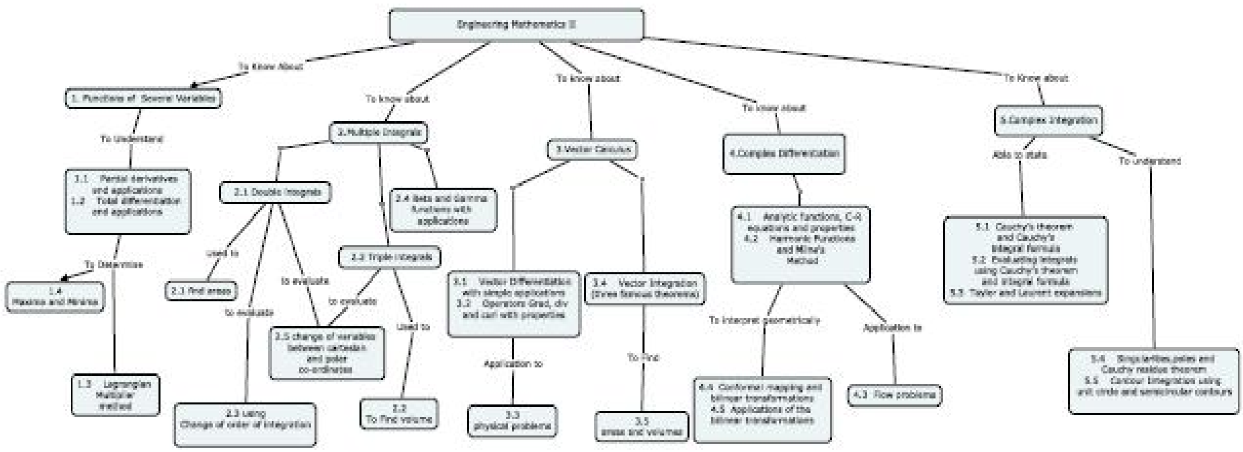
6. If $\vec{f} = 3x^2\vec{i} + 5xy^2\vec{j} + xyz^3\vec{k}$ the estimate the value Of $\nabla \bullet f; \nabla(\nabla \bullet f); \nabla \times f; \nabla \bullet (\nabla \times f)$ and $\nabla \times (\nabla \times f)$ at the point (1,2,3)
7. Predict the value of a and b, so that the surface $ax^3 - by^2z = (a+3)x^2$ and $4x^2y-$
   a. $z^3 = 11$ may cut orthogonally at the point (2,-1,-3)
8. Estimate the integral $\iint_c \vec{f} \times dr$ along the curve x=cost ,y=2sint and z=cost from t=0 to t=$\frac{\pi}{2}$ given that $\vec{f} = 2x\vec{i} + y\vec{j} + z\vec{k}$
9. Predict the value of the integral ∫ $(z+4)/(z^2+2z+5)\,dz$, over the circle $|z+1-i|=2$.
10. Find the Taylor's series expansion of $f(z)=z/(z+1)(z-3)$ about z=0.

Apply

1. Show the volume of the region of the space bounded by the coordinate planes and surface $\sqrt{\frac{x}{a}} + \sqrt{\frac{y}{b}} + \sqrt{\frac{z}{c}} = 1$ is abc/90
2. Show that the rectangular solid of maximum volume which can be inscribed in a sphere is a cube.
3. Apply Green's theorem in a plane to evaluate $\int_c \{x^2(1+y)dx + (x^3+y^3)dy\}$;where c is the square formed by $x = \pm 1, y = \pm 1$.
4. If z=f(x,y) where $u = x^2 - y^2$ and v=xy show that $(\frac{\partial z}{\partial x})^2 + (\frac{\partial z}{\partial y})^2 = 4(x^2+y^2)\{(\frac{\partial z}{\partial u})^2 + (\frac{\partial z}{\partial v})^2\}$
5. Examine the maximum and minimum distance from the origin to the curve $5x^2 + 6xy + 5y^2 - 8 = 0$
6. Examine the functional dependence of the functions $u = \frac{x+y}{x-y}$ and $v = \frac{xy}{(x-y)^2}$:

   If they are dependent , find the relation between them
7. Verify stokes theorem for $\overline{F}$ = $xy\bar{i} - 2yz\bar{j} - zx\bar{k}$ where S is the surface of the rectangular parallelopiped formed by the planes x = 0 , x = 1, y=0, y=2, and z = 3 above the xy-plane
8. Apply reen's theorem in a plane to evaluate $\int_c \{x^2(1+y)dx + (x^3+y^3)dy\}$;where c is the square formed by $x = \pm 1; y = \pm 1$

Concept Map



Syllabus

Functions of Several Variables: Partial derivatives and Jacobians, Total differentiation and applications, Lagrangian Multiplier method, Applications to Maxima and Minima **Multiple Integrals:** Double integrals and areas, Triple integrals and volumes, Change of order of integration, Beta and Gamma functions with applications, Change of variables between Cartesian and polar with applications **Vector calculus:** Vector Differentiation with simple applications, Operators Grad, div and curl with properties, Applications to Physics, Vector Integration(three famous theorems), Applications to areas and volumes **Complex Differentiation:** Analytic functions, C-R equations and properties, Harmonic Functions and Milne-Thompson Method, Applications to flow problems, Conformal maps and bilinear transformations, Applications of the bilinear transformations **Complex Integration:** Cauchy's theorem and consequences, Evaluating integrals using Cauchy's integral formula, Taylor and Laurent expansions, Singularities, poles and Cauchy residue theorem, Contour integration using unit circle and semicircular contours

Text Book:

B.S. Grewal: Higher Engineering Mathematics, 39th Edn., Khanna Publishers, New Delhi,2006

Reference Books:

1. Lecture Notes by the faculty of Department of Mathematics, TCE, Madurai
2. Veerarajan T., Engineering Mathematics, 3rd Edn., Tata McGraw Hill, New Delhi, 2004

3. Venkataraman M.K., Multiple Integrals and Gamma, Beta functions, National Publishing Co., 2004
4. Kreyszig E., Advanced Engineering Mathematics, 8th Edn. John Wiley & Sons,2004
5. Thomas Phinny, Calculus,13th Edition Pearson Education, New Delhi,2005

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Functions of Several Variables**	
1.1	Partial derivatives and Jacobians	2
1.2	Total differentiation and applications	2
1.3	Lagrangian Multiplier method	2
1.4	Applications to Maxima and Minima	2
2.	**Multiple Integrals**	
2.1	Double integrals and areas	1
2.2	Triple integrals and volumes	1
2.3	Change of order of integration	2
2.4	Beta and Gamma functions with applications	2
2.5	Change of variables between Cartesian and polar with applications	2
3	**Vector calculus**	
3.1	Vector Differentiation with simple applications	1
3.2	Operators Grad, div and curl with properties	3
3.3	Applications to Physics	1
3.4	Vector Integration(three famous theorems)	4
3.5	Applications to areas and volumes	3
4	**Complex Differentiation:**	
4.1	Analytic functions, C-R equations and properties	3
4.2	Harmonic Functions and Milne-Thompson Method	2
4.3	Applications to flow problems	1

No.	Topic	No. of Lectures
4.4	Conformal maps and bilinear transformations	2
4.5	Applications of the bilinear transformations	2
5.	**Complex Integration**	
5.1	Cauchy's theorem and consequences	2
5.2	Evaluating integrals using Cauchy's integral formula	2
5.3	Taylor and Laurent expansions	2
5.4	Singularities, poles and Cauchy residue theorem	2
5.5	Contour integration using unit circle and semicircular contours	4
	Total	50

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E 22	4	0	-	4

E22 Electric Circuit Analysis

Program outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

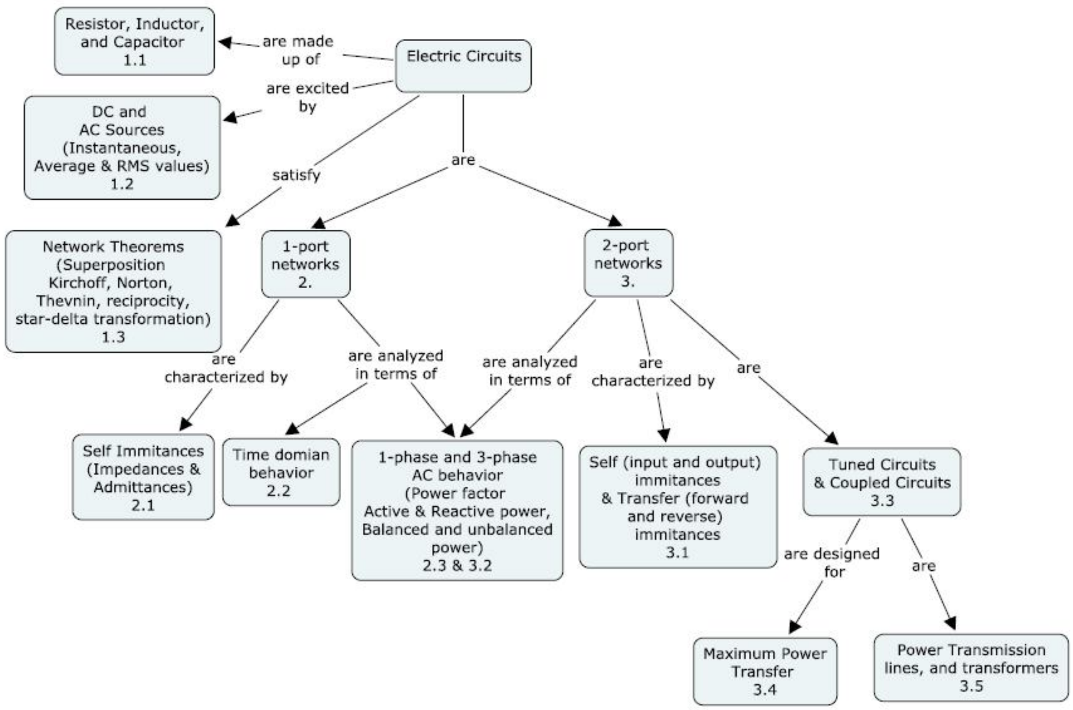
Competencies: At the end of the course the student should be able to

1. Explain the nature of time domain and frequency domain behavior of ideal one-port networks
2. Determine the time-domain and frequency-domain behavior of networks using resistors, inductors, mutual inductance and capacitors, in response to step, and sinusoidal signals at different frequencies
3. Determine the performance of two-port networks
4. Compute the behavior of single tuned and double tuned networks
5. Compute the behavior of three-phase balanced and unbalanced networks
6. Calculate the power consumed by single-phase and three-phase networks
7. Transform the topology of given networks

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	10	10
2	Understand	30	20	20
3	Apply	30	50	50
4	Analyze	20	20	20
5	Evaluate	0	0	0
6	Create	0	0	0

Concept Map



Syllabus

Electric Circuits Analysis: Circuit elements and their electrical behavior, Sources and their characteristics, Network theorems: Mesh and Node Analysis, Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Star-Delta Transformation **One-port Networks**: Self Impedance and admittances, Time domain behavior, AC behavior, Power Triangle, Resonance **Two-port Networks:** Self and Transfer Impedance and admittances, AC behavior, Tuned and Coupled Circuits, Maximum Power Transfer, Power Transmission Lines, Transformers

Textbooks:

1. W.H. Hayt & J.K. Kemmerly and Steven M. Durbin, "Engineering circuit analysis", Tata McGraw Hill, 7th edition, New Delhi, 2007
2. Sudhakar A and Shyam Mohan SP, "Electric Circuit Analysis", Tata Mcgraw Hill, New Delhi, 2008

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	Electric Circuit	
1.1	Circuit elements and their electrical behavior	2
1.2	Sources and their characteristics	5
1.3	Network theorems	
1.3.1	Mesh and Node Analysis	2
1.3.2	Superposition Theorem	2
1.3.3	Thevenin's Theorem	2
1.3.4	Norton's Theorem	2
1.3.5	Star-Delta Transformation	1
2.	One-port Networks	
2.1	Self Impedance and admittances	2
2.2	Time domain behavior	5
2.3	AC behavior	
2.3.1	Power Triangle	3
2.3.2	Resonance	3
3.	Two-port Networks	
3.1	Self and Transfer Impedance and admittances	4
3.2	AC behavior	5
3.2.1	Tuned and Coupled Circuits	4
3.2.2	Maximum Power Transfer	2
3.3	Power Transmission Lines	4
3.4	Transformers	2

Course Designers :

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Sub Code	Lectures	Tutorial	Practical	Credit
E 23	4	0	-	4

E23 Analog Circuits and Systems

Preamble: Signals contain information about a variety of things and activities in our physical world. An observer, be it a human or a machine, invariably needs to condition and process the signals in some predetermined manner to extract the required information. This signal conditioning/processing is usually most conveniently performed by electronic systems. For this to be possible, however, the signal must first be converted into an electrical signal, that is, a voltage or current. This process is accomplished by devices known as transducers, which can be considered as non-ideal voltage or current sources. The signals from the transducers have to be conditioned and processed as per the requirements of the application. These could involve amplification, filtering, modulation demodulation, mixing, frequency synthesizing etc. Complex analog computations can be performed on the signals if analog integrators and adders are available. Many of these processes would require availability signal sources like LC and crystal oscillators as signal carriers and clock generators. In many applications the power level of the processed signal has to be increased significantly using a power amplifier to operate an actuator. While the circuits that performed these functions were designed until a few years ago using discrete active and passive components, they are now increasingly made available in integrated circuit form. However, a small percentage of these circuits have to be still designed using discrete components. Therefore, an electronic designer should acquire the competency of designing the discrete as well as integrated version of these signal conditioning and processing circuits. Initially these circuits were realized vacuum tubes, and since 1960s with bipolar transistors, and now with the mastering of CMOS technology all circuits both discrete and integrated versions are at present mainly designed using MOSFETS.

This course 'E23: Analog Circuits and Systems' is preceded by a two credit course 'Basics of Electronic and Communication Engineering' offered in the first semester which presents an over view of the entire field of electronic engineering. This course is followed by courses 'Mixed Signal Circuits and Systems' and 'Power Electronics'. This course, therefore, is mainly concerned with discrete analog amplifiers and signal generators, and signal conditioning and processing of signals using operational amplifiers. In view of the present day technologies the discrete circuits addressed are MOSFET based.

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

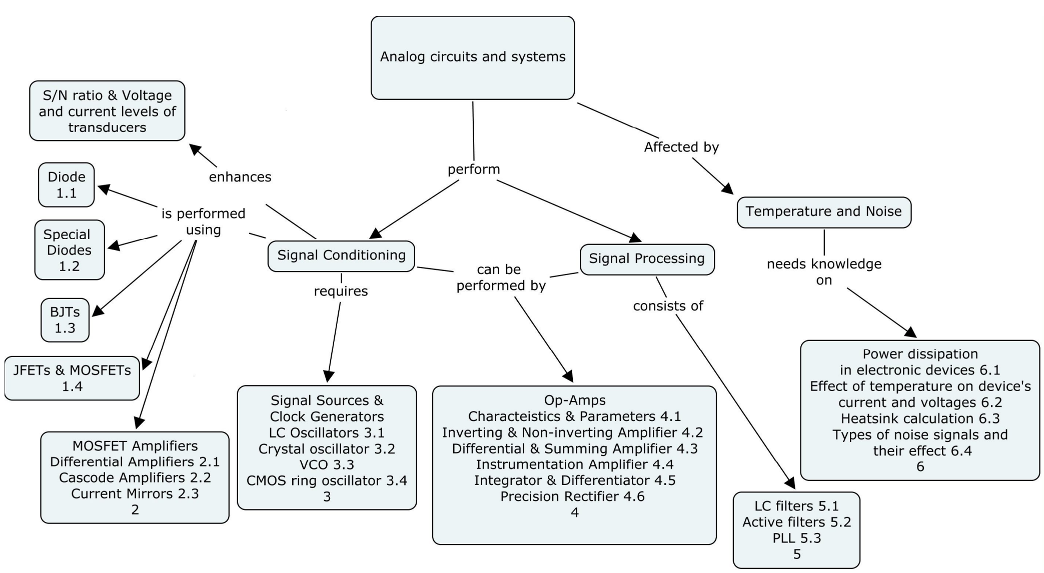
Competencies

1. Design signal conditioning circuits including differential, current and cascode amplifiers and filters using discrete MOSFETs and operational amplifiers
2. Design signal sources for signal conditioning circuits and testing including LC and crystal oscillators, VCO, and clock generators

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	10
2	Understand	20	20	20
3	Apply	40	40	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	40

Concept Map



Syllabus

Devices for Signal Conditioning Circuits: Diode -Operation, V-I Characteristics, Current equation, Parameters and equivalent circuit, Load line analysis, Transition and Diffusion capacitance, Reverse recovery Characteristics, Application of Diodes – Rectifier, Clipper, Clamper **Special Diodes:** Zener diode, Varactor diode, Schottky Diode and their application **BJTs** – Operation, Comparison of characteristics of CB, CE and CC configurations, Fixed and Voltage divider biasing, Stability factor, Application as amplifier and switch, switching characteristics, DC & AC Load line, Low frequency and high frequency hybrid model, AC analysis of BJT CE amplifier **JFETs & MOSFETs -** Construction, Operation, Characteristics, Parameters, Drain current equation, Application as voltage controlled resistor, Small signal model of JFET & MOSFET, Voltage divider biasing, AC analysis of MOSFET CS amplifier **MOSFET Amplifiers:** Differential Amplifiers, Cascode Amplifiers, Current Mirrors **Signal Sources and Clock Generators:** LC Oscillators, Crystal Oscillator, Voltage Controlled Oscillator, CMOS Ring Oscillator **Operational Amplifiers:** Characteristics and Parameters, Inverting and Non-inverting Amplifiers, Differential and Summing Amplifiers, Instrumentation Amplifier, Integrator and Differentiator, Precision Rectifiers, V to I and I to V converters **Filters and PLL:** LC Filters, Active filters – Low pass, High pass, Band pass and Band reject, Phase Locked Loop (PLL) and its applications **Effect of Temperature & noise:** Power dissipation in diode, BJT, JFET and MOSFET, Effect of temperature on device currents, voltages and stability, Heat sink calculation, Types of noise signals -line induced noise, notch filter using an Op-Amp, suppression of RFI and EMI Emissions.

Reference Books:

1. Sedra A.S. and Smith K.C.: Microelectronic Circuits, 5th Edition, Oxford press, 2003
2. Ramakant Gayakwad: Op-Amps and Linear Integrated Circuits, Eastern economy edition, PHI Ltd.,2003
3. Donald A.Neamen: Electronic circuit analysis and design, Second edition, Tata Mc-Graw Hill,2003
4. Robert Boylestad and Lowis Nashelsky: Electronic Devices and Circuit Therory, 6th Edition, PHI Ltd., 2002

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Devices for Signal Conditioning Circuits**	
1.1	**Diode** – Operation, V-I Characteristics, Current equation, Parameters and equivalent circuit, Load line analysis, Transition and Diffusion capacitance, Reverse recovery Characteristics, Application of Diodes – Rectifier, Clipper, Clamper	4
1.2	**Special Diodes:** Zener diode, Varactor diode, Schottky Diode and their application	2
1.3	**BJTs** – Operation, Comparison of characteristics of CB, CE and CC configurations, Fixed and Voltage divider biasing, Stability factor, Application as amplifier and switch, switching characteristics, DC & AC Load line, Low frequency and high frequency hybrid model, AC analysis of BJT CE amplifier	5
1.4	**JFETs & MOSFETs –** Construction, Operation, Characteristics, Parameters, Drain current equation, Application as voltage controlled resistor, Small signal model of JFET & MOSFET, Voltage divider biasing, AC analysis of MOSFET CS amplifier	5
2.	**MOSFET Amplifiers**	
2.1	Differential Amplifiers	4
2.2	Cascode Amplifiers	2
2.3	Current Mirrors	3
3.	**Signal Sources and Clock Generators**	
3.1	LC Oscillators	3
3.2	Crystal Oscillator	2
3.3	Voltage Controlled Oscillator	2
3.4	CMOS Ring Oscillator	1
4.	**Operational Amplifiers**	
4.1	Characteristics and Parameters	2
4.2	Inverting and Non-inverting Amplifiers	1
4.3	Differential and Summing Amplifiers	1
4.4	Instrumentation Amplifier	1
4.5	Integrator and Differentiator	2
4.6	Precision Rectifiers, V to I and I to V converters	1
5	**Filters and PLL**	
5.1	LC Filters	2
5.2	Active filters- Low pass, High pass, Band pass and Band stop	3
5.3	Phase Locked Loop (PLL) and its applications	1
6	**Effect of Temperature & noise**	
6.1	Power dissipation in diode, BJT, JFET and MOSFET	1
6.2	Effect of temperature on device currents, voltages and stability, Heat sink calculation	1
6.3	Types of noise signals -line induced noise, notch filter using an Op-Amp, suppression of RFI and EMI Emissions.	1

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E 24	3	0	-	3

E24 Computers and Programming

(Common to all branches of Engineering B24, C24, D24, E24, G24, T24)

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

c. An ability to design a system or component, or process to meet stated specifications

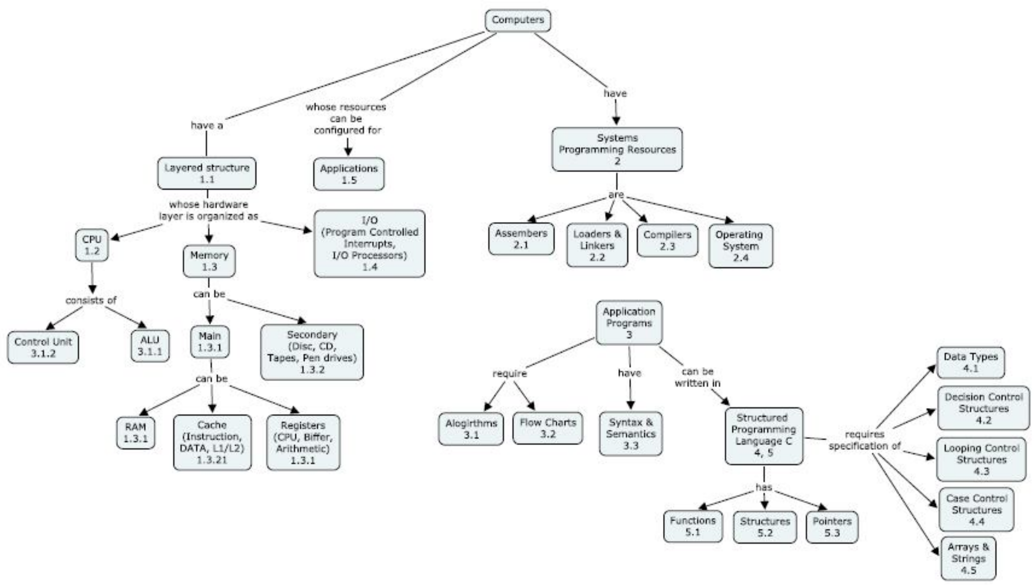
Competencies

1. Select computers for different applications.
2. Comprehend the nature of problems that a computer can solve extremely well - be able to list 5 non-trivial, interesting problems (unique in their own way) which are difficult to solve for a human being but can be solved easily by a computer.
3. Comprehend the following terms in the context of problem solving by a computer: Problem specification, input-output analysis, algorithm, flowchart, pseudo-program, programming language, assembly language, machine language, compiler, assembler, program correctness
4. Explain the difference between arrays and linked lists, and create two examples where arrays are better than linked lists and two examples where linked lists are better than arrays.
5. Explain the difference between iteration and recursion, and create two examples where iteration is better than recursion and two examples where recursion is better than iteration.
6. Design the flowchart and write efficient code for problems like
   - Recursive and iterative programs for binary search
   - Recursive and iterative programs for Fibonacci numbers
   - Recursive and iterative programs for finding the GCD of two numbers
   - Reverse a linked list while traversing it only once
7. Explain the role of pointers in implementing singly linked lists, doubly linked lists, binary trees, and general trees.
8. Explain the reason why different constructs are available for iteration, such as "for" loops, "do...while" loops.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	10	0
2	Understand	20	20	10
3	Apply	50	40	50
4	Analyze	10	20	20
5	Evaluate	0	10	20
6	Create	0	0	0

Concept Map:



Syllabus

Introduction to computers: Layered Structure of a computer, CPU, Memory, Input/Output, Configuring resources of computers for applications **Application Programming:** Algorithms, Flowcharts, Syntax, semantics and execution, **Structured Programming Language:** Symbols and data types, Looping control structures, Decision control structures, Case control structures, Arrays and Strings, **Functions and Pointers:** Functions, Structures, and Pointers **Systems Programming :** Assemblers, Loaders and Linkers, Compilers, Operating Systems

References

1. Leland L. Beck: System Software, Pearson Education, 3rd Edition, 2004
2. John. J Donovan: System Programming, Tata McGraw Hill Edition, 2000
3. Yashavant Kanetkar: Programming in ANSI C, 2nd Edition-BPB Publications
4. Yashavant Kanetkar: Let us C, BPB Publications 8th Edition 2007
5. Yeshavant Kanetkar: Understanding Pointers in C, 2nd Edition BPB Publications
6. Peter Norton : Introduction to computers 6th Edition.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Introduction to computers**	
1.1	Layered Structure of a computer	1
1.2	CPU, Memory	1
1.3	Input/Output	2
1.4	Configuring resources of computers for applications	1
2	**Applications Programming**	
2.1	Algorithms	1
2.2	Flowcharts	1
2.3	Syntax, semantics and execution	1
3.	**Structured Programming Language**	
3.1	Symbols and data types	1
3.2	Looping control structures	3
3.3	Decision control structures	3
3.4	Case control structures	2
3.5	Arrays and Strings	3
4.	**Functions and Pointers**	
4.1	Functions	3
4.2	Structures	3
4.3	Pointers	4
5	**Systems Programming**	
5.1	Assemblers	2
5.2	Loaders and Linkers	4
5.3	Compilers	2
5.4	Operating Systems	2

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
E 25	3	0	-	3

E25 Materials Science

Program Outcomes Addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

Competencies:

1. Explain the physics of thermal expansion, electrical conductivity, ferromagnetic behavior, mechanical hardness, fatigue, creep, and wear at bulk and nano particle level.
2. Explain the chemistry of corrosion and its impact on materials.
3. Choose appropriate material for windings of motors and transformers, wiring harnesses for electrical and electronic equipment, signal interconnects on wiring boards, and on-board and off-board connectors.
4. Choose a conductive coating material for a given specified performance requirement in printed wiring boards and EMI shielding.
5. Identify appropriate laminate for making a printed wiring board for given performance requirement and specified technology.
6. Select with justification suitable magnetic materials for transformers, motors, linear motors, pulse transformers, electromagnets, relays, magnetostrictive sensors and actuators, and smart antennae.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	20
2	Understand	30	30	30
3	Apply	30	30	30
4	Analyze	0	0	0
5	Evaluate	20	20	20
6	Create	0	0	0

Syllabus

Engineering Properties of Materials: Thermal Properties: Expansion, Heat Capacity and Conductivity, Electrical Properties: Conductivity, Dielectric Constant, Dielectric Losses, Dielectric Breakdown, and Insulation; Magnetic Properties: Permittivity, Permeability, Hysteresis, Susceptibility, Magnetic Intensity, Magnetic Saturation and Anisotropy; Mechanical Properties of Bulk Materials: Hardness, Tensile Strength, Fatigue, Creep, Wear, Mechanical Properties of Nano-particles; Corrosion **Conducting Materials:** Windings of motors and transformers, Wiring harnesses for electrical and electronic equipment, Signal interconnects on wiring boards, On-board and off-board connectors, Conductive coatings **Ceramics:** Glasses, Glass-Ceramics, Clay Products, Refractory, Piezoelectric Ceramics

Magnetic Materials: Iron-Silicon Alloys, Transformers, motors, Ferrimagnetic materials –$SmCo_5$, YIG, Al-Ni-Co, Cu-Ni-Fe, Electromagnets and relays, Magnetostrictive sensors and actuators, Smart antennae

Reference books:

1. Van Vlack L.H.: Elements of Materials Science and Engineering, 6th Edition, Addison-Wesley, 1989
2. Callister W. D.: Materials Science and Engineering, John Wiley &Sons, 2007
3. O'Handley R.C.: Modern Magnetic Materials, John Wiley & Sons, 2000

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Engineering Properties of Materials**	
1.1	Thermal Properties: Expansion, Heat Capacity and Conductivity	3
1.2	Electrical Properties: Conductivity, Dielectric Constant, Dielectric Losses, Dielectric Breakdown, and Insulation	3
1.3	Magnetic Properties: Permittivity, Permeability, Hysteresis, Susceptibility, Magnetic Intensity, Magnetic Saturation and Anisotropy	3
1.4	Mechanical Properties of Bulk Materials: Hardness, Tensile Strength, Fatigue, Creep, Wear	3
1.5	Mechanical Properties of Nano-particles	3
1.6	Corrosion	3
2	**Conducting Materials**	
2.1	Windings of motors and transformers	1
2.2	Wiring for electrical and electronic equipment	2
2.3	Signal interconnects on wiring boards	2
2.4	On-board and off-board connectors	2
2.5	Conductive coatings	2
3.	**Ceramics**	

No.	Topic	No. of Lectures
3.1	Glasses, Glass-Ceramics	2
3.2	Clay Products, Refractory	1
3.2	Piezoelectric Ceramics	2
4.	**Magnetic Materials**	
4.1	Iron-Silicon Alloys- Transformers, motors	2
4.2	Ferrimagnetic materials –$SmCo_5$	1
4.3	YIG, Al-Ni-Co, Cu-Ni-Fe -Electromagnets	2
4.4	Magnetostrictive sensors and actuators	2
4.5	Smart antennae	1

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
E 26	2	0	-	2

E26 Ecology

(Common to all branches of Engineering B46, C26, D26, E26, G36, T26)

Preamble: Progress, as majority perceives it, implies increasing energy flow through the society. With exponentially increasing population and per capita consumption, single most concern of all people across the world ought to be the threat to the sustainability of life we know of. World Commission on Environment and Development issued a report in 1987 entitled “Our Common Future” which concluded that then existing trends of economic development and the accompanying environmental degradation were unsustainable. It clearly emphasized that the health of global environment is essential for the future of every one. Therefore, engineers, who through their technological activities greatly influence the health of global environment, need to be sensitive about what keeps the ecosystem sustainable for humans. This course aims to achieve this sensitization.

Program outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

d. An ability to identify, formulate and solve engineering problems

h. An ability to engage in life-long learning

i. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.

j. An ability to consider issues from global and multilateral views.

Competencies: At the end of the course the student should be able to

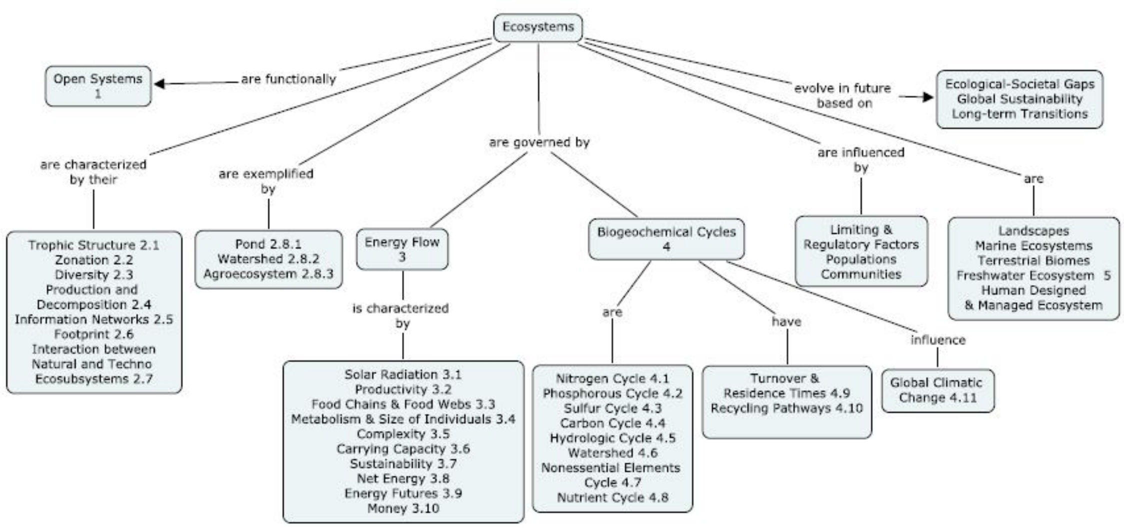
1. Explain why an ecosystem is an open system
2. Explain how an ecosystem is characterized by trophic structure, zonation, diversity, production and decomposition, information networks, footprint, interaction between natural and techno ecosubsystems.
3. Analyze specific ecosystems like a pond, watershed and agroecosystem.
4. Trace the energy flows through an ecosystem by way of solar radiation, productivity, food chains and food webs, metabolism and size of individuals, carrying capacity, complexity, sustainability, net energy, energy futures and money.

5. Trace how an ecosystem is governed by different biogeochemical cycles, including nitrogen, phosphorous, sulfur, carbon, hydrologic, non-essential elements and nutrient cycles, and watershed.
6. Analyze the biogeochemical cycles in terms of turnover and residence times and recycling pathways.
7. Explain how global climatic changes occur.
8. Analyze the fresh water ecosystem

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	30	20	10
2	Understand	50	40	40
3	Apply	10	20	20
4	Analyze	10	10	20
5	Evaluate	0	10	10
6	Create	0	0	0

Concept Map



Syllabus

Ecosystem as an Open System; Characterization of Ecosystems: Trophic structure, Zonation, Diversity, Production and Decomposition, Information Networks, Ecological Footprint, Interaction between Natural and Techno Eco-subsystems, Examples of Ecosystems: Pond, Watershed, Agro-ecosystem **Energy Flow in Ecosystem:** Solar Radiation, Productivity, Food Chains and Food Webs, Metabolism and Size of Individuals, Carrying Capacity, Complexity, Sustainability, Net energy, Energy Futures, Money **Biogeochemical Cycles:** Nitrogen Cycle, Phosphorous Cycle, Sulfur Cycle, Carbon Cycle, Hydrologic Cycle, Non-essential Elements Cycle, Nutrient Cycle, Watershed, Turnover and Residence Times, Recycling Pathways, Global Climatic Change **Fresh Water Ecosystem**

Text Book

1. Odum E.P. and Barret G. W.: Fundamentals of Ecology, 2005, Thomson Brooks/Cole

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Ecosystem as an Open System**	1
2	**Characterization of Ecosystems**	
2.1	Trophic structure and Zonation	1
2.2	Diversity and Ecological Footprint	1
2.3	Production and Decomposition	1
2.4	Information Networks	1
2.5	Interaction between Natural and Techno Ecosubsystems	1
2.6	Examples of Ecosystems	
2.6.1	Pond / Watershed / Agroecosystem	2
3	**Energy Flow in Ecosystem**	
3.1	Solar radiation , Productivity	1
3.2	Food Chains and Food Webs	1
3.3	Metabolism and Size of Individuals	1
3.4	Carrying Capacity and Complexity	1
3.5	Sustainability	1
3.6	Net Energy, Energy Future and Money	2
4.	**Biogeochemical Cycles**	
4.1	Nitrogen Cycle	1
4.2	Phosphorous Cycle	1
4.3	Sulfur Cycle	1
4.4	Carbon Cycle	1
4.5	Hydrologic Cycle	1
4.6	Non-essential Elements Cycle and Nutrient Cycle	1
4.7	Watershed	1
4.8	Turnover, Residence Times and Recycling Pathways	1
4.9	Global Climatic Change	1
5.	**Fresh Water Ecosystem**	**2**

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5. K. Radha krchem@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
E 27	-	-	2	1

E27 Analog Circuits and Systems Lab

1. Static characteristics of BJT and MOSFET
2. Inverting, non-inverting, summing and differential amplifiers using op-amp
3. Integrator and differentiator using op-amp
4. Precision rectifier and Schmitt trigger using op-amp
5. Second order Butterworth / Sallen-key low pass and high pass active filters
6. Colpitts oscillator
7. Transient response of RLC circuits
8. Simulation of differential amplifier and instrumentation amplifier using PSPICE
9. Simulation of precision rectifier and current mirror using PSPICE
10. Simulation of active filters using PSPICE
11. Simulation of I to V and V to I converters
12. Simulation of VCO and PLL

Sub Code	Lectures	Tutorial	Practical	Credit
E 28	-	-	2	1

E28 Computer Programming Lab

(Common to all branches of Engineering B28, C28, D28, E28, G28, T28)

Any twelve experiments to be performed

List of Experiments

1. Simple Programs
    a. Fibonacci Series
    b. Sum of set of numbers
    c. Generation of prime numbers
2. Matrix Addition, Subtraction and Multiplication
3. Sorting of Names & Numbers
4. String Manipulation
5. Bitwise Operation
6. Macro Expansion with Conditional Compilation
7. Array of Structures
8. Pointers to functions
9. Pointers to Pointers
10. File Manipulations
    a. Read the file and display the contents of the file
    b. Read the lines from the keyboard and write it into a specified file
12. Store and retrieve the structure elements in a specific file
13. Program to Illustrate int 86() function
14. Program for creating files with read and write permissions

Sub Code	Lectures	Tutorial	Practical	Credit
E 29	-	-	2	1

E29 Work Shop

(Common to all branches of Engineering B29, C29, D29, E29, G29, T29)

Objective: The students of all branches of engineering would get exposure to basic practices in a mechanical workshop. The students get trained to acquire skills at basic level in fitting, carpentry, joining, metal forming and plumbing.

List of Exercises

I Fitting

1. Fitting tools and practice
2. Joining of two different metals with adhesives
3. Preparation of single step joint
4. Preparation of 'V' joint
5. Preparation of Gauge joint
6. Preparation of Taper sep joint

II Carpentry

1. Carpentry tools and practice
2. Joining different types of wood with adhesives
3. Preparation of Half joint
4. Preparation of Dovetail joint
5. Preparation of T-brittle joint
6. Turning on wood lathe

III Demonstration on Tools and Practice

1. Welding
2. Soldering
3. Brazing
4. Foundry and Moulding practice
5. Smithy forging
6. Plumbing
7. House wiring
8. Press work

Terminal Examination: Students are tested in fitting and carpentry trades

BOARD OF STUDIES MEETING

B.E Degree (Electrical and Electronics Engg.) Program

Third Semester

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

REVISED CURRICULUM AND DETAILED SYLLABI

FOR

B.E. DEGREE (Electrical and Electronics Engg.) PROGRAM

THIRD SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2008-2009 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Department of Electrical and Electronics Engineering

Graduating Students of B.E. program of EEE will be able to

1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power
2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015

Department of Electrical and Electronics Engg.

Scheduling of Courses

Semester	Theory Courses						Practical/Project		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					E88 Project 0:12	
7th (21)	E71 Mgmt. The. & Practice 3:0	E72 Protection & Switchgear 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0			E78 Project 0:6	
6th (21)	E61 Accounting & Finance 3:0	E62 Power System Analysis 3:0	E63 Electric Drives 3:0	E64 Design with FPGAs 3:1	Elective 1 3:0	Elective 2 3:0	E67 Power System Simulation Lab 0:1	E68 Power Electronic & Drives Lab 0:1	
5th (24)	E51 Engineering Mathematics – 5 4:0	E52 Generation, Transmission & Distribution 4:0	E53 Power Electronics 3:0	E54 Embedded Systems 3:1	E55 Mixed Signal Circuits and Interfacing 3:0	E56 Electrical Machine Design 3:0	E57 Digital Signal Processing Lab 0:1	E58 Microprocessors Lab. 0:1	E59 Instrumentation and Control Lab 0:1
4th (25)	E41 Engineering Mathematics – 4 4:0	E42 AC Machines 3:1	E43 Microprocessors 4:0	E44 Thermal Engineering 3:0	E45 Digital Signal Processing 3:0	E46 Instrumentation 3:0	E47 AC Machines Lab. 0:1	E48 Thermal Engineering Lab 0:1	E49 Professional Communications 1:1
3rd (24)	E31 Engineering Mathematics – 3 4:0	E32 Electromagnetics 3:1	E33 DC Machines & Transformers 3:1	E34 Digital Systems 3:0	E35 Data Structures 3:0	E36 Control Systems 3:1	E37 Digital Systems Lab 0:1	E38 DC Machines & Transformers Lab 0:1	
2nd (23)	E21 Engineering Mathematics – 2 4:0	E22 Electric Circuit Analysis 4:0	E23 Analog Circuits & Systems 4:0	E24 Computers and Programming 3:0	E25 Material Science 3:0	E26 Ecology 2:0	E27 Analog Circuits and Systems Lab 0:1	E28 Computer Programming Lab 0:1	E29 Workshop 0:1
1st (25)	H11 Engineering Mathematics – 1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of M & CE 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab 0:1	H18 Chemistry Lab 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engg.) Program

SUBJECTS OF STUDY

(For the candidates admitted from 2008-2009 onwards)

THIRD SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
E 31	Engineering Mathematics III	BS	4	-	-	4
E 32	Electro magnetics	DC	3	1	-	4
E 33	DC Machines and Transformers	DC	3	1	-	4
E 34	Digital systems	DC	3	-	-	3
E 35	Data Structures	ES	3	-	-	3
E 36	Control Systems	DC	3	1	-	4
PRACTICAL						
E 37	Digital systems Lab.	DC	-	-	2	1
E 38	DC Machines and Transformers Lab.	DC	-	-	2	1
Total			**19**	**3**	**4**	**24**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engg.) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2008-2009 onwards)

THIRD SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	E31	Engineering Mathematics III	3	50	50	100	25	50
2	E32	Electro magnetics	3	50	50	100	25	50
3	E33	DC Machines and Transformers	3	50	50	100	25	50
4	E34	Digital systems	3	50	50	100	25	50
5	E35	Data Structures	3	50	50	100	25	50
6	E36	Control Systems	3	50	50	100	25	50
PRACTICAL								
7	E37	Digital systems Lab.	3	50	50	100	25	50
8	E38	DC Machines and Transformers Lab.	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

E31 Engineering Mathematics III **4:0**

Preamble:

An engineering student needs to have some basic mathematical tools and techniques. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this the course aims at giving the adequate exposure in the theory and applications of Fourier series, Fourier Transforms, PDE's and BVP

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

j. Graduate will develop confidence for self education and ability for life-long learning.

Competencies

1. Express the periodic functions arising in the study of engineering problems as Fourier series of Sines and Cosines.
2. Find the Fourier series for the typical waveforms.
3. Find the Fourier series for discrete data using Harmonic Analysis.
4. To study some of the well-known integral transforms (like Fourier, Fourier Sine and Cosine) and properties.
5. Formulate simple Engineering problems as Partial Differential Equations and state the boundary conditions.
6. Solve Partial Differential Equations, linear, nonlinear, homogeneous and non-homogeneous, by various methods.
7. Solve the standard Partial Differential Equations arising in engineering problems like Wave equation, Heat flow equation (one dimensional and two dimensional, Cartesian and polar coordinates) by Fourier series.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Define Periodic function?
2. Show that f(x)= x^3 is an odd function?
3. State the Fourier Series for the function f(x) in the interval (1, 3)?
4. Identify the Kernel for Fourier Cosine and Sine Transforms?
5. State Parsevals Identity?
6. State Convolution Theorem?

Understand

1. Distinguish between Odd and Even functions?
2. Use the Fourier series expansion of $x^2 = \frac{\pi^2}{3} + 4\sum_{1}^{\infty}(-1)^n \frac{\cos nx}{n^2}$, $-\pi < x < \pi$

to predict the value of $\sum \frac{1}{n^2}$?

3. Discuss harmonic analysis?
4. Discuss Fourier Series in Complex form?
5. Interpret the result $F\left[f(ax)\right] = \frac{1}{a}F\left(\frac{s}{a}\right)$.
6. Interpret the usage of Parsevals theorem?
7. Discuss the two methods of forming partial differential equations.
8. Discuss the solution of $\frac{\partial^2 z}{\partial x \partial y} = x^2 y$ by direct integration?
9. Discuss the working rule of solving the Lagrange's linear equation?
10. Discuss the working rule of solving f(p,q)=0?
11. Discuss the working rule of solving f(z,p,q)=0?

Apply

1. Find the Fourier transform of $e^{-a^2x^2}$. Hence prove that $e^{-\frac{x^2}{2}}$ is self reciprocal with respect to Fourier transforms and (i) Find the Fourier Cosine transform of e^{-x^2}?
2. Solve the equation $z^2(p^2 + q^2 + 1) = c^2$ where c is a constant?
3. Obtain the first three harmonics in the Fourier series expansion in (0,12) for the function y=f(x) defined by the table given below:

X:	0	1	2	3	4	5	6	7	8	9	10	11
Y:	1.8	1.1	0.3	0.1	0.5	1.5	2.16	1.88	1.25	1.30	1.76	2

4. Find the Fourier transform of f(x), if $f(x) = \{1 - |x|, for|x| < 1 and 0, for|x| > 1\}$.

Syllabus

Fourier Series: Dirichlet's conditions, General Fourier Series, Half range Sine and Cosine series, Parse Val's Identity, Harmonic Analysis, Complex form of Fourier Series, Fourier Transformation: Fourier Integral Theorem, Fourier Transform, Fourier Sine and Cosine Transforms, Convolution Theorem, properties, Parseval's Identity .Partial Differential Equations: Formation, Solution of standard types of first order equations, Lagrange's linear equation, Linear partial differential equations of second and higher order with constant coefficient. Boundary Value Problem: Classification of Second Order linear partial differential equations, One-dimensional Wave equation, One dimensional heat equation, Solution by Fourier Series, Boundary Value Problem (contd.): Steady State Solution of two dimensional heat equation in Cartesian Co-ordinates, Laplace equation in Polar Co-ordinates, Solution by Fourier Series method.

Text Book

B.S. Grewal: Higher Engineering Mathematics, 39^{th} Edn. , Khanna Publishers, New Delhi, 2007.

References

1. Lecture Notes by the faculty of Department of Mathematics, TCE ,Madurai.
2. Veerarajan .T: Engineering Mathematics, 3^{rd} Edition. , Tata McGraw Hill, NewDelhi,2004
3. Kandasamy. P, Thilagavathy.k and Gunavathy.K "Engineering Mathematics" Fourth Revised Edition, S.Chand& Co., New Delhi.2000.
4. Venkatraman M.K., Engineering Mathematics (Vol II), National Publishing Chennai.

Course contents and Lecture Schedule

No.	Topic	No. Of Lectures
1.	**Fourier Series**	
1.1	Dirichlet's conditions, General Fourier Series	3
1.2	Half range Sine and Cosine series	3
1.3	Parse Val's Identity	1
1.4	Harmonic Analysis	2

1.5	Complex form of Fourier Series	2
2.	**Fourier Transformation**	
2.1	Fourier Integral Theorem, Fourier Transform	2
2.2	Fourier Sine and Cosine Transforms	2
2.3	Convolution Theorem	1
2.4	Properties, Parseval's Identity	2
2.5	Discrete Fourier Transform, Discrete time Fourier Transform	2
3	**Partial Differential Equations**	
3.1	Formation	2
3.2	Solution of standard types of first order equations	3
3.3	Lagrange's linear equation	2
3.4	Linear partial differential equations of second and higher order with constant coefficient	3
4	**Boundary Value Problems**	
4.1	Classification of Second Order linear partial differential equations	1
4.2	One-dimensional Wave equation, Solution by Fourier Series	4
4.3	One dimensional heat equation, Solution by Fourier Series	4
4.4	Steady State Solution of two dimensional heat equation in Cartesian Co-ordinates, Solution by Fourier Series	4
4.5	Laplace equation in Polar Co-ordinates, Solution by Fourier Series	4

Course Designers

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E32 Electromagnetics **3:1**

Preamble:

The Course is designed to impart knowledge of fundamentals of vector calculus, concept of electric and magnetic fields (both static and time varying) applicable to electrical engineering. The course exposes the students to the concept of capacitance, Inductance, magnetic/conducting/Insulating materials and its boundary conditions. Force and Torque produced by the Electromagnetic Fields.

After completing this course, student can

- Understand the concept of Electric & Magnetic fields and their effects.
- Perform calculation.
- Study application in various electrical systems.

Program Outcomes addressed

After studying this course students can:

a. demonstrate knowledge of mathematics, Science and engineering relevant to Electromagnetic fields.

b. demonstrate an ability to identify, formulate and solve Electromagnetic field problems.

d. demonstrate an ability to design a capacitors, Inductors, dielectric circuits for cables and magnetic circuits fir Transformer and Electric machines

k. participate and succeed in competitive examinations.

Competencies

1. Visualize, sketch, model and compute the static electric field distribution resulting from a set of static charges in vacuum, conductors and dielectrics.
2. Visualize, sketch, model and compute the static magnetic field distribution resulting from a set of current densities in vacuum and magnetic materials.
3. Visualize, sketch and compute the static and dynamic electromagnetic field distribution in transformers, dc machines and ac machines.
4. Select and apply dielectric, magnetic and conducting materials to meet the circuit requirements of basic electric components such as capacitors, inductors, resistors and transformers.
5. Model and analyze capacitors, cables and transmission lines.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	0
2	Understand	30	30	20
3	Apply	40	40	60
4	Analyze	10	10	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Understand

1. Draw the sketch of electric field and equipotential surface for a point charge.
2. Distinguish electric and magnetic dipoles.
3. Estimate the total electric flux density at the origin due to point charge of 100 μC at (2,3,-5) and an infinite line charge with a density of 20pC/mt. at x=4
4. Discuss the continuity equation of current with respect to skin effect in the conductors.
5. Is a field produced by a current carrying conductor is rotational or irrotational?
6. Predict the causes for the field to refract or reflect at the interface of different mediums.
7. Compare and contrast polarization and magnetization.
8. Compare electric and magnetic potentials.
9. Classify the magnetic materials according to magnetization of dipoles.
10. Explain the concept of images in finding capacitance between a transmission line and ground.
11. Illustrate the concept of calculating the mutual inductance between transmission line conductors.
12. Explain the concept of emf induced in an AC machine using Maxwell's equation?
13. At the interface of two different dielectrics only tangential component of electric field and normal component of electric flux density exists. Why?
14. Summarize the Maxwell's equation both in point form and integral form for static and dynamic fields?

15. In a parallel plate capacitor to increase the energy stored in dielectrics for the same applied voltage, what changes have to be made in the capacitor design?
16. Explain the reasons for using multiple dielectrics in a cable?
17. Summarize and support with equations that the principles which apply to conductors in electrostatic fields.
18. What the force produced by a square loop of current carrying conductor in a uniform magnetic field.

Apply

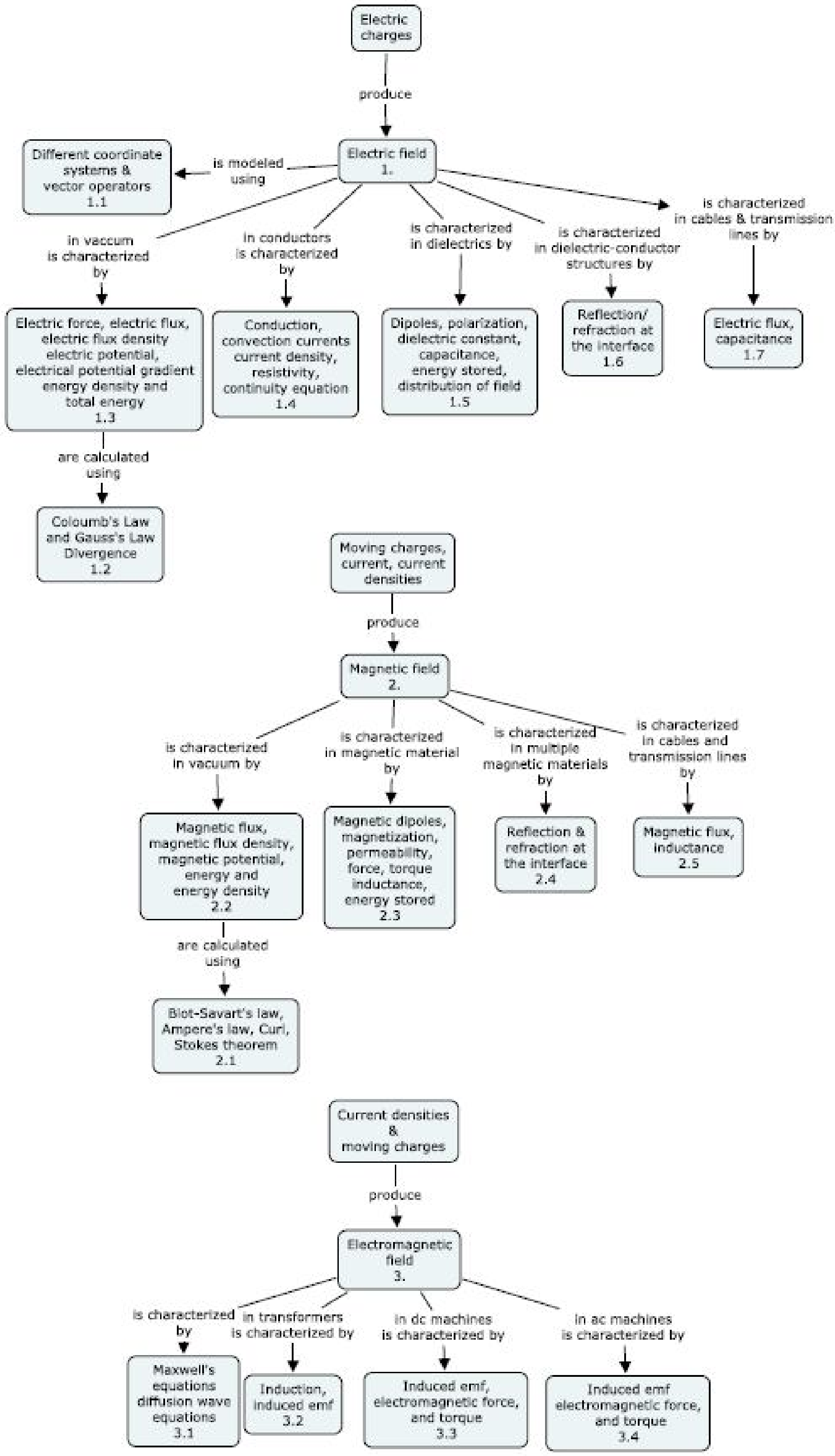
1. Show that electric filed between capacitor plates is given by $\rho_s/\epsilon o$; Volts/mt.
2. Derive an expression for dynamically induced emf using Maxwell's equation for a DC machine?
3. Show that the net electric force produced by set of charges (point, line, surface) in vacuum obeys superposition principle?
4. Calculate the electric potential at (2, 0, 4) due to an infinite line with a charge density of 20 nC/M placed along Z axis?
5. Calculate the magnetic flux density at (5, 0, 3) due to a finite line of 10 M along z axis and carrying current of 5 Amps in z direction?
6. Derive an expression to find the torque experienced by a square current carrying loop in a uniform magnetic field?
7. Derive an expression for finding diffusion when the conductor is exposed to electromagnetic fields?
8. Estimate the force experienced by an armature conductor of 1 M. length carrying current of 10 Amps in Z direction in an uniform magnetic field of B = 10 ($a_x + 2\ a_y$); mT
9. Estimate the change in capacitance when the separation between transmission lines is increased twice for the same charge densities.
10. Find the area of the curved surface of a right circular cylinder of radius r and height h using cylindrical coordinates?
11. Find the internal inductance per unit length of a cylindrical conductor of radius a using the energy integral?
12. A square cross section air core toroid has r1 = 5 cm, r2 = 7 cm, a = 1.5 cm and 700 turns. If the inductance is 495 µH, find the turns in toroid using exact and approximate relationships?
13. What voltage is developed by a Faraday's disk generator with the meter connections at r1= 1mm and r2 = 100 mm, when the disk turns at 500 r.p.m. in flux density of 0.8 T?
14. A dipole for which p = 10 $\epsilon_o\ a_z$, C.M. is located at the origin. What is the equation of the surface on which E_z=0 but $E \neq 0$?

15. Determine displacement current and conduction current flowing through the capacitor C connected to an AC source with $v=V_m \sin\omega t$ through a conducting wire?
16. Determine both sides of divergence theorem for the field **D** = $2xy\, a_x + x^2\, a_y$; c/m^2 and the rectangular parallelepiped formed by the planes x =0 and 1, y = 0 and 2 and z = 0 and 3?
17. Calculate **H** at a point midway between the two similar circular current loops of radius 3 M. and I = 20 amps are in parallel planes?

Analysis

1. A conductor of substantial thickness has a surface charge density of ρ_s. Assuming that $\Psi = 0$ within the conductor. Show that $D = \pm \rho_s$ just outside the conductor by constructing a small special Gaussian surface?
2. A parallel plate capacitor has free space as the dielectric and a separation of d. Without disturbing the charge Q, the plates are moved close together to d/2, with a dielectric of $\epsilon_r = 3$ completely filling the space between the plates. What changes occur in **D**, **E**, V, C and W_E?
3. Two finite current sheets with density k_o are parallel and have their currents in opposite direction. Is the force repulsion or attraction? Justify your answer with sketches of magnetic flux line and calculating force per unit area on the sheets?
4. In a DC machine, if the air gap length is reduced for the same machine rating, what happens to the exciting current requirement?

Concept Map


Electric charges
produce
Electric field 1.
is modeled using
Different coordinate systems & vector operators 1.1
in vaccum is characterized by
Electric force, electric flux, electric flux density electric potential, electrical potential gradient energy density and total energy 1.3
are calculated using
Coloumb's Law and Gauss's Law Divergence 1.2
in conductors is characterized by
Conduction, convection currents current density, resistivity, continuity equation 1.4
is characterized in dielectrics by
Dipoles, polarization, dielectric constant, capacitance, energy stored, distribution of field 1.5
is characterized in dielectric-conductor structures by
Reflection/ refraction at the interface 1.6
is characterized in cables & transmission lines by
Electric flux, capacitance 1.7
Moving charges, current, current densities
produce
Magnetic field 2.
is characterized in vacuum by
Magnetic flux, magnetic flux density, magnetic potential, energy and energy density 2.2
are calculated using
Biot-Savart's law, Ampere's law, Curl, Stokes theorem 2.1
is characterized in magnetic material by
Magnetic dipoles, magnetization, permeability, force, torque inductance, energy stored 2.3
is characterized in multiple magnetic materials by
Reflection & refraction at the interface 2.4
is characterized in cables and transmission lines by
Magnetic flux, inductance 2.5
Current densities & moving charges
produce
Electromagnetic field 3.
is characterized by
Maxwell's equations diffusion wave equations 3.1
in transformers is characterized by
Induction, induced emf 3.2
in dc machines is characterized by
Induced emf, electromagnetic force, and torque 3.3
in ac machines is characterized by
Induced emf electromagnetic force, and torque 3.4

Syllabus

Electric Fields: Vector Operators and Coordinate Systems, Coulomb's Law; Gauss's Law and Divergence Theorem; Electric force, electric flux, electric flux density, electric potential, electrical potential gradient, energy density and total energy in vacuum; Conduction & convection currents, current density, resistivity and continuity equation in conductors; Dipoles, polarization, dielectric constant, capacitance, energy stored, distribution of field in dielectric materials; Reflection/refraction at the interface in conductor-dielectric structures; Electric flux and capacitance in cables and transmission lines.

Magnetic Fields: Biot-Savart's law, Ampere's law and Stoke's theorem; Magnetic flux, magnetic flux density, magnetic potential, Energy and energy density in vacuum; Magnetic dipoles, magnetization, permeability, force, torque, inductance and energy stored; Magnetic flux density and angle of refraction in multiple magnetic materials; Magnetic flux and inductance in cables and transmission lines.

Electromagnetic Fields: Maxwell's and diffusion wave equations; Induced emf in transformers; Induced emf, electromagnetic force and torque in dc machines; Induced emf, electromagnetic force and torque in ac machines.

Text Book:

1. William Hayt Jr. and John A. Buck , "Engineering Electromagnetics", TMH publishing co. ltd., 7th Edition, 2003.

Reference Books:

1. Joseph A. Edminister , "Theory and problems of Electromagnetics", Schaum's series Mc Graw Hill International Edition, 2nd Edition, 1993, Singapore.
2. K.A.Gangadhar, " Field theory", Khanna Publishers, 13th Edition 1997, N.Delhi
3. S.P.Seth," Fundamentals of Electromagnetics", Wiley Eastern Ltd., 1st Edition, 2002.

Course content and Lecture Schedule

Sl. No.	Topic	Periods
1.	**Electric Fields**	
1.1	Vector Operators and Coordinate Systems	2
1.2	Coulomb's Law, Gauss's Law and Divergence theorem	3

1.3	Electric force, electric flux, electric flux density, electric potential, electrical potential gradient, energy density and total energy in vacuum	4
1.4	Conduction & convection currents, current density, resistivity and continuity equation in conductors	3
1.5	Dipoles, polarization, dielectric constant, capacitance, energy stored, distribution of field in dielectric materials	3
1.6	Reflection/refraction at the interface in conductor-dielectric structures	2
1.7	Electric flux and capacitance in cables and transmission lines	2
2.	**Magnetic Fields**	
2.1	Biot-Savart's law, Ampere's law and Stoke's theorem	2
2.2	Magnetic flux, magnetic flux density, magnetic potential, Energy and energy density in vacuum	3
2.3	Magnetic dipoles, magnetization, permeability, force, torque, inductance and energy stored	3
2.4	Magnetic flux density and angle of refraction in multiple magnetic materials	3
2.5	Magnetic flux and inductance in cables and transmission lines	2
3.	**Electromagnetic Fields**	
3.1	Maxwell's and diffusion wave equations	3
3.2	Induced emf in transformers	1
3.3	Induced emf, electromagnetic force and torque in dc machines	2
3.4	Induced emf, electromagnetic force and and torque in ac machines	2

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E33 DC Machines and Transformers 3:1

Preamble: Electrical drive is the common motive power for driving the wheels of the industry. Nearly three quarters of total power generated is utilized by the industry. Electrical drive is superior to other forms of prime movers in terms of efficiency, control and pollution. Electrical machines can be static or dynamic in nature. Transformers are static electrical devices used to convert voltage levels in transmission, distribution and utilities. DC, induction, synchronous and special machines are dynamic in nature. DC machines have simple operating characteristics even though they are less preferred today because of several construction and maintenance issues. They are still the best machines for controlling.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

k. Graduate who can participate and succeed in competitive examinations.

Competencies: At the end of the course the student should be able to

1. Explain the basic principles of electromechanical energy conversion
2. Determine the behavior of multiple excited systems such as synchronous machines
3. Explain and determine the electro-mechanical, heating, cooling behavior of rotating machines under different operating and load conditions
4. Determine the performance of DC machines and transformers from the pre-determined and determined test data
5. Choose from currently commercially available DC machines and transformers for a given application

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	10	10	10
2	Understand	40	40	40
3	Apply	50	50	50
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember

1Define field energy and co-energy

2. How transformers classified

3. State the advantages of an autotransformer

4. Write the emf equation of a dc machine

5. What is meant by armature reaction

6. Draw the speed torque characteristics of dc series and shunt motor

7 .Name the various methods of speed control of dc motor

8. List the merits and demerits of Swinburne's test

Understand

1. Enumerate the chief advantages of electric energy over other forms of energy.

2. Derive the emf equation of an alternator

3. Deduce an expression for torque in round rotor machines

4. Explain the principle of operation of Transformer

5. What are the various losses in a dc machine? How they vary with load?

6. Derive the condition for maximum efficiency of a transformer.

7. Describe the mechanical construction and electrical characteristics of a commutator .Explain it's action.

8. Obtain the equivalent circuit of the transformer from the basic principles.

9. What are the applications of dc series ,shunt and compound motors.

10. Where and why autotransformers are used?

11. Why do all practical energy conversion devices make use of the magnetic field as a coupling medium rather than an electric field.

12. What is the significance in torque/force derivation in an electro mechanical energy device.

Apply

1. In an electromagnetic relay the exciting coil has 1000 turns. The cross sectional area of the core is 25 sq,.cm.The reluctance of the magnetic circuit may be neglected. Find the coil inductance for an airgap of 1cm. What is the field energy when the coil carries a current of 2A.
2. Find the number of series turns required for each phase of 50Hz,10 pole alternator with 90 slots. The winding is to be star connected to give a line voltage of 11KV. The flux per pole is 0.16 wb.

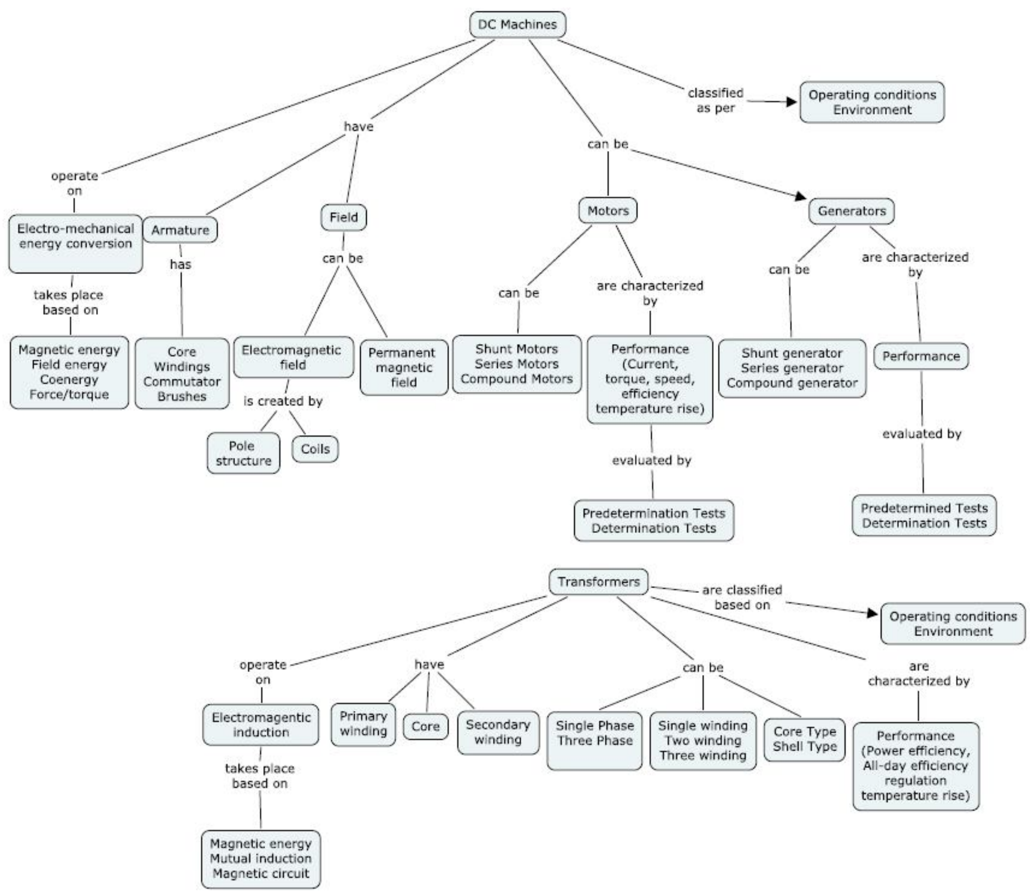
3. In a 25 KVA,2000/200 V transformer the iron and the copper losses are 350 and 400 W respectively. Calculate the efficiency on upf at full load and half full load.
4. A200V shunt motor takes 10A on no load . The stray load loss at aline current of 100A is 50% of the no load loss. Calculate the efficiency at a line current of 100 A if armature and field resistances are 0.2 and 100 ohms respectively.
5. A 50 KVA ,2200/110V transformer gave the following test results

OC TEST: 400W,10A,110V(lv side)

SC TEST: 808W,20.5A,90V(hv side)

Compute all the parameters of the equivalent circuit referred to hv side of the transformer.

Concept Map



Syllabus:

Principles of Electro mechanical Energy Conversion- Energy in magnetic systems- Field energy and Coenergy- Multiple excited Magnetic field system- Forces /torques in systems- Energy conversion via Electric field- Dynamic equation in Electro mechanical systems

Basic concept in Rotating machines-Elementary machines- Generated Emf- MMF of distributed AC winding- Rotating magnetic fields- Torques in round Rotor machines- Losses and efficiency- Rating and loss dissipation- Matching characteristics of machines and loads

Transformers- Transformer construction and principle- Ideal Transformer- Transformer on no load &load- Equivalent circuit of Transformer- Losses, efficiency and regulation- Auto transformer and three phase transformer- Parallel operation of Transformers

Dc machines- Emf and torque- Circuit model-Armature reaction- commutation- Characteristics of generators and Motors- Speed control of dc motors- DC machine application

Testing of DC machines and Transformers- OC &SC test on transformers- Sumpner's test- Swinburne's test- Heat run test- Hopkinson's test- Testing standards

TEXT BOOKS:

1. D.P.Kothari & I.J.Nagrath, " Electrical Machines", Tata-McGrawhill, Newdelhi, 3rd Edition, 2004

2. R.K.Rajput, " Electrical Technology", Laxmi Publications, 3rd edition, 2005.

Reference Books:

1. Vincent Del Toro, "Electro-mechanical Energy Conversion", PHI, 1989

2.Gupta J B ,"Theory and performance of Electrical Machines" ,Katson 1987 7th edition

References :

1. Vincent Deldoro ," Electyromechanical Energy Conversion " PHI III edition,

2.Gupta.J.B,"Theory of Performances of Electrical Machines' Katson, 7th Edition, 1987

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Principles of Electro mechanical Energy Conversion**	
1.1	Energy in magnetic systems	2
1.2	Field energy and Coenergy	1
1.3	Multiple excited Magnetic field system	2
1.4	Forces /torques in systems	1
1.5	Energy conversion via Electric field	1
1.6	Dynamic equation in Electro mechanical systems	1
2.0	**Basic concept in Rotating machines**	
2.1	Elementary machines	1
2.2	Generated Emf	1
2.3	MMF of distributed AC winding	1
2.4	Rotating magnetic fields	1
2.5	Torques in round Rotor machines	1
2.6	Losses and efficiency	1
2.7	Rating and loss dissipation	1
2.8	Matching characteristics of machines and loads	1
3.0	**Transformers**	
3.1	Transformer construction and principle	1
3.2	Ideal Transformer	1
3.3	Transformer on no load &load	1
3.4	Equivalent circuit of Transformer	2
3.5	Losses, efficiency and regulation	2
3.6	Auto transformer and three phase transformer	1
3.7	Parallel operation of Transformers	1
4.0	**Dc machines**	

4.1	Emf and torque	2
4.2	Circuit model	0.5
4.3	Armature reaction	1
4.4	commutation	1
4.5	Characteristics of generators and Motors	1
4.6	Speed control of dc motors	2
4.7	DC machine application	0.5
5.0	**Testing of DC machines and Transformers**	
5.1	OC &SC test on transformers	1
5.2	Sumpner's test	1
5.3	Swinburne's test	1
5.4	Heat run test	1
5.5	Hopkinson's test	1
5.6	Testing standards	1

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E34 Digital Systems 3:0

Preamble: The proposed course is offered in the third semester. This course will be followed by the course Design with PLDs and FPGAs. In designing this course the following assumptions are made.

- The course aims at design of combinational and sequential functions at gate level and simulate and verify their functionality using the Hardware Description Language (Verilog)
- No reference will be made to any technology or logic family.
- No hardware aspects (voltages, currents, noise margins, transients etc.) other than the delay time would be considered in designing logic functions.
- As SSIs and MSIs are not in use any more, no reference needs to be made to these ICs.
- This course will be followed by another course which will deal with technology and electrical behavior of modern logic devices, design of general digital system at RTL level, functional verification using test benches in Verilog, synthesizing into a circuit with desired functionality, mapping into a selected CPLD or FPGA, verifying the timing performance, and generating the final configuration file.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

f. Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

Competencies

1. Determine the functional behavior and timing performance of a given combinational circuit.
2. Determine the functional behavior and timing performance of a given sequential circuit using state diagrams, timing diagrams, and PS-NS-O tables.
3. Determine the behavior of a given digital circuit with regard to hazards, asynchronous inputs, and output races.
4. Design digital circuits to perform specified combinational and sequential functions.

5. Describe, simulate and test combinational and sequential logic, and finite state machines in Verilog through behavioral, data flow and structural models.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	10	10	0
2	Understand	20	20	10
3	Apply	40	20	20
4	Analyze	30	20	20
5	Evaluate	0	10	10
6	Create	0	20	40

Course Level Learning Objectives

Understand

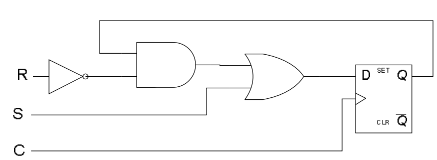
1. Differentiate between a truth table and an excitation table
2. Differentiate between a combinational circuit and a sequential circuit

Apply

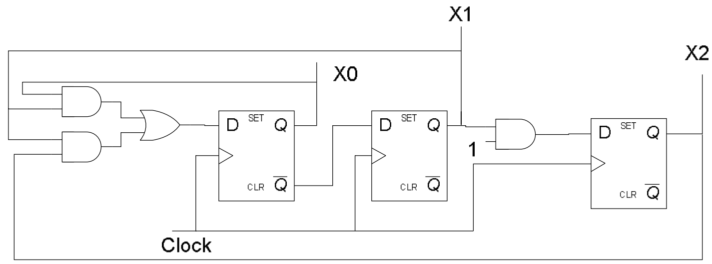
1. Design a logic circuit for a children's math toy to teach number theory. A child enters two numbers, each from 0 to 20. The indicator light should be on if the two numbers are equal or if the first number is greater.
2. Design an elevator controller for a building that has four floors. There are four buttons in the elevator, one for each floor. As people enter the elevator, the buttons are being pushed. Design a circuit that determines which floor it should go next when the doors are closed.

Analyze

1. Analyze the circuit shown in the figure by constructing a timing diagram.



2. Explain why unused states generate don't-care terms when translating a state table to a transition table? Illustrate your response with a sample state table.
3. Explain why J-K flip-flops produce more don't-care terms than the other flip-flop types, even when all of the states are specified.
4. Analyze the circuit shown in the figure by obtaining its timing diagram. Start the timing diagram at state 1.



Create

1. Develop two different solutions for an ALU to detect whether the input word is a palindrome or not. A palindrome has bits reading from left to right being the same as the bits reading from right to left. Hence 1001 is a palindrome but 1011 is not. Another example is ABCCBA. To test for a palindrome for ABCCBA, you compare the most significant bit with the least significant bit, e.g. A with A. Then you compare the next most significant bit with the next least significant bit, e.g. (B with B), etc. Implement the design using Verilog.
2. An arithmetic logic unit, or *ALU*, is an essential component of computing systems, providing the combinational logic needed to implement commonly used arithmetic functions. In this exercise you will design a 32-bit (that is, the design will cater for numbers represented with 32-bits) ALU. The ALU is to provide options (i.e. *instructions*) for *ADD*, *SUBTRACT* and also bitwise operations for *AND* and *OR*. The number formats used are to be 2's complement.

   The ALU is to input:
   - Two 32-bit numbers A and B.
   - Two single bit lines used to indicate which operation is required.

   It is to output:
   - A single 32-bit result Y.
   - Flags (i.e. single bits) for overflow, zero, and sign of Y. The overflow flag should indicate whether the last ADD or SUBTRACT produced a 2's complement overflow. The zero flag is true if Y is all zeros, and the sign flag indicates whether Y is positive (denoted by a zero) or negative (denoted by a one) in the 2's complement sense.

   The input/output lines of the design *MUST* be named as follows:
   - A<0:31> and B<0:31> where bit 31 is the least significant.
   - Y<0:31> where bit 31 is again the least significant.
   - OV, ZR and SN for the overflow, zero and sign bits.
   - S0 and S1 for the operation select lines. These lines are coded as follows:
     - Add A to B : S0 = 0, S1 = 0

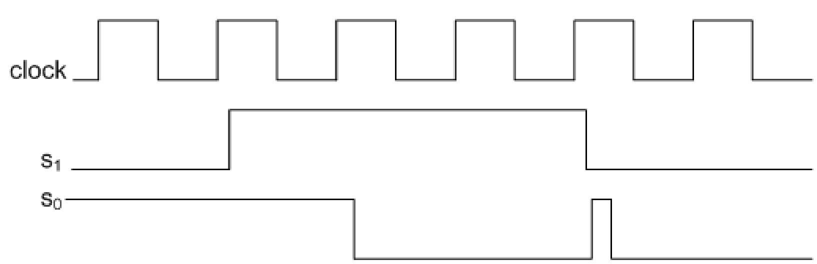
- o Subtract A from B : S0 = 0, S1 = 1
- o Bitwise AND A and B : S0 = 1, S1 = 0
- o Bitwise OR A and B : S0 = 1, S1 = 1

Determine the functional correctness of your design, by determining the maximum propagation delay of the circuit.

2. Design a Mealy sequential machine that will detect the following input sequences x = 01101 or 01111. If input sequence x=01101 is met, cause z1 = 1. If x = 01111, cause z2 = 1. Each input sequence may overlap with itself or other sequence. Document the whole procedure.
3. Design two different finite state machines that act as a 3 bit parity generator. For every 3 bits that are observed on the input 'w' during 3 consecutive cycles, the FSM generates the parity bit p=1 if and only if the number of 1's in the 3 bit sequence is odd. Verify using timing diagrams. (Use suitable assumptions)
4. A two bit counter has two control lines s1 s0. Its function is described in the table below. Two positive edge triggered flip flops A and B are used to implement this counter. A is the most significant bit of a count.

s1s0	Function
00	Unchanged
01	Count up
10	Count down
00	Clear (Synchronous)

   a. Sketch the state diagram. Label each state with A(t)B(t) = 00,01,10,11 respectively.
   b. Carefully draw the waveforms for A and B for the given initial values



   c. Flip-flop A is a JK flip flop; B is a D flip flop. Derive input equations for the two flip flops.

5. Design a special hardware comparator that would keep track of the maximum and minimum of a series of numbers. The numbers are presented to the

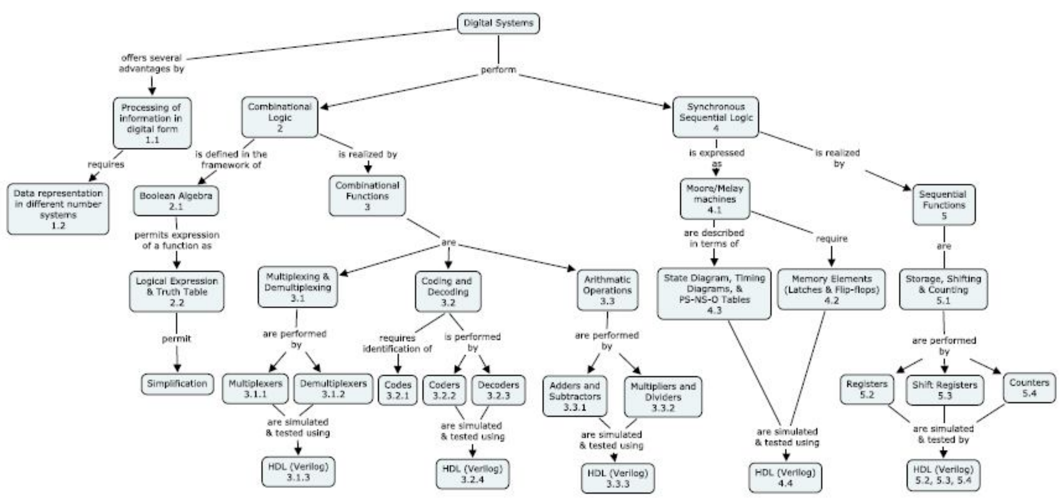
hardware one at a time beginning with the count of numbers followed by the numbers themselves.

Evaluate

1. Design a synchronous circuit that has a single input variable and single output variable. The input data are received serially. The output Z is to change only when three consecutive input bits have the same value. Decide whether a Moore or a Mealy performs better.

2. Design a serial bit pattern detector that will detect the input sequence 01010 in a longer bit string. If the pattern is detected, then cause output Q to be active high. If a 011 bit pattern occurs within the same serial data string, cause output P to be active high. If the 011 pattern occurs, cause the state machine to initialize and start over looking for the 01010 pattern. Overlapping sequences can occur. Compare the performance of the circuit for a Moore and Mealy configurations.

Concept Map



Syllabus

Digital systems process information digital form offering many advantages. **Combination Logic**: Boolean Algebra, Logic Expressions and Truth Tables, Logic Minimization. **Combinational Functions**: Multiplexing and Demultiplexing, Verilog description of Multiplexers and Demultiplexers; Encoding and Decoding: Codes and Verilog description of Encoders and Decoders; Arithmetic Operations: Adders and Subtractors, Multipliers and Dividers, and Verilog Description of Arithmetic Operators. **Synchronous Sequential Logic**: Moore and Melay Machines, Latches and Flip-Flops, State Diagrams, Timing Diagrams and PSNSO

Tables, Verilog description of Synchronous Sequential Logic. **Sequential Functions**: Storing, Shifting and Counting.

Text Book:

1. Morris Mano: Digital Design, Third Edition, Prentice Hall, 2001

Course Contents and Lecture schedule :

No.	Topic	No. of Lectures
1	**Digital Information Processing**	
1.1	Advantages of processing information in digital form	1
1.2	Number systems	1
2.	**Combinational Logic**	
2.1	Boolean Algebra	2
2.2	Logic Expressions and Truth Tables	2
2.3	Logic Minimization	2
3.	**Combinational Functions**	
3.1	**Multiplexing and Demultiplexing**	
3.1.1	Multiplexers	0.5
3.1.2	Demultiplexers	0.5
3.1.3	Introduction to Verilog and Verilog description of Multiplexers and Demultiplexers	3
3.2	**Encoding and Decoding**	
3.2.1	Codes	1
3.2.2	Encoders	1.5
3.2.3	Decoders	1.5
3.2.4	Verilog description of Encoders and Decoders	1
3.3	**Arithmetic Operations**	
3.3.1	Adders and Subtractors	2
3.3.2	Multipliers and Dividers	2
3.3.3	Verilog Description of Arithmetic Operators	2

4.	**Synchronous Sequential Logic**	
4.1	Moore and Melay Machines	1
4.2	Latches and Flip-Flops	2
4.3	State Diagrams, Timing Diagrams and PSNSO Tables	3
4.4	Verilog description of Synchronous Sequential Logic	2
5.	**Sequential Function**	
5.1	Storing, Shifting and Counting	1
5.2	Registers and their Verilog description	2
5.3	Shift Registers and their Verilog description	3
5.4	Counters and their Verilog description	3

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E35 Data Structures 3:0

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

Competencies

1. Ability to identify and implement appropriate data structure for a given application
2. Comprehend the terms "data abstraction", "abstract data type", and "data structures", and how data structures and algorithms have to be blended carefully to obtain efficient implementations.
3. Explain the notion of time complexity and the asymptotic notions of "Big Oh" with non-trivial examples.
4. Explain the difference between worst case complexity and best case complexity. Justify with an example algorithm for each of the complexities: O(n), O(n*2), O(n*3), O(2**n), O(n log n), O(n*2 log n),O(log n), O(log log n), O(sqrt(n)).
5. Identify all the trade-offs involved in choosing static versus dynamic data structures
6. In the context of searching, identify the trade-offs involved in selecting the most efficient data structure.
7. In the context of sorting, identify the trade-offs involved in selecting: (a) bubble-sort (b) insertion sort (c) selection sort (d) quick sort (e) merge sort (f) heap sort.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	30	20	10
2	Understand	30	20	10
3	Apply	20	30	30
4	Analyze	10	20	20
5	Evaluate	10	10	30
6	Create	0	0	0

Course Level Learning Objectives:

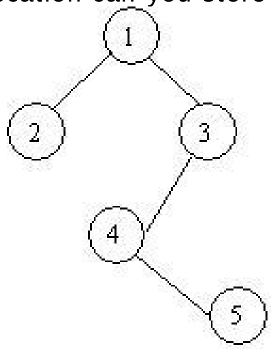
Remember

1. What is data structure?
2. List out the areas in which data structures are applied extensively?
3. What are the major data structures used in the following areas: RDBMS, Network data model and Hierarchical data model?
4. What are the notations used in Evaluation of Arithmetic Expressions using prefix and postfix forms?
5. List out few of the applications of tree data-structure?
6. List out few of the applications that make use of Multilinked Structures?
7. What is the bucket size, when the overlapping and collision occur at same time?
8. What are the Collision Resolution Techniques and the methods used in each of the type?
9. Draw a hash table with open addressing and a size of 9. Use the hash function "k%9". Insert the keys: 5, 29, 20, 0, 27 and 18 into your table (in that order).
10. Suppose that an open-address hash table has a capacity of 811 and it contains 81 elements. What is the table's load factor? (An appoximation is fine.)

Understand

1. If you are using C language to implement the heterogeneous linked list, what pointer type will you use?
2. What is the minimum number of queues needed to implement the priority queue?
3. How many null branches are there in a binary tree with 20 nodes?
4. How many different trees are possible with 10 nodes?
5. What is the condition for balancing to be done in an AVL tree?
6. How do you traverse a given tree using Inorder, Preorder and Postorder traversals.
7. What is the suitable efficient data structure for constructing a tree?
8. There are 8, 15, 13, 14 nodes were there in 4 different trees. Which of them could have formed a full binary tree?

9. At what location can you store the node 4 in a given binary tree using array?



10. Sort the given values using Quick Sort?

65	70	75	80	85	60	55	50	45

11. Classify the Hashing Functions based on the methods by which the key value is found.
12. What are the steps to inserting a new item at the head of a linked list? Use one short English sentence for each step.
13. Suppose that p is a reference to an IntNode in a linked list, and it is not the tail node. What are the steps to removing the node after p? Use one short English sentence for each step.
14. Write a class definition that could be used to define a node in a doubly linked list. Include only the instance variables, not the methods. Also write one sentence to describe a situation when a doubly linked list is appropriate.
15. Describe a situation where storing items in an array is clearly better than storing items on a linked list.
16. Describe why it is a bad idea to implement a linked list version a queue which uses the head of the list as the rear of the queue.

Apply

1. Convert the expression ((A + B) * C - (D - E) ^ (F + G)) to equivalent Prefix and Postfix notations.
2. Draw the B-tree of order 3 created by inserting the following data arriving in sequence - 92 24 6 7 11 8 22 4 5 16 19 20 78
3. Draw a binary Tree for the expression : A * B - (C + D) * (P / Q)
4. Is a Linked List a linear or non-linear data structure?
5. Suppose we are using the usual IntNode class (with instance variables called data and link). Your program is using an IntNode variable called head to refer

to the first node of a linked list (or head is null for the empty list). Write a few lines of C++ code that will print all the double numbers on the list?

6. Suppose we are using the usual IntNode class (with instance variables called data and link), and that locate is referring to a node in a linked list. Write an assignment statement that will make locate refer to the next node in the list (if there is one). If there is no next node, then your assignment statement should set locate to null.

7. Suppose that p, q, and r are all references to nodes in a linked list with 15 nodes. The variable p refers to the first node, q refers to the 8th node, and r refers to the last node. Write a few lines of code that will make a new copy of the list. Your code should set THREE new variables called x, y, and z so that: x refers to the first node of the copy, y refers to the 8th node of the copy, and z refers to the last node of the copy. Your code may NOT contain any loops, but it can use the other IntNode methods.

Analyze

1. Why is the order of an algorithm generally more important than the speed of the processor?
2. Convert each time formula to the best possible big-O notation. Do not include any spurious constants in your big-O answer.

Time Formula	Big-O
10n	.
$2n^2$	.
3 times log (base 2) of n	.
$2n^2 + 10n$	.

3. Which of these is the correct big-O expression for 1+2+3+...+n?

   A. O(log n)
   B. O(n)
   C. O(n log n)
   D. $O(n^2)$

4. Which of the following formulas in big-O notation best represent the expression $n^2+35n+6$?

   A. $O(n^3)$
   B. $O(n^2)$
   C. O(n)
   D. O(42)

5. Answer true or false for this statement: For all possible inputs, a linear algorithm to solve a problem must perform faster than a quadratic algorithm to solve the same problem.
   - o TRUE
   - o FALSE

6. Answer true or false for this statement: True or false: An algorithm with worst case time behavior of 3n takes at least 30 operations for every input of size n=10.
   - o TRUE
   - o FALSE

7. What term is used to describe an O(n) algorithm.
   A. Constant
   B. Linear
   C. Logarithmic
   D. Quadratic

8. Here is some code for an *integer* variable n:

```
while (n > 0)
{
   n = n/10; // Use integer division
}
```

What is the worst-case time analysis for the above loop?
   A. O(1)
   B. O(log n)
   C. O(n)
   D. $O(n^2)$

9. Express the formula (n - 2)*(n - 4) using big-O notation:
   A. O(1)
   B. O(8)
   C. O(log n)
   D. O(n)
   E. None of the above

10. Fill in the following table for the times to sort an array of n items. Use only big-O notation, and do not have any extraneous constants in your expressions.

	Worst Case	**Average Case**
Binary search of a sorted array	.	.
Insertion sort	.	.
Merge sort	.	.
Quick sort without "median of three" pivot selection	.	.
Quick sort with "median of three" pivot	.	.

selection		
Selection sort	.	.
Heap sort	.	.

Evaluate

1. Compare the worst-case big-O time analysis for these two methods: The add method for the Bag that is implemented using an array, and the add method for the Bag that is implemented using a linked list.
2. Compare the worst-case big-O time analysis for these two methods: The remove method for the Bag that is implemented using a fixed-sized array, and the remove method for the Bag that is implemented using a linked list.
3. Compare the worst-case big-O time analysis for these two methods: The addBefore method for the Sequence that is implemented using an array, and the addBefore method for the Sequence that is implemented using a linked list.
4. Compare the worst-case big-O time analysis for these two methods: The remove method for the Sequence that is implemented using an array, and the remove method for the Sequence that is implemented using a linked list.
5. I am going to execute this code with THREE pushes and ONE pop:

```
IntStack s = new IntStack( );
s.push(1);
s.push(2);
s.push(3);
System.out.println(s.pop( ));
```

   Suppose that s is represented by a linked list. Draw the state of the private member variables of s after the above code:

```
        _________
  head |    |    |
       |_ __|___ |
```

6. Implement the following method. You may use the IntStack class and the Stack operations of push, pop, peek, isEmpty, and size. The parameter, in, is an EasyReader from Appendix B of the text and it is already attached to some kind of input. You may use the methods:

   in.isEOLN() -- returns true when the end of line is reached.
   in.peek() -- returns the next input character without actually reading it.
   in.ignore() -- reads and throws away the next input character.
   in.intInput() -- reads and returns an integer value from the EasyReader.

This should be used only if you know that the next input characters form a valid integer value.

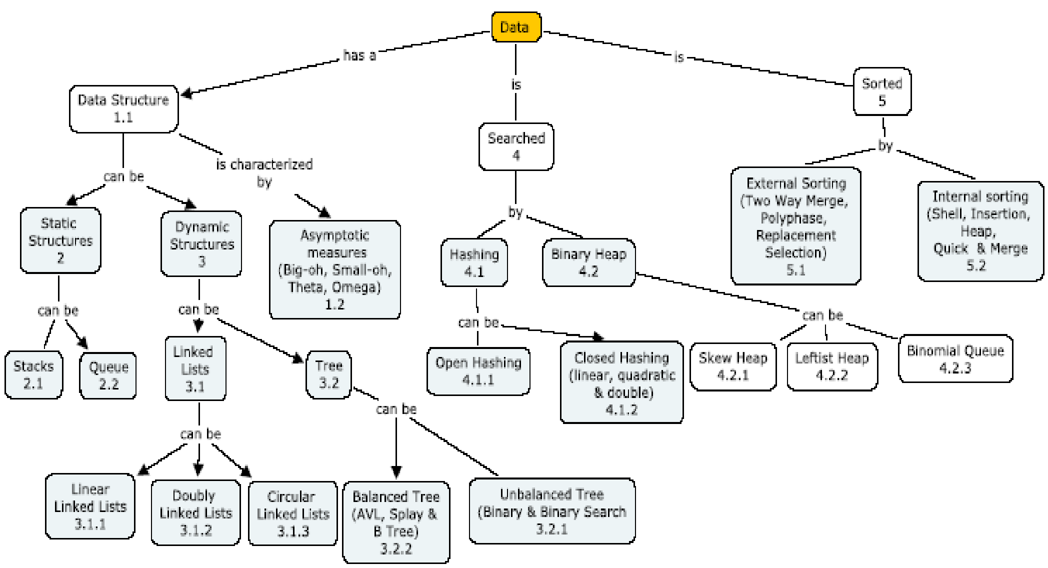
The method specification is:

public static int evaluatePostfix(EasyReader in)
Precondition (Which is not checked): The next input line of in is a properly formed postfix expression consisting of integers, the binary operations + and -, and spaces.
Postcondition: The method has read the next input line (including the newline) and returned the value of the postfix expression.

7. Consider the usual algorithm to convert an infix expression to a postfix expression. Suppose that you have read 10 input characters during a conversion and that the stack now contains these symbols: +(top), (, *(bottom)Now, suppose that you read and process the 11th symbol of the input. Draw the stack for the case where the 11th symbol is:

- A number:
- A left parenthesis:
- A right parenthesis:
- A minus sign:
- A division sign:

Concept Map



Syllabus

Data: Data Structure, Asymptotic Measures **Static Data Structures:** Stacks, Queues **Dynamic Data Structures:** Linked Lists: Linear Linked Lists, Doubly Linked Lists and Circular Linked Lists, Trees: Unbalanced and Balanced Trees, **Data Search:** Hashing: Open Hashing and Closed Hashing; Heap: Skew Heap, Leftist Heap, Binomial Queue **Data Sorting:** Internal Sorting: Insertion sorting, Shell sorting, Quick sorting, Merge sorting and Heap sorting; External Sorting

Textbook

1. Richard F. Gilberg , Behrouz A. Forouzan: Data Structures: A Pseudocode Approach With C, 2nd Edition, Thomson Learning, 2003

Reference

1. Mark Allen Weiss: Data Structures and Algorithms in C, Addison-Wesley, 1997

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Data**	
1.1	Data Structure	0.5
1.2	Asymptotic Measures	1
2	**Static Data Structures**	
2.1	Stacks	3
2.2	Queues	2
3	**Dynamic Data Structures**	
3.1	Linked Lists	0.5
3.1.1	Linear Linked Lists	2
3.1.2	Doubly Linked Lists	1.5
3.1.3	Circular Linked Lists	1.5
3.2	Trees	1
3.2.1	Unbalanced Trees	3
3.2.2	Balanced Trees	6
4	**Data Search**	
4.1	Hashing	0.5
4.1.1	Open Hashing	1
4.1.2	Closed Hashing	2.5
4.2	Heap	2
4.2.1	Skew Heap	1.5

4.2.2	Leftist Heap	1.5
4.2.3	Binomial Queue	1
5	**Data Sorting**	
5.1	Internal Sorting	
5.1.1	Insertion sorting	1
5.1.2	Shell sorting	1
5.1.3	Quick sorting	1
5.1.4	Merge sorting	1
5.1.5	Heap sorting	2
5.2	External Sorting	2

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E36 Control Systems 3:1

Preamble: In recent years control systems have increasing its role in the development and advancement of modern civilization. Control system found in abundance in all sectors of industries such as quality, Automatic assembly line, Machine tool control, space technology, computer control, robotics and many others. Control systems predict the unknown behavior of nature system in an known mathematical form .Hence Control system can be used to analyze and control nature process. Control system is used to reduce nonlinearity of a system. It spreads its application everywhere and it is still prevalent today

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

f. Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

k. Graduate who can participate and succeed in competitive examinations.

Competencies

1. Model a given electromechanical system.
2. Analyze, in time domain and frequency domain, the performance of a given electromechanical system.
3. Specify performance requirement for a given electromechanical system.
4. Select appropriate controller to achieve desired system performance.
5. Design / Tune a Single loop PID Controller for desired system performance.
6. Design / Tune cascade control with PID controller for desired system performance.
7. Design full state feed back controller for desired system performance.
8. Evaluate the controller design against the stated system performance requirement.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	10	10	0
2	Understand	20	20	10
3	Apply	40	20	20
4	Analyze	30	20	20
5	Evaluate	0	10	10
6	Create	0	20	40

Course level Learning Objectives:

Remember:

1. Define transfer function?
2. Write the equations for settling time and peak over shoot of a unit step response.
3. Define phase margin and gain margin of a system.
4. Define gain cross over frequency of a system.
5. Define Phase cross over frequency f a system.
6. State any two properties of state transition matrix.
7. Define transient response of a system.
8. List the time domain specifications.
9. Mention some physical nonlinearity present in the instruments.
10. State principle of homogeneity and superposition theorem.
11. What are the methods used to reduce non-linearity?
12. What are different control problems?

Understand:

1. What is meant by dynamic system?
2. What is meant by servo operation?
3. Distinguish between servo and regulator operation.
4. What is meant by steady state error?
5. Distinguish between closed loop system and open loop system.
6. What is the significance of PI controller?
7. Why controllers need to be tuned?
8. Distinguish relative stability from absolute stability.
9. How will you distinguish between linear and non- linear system?
10. Why nonlinearities arise in instruments?
11. The unit step response of a system is $c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}$ .Find the closed loop poles.

12. The unity feedback system is characterized by an open loop transfer function $G(S)=\dfrac{K}{S(S+10)}$ .Determine the gain K When damping ratio is 0.5.

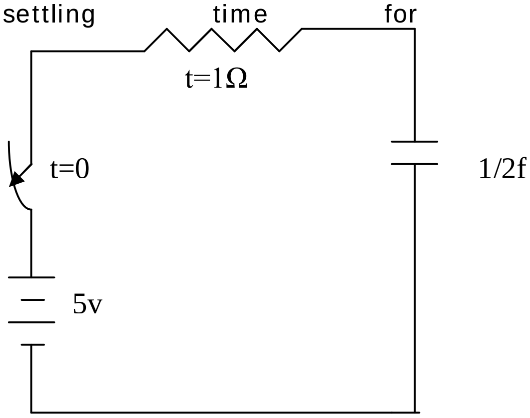
Application:

1. Find the analytical expressions for the magnitude and phase responses of $G(S)=\dfrac{1}{(S+2)(S+4)}$.

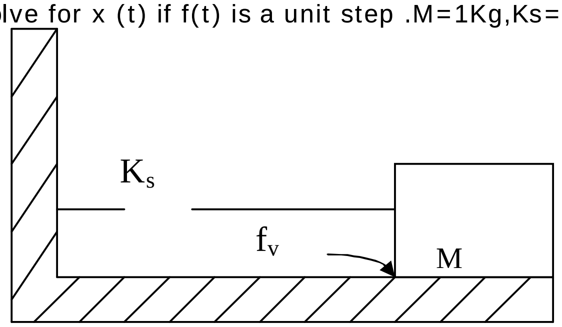
2. Sketch the bode plots for $G(S)=\dfrac{1}{S}$.

3. Sketch Magnitude versus phase curve for the system $G(S)=\dfrac{1}{(S+a)}$.

4. Find the capacitor voltage in the network shown in figure, if the switch closes at t=0.Assume zero initial conditions .Also find the time constant, rise time, and settling time for the capacitor Voltage.



5. Solve for x (t) if f(t) is a unit step .M=1Kg,Ks=5n/m,fv=1N-s/m,f(t)=u(t) N



6. Check the stability of the system with routh criterion.
$s^4+8s^3+18s^2+16s+5=0$

7. Test whether the system is controllable or not?

A= $\begin{bmatrix} 0 & 1 & 0 \\ 64 & 0 & -16 \\ 0 & 0 & -100 \end{bmatrix}$ B= $\begin{bmatrix} 0 \\ 0 \\ 100 \end{bmatrix}$

8. Test whether the system is observable or not?

A= $\begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix}$ B= $\begin{bmatrix} 1 \\ 2 \end{bmatrix}$ c= $\begin{bmatrix} 1 & 1 \end{bmatrix}$

9. A matrix linear system is given by the state equation A= $\begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix}$

Find the state transition matrix.

10.for the transfer function given with unity feedback system $G(s) = \dfrac{10}{s(0.1s+1)}$.find the steady state error of the system subjected to unit step input.

11.Find the eigen values and eigen vectors for the matrix given

A= $\begin{bmatrix} 1 & -2 \\ -3 & -4 \end{bmatrix}$

ANALYZE:

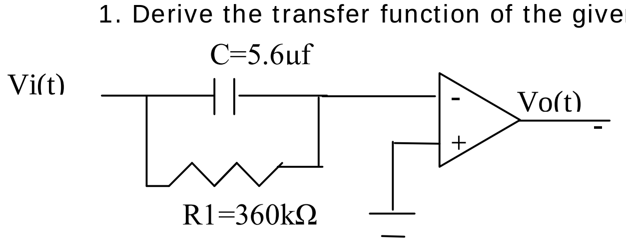
1. How frequency response is used to find the stability of a system?
2. What is the significance of the state transition matrix?
3. What happens when damping ratio of a system is increased?
4. What is the effect increasing steady state gain (K) in a critically damped system?
5. What are the ways to improve the stability of a LTI system?
6. How can you justify pole –zero cancellation? Explain with suitable example.

If a pole is moved with constant imaginary part, what will the response have in common?

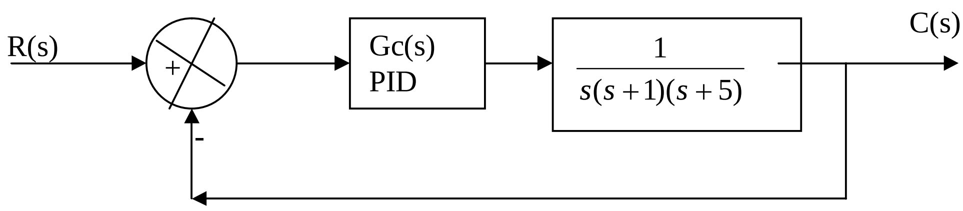
7. If a pole is moved along a radial line extending from origin, what will the response have in common?
8. How the roots of the characteristic equation are related to stability?
9. In routh array what conclusion you can make when there is a row of all zeros?
10. how can you analyze whether a system is marginally stable ?

Evaluate:-

1. Derive the transfer function of the given system. $\dfrac{Vo}{Vs}$



2. Consider the control system with PID controller.



2. Evaluate the Kp,Ti,Td,Proportional,integral,derivative gains for the above system and tune the controller with Ziegler-nichols tuning method.

3. Check whether the system is designed to meet 25% overshoot .Make a fine tuning if the maximum overshoot is excessive and reduce to 25%.

4. Evaluate the differences between Ziegler –nichols and cohen coon tuning methods.

5.how can a controller can be selected for various processes.

6. Evaluate the various tracking problems .

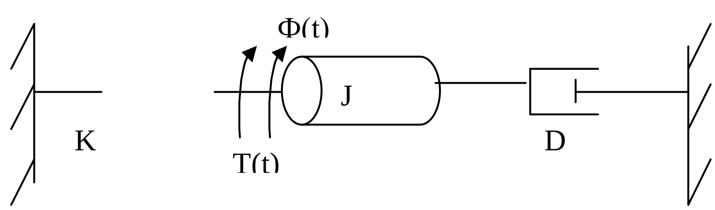
7. Classify the various tracking methods and discuss their effects in control problems.

8. Evalute the controller PID controller performance indices when subjected to various inputs.

9. Discuss and bring out the differences between time domain and frequency domain in the stability point of view.

10. How robustness is related with system parameters.

Create:-



1. For a rotational mechanical system given .find the J and D to yield 20%overshoot and settling time of 2 seconds for a step input of torque T (t).K=5NM/rad.

2. Design and tune a PID controller for the desired system performance of damping ratio=0.5 given.

$$G(s) = \frac{1}{s^3 + 3s^2 + 3s^2 + 1}.$$

3.A single input system is described by

$$X = \begin{bmatrix} -1 & 0 & 0 \\ 1 & -2 & 0 \\ 2 & 1 & -3 \end{bmatrix} X + \begin{bmatrix} 10 \\ 1 \\ 0 \end{bmatrix} u$$

Design a feed back controller which will givw closed loop poles at $-1 \pm j2, -6$

4. Consider the system $\dfrac{Y(s)}{U(s)} = \dfrac{10}{s(s+1)(s+2)}$ .Design a state feedback controller so that the eigen values of the closed loop system $-1 \pm j1, -2$.

5. Consider the differential equation
$\dddot{Y} + 6\ddot{Y} + 11\dot{Y} + 6Y = \dddot{u} + 8\ddot{u} + 17\dot{u} + 8u$ .convert into Jordan canonical form.

5. Find the state transition matrix using power series method.

A= $\begin{bmatrix} 1 & -2 \\ -3 & -4 \end{bmatrix}$

6. Design a cascade compensator that will give approximately 15%over shoot with step input. Settling time is decreased by factor 2.5 and Kv≥ 20.

$$G(s) = \frac{K}{s(s+3)(s+9)}$$

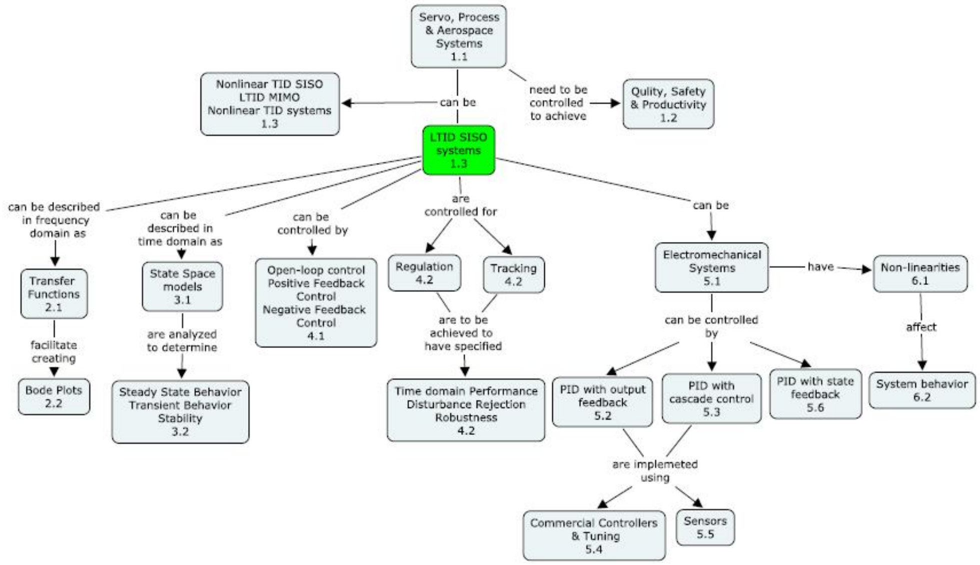
7. Design a phase lead compensator to satisfy the following specification
The phase margin>45° and gain crossover frequency must be < 7.5 rad/sec.

8. for the system $G(s) = \dfrac{10}{s(1+.5s)(1+0.1s)}$ a network of $G(s) = \dfrac{(1+0.23s)}{(1+0.23s)}$ in tandem. Draw bode plot and find new gain and phase margins.

9. Design a PID cascade compensator that will give approximately 25%over shoot with step input. Settling time is 25sec and Kv≥ 20.

10. Design a PI- cascade compensator that will give approximately 25%over shoot with step input. Settling time is 10 sec and Kv≥ 10.

Concept Map



SYALLABUS :

Nature of Dynamic Systems

Servo, Process and Aerospace Systems,Quality, Safety and Productivity of Dynamic Systems, Structure and Complexity of Dynamic Systems,Transfer Function Description of LTID SISO Systems, Graphic (Bode Plots) Description of LTID SISO Systems, State Space Models of LTID SISO Systems, Steady state, transient and stability behavior of LTID SISO systems

Control of LTID SISO Systems& Control of Electromechanical Systems

Open loop and feedback control of dynamic systems, Control problems: regulation, tracking and performance specifications, Nature of electromechanical control problems, PID control with output feedback, Cascade control, Selection of controllers and their tuning, Sensors, PID control with state feedback

Nonlinearities in electromechanical systems

Nature of nonlinearities, Effect of nonlinearities on the system behavior

REFERENCES:

1. Control Systems Engineering, Norman .S.Nise edition, 2007, JohnWiley &sonsLtd
2. Automatic Control Systems, Benjamin C.Kuo., edition 1995,PrenticeHall India.
3. Control systems Engineering –Nagrath and Gopal edition,2001,New Age International Ltd.
4. Digital Control and State variables methods, M.Gopal, edition 1997,TataMCgrawhill

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Nature of Dynamic Systems**	
1.1	Servo, Process and Aerospace Systems	1
1.2	Quality, Safety and Productivity of Dynamic Systems	1
1.3	Structure and Complexity of Dynamic Systems	1
2.	**Frequency Domain Description of LTID SISO Systems**	
2.1	Transfer Function Description of LTID SISO Systems	3
2.2	Graphic (Bode Plots) Description of LTID SISO Systems	3
3.	**Time Domain Description of LTID SISO Systems**	
3.1	State Space Models of LTID SISO Systems	5
3.2	Steady state, transient and stability behavior of LTID SISO systems	5
4.	**Control of LTID SISO Systems**	
4.1	Open loop and feedback control of dynamic systems	2
4.2	Control problems: regulation, tracking and performance specifications	3
5.	**Control of Electromechanical Systems**	
5.1	Nature of electromechanical control problems	2
5.2	PID control with output feedback	5
5.3	Cascade control	2
5.4	Selection of controllers and their tuning	3
5.5	Sensors	1
5.6	PID control with state feedback	3
6.	**Nonlinearities in electromechanical systems**	
6.1	Nature of nonlinearities	1
6.2	Effect of nonlinearities on the system behavior	2

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E37 Digital Systems Lab **0:1**

Purpose:

All the experiments require creating a design to meet the specified functional requirements, generation of Verilog code using structural modeling, simulating the design using Xilinx Foundation Tools, generating test vectors, and verifying the design for functional correctness. The students are required to solve a minimum of three problems from the problem set given for each experiment.

List of Experiments

1. Multiplexers
2. Demultiplexers
3. Encoders
4. Decoders
5. Simulating hazards
6. Adders/Subtractors
7. Arithmetic Logic Unit
8. Multipliers
9. Dividers
10. Registers
11. Shifters
12. Counters
13. Pattern recognizers
14. PRBS generators

E38 D.C machines and Transformers Lab 0:1

List of Experiments

1. Open circuit characteristics of d.c shunt generator
2. Load test on d.c. shunt generator
3. Internal and External characteristics of d.c compound generator
4. Swinburne’s test
5. Load test on d.c shunt motor
6. Speed control on d.c shunt motor
7. Load test on d.c series motor
8. Hopkinson’s test
9. Ratio and polarity test on single phase transformer
10. Open circuit and short circuit test on single phase transformer
11. Load test on single phase transformer
12. Sumpner’s test on single phase transformer
13. Internal and External characteristics of d.c series generator

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Graduating Students of B.E. program of EEE will be able to

1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power
2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015

Department of Electrical and Electronics Engg.

Scheduling of Courses

Semester	Theory Courses						Practical/Project		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					E88 Project 0:12	
7th (21)	E71 Mgmt. The. & Practice 3:0	E72 Protection & Switchgear 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0			E78 Project 0:6	
6th (21)	E61 Accounting & Finance 3:0	E62 Power System Analysis 3:0	E63 Electric Drives 3:0	E64 Design with FPGAs 3:1	Elective 1 3:0	Elective 2 3:0	E67 Power System Simulation Lab 0:1	E68 Power Electronic & Drives Lab 0:1	
5th (24)	E51 Engineering Mathematics – 5 4:0	E52 Generation, Transmission & Distribution 4:0	E53 Power Electronics 3:0	E54 Embedded Systems 3:1	E55 Mixed Signal Circuits and Interfacing 3:0	E56 Electrical Machine Design 3:0	E57 Digital Signal Processing Lab 0:1	E58 Microprocessors Lab. 0:1	E59 Instrumentation and Control Lab 0:1
4th (25)	E41 Engineering Mathematics – 4 4:0	E42 AC Machines 3:1	E43 Microprocessors & Microcontrollers 3:1	E44 Thermal Engineering 3:0	E45 Digital Signal Processing 3:0	E46 Electrical & Electronic Measurments 3:0	E47 AC Machines Lab. 0:1	E48 Thermal Engineering Lab 0:1	E49 Professional Communications 1:1
3rd (24)	E31 Engineering Mathematics – 3 4:0	E32 Electromagnetics 3:1	E33 DC Machines & Transformers 3:1	E34 Digital Systems 3:0	E35 Data Structures 3:0	E36 Control Systems 3:1	E37 Digital Systems Lab 0:1	E38 DC Machines & Transformers Lab 0:1	
2nd (23)	E21 Engineering Mathematics – 2 4:0	E22 Electric Circuit Analysis 4:0	E23 Analog Circuits & Systems 4:0	E24 Computers and Programming 3:0	E25 Material Science 3:0	E26 Ecology 2:0	E27 Analog Circuits and Systems Lab 0:1	E28 Computer Programming Lab 0:1	E29 Workshop 0:1
1st (25)	H11 Engineering Mathematics – 1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of M & CE 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab 0:1	H18 Chemistry Lab 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engg.) Program

SUBJECTS OF STUDY

(For the candidates admitted from 2008-2009 onwards)

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
E 41	Engineering Mathematics IV	BS	4	-	-	4
E 42	AC Machines	DC	3	1	-	4
E 43	Microprocessors & Microcontrollers	DC	3	1	-	4
E 44	Thermal Engineering	ES	3	0	-	3
E 45	Digital Signal Processing	DC	3	-	-	3
E 46	Electrical & Electronic Measurements	DC	3	-	-	3
PRACTICAL						
E 47	AC Machines Lab.	DC	-	-	3	1
E 48	Thermal Engineering Lab.	ES	-	-	3	1
E 49	Professional Communications	HSS	1	1	-	2
Total			**21**	**3**	**6**	**25**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:
1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engg.) Program

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2008-2009 onwards)

FOURTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	E41	Engineering Mathematics IV	3	50	50	100	25	50
2	E42	AC Machines	3	50	50	100	25	50
3	E43	Microprocessors & Microcontrollers	3	50	50	100	25	50
4	E44	Thermal Engineering	3	50	50	100	25	50
5	E45	Digital Signal Processing	3	50	50	100	25	50
6	E46	Electrical & Electronic Measurements	3	50	50	100	25	50
PRACTICAL								
7	E47	AC Machines Lab.	3	50	50	100	25	50
8	E48	Thermal Engineering Lab.	3	50	50	100	25	50
9	E49	Professional Communications	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

Sub Code	Lectures	Tutorial	Practical	Credit
E 41	4	0	-	4

E41 Engineering Mathematics IV 4:0

Preamble:

An engineering student needs to have some basic mathematical tools and techniques. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this the course aims at giving adequate exposure in the theory and applications of Statistics, Probability, Sampling and Quality Control and Simulation.

Program Outcomes addressed

a. An ability to apply knowledge of Engineering and Information Technology in mathematics and Science
b. An ability to identify , formulate and solve Engineering problems.
c. An ability to engage in life-long learning..

Competencies

At the end of the course the student should be able to

1. Express the probability distributions arising in the study of Engineering problems and their applications.
2. Know the various designs of experiments and how these designs are used to test the various attributes in Engineering and Technological Applications.
3. Know and apply the various Charts in Statistical Quality Control theory for the purpose of Quality Control in Industries.
4. To Justify and construct the various tests essentially needed for testing of samples on different chosen attributes
5. Know about the concept of simulation, Random Numbers, Meaning, Properties, Importance and applications of them.

Assessment Pattern

	Bloom's category	Test 1	Test 2	Test 3 / End Semester Examinations
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define Discrete and Continuous Random Variables
2. State the properties of probability distribution function.
3. Give the PDF of a Normal Distribution
4. What do you mean by test of Hypotheses?
5. State the convolution theorem on Z transforms
6. Define the order and degree of a Difference equation.
7. Mention the basic designs of experiments.
8. State the properties of random numbers.

Understand

1. Compare the designs RBD and LSD
2. Discuss the uses of t – distribution.
3. Discuss the properties of a Normal probability distribution
4. Discuss the procedure for testing of hypothesis.
5. Interpret the level of significance and degrees of freedom for a chi square variate.

Apply

1. A con is tossed 900 times and heads appeared 490 times. Would you conclude that the coin is a biased one?
2. Two random samples gave the following

$$n_1 = 10; \sum (x_i - \overline{x})^2 = 90 \ ; \ n_2 = 12 \ ; \ \sum (y_i - \overline{y})^2 = 108$$

   Test whether the samples came from the same population
3. Given the observations

	Blocks				
Treatment1	14	6	11	0	9
Treatment2	14	10	16	9	16
Treatment3	12	7	10	9	12
Treatment4	12	9	11	6	7

Construct the analysis of variance table and test for difference among the treatments using 5% level of significance.

4. Solve the difference equation $y_{n+2} - 4y_{n+1} + 3y_n = 0$ given $y_0 = 2\,; y_1 = 4.$

Concept Map

Course contents and lecture schedule

No	Topic	No. of Lectures
1	**Probability Distributions and Test of Hypotheses**	
1.1	Probability Distributions Discrete & Continuous (Definition).	2
1.2	Exponential, Weibull , Normal Distributions.	2
1.3	Problems based on the above distributions.	1
1.4	Test of hypotheses – large samples.	2
1.5	Test of hypotheses – Small samples.	2
2	**Difference Calculus and Z Transforms**	
2.1	Operators, Relations, Problems based on Operators.	2
2.2	Difference Equations	3
2.3	Z transforms ,Definitions , properties, transforms of derivatives , Inverse Z transforms	3
2.4	Convolution, application to solutions of difference equations.	2
3	**Statistical Quality Control**	
3.1	Introduction, control charts for measurements, $\overline{X}$ chart, R chart (σ Chart)	4
3.2	controlcharts for attributes, pcharts, npcharts, c charts	3
3.3	Tolerance limits.	3
4	**Design of Experiments**	
4.1	Introduction – aim – Basic designs of experiments	3
4.2	Completely Randomized design	2
4.3	Randomized Block Design	3
4.4	Latin Square Design.	2
5	**Simulation**	
5.1	Introduction ,System simulation.	2
5.2	Random Numbers Techniques of generating Random numbers.	3
5.3	Tests for Random Numbers, Chi square, Kolmogrov ,Poker Tests.	3
5.4	Random Variate Generators.	2

Syllabus

Probability Distributions and Test of Hypotheses: Probability distributions – Discrete – Continuous - Exponential – Weibull – Normal – Simple problems based on them. Test of hypotheses – large samples – small samples.

Difference Calculus and Z Transforms: Operators – Relations between them – Problems based on Operators – Difference Equations – Z transforms – Definitions – properties – transforms of derivatives – Inverse Z transforms – convolution – application to solutions of difference equations.

Statistical Quality Control: Introduction - control charts for measurements - $\overline{X}$ chart - R chart (σ Chart) – control charts for attributes – p charts- np charts – c charts – tolerance limits.

Design of Experiments: Introduction – aim – Basic designs of experiments – Completely Randomized design – Randomized Block Design – Latin Square Design

Simulation: Introduction –System simulation – Random Numbers – Techniques of generating Random numbers – Tests for Random Numbers – Chi square – Kolmogrov – Poker - Tests – Random Vaariate Generators.

Text Books

1. Veerarajan .T "Probability and Random Processes" TMH (I,2,5)
2. Grewal.B.S "Higher Engineering Mathematics " (3)
3. Jerry Banks ,John S. Curson Bary I Nelson , "Discrete Event System Simulation – PHI (5)

References

1. Lecture Notes by the faculty of department of Mathematics, TCE,Madurai
2. P.Kandasamy.,K.Thilagavathy.,K.Gunavathy, 'Probability Random Variable and Random Processes' S.Chand & Co –2004.
3. S.C.Gupta ." Fundamentals of Statistics – Himalaya Publishing House New Delhi (1988).
4. S.C.Gupta. Fundamentals of Applied Statistics – Sultan Chand & Co – New Delhi (1988).

Course Designers

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Degree :B.E. ***MODEL QUESTION PAER FOR TERMINALEXAMINATIONS***

Semester :IV

Subject code :E 41

Subject Title :Engineering Mathematics IV

Assessment pattern:

Remember:10 Understand:50 Apply:40 Analyze:0 Evaluate:0 Create:0

Time: 3 Hrs. Answer ALL Questions Max. marks: 100

Part A **Answer all the Questions** **5 X 2 = 10 Marks**

A1. Define: Type1 and Type2 errors

A2. State the First shifting property of Z transforms

A3. State the types of Control Charts.

A4. Mention the ANOVA table for 2 factors classification

A5. Mention the tests for checking the independence of random Numbers.

Part B **Answer all the Questions** **6 X10= 60 Marks**

B1. The marks obtained by the students in Mathematics, Physics and Chemistry in an examination are normally distributed with means 52, 50 &48 and with SDs 10, 8 & 6 respectively. Find the probability that a student selected at random has secured a total of i) 180 and above ii) 135 or less.

B2. In a large City A 20% of a random sample of 900 school boys had a slight physical defect. In another city B , 18.5% of a random sample of 1600 school boys had the same defect. Is the difference between the proportions significant? Use 5% LOS.

B3. A sequence of 1000 three digit numbers has been generated and an analysis indicates that 680 have three different digits, 289contains exactly one pair of like digits and 31 contain three like digits. Base on Poker's test, are these numbers independent? Use 5% LOS.

B4. A nation wise mail order house desire to verify the accuracy of its clerical work in completing invoice .Subgroups of 200 are taken each day for 30 consecutive days for inspection . A defective is defined in invoice form containing at least one if a number of possible errors. The numbers of defectives found I each of these (30) groups are as follows

7	5	6	3	4	10	3	2	5	8
6	1	2	3	5	4	8	9	7	10
3	5	4	2	3	7	6	4	3	5

Construct control chart of data given above and comment on the state of control.

B5. Develop a generstor for a triangular distribution wit range (0,10) and mean at $x = 4.$

B6. Two random samples were drawn from two normal populations and their values are given

A	66	67	75	76	82	84	88	90	92		
B	64	66	674	78	82	85	87	92	93	95	97

Test whether the two populations have the same variance.

Part C **Answer all the Questions** **2 X15=30 Marks**

C1. i) Using convolution theorem find $Z^{-1}(\frac{z^2}{(z-a)(z-b)})$. **(7)**

ii) Solve Using Z transforms: $U_{n+2} - 2U_{n+1} + U_n = 2^n \ with \ \ U_0 = 2 \ ; U_1 = 1.$ **(8)**

(OR)

C2. i) Find the Z-Transform of : i) n^2 ii) na^n. **(7)**

ii) Solve Using Z transforms : $y_{n+2} - 3y_{n+1} + 2y_n = 2^n \ given \ y_0 = y_1 = 0.$ **(8)**

C3. An experiment was designed to study the performance of four different detergents for cleaning fuel injectors. The following "cleanness" readings were obtained with specially designed equipment for 12 anks of gas distributed over three different models of engines.

	Engine 1	Engine 2	Engine 3
Detergent A	45	43	51
Detergent B	47	46	52
Detergent C	48	50	55
Detergent D	42	37	49

Looking at the detergents treatment s and the engines as blocks, obtain appropriate ANOVA table and test at the 0.01 level of level of significance whether there are differences in the detergents or in the engines. **(15)**

(OR)

C4. Analyze the variance in the following Latin square of yields (in Kgs) of paddy where A,B,C,D denote the different methods of cultivation .

D122	A121	C123	B122
B124	C123	A122	D125
A120	B119	D120	C121
C122	D123	B121	A122

Examine whether the different methods of cultivation have given significantly different yields. **(15)**

*****

Sub Code	Lectures	Tutorial	Practical	Credit
E 42	3	1	-	4

E42 AC Machines 3:1

Preamble:

Rotating electrical machines are widely used for the purpose of converting energy from one form to another. AC machines are becoming more and more attractive in many applications such as those requiring variable speed and flexible control. Alternating Current (AC) machines are the most preferred for generation of electric power. AC motors are the commonly used in industry for motive power for applications. Electrical drive is superior to other forms of prime movers in terms of efficiency, control and pollution. There are three families of rotating machines one of which is the synchronous machine commonly in the form of the AC synchronous generator such machines are widely used in power stations for electric power generation. The synchronous motor has limited application. However an asynchronous machine, the induction motor has wide spread industrial and domestic application such that about 85 % of electric power consumption is due to induction motor loads. Single phase motor has wide spread small power application for example in the home.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduate who can participate and succeed in competitive examinations.

Competencies:

At the end of the course the student should be able to

1. Explain the basic principles of Alternator
2. Determine the behavior of AC Motors systems such as synchronous machines

3. Explain and determine the electro-mechanical, heating, cooling behaviour of rotating machines under different operating and load conditions
4. Determine the performance of AC machines from the pre-determined and determined test data
5. Choose from currently commercially available AC machines for a given application

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	10	10	10
2	Understand	50	50	50
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What types of generators are used in hydroelectric power station and thermal power station?
2. Why salient pole alternator is more suitable for low speed operation?
3. Compare the salient pole rotor and cylindrical pole rotor on stability point of view
4. Where the damper winding is located in a machine? What are its functions?
5. What is the need of parallel operation of Alternators?
6. Define regulation of alternator
7. What is meant by the term hunting?
8. State the applications of synchronous motors
9. What is a synchronous condenser?
10. What is an inverted V curve?
11. Why an induction motor is called a rotating transformer?
12. Define slip of an induction motor.
13. What is an induction generator?
14. What is meant by cogging?

15. Differentiate between Induction motor and Synchronous motor.
16. Name the various speed control methods of induction motor.
17. List the various types of single phase induction motor.
18. What is the use of shading ring in a shaded pole motor?
19. List the applications of Single phase induction motor
20. How can be the direction of rotation of induction motor is reversed?
21. Why bright lamp method is preferred over dark lamp method for synchronization of alternator?
22. How do synchronizing lamps indicate the phase variation of the incoming machine and the running machine?
23. What is the role of damper winding in an (i) alternator (ii).Synchronous Motor?
24. How will you reverse the direction of rotation of synchronous motor?
25. What is the application of induction generator?
26. What is meant by single phasing?
27. How will you improve the staring torque of 3 phase induction motor?
28. Which type of induction motor develops higher starting torque.
29. What type of protection is provided in the starter meant for 3-phase induction motor?
34. What is a Universal motor? How can the direction of rotation be reversed?

Understand

1. Explain the Potier Triangle method of finding the regulation of an alternator
2. Derive an expression for synchronizing power.
3. Explain, how will you determine Quatrature axis and direct axis reactance of Salient pole alternator
4. Describe any two method of starting synchronous motors
5. Write explanatory notes on a) Repulsion motor, b) Linear induction motor
6. Explain the development of power circles for a cylindrical rotor synchronous motor
7. Describe the equivalent circuit of three phase induction motor.
8. Describe the constructional features of Universal motor. Also explain the working principle
9. Why starter is necessary to start three phase induction motor? Explain in detail about Star Delta starter used for stating three phase induction motor
10. Explain the double field revolving theory applied to a single phase induction motor

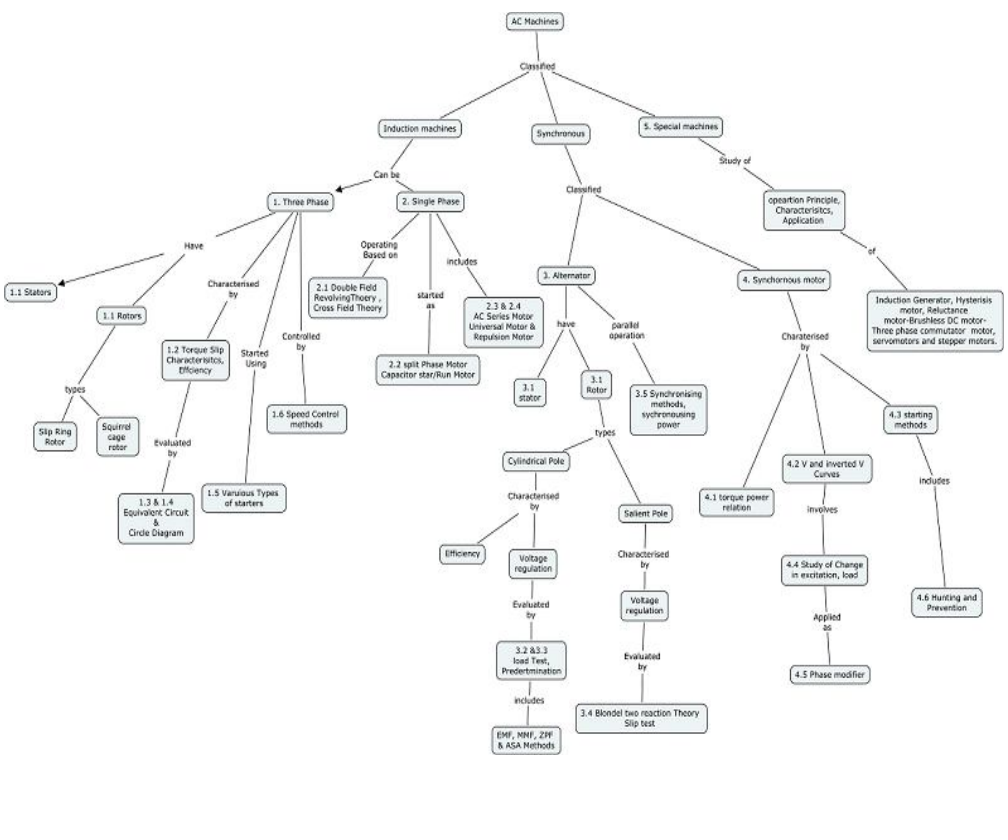
11. State the requirements for paralleling of alternators.
12. Explain the construction and principle of operation of 3-phase alternator
13. Explain about crawling and cogging
14. Bring out the characteristics of two alternators working in parallel. What is the effect of change in excitation on load sharing.
15. Derive the equation for torque developed by an Induction Motor. Draw the typical torque slip curve and deduce the condition for maximum torque.
16. Two alternators are connected in parallel, what happens when we (i)increase the excitation of one machine (ii) increase the steam supply of one machine.
17. Explain why synchronous motor is not self starting.
18. Explain the various schemes of starting of 3 phase I M
19. Describe how 3-phase supply produces a rotating magnetic field of constant value at constant speed with vector diagrams.
20. Write short notes on induction generator. Mention its advantages and disadvantages,
21. What is meant by cogging and crawling? How to avoid it?
22. Which type of induction motor develops higher starting torque.
23. What type of protection is provided in the starter meant for 3-phase induction motor?
24. What is a Universal motor? How can the direction of rotation be reversed?

Apply

1. A two pole,50 Hz, 3-phase, turbo alternator is excited to generate the bus-bar voltage of 11 kV on no load. The machine is star connected and the short circuit current for this excitation is 1000A. Calculate the synchronizing power per degree of mechanical displacement of the rotor and the corresponding synchronizing torque.
2. A 3300V, 3 phase star connected alternator has a full load current of 100A.On short circuit a field current of 5A was necessary to produce full-load current. The e m f on open circuit for the same excitation was 900V.The armature resistance was 0.8 ohm/phase. Determine the full load voltage regulation for (i) 0.8 p f lagging (ii) 0.8 p f leading.
3. The following data refers to a 20pole,460V,60Hz, 3-phase I M :
   R1=2 ohm,X1=1 ohm, R2' =3 ohm, X2' =7 ohm. When the motor is tested on no load, it is observed that it takes 3.9A and the total core loss is 450W.By using an approximate equivalent circuit at 5% slip, calculate
   (i) Rotor current (ii) Supply current and pf (iii) Gross load torque
   (iv) draw the equivalent circuit.

4. A 3 MVA , 50Hz, 11 kV, 3-phase star connected alternator supplies 100A at zero p f leading. The line voltage is 12370V.When the load is removed, the line voltage is 1100V.Find the regulation at full load,0.8 pf lagging. Ra=0,4ohm/phase.
5. A three phase star connected alternator has direct axis synchronous reactance of 0,7p u and quadrature axis reactance of 0,5 p u, If the generator delivers 100kVA at rated voltage at full load and lagging, find the percentage regulation. Resistance drop at full load is 0.017 p u.
6. Two similar 3000kVA synchronous generators work in parallel. The governor of first machine is such that frequency drops uniformly from 50Hz on no load to 48 Hz on full load. The corresponding speed drop of second machine is from 50Hz to 47.5Hz.determine the following
   (i) How will the two machines share a load 5000kW at full load
   (ii) What is the maximum load at u p f that can be delivered without overloading either of the two machines?

Concept Map



Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Three phase induction motor**	
1.1	Constructional features of 3 phase induction motor.	1
1.2	Torque production – Torque –slip characteristic	3
1.3	Equivalent circuit of induction motor	2
1.4	construction of circle diagram	3
	Tutorial	1
2.0	**Three phase Induction motor starting & Speed Control**	
2.1	Starters	2
2.2	speed control of Induction motor	2
2.3	**Single phase motors:-** Double field revolving theory, Cross field theory	2
2.4	split phase induction motor-, (resistance & capacitance type), Shaded pole	2
2.5	Repulsion motor	1
2.6	A.C. series- Universal motor.	1
3.0	**Synchronous generator**	
3.1	Types and construction	1
3.2	Voltage regulation by EMF, MMF, ZPF and ASA methods	4
3.3	Load characteristics.	1
3.4	Salient pole machine -Blondel two reaction Theory for salient pole machine -	1

3.5	Slip test for the measurement of Xd and Xq	1
3.6	Phasor diagram using Xd, Xq - losses and efficiency.	2
3.7	Parallel operation of synchronous machines –Power output of alternators in parallel, Synchronizing methods - Use of synchronoscope,	2
	Tutorial	1
4.0	**Synchronous motor :**	
4.1	Principles of operation **-**Torque and power relations	2
4.2	Phasor diagrams - V and inverted V curves	2
4.3	Starting methods of synchronous motor	1
4.4	Variation of Excitation of synchronous motor	1
4.5	Use of synchronous motor as phase modifier	1
4.6	Condition for stability - Hunting and prevention of hunting	2
5.0	**Special Machines : Principles of operation - Constructional features and performance characteristics**	
5.1	Linear induction motor	1
5.2	Induction Generator	1
5.3	Hysterisis motor, Reluctance motor	2
5.4	Three phase commutator motor,	1
5.5	Brushless DC motor	1
5.6	Servomotors	1
5.7	Stepper motors.	1

Syllabus:

Three phase induction motor: Constructional features of 3 phase squirrel cage and slip ring induction motors - - Torque production – Torque –slip characteristic - Analysis of performance characteristics by equivalent circuit and circle diagram.

Three phase Induction motor starting & Speed Control - Starters, speed control by rotor resistance, Pole changing, change of supply frequency, injection of EMF in the rotor circuit

Single phase motors- Double field revolving theory - Cross field theory, split phase induction motor (resistance & capacitance type), shaded pole, repulsion, A.C. series, Universal motor.

Synchronous generator: Types and construction - - Synchronous reactance and impedance - Voltage regulation by EMF, MMF, ZPF and ASA methods, load characteristics, salient pole machine. Blondel two reaction Theory for salient pole machine - Slip test for the measurement of Xd and Xq - Phasor diagram using Xd, Xq - losses and efficiency. Parallel operation of synchronous machines – Synchronizing methods - Use of synchronoscope - Power output of alternators in parallel.

Synchronous motor : Torque and power relations - Phasor diagrams - V and inverted V curves - Starting methods of synchronous motor – Variation of Excitation of synchronous motor - Use of synchronous motor as phase modifier – Condition for stability - Hunting and prevention of hunting.

Special Machines : Principles of operation - Constructional features and performance characteristics, Linear induction motor - Induction Generator, Hysterisis motor, Reluctance motor-Brushless DC motor-Three phase commutator motor, servomotors and stepper motors.

Text Books:

1. J.B.Gupta , “Electrical Machines - II”, 3rd edition ,S.K.Kataria & Sons, 2000
2. Theraja B.L. A text of Electrical Technology, Volume-II, S.Chand & Co Ltd,2005.

Reference Books:

1. Bhattacharya,P.S., Electrical Machines, Tata Mc Graw Hill, 8 th Reprint,1997.
2. P.S.Bimbhra- Electrical Machines, Khanna Publishers, 1984.
3. Say.M.G. Alternating current Machines, ELBS & Pitman, London, IV Edition, 1980.
4. Nagrath.I.J. and Kothari D.P. Electrical Machines, Tata Mc Graw Hill Publishing Company Ltd.,New Delhi,1990.

Course Designers

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Degree :B.E. ***MODEL QUESTION PAER FOR TERMINALEXAMINATIONS***

Semester :IV

Subject code :E 42

Subject Title :AC Machines

Assessment pattern:

Remember:10 Understand:50 Apply:40 Analyze:0 Evaluate:0 Create:0

Time: 3 Hrs. Answer ALL Questions Max. marks: 100

Part-A **5x2= 10 marks**

(Remember type questions)

A1. What types of generators are used in hydroelectric power station and thermal power station?

A2. What is a synchronous condenser?

A3. Name the various speed control methods of induction motor.

A4. What is an induction generator?

A5. How can be the direction of rotation of induction motor is reversed?

Part-B **5x10=50 marks**

(Understand type questions)

B1. Explain the Potier Triangle method of finding the regulation of an alternator

B2. Describe any two methods of starting synchronous motors

B3. Explain why synchronous motor is not self starting? How to start it?

B4. Describe the constructional features of Universal motor. Also explain the working principle

B5. Why starter is necessary to start three phase induction motor? Explain in detail about Star Delta starter used for stating three phase induction motor

Part-C **4x10=40 marks**

(Apply type questions)

(Answer any Four)

C1. Draw the circle diagram for a 400V ,5 H.P.(Metric) delta connected 3-phase induction motor from the following test results(line values):

No load test: 400v, 3.0A, p.f =0.2

Short-circuit test: 200v, 12.0A, p.f =0.4

From the circle diagram determine (a) full load current, (b) full load power factor and (c) starting torque in terms of full load torque at the normal voltage.

Assume the copper losses to be equally divided between the stator and rotor.

C2. A 3300V, 3 phase star connected alternator has a full load current of 100A.On short circuit a field current of 5A was necessary to produce full-load current. The e m f on open circuit for the same excitation was 900V.The armature resistance was 0.8 ohm/phase. Determine the full load voltage regulation for (i) 0.8 p f lagging (ii) 0.8 p f leading.

C3. The following data refers to a 20pole,460V,60Hz, 3-phase I M : R1=2 ohm,X1=1 ohm, R2' =3 ohm, X2' =7 ohm. When the motor is tested on no load, it is observed that it takes 3.9A and the total core loss is 450W.By using an approximate equivalent circuit at 5% slip, calculate (i) Rotor current (ii) Supply current and pf (iii) Gross load torque (iv) draw the equivalent circuit.

C4. A 3 MVA , 50Hz, 11 kV, 3-phase star connected alternator supplies 100A at zero p f leading. The line voltage is 12370V.When the load is removed, the line voltage is 1100V.Find the regulation at full load,0.8 pf lagging. Ra=0,4ohm/phase.

C5. A three phase star connected alternator has direct axis synchronous reactance of 0,7p u and quadrature axis reactance of 0,5 p u,If the generator delivers 100kVA at rated voltage at full load and lagging, find the percentage regulation. Resistance drop at full load is 0.017 p u.

C6. Two similar 3000kVA synchronous generators work in parallel. The governor of first machine is such that frequency drops uniformly from 50Hz on no load to 48 Hz on full load. The corresponding speed drop of second machine is from 50Hz to 47.5Hz.Determine, how the two machines will share a load 5000kW at full load

***

Sub Code	Lectures	Tutorial	Practical	Credit
E 43	3	1	-	4

E43 Microprocessors and Microcontrollers 3:1

Preamble

Microprocessor and microcontroller have revolutionized information processing and automation in this modern world. Due to advancements in VLSI technology, these devices have become smaller in size but with increased computing speed. One of the main applications of microprocessor is being used as CPU in digital computers. Since microcontroller has many hardware features inbuilt in it, any application can be easily realized with it. Nowadays in most of the embedded systems, one or more microcontrollers are used. This course aims at imparting knowledge about hardware and software details of microprocessor and microcontroller to the students. Since memory and I/O devices form part of any microprocessor/microcontroller based systems, interfacing of memory and I/O devices are also addressed. The assembly language programming of microprocessor and microcontroller is also discussed to make the students to write programs for many applications. This course offers the possibility of developing novel projects based on microprocessor and microcontroller to motivate engineering students.

Programme outcomes addressed

a. Graduates will demonstrate knowledge of assembly language programming of microprocessor and microcontroller
b. Graduate will demonstrate skills to solve real world problems using microprocessor and microcontroller
c. Graduate will design new microprocessor/microcontroller based systems

Competencies

1. Become familiar with the basic concepts of microprocessor and microcontroller
2. Understand the architecture of microprocessor and microcontroller

3. Know the details of memory organization, interrupts and timing diagram for general bus operation in microprocessor.
4. Recognize the memory, parallel ports, serial port, Timer/Counter and interrupts of microcontroller.
5. Become familiar with addressing modes and instruction set of microprocessor and microcontroller.
6. Able to write assembly language programs for microprocessor and microcontroller.
7. Design memory and I/O interfacing circuit
8. Capable of developing programs to solve real world problems

Knowledge

- Architecture of microprocessor
- Addressing modes, Instruction set of microprocessor
- Interfacing memory and I/O devices with microprocessor
- Assembly language programming of microprocessor
- Applications of microprocessor
- Architecture of microcontroller
- Addressing modes, Instruction set of microcontroller
- Interfacing memory and I/O devices with microcontroller
- Assembly language programming of microcontroller
- Applications of microcontroller

Methods

1. Assembly language programming
2. Interfacing memory
3. Interfacing I/O devices

Tools

1. 8086/ 8051 Trainer kit
2. Assembler

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	10
2	Understand	40	20	20
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	20	20

Course Level Learning Objectives

Remember

1. What is the size of address bus and data bus in 8086?
2. What is the function of instruction queue in 8086?
3. Write the different segment registers in 8086 along with their function.
4. Write the default offset registers for the different segment registers in 8086.
5. What is meant by segment override prefix in 8086? Give an example.
6. Write the function of ALE and READY pins in 8086?
7. What is meant by effective address?
8. What is the function of REP prefix?
9. Write the operation carried out when XLAT instruction is executed?
10. What is an assembler?
11. What is the function of ORG and ENDS directives?
12. Write the hardware features present in 8051?
13. How many clock cycles constitute one machine cycle in 8051?
14. What are the different modes of operation of timer in 8051?
15. What is meant by indirect addressing in 8051?
16. What is meant by software de-bouncing in interfacing keyboard with 8051?
17. Explain the architecture of 8086 with neat block diagram.
18. Draw the timing diagram of general bus operation in 8086 and explain it.
19. Describe the interrupt structure of 8086 in detail.
20. Explain the different data memory addressing modes in 8086 with examples.
21. Explain the architecture of 8051 with neat block diagram.
22. Explain the different addressing modes in 8051 with examples.

Understand

1. What is the maximum size of memory that can be interfaced with 8086?
2. How the physical memory address is calculated in 8086?
3. If DS=1000H, SS=3000H, BX=2000H and SI=4000H, find the effective address and physical memory address in the following instructions:
i) MOV AX, [BX] ii) MOV AX, [BX+50H] iii) MOV AX, [BP+SI]
iv) MOV AX, [BX+SI+20H]
4. While executing following instructions, which segment is accessed by 8086?:
i) MOV CX,[BX] ii) MOV CX,[BP+5] iii) MOV CX,ES:[BX]
5. Distinguish between intersegment jump and intrasegment jump.
6. What is the difference between SUB and CMP instructions in 8086?
7. Which instruction in 8086 can be used to complement specific bits in a register or memory?
8. When DAA instruction is used?
9. Distinguish between software and hardware interrupt.
10. What is the difference between timer and counter in 8051?
11. What is the function of SM2 bit present in SCON of 8051?

Apply

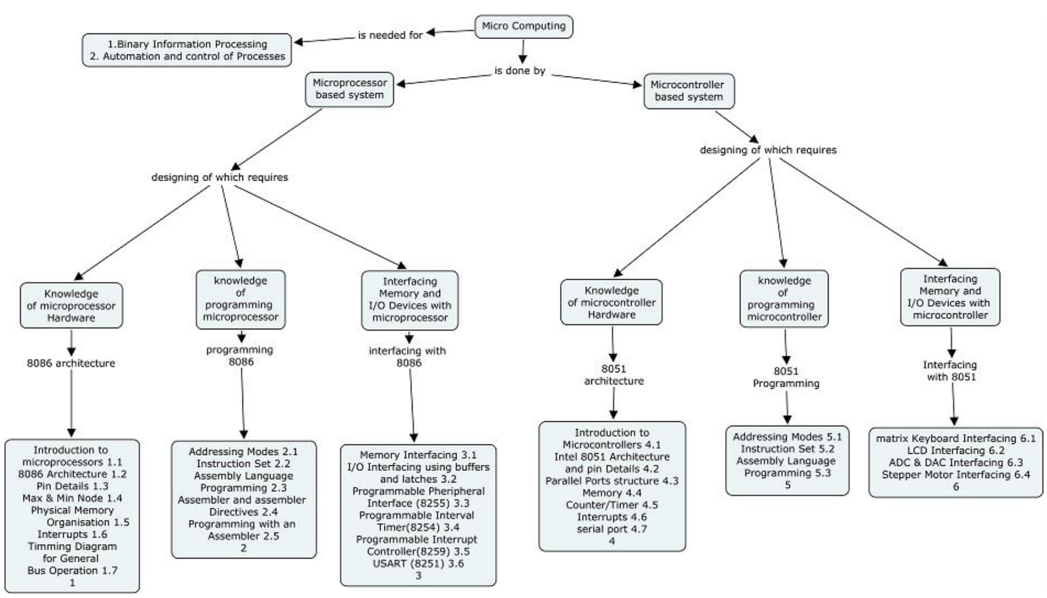
1. Write 8086 assembly language program (ALP) to add one hundred words in an array stored in memory from 2000H:3000H and store the result at 2000H:4000H.
2. Write 8086 ALP to arrange the given array having fifty byte type data stored in memory from 3000H:3000H in descending order.
3. Write 8086 ALP to find the factorial of the given byte type data stored in memory at 4000H:3000H and store the result at 2000H:3000H.
4. Write 8051 ALP to add two multi-byte numbers and store the result in memory.
5. Write 8051 ALP to convert 8-bit BCD number to binary number and binary number to seven segment code.
6. Write 8051 ALP to evaluate the expression A/B+C*D where A,B,C and D are 8-bit data. Assume A is perfectly divisible by B.
7. Write 8051 ALP to get five hundred samples of analog input data sampled at a frequency of 1KHz and store result in memory.
8. Write 8051 ALP to display the message “TCE, MADURAI” in the first line of a 20x2 LCD.

9. Write 8051 ALP to identify the key pressed in the matrix keyboard interfaced with 8051.
10. Write 8051 ALP to generate a square wave of 1 KHz using timer 0 of 8051.

Create

1. Interface two 8Kx8 RAM chips and two 8Kx8 ROM chips with 8086 such that the starting address 20000H and FC000H is assigned to RAM and ROM respectively..
2. Interface an 8-bit DIP switch with 8086 such that the address 80H is assigned to it.
3. Interface a seven segment display with 8086 such that the address 8FFFH is assigned to it.
4. Interface a 16-bit DIP switch with 8086 such that the address F0H is assigned to it.
5. Interface two seven segment displays with 8086 such that the address FFF0H is assigned to it.
6. Write 8051 ALP to generate sine wave of 2KHz frequency using DAC.
7. Interface one 8Kx8 RAM chip and one 8Kx8 ROM chip with 8051 such that the starting address 20000H and 1000H is assigned to RAM and ROM respectively.

Concept Map



Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**8086 Microprocessor**	
1.1	Introduction to microprocessors	2
1.2	8086 Architecture	1
1.2	Pin details	1
1.3	Minimum/ Maximum mode of operation	1
1.4	Physical memory organization	1
1.5	Interrupts	2
1.6	Timing diagram for general bus operation	1
2	**8086 Programming**	
2.1	Addressing modes	2
2.2	Instruction set	3
2.3	Assembly language programming	2
2.4	Assembler, Assembler directives	1
2.5	Programming with an assembler	2
3.	**Interfacing with 8086**	
3.1	Memory interfacing	1
3.2	I/O interfacing using buffers and latches	2
3.3	Programmable peripheral interface (8255)	2
3.4	Programmable Interval Timer (8254)	1
3.5	Programmable Interrupt Controller (8259)	2
3.6	USART (8251)	1
4.	**8051 Microcontroller**	
4.1	Introduction to microcontrollers	1
4.2	Intel 8051 Architecture and Pin details	2
4.3	Parallel Ports structure	2
4.4	Memory	1

4.5	Counter/Timer	1
4.6	Interrupts	1
4.7	Serial port	2
5.	**8051 Programming**	
5.1	Addressing modes	1
5.2	Instruction set	2
5.3	Assembly language programming	2
6.	**Interfacing with 8051**	
6.1	Matrix Keyboard interfacing	2
6.2	LCD interfacing	2
6.3	ADC & DAC interfacing	2
6.4	Stepper motor interfacing	1

Syllabus

8086 Microprocessor Introduction to microprocessors, 8086 Architecture, Pin details, Minimum/ Maximum mode, Physical memory organization, Interrupts, Timing diagram for general bus operation

8086 Programming Addressing modes, Instruction set, Assembly language programming, Assembler, Assembler directives, Programming with an assembler

Interfacing with 8086 Memory interfacing, I/O interfacing using buffers and latches, Programmable peripheral interface (8255), Programmable Interval Timer (8254), Programmable Interrupt Controller (8259), USART (8251)

8051 Microcontroller Introduction to microcontrollers, Intel 8051 Architecture and Pin details, Parallel ports structure, Memory, Counter/Timer, Interrupts, Serial port

8051 Programming Addressing modes, Instruction set, Assembly language programming

Interfacing with 8051 Matrix Keyboard interfacing, LCD interfacing, ADC & DAC interfacing, Stepper motor interfacing

Text Books:

1. A.K.Ray , K.M.Bhurchandi, Advanced microprocessors peripherals-Architecture, Programming and interface, Tata Mc-Graw hill ,2000, sixteenth reprint.
2. The 8051 Microcontroller and Embedded Systems, (second edition). By Muhammad Ali Mazidi, Janice Gillispie Mazidi, and Rolin D. McKinlay © 2005 Pearson Education, Inc

Reference Books:

1. K.J. Ayala, The 8051 Microcontroller, Architecture, Programming & Applications (third edition), Penram International, India (2004).
2. Douglas V.Hall, Microprocessors and Interfacing – Programming and hardware, (Second edition), Tata Mc-Graw hill, 2000.

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Degree :B.E. ***MODEL QUESTION PAER FOR TERMINALEXAMINATIONS***

Semester :IV

Subject code :E 43

Subject Title :Microprocessors and Microcontrollers

Assessment pattern:

Remember:10 Understand:30 Apply:30 Analyze:0 Evaluate:0 Create:30

Time: 3 Hrs. Answer ALL Questions Max. marks: 100

Part- A **40 Marks**

(Remember & Understand)

Answer all the questions

A1. Write the default offset registers for the different segment registers in 8086. (2)

A2. Write the function of ALE and READY pins in 8086? (2)

A3. Write the operation carried out when XLAT instruction is executed? (2)

A4. What are the different modes of operation of timer in 8051? (2)

A5. Write the different interrupts along with their priority in 8051? (2)

A6. How the selection of a particular register bank is done in 8051? (2)

A7. What are different methods by which the content of internal RAM with address 00H can be accessed? (2)

A8. Why the word type array is normally stored starting from an even address in memory in 8086? (2)

A9. What is the difference between TEST and AND instructions in 8086?. (2)

A10. If DS=5000H, SS=3000H, BX=3000H, BP=6000H and SI=4000H, find the effective address and physical memory address in the following instructions:

i) MOV AX, [BX] ii) MOV AX, [BX+30H] iii) MOV AX, [BP+SI]

iv) MOV AX, [BX+SI+20H] (4)

A12. Is it possible to access the ISR of divide by 0 interrupt using software interrupt instruction? How? (2)

A13. Which instruction in 8086 can be used to complement specific bits in a register or memory?. Explain with an example. (3)

A14. How the LCD is tested whether it is busy or not ? (3)

A15. Explain the architecture of 8086 with neat block diagram. (10)

Part- B **(30 Marks)**

(Answer All Questions)

(Apply)

B1. Write a 8086 ALP to find the factorial of a 8-bit data. Assume that the maximum result is 32-bits. (10)

B2. Write an 8086 program to convert the given ASCII code to binary code and 8-bit binary code to BCD code. (10)

B3. Write 8051 ALP to interface a 4x4 matrix keyboard with 8051 and display the key number that is pressed in port 1. (10)

Part- C **(30 Marks)**

(Create)

C1. Interface two 8Kx8 RAM chips and two 8Kx8 ROM chips with 8086 such that the starting address 40000H and 80000H is assigned to RAM and ROM respectively. (10)

(or)

C2. Interface a seven segment display with 8086 such that the address 8FFFH is assigned to it. (10)

C3. Interface an 8-bit DIP switch with 8086 such that the address F0H is assigned to it. (10)

(or)

C4. Interface two seven segment displays with 8086 such that the address FFE0H is assigned to it. (10)

C5. Write 8051 ALP to generate sine wave of 1 KHz frequency using DAC. (10)

(or)

C6. Write 8051 ALP to generate square wave of 2KHz in P1.0 pin using timer 0. (10)

***

Sub Code	Lectures	Tutorial	Practical	Credit
E 44	3	0	-	3

E44 Thermal Engineering 3:0

Preamble

Thermal Engineering deals with the application of laws of thermodynamics and heat transfer to various engineering systems. It plays a major part in the design and analysis of automotive engines, steam and gas turbine systems and components used in various power plants.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduates will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.
i. Graduates who can participate and succeed in competitive examinations.

Competencies

1. Understand the concepts of thermodynamics and its application in thermal systems.
2. Explain working principles of gas cycle, vapor cycle, and air standard cycle.
3. Determine the performance parameters of IC engines, steam turbines, gas turbines and compressors.
4. Understand the principles of heat transfer and its application in thermal and electrical systems.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	10
2	Understand	30	30	30
3	Apply	30	30	40
4	Analyze	20	20	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember:

1. State second law of thermodynamics
2. List the different types of vapour power cycles
3. Define reheat cycle
4. List the various methods of cooling gas turbine blades
5. Give the different types of air compressors
6. State Fourier heat conduction law

Understand:

1. Why do electronic components fail under prolonged use at high temperature?
2. Distinguish between change of state, path and process
3. Distinguish between Carnot cycle and Rankine cycle.
4. What are the advantages of a closed circuit gas turbine plant over an open circuit type?
5. Explain the significance of reheat and regenerative cycles.
6. What is meant by work ratio?
7. How will you determine the steam rate?
8. What are the advantages of reheat and regenerative cycles?

9. How do you determine the volumetric efficiency of an air compressor?
10. Name some good conductors and some poor conductors of heat

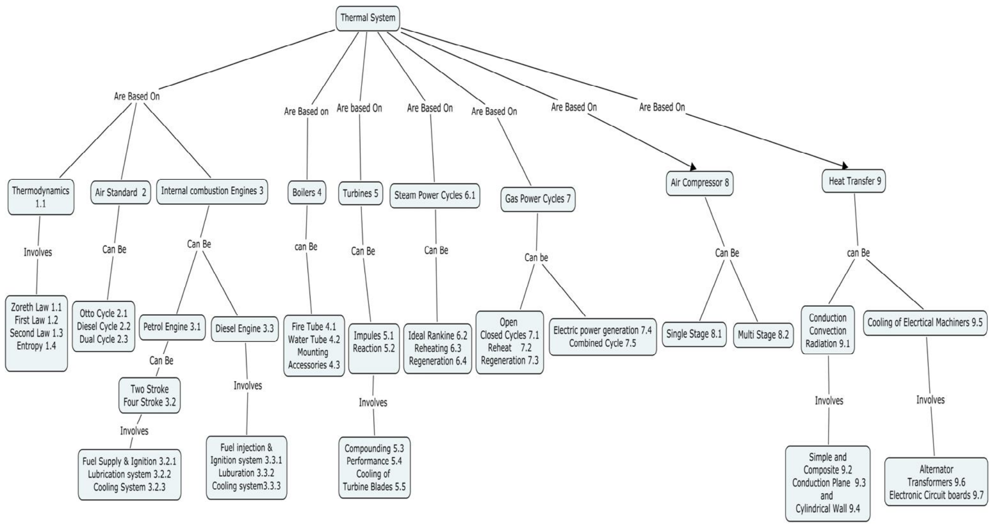
Apply:

1. Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7 m/s velocity, 100 kPa pressures and 0.95 m^3/kg and leaving at 5 m/s velocity, 700 kPa pressures and 0.19 m^3/kg. The internal energy of the air leaving is 90 kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. Compute the rate of shaft work input to the air in kW and find the ratio of the inlet pipe diameter to outlet pipe diameter
2. For an air standard Diesel cycle the following data are available. CR = 16. Heat added per kg = 2500 kJ/kg. Lowest temperature in the cycle = 300 K. Lowest pressure in the cycle = 1 bar. Calculate i) pressure and temperature at each point in the cycle. ii) thermal efficiency iii)power output for the cycle for air flow rate of 0.25 kg /sec
3. Steam pipe of 0.12 m outside diameter is insulated with a 20mm thick layer of calcium silicate. If the inner and outer surfaces of the insulation are at temperatures of $T_{s,1}$=800K and $T_{s,2}$=490 K, respectively, what is the heat loss per unit length of the pipe? For calcium silicate: k=0.089W/m.K

Analyze:

1. Show that the efficiency of a reversible engine is independent of the working substance going through the cycle.
2. Compare different vapour power cycles
3. Differentiate a gas turbine plant for electric power generation from a gas turbine air craft engine.
4. Explain why and when does cooling of gas turbine blades become necessary.
5. Distinguish two stroke petrol and a four stroke petrol engine.
6. Distinguish single stage and multi stage air compressor
7. Can a low-power electronic system in space be cooled by natural convection? Can it be cooled by radiation?

Concept Map



Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Thermodynamics**	
1.1	Basic concepts, Zeroth law	1
1.2	First law, Non-flow, Steady flow,	1
1.3	Second law, Carnot engine, Heat pump,	1
1.4	Entropy, Clausius's inequality, principle of entropy increase	1
2	**Air-standard cycles**	
2.1	Otto cycle	1
2.2	Diesel cycle	1
2.3	Dual cycle	1
3	**Internal combustion engines**	
3.1	Petrol engine	1
3.2	Two stroke and four stroke cycles	1
3.2.1	Fuel supply and ignition system	1

No.	Topic	No. of Lectures
3.2.2	Lubrication system	1
3.2.3	Cooling system	1
3.3	Diesel engine	1
3.3.1	Fuel supply and ignition system	1
3.3.2	Lubrication system	1
3.3.3	Cooling system	1
4	**Boilers:**	
4.1	Fire tube boilers	1
4.2	water tube boilers	1
4.3	Mounting and accessories	1
5	**Turbines:**	
5.1	Impulse	1
5.2	reaction	1
5.3	compounding	1
5.4	Performance of turbines	1
5.5	cooling of turbine blades	1
6	**Steam power cycles**	
6.1	Steam properties, Mollier diagram	2
6.2	Rankine cycle	1
6.3	Reheat cycle	1
6.4	Regeneration cycle	1
7	**Gas power cycles:**	
7.1	Components of gas power plant, gas turbine open and closed power cycles,	1
7.2	Reheat	1
7.3	Regeneration cycles	1
7.4	Electric power generation	1

No.	Topic	No. of Lectures
7.5	Combined steam and Gas turbine plants	2
8	**Reciprocating Air compressors**	
8.1	Single stage compressor	1
8.2	Multi stage compressor	1
9	**Heat Transfer**	
9.1	Conduction, convection and radiation.	1
9.2	Simple and composite system.	1
9.3	Conduction through plane wall	1
9.4	Conduction through cylinders,	1
9.5	Cooling of electrical machines,	1
9.6	Alternator and Transformer cooling	1
9.7	Cooling in electronic circuit boards.	1

Syllabus

Thermodynamics: Basic concepts, Zeroth law, First law, Non-flow, Steady flow, Second law, Carnot engine, Heat pump, Entropy, Clausius's inequality, principle of entropy increase.

Air standard Cycles: Otto, Diesel, Dual, Calculation of mean effective pressure and air standard efficiency.

Internal combustion engines: 2 stroke and 4 stroke petrol and diesel engines, Ignition, Fuel, Cooling and lubricating systems. Performance calculation, various efficiencies.

Boilers: Fire tube and water tube boilers, Mounting and accessories.

Turbines: Impulse, reaction, types of compounding, cooling of turbine blades, Performance of turbines.

Steam power cycles: Steam properties, Mollier diagram, Components of steam power plant, Ideal Rankine cycle, and Reheating and Regeneration cycles, Heat rate and work rate.

Gas power cycles: Components of gas power plant, gas turbine open and closed power cycles, Reheat and Regeneration cycles, Electric power generation. Combined steam and
Gas turbine plants.

Air compressors: Reciprocating type- work of compression, volumetric efficiency, performance calculation, multistage compression.

Heat Transfer: Conduction, convection and radiation. Conduction through plane wall and cylinders, simple and composite system. Cooling of electrical machines, Alternator, Transformer and electronic circuit boards.

Text Books

1. Rudramoorthy R, “Thermal Engineering”, Tata McGraw-Hill, New Delhi, 2003
2. Nag,P.K, “Engineering Thermodynamics”, Tata McGraw-Hill, New Delhi, 2005
3. Yahya S.M., Turbines, Compressors and Fans, Tata Mc Graw Hill, 1997
4. Sachdeva R.C, “Fundamentals of Engineering Heat and Mass Transfer”, New Age International Ltd Publishers,2003

Reference Books

1. Rajput.R.K , “Thermal Engineering”, S. Chand publishers,
2. Yunus A. Cengel and Michael A. Boles, “Thermodynamics: An Engineering Approach”, Second edition, Mc Graw Hill, 2001.
3. Dixon S.L., Fluid Mechanics and Thermodynamics of Turbo machinery, Fifth edition, Science and Technology, Books Division, South Asia, 2005.
4. Yunus A. Cengel ,“Heat transfer: A practical Approach”, Second edition, Mc Graw Hill, 2004.

Course Designers:

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2. **Mr .M. Babu bobby@tce.edu**

Degree :B.E. ***MODEL QUESTION PAER FOR TERMINALEXAMINATIONS***

Semester :IV

Subject code :E 44

Subject Title :Thermal Engineering

Assessment pattern:

Remember:20 Understand:20 Apply:30 Analyze:30 Evaluate:0 Create:0

Time: 3 Hrs. Answer ALL Questions Max. marks: 100

(Use of Steam Tables, Mollier Chart and Heat transfer Data book permitted)

Answer **ALL** questions

PART – A (10×2 = 20 marks)

(Remember & Understand)

A1. State second law of thermodynamics

A2. List the different types of vapour power cycles

A3. List the various methods of cooling gas turbine blades

A4. Give the different types of air compressors

A5. Distinguish between Carnot cycle and Rankine cycle.

A6. What are the advantages of a closed circuit gas turbine plant over an open circuit type?

A7. Explain the significance of reheat and regenerative cycles.

A8. What is meant by work ratio?

A9. How do you determine the volumetric efficiency of an air compressor?

A10. Name some good conductors and some poor conductors of heat

PART – B (4×5 = 20 marks)

(Remember & Understand)

B1. Compare different vapour power cycles

B2. Differentiate a gas turbine plant for electric power generation from a gas turbine air craft engine.

B3. Distinguish two stroke petrol and a four stroke petrol engine.

B4. What are methods used for cooling alternator, Transformer and electronic circuit boards.

PART – C (3×20= 60 marks)

(Analyzer & Apply)

C1. a) For an air standard Diesel cycle the following data are available. CR = 16. Heat added per kg = 2500 kJ/kg. Lowest temperature in the cycle = 300 K. Lowest pressure in the cycle = 1 bar. Calculate i) pressure and temperature at each point in the cycle. ii) Thermal efficiency iii) power output for the cycle for air flow rate of 0.25 kg /sec

b) Derive an expression to find the Mean effective pressure of otto cycle?

(or)

C2. a) With neat sketch explain the battery coil ignition system

b) With a neat sketch any one type of lubrication system

C3. a) Explain the function of a high pressure Boiler

b) What is Compounding of turbine? Explain any one type of compounding

(or)

C4. In a constant pressure cycle gas turbine plant the minimum and maximum temperature are 50 ^{o} c and 950 ^{o}c respectively. If the compressor and the turbine efficiencies are 0.82 and 0.87, determine for maximum power output:

(i) The pressure ratio of the turbine and compressor

(ii) The maximum power output per unit flow rate and

(iii) The thermal efficiency of the plant.

Assume for both compressor and turbine γ = 1.4 and c_p= 1.005 kJ/kg K.

C5. a) Steam expands from 160 bar, 500 o c to 60 bar in a steam turbine plant compare the plant efficiencies, heat rate and dryness fraction of the exhaust steam for reheat pressures of 70 bar , 50 bar and 25 bar. Assume isentropic expansion. Ignore the feed pump work.

b) How do you determine the volumetric efficiency of an air compressor?

(or)

C6. a) Steam pipe of 0.12 m outside diameter is insulated with a 20mm thick layer of calcium silicate. If the inner and outer surfaces of the insulation are at temperatures of $T_{s,1}$=800K and $T_{s,2}$=490 K, respectively, what is the heat loss per unit length of the pipe? For calcium silicate: k=0.089W/m.K

b) Brief:

i) Convection ii) Conduction iii) Radiation

***

Sub Code	Lectures	Tutorial	Practical	Credit
E 45	3	0	0	0

E45 Digital Signal Processing 3:0

Preamble:

Digital Signal & Digital Signal Processing (DSP) is the best starting point for the study of Electrical science & Engineering. It introduces the students to the use of mathematics as a language for thinking about engineering problems; it creates useful ground work for subsequent courses; it makes a strong connection to digital computation as a means for implementing systems; and it offers the possibility of interesting applications to motivate engineering students to do the hard work of connecting mathematics and computation to problem solving.

Hands on experience with real signals are crucial. This can be provided by assignments based on MATLAB/Silab provided on PCs. Sound and image signals are the most familiar signals to students of first year. In assignments, students gain direct reinforcement from hearing and seeing the effects of filtering operations that they have implemented on sound and image signals. They synthesize music from sinusoids, and they see that those same sinusoids are the basis for the data modems that are used routinely to access internet. Also students can design DSP based controllers for electrical applications such as speed control of motor, power system control etc.

Programme outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduate will demonstrate skills to use modern engineering tools, software's and equipment to analyze problems.
c. Graduate who can participate and succeed in competitive examinations.

Competencies

1. To express complex continuous time signals (beat notes, amplitude modulated signals, periodic waveforms and synthetic vowels) as sums of sinusoids and Fourier series.
2. To convert analog signals into digital signals through sampling and reconstruct analog signals from digital signals.
3. To perform well-informed interpretation of data by computing the spectrum of signals.
4. To characterize linear time invariant discrete-time systems, that have finite impulse response (FIR filters), in time domain, frequency domain and z-domain.
5. To design and analyze FIR filters in the aspect of practical implementation.
6. To characterize linear time invariant discrete-time systems, that have infinite impulse response (IIR filters), in time domain, frequency domain and z-domain.
7. To design and analyze IIR filters in the aspect of practical implementation.
8. To characterize linear time invariant continuous-time systems, samplers, modulators and filters, in time domain and frequency domain.
9. To design DSP based controllers for electrical applications such as speed control of motor.

Knowledge

- Mathematical Representations of signals
- Parameters of analog and digital signals
- Concept of sampling
- Fourier analysis of periodic signals
- Time and Frequency domain response of continuous time signals
- Frequency domain representation for analog and digital signals
- Implementation and Responses of FIR filters
- Implementation and Responses of IIR filters
- Analysis of Filters using z-Transforms, DFT and FFT
- Architecture of DSP

Methods

1. Difference equations
2. z-Transforms
3. Fourier series
4. Fourier Transforms
5. Discrete Fourier Transforms
6. Fast Fourier Transforms

Tools

1. MATLAB
2. Lab View

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	10	10	0
2	Understand	20	20	20
3	Apply	40	20	20
4	Analyze	30	20	20
5	Evaluate	0	10	10
6	Create	0	20	30

Course Level Learning Objectives

Remember

1. Define the following
    a. unit impulse function
    b. unit step function
3. State sampling theorem
4. Define, aliasing.
5. Define, FIR & IIR filter
5. List the basic blocks for implementing FIR filter.
6. Define the linearity and time invariance property of LTI system.
7. What is the relationship between z-transform and Discrete Time Fourier Transform?
8. List the methods available to design FIR & IIR filter.

Understand

1. What is the difference between continuous and discrete time signal?
2. Is the signal $7\cos(9.6\pi n + 0.2\pi)$ is an alias of the signal $7\cos(0.4\pi n - 0.2\pi)$?
3. What is a causal system? Give an example.
4. Is the time flip system $y(n) = x(-n)$ linear system?
5. Distinguish between continuous time signal and discrete time signal.
6. Relate DFT with CTFT.
7. What is meant by linear phase response?
8. What is radix-2 FFT?
9. What is the function of wait state generator in digital signal processor?

Apply

11. Compute the output $y(n)$ for the length-4 filter whose coefficients are $\{b_k\}=\{3, -1, 2, 1\}$ where $x(n) = \{2,4,6,4,2\}$.
12. An LTI system is described the following equation

    $$y(n) = x(n) + 2x(n-1) + x(n-2)$$

    a) Obtain an expression for the frequency response of this system.

    b) Sketch the magnitude and phase response as a function of frequency.

    c) Determine the output when the input is $x(n) = 10 + 4\cos(0.5\pi n + \pi/4)$

    d) Determine the output when the input is unit impulse sequence.

    e) Determine the output when the input is unit step sequence.
13. An LTI system is described by the following equation

    $$y(n) = 1/4\{x(n) + x(n-1) + x(n-2) + x(n-3)\}$$

    $$= 1/4\sum_{k=0}^{3} x(n-k)$$

    a) what is h(n) , the impulse response of the system?

    b) Determine the system function H(z) for this system.

    c) Plot the poles and zeros of H(z) in the complex z-plane.

    d) From H(z) , obtain an expression for the frequency response $H(e^{j\omega})$ of this system.
14. Determine 8-point DFT of the following

    a) x(n) = 1 n=0

    0 n=1,2...7

b) x(n) = 1 for n= 0,1,2….7

c) x(n) = 1 n=4

= 0 n≠4

d) $x(n) = e^{j\pi n/5}$ for n=0,1,2….7

15. Find the Z –Transform of the following discrete time signal and find ROC for each signal.

$$x(n) = [-1/5]^n u(n) + 5[1/2]^{-n} u(-n-1)$$

16. Compute 8-point DFT of the sequence x(n) = {1, -1, 1, -1, 0, 0, 0, 0} using radix-2 DIT algorithm.

17. Obtain direct form-I & direct form-II structures for the following system.

$$y(n) = \tfrac{1}{2}\, y(n-1) + \tfrac{1}{4}\, y(n-2) + x(n) + x(n-1)$$

Analyze

1. Suppose that S is a linear time-invariant system whose exact form is unknown. It has been tested by observing the output signals corresponding to several different test inputs. Suppose that the following input-output pairs were the result of the tests:

Input: x(n)	Output: y(n)
$\delta(n)$	$\delta(n)$ - $\delta(n-3)$
$\cos(2\pi n/3)$	0
$\cos(\pi n/3 + \pi/3)$	$2\cos(\pi n/3 + \pi/3)$

Is the following statement true or false? Explain.

$$H(e^{j\pi/2}) = 0$$

2. Find whether the systems are linear, time invariant, causal and static or not.

(i) y(n) = $e^{-x(n)}$, (ii) y(n) = x(n)cosωn, and (iii) $y(n) = \sum_{k=-\infty}^{n} x(k+3)$

3. State whether the system described by the following equation is stable or not.

$$H(z) = (2 + 2z^{-1})/(1 - 1.25z^{-1})$$

4. Let

$H(S) = \dfrac{2}{(S+1)(S+2)}$, Determine H(z) using impulse invariance method.

Evaluate

1. Compare the different Fourier transforms techniques.
2. Evaluate the convolution of two identical pulses defined by

$$x(n) = u(n+(1/2)n) - u(n-(1/2)n)$$

Create

8. A LTI system has impulse response

$$h(n) = 3\delta(n) - 2\delta(n-1) + 4\delta(n-2) + \delta(n-4)$$

Synthesize a system as a block diagram in direct form.

9. Design an ideal high pass filter using hamming window with a frequency Response. Assue, N = 7.

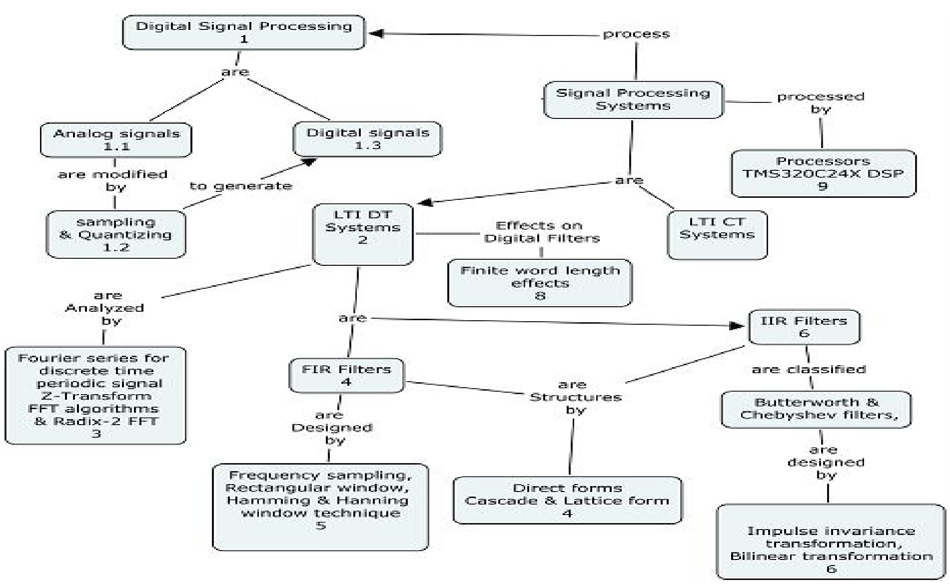
$$H_d(e^{jw}) = 1 \;;\; \Pi/4 \le |w| \le \Pi$$
$$= 0 \;;\; |w| \le \Pi/4$$

10. Design Butterworth filter satisfying the following constraints with T= 1 second using impulse invariance method.

$$0.707 \le |H(e^{jw})| \le 1 \quad \text{for} \quad 0 \le w \le \Pi/2$$

$$|H(e^{jw})| \le 0.2 \quad \text{for} \quad 3\,\Pi/4 \le w \le \Pi$$

Concept Map



Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Signals**	
1.1	Analog Signals	1
1.2	Sampling and Quantizing	1
1.3	Digital Signals	1
2	**Discrete Time Signals & Systems**	
2.1	Operation on discrete time signals	1
2.2	Frequency analysis of discrete time signals	1
2.3	Classifications of discrete time systems	2
3	**Characterization of Digital Signal & System**	
3.1	Fourier series for discrete time periodic signal	1
3.2	Properties of FFT for discrete time signals	1
3.3	Z Transform	1
3.4	Properties and computation of DFT	2
3.5	FFT algorithms & Radix-2 FFT	2
4.	**FIR Filter Structures**	
4.1	Properties of FIR filter	1
4.2	Direct forms	1
4.3	Cascade & Lattice form	1

5.	**Design of FIR Filters**	
5.1	Frequency sampling technique	1
5.2	Rectangular window technique	1
5.3	Hamming & Hanning window technique	2
6.	**IIR Filter Structures**	
6.1	Properties of IIR filter	1
6.2	Direct forms	1
6.3	Cascade & Lattice form	1
7.	**Design of IIR Filters**	
7.1	Design of IIR filters from continuous time filters	1
7.2	Butterworth & Chebyshev filters	1
7.3	Impulse invariance transformation	1
7.4	Bilinear transformation	1
8.	**Finite word length effects in Digital Filters**	
8.1	Effects of co-efficient on quantization process	1
8.2	Effects on realization of digital filters	2
9.	**TMS320C24X DSP**	
9.1	Architecture of TMS320C24X DSP	1
9.2	Central Processing Unit of TMS320C24X DSP	1
9.3	Memory and I/O Spaces	1
9.4	Induction motor speed control	1

Syllabus

Signals - Analog Signals, Sampling and Quantizing, Digital Signals

Discrete Time Signals & Systems - Operation on discrete time signals, Frequency analysis of discrete time signals, Classifications of discrete time systems

Characterization of Digital Signal & System - Fourier series for discrete time periodic signal, Properties of FT for discrete time signals Z Transform, Properties and computation of DFT, FFT algorithms & Radix-2 FFT

FIR Filter Structures - Properties of FIR filter Direct forms, Cascade & Lattice form

Design of FIR Filters - Frequency sampling technique, Rectangular window technique, Hamming & Hanning window technique

IIR Filter Structures - Properties of FIR filter, Direct forms, Cascade & Lattice form

Design of IIR Filters - Design of IIR filters from continuous time filters, Butterworth & Chebyshev filters, Impulse invariance transformation, Bilinear transformation

Finite word length effects in digital Filters - Effects of co-efficient on quantization process, Effects on realization of digital filters

TMS320C24X DSP - Architecture of TMS320C24X DSP, Central Processing Unit of TMS320C24X DSP, Memory and I/O Spaces, Induction motor speed control.

Text Book:

1. John J.Proakis & Dimitris G. Manolakis – Digital Signal Processing-Principles, Algorithms & Applications – Pearson Education, 2007.

Reference Books:

1. P.Ramesh Babu - Digital signal processing, Scitech publications of India, 2008.
2. TMS320C24X DSP Controllers Reference Guide – Texas Instruments, 1999.
3. Sanjit K. Mitra - Digital Signal Processing-A computer based approach – Tata McGraw Hill, 2007.

4. A.V.Oppenheim & R.W.Scaffer - Digital signal processing, Prentice Hall of India, 2003.

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Semester : III ***MODEL QUESTION PAPER FOR TERMINAL EXAMINATION***

Subject code : E 45

Subject Title : Digital Signal Processing

Assessment pattern:

Remember:10 Understand: 10 Apply: 20 Analyze: 20 Evaluate: 20 Create: 20

Time: 3 Hrs. Answer ALL Questions Max. Marks: 100

SECTION A
(Remember & Understand)

A1. State sampling theorem. (2)

A2. Define aliasing. (2)

A3. Distinguish between continuous time signal and discrete time signal. (4)

A4. What is the relationship between z-transform and Discrete Time Fourier Transform? (2)

A5. What is meant by linear phase response? (2)

A6. What is a causal system? Give examples. (2)

A7. Distinguish between IIR & FIR Filters. (4)

A8. What is the function of wait state generator in digital signal processor? (2)

SECTION B
(Apply & Analyze)

B1. Find the Z –Transform of the following discrete time signal and find ROC for the following signal.

$x(n) = [-1/5]^{n} u(n) + 5[1/2]^{-n} u(-n-1)$ (10)

B2. Determine 8-point DFT of the following sequence,

x(n) = {0.5,0.5,0.5,0.5,0,0,0,0} using radix-2 DIT algorithm. (10)

B3. Find whether the systems are linear, time invariant, causal and static or not.

(i) $y(n) = e^{-x(n)}$, (ii) $y(n) = x(n)\cos\omega n$, and (iii) $y(n) = \sum_{k=-\infty}^{n} x(k+3)$ (15)

B4. State whether the system described by the following equation is stable or not.

$H(z) = (2 + 2z^{-1})/(1 - 1.25z^{-1})$ (5)

SECTION C
(Evaluate & Create)

C1. Evaluate the Fourier Transform value at π/4 radians for a 4-point sequence whose DFT coefficients are given below. (10)

k	Real Part	Imaginary Part
0	10.00	+0.00

1	+2.00	-2.00
2	+2.00	+0.00
3	+2.00	+2.00

(OR)

C2. Two sequences $x_1(n)$ and $x2(n)$ are given below. Find the linear convolution between them by evaluating circular convolution of suitable length.

$x_1(n) = 1$ for $0 \le n \le 3$ and 0 for other values of 'n'

$x_2(n) =$ 'n' for $0 \le n \le 7$ and 0 for other values of 'n' (10)

C3. A LTI-DTS transfer function has poles at $0.3 \pm j\,0.4$ and $0.6 \pm j\,0.7$. It has zero at $z = -1$ with multiplicity of four. It has a DC Gain of unity. Draw the signal flow graph in (i) Cascade form and (ii) Parallel form (10)

(OR)

C4. Design an ideal high pass filter using hamming window with a frequency response. Assume, N = 7. (10)

$$H_d(e^{jw}) = 1 \;;\; \Pi/4 \le |w| \le \Pi$$
$$= 0 \;;\; |w| \le \Pi/4$$

C5. Design Butterworth filter satisfying the following constraints with T= 1 second using impulse invariance method. (10)

$$0.707 \le |H(e^{jw})| \le 1 \quad \text{for} \quad 0 \le w \le \Pi/2$$

$$|H(e^{jw})| \le 0.2 \quad \text{for} \quad 3\,\Pi/4 \le w \le \Pi$$

(OR)

C6. Evaluate the FFT using DIT algorithm for the sequence x(n) = {1, 2, 3, 4, 4, 3,2, 1 } and draw the corresponding flow diagram.

C7. Explain the Type I & Type 2 design of FIR filter using frequency sampling Technique? (10)

(OR)

C8. Design a Butterworth filter using bilinear transformation for the specifications

$0.8 \le |H(ej\omega)| \le 1 \quad 0 \le \omega \le 0.2\pi$

$|H(ej\omega)| \le 0.2 \quad 0.6\pi \le \omega \le \pi$ (10)

***

Sub Code	Lectures	Tutorial	Practical	Credit
E 46	3	0	-	3

E46: Electrical and Electronic Measurements 3:0

Preamble

The proposed course is offered in fourth semester and its main purpose is to

- To elaborate on the practical aspects of measurements like symbols used, mounting of instruments, accuracy classes, various national and international Standards for measurement, calibration, National and International Standards laboratories etc.
- To explain the static and dynamic characteristics of measuring instruments.
- Discuss and calculate various types of errors in measurements.
- To impart knowledge about various electrical and electronic measuring instruments, their construction, working principle and applications.
- In view of present day technologies fundamental concepts of some of the special instruments like CRO , Digital Frequency meters, Recorders.., are included

Program Outcomes addressed:

a. After completion of this course the students will have basic knowledge about the concepts of various types of electrical and electronic measuring instruments.

b. An ability to identify the type of measuring instruments to be used for specific applications.

c. Students should be able to choose the particular instrument for the specific application that will function with minimum error.

Competencies:

At the end of the course students should be able to

1. To explain the basic characteristics, terminologies, practical aspects of various measuring instruments 2. 2. Explain the constructional aspects, operating principle of different types of ammeters, voltmeters, wattmeter's , energy meters , flux meters, galvanometers, and special instruments like CRO, Recorders , function generators, frequency meters.
2. To perform the error calculations and statistical analysis of errors.
3. To measure the R, L and C parameters in any electrical networks using bridges.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	15	10
2	Understand	10	20	10
3	Apply	20	15	20
4	Analyze	20	15	20
5	Evaluate	20	15	20
6	Create	10	20	20

Course Level Learning Objectives

Remember

1. List the different types of errors in measurements.
2. Define the term accuracy.
3. Mention some important static characteristics of measuring instruments.
4. Define the term calibration in measurements.
5. Name the two types of MI instruments.
6. List the major parts of general purpose CRO.
7. List the four sources of possible errors in measurements.

Understand

1. Mention the types of bridges used for resistance measurements.
2. Differentiate the terms ‘accuracy’ and ‘resolution’.
3. What is the basic operating principle of a rectifier type measuring instrument?
4. What is the difference between true rms value and average value?
5. What is need for separation of iron losses in magnetic measurements?
6. Why vibration galvanometer is used as detector for operation of AC bridges
7. State the limitations of Wheatstone bridge.
8. Define the term ‘limiting error’
9. Explain the working and constructional details of attraction type instruments
10. What is the basic principle of a rectifier instrument?
11. State the difference between LPF and UPF wattmeter’s

Apply

1. Explain how frequency and phase angle are measured using CRO.
2. Explain how three phase power measurement is done by using two wattmeter method.
3. Discuss the applications of Digital magnetic tape recorders.
4. A meter whose constant is 600 revolutions per kWh, makes 5 revolutions in 20 seconds. Calculate the load in kW.
5. Discuss the various types of errors and method of their compensation in dynamometer type wattmeter

Analyze

1. Why moving iron instruments have non uniform scale?
2. What is phantom loading and explain with an example how it is more advantageous than direct loading?
3. How the difficulties associated with measurement of high resistance can be overcome?

4. The iron loss in the sample is 300 watts at 50 Hz with the eddy current component 5 times as big as the hysterisis loss component. At what frequency will the iron loss be doubled if the flux density is kept the same?
5. In a test run of 30 minutes duration with a constant current of 5A, the A-H meter registers 525 wh. The supply voltage is 220V. Calculate the error and state whether the meter is fast or slow.

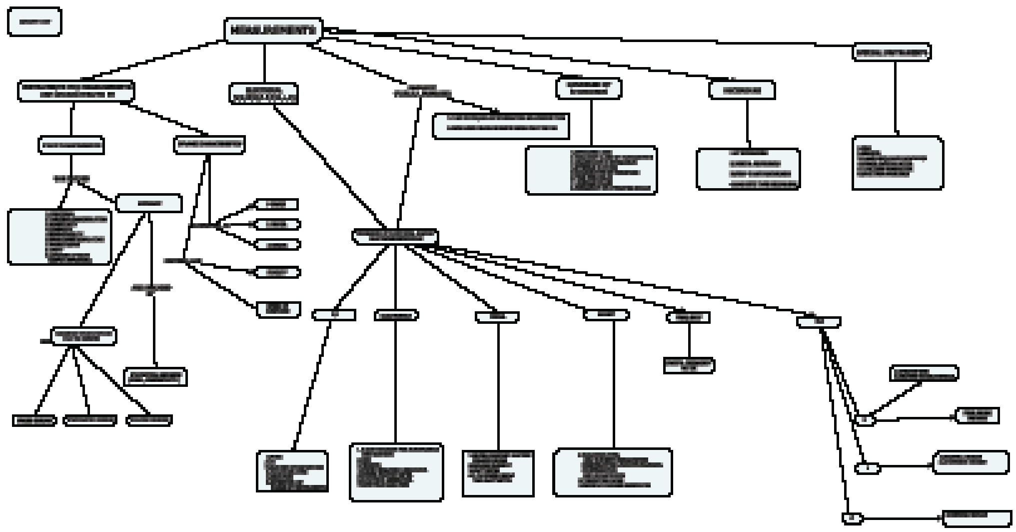
Evaluate

1. A Maxwell bridge is used to measure inductive impedance. The bridge constants at balance are C_1=0.01μ F, R_1=470 K Ω, R_2=5.1 K Ω and R_3=100 K Ω. Find the series equivalent of the unknown impedance.
2. A set of independent voltage measurements taken by four observers was recorded as 117.02 V, 117.11V, 117.08V, 117.03V. calculate a) average error b) range of error
3. Obtain the bridge balance equation for a Kelvin's Double bridge.
4. A fluxmeter is connected to a search coil of 100 turns and the mean area of the coil is .0005 square meter. The search coil is placed at the centre of a standard solenoid, 1 meter long, uniformly wound with 800 turns. When a current of 5 A is reversed, a deflection of 10 scale divisions is obtained with the flux meter. Calculate the calibration constant of the instrument in wb-turns per division.
5. What is the difference between a primary and secondary standard

Create

1. Obtain the difference between potential and current transformer
2. What is creeping? How it can be prevented?
3. Describe how a waveform is stored and analyzed using DSO.
4. Describe how permeability of magnetic specimen is measured using permeameter.
5. A meter, whose constant is 600 revolutions per kWh, makes 5 revolutions in 20 seconds. Calculate the load in kW.

Concept Map



Course contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Static and Dynamic Characteristics of Measuring Instruments**	**4**
1.1.	Static characteristics	3
1.1.1	Accuracy and Precision	
1.1.2	Threshold and Resolution	
1.1.3	Sensitivity	
1.1.4	Linearity	
1.1.5	Repeatability	
1.1.6	Dead Zone and Dead time	
1.1.7	Range and Span	
1.1.8	Drift	
1.1.9	Loading effects and Input impedance	

1.2	Dynamic Characteristics	1
1.2.1	Dynamic response of Zero, First and Second order systems	
1.2.2	Fidelity	
1.2.3	Speed of response	
2.	**Errors in Measurements**	**3**
2.1	Definition of Error	1
2.2	Types of Errors	
2.2.1	Gross Error	
2.2.2	Systematic Error	
2.2.3	Random Error	
2.3	Statistical analysis of Errors	2
2.3.1	Mean	
2.3.2	Variance	
2.3.3	Standard Deviation	
2.3.4	Probable error	
3	**Important terms in practical measurements.**	**3**
3.1	Standard Laboratories	
3.2	Accuracy class of Instruments	
3.3	Calibration and Standards	
3.4	Symbols in meters	
3.5.	Various types of mountings	
3.6	True RMS Value	

3.7.	Average Value	
3.8	Frequency of operating range	
4	**Current and Voltage measurements**	**6**
4.1	PMMC type of instruments	1
4.2	Moving Iron type instruments	1
4.3	Electrodynamometer type instruments	1
4.4	Induction type instruments	1
4.5	Rectifier type instruments	1
4.6	Extension of range of Instruments	
4.7	Block diagram representation of a general electronic instrument (Current measurement)	1
5	**Power and Energy Measurements**	**7**
5.1	Electrodynamometer type of single element and double element wattmeter	1
5.2	Power measurement in three phase circuit using two wattmeter / double element method.	1
5.3	Induction type single element and double element energy meter	2
5.4	Errors, compensation and adjustments	1
5.5	Trivector meter	1
5.6	Maximum demand Indicator	1
6.	**Measurement of R, L, C using bridges**	**5**
6.1	Measurement of Resistance	
6.1.1.	Wheatstone Bridge	1
6.1.2.	Kelvin double Bridge	1

6.2.	Measurement of Inductance	
6.2.1.	Maxwell's Bridge	1
6.2.2	Andersons Bridge	1
6.3.	Measurement of Capacitance	
6.3.1.	Schering Bridge	1
7.	**Magnetic Measurements**	**6**
7.1.	Ballistic Galvanometer	1
7.2.	Vibration Galvanometer	1
7.3.	Flux meter	1
7.4.	Permeameter	1
7.5.	Separation of Iron losses	1
7.6.	Measurement of Iron losses using wattmeter method	1
8.	**Special Instruments**	**6**
8.1.	Constructional aspects and operation of a general purpose Analog and digital CRO	1
8.2.	Megger	1
8.3.	Phase sequence Indicator	
8.4.	Power Factor meter	
8.5.	Digital frequency meter	1
8.6.	Function Generator	
8.7.	Spectrum analyzer	1
8.8.	X-Y Recorders	
8.9.	Digital magnetic tape recorder	1

Syllabus

Static and Dynamic Characteristics of Measuring Instruments : Static Characteristics, Accuracy and Precision, Threshold and Resolution, Sensitivity, Linearity, Repeatability, Dead Zone and Dead time, Range and Span, Drift, Loading , effects and Input impedance, Dynamic Characteristics, Dynamic response of Zero, First and Second order systems, Fidelity, Speed of response.

Errors in Measurements: Definition of Error, Types of Errors, Gross Error, Systematic Error, Random Error, Statistical analysis of Errors, Mean, Variance, Standard Deviation, Probable error.

Definitions of important terms connected with practical measurements : Standard Laboratories, Accuracy class of Instruments, Calibration and Standards, Symbols in meters, Various types of mountings, True RMS Value, Average Value, Frequency of operating range**.**

Current and Voltage measurements: PMMC type of instruments, Moving Iron type instruments, Electrodynamometer type instruments, Induction type instruments, Rectifier type instruments, Extension of range of Instruments, Block diagram representation of a general electronic instrument (Current measurement).

Power and Energy measurements: Electrodynamometer type of single element and double element wattmeter, Power measurement in three phase circuit using two wattmeter / double element method, Induction type single element and double element energy meter, Errors, compensation and adjustments, Trivector meter, Maximum demand Indicator.

Measurement of R, L C using Bridges: Measurement of Resistance, Wheatstone Bridge, Kelvin double Bridge, Measurement of Inductance, Maxwell's Bridge, Anderson's Bridge, Measurement of Capacitance, Schering Bridge.

Magnetic Measurements: Ballistic Galvanometer, Vibration Galvanometer, Flux meter, Permeameter, Separation of Iron losses, Measurement of Iron losses using wattmeter method.

Special Instruments: Constructional aspects and operation of a general purpose Analog and digital CRO, Megger, Phase sequence Indicator, Power Factor meter, Digital frequency meter, Function Generator, Spectrum analyzer, X-Y Recorders, Digital magnetic tape recorder

Text Book:

1. A Course in Electrical and Electronic Measurements and Instruments ,"A.K.Sawhney", Dhanpat Rai & Sons, 1999

Reference Books:

1. Electronic Instrumentation ," Kalsi.H.S ",Tata McGraw-Hill 2003
2. Measurements and Measuring Instruments," E.W.Golding and F.E.Widdies "Sir Isaac Pitman and Sons (P) Ltd., 1985.
3. Modern electronic Instrumentation and Measurement techniques, "Albert D.Cooper,William D.Cooper",PHI
4. A Course in Electronic and Electrical Measurements and Instrumentation "J.B.Gupta",S.K.Kataria & Sons 2001

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Semester :III ***MODEL QUESTION PAPER FOR TERMINAL EXAMINATION***

Subject code : E 46

Subject Title :Electrical and Electronic Measurements

Assessment pattern:

Remember:10 Understand: 10 Apply: 20 Analyze: 20 Evaluate: 20 Create: 20

Time: 3 Hrs. Answer ALL Questions Max. Marks: 100

Part-A 10x2= 20 marks

(Remember)

A1. List the different types of errors in measurements.

A2. Define the term accuracy.

A3. Define the term calibration in measurements

A4. Name the two types of MI instruments.

A5. List the major parts of general purpose CRO.

(Understand)

A6. What is the basic operating principle of rectifier instrument?

A7. State the difference between LPF and UPF WATTMETERS.

A8. What is the need for separation of iron losses in magnetic measurements?

A9. Why vibration galvanometer is used as detector for operation of AC bridges?

A10. What is the difference between true RMS value and average value?

Part-B 8x5=40 marks

(Apply)

B1. Explain how three phase power measurement is done by using two wattmeter method.

B2. Discuss the applications of Digital magnetic tape recorders.

B3. A meter whose constant is 600 revolutions per Kwh , makes 5 revolutions in 20 seconds. Calculate the load in KW.

B4. Explain how data are getting recorded in digital magnetic tape recorder.

(Analyze)

B5. What is phantom loading and explain with an example how it is more advantageous than direct loading ?

B6. How the difficulties associated with measurement of high resistance can be overcome ?

B7. The iron loss in the sample is 300 watts at 50 Hz with the eddy current component 5 times as big as the hysterisis loss component. At what frequency will the iron loss be doubled if the flux density is kept the same ?

B8. In a test run of 30 minutes duration with a constant current of 5A, the A-H meter registers 525 Wh. The supply voltage is 220V. Calculate the error and state whether the meter is fast or slow.

Part-C 4x10=40 marks

(Create and Evaluate)

C1. Explain how a waveform is stored and analyzed using DSO.

(OR)

C2. Explain how frequency and phase angle are being measured using CRO.

C3. A flux-meter is connected to a search coil of 100 turns and the mean area of the coil is 0.0005 square meter. The search coil is placed at the centre of a standard solenoid, 1 meter long, uniformly wound with 800 turns. When a current of %A is reversed, a deflection of 10 scale divisions is obtained with the flux meter. Calculate the calibration constant of the instrument in Weber-turns per division.

(OR)

C4. Describe how permeability of magnetic specimen is measured using permeameter.

C5. A Maxwell bridge is used to measure inductive impedance. The bridge constants at balance are C_1=0.01µ F, R_1=470 K Ω, R_2=5.1 K Ω and R_3=100 K Ω. Find the series equivalent of the unknown impedance.

(or)

C6. A set of independent voltage measurements taken by four observers was recorded as 117.02 V, 117.11V, 117.08V, 117.03V. calculate a) average error b) range of error

C7. A sample of bakelite was tested by the Schering bridge method at 25 KV, 50Hz. Balance was obtained with a standard condenser of 109 pF capacitance, a condenser of capacitance 0.5 micro farad in parallel with a non-reactive resistor of 309 ohms and a non-reactive resistor of 100 ohms. Determine the equivalent series resistance and the power factor of the specimen.

(OR)

C8. A wattmeter is used to measure the power in the circuit with the help of the equation $P=E^2/R$ where limiting values of voltage and resistance are, E=200 V + 1% and R= 100 ohm + 5 %.

Calculate: (1) the nominal power consumed and (2) The limiting error of power in percent and watts.

***

Sub Code	Lectures	Tutorial	Practical	Credit
E 47	--	--	3	1

E47 AC Machines Laboratory 0 : 1

Purpose of Laboratory Experiments

The purposes of the conducting the experiments in the laboratory are any of the following:

- To understand the physical concepts
- To be familiar with the electrical machines regarding its usage
- To study the important characteristics of the electrical machines

List of Experiments

1. Load Test Three phase Induction Motor
2. Predetermination of performance characteristics of Three phase induction motor
3. Load Test on Single phase induction motor
4. Regulation of Alternator by EMF and MMF Methods
5. Determination of Regulation of Alternator by Actual loading
6. Regulation of Alternator using Zero Power Factor Method
7. Determination of Direct axis and Quadrature Axis reactance's of Salient pole Alternator
8. V Curves and Inverted V Curves of Synchronous motor
9. Study of Starters for AC Motors
10. Speed Control of Three Phase Induction Motor by Variable Frequency Drive
11. Performance Characteristics of Commutator Motor
12. Parallel operation of Alternators

Course Designers

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6. Dr.V.Saravanan vseee@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
E 48	--	--	3	1

E48 Thermal Engineering Lab 0:1

Purpose of Laboratory Experiments

To enable the students to conduct tests on various experimental test rigs and to determine the performance and characteristics of heat engines and the performance of air compressor and Boiler.

List of Experiments

(Any Twelve experiments to be conducted)

1. Performance test on a single cylinder petrol engine.
2. Performance test on a single cylinder diesel engine
3. Retardation test to determine friction power of a diesel engine
4. Morse test to determine friction power of a multi cylinder petrol engine.
5. Determination of Valve timing diagram
6. Determination of Port timing diagram
7. Performance test on turbo charged diesel engine
8. Performance test on a Multipoint fuel injection engine
9. Energy balance test on diesel engine using airflow measurement method
10. Energy balance test on diesel engine using Exhaust gas Calorimeter measurement method
11. Performance test on a two stage reciprocating air compressor
12. Determination of boiler efficiency and equivalent evaporation of boiler
13. Emission analysis on petrol engine
14. Emission analysis on diesel engine

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
E 49	**1**	**0**	**1**	**2**

E49 Professional Communication
1:1

(Common to All branches of B.E & B.Tech. :**B49, C49, D49, E49, G49, IT49**)

Preamble

Professional communication aims to develop Listening, Speaking, Reading and Writing skills in Engineering students' professional development contexts such as projects, competitive exams, organizational communication and soft skills.

Program outcomes addressed

g. Graduate will demonstrate knowledge of professional and ethical responsibilities.

h. Graduate will be able to communicate effectively in both verbal and written form.

j. Graduate will develop confidence for self education and ability for life- long learning.

k. Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course the students will be able to:

Listening:

1. Listen and understand the project presentations, competitive exam exercises, organizational communication activities
2. Listen to the lectures on soft skills for practice.

Speaking:

1. Present project reports, self introduction
2. Participate in GD and interview in work context.

Reading:

1. Read and collect information for project report writing.
2. Read and understand the comprehension passages given in competitive examinations.
3. Read and understand the company profile

Writing:

1. Write a project report adhering to proper format
2. Create a paragraph and essay using their own ideas
3. Write circulars, minutes of the meetings, and curriculum vitae

Assessment Pattern

	Bloom's Category	Continuous Assessment	End-semester examination
1	Remember	20	10
2	Understand	20	20
3	Apply	20	20
4	Analyze	20	30
5	Evaluate	10	10
6	Create	10	10

Course Content:

1. Listening:

1.1 Attention, understanding and responding

1.2 Project report writing, competitive exam exercises, organizational communication and soft skills practice

2. Speaking:

2.1 Planning, preparation and presentation

2.2 Project report, self introduction, GD and interview

3. Reading:

3.1 Rapid reading and reference skills

3.2 Project reports, competitive exam exercises and company profiles

4. Writing:

4.1. Structure

4. 1.1 Sentence structure

4.1.2 Abstract writing

4.1.3. CV writing

4.1.4. Project report writing

4.2 Organizational Communication

4.2.1 Circulars

4.2.2 Minutes of the meeting

Syllabus:

Listening: Listening to Project presentation: Asking Questions, Listening test as conducted in TOEFL and BEC, Listening in the context of Organizational communication and Soft skill practice.

Speaking: Project presentation skill, Speaking in the context of Group Discussion, Interview, TOEFL and BEC Exam Spoken Test, Speaking in the work Contexts : Self introduction, Mini Presentation

Reading: Reference Skills for Project Report Writing: Topic selection, Data Collection. Rapid Reading, Reading comprehension tests conducted in CAT, TOEFL, GRE and BEC, Reading skills in work situation: Company Profile

Writing: Project Report Writing : Format, Abstract, Bibliography, Structure : Sentence structure, CV Writing, Writing in Work context : Circulars, Minutes of the meeting

Reference Books

1. Tony Lynch: Study Listening. Cambridge, Cambridge University Press, 2007
2. Sangeeta Sharma and Binod Mishra: Communication Skills for Engineers and Scientists. New Delhi, PHI Learning Pvt. Ltd. 2009.
3. Hari Mohan Prasad and Uma Rani Sinha: Objective English for Competitive Examination. New Delhi, Tata McGraw – Hill, 2005
4. Bob Dignen, Steeve Flinders et. al.: Work and Life: English 365. Students Book 1,2 & 3. New Delhi, Cambridge, 2004.
5. McGrath, " Basic Skill for all" , PHI, New Delhi,2008

List of Lecture sessions:

Listening:

1. Effective listening skills
2. Nature of listening tests in competitive examinations
3. Introduction of soft skills

Speaking:

1. Introduction of Presentation skills
2. Suggestions for speaking tests in competitive exams
3. How to participate in GD
4. Interview techniques

Reading:

1. Rapid reading techniques
2. Reference skills
3. Suggestions for reading tests in competitive exams

Writing:

1. Format of project report
2. Abstract of the project
3. Sentence structure
4. Organizational communication like sending circulars, writing minutes of the meetings
5. CV writing

List of Practice Sessions:

Listening:

1 Messages, descriptions, conversations and lectures

Speaking:

1. Self Introduction
2. Mini Presentation
3. GD
4. Interview

Reading:

1. Rapid reading practices
2. Comprehension exercises
3. Topic selection and data collection for project report

Writing:

1. Sentence structure
2. Abstract writing
3. Project Report Writing
4. Circulars
5. Minutes of the meeting
6. Model test

Course Designers

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B.E Degree (Electrical and Electronics Engineering) Program

Fifth Semester

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

B.E. DEGREE (Electrical and Electronics Engineering) PROGRAM

FIFTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2008-2009 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
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MADURAI – 625 015, TAMILNADU

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Web: www.tce.edu

Department of Electrical and Electronics Engineering

Graduating Students of B.E. program of EEE will be able to

1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power
2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015

Department of Electrical and Electronics Engineering

Scheduling of Courses

Semester	Theory Courses						Practical/Project		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					E88 Project 0:12	
7th (21)	E71 Mgmt. The. & Practice 3:0	E72 Protection & Switchgear 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0			E78 Project 0:6	
6th (21)	E61 Accounting & Finance 3:0	E62 Power System Analysis 3:0	E63 Electric Drives 3:0	E64 Design with FPGAs 3:1	Elective 1 3:0	Elective 2 3:0	E67 Power System Simulation Lab 0:1	E68 Power Electronic & Drives Lab 0:1	
5th (24)	E51 Numerical Methods 4:0	E52 Generation, Transmission and Distribution 4:0	E53 Power Electronics 3:0	E54 Embedded Systems 3:0	E55 Mixed Signal Circuits 3:0	E56 Design of Electrical Machines 4:0	E57 Digital Signal Processing Lab 0:1	E58 Microprocessor and Microcontroller Lab. 0:1	E59 Instrumentation and Control Lab 0:1
4th (25)	E41 Engineering Mathematics – IV 4:0	E42 AC Machines 4:0	E43 Microprocessors 4:0	E44 Thermal Engineering 3:0	E45 Digital Signal Processing 3:0	E46 Electrical & Electronic Measurements 3:0	E47 AC Machines Lab. 0:1	E48 Thermal Engineering Lab 0:1	E49 Professional Communications 1:1
3rd (24)	E31 Engineering Mathematics – III 4:0	E32 Electromagnetics 4:0	E33 DC Machines and Transformers 4:0	E34 Digital Systems 3:0	E35 Data Structures 3:0	E36 Control Systems 4:0	E37 Digital Systems Lab 0:1	E38 DC Machines & Transformers Lab 0:1	
2nd (23)	E21 Engineering Mathematics – II 4:0	E22 Electric Circuit Analysis 4:0	E23 Analog Circuits and Systems 4:0	E24 Computers and Programming 3:0	E25 Material Science 3:0	E26 Ecology 2:0	E27 Analog Circuits and Systems Lab 0:1	E28 Computer Programming Lab 0:1	E29 Workshop 0:1
1st (25)	H11 Engineering Mathematics – I 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of M & CE 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab 0:1	H18 Chemistry Lab 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2008-2009 onwards)

FIFTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
E 51	Numerical Methods	BS	4	-	-	4
E 52	Generation, Transmission and Distribution	DC	3	1	-	4
E 53	Power Electronics	DC	3	-	-	3
E 54	Embedded Systems	DC	3	-	-	3
E 55	Mixed Signal Circuits	DC	3	-	-	3
E 56	Design of Electrical Machines	DC	3	1	-	4
PRACTICAL						
E 57	Digital Signal Processing Lab.	DC	-	-	3	1
E 58	Microprocessor and Microcontroller Lab.	DC	-	-	3	1
E 59	Instrumentation and Control Lab.	DC	-	-	3	1
Total			**19**	**2**	**9**	**24**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2008-2009 onwards)

FIFTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	E51	Numerical Methods	3	50	50	100	25	50
2	E52	Generation, Transmission and Distribution	3	50	50	100	25	50
3	E53	Power Electronics	3	50	50	100	25	50
4	E54	Embedded Systems	3	50	50	100	25	50
5	E55	Mixed Signal Circuits	3	50	50	100	25	50
6	E56	Design of Electrical Machines	3	50	50	100	25	50
PRACTICAL								
7	E57	Digital Signal Processing Lab.	3	50	50	100	25	50
8	E58	Microprocessor and Microcontroller Lab.	3	50	50	100	25	50
9	E59	Instrumentation and Control Lab.	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

Sub Code	Lectures	Tutorial	Practical	Credit
E 51	4	0	-	4

E51 Numerical Methods 4:0

(Common to D51,B51,G51)

Preamble

An engineering student needs to have some basic mathematical tools and techniques. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims at giving adequate exposure in the numerical solutions in the field of polynomial and transcendental equations, simultaneous equations, interpolation, differentiation and integration, ordinary and partial differential equations.

Program Outcomes addressed

a. Graduate will demonstrate an ability to apply knowledge of Engineering and Information Technology in mathematics and Science.
b. Graduate will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduate will develop confidence for self education and ability to engage in life-long learning.

Competencies

At the end of the course the student should be able to:

1. Differentiate between the analytical and numerical / approximate solutions for the problems in engineering and technology.
2. Apply the concept of solutions of algebraic and transcendental equations in engineering problems by formulating such equations.
3. Apply the different techniques for getting the solution of a system of simultaneous equations using direct and iterative methods.
4. Identify the importance of Eigen values for a matrix and calculate those using different techniques.
5. Interpolate and extrapolate the given data using different methods of interpolation with the help of various operators.
6. Apply the process of Numerical Integration to related problems of engineering and technology for getting approximate values of the given integral .
7. Formulate and Give Numerical solutions using various techniques for ODEs modeled in engineering and technology.
8. Formulate and Give Numerical solutions using various techniques for PDEs modeled in engineering and technology.

Assessment Pattern

	Bloom's category	Test 1	Test 2	Test 3 / End Semester Examination
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Understand

1. Compare the exact solution and approximate solution of equations
2. Discuss the various techniques for the approximate solution of Algebraic and transcendental equations.
3. List the various methods for obtaining the approximate solution of system of simultaneous equations stating the basic principles used.
4. Discuss the various methods to interpolate and extrapolate the given data using various methods of interpolation.
5. Interpret the importance and significance of the process of numerical integration.

Apply

1. Solve the following system of equations by Gauss Jacobi method
   $8x+y+z=8$; $2x+4y+z=4$; $x+3y+3z=5.$
2. Using Newton's method find the root of $x^3-4x^2+x+6=0$; $x_0=5$ correct to 4 decimal places
3. Using Lagrange's formula for interpolation find $y(9.5)$ given:

x	:	7	8	9	10
y	:	3	1	1	9

4. The following data gives the velocity of the particle for 2 seconds at an interval of 5 seconds. Find the acceleration at 5 seconds

Time	:	0	5	10	15	20
Velocity	:	0	3	14	69	228

5. Compute $\int_0^6 \frac{dx}{1+x}$, using Simpson's $\frac{1}{3}rd\ and\ \frac{3}{8}th$ rule.
6. Find the value of $y(0.2)\ and\ y(0.4)$ using Runge-Kutta method of fourth order with h=0.2 given that $\frac{dy}{dx}=\frac{y^2-x^2}{y^2+x^2}$; $y(0)=1.$
7. Solve : $u_t=u_{xx}$ given $u(0,t)=0$; $u(x,0)=x(1-x)$; $u(1,t)=0$; assume h=0.1 and choose suitable k so that u(i,j) is found out for i=0,0.1...1 and j=k,2k,3k.

Syllabus

Solution of Transcendental and Polynomial Equations: Bisection, Regula falsi, Newton-Raphson, Iterative Methods, Horner's Method, Giraeffes Root Squaring Method.

Solution to System of Equations: Gauss Elimination, Gauss Jordan, Crouts, Gauss Seidel, Gauss Jacobi, Inversion by Gauss Jordan and Crout's Method.

Eigen Values: Power method, Jacobi Method.

Interpolation and Differentiation: Newton's forward difference interpolation and differentiation formula and backward difference interpolation and differentiation formula, Gauss's Forward difference interpolation and differentiation formula and backward difference interpolation formula, Lagrange's Interpolation formula. Newton's formulae for derivatives.

Integration:

Trapezoidal, Simpson's $\frac{1}{3}$rd , $\frac{3}{8}$th rules, Gauss quadrature 1point, 2point, 3point formula

Ordinary Differential Equations:

Initial value Problem - Runge-Kutta Method, Predictor-Corrector Methods -Milne's, Adams -Boundary Value Problem - Finite difference Method- Numerov's method

Partial Differential Equations:

Classification: Parabolic (Schmidt)-Hyperbolic- Elliptic- Implicit and Explicit methods, Crank Nicholson method.

Text Book:

1. Jain.M.K.,Iyengar.S.R.K.,Jain R.K., "Numerical Methods for Scientific and Engineering Computation"-Fifth edition, New Age International Publishers, New Delhi-2009.

Reference Books:

1. Robert.J Schilling, Sandra L.Harris "Applied Numerical Methods for Engineers using Matlab and C" Thomson Books/cole,1999
2. Sastry S.S "Introductory Methods of Numerical Analysis" Prentice Hall of India -2006

Course contents and Lecture schedule

No	Topic	No. of Lectures
1.0	**Solution of transcendental and polynomial equations**	
1.1	Bisection , Regulafalsi , Newton- Raphson method	3
1.2	Iterative method	2
1.3	Horner's method	3
1.4	Graffe's root squaring method	2
2.0	**Solution to system of equations**	
2.1	Gauss elimination and Gauss Jordan methods	2
2.2	Crout's method	2
2.3	Gauss Jacobi and Gauss siedal methods.	2
2.4	Inversion by Gauss Jordan and Crout's methods.	2
2.5	Power method and Jacobi method for finding eigen values	2
3.0	**Interpolation, Differentiation and integration**	
3.1	Newton Gregory's forward and backward difference	2

	interpolation formulae	
3.2	Gauss's and Lagrange's interpolation formulae	2
3.3	Newton's forward formulae for derivatives	2
3.4	Trapezoidal, Simpson's 1/3rd & 3/8th Rules	2
3.5	Gauss quadrature ,1 point , 2 point and 3 point formulae	2
4.0	**Ordinary Differential equations**	
4.1	Introduction – Initial value problems	2
4.2	Runge- Kutta Methods-second and fourth order	2
4.3	Predictor corrector methods-Milne and Adams	2
4.4	Boundary value problems Finite difference method.	2
4.5	Numerov's method	2
5.0	**Partial Differential equations**	
5.1	Introduction, Classification of PDEs.	2
5.2	Solution of parabolic equations-Implicit and explicit methods,Bender Schmidt method, Crank Nicholson Method	3
5.3	Solution of hyperbolic equations by explicit scheme.	3
5.4	Solution of elliptic equations - Leibmann's process	2

Course Designers

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5. M.Kameshwari mkmat@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
E 52	3	1	-	4

E52 Generation, Transmission and Distribution 3:1

Preamble

The objective of any power system is to generate electrical energy in sufficient quantities at the best locations, to transmit it to various load centers and then distribute it to various consumers, and to maintain the quality and reliability of transmission at an economic price. To maintain the quality, the frequency and voltage are constantly maintained at a specified value. The interruptions in supply of power to consumers should be minimal.

Programme Outcomes addressed

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

k. An ability to consider issues from global and multilateral views

Competencies

At the end of the course the student should be able to:

1. Plan power generation to meet the demands of a State.
2. Determine the adequacy of power generation to meet the specified demand.
3. Determine the performance of a given electric power transmission system.
4. Determine corona loss of a transmission line.
5. Determine the sag and tension in overhead transmission lines
6. Determine the number of String Insulators and string efficiency for overhead transmission lines
7. Determine the parameters of an underground cable for a specified power transmission.
8. Determine the location of distribution transformers to meet the demand of consumers.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	10
2	Understand	50	40	40
3	Apply	30	40	50
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

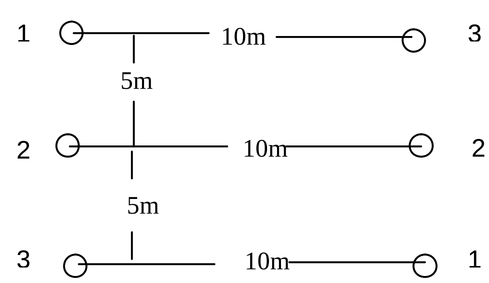
1. Define the term Plant Capacity factor
2. Define the term plant use factor
3. Define the term Diversity factor
4. Write the suitable turbine used for tidal power plant
5. Define the terms GMD and GMR.
6. What are the ABCD constants of long transmission lines?
7. Define the term Critical Disruptive Voltage.
8. What are the factors affecting the corona?
9. What are the methods of damping of vibrations in conductors?
10. State the causes of failure of insulators?

Understand

1. The connected load of a consumer is 2 KW and his maximum demand is 1.5KW. Find the demand factor of consumer.
2. The maximum demand of a consumer is 2KW and his daily energy Consumption is 20 units. Find the load factor.
3. What is meant by proximity effect?
4. What are the factors affecting the skin effect?
5. What is meant by surge impedance loading?
6. What is the need of transposition of conductors?
7. What is meant by Sag template?
8. What are the various types of Under-Ground cables?
9. Distinguish between radial and ring main distribution systems.
10. What are the factors affecting the corona loss and explain the methods of reducing the corona loss.

Apply

1. The six conductors of a double circuit three phase line are arranged as shown in the following figure. The diameter of each conductor is 3cm. Find the inductive and capacitive reactance to neutral and the charging current per km per phase at 66 KV and 50Hz, assuming that the line is transposed.



2. A 3 phase 50 Hz transmission line is 150 km long and delivers 25MW at 110 kV and 0.85 p.f. lagging. The resistance and reactance of the line per conductor per kilometer are 0.3 ohms and 0.9 ohms respectively. The line charging admittance 0.3 mho/km/ph. Compute the voltage regulation and transmission efficiency by applying nominal-Π method.
3. A string of three insulators has mutual capacitance of C and capacitance to ground of 0.25C. Determine the voltage across each unit as a fraction of the operating voltage. Also determine the string efficiency (i)without guard ring (ii) with guard ring that gives capacitance between the link pin and the ring of 0.1C.

4. The generalized circuit constants of a transmission line are as follows

$A=D=0.895\angle 1.4°$; $B=182.5\angle 78.6°$

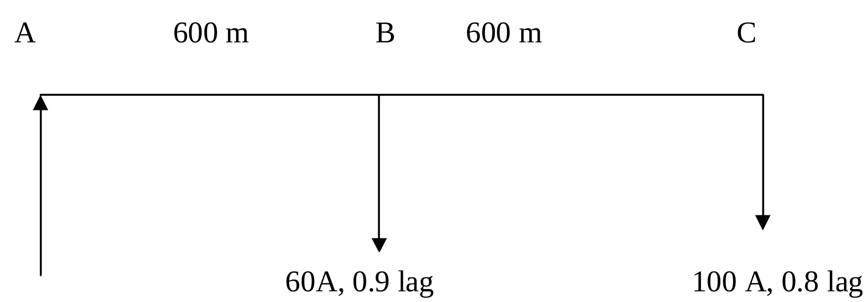
I. If the line supplies a load of 50MW at 0.85 p.f. and 220kV, find the sending-end voltage.
II. For a load of 80MVA at 0.85 p.f. lagging, at 220 kV, determine the reactive power supplied by the line and by the synchronous condenser, if the sending-end voltage is 240 kV. Also determine the power factor of the line at the receiving end.
III. Determine the maximum power transmitted if the sending-end and receiving-end voltages are as in (II).

5. A transmission line conductor at river crossing is supported from two towers at heights of 45 meters and 75 meters above water level. The span length is 300metres. Weight of the conductor is 0.85 kg/meter. Determine the clearance between the conductor and water?

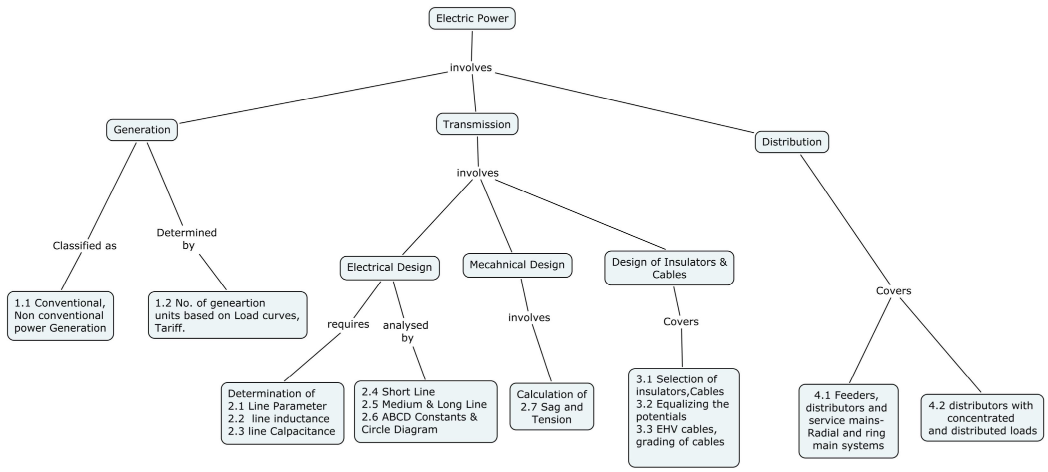
(a) at a point midway between towers and

(b) at a point with a distance of 200m from its starting point. The tension in the conductor is 2050 kg.

6. A 2 wire distributor 1200m long is loaded as shown in the following figure. B is the mid point. The Power factors at the two load points refer to the voltage at C. The impedance of each line is (0.15 + j 0.2) ohms. Calculate the sending end voltage and current? The voltage at C is 220V.



Concept Map



Syllabus

Generation – Introduction to Indian Power Scenario, Generation of electrical power by conventional methods a brief review about generation from tidal, wind, geothermal and solar sources, Determination of number and size of units based on load curves, Cost of electrical energy and tariff.

Design of Transmission Line - Inductors and Inductance- Inductance of two wire transmission line- Inductance of three phase asymmetrically spaced transmission line Transposition of Power lines-Composite conductors- Inductance of Composite conductors- Inductance of double circuit three phase line – Bundled conductors- Skin and Proximity effect- Capacitance of Single phase transmission line- Capacitance of double circuit line- Effect of earth on the capacitance of the conductor. Representation of lines - Short transmission lines- Medium length transmission lines- Long transmission lines – ABCD constants – Circle diagram – Mechanical Design of Transmission Lines **-** Sag and tension Calculations- Stringing Chart - Sag template- Equivalent span – Stringing of conductors, Corona, Ferranti effect.

Design of Insulators and Cables - Types of Insulators – Potential distribution over a string of suspension insulators- Methods of equalizing the potential- Failure of Insulators- Testing of Insulators- Extra High voltage cable- Grading of Cables- Insulation resistance of a cable- Capacitance of single core cable- Heating of cables- Overhead lines versus underground cables- Types of Cables.

Distribution systems - Feeders, distributors and service mains- Radial and ring main systems- Types of Distributors – Calculation of voltage in distributors with concentrated and distributed loads – Concentrated and Distributed load fed at both ends. Load balancing.

Text Books:

1. C.L. Wadwa - Electrical Power system – New Age International-4th Edition – 2005.
2. B.R. Gupta, “Generation of Electrical Energy”, Euresia Publishing House Pvt., Ltd., New Delhi – 2003.

Reference Books:

1. S.L. Uppal - Electrical power, Khanna Publishers, 1996.
2. C.L. Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Publishers, Second Edition, 2006

3. T.S.M. Rao - Principles and practice of electric power transfer systems, 1994.
4. Soni ML and Gupta PV - A Textbook on Power Systems Engineering – Dhanpath Rai 1st Edition-1998.
5. H. Cotton and H. Barber - Transmission and distribution of electrical energy – BI, NewDelhi -1992

Course contents and Lecture schedule

Sl. No.	Topic	No. of Lectures
1.0	**Generation of Electrical Power**	
1.1	Introduction to Indian power Scenario; Generation of electrical power by conventional methods, a brief review about generation from tidal, wind, geothermal and solar sources	5
1.2	Determination of number and size of units based on load curves Cost of electrical energy and tariff.	2
2.0	**Design of Transmission lines**	
2.1	Line Parameters	1
2.2	Inductance of 2wire, 3phase unsymmetrical spaced lines, composite conductors, Inductance of double circuit(3phase)lines, Bundled conductors, Skin & proximity effect	3
2.3	Capacitance of 1phase & double circuit lines, effect of earth on capacitance	3
2.4	Representation of short transmission lines	1
2.5	Medium & Long transmission lines	3
2.6	ABCD constants, Circle diagram , Ferranti effect	4
2.7	Sag & Tension calculations, String chart, vibration and dampers,	4
2.8	Corona-Formation, effects & reduction methods.	2
3.0	**Design of Insulators and Cables**	
3.1	Types of insulators, potential distribution of insulator string	3
3.2	Equalizing the potentials, failure & testing of insulators	2
3.3	EHV cables, grading & types of cables Insulation resistance, capacitance & Heating, O.H (Vs) U.G cables	4
4.0	**Distribution Systems**	
4.1	Feeders, Distributors & service mains, Radial & Ring main systems	4
4.2	Calculation of voltage in distributors- Concentrated & Distributed loads, Load balancing	4
	TOTAL	45

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Sub Code	Lectures	Tutorial	Practical	Credit
E 53	3	-	-	3

E53 Power Electronics 3:0

Preamble

Power Electronics is a field which combines Power (electric power), Electronics and Control systems. Power electronics may be defined as the subject of applications of solid state power semiconductor devices for the control and conversion of electric power.

The course will start with a brief review of the power semiconductor switches used in the power supply circuits. As all the dc-dc converters need to use some power semiconductor switch for their operation, the drive circuits of the three most popular devices viz. BJT, MOSFET and IGBT will be addressed. Concepts and circuits for protecting and de-stressing the devices will also be discussed.

Almost all power supplies will draw the energy from the mains grid. As a consequence the first stage is always a AC-DC converter. The most popular AC-DC converter is the rectifier-capacitor filter. This topology will be discussed, analyzed and designed.

In most multi-output power supplies, the final stages of the uncontrolled outputs are in general linear power ICs. Therefore, a proper understanding of the concepts, ability to analyse and design linear power supplies is essential. Thus the review of the power semiconductor switches and drive circuits will be followed by a treatment on the linear power supply strategies and their design aspects.

Next the dc-dc switched mode converter topologies as applied to power supplies will be dealt, with both analysis and design.

This will include the non-isolated primary converter (viz. Buck, boost and the buck-boost) and their isolated derivatives like the push-pull, half bridge and the full bridge topologies. The popular flyback topology which is the derivative of the non-isolated buck-boost topology will also be addressed.

Following the discussion on the dc-dc converters, typical applications of dc-dc converters like power supplies, unity power factor converters and battery chargers will be addressed with special emphasis on batteries and battery charging circuits.

Next the dc-ac inverter is discusses the various VSI and CSI based inverters and explains the 120 degree and 180 degree of operation.

This course will primarily need a strong background of electric circuits and electric networks as pre-requisite. Therefore, these two topics must have already been taught in an earlier semester.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
d. Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.
e. Graduate will be able to communicate effectively in both verbal and written form.
f. Graduate will develop confidence for self education and ability for life-long learning.
g. Graduate who can participate and succeed in competitive examinations.

Competencies

The student, at the end of the course, should be able to:

1. Understand the requirements of an ideal switch and the characteristics of important power semiconductor switches thereby enabling one to model and simulate the power semiconductor switches
2. Estimate the conduction and switching power losses in various power semiconductor switches.
3. Design drive circuits for BJTs, MOSFETs and IGBTs
4. Understand the operation of rectifiers and the effect of the various loads on rectifier functioning and draw current and voltage waveforms at various points in the circuit.
5. Design capacitor-filter rectifier circuits.
6. Analyze and characterize the linear regulators
7. Design the various types of linear regulators
8. Analyze the steady-state operation of a DC–DC converter
9. Design non-isolated and isolated DC–DC converters
10. Design battery chargers using dc-dc converters
11. Design of dc-ac inverters

Assessment pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	10	0
2	Understand	20	20	20
3	Apply	40	30	40
4	Analyze	10	20	30
5	Evaluate	10	10	10
6	Create	0	0	0

Course level Learning Objectives

Remember

1. List the advantages of MOSFET.
2. List the types of Power Converters.
3. In any converter topology, the inductor should be placed in such a manner where its current will not become ___________ at instant of operation.
4. In any converter topology, the capacitor should be placed in such a manner where its ______ will not become discontinuous at instant of operation.
5. The capacitor value is calculated by applying the _____________rule.

Understand

1. What is a power converter?
2. Mention the advantages and disadvantages of on – off control method of ac voltage control.
3. Why the series inverter is called so?
4. State the use of flywheel diode.
5. Differentiate full converter and semi-converter.
6. What is frequency modulation control of a converter?

7. What is meant by a static circuit breaker?
8. What is meant by line commutated inverter?
9. Explain time ratio control of choppers.

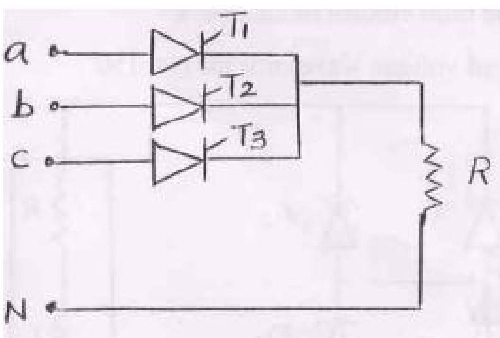
Apply

1. Using engineering approximations, obtain a simpler static characteristic of a diode.
2. A BJT is driving a 10A resistive load from a 100V dc supply. The base drive signal is switching at frequency of 50KHz and duty cycle of 0.75. The BJT has the following datasheet specifications: V_{besat} = 0.7V, V_{ceo} = 30V, I_{cm} = 15A, V_{cesat} = 0.3V, h_{FEmin} = 100, t_d = 1□s, t_s = 2□s, t_r = 1.5□s, t_f = 1.5□s. Calculate the power loss in the BJT.
3. A diode and a 10 ohm resistor are connected in series to a square wave voltage source of 50V peak. The reverse recovery time for the diode is given to be 200ns. Find the reverse recovery charge.
4. For three phase thyristor controlled half wave rectifier feeding load R as shown in fig. Show that the average output voltages are given by

   $V_o = (3\sqrt{3}\, V_m \cos\alpha) / 2\pi$ for $0 \le \alpha \le \pi/6$

   $V_o = (3/2\pi)\, V_m [1+\cos(\alpha + \pi/6)]$ for $\pi/6 \le \alpha \le 5\pi/6$

   Where Vm is the maximum value of phase voltage and α is the firing angle delay.



5. The input to a chopper is from a 100V dc source. The chopper is switched at a frequency of 100KHz with a pulse width of 4□s. What is the average output voltage of the chopper?

Analyze

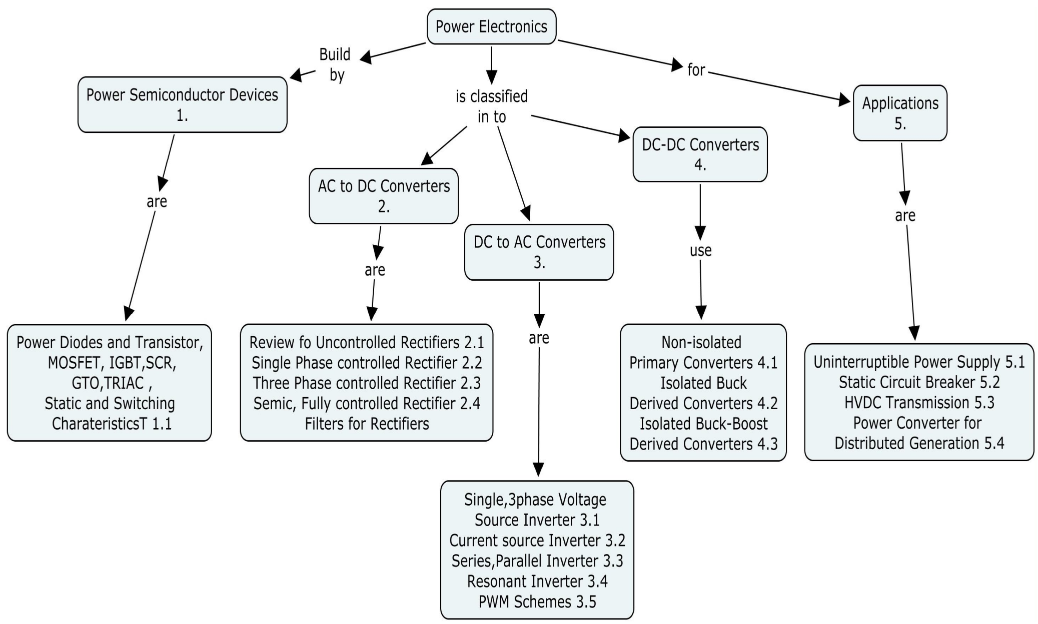
1. Derive relationship for the power dissipation within the transistor between the applied collector-emitter voltage, the collector current and the switching frequency of the transistor for a resistive load in the collector.
2. A MOSFET is operated such that the operating point is in the active region. The MOSFET has a gate-source threshold voltage value of 2.5V. A gate-source voltage of 5V is applied to the gate source terminals of the MOSFET which results in the flow of drain current. On increasing the gate-source voltage to 7.5V, what is the factor by which the drain current increases?
3. Analyze with typical values, the effect on the gate-source oxide layer of a MOSFET when the unprotected gate lead is touched by our body or hands. Suggest remedial measures that can the above mentioned problem.
4. Analyze the effect of the output voltage, duty ratio and the load current in the determination of the inductor value of the buck converter.

Evaluate

1. Between the BJT and the IGBT, which is closer to the Ideal SPST switch?

2. Evaluate the effect of the base current wave shape on the turn-ON switching behavior of a BJT?

Concept Map of the Course



Syllabus

Power Semiconductor Devices: Static and switching Characteristics of Power diode, Power Transistor, MOSFET, IGBT, SCR, GTO, and TRIAC.

AC to DC Converter: Review of Uncontrolled Rectifiers, Single Phase and Three Phase controlled rectifiers, Semi controlled and Fully controlled Rectifiers, Filters for rectifiers.

DC to AC converter: Single Phase and three Phase Voltage Source Inverters, Current source inverter, Series and parallel inverter, Resonant Inverter, PWM Schemes.

Switch Mode Power Converters (DC-DC Converters): Introduction to Linear Power supplies –SMPC-Topology, input-output relationships, and waveform analysis - Non-isolated Primary Converters, Isolated Buck Derived Converters, Isolated Buck-Boost Derived Converters (fly back).

Applications: Uninterrupted power Supply, Static Circuit Breakers, HVDC Transmission, Power Converter for Distributed Generation.

Text book:

1. Muhammad H.Rashid, Power Electronics Circuits, Devices & Applications - Pearson Education India Publication, New Delhi, 2nd Edition, 2007.

Reference Books:

1. M.D.Singh & K.B.Khanchandani, Power Electronics – Tata Mc Graw Hill publishing company Ltd, New Delhi, 2004.

2. Ned Mohan, Tore Undeland & William Robbins, Power Electronics: converters Applications and Design-John Willey and sons 2003.
3. P.S. Bimbra, Power Electronics- Khanna Publishers,1996.
4. Daniel W.Hart, Introduction to power Electronics – Prentice Hall International Inc., 1997.
5. P.C.Sen, Power Electronics - Tata McGraw Hill publishers Pvt. Ltd, 2004.
6. L. Umanand, Power Electronics: Essentials and Applications- Wiley India, 2009.

Course Contents and Lecture Schedule

S.No.	**Topic**	**Lectures**
1.0	**Power Semiconductor Devices**	
1.1	Static and Switching Characteristics-Power Diode & Power Transistor, MOSFET, IGBT, SCR, GTO, and TRIAC.	4
2. 0	**AC to DC Converter**	
2.1	Review of Uncontrolled Rectifiers	1
2.2	Single Phase controlled Rectifier	1
2.3	Three Phase controlled Rectifiers	1
2.4	Semi controlled Rectifier, Fully controlled Rectifier	2
2.5	Filters for Rectifiers	1
3.0	**DC to AC converter**	
3.1	Single Phase, three Phase Voltage Source Inverters	3
3.2	Series and parallel inverters	3
3.3	Resonant Inverters	2
3.4	Current source inverters	2
3.5	PWM Schemes	2
4.0	**Switch Mode Power Converters (DC-DC Converters)**	
4.1	Introduction to Linear Power supplies	2
4.2.1	Non-isolated Primary Converters	1
4.2.2	Topology of non-isolated primary converters	1
4.2.3	Input-output relationships	1
4.2.4	Waveform Analysis	1
4.2.5	Analysis of non-isolated primary converter circuits	1
4.2.6	Specifying switch mode power supplies for different applications	1
4.3	Isolated Buck Derived Converters	1
4.3.1	Topology of isolated buck derived converters	2
4.3.2	Input-output relationships	1
4.3.3	Waveform Analysis	1
4.3.4	Analysis of isolated buck derived converter circuits	1
4.3.5	Specifying switch mode power supplies for different applications	1

4.4	Isolated Buck-Boost Derived Converters (flyback)	1
4.4.1	Topology of isolated buck-boost derived converters	2
4.4.2	Input-output relationships	1
4.4.3	Waveform Analysis	1
4.4.4	Analysis of isolated buck-boost derived converters circuits	1
4.4.5	Specifying switch mode power supplies for different applications	1
5.0	**Applications**	
5.1	Uninterrupted Power Supply	2
5.2	Static Circuit Breakers	1
5.3	HVDC Transmission	1
5.4	Power Converter for Distributed Generation	2

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Sub Code	Lectures	Tutorial	Practical	Credit
E 54	3	-	-	3

E54 EMBEDDED SYSTEMS 3:0

Preamble

Microcontrollers are used as the main controller in most of the embedded systems. This course attempts to make the students familiar with the architecture and programming of Intel 8051 (CISC type) and PIC 16F877 (RISC type) microcontrollers, which have most of the common features present in modern microcontrollers, and interfacing them with various peripherals. The basics of PLC and PLC ladder programming are introduced. Modern Programmable Logic Controllers (PLC) have many in-built functions so that they can be used as the main controller in many industrial control systems.. Students are made to be familiar with the basics of real time operating system (RTOS) and various software tools used in the development of embedded systems.

Programme outcomes addressed

b. An ability to design and conduct experiments, as well as to analyze and interpret data

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

Competencies

1. Explain the architecture of CISC type (Intel 8051) and RISC type (PIC 16F877) microcontrollers.
2. Understand the difference between CISC type and RISC type microcontrollers used in embedded systems.
3. Develop efficient assembly language programs for performing different computing functions in 8051 and 16F877
4. Interface various peripherals with 8051 and 16F877
5. Understand the basics of PLC and PLC ladder programming
6. Understand the basics of RTOS and various software development tools used for the development of embedded systems.

Assessment Pattern

	Bloom’s Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	20
2	Understand	40	20	20
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	20	20

Course Level Learning Objectives

Remember

1. Write the hardware features of 8051.
2. What is the function of EA* and PSEN* signals in 8051 (*-Active low signal)?
3. What is meant by indirect addressing in 8051?
4. Name the signals used to access external data memory in 8051?
5. Which instructions of 8051 are used to access look-up table in ROM?
6. Write the operation of BTFSC instruction.
7. What is the function of watch dog timer?
8. Draw the start and stop signal timing diagram of I^2C.
9. What is meant by rate monotonic scheduling ?
10. What are the commercial RTOS available ?

Understand

1. If a 12 MHz crystal is connected to 8051, how much is the time duration for one state and one machine cycle?
2. How to program the external interrupts of 8051 as falling edge or low level triggered interrupt?
3. Why external pull-up resistor is required for port-0 in 8051?
4. What must be done to configure a port as input port in 8051?
5. What is the difference between timer and counter in 8051?
6. If a 12 MHz crystal is connected to 8051, what is the time period of timer clock?
7. Find out the time for one machine cycle when using 12 MHz crystal is used with PIC 16F877.
8. Explain the state diagram for a typical real-time kernel.
9. How interrupt routines are handled within an operating system ?
10. Explain the alternative for time-slicing.

Apply

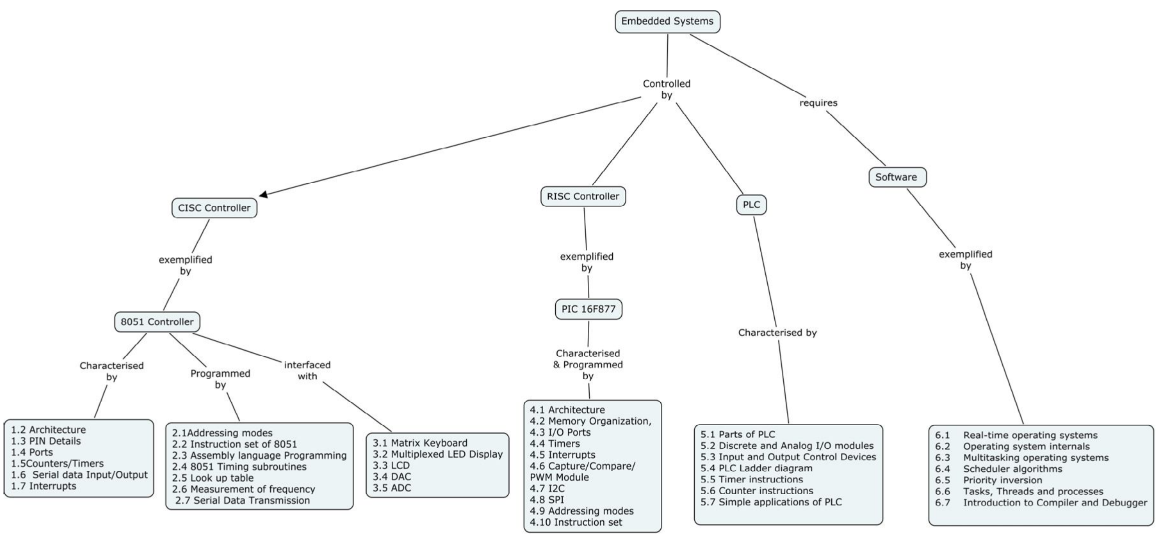
1. Write the 8051 ALP to add the bytes in an array, stored in the external data memory from the address 2000H and store the result in the addresses 3000H and 3001H. The array contains one hundred bytes of data.
2. Write the 8051 ALP to find the largest byte in an array, stored in the external data memory from the address 2000H and store the result in the address 3000H. The array contains one hundred bytes of data.
3. Write 8051 ALP to convert the given 8-bit binary number into BCD number.
4. Write 8051 ALP to convert the given 8-bit binary number into ASCII number.
5. Write 8051 ALP to find the seven segment code of an 8-bit binary number using look-up table technique.
6. Interface an 2*16 LCD with 8051 and write ALP to display the branch and year of your study in the middle portion of the LCD.
7. Interface an 8-bit ADC with 8051 and write ALP to get 100 samples of input data each taken at a time interval of 100 micro seconds and store the result in external data memory from the address 2000H.
8. How to choose an OS for an embedded system?
9. Write a PLC ladder program to control the starting of a dc motor. There is a start switch and stop switch. There are two lamps to indicate motor on and off condition.

10. Write a PLC ladder program to count the number of objects moving over a conveyor. There is a proximity switch to count the number of objects.

Create

1. Interface an 8-bit DAC with 8051 and generate sine wave and triangular wave of 2 KHz frequency.
2. Interface an 8K x 8 EPROM and an 8Kx8 RAM with 8051 to assign the starting address 0000H to both of them.
3. Design a burglar alarm system indicating the software development process with necessary flowchart.
4. Digital echo unit indicating the software development process with necessary flowchart.
5. Write a PLC ladder program to start three motors one by one each with a time delay of 5 minutes between them when a start button is pressed.

Concept Map



Syllabus

8051 Microcontroller: Introduction to Embedded systems, 8051 Architecture, Pin details, Ports, Counters/Timers, Serial data Input/Output, Interrupts. **Programming 8051:** Addressing modes, Instruction set of 8051, Assembly language Programming, 8051 Timing subroutines, Look up table, Measurement of frequency, Serial Data Transmission. **Interfacing with 8051:** Matrix Keyboard, Multiplexed LED Display, LCD, DAC, ADC. **PIC 16F877 Microcontroller:** PIC16F877 Architecture, Memory Organization, I/O Ports, Timers, Interrupts, Capture/Compare/PWM Module, I^2C, SPI, Addressing modes, Instruction set of PIC 16F877. **Programmable Logic Controller:** Parts of PLC, Discrete and Analog I/O modules, Input and Output Control Devices, PLC Ladder diagram, Timer instructions, Counter instructions, Simple applications of PLC. **Software for embedded systems:** Real-time operating system, Operating system internals, Multitasking operating systems, Scheduler algorithms, Priority inversion, Tasks, Threads and processes, Introduction to Compiler and Debugger.

Textbooks:

1. Mohammed Ali Mazidi, 8051 Microcontroller and embedded systems using assembly and C, 2nd edition, Pearson Education, 2006.
2. John B.Peatman, Design with PIC Microcontrollers, Pearson Education, 2002

3. Frank D. Petrurzella, Programmable logic controllers, Mc-Graw Hill Book Company, 2003.
4. Steve Heath, Embedded Systems Design, Second edition, Newnes Publisher, 2003

Reference Books:

1. Kenneth Ayala, "8051 microcontroller – Architecture, Programming and applications", Third Edition, Penram International Publishing, 2007
2. Myke Predko, Programming and customizing the PIC microcontroller, 3rd edition,TMH Publisher, 2007
3. Rajkamal, Embedded systems, Architecture, programming and design, Tata McGraw Hill, 2005
4. Ajay V.Deshmukh, Microcontrollers- Theory and applications, Tata McGraw Hill, 2005

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**8051 Microcontroller**	
1.1	Introduction to Embedded systems	1
1.2	8051 Architecture	2
1.3	Pin details	1
1.4	Ports	1
1.5	Counters/ Timers	1
1.6	Serial data Input/Output	1
1.7	Interrupts	1
2.0	**Programming 8051**	
2.1	Addressing modes	1
2.2	Instruction set of 8051	2
2.3	Assembly language Programming	2
2.4	8051 Timing subroutines	2
2.5	Look up table	1
2.6	Measurement of frequency	1
2.7	Serial Data Transmission	1
3.0	**Interfacing with 8051**	
3.1	Matrix Keyboard	1
3.2	Multiplexed LED Display	1
3.3	LCD	1
3.4	DAC	1
3.5	ADC	1
4.0	**PIC 16F877 Microcontroller**	
4.1	PIC16F877 Architecture	1
4.2	Memory Organization	1

4.3	I/O Ports	1
4.4	Timers	1
4.5	Interrupts	1
4.6	Capture/Compare/PWM Module	1
4.7	I^2C	1
4.8	SPI	1
4.9	Addressing modes	1
4.10	Instruction set of PIC 16F877	1
5.0	**Programmable Logic Controller**	
5.1	Parts of PLC	1
5.2	Discrete and Analog I/O modules	1
5.3	Input and Output Control Devices	2
5.4	PLC Ladder diagram	1
5.5	Timer instructions	2
5.6	Counter instructions	2
5.7	Simple applications of PLC	1
6.0	**Software for embedded systems**	
6.1	Real-time operating systems	1
6.2	Operating system internals	1
6.3	Multitasking operating systems	1
6.4	Scheduler algorithms	1
6.5	Priority inversion	1
6.6	Tasks, Threads and processes	1
6.7	Introduction to Compiler and Debugger	1

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Sub code	Lectures	Tutorial	Practical	Credit
E55	3	0	-	3

E55 Mixed Signal Circuits 3:0

Preamble

This course ‘E55 Mixed Signal Circuits and Interfacing’, a departmental core course, is preceded by courses “E45: Digital Signal Processing”, ‘E23: Analog Circuits and Systems’ and ‘H16: Basics of Electrical and Electronic Engineering’ which presents an over view of basic electronics, analog and digital signals and systems. The course mainly discusses the switching circuits for data converters, data converters (digital-to-analog converters and analog-to-digital converters), power amplifiers.

The course mainly presents state-of-the-art digital-to-analog converters, a range of analog-to-digital converters, and the design of Class A, B, C, D and E power amplifiers.

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science.
b. An ability to design and conduct experiments, as well as to analyze and interpret data.
c. An ability to design a system or component, or process to meet stated specifications.

Competencies

1. Determine the performance (error/accuracy, noise, and speed) of analog-to-digital conversion and digital-to-analog conversion systems
2. Design switches, switched-capacitor networks, pre filters, post filters, off-set/error compensating networks, and sample and hold circuits using MOSFETs and op amps/comparators
3. Design feedback, flash, and over-sampling ADCs
4. Design DACs using R-2R or C-2C networks
5. Design Class A, B, C and D power amplifiers

Assessment Pattern

	Bloom’s Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	10	10	0
2	Understand	20	20	20
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	30	30	40

Course Level Learning Objectives

Remember

1. What is Post filter and Prefilter in DAC and ADC?
2. Describe, in your own words, what are the difference between specifying SNR and SNDR of a data converter.

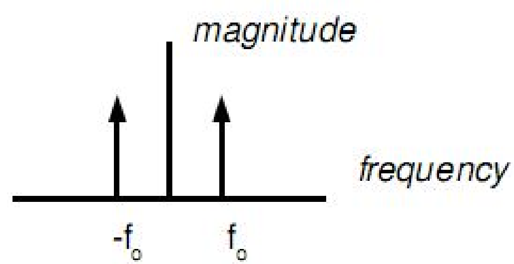
3. How will be the SNR ideal by increasing the value of N or the bit resolution of the quantizer?
4. Define offset, linearity errors of an ADC and DAC?
5. Define preamplifier and power amplifier.
6. What is the best input signal for class-E power amplifier?

Understand

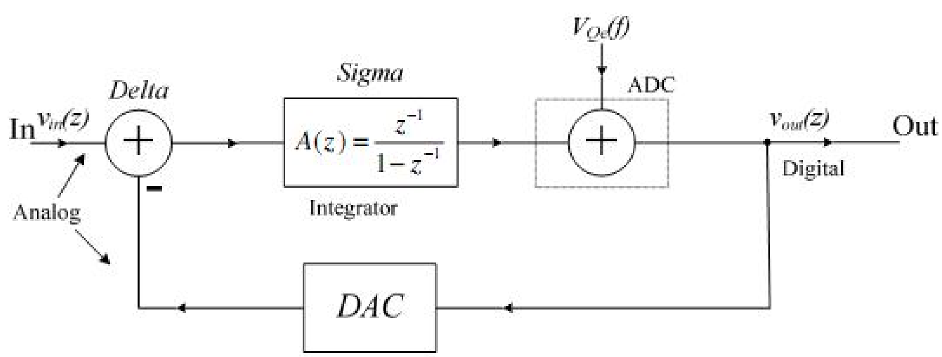
1. Is it possible to design a S/H with a gain of 0.5? How can this be done or why can't it be done?.
2. How can you decimate and interpolate the samples?
3. What do you do in the circuit to improve SNR?
4. How do you distinguish between efficiency and gain of a power amplifier?
5. Explain how the microphone in your amplifier works. How, exactly, does it convert waves of air pressure (sound) into electrical signals?

Apply

1. How impulse sampling a sine wave can result in an alias of the sampled sine wave at a different frequency. The Fourier transform of a sinusoid with frequency f0 looks like



2. Find the transfer function for structure given below.



3, If an extra delay, z−1 , is added to the forward path of the modulator in above Fig. would the resulting topology be stable? Why or why not?

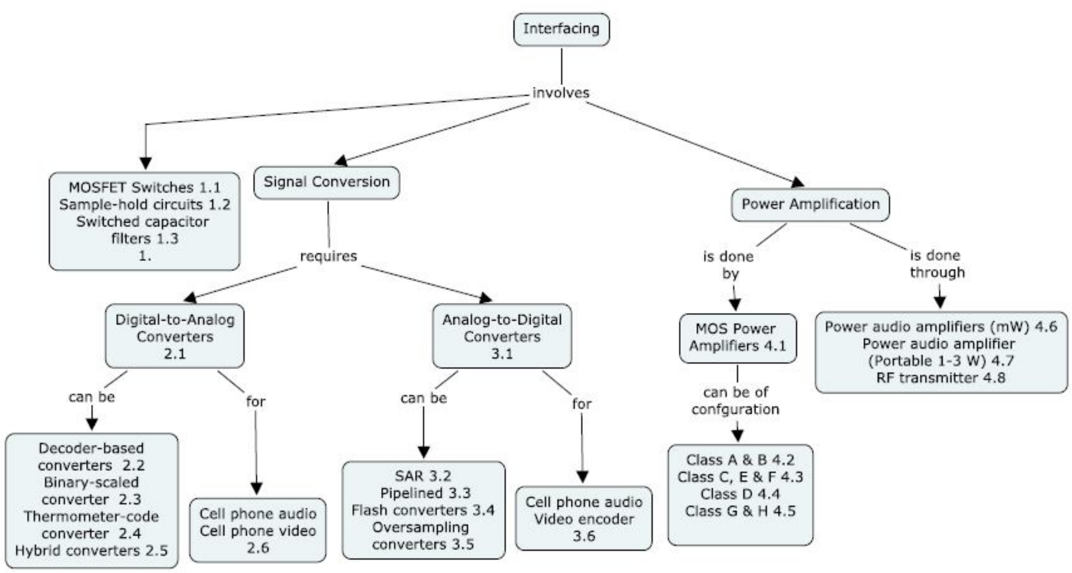
4. While Class A amplifier circuits are simpler to design and build, they are rarely used for high-power applications. Why is this? Why are Class B amplifier designs much more popular for high-power applications? Would it be practical for you to build a microphone amplifier such as this using nothing but Class A circuitry?

5. Explain how you plan to test for and eliminate (if necessary) any crossover distortion from your amplifier circuit. Do you suspect crossover distortion will be more noticeable at low volume levels or high volume levels? Explain why.
6. How accurate does an 8-bit ADC have to be in order to use a digital filter to average 16 output samples for a final resolution for 10-bits? Assume the ideal LSB of the 8-bit converter is 10mV.

Create

1. Develop an expression for the effective number of bits in terms of the measured signal- to-noise ratio if the input sine wave has a peak amplitude of 50% of (VREF+ - VREF-).
2. Design a Digital circuit which will decimate or interpolate the samples.
3. Design a full-differential second-order Noise Shaping modulator.
4. Design a dual slope ADC with 2000 count resolution.
5. Design a switched current source based 4 bit DAC.
6. Design a RF class E power amplifier driving an antenna which is modeled as a load resistor with 50Ω impedance. and the EIRP should ≤-45dbm
7. Design a Class D amplifier to deliver maximum power of 28watts to an 8ohm speaker.

Concept Map



Syllabus

Switching Circuits for Data conversion: OPAMP circuits- principles and characteristics **,** Analog multiplexers (MOSFET Switches), Sample-hold Circuits, Switched Capacitor Filters **Digital to Analog converter:** DAC architecture and characteristics, Decoder-based DACs, Binary Scaled Converters, Thermometer-code Converter, Hybrid Converters, Cell phone Audio and Video Converters **Analog to Digital converter:** ADC architecture and characteristics, Successive Approximation ADC, Pipelined ADC, Flash Converters, Over sampling-first order and second order Sigma delta ADCs**,** Cell Phone Audio and Video Encoders **Power amplifiers:** BJT Power Amplifier: Characteristics, BJT based Class A, B, AB amplifiers, Class C, E and F MOSFET power amplifiers, Class D MOSFET Power Amplifier, Class T and H MOSFET Power Amplifier, Power Audio Amplifier (mW), Power Audio Amplifiers (Portable Devices).

Text Books:

1. David A. Johns and Ken Martin: Analog Integrated Circuit Design, Wiley India, 1997
2. R. J Baker, CMOS Mixed signal circuit Design. Wiley Interscience, 2nd edition, 2009

Reference books:

1. R. Jacop Baker, CMOS Design, layout, simulation. Wiley Interscience, 2nd edition, 2005.
3. Sundaram Natarajan: Microelectronics Analysis& design, McGraw-Hill 2006.
4. Razavi, Design of Analog CMOS Integrated Circuits. Electrical Engineering, McGraw-Hill International, 2001.
5. Sorin Alexander Huss: Model Engineering in Mixed-Signal Circuit Design, Springer, 2001.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**Switching Circuits for Data conversion**	
1.1	OPAMP circuits-principles and characteristics	3
1.1	Analog multiplexers (MOSFET Switches)	2
1.2	Sample-hold Circuits	2
1.3	Switched Capacitor Filters	3
2.0	**Digital to Analog converter**	
2.1	DAC architecture and characteristics	1
2.2	Decoder-based DACs	1
2.3	Binary Scaled Converters	2
2.4	Thermometer-code Converter	2
2.5	Hybrid Converters	2
2.6	Cell phone Audio and Video Converters	2
3.0	**Analog to Digital converter**	
3.1	ADC architecture and characteristics	1
3.2	Successive Approximation ADC	1
3.3	Pipelined ADC	1
3.4	Flash Converters	2
3.5	Over sampling-first order and second order Sigma delta ADCs.	2
3.6	Cell Phone Audio and Video Encoders	3
4.0	**Power amplifiers**	
4.1	BJT Power Amplifier: Characteristics	2
4.2	BJT based Class A, B, AB amplifiers	3

4.3	Class C, E and F MOSFET power amplifiers	2
4.4	Class D MOSFET Power Amplifier	2
4.5	Class T and H MOSFET Power Amplifier	2
4.6	Power Audio Amplifier (mW)	2
4.7	Power Audio Amplifiers (Portable Devices)	2

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E 56	3	1	-	4

E56 Design of Electrical Machines 3:1

Preamble

The course is designed to impart knowledge:

- on the selection of magnetic materials, conducting materials & insulating materials for the design of electrical machines
- to obtain the dimensions of various parts in the design of electrical machines such as Transformers, DC machines and AC machines
- to design the magnetic circuits & electric circuits of electrical machines and cooling circuits of Transformers

After completing this course, student can design the electrical machines based on the given specifications and constraints on their own.

Program Outcomes addressed

b. An ability to design and conduct experiments, as well as to analyze and interpret data

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

h. An ability to function on multidisciplinary teams

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

1. Select dielectric, magnetic and conducting materials to meet the requirements and specifications.
2. Design the windings of DC and AC machines of different specifications, and sketch the windings.
3. Design magnetic and electric circuits of DC and AC machines of different specifications.
4. Determine the performance of designed DC and AC machines.
5. Design the electric and magnetic circuits of transformers as per given specifications, and sketch the magnetic circuits.
6. Design the cooling circuit of a given transformer, and sketch the scheme.
7. Determine the performance of the designed transformer.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test3 / End-semester examination
1	Remember	20	20	0
2	Understand	30	30	30
3	Apply	40	30	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	10	20	30

Course Level Learning Objectives

Remember

1. Define gap contraction factor.
2. What is meant by stacking factor?
3. Name the various class of insulating materials with its maximum temperature limit.
4. What is S4 duty?
5. Define Electric and magnetic loadings.
6. Define back pitch and front pitch of armature winding.

Understand

1. Estimate the number of cooling ducts required for an armature of length 40 cm.
2. Predict the change in eddy current loss if the flux reversal frequency doubles.
3. Distinguish the lap and wave winding
4. Distinguish shell and core type transformer
5. Estimate the back pitch, front pitch, commutator pitch and winding pitch for a 13 slot double layer wave type armature winding.
6. Estimate the net iron length if a length of armature is 300 mm and having 2 radial ventilating ducts of each 10 mm wide. Take stacking factor as 0.8

Apply

1. Derive the output equation of 3 phase core type transformer.
2. Show that equal current densities to be assumed for HV and LV conductors in the transformer design, to have minimum copper loss.
3. Show that, for a cruciform core the ratio of net core area to area of circum scribing circle is 0.71.
4. Calculate the apparent flux density at a section of the teeth of an armature of a D.C. machine from the following data: Slot pitch = 24 mm; Slot width = 12 mm; Length of armature including 5 ducts of 10 mm width each = 0.38 Mt; Iron stacking factor = 0.92; true flux density in the teeth of that section = 2.2 Tesla for which the MMF is 70,000 Amps. / Mt.
5. Calculate the main dimensions, turns per phase, number of slots, conductor area and slot area of a 250 HP, 3 phase, 50 Hz, 400 Volts, Delta connected Slip Ring Induction motor. The data given are:

   Bav. = 0.5 Tesla; ac = 30,000 A/Mt.; Efficiency = 90%; P.f. =90%;

   Kws = 0.955 ; Current Density = 3.5 A / mm ^{2} ; Space factor = 0.4;

   Ratio of core length to pole pitch = 1.5
6. Classify the Insulating materials with respect to temperature and give examples for each.
7. Two single phase transformers having linear dimensions ratio x:1 are designed to work with same current density, flux density and frequency. Compare the relative ratings, losses nd total weights per KVA of the two transformers.
8. A laminated iron cylinder rotating magnetic field has iron loss 250 W at 600 r.p.m. and 312 W at 720 r.p.m. What is the loss if the laminations were twice as thick, flux density increased by 25% and the speeds were 800 r. p. m.
9. Give the coil group per phase and coil allocation per phase per pole for an

   Armature winding of a 8 pole, 3 phase, 54 slots double layer winding.
10. On what factors does the length of air gap in dc machine depend?

Create

1. Design suitable dimensions of tank walls and sketch the scheme of cooling tubes arrangements of a 500 KVA, 3 phase transformer with the following data:
   Efficiency = 98% at 0.8 p.f.; Temp. rise = 35 ^{o}C ; No. of tubes = 100 with 6 cm diameter and average length of 120 cm; Heat dissipation = 12.5 W/M^{2}/^{o}C; ratio breadth : Length: height of transformer = 1:2:3; Top & Bottom surface area should be neglected for the design.

2. Design a 25 KVA, 11 KV / 433 volts, 50 Hz, 3 Phase, Delta / Star, Core type, Oil immersed Natural Cooled distribution transformer.
   The following data may be assumed:

   K = 0.45; where $E_t = K(Q)^{1/2}$
   Max. Flux density =1.0 Tesla.
   Window Space factor = 8 / (30 + KV); Where KV is the value of HV.
   Ratio of height to width of window is 2.50
   Area of the yoke is 1.2 times that of limb area (use rectangular yoke).
   Specific iron loss in core = 1.2 Watts per Kg.
   Specific iron loss in yoke = 0.85Watts per Kg.
   Stray load loss is 15% of total Copper loss.
   Density of iron = 7.6x 10 ^{3} Kg / M ^{3} .
   Current Density = 2.4 A / mm ^{2} .
   Length of mean turn of HV winding = 0.666 mt.
   Length of mean turn of LV winding = 0.468 mt.
   Resistivity of copper wire = 2.1x 10 $^{-8}$ Ohm – Mt.
   MMF per unit length of core = 120 A/Mt.
   MMF per unit length of yoke = 80 A/Mt.
   MMF required for the joints = 10% of the MMF required for iron parts.

   The answer should include overall dimensions of the core, No. of turns in HV and LV windings and it's conductor size, Iron loss, Copper loss, % Efficiency at full load & UPF, % of full load at which maximum efficiency occurs and No-load current.

3. Design a shunt field coil from the following data:
   Field MMF per pole = 9000
   Mean length of turn = 1.4 mt.
   Depth of coil = 35 cm
   Voltage across each field coil = 40
   Resistivity of wire = 2.1 x 10 $^{-8}$ Ohm-mt.
   Thickness of insulating varnish on the wire = 0.2 mm
   Power dissipation from total surface of the coil should not exceed 700 Watts/ m^{2}

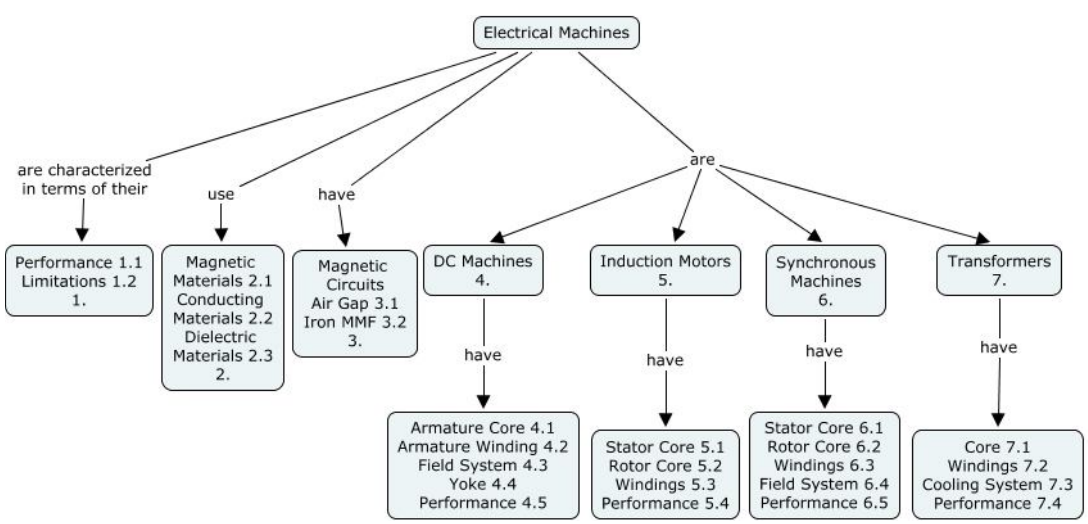
   Check your design for power dissipation.

4. Design a 10 H.P., 415 Volts, 3-Phase, 50 Hz, 140 r.p.m., squirrel cage Induction motor. The machine is to be started by Star-Delta starter. Consider the following design data:

Specific Magnetic loading	=	0.45 Tesla
Specific electric loading	=	23000 A/Mt.
Winding factor	=	0.955
Power factor & Efficiency at full load	=	0.87 (each)
Core length to Pole pitch ratio	=	to obtain overall good design
Iron stacking factor	=	0.9
Slot pitch should not exceed 15 mm		
Space factor	=	0.4
Max. allowable flux density in tooth	=	1.7 Tesla
Flux density in the stator core	=	1.25 Tesla
Current density – Stator winding	=	4 A/Sq.mm
Current density – Rotor bars	=	5 A/Sq.mm
Current density – End ring.	=	6 A/Sq.mm
Length of Air gap	=	$0.2 + 2 (D * L)^{1/2}$; mm
Copper resistivity	=	0.021 Ohm Mt/Sq.mm
Gap contraction factor	=	1.2
MMF for Iron parts	=	20% of air gap MMF
Friction & Windage loss	=	2% of rated output
Iron Loss	=	150 Watts
Stator winding resistance	=	2.05 Ohms per phase

The answers should include complete dimensions of the stator and rotor stampings, Stator and rotor winding details, end ring dimensions, No load current, No load power factor and Efficiency & Slip at full load

Concept Map



Syllabus

Introduction: Performance Specifications, Duty Cycle, Design factors and Limitations.

Materials: Properties, selection and applications of Magnetic materials, conducting materials and insulating materials.

Design of Magnetic Circuits: MMF calculation for Air gap and Teeth. Performance Calculation of Iron losses and Magnetizing current.

Design of Transformers: Design of Core and Overall dimensions. Types of Windings. Design of Tank and cooling tubes. Performance calculations of No load current, Losses and Efficiency.

Design of DC machines: Design of Armature Core. Design of Armature windings. Design of Pole and field windings. Design of Yoke. Performance calculations of Voltage Regulation, losses and efficiency.

Design of Three Phase & Single Phase Induction Motors: Design of Stator core & Rotor core. Design of Stator & Rotor windings. Performance calculations of No load current, Power factor, slip, losses and efficiency.

Design of Synchronous machines: Design of Stator core & Rotor core. Design of Stator and Rotor windings. Design of field systems. Performance calculations of losses, Efficiency and Voltage Regulation

Text Book:

A.K.Sawhney. Electrical machine Design, Dhanpat Rai & Sons, 6th Edition, 2006

Reference Books:

1. H.M.Rai, Electrical machine design – Sathiya Prakashan Publication, 5th edition 2008
2. R.K.Agarwal, Electrical machine design, S.Kataria & Sons, 5th edition 2007
3. S.K.Sen, Principles of Electrical machine design, Oxford & IBH pu. Co. Pvt. Ltd. 3rd edition 2005.
4. Balbir Singh, Electrical Machine Design, Vikas Pub. Co. 1982

Course Contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1.0	**Introduction**	
1.1	Performance Specifications Design Factors, Duty Cycle,	1
1.2	Limitations	1
2.0	**Materials**	
2.1	Magnetic materials	1
2.2	Conducting materials	1
2.3	Insulating materials	1
3.0	**Design of Magnetic Circuits**	
3.1	MMF calculation for Air gap	2
3.2	MMF calculation for Teeth	1
3.3	Performance: Iron losses and Magnetizing current	2
4.0	**Design of Transformers**	

4.1	Design of Core and Overall dimensions	4
4.2	Types of Windings	1
4.3	Design of Tank and cooling tubes	3
4.4	Performance: No load current , Losses and Efficiency	1
5.0	**Design of DC machines**	
5.1	Design of Armature core	2
5.2	Design of Armature windings	4
5.3	Design of Poles and filed windings	2
5.4	Design of Yoke	1
5.5	Performance: Voltage Regulation, losses and Efficiency	1
6.0	**Design of Three Phase & Single Phase Induction Motors**	
6.1	Design of Stator core	2
6.2	Design of Rotor core	2
6.3	Design of Stator & Rotor windings	4
6.4	Performance: No load current, P.f., Slip, losses and Efficiency	1
7.0.	**Design of Synchronous machines**	
7.1	Design of Stator core	2
7.2	Design of Rotor core	2
7.3	Design of stator & rotor windings	2
7.4	Design of field systems	2
7.5	Performance: Losses, Efficiency and Voltage Regulation	1

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E 57	--	--	3	1

E57 Digital Signal Processing Lab 0:1

Purpose of Laboratory Experiments

To enable the students to understand and apply the algorithms applicable to DSP and to design DSP based circuits.

List of Experiments

I. Programming using MATLAB
- Arithmetic Operations
- Concept of aliasing
- FT/DFT/FFT Computation
- Linear and Circular Convolution
- Auto and Cross Correlation
- FIR Filter Design
- IIR Filter Design

II. Experiments on TMS320C5x and TMS320F240x Processors
  i. Arithmetic Operations
  ii. FT/DFT/FFT Computation
  iii. Linear and Circular Convolution
  iv. Auto and Cross Correlation
  v. FIR Filter Design
  vi. IIR Filter Design

III. Audio signal analysis

IV. Video signal analysis

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E 58	--	--	3	1

E58 Microprocessor and Microcontroller Lab 0:1

Purpose of Laboratory Experiments

- To enable the students to write assembly language programs for the microprocessor and the microcontroller.
- To interface various peripherals with the microprocessor and the microcontroller.

List of Experiments

Microprocessor

1. Evaluation of arithmetic expressions.
2. Code conversions
3. Sorting of numbers
4. Look up table
5. Interrupts
6. Traffic light control
7. ADC and DAC interfacing
8. MASM Programs

Microcontroller

9. Evaluation of arithmetic expressions
10. Generation of square wave
11. Frequency measurement
12. Serial communication
13. Interrupts
14. Stepper motor interfacing
15. PIC On-chip ADC interfacing
16. Keil Compiler/Hi-Tech C compiler

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3. B.K.Shobana bkseee@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
E 59	--	--	3	1

E59 Instrumentation and Control Lab 0:1

Purpose of Laboratory Experiments

To enable the students to:

- Gain practical knowledge on measurements techniques, calibaration of meters, use of transducers, PLCs and to find transfer function and simulate simple control systems.

List of Experiments

1. Calibration of energy meter (1 phase & 3 phase)
2. I/V and V/I converters.
3. Study of transducers.

    a) Strain gauges. b) Load cell.
    c) Thermo couples. d) Photo Diode & LVDT.
    e) Opto couplers.

4. Measurement of capacitance and loss angle of a capacitor using Schering bridge.
5. Measurement of self inductance and resistance of a choke coil using Anderson bridge.
6. Measurement of reactive power.
7. Measurement of frequency, time and phase angle using DSO
8. Measurement of power using C.T and P.T.
9. Transfer function of separately excited D.C generator.
10. Transfer function of armature controlled DC motor.
11. Compensating networks.
12. Simulation of digital control (P &PI) of First and Second order plants using MATLAB.
13. Experiments with Programmable Logic Controller.

Course Designers

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E. DEGREE (Electrical and Electronics Engineering) PROGRAM

SIXTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2008-2009 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Govt. Aided ISO 9001-2008 certified Autonomous Institution affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
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Department of Electrical and Electronics Engineering

Graduating Students of B.E. program of EEE will be able to:

1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power
2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015

Department of Electrical and Electronics Engineering

Scheduling of Courses

Semester	Theory Courses						Practical/Project		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					E88 Project 0:12	
7th (21)	E71 Mgmt. The. & Practice 3:0	E72 Protection & Switchgear 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0			E78 Project 0:6	
6th (21)	E61 Accounting and Finance 3:0	E62 Power System Analysis 3:1	E63 Electric Drives 3:0	E64 VLSI design 3:0	Elective 1 3:0	Elective 2 3:0	E67 Power System Simulation Lab 0:1	E68 Power Electronics and Drives Lab 0:1	
5th (24)	E51 Numerical Methods 4:0	E52 Generation, Transmission and Distribution 4:0	E53 Power Electronics 3:0	E54 Embedded Systems 3:0	E55 Mixed Signal Circuits 3:0	E56 Design of Electrical Machines 4:0	E57 Digital Signal Processing Lab 0:1	E58 Microprocessor and Microcontroller Lab. 0:1	E59 Instrumentation and Control Lab 0:1
4th (25)	E41 Engineering Mathematics – IV 4:0	E42 AC Machines 4:0	E43 Microprocessors 4:0	E44 Thermal Engineering 3:0	E45 Digital Signal Processing 3:0	E46 Electrical & Electronic Measurements 3:0	E47 AC Machines Lab. 0:1	E48 Thermal Engineering Lab 0:1	E49 Professional Communications 1:1
3rd (24)	E31 Engineering Mathematics – III 4:0	E32 Electromagnetics 4:0	E33 DC Machines and Transformers 4:0	E34 Digital Systems 3:0	E35 Data Structures 3:0	E36 Control Systems 4:0	E37 Digital Systems Lab 0:1	E38 DC Machines & Transformers Lab 0:1	
2nd (23)	E21 Engineering Mathematics – II 4:0	E22 Electric Circuit Analysis 4:0	E23 Analog Circuits and Systems 4:0	E24 Computers and Programming 3:0	E25 Material Science 3:0	E26 Environment and Ecology 2:0	E27 Analog Circuits and Systems Lab 0:1	E28 Computer Programming Lab 0:1	E29 Workshop 0:1
1st (25)	H11 Engineering Mathematics – I 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of M & CE 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab 0:1	H18 Chemistry Lab 0:1	H19 Engineering Graphics 0:2

Passed in the BOS meeting held on 9th October, 2010 Approved in 41st Academic Council meeting on 30th October 2010

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2008-2009 onwards)

SIXTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
E61	Accounting and Finance	HSS	3	-	-	3
E62	Power System Analysis	DC	3	1	-	4
E63	Electric Drives	DC	3	-	-	3
E64	VLSI Design	DC	3	-	-	3
ECx	Elective 1	DE	3	-	-	3
xGx	Elective 2	GE	3	-	-	3
PRACTICAL						
E67	Power system simulation lab	DC	-	-	3	1
E68	Power Electronics and Drives lab	DC	-	-	3	1
Total			**18**	**1**	**6**	**21**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DE : Departmental Elective
GE :General Elective

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2008-2009 onwards)

SIXTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	E61	Accounting and Finance	3	50	50	100	25	50
2	E62	Power System Analysis	3	50	50	100	25	50
3	E63	Electric Drives	3	50	50	100	25	50
4	E64	VLSI Design	3	50	50	100	25	50
5	ECx	Elective 1	3	50	50	100	25	50
6	xGx	Elective 2	3	50	50	100	25	50
PRACTICAL								
7	E67	Power system simulation lab	3	50	50	100	25	50
8	E68	Power Electronics and Drives lab	3	50	50	100	25	50

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

LIST OF ELECTIVE SUBJECTS

Departmental Electives			
Sub. code	Subject Name	Pre/Co requisites	Credits
ECA	Special Machines	--	3
ECB	Digital Control Systems	--	3
ECC	High Voltage Engineering	--	3
ECD	Soft Computing	--	3
ECE	Analog Integrated Circuit Design	--	3
ECF	Digital Systems Design with PLDs and FPGAs	--	3
ECG	Power System Control	--	3
ECH	Robotics	--	3
ECJ	Operation and Maintenance of Electrical Equipment	--	3
ECK	Power plant economics	--	3
ECL	Instrumentation Systems	--	3
General Electives			
EGA	Industrial Safety and Environment	--	3
EGB	Renewable Energy Sources	--	3
EGC	Soft Computing	--	3
EGD	Sensors and Transducers	--	3
EGE	Domestic and Industrial Electrical Installations	--	3

Sub Code	Lectures	Tutorial	Practical	Credit
E 61	3	0	0	3

E 61 Accounting and Finance 3.0

(Common to G56 Accounting and Finance – B.E. Mechanical Engineering)

Preamble

Engineering profession involves lots of decision making. The decisions may range from operation to non-operation. For taking decisions of these kinds an engineer needs among other things data about the organizations routine operations and non-routine operations. Accounting is a science which provides all the data by recording, classifying, summarizing and interpreting the various transactions taking place in an organization and thereby helps an engineer in taking vital decisions in an effective manner. Finance is an allied but a separate field relying on accounting, and enables engineers in taking useful financial and cost related decisions by providing well defined concepts, tools and techniques.

Program outcomes addressed

- Engineering graduates will understand the basic concepts, processes, tools and techniques of accounting and finance.
- Engineering graduates will apply the concepts, processes, tools and techniques of accounting and finance and take effective decisions in organizational settings.

Competencies

At the end of the course, the students will

1. Develop an understanding about what accounting is and its importance in decision making.
2. Understand the recording function of accounting.
3. Understand the classification function of accounting.
4. Understand the summarizing function of accounting.
5. Understand the analysis and interpretation function of accounting.
6. Perform the various functions of accounting.
7. Prepare trial balance and there from financial statements like trading account, Profit & loss account and balance sheet.
8. Interpret the financial statements of an organization.
9. Understand the meaning of financing and its functions and objectives.
10. Understand some of the basic concepts, tools and techniques of finance and their applications.

Assessment pattern

S.No.	Bloom's category	Test 1	Test 2	Test 3/End Semester examination
1	Remember	20	20	20
2	understand	30	30	30
3	Apply	50	50	50
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	create	0	0	0

Course level learning objectives

Remember

1. The meaning of the term "accounting" and definition of accounting
2. The concepts and conventions of accounting.
3. Its importance in decision making.
4. The functions of accounting
5. The meaning of the term Depreciation and causes of Depreciation
6. The meaning of the term "Cost accounting"
7. The bases of cost classification
8. The relationship between volume of output cost of production and profit
9. The meaning of the terms "Budget and Budgetary control"

Understand

1. Understand the definition of accounting
2. Explain the various functions of accounting.
3. Discuss the concepts and conventions of accounting.
4. Understand the process of preparing final accounts.
5. Understand the concept of depreciation and methods of providing depreciation
6. Explain the classification of cost.
7. Describe the process of preparing cost sheet.
8. Discuss the importance of budgets and budgetary control
9. Understand the functions of financing
10. Explain the process of preparing working capital budget.

Apply

1. Journalise the following business transactions:

A) A brings in cash Rs.10, 000 as the capital and purchases land worth Rs.2000.

b) He purchases goods worth Rs.5, 000.

C) He returns goods worth Rs.500 as they are defective.

d) He sells goods for Rs.7, 000.

e) He incurs traveling expenses of Rs.200.

2. Record and classify the following transactions in the books of Suresh

Suresh introduces capital of Rs.20, 000 into his business.

He purchases furniture worth Rs.2000.

He purchases goods worth Rs, 8,000.

He incurs Rs.200 as freight expenses.

He sold goods for cash Rs.5, 000 and for credit Rs.2000

He paid salary Rs.3, 000

He paid electricity expenses Rs.800.

3. Prepare Trading and profit and loss account and Balance sheet on 31.12.96 from the following trial balance extracted from the books of Mr. Kumar as on 31.12.96.

Debit Balances	Rs.	Credit Balances	Rs.
Buildings	30,000	Capital	40,000
Machinery	31,400	Purchase returns	2,000
Furniture	2,000	Sales	2,80,000
Motor car	16,000	Sundry creditors	9,600
Purchases	1,88,000	Discounts received	1,000
Sales return	1,000	Provision for bad and doubtful debts	600
Sundry debtors	30,000		
General expenses	1,600		
Cash at bank	9,400		
Rates and taxes	1,200		
Bad debts	400		
Insurance premium	800		
Discount allowed	1,400		
Opening stock	20,000		
Total	3,33,200		3,33,200

4. Senthil purchased machinery for Rs.4, 00,000 on 1st April 2000.On 1st April 2001 additional machinery was purchased for Rs.40, 000.prepare the asset account for three years. Depreciation is to be provided at 10%p.a using straight line method. The firm closes its books on 31st March of every year.

5. A factory is currently working at 50% capacity and the product cost is Rs.180 per unit as below:

Material ------------- Rs.100

Labor -------------- Rs.30

Factory overhead— Rs.30 (40%fixed)

Administration overhead Rs.20 (50% fixed)

The product is sold at Rs.200 per unit and the factory produces 10,000 units at 50%capacity.

Estimate profit if the factory works to 60% capacity. At 60%working raw material increases by 20% and selling price falls by 20%.

6. The following particulars are extracted from the books of a company relating to commodity "A" for the half year ending 30^{th} June1993.

Purchase of raw materials ------------------ Rs.1, 32,000

Direct wages ----------------- Rs.1, 10,000

Rent, rates, insurance and works cost-------- Rs.44, 000

Carriage inward --------- Rs.1584

Stock on 1-1-93

Raw materials--------------------------------- Rs.22, 000

Finished product (1600 tones) - Rs.17, 000

Stock on 30-6-93

Raw materials ------------------- Rs.24, 464

Finished products (3,200 tones) ---------- Rs.35, 200

Work-in-progress on 1-1-93 ------------- Rs.17, 600

Work-in-progress on 30-6-93 ------ Rs.5280

Factory supervision ------------------------ Rs.8, 800

Sales-Finished products ---------------- Rs.33, 000

Advertising discount allowed and selling cost at Re.0.75per tones sold.25, 600 tones of commodity was sold during the period.

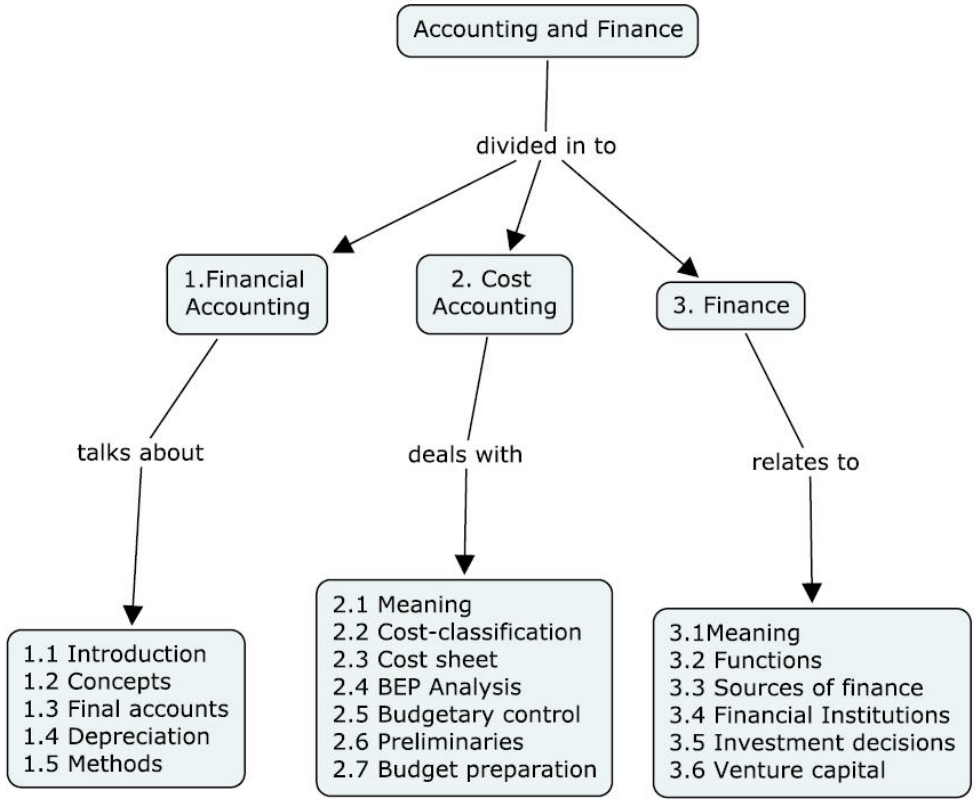
You are required to ascertain:

i) prime cost ii) factory cost iii) cost of sales iv) profit v) No of tones of the commodity sold.

7. From the following information calculate the Break even point in terms of units and Break even point in terms of sales

Sales in Rs.10, 000, Variable costs (direct material and direct labor) Rs.6, 000, Fixed cost Rs.2, 000 profit Rs.2, 000, No. of units produced 1,000 units.

Concept Map



Syllabus

Accounting: Introduction and Definition-Accounting concepts and conventions-final Accounts-Preparation of Trading, Profit and Loss account and Balance sheet. Depreciation-Meaning-Need and objectives-Basic factors-Methods for providing depreciation.

Cost Accounting: Meaning and importance-Cost-Elements of Cost-cost Classification-Preparation of cost sheet-Material costing-Valuation of purchases-pricing of material issues. Break-even analysis-managerial applications. Budgetary control-Introduction-objectives of budgetary control-preliminaries for operation of budgetary control-Budgets-types of budgets and their preparation.

Finance: Meaning-Definition-Objectives-functions of finance-source of finance-short-term, Long-term and medium-term-Role of special financial institution in financing-Investment decisions-short-term Investments and long-term investments-Venture Capital.

Text Books

1. M.c.Shukla, T.s.Grewal, S.C.Gupta: "Advanced Accounts-volume I", 2007 Reprint, S.Chand & Company Ltd.,2007.
2. S.P.Jain, K.L.Narang: "Advanced Accountancy-Volume I", Thirteenth Revised Edition, Kalyani Publishers,2006.
3. V.K.Saxena, C.D.Vashist: "Advanced cost and Management Accounting", Seventh Enlarged Edition, Sultan Chand and Sons, 2008.

Reference Books

1. Prasanna Chandra, "Financial Management-Theory and Practice" Sixth Reprint, Tata McGraw-Hill publishing company Limited, 2007.
2. Ramachandra Aryasri, A, Ramana Moorthy, V.V, Engineering Economics and financial Accounting", Tata McGraw hill, 2007.
3. S.N.Maheswari, "Advanced accountancy" Vikas publishing, 2007.

Course content and Lecture schedule

S.No.	Topics	No. of Lectures
1.	**Financial Accounting**	
1.1	Introduction and Definition	1
1.2	Accounting concepts and conventions	2
1.3	Final Accounts- Preparation of Trading, Profit &Loss account and Balance sheet.	6
1.4	Depreciation –Meaning-Need and objectives	2
1.5	Basic factors-Methods for providing depreciation	3
2.	**Cost Accounting**	
2.1	Meaning and importance	2
2.2	Cost-Elements of cost-Cost classification	2
2.3	Preparation of Cost sheet-Material costing-valuation of purchases-pricing of material issues.	6
2.4	Break-even analysis-managerial applications	2
2.5	Budgetary control-introduction-objectives of budgetary control	1
2.6	Preliminaries for operation of budgetary control	1
2.7	Budget-Types of budgets and their preparation	4
3	**Finance**	
3.1	Meaning-Definition-objectives	2
3.2	Functions of finance	1
3.3	Source of finance-short-term, medium-term, long-term	2
3.4	Role of special financial institutions in financing	2
3.5	Investment decisions-Short-term investments and long-term investments	5
3.6	Venture capital	2
	Total	**46**

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Sub code	Lectures	Tutorial	Practical	Credit
E62	3	1	-	4

E62 Power System Analysis **3:1**

Preamble

Mathematical modeling and solutions on digital computers constitute an extremely viable approach to system analysis and planning studies for a modern-day power system with its large size, complex and integrated nature. A stage has, therefore, been reached where an under-graduate must be trained in the latest techniques of analysis of large scale power systems. This course has been designed to fulfill this need by integrating the basic principles of power system analysis illustrated through a simplest system structure with analysis techniques. This course provides an exposure of representation of power system, formulation of network matrices, power flow analysis, symmetrical fault analysis, and symmetrical component method of unsymmetrical fault analysis and stability studies.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics and Engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduate will demonstrate skills to use modern engineering tools and software to analyze problems.
d. Graduate will develop confidence for self education and ability for life-long learning.
e. Graduates can participate and succeed in competitive examinations.

Competencies

At the end of the course the student should be able to:

1. Represent a power system by single line diagram and understand per unit notations.
2. Model generators, transformers, transmission lines and loads and form Y bus using inspection and singular transformation methods.
3. Perform load flow analysis, compute slack bus power, and transmission losses.
4. Compute the effects of symmetric short circuit problems on system parameters including voltage, current and power
5. Compute the effects of un-symmetric short circuit problems on system parameters including voltage, current and power
6. Determine sequence impedances of a given power system.

7. Develop sequence impedance network for SLG, LL and LLG unsymmetrical faults
8. Understand the role of stability, swing equation and equal area criterion.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test3 /End-semester examination
1	Remember	10	10	10
2	Understand	30	30	30
3	Apply	30	30	30
4	Analyze	30	30	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Give the standard symbols for power system components?
2. What is an impedance diagram?
3. Define bus incidence matrix?
4. State the applications of Y bus?
5. Draw the ∏ equivalent circuit of a transmission line.
6. State the load flow problem.
7. Define sequence impedance?
8. What are the uses of symmetrical components?
9. State the bad effects of instability.
10. What is equal area criterion?

Understand

1. How will you change the base impedance from one set of base values to another set?
2. Draw a single line per phase impedance diagram consisting of generators, transformers, transmission lines and loads.
3. Develop the relation between bus admittance matrix, bus incidence matrix and primitive admittance matrix.
4. Explain how the nodal admittance matrix of a system is changed when an off-nominal turns ratio transformer is introduced in a line connected between two buses.

5. What are the three types of buses used to define the power flow problem? Is it possible to solve the power flow problem without such definition?
6. Compare between different approaches available for solving the power flow problem?
7. Draw the sequence network for a L-G fault on an unloaded generator?
8. What do you understand by swing equation?
9. Develop the load flow equations for a sample system (including PV buses) by Gauss – Seidel method.
10. Why is the node voltage analysis preferred over Mesh current Analysis for power systems?
11. Explain the significant differences between direct axis transient reactance and direct axis sub transient reactance of alternator
12. What are the causes of unsymmetrical faults in power systems?
13. Distinguish between steady state and transient stabilities.

Apply

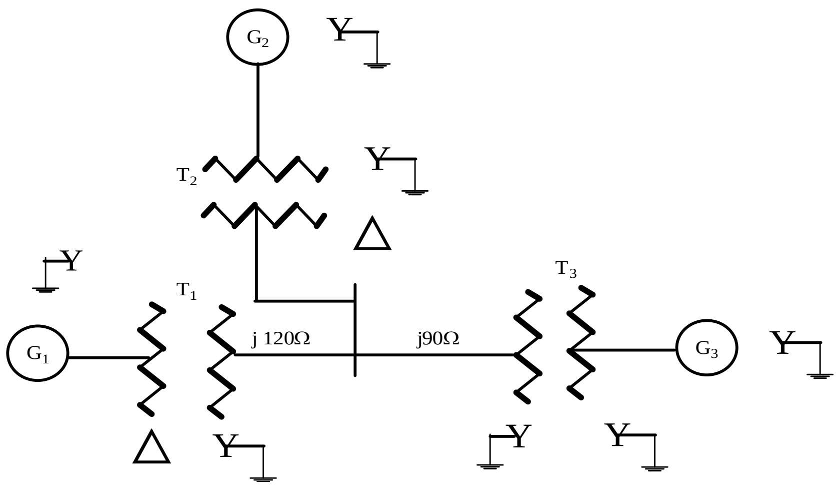
1. Prove that, when there is no mutual coupling between the lines, Y_{bus} can be computed from

   $Y_{ii} = \Sigma y_{ij}$ & $Y_{ij} = -y_{ij}$

2. Draw the reactance diagram for the power system shown in figure 1. Mark the values in per unit. Use a base of 30 MVA, 6.6 KV in the generator circuit

   The ratings are as follows:

Generator 1	-	25 MVA, 6.6 KV, X"=20%
Generator 2	-	15 MVA, 6.6 KV, X"=15%
Generator 3	-	30 MVA, 13.2 KV, X"=15%
Transformer 1	-	30 MVA, 6.6 ▲ / 115 Y KV, X"=10%
Transformer 2	-	15 MVA, 6.6 ▲ / 115 Y KV, X"=10%
Transformer 3	-	3 Single phase units each rated 10 MVA,6.9 Y / 69 Y KV, X"=10%



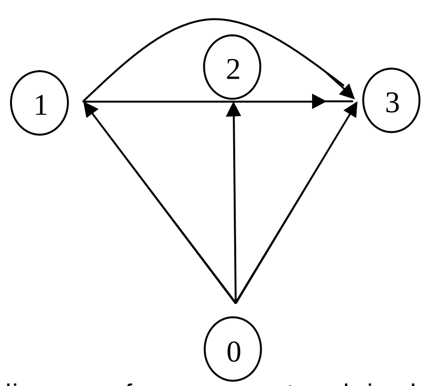
3. Form Y bus by inspection method for the 4 bus system with line series impedances as given below:

Line (bus to bus)	Impedance
1 - 2	0.15 + j0.6 p.u
1 - 3	0.01 + j0.4 p.u
1 - 4	0.15 +j0.6 p.u
2 - 3	0.05 +j0.2 p.u
3 - 4	0.05 +j0.2 p.u

Values shown are impedances in per unit.

4. Consider the linear graph in figure which represents a 3 bus transmission system with all shunt admittances at a bus lumped together. Each transmission line has a series impedance of 0.02+j0.08 and a half line charging admittance of j0.02.

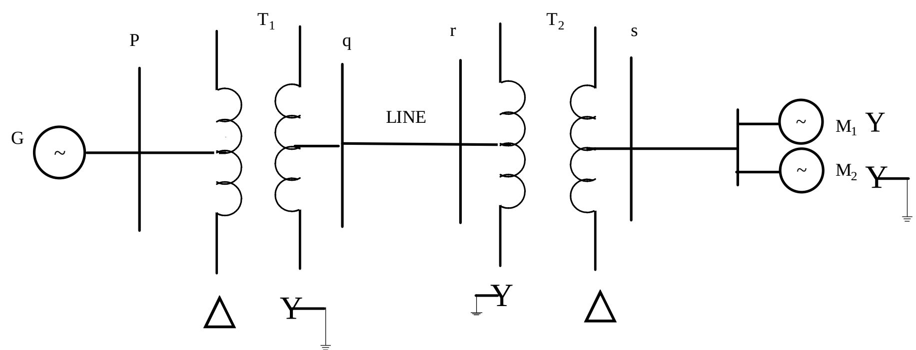
Assume node 0 as the ground, form Y_{bus}.



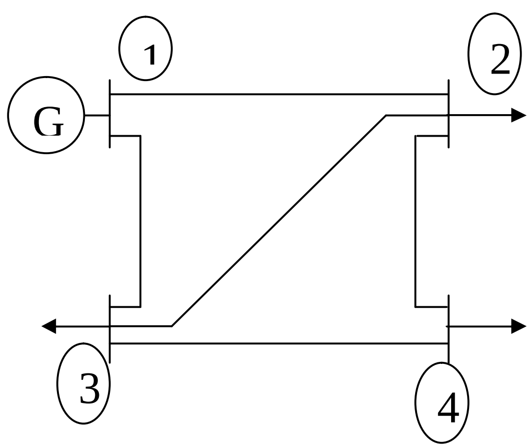
5. A Single line diagram of a power network is shown in figure. The system data are:

Element	+ve seq. reactance p.u	-ve seq. reactance p.u	zero seq. reactance p.u
Generator	0.1	0.12	0.05
Motors	0.05	0.06	0.025
Transformers	0.08	0.08	0.08
Line	0.10	0.10	0.10

Draw sequence networks. Find fault current for a line to line fault on phase b and c at point q. Assume 1 p.u as pre-fault voltage.



6. Load flow data for a power system shown in figure is given in table with bus 1 as slack. Determine the bus voltages at the end of I iteration using Gauss-Seidel method with an acceleration factor of 1.6.Assume flat voltage profile.



Bus Code	Line admittance
1 – 2	2-j8
1 – 3	1-j4
2 – 3	0.666 - j2.664
2 – 4	1-j4
3 – 4	2-j8

Bus No.	Load (p.u)		Remarks
	P	Q	
1	-	-	Slack
2	0.5	0.2	P – Q
3	0.4	0.3	P – Q
4	0.3	0.1	P – Q

7. A 50 MVA, 11kV, three phase synchronous generator was subjected to different types of faults. The fault currents are as follows:

   LG fault: 4200 A

   LL fault: 2600 A

   LLG fault: 2000A

   The generator neutral is solidly grounded. Find the p.u values of the three sequence reactance of the generator.

8. Consider a 60 Hz machine for which H=2.7MJ/MVA and it is initially operating in steady state with input and output of 1 p.u. and an angular displacement of 45 electrical degree with respect to an infinite bus bar. Upon occurrence of a fault, assume that the input remains constant and the output is given by $P_u = \delta/90$. Calculate and plot swing curve.

9. A generator operating at 50Hz delivers 1 p.u power to an infinite bus through a transmission circuit in which resistance is ignored. A fault takes place reducing the maximum power transferable to 0.5p.u. Whereas before the fault, this power was 2.0 p.u. and after the clearance of the fault, it is 1.5 p.u. By the use of equal area criterion, determine the critical clearing angle.

Analyze

1. The reactance of a generator designated X'' is given as 0.25 per unit based on the generator's name plate rating of 18 kV, 500 MVA. The base for calculations is 20 kV, 100 MVA. Evaluate X" on the new base.

2. For the network given below form Y bus using singular transformation method and evaluate the change in bus admittance if the line 2-3 is opened

Line (bus to bus)	Impedance
1- 2	0.15 + j0.6 p.u
1- 3	0.1 + j0.4 p.u
1- 4	0.15 +j0.6 p.u
2- 3	0.05 +j0.2 p.u
3- 4	0.05 +j0.2 p.u

3. Analyze with an example system and show that, $Y_{bus} = A^T yA$ Where, Y_{bus} – Bus admittance matrix, y- Primitive admittance matrix, A- Bus incidence matrix.

4. A 75 kVA, 14 kV/4.16 kV, delta/wye-grounded, 6% impedance transformer is to be used in a 13.8 kV distribution system. The system studies are performed on a 100 MVA base. Evaluate the transformer impedance for the new bases.

5. Two synchronous machines are connected through three-phase transformers to the transmission line as shown in Figure. The ratings and reactance of the machines and transformers are:

   Machine 1 and 2: 100MVA, 20 kV; $X_d'' = X_1 = X_2 = 20$ %

   $X_0 = 4\%$, $X_n = 5\%$

   Transformer T_1 and T_2 : 100MVA, 20Δ/345 Y kV; X=8%

   Find the sub transient current in the machine 1 and 2 for a fault at machine 1.

6. Consider the power system with the following data:

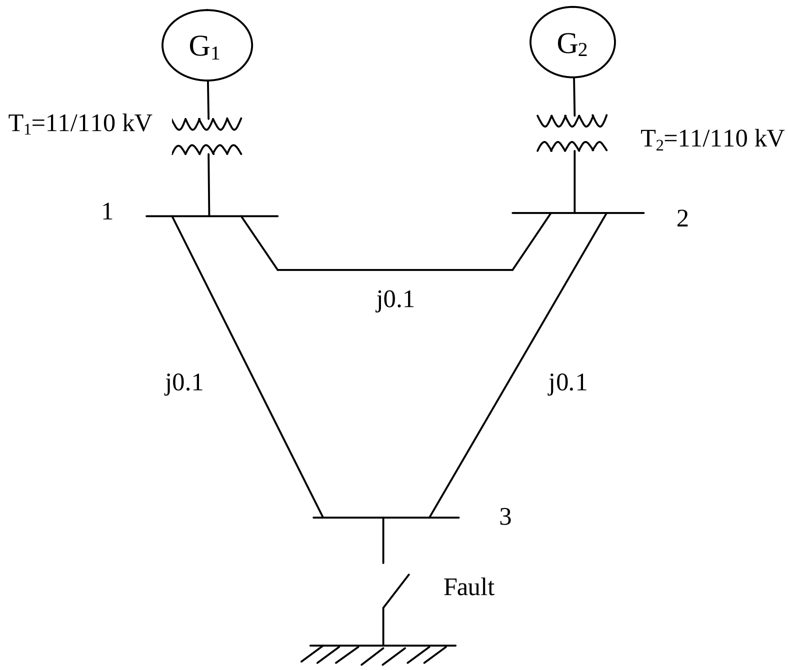
$$Y_{bus} = \begin{pmatrix} -j12 & j8 & j4 \\ j8 & -j12 & j4 \\ j4 & j4 & -j8 \end{pmatrix}$$

Bus No	Type	Generator		Load		Voltage	
		P	Q	P	Q	Magnitude	Phase angle
1	Slack	-	-	-	-	1.0	0
2	P - V	5.0	-	0	-	1.05	-
3	P - Q	0	0	3.0	0.5	-	-

   Assume that the bus 2 can supply any amount of reactive power. Assuming flat voltage profile perform the first iteration of power flow analysis using Newton-Raphson method

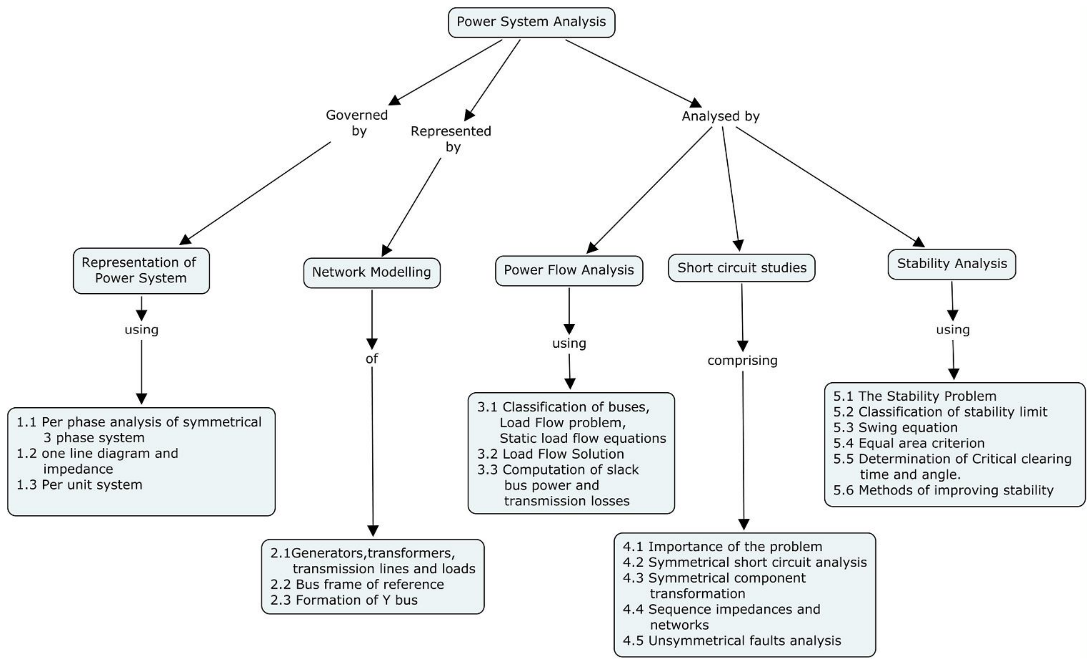
7. One conductor of a three phase line is open. The current flowing to the ▲ connected load through line A is 10 A and line B is 10 ∟180 A. Assuming that line C is opened, examine the change in symmetrical components of currents?

8. Consider a 3-bus system shown in figure. The generators are 100 MVA, with transient reactance 10% each. Both the transformers are 100MVA; 110KV and 10% reactance. Obtain the short circuit solution for a three-phase solid short circuit on bus 3. Assume pre-fault voltages to be 1.p.u and pre-fault currents to be zero.



9. A generator is delivering 1p.u power to an infinite bus system through a purely reactive network when the occurrence of a fault reduces the generators output power to zero. The maximum power that could be delivered is 2.5p.u. When the fault is cleared, original network conditions again exist. Determine critical clearing angle. If H=6 MJ/MVA, Calculate critical clearing time.
10. A synchronous motor having a steady state stability limit of 200MW is receiving 50MW from the infinite bus bars. Find the Maximum additional load that can be suddenly applied without causing instability

Concept Map



Syllabus

Representation of power system: Per phase analysis of symmetrical 3 phase system, one line diagram and impedance or reactance diagram, per unit (PU) system

Network Modeling: Modeling of generators, transformers, transmission lines and loads. Bus frame of reference (Elements of Z bus), Y bus formation-by inspection and singular transformation methods.

Power Flow Analysis: Classification of Buses, Load flow problem, Static Load Flow equations, Load flow solutions-using Gauss Seidal, and Newton Raphson method and Decoupled Load Flow, Computation of slack bus power and transmission line losses, Comparison of above methods

Short circuit Studies: Importance of the problem, Symmetrical short circuit analysis, Symmetrical component transformation, Sequence impedances and networks, Unsymmetrical fault analysis.

Stability Analysis: The Stability Problem, Classification of Stability, Swing equation- Solution by Numerical methods (Modified Euler's Method, Runge Kutta Method), Equal area criterion, Determination of critical clearing time and angle, Methods of improving stability limit.

TEXT BOOKS

1. John J. Grainger and Stevenson Jr. W.D., 'Power System Analysis', McGraw Hill International Edition, Fourth Edition,1994.
2. Nagarath.I.J, Kothari.D.P, 'Modern Power System Analysis', Tata McGraw Hill Pub. Co. Ltd., Third Edition, 2004.
3. C.L.Wadhwa., 'Electrical Power systems', Wiley Eastern Limited, Second Edition, 1993.
4. Hadi Saadat., 'Power System Analysis' Tata McGraw Hill Pub. Co. Ltd., 2002.

REFERENCE BOOKS

1. Nagarath, I.J., and Kothari, D.P., 'Power System Engineering', Tata McGraw Hill Publishing Company, 1994.
2. K.A. Gangadhar., 'Electric Power Systems (Analysis ,Stability and Protection)', Khanna Phublishers Second Edition, 1992.

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**Representation of power system**	
1.1	Per phase analysis of symmetrical 3phase system	1
1.2	One line diagram and impedance or reactance diagram	2
1.3	Per unit (PU) system	2
2.	**Network Modeling**	
2.1	Modeling of generators, transformers, transmission lines and loads	3
2.2	Bus frame of reference	1
2.3	Y bus formation-by Inspection and singular transformation methods	6
3	**Power Flow Analysis**	
3.1	Classification of buses , Load flow problem, Static Load Flow equations	1
3.2	Load flow solution methods- Gauss Seidal, Newton Raphson and Decoupled Load Flow	7
3.3	Computation of slack bus power and transmission line losses, Comparison of above methods	2
4	**Short circuit Studies**	
4.1	Importance of the problem	1

4.2	Symmetrical short circuit analysis	3
4.3	Symmetrical component transformation	2
4.4	Sequence impedances and networks	2
4.5	Unsymmetrical fault analysis	3
5	**Stability Analysis**	
5.1	The Stability Problem	1
5.2	Classification of stability	1
5.3	Swing equation – Solutions by numerical methods	2
5.4	Equal area criterion	2
5.5	Determination of Critical clearing time and angle.	2
5.6	Methods of improving stability	1
	Total	45

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Sub Code	Lectures	Tutorial	Practical	Credit
E63	3	-	-	3

E63 Electric Drives 3:0

Preamble

Electric Drives, both ac and dc types, come in many shapes and sizes. Some are standardized versions for general-purpose applications. Others are intended for specific tasks. In any case, motors should be selected to satisfy the dynamic requirements of the machines on which they are applied without exceeding rated motor temperature. Thus, the first and most important step in motor selection is determining load characteristics, torque and speed versus time. Selection is also based on mission goals, power available, and cost.

Program Outcomes Selected

a) Graduates will demonstrate knowledge of mathematics, science and engineering.
b) Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c) Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
d) Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
e) Graduate will be able to communicate effectively in both verbal and written form.
f) Graduate will develop confidence for self education and ability for life-long learning.
g) Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course, the students should be able to:

1. Understand the concept of Electric Drives
2. To classify the choice of electrical drives for practical applications.
3. Analyze and characterize various control strategies for DC & AC motor Drives.
4. Analyze the role of power electronic converters in drives

Assessment pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 /End-semester examination
1	Remember	20	20	10
2	Understand	20	20	10
3	Apply	30	30	40
4	Analyze	30	30	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What are the basic elements of Electric Drives?
2. What are the advantages of electric drive over mechanical drive?
3. Draw the block diagram of Electric Drive.
4. What are the advantages and disadvantages of Group drive system?
5. List the advantages of solid state drives.
6. List the types of converters used in ac drives.
7. List the advantages and applications of BLDC motor.
8. Define short time duty of motor.
9. Derive the rotor flux model of induction motor using the concept of vector control.

Understand

1. What is an electrical drive?
2. Mention the advantages and disadvantages of PWM control method of solid state drives.
3. What is frequency modulation control of a converter?
4. What is meant by vector control?
5. What is the need for closed loop control in drives?
6. Between the AC and DC drive, which is ideal for traction application?
7. Explain in detail the single phase semi-converter speed control for DC drive for separately excited motor.
8. Explain the loading of an electric motor and its duty cycle with a simple diagram.
9. Compare D.C and A.C drives
10. Explain the method of regenerative braking employed in DC Motors.

Apply

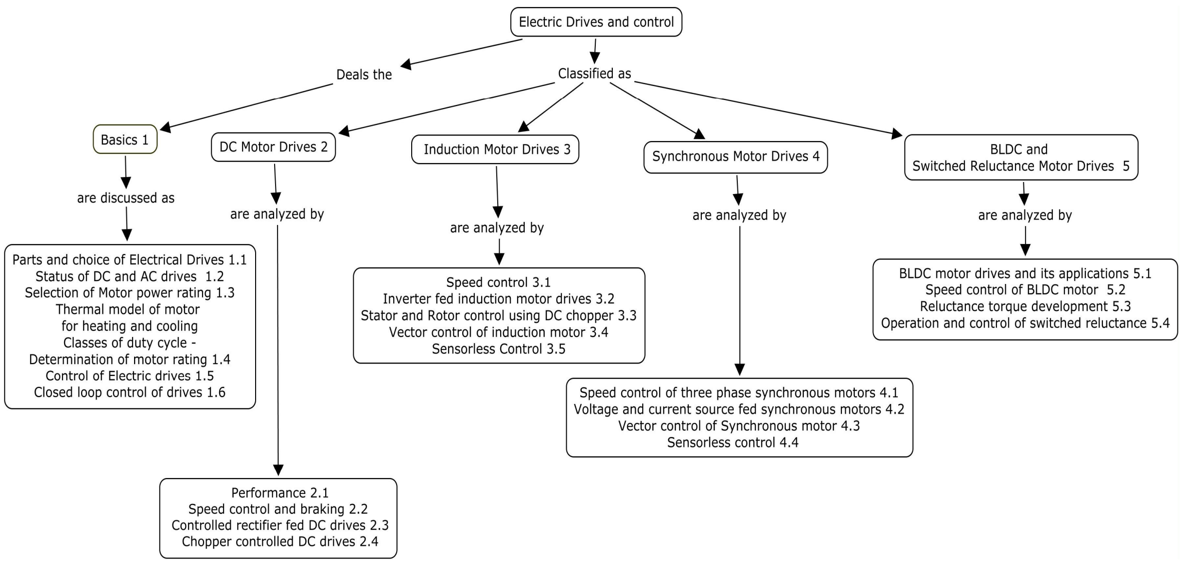
1. A 100 kW motor, having rated temperature rise of 60°C, has full-load efficiency of 80% and the maximum efficiency occurs at 85% full load. It has thermal time constants of 80 minutes and 65 minutes. It is cyclically loaded, 120% of full load for one hour and 50% of full load for the next hour. Find the temperature rise after 3 hours.
2. The thermal time constant and final steady temperature of a motor on continuous running is 30 minutes and 60°C. Find the temperature.
   i) After 15 minutes at this load.
   ii) After 1 hour at this load.
   iii) If temperature rise at 1 hour rating is 60°C, find the maximum steady temperature.
   iv) What will be the time required to increase the temperature from 40°C to 60°C at 1 hour rating.
3. A 220V shunt Motor has an armature resistance of 0.062 Ω and with full field has an emf of 215V at a speed of 960 rpm, the motor is driving an overhauling load with a torque of 172 Nm. Calculate the minimum speed at which the motor can hold the load by means of regenerative braking.
4. A 500V series motor having armature resistance and field resistance of 0.2 Ω and 0.3 Ω respectively runs at 500 rpm when taking 70A. Assuming unsaturated field, find out its speed when field diverter of 0.684 Ω is used constant load torque.
5. A 250V DC Series Motor takes 40A of current when developing a full load torque at 1500 rpm. Its resistance is 0.5 Ω. If the load torque varies as the square of the speed determine the resistance to be connected in series with the armature to reduce the speed to 122 rpm. Assume the flux is proportional to the field current.
6. The input to a chopper is from a 100V dc source. The chopper is switched at a frequency of 100KHz with a pulse width of 4μs. What is the average output voltage of the chopper?

Analyze

1. Between the AC and DC drives, which is suitable for lift and crane?
2. Evaluate the effect of closed loop speed control of BLDC motor.
3. Analyze the effect of the output voltage, duty ratio and the load current in the determination of the inductor value of the buck converter.
4. Analyze the effect of harmonics on PWM inverters fed drives.

5. Analyze the effect of the output voltage, duty ratio and the load current in the determination of the inductor and capacitor value of the filter used in buck converter based DC drives.
6. Discuss the effect of harmonics in an inverter fed drives.

Concept Map



Syllabus

Electric Drives - Advantage of solid state electric drives - Parts and choice of electrical drives – Status of DC and AC drives - Torque-speed characteristics of motor and load - Selection of Motor power rating - Thermal model of motor for heating and cooling - Classes of duty cycle - Determination of motor rating - Control of Electric drives - Modes of operation - Speed control and drive classifications - Closed loop control of drives.

DC Motor Drives - DC motor and their performance - Speed control - Braking Controlled rectifier fed DC drives - Chopper controlled DC drives.

Induction Motor Drives - Speed control – Stator control-Inverter fed induction motor drives - Rotor resistance control and slip power recovery schemes - Static control of rotor resistance - Vector control of induction motor- Sensorless control- Speed Estimation methods – Slip calculation – Direct Synthesis from state equations – Direct Vector control without Speed signal.

Synchronous Motor Drives - Speed control - Inverter fed synchronous motors – Vector control of Synchronous motor – Sensorless control – Trapezoidal SPM machine – Sinusoidal PM Machine.

BLDC Motor and SRM Drives - Operation and control of BLDC motor and switched reluctance motor drives.

Text Book

G. K. Dubey: Fundamental of Electrical Drives - Narosa Publishing House, Chennai, 2004.

Reference Books

1. Bimal K.Bose – Modern Power Electronics and AC Drives – Pearson Education Asia Publication, 2003.
2. R.Krishnan - Electric motor drives – Modeling, analysis and control, Pearson Education, New Delhi, 2003.
3. Muhammad H.Rashid, Power Electronics Circuits, Devices & Applications - Pearson Education India Publication, New Delhi, II Edition, 2007.
4. Ned Mohan, Tore Undeland & William Robbins, Power Electronics : converters Applications and Design-John Willey and sons 2003.

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.	**Electric Drives**	
1.1	Advantage of Electric Drives - Parts and choice of Electrical Drives	1
1.2	DC and AC drives	1
1.3	Torque-speed characteristics of motor and load - Selection of Motor power rating	1
1.4	Thermal model of motor for heating and cooling - Classes of duty cycle - Determination of motor rating	2
1.5	Control of Electric drives - Modes of operation - Speed control and drive classifications	2
1.6	Closed loop control of drives	1
2.	**DC Motor Drives**	
2.1	DC motor and their performance	1
2.2	Speed control and Braking methods	2
2.3	Controlled rectifier fed DC drives	2
2.4	Chopper controlled DC drives	2
3.	**Induction Motor Drives**	
3.1	Speed control	2
3.2	Inverter fed induction motor drives	4
3.3	Rotor resistance control and slip power recovery scheme - Static control of rotor resistance using DC chopper	3

3.4	Vector control of induction motor	3
3.5	Sensorless control - Speed Estimation methods – Slip calculation – Direct Synthesis from state equations – Direct Vector control without Speed signal	3
4.	**Synchronous Motor Drives**	
4.1	Speed control of three phase synchronous motors	1
4.2	Voltage and current source inverter fed synchronous motors	2
4.3	Vector control of Synchronous motor	2
4.4	Sensorless control - Trapezoidal SPM machine – Sinusoidal PM Machine	3
5.	**BLDC and Switched Reluctance Motor Drives**	
5.1	BLDC motor drives and its applications	2
5.2	Speed control of BLDC motor	2
5.3	Reluctance torque development	1
5.4	Operation and control of switched reluctance motor	2
	Total	45

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E64	3	0	-	3

E64 VLSI Design 3:0

Preamble

VLSI is an acronym that stands for Very Large Scale Integration. VLSI contains more than 100 million of logic gates. VLSI is a technology that can be harnessed for various applications covering analog, digital and mixed signal electronics. The current trend is to reduce the entire system design to a single chip solution called as system on chip.

VLSI has become a major driving force in modern technology. It provides the basis for computing and telecommunications, and the field continues to grow at an amazing pace.

Program Outcomes addressed

a) Graduates will demonstrate knowledge of mathematics, science and engineering.

b) Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c) Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

d) Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

Competencies

The student, at the end of the course, should be able to:

1. Gain the knowledge of the basic CMOS circuits.
2. Understand the CMOS process technology.
3. Designing techniques of VLSI systems using programmable devices.
4. Implement CMOS Logic Design.
5. Design VLSI subsystems.
6. Apply the VLSI clocking in system design.
7. Test the VLSI Circuits.
8. Do modeling a digital system using Hardware Description Language.

Assessment pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	10
2	Understand	20	20	30
3	Apply	20	20	20
4	Analyze	10	10	10
5	Evaluate	0	0	0
6	Create	30	30	30

Course level Learning Objectives

Remember

1. What are four generations of Integration Circuits?
2. Give the advantages of CMOS IC?
3. Give the variety of Integrated Circuits?
4. What are the different MOS layers?
5. What are the different layers in MOS transistor?
6. What are the different types of oxidation?
7. Give the different types of CMOS process.
8. Define threshold voltage.
9. Define fan in and fan out.
10. Define controllability.

Understand

1. What is Intrinsic and Extrinsic Semiconductor?
2. What is CMOS Technology?
3. Why NMOS technology is preferred more than PMOS technology?
4. What is Enhancement mode transistor
5. What is diffusion process? What are doping impurities?
6. What are the special features of Twin-tub process?
7. What is meant by fowler Nordheim tunneling?
8. Explain n-well and c-well process and analyze its performance.
9. Explain different CMOS circuits testing methods
10. Explain PLL with necessary diagrams**.**

Apply

1. Draw a CMOS logic gate for the function Z= NOT(((A.B)+C).D)

2. Draw the physical layout of 2 input nand gate using static CMOS logic and explain it.
3. Consider an nFET that has a gate oxide thickness of t_{ox} = 12nm and an electron mobility of µn=540 cm square/V-sec. Find oxide capacitance.
4. Draw the circuit diagram for a dynamic logic gate that has an output of f=NOT(a.b+c.a)
5. A CMOS inverter is characterized by the switching times tr = 430 + 3.68C_L ps and

   t_f = 300 + 2.56C_L ps. Plot the rise and fall time for C_L = 0 to 200fF
6. Consider a CMOS process that is characterized by Vdd= 5V, Vtn = 0.7V,

   Vtp = -0.85V, Kn=120µA/V^2 and Kp=55 µA/V^2. A pseudo – nMOS is designed using an nFET aspect ratio of 4. Find the pFET aspect ratio needed to achieve Vol = 0.3V.

Analyze

1. Compare between CMOS and bipolar technologies
2. What are the different regions that can be defined in n-MOS depending upon the voltages applied?
3. Compare different types of clock distribution techniques.
4. Discuss about single phase clocking system.
5. Consider the dual expressions g = NOT(x.y+z.w) and G = NOT((x+y).(z+w)), which form OAI OR AOI would be the best performance when built using pseudo-nMOS design.
6. Analyze the advantages of Bicmos logic.

Create

1. Write the VHDL coding for full adder using behavior and structural modeling.
2. Generate the VHDL coding for given Boolean expression using data flow modeling.

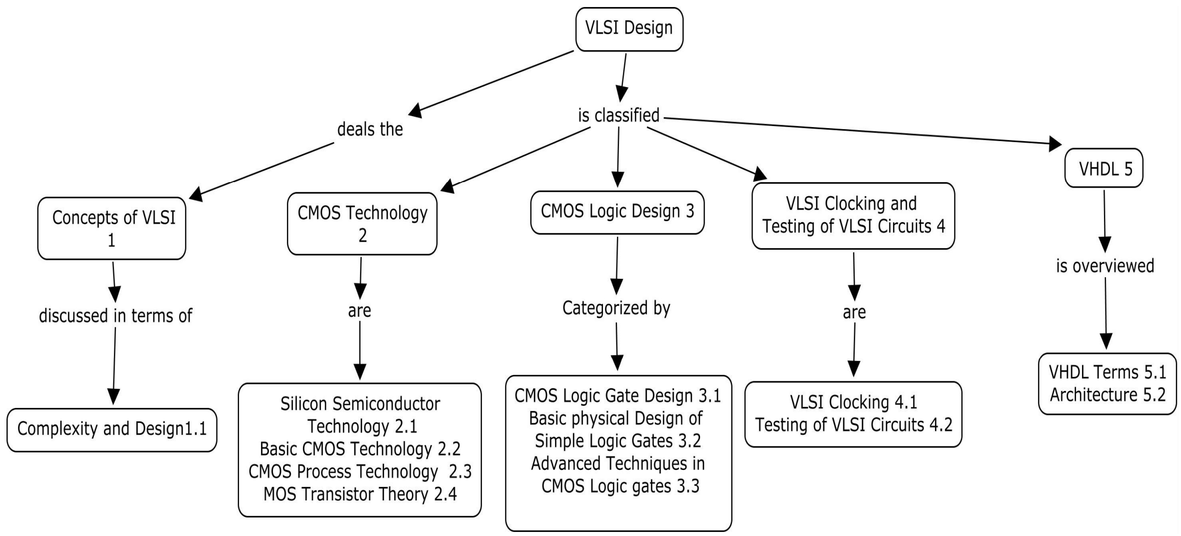
   Y= NOT((a.b)+(b.c))
3. Give the VHDL coding for half adder using structural modeling.
4. Write short notes on IDDQ testing.
5. Design CMOS logic gates for given functions.

   i) 2:4 decoder

   ii) (A.B) + (C.D)

6. Design a tristate circuit that is in the a high-impedance state when the control signal T=1, and acts as a non-inverting buffer when T=0.

Concept Map



Syllabus

An overview of VLSI: Complexity and Design , Basic Concepts

CMOS Technology: Silicon Semiconductor Technology, Basic CMOS Technology(N-well, P-well, Twin Tub, SOI), CMOS Process Technology, Inter connect, Circuit Elements, Layout Design Rules, MOS Transistor Theory**:** Introduction of nMOS and pMOS Enhancement Transistor, Threshold Voltage and Body Effect, MOS Device Design Equation and Basic DC Equations, Second Order Effects, The Complementary CMOS Inverter-DC Characteristics, The Transmission Gate.

CMOS Logic Design: CMOS Logic Gate Design, Fan in & Fan out, Transistor Sizing, Basic physical Design of Simple Logic Gates, Inverter, NAND & NOR Gate, CMOS Standard Cell, General CMOS Logic Gates , Layout Guidelines, Transmission- Gate Layout Considerations.

Advanced Techniques in CMOS Logic gates **:** Pseudo nMOS, Tri-state Circuits, Clocked circuits, Dynamic CMOS Logic Circuits.

VLSI Clocking and Testing of VLSI Circuits : Clocked FlipFlops, CMOS Clocking Styles, Pipelined Systems, Clock Generation and Distribution. Testing of VLSI Circuits : General Concepts, CMOS Testing, Test Generation Methods.

VHDL : Introduction on VHDL & VHDL Terms, Behavioral description and sequential description, Data flow description, Introduction to Synthesis and Entity.

Text Books

1. Neil H.E. Weste & Kamran Eshraghian, "Principles of CMOS VLSI Design", Second Edition, Addison –Wesley Publishers, 1998.
2. John P. Uyemura "Introduction to VLSI Circuits and systems" – John Wiley & Sons, Inc.

Reference Books

1. Wayne Wolf, "Modern VLSI Design," 2nd edition, Prentice Hall PTR, 2000.
2. Sung – Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated circuits, Analysis & Design", 3rd edition, Tata Mcgraw – Hill Publishing, 2003.
3. J. Bhaskar**,** "A VHDL Primer", Third Edition, Addition Wesley, 1999.
4. Neil H.E. Weste, David Harris Ayan Banerjee "CMOS VLSI Design" Pearson Education-3rd edition.

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**An overview of VLSI**	
1.1	Complexity and Design ,Basic Concepts	1
2	**CMOS Technology**	
2.1	Silicon Semiconductor Technology	1
2.2	Basic CMOS Technology(N-well, P-well, Twin Tub, SOI)	2
2.3	CMOS Process Technology	1
2.3.1	Inter connect, Circuit Elements	1
2.3.2	Layout Design Rules	2
2.4	MOS Transistor Theory	
2.4.1	nMOS and pMOS Enhancement Transistor	2
2.4.2	Threshold Voltage and Body Effect	1
2.4.3	MOS Device Design Equation and Basic DC Equations	2
2.4.4	Second Order Effects	1
2.4.5	The Complementary CMOS Inverter-DC Characteristics	2
2.4.6	The Transmission Gate	1
3	**CMOS Logic Design**	
3.1	CMOS Logic Gate Design	1
3.1.1	Fan in & Fan out	1
3.1.2	Transistor Sizing	1
3.2	Basic physical Design of Simple Logic Gates	1

3.2.1	Inverter	1
3.2.2	NAND & NOR Gate	1
3.2.3	CMOS Standard Cell	1
3.2.4	General CMOS Logic Gates Layout Guidelines	1
3.2.5	Transmission- Gate Layout Considerations	1
3.3	**Advanced Techniques in CMOS Logic gates**	
3.3.1	Pseudo nMOS	1
3.3.2	Tri-state Circuits	1
3.3.3	Clocked circuits	2
3.3.4	Dynamic CMOS Logic Circuits	2
4	**VLSI Clocking and Testing of VLSI Circuits**	
4.1	VLSI Clocking	
4.1.1	Clocked FlipFlops	1
4.1.2	CMOS Clocking Styles	1
4.1.3	Pipelined Systems	1
4.1.4	Clock Generation and Distribution	1
4.2	Testing of VLSI Circuits	
4.2.1	General Concepts	1
4.2.2	CMOS Testing	2
4.2.3	Test Generation Methods	1
5	**VHDL**	
5.1	VHDL Terms	1
5.2	Architecture	
5.2.1	Behavioral and sequential description	2
5.2.2	Data flow description	1
5.2.3	Synthesis and Entity	1
	Total	45

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E67	-	-	3	1

E67 Power System Simulation Lab 0:1

Aim:

i) To train the students to solve the Power System problems using MATLAB

ii) To expose the students to power system software packages like Power World Simulator, PSCAD, and ETAP.

A student must complete a minimum of five experiments from each category

List of experiments

A. Matlab coding

1. Solving Linear and Nonlinear equations
2. Formation of bus admittance matrix
3. Power flow equation by Gauss - Seidal method
4. Economic load dispatch without losses
5. Load forecasting using least square method
6. Swing equation by modified Euler's method

B. Matlab Tool Box

1. Simulation of RLC series circuit
2. Simulation of Single phase converter for R and RL loads
3. Simulation of Static VAR compensator
4. Simulation of Load Frequency Control

Power World Simulator

5. Verification of Power flow program results.

ETAP & PSCAD

6. Study of ETAP and PSCAD Packages

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E68	-	-	3	1

E68 Power Electronics and Drives lab 0:1

Purpose of Laboratory Experiments

To impart practical skills on different power electronic circuits and drives.

A student must complete a minimum of five experiments from each category

List of experiments

Power Electronics

1. Power electronic circuit analysis using PSCAD/PSPICE/MATLAB/PSIM
2. Controlled rectifiers
3. Voltage source inverters
4. DC Choppers
5. Flyback converter
6. Forward converter
7. Solid state relay and static circuit breaker
8. Battery charger and UPS
9. HVDC converters analysis using PSCAD/MATLAB/PSIM
10. Analysis of converters for distributed generation using PSCAD/MATLAB/PSIM

Drives

1. Analysis of DC drives using PSCAD/PSPICE/MATLAB/PSIM
2. Analysis of AC drives using PSCAD/PSPICE/MATLAB/PSIM
3. Controlled rectifier fed DC drive
4. DC chopper fed DC drive
5. Inverter fed induction motor drive
6. Inverter fed synchronous motor drive
7. BLDC motor drive
8. SRM drive
9. DSP based DC drive
10. DSP based AC drive

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B.E.(Electrical & Electronics Engg.) Degree PROGRAM

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2008-2009 ONWARDS

Departmental Electives

Sub Code	Lectures	Tutorial	Practical	Credit
ECD	3	-	-	3

ECD Soft Computing 3:0

Preamble

Soft computing is a discipline that deals with the design of intelligent systems, which is in contrast to classical hard computing technique. A consortium of computing methodologies that provides a foundation for the conception, design, and deployment of intelligent systems and aims to formalize the human ability to make rational decisions in an environment of uncertainty, imprecision, partial truth, and approximation. The main constituents of soft computing involve fuzzy logic, neuro computing, and genetic algorithms and its applications.

Students acquire knowledge of soft computing theories, fundamentals and so they will be able to design program systems using approaches of these theories for solving various real-world problems. Students also awake the importance of tolerance of imprecision and uncertainty for design of robust and low-cost intelligent machines.

Program outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science

b. An ability to design and conduct experiments, as well as to analyze and interpret data

c. An ability to identify, formulate and solve engineering problems

d. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

Competencies

After successfully completing the course, students are able to:

1. Acquire the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience
2. Acquire the knowledge of neural networks that can learn from available examples and generalize to form appropriate rules for inferencing systems
3. Provide the mathematical background for carrying out the optimization associated with neural network learning

4 Acquire knowledge of various optimization techniques and genetic algorithm procedures useful while seeking global optimum in self-learning situations

5. Detailed case studies utilizing the above and illustrate the intelligent behavior of programs based on soft computing

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End semester examination
1	Remember	20	20	10
2	Understand	40	40	30
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	20
6	Create	0	0	0

Course level learning objectives

Remember

1. What are the different paradigms of soft-computing?
2. Give some common applications of fuzzy logic?
3. What are the different methods of De-fuzzification?
4. What are the parameters to be considered for the design of membership function?
5. Define: optimization
6. Mention the different methods selection.
7. What are the genetic operators used in GA?
8. Mention the linear and non-linear activation functions used in ANN.
9. What is perceptron?
10. Mention the special features of Boltzman machine.

Understand

1. Explain Sugeno fuzzy model
2. Explain the construction of fuzzy model for a nonlinear equation
3. Explain Widrow-Hoff LMS Learning Algorithms.
4. Explain multilayer perceptron with its architecture. How is it used to solve XOR Problem?
5. What do you mean by supervised and unsupervised learning?
6. Explain back propagation algorithm in detail.
7. Describe the learning expressions in the back propagation network.
8. What is competitive learning? How does it differ from signal Hebbrian learning?
9. Explain the basic idea behind SVM with suitable illustrations
10. Explain the various steps involved in GA in detail

Apply and Evaluate

1. Compute the centroid defuzzifier for

$\overline{A} = \left\{ \frac{0.9}{-3}, \frac{0.7}{-2}, \frac{0}{-1}, \frac{0.3}{1}, \frac{1}{2}, \frac{0.2}{3} \right\}$

Let $X = \{0,1,2,3,4,5\}$ and $\overline{A} = \left\{ \frac{0.9}{-3}, \frac{0.7}{-2}, \frac{0}{-1}, \frac{0.3}{1}, \frac{1}{2}, \frac{0.2}{3} \right\}$, $\overline{B} = \left\{ \frac{0.9}{-3}, \frac{0.7}{-2}, \frac{0}{-1}, \frac{0.3}{1}, \frac{1}{2}, \frac{0.2}{3} \right\}$

Find the fuzzy max and fuzzy min of $\overline{A}$ and $\overline{B}$

2. Let A={(x1,0.2),(x2,0.7),(x3,0.4)} and B={(y1,0.5),(y2,0.6)} be two fuzzy sets defined on the universe of discourse X={x1,x2,x3} and Y={y1,y2,y3} respectively. Find the Cartesian product of the A and B and fuzzy relation R.
3. Describe the structure and operation of continuous Hopfield network. & Construct an auto associative BAM using the following training vectors. X1 = $(1,-1,-1,1,-1,1)^T$ and x2 = $(1,1,1,-1,-1,-1)^T$. Determine the output using xo $=(1,1,1,1,-1,1)^T$

3. Find the optimal layer associative memory (OLAM) matrix M for the association given below

   $A1 = (1\ 2\ 3)^T$ $B1 = (4\ 3\ 2\ )^T$

   $A2 = (2\ 3\ 4)^T$ $B2 = (3\ 5\ 2\ )^T$

   $A3 = (3\ 4\ 6)^T$ $B3 = (2\ 2\ 1)^T$

   Determining whether Ai= M - Bi

4. Perform two generations of simple binary coded genetic algorithm to solve the following optimization problem. Maximize $f(x) = x^2$ $0 \leq x \leq 31$, x is an integer.Use proportionate selection, single point crossover, binary mutation and population size of six.

5. Perform two generations of simple binary coded and real coded genetic algorithm to solve the following optimization problem.

   Maximize $f(x) = |x| \sin(x)$ $-5 \leq x \leq 5$, x is real number.

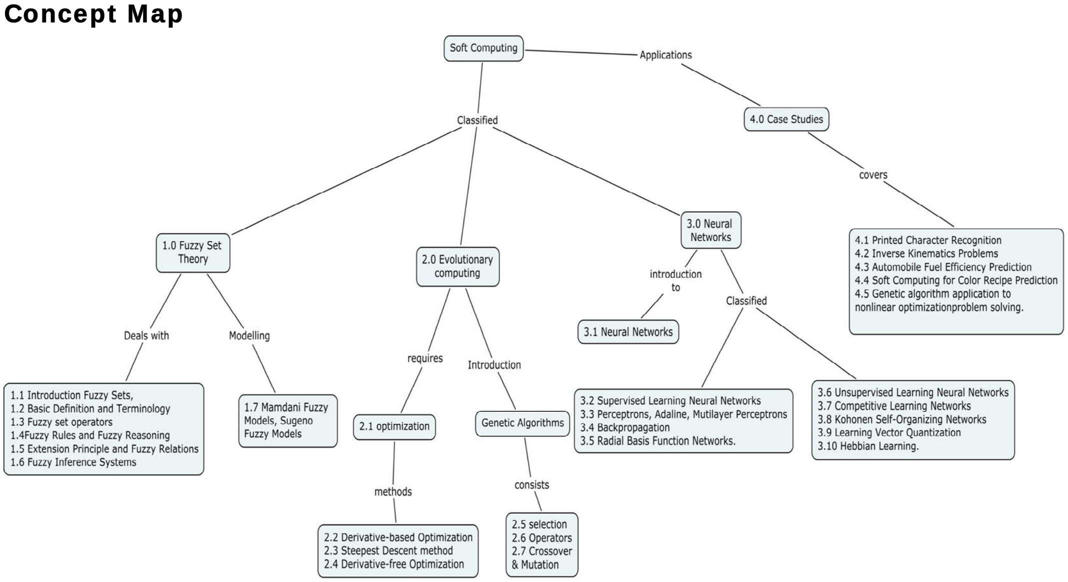
Use proportionate selection, single point crossover, and binary mutation for simple GA and proportionate selection, Arithmetic crossover, and Gaussian mutation for RGA .Use population size of six for both SGA and RGA. Evaluate the performance of SGA and RGA after two generations

6. For the following data set, generate a suitable simple fuzzy and perceptron neuron model

```
OriginalData = {{1, 20}, {2, 12}, {3, 9}, {4, 6},
  {5, 5}, {6, 4}, {7, 5}, {8, 6}, {9, 9}, {10, 12}, {11, 20}};
```

Evaluate their performance.

Concept Map



Syllabus

FUZZY SET THEORY

Introduction to Soft Computing – Fuzzy Sets – Basic Definition and Terminology – Fuzzy set operators – Fuzzy Rules and Fuzzy Reasoning – Extension Principle and Fuzzy Relations – Fuzzy Inference Systems – Mamdani Fuzzy Models – Sugeno Fuzzy Models – Fuzzy Modeling.

GENETIC ALGORITHMS

Introduction to optimization techniques - Derivative-based Optimization – Steepest Descent Method – Derivative-free Optimization – Genetic Algorithms - Selection, -Genetic operators- Crossover and Mutation –Simple binary coded GA-Real coded GA.

NEURAL NETWORKS

Introduction - Supervised Learning Neural Networks – Perceptrons - Adaline – Multilayer Perceptrons – Back propagation - Radial Basis Function Networks –

Unsupervised Learning Neural Networks – Competitive Learning Networks – Kohonen Self-Organizing Networks – Learning Vector Quantization – Hebbian Learning –Support vector Machines .

APPLICAIONS

Load Forecasting Problem – Electrical fault classification- Speed Controller using Fuzzy and Neural Networks – Genetic Algorithm application to Economic Dispatch problem.

TEXT BOOK

J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, 2004, Pearson Education 2004.

REFERENCE BOOKS

1. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", McGraw-Hill, 1997.
2. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.
3. Simon Haykin, "Neural Networks A comprehensive foundation", PHI, Second Edition,1999.

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0 FUZZY SET THEORY		
1.1	Introduction to Soft Computing	1
1.2	Fuzzy Sets, Basic Definition and Terminology	1
1.3	Fuzzy set operators	1
1.4	Fuzzy Rules and Fuzzy Reasoning	2
1.5	Extension Principle and Fuzzy Relations	1
1.6	Fuzzy Inference Systems	1
1.7	Mamdani Fuzzy Models Sugeno Fuzzy Models	3
2.0 GENETIC ALGORITHMS		
2.1	Introduction to optimization techniques	1
2.2	Derivative-based Optimization	1
2.3	Steepest Descent method and Derivative-free Optimization	2
2.4	Genetic Algorithms- Selection	1
2.5	Genetic operators	1
2.6	Crossover and Mutation schemes	2
2.7	Simple binary coded GA	2
2.8	Real coded GA	2
3.0 NEURAL NETWORKS		
3.1	Introduction	1
3.2	Supervised and unsupervised Learning Neural Networks	2
3.3	Perceptrons, Adaline, Mutilayer Perceptrons	2
3.4	Backpropagation	2
3.5	Radial Basis Function Networks	1
3.6	Competitive Learning Networks	1

3.7	Kohonen Self-Organizing Networks	2
3.8	Learning Vector Quantization	1
3.9	Hebbian Learning.	1
3.10	Support vector machines	3
4.0 APPLIATIONS		
4.1	Load Forecasting Problem	2
4.2	Electrical fault classification	2
4.3	Speed Controller using Fuzzy and Neural Networks	2
4.4	Genetic Algorithm application to Economic Dispatch problem.	2
	Total	45

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Sub code	Lectures	Tutorial	Practical	Credit
ECE	3	0	-	3

ECE Analog Integrated Circuit Design 3:0

Preamble

This course 'ECE -Analog Integrated Circuit Design', a departmental elective course is preceded by departmental core courses 'E55 Mixed Signal Circuits and Interfacing', 'E23: Analog Circuits and Systems' which presents an overview of basic analog circuits and mixed signal circuits. This course mainly discusses the modeling of integrated-circuit devices, noise analysis, basic op-amp design and its compensation, design of advanced current mirrors, op-amps, sample and hold circuits, voltage references, translinear circuits, bipolar continuous time filter and PLL.

Program Outcomes addressed

a) Graduates will demonstrate knowledge of mathematics, science and engineering.
b) Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c) Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
d) Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
e) Graduate will be able to communicate effectively in both verbal and written form.
f) Graduate will develop confidence for self education and ability for life-long learning.
g) Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course, the students should be able to**:**

1. Understand the modeling of integrated-circuit devices such as diode, BJT and MOS transistors.
2. Understand the noise sources and its influence on the performance of integrated circuits.
3. Design basic op-amps and their compensation.
4. Design advanced current mirrors and op-amps
5. Design sample and hold circuits, voltage references and translinear circuits.
6. Design bipolar continuous time filters and PLL.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 /End-semester examination
1	Remember	20	20	0
2	Understand	20	20	20
3	Apply	30	30	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	30	30	40

Course Level Learning Objectives

Remember

1. What is meant by diffusion capacitance of a diode?
2. Draw the large signal model of BJT operating in the saturation region.
3. Define the SNR value of a signal node in a system.
4. What is meant by noise spectral density?
5. What are the ways of improving the slew rate for the two-stage CMOS op-amp?
6. What is OTA?
7. What is aperture jitter in sample and hold circuit?
8. What is the use of bandgap voltage reference?
9. What is a transconductor?
10. What is meant by lock range and capture range of a PLL?

Understand

1. Why is the BJT never allowed to saturate in high-speed microcircuit designs?
2. What is the need for op-amp compensation?
3. Why is it more difficult to achieve reasonable op-amp gains when shorter channel lengths are used?
4. Why a current mirror op-amp is usually preferred over a folded-cascade op-amp?
5. Why zener diode is not popular nowadays to realize a voltage reference?
6. How PTAT circuit is used to generate band gap reference?
7. Why is the maximum collector currents through transistors are usually constrained to be less than 0.1mA in CMOS band gap references?
8. Why continuous time filters are preferred in high frequency applications?
9. Why fully differential circuits are desired in integrated circuits?
10. Why PLL with charge-pump phase comparator is preferred in many applications?

Apply

1. Find I_D for an n-channel transistor that has doping concentrations of $N_D = 10^{25}$, $N_A = 10^{22}$, $\mu_n C_{ox} = 92\mu A/V^2$, $W/L = 20\mu m/2\mu m,$ $V_{GS} = 1.2V, V_{tn} = 0.8V$ and $V_{DS} = V_{eff}$,Assume λ remains constant, estimate the new value of I_D if V_{DS} is increased by 0.5V.
2. Show that when two resistors of values R_1 and R_2 are in series, their noise model is same as a single resistance of value $R_1 + R_2$. Repeat the problem for parallel resistances.

3. Calculate the output impedance of the two transistor diode connected circuit shown in Fig.1 using small signal analysis. Assume both transistors are in the active region, ignore the body effect and assume $g_{m1} = g_{m2}, r_{ds1} = r_{ds2}$, and $g_m r_{ds} >> 1$.

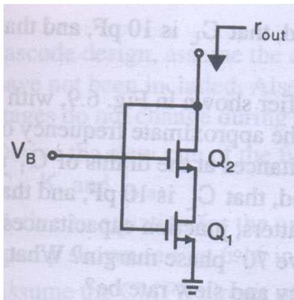


Fig.1

3. Assume two transistors are biased at a current density ratio of 10:1 at T= 300 $^\circ$K. What is the difference in their base-emitter voltages and what is its temperature dependence?

4. What transconductance is needed for an integrator that has unity-gain frequency of 20 MHz, assuming a 2 pF integrating capacitor?

5. Consider a PLL where the amplitudes of the input signal and the oscillator output are both at a 0.75V peak. An analog multiplier is being used for the phase detector which would have a 2V output when both inputs are dc values of 2v. The VCO has a free running frequency of 10 MHz, which would decrease to zero for V_{cntl} =-1V and the gain block is unity. When in lock what is the phase difference between the input and oscillator output when the input frequency is 11MHz.

6. Find the capacitances C_{gs}, C_{gd}, C_{db} and C_{sb} for an active transistor having $W = 50\mu m$ and $L = 1.2\mu m$. Assume that the source and drain junctions extend $4\mu m$ beyond the gate, resulting in source and drain areas being $A_s = A_d = 200(\mu m)^2$ and the perimeter of each being $P_s = P_d = 58\mu m$.

7. Sketch the spectral density of voltage noise across a 100 pF capacitor when it is in parallel with a 1 $K\Omega$ resistor.

8. An op-amp has its first pole at 3 KHz and high frequency poles at 130MHz,

160MHz and 180 MHz. Using iteration find the frequency where the phase shift is -135° and therefore find the equivalent time constant that models the high frequency poles.

9. Assuming $V_{BE0-2} = 0.65V$, what is the value required for K in order to get temperature dependence at T= 320°K for a current density ratio of 8:1 in the two transistors in a PTAT cell?

Create

1. A given diode has a transit time of 100 ps and is biased at 1 mA. What are the values of its small signal resistance and diffusion capacitance? Assume room temperature so that $V_T = KT/q = 26mV$.

2. At a room temperature of 300 $°K$, what capacitor size is needed to achieve a 96db dynamic range in an analog circuit with maximum signal levels of 1V rms?

3. A closed loop amplifier is compensated to have a 75° phase margin for $\beta = 1$ what is ω_t if $f_{eq} = \omega_{eq}/2\pi =$ 50 MHz? What is ω_{ta}?

4. For the circuit shown in Fig. 2, using small signal analysis, find the output impedance assuming $R_E >> r_\pi$? Compare this to the upper limit on the output impedance of a simple cascode mirror (i.e A=0) for the same case.

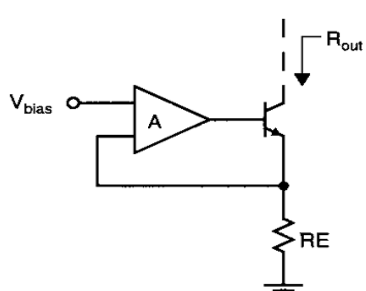


Fig.2

5. Design a four- quadrant translinear multiplier having differential voltage current conversion stages based on emitter degeneration at both inputs and a differential voltage output .All transistors are biased at

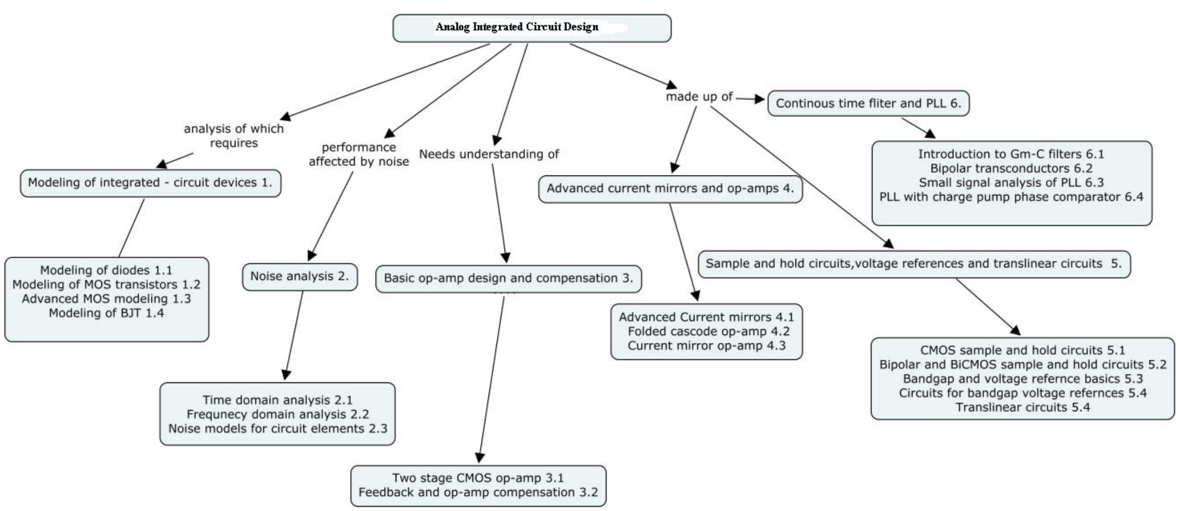
0.2mA.Design a multiplier so that when both differential output should be 1V.Assume 5V power supply is available.

6. A CMOS exclusive –OR gate is being used as phase-detector in a PLL.The power supply voltages are 0V and 5V. The low pass filter is composed of discrete components. The VCO has 10MHz free running frequency for when $V_{cntl} = 2.5V$ and it has $K_{osc} = 5MHz/V$.Assume we want the time constant of the loop to be 50 μs .Design the low pass filter for Q=0.5.

7. At an input -signal of 0dBm, an intermodulation ratio of -40dB was measured in an filter with a filter gain of 2dB.Calculate the value of the input and output third order incept points. What input signal should be applied if one wants intermodulation ratio of -45dB?If the noise power at the output is measured to be -50dBm, what is the expected SFDR?

8. A PLL with a multiplier phase detector has been designed so its linearized small signal transfer function has a Q factor of 1/2 and a resonant frequency of one- hundredth the free running frequency of the VCO, when the VCO is at its free running frequency. What are the resonant frequency and the Q-factor when the VCO's frequency is different from its free running frequency by one half the lock range.

Concept Map



Syllabus

Modeling of integrated-circuit devices: Modeling of diodes, Modeling of MOS Transistors, Advanced MOS modelling, Modeling of BJT

Noise analysis: Time domain analysis, Frequency domain analysis, Noise models for circuit elements

Basic op-amp design and compensation: Two stage CMOS op-amp, Feedback and op-amp compensation

Advanced current mirrors and op-amps: Advanced current mirrors, Folded–cascade op-amp, Current-mirror op-amp

Sample and hold circuits, Voltage references and Translinear circuits: CMOS, Bipolar and BiCMOS sample and hold circuits, Bandgap voltage reference basics, Circuits for bandgap voltage references, Translinear circuits

Continuous time filter and PLL: Introduction to Gm-C filters, Bipolar transconductors, Small signal analysis of PLL, PLL with charge-pump phase comparator

Text books

1. David A. Johns and Ken Martin: Analog Integrated Circuit Design, John Wiley & sons Inc., 1997 (Reprint: 2009).
2. Gray, Lewis and Meyer, Analysis and design of analog integrated circuits, Fourth edition, John wiley & sons, 2003.

Reference books

1. R. J Baker, CMOS Mixed signal circuit Design. Wiley Interscience, 2nd ed., 2009.
2. Sundaram Natarajan: Microelectronics Analysis & design, McGraw-Hill 2006.
3. Razavi, Design of Analog CMOS Integrated Circuits. Electrical Engineering, McGraw-Hill International, 2001.
4. Sedra A.S. and Smith K.C.: Microelectronic Circuits, 5th Edition, Oxford press, 2003

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**Modeling of integrated-circuit devices**	
1.1	Modeling of diodes	2
1.2	Modeling of MOS Transistors	2
1.3	Advanced MOS modeling	2
1.4	Modeling of BJT	2
2	**Noise analysis**	
2.1	Time domain analysis	2
2.2	Frequency domain analysis	2
2.3	Noise models for circuit elements	2
3	**Basic op-amp design and compensation**	
3.1	Two stage CMOS op-amp	3
3.2	Feedback and op-amp compensation	3
4	**Advanced current mirrors and op-amps**	
4.1	Advanced current mirrors	3

4.2	Folded–cascade op-amp	2
4.3	Current-mirror op-amp	2
5	**Sample and hold circuits, Voltage references and Translinear circuits**	
5.1	CMOS sample and hold circuits	2
5.2	Bipolar and BiCMOS sample and hold circuits	2
5.3	Bandgap voltage reference basics	2
5.4	Circuits for Bandgap voltage references	2
5.5	Translinear circuits	2
6	**Continuous time filter and PLL**	
6.1	Introduction to Gm-C filters	2
6.2	Bipolar transconductors	2
6.3	Small signal analysis of PLL	2
6.4	PLL with charge-pump phase comparator	2
	Total	45

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECF	3	-	-	3

ECF Digital Systems Design with PLDs and FPGAs 3:0

Preamble

A decade back SSI, and MSI circuits were used largely to build digital systems. With advent of VLSI devices most of the designs moved to ASIC domain. Also, at the same time Filed Programmable devices started to evolve. As time progressed these devices has taken up the space of SSI and MSI devices and started to even replace ASICs at lowest end. Presently Field programmable devices are able to match the functional complexity of ASIC Devices.

The first, filed programmable device was a PROM which is used to implement any combinational function by programming the truth table of the function in the PROM. Advent of EPROM enabled reprogramming. PROM is essentially a fixed AND followed with a programmable-OR structure, drawback was the exponential area requirement as the minterms grow exponentially with input size. Next in line was Programmable Logic Array (PLA), where the fixed-AND of PROM was changed to programmable-AND to reduce the number of minterms. The Programmable Logic Array (PAL) or Programmable Logic Device (PLD) simplified this structure with a programmable-AND and fixed-OR structure, programmable-AND is used for minimized product terms, fixed-OR combines these product terms. PALs were widely used for glue logic and replaced SSI and MSI devices. Complex PLD's are hierarchical PLD's that connects smaller PLD's through a central programmable interconnect to enable the implementation of medium complexity digital circuits. Main feature of CPLDs are the wide decoding, but has a low register to logic ratio. CPLD's architecture is not scalable, due to the central switch used in connecting small PLD structures.

This course is appropriate for all introductory-to-intermediate level courses in FPGAs, Digital designs once built in custom silicon are increasingly implemented in field programmable gate arrays (FPGAs), but effective FPGA system design requires a understanding of new techniques developed for FPGAs. This course deals FPGA fabrics, introduces essential FPGA concepts, and compares multiple approaches to solving basic problems in programmable logic.

Program Outcomes addressed

a) Students will reveal an ability to identify, formulate and solve digital engineering problems.

b) Graduates will demonstrate knowledge of mathematics, science and engineering.

c) Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d) Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

e) Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

f) Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course, the students should be able to:

1. Gain the Knowledge of SPLDs and CPLDs

2. Gain the knowledge of FPGAs based sytem.
3. Understand the FPGA Fabrics technology.
4. Do modeling a digital system using Hardware Description Language (Verilog).

Assessment pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	10
2	Understand	30	30	30
3	Apply	30	30	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	30

Course level Learning Objectives

Remember

1. Explain the architecture of PLA.
2. Gives the Goals of FPGAs based system.
3. Define Clock Skew.
4. Define Design Abstraction of FPGAs.
5. Define One-Hot State Encoding .
6. Explain the type of packages used in CPLDs

Understand

1. Which technology is used for CPLD Programmable elements?
2. Explain the programmable AND, fixed OR structure of SPLD
3. Explain the Methodology for evaluating FPGA fabrics.
4. How the antifuses can be programmed?
5. Explain the Logic Implementation methods for FPGAs.
6. What is meant by Antifuses?
7. Explain the Physical Design for FPGAs.

Apply

1. Draw the internal architecture of a PLA device.
2. Show the logic arrangement of both a PROM and a PLA required to implement a binary full adder.

3. How many two-input LUTs would be required to implement a four-bit ripple-carry adder?
4. How many three-input LUTs? How many four-input LUTs?
5. Draw a transistor-level schematic diagram for the programmable interconnection point shown in Figure. The interconnection point should be controlled by a five-transistor SRAM cell.

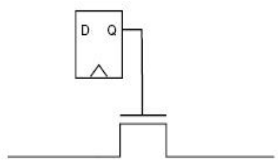


Fig1

6. You have a logic element with two lookup tables, each with three inputs. The output of the first lookup table in the pair can be connected to the first input of the second lookup table using an extra configuration bit.
7. Show how to program this logic element to perform:
   a. a + b + c (arithmetic, sum only not carry).
   b. a - b (arithmetic, difference only not borrow).
8. Draw a transistor-level schematic for a programmable interconnection point implemented using a three-state buffer.

Create

1. Design each of these functions using a tree of multiplexers:
   a. a | ~b.
   b. a & (b | c).
   c. (a & ~b) | (c & d).
2. You have a three-input lookup table with inputs a, b, and c. Write the lookup table contents for these Boolean functions:
   a. a AND b.
3. Design a four-input multiplexer that uses a combination of pass transistors and static gates. The first stage of multiplexing should be performed by pass transistors while the remaining multiplexing should be performed by static gates.
4. Program the logic element of shown Figure to perform these functions:
   a. a & b.
   b. a | b.
   c. a NOR b.

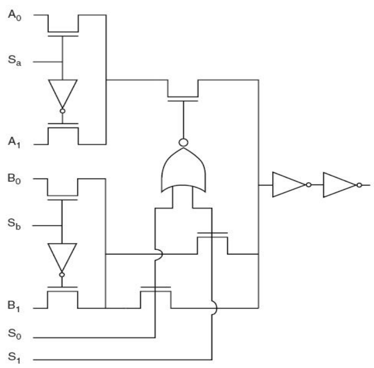


Fig2

5. Populate the array of logic elements in inter connect with wires and programmable interconnection points. Each wiring channel should have two wires. Assume that each logic element has two inputs and one output; each logic element should be able to connect its inputs to the channel on its left and its output to the channel on its right. When two wiring.
6. Redesign the logic element of Figure 3to be controlled by a0 OR a1 in the first stage and b0 AND b1 on the second stage. Draw the schematic and write the truth table.

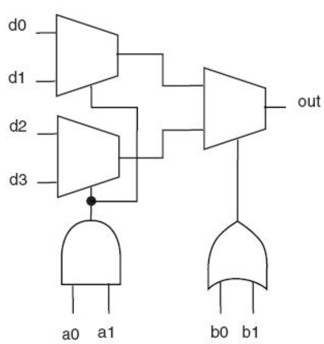


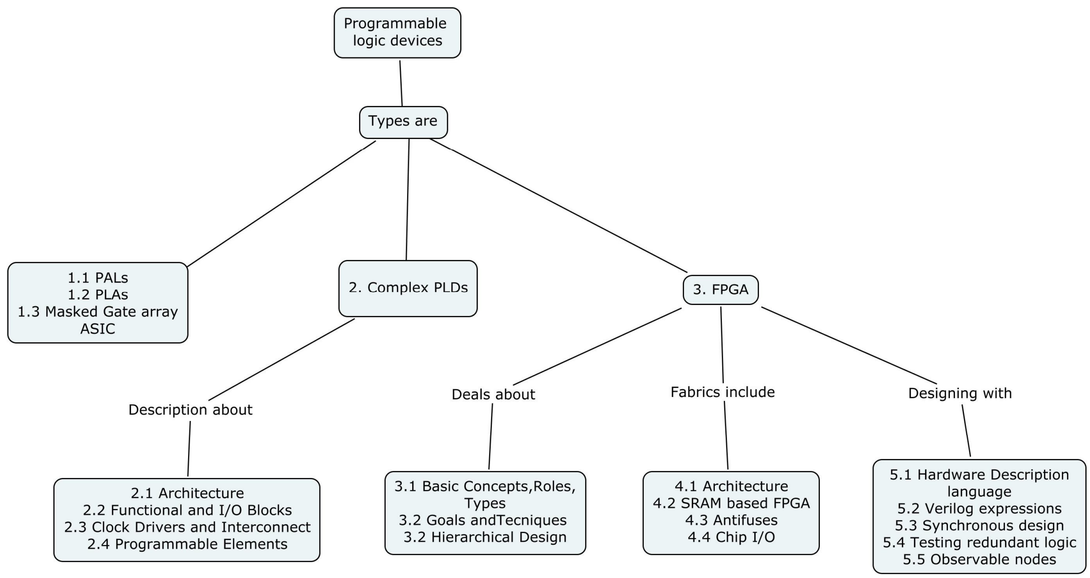
Fig 3

7. Implement the following two Boolean functions with a PLA:

F1(A, B, C) = $\sum$(O,1,2,4)

F2(A, B, C) = $\sum$(0,5,6,7).

Concept Map



Syllabus

Programmable Logic to ASICs: Programmable Read Only Memories (PROMs), Programmable Logic Arrays (PLAs), Programmable Array Logic (PALs), the Masked Gate Array ASIC, CPLDs and FPGAs.

Complex Programmable Logic Devices (CPLDs): CPLD Architectures, Function Blocks, I/O Blocks, Clock Drivers, Interconnect CPLD Technology and Programmable Elements.

FPGA-Based Systems: Introduction: Basic Concepts (Boolean algebra and karnaugh map), Digital Design and FPGAs, The roles of FPGAs, FPGA types, FPGA-Based System: Design, Goals & techniques, Hierarchical design, Design abstraction, Methodologies.

FPGA Fabrics: FPGA Architectures, SRAM-Based FPGAs, Characteristics of SRAM-Based FPGAs, Characteristics of SRAM-Based FPGAs, Logic elements & Interconnections networks, Chip I/O, Circuit Design of FPGA Fabrics.

Design Techniques, Rules, and Guidelines : Basics of Hardware Description Language (Verilog), Top-Down Design, Synchronous Design, Floating Nodes, Bus Contention, One-Hot State Encoding, Design For Test (DFT) , Testing Redundant Logic, Initializing State Machines, Observable Nodes.

Text Books

1. Wayne Wolf “FPGA –Based System Design” Pearson Education, 2004.
2. Bob Zeidman, “Designing with FPGAs and CPLDs”, Elsevier, CMP Books, 2002.

Reference Books

1. M. Morris Mano and Michael D. Ciletti, "Digital Design", PHI, fourth edition, 2008
2. R.F.Tinder: Engineering Digital Design, (2/e), Academic Press, 2000
3. Digital Electronics Principles, Devices and Applications Anil K. Maini – Wiley 2007
4. Samir Palnitkar, "Verilog HDL", Pearson Education, 2nd Edition, 2004.
5. Stephen Brown Zvonko Vranesic "Fundamentals of Digital Logic with VHDL Design" Tata McGraw- Hill Edition.
6. www.xilinx.com
7. www.acctel.com

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**Programmable Logic to ASICs**	
1.1	Programmable Read Only Memories (PROMs).	1
1.2	Programmable Logic Arrays (PLAs)	2
1.3	Programmable Array Logic (PALs)	2
1.4	The Masked Gate Array ASIC	1
1.5	CPLDs and FPGAs	1
2	**Complex Programmable Logic Devices (CPLDs)**	
2.1	CPLD Architectures	1
2.2	Function Blocks.	1
2.3	I/O Blocks	1
2.4	Clock Drivers	1
2.5	Interconnect	1
2.6	CPLD Technology and Programmable Elements	2
3	**FPGA-Based Systems**	
3.1	Introduction	1
3.1.1	Basic Concepts(Boolean Algebra and karnaugh map)	2
3.1.2	Digital Design and FPGAs.	1

3.1.3	The roles of FPGAs	1
3.1.4	FPGA types	1
3.2	FPGA-Based System Design	1
3.2.1	Goals & techniques	1
3.2.2	Hierarchical design	1
3.2.3	Design abstraction	1
3.2.4	Methodologies	1
4	**FPGA Fabrics**	
4.1	FPGA Architectures	1
4.2	SRAM-Based FPGAs	1
4.2.1	Characteristics of SRAM-Based FPGAs	1
4.2.2	Logic elements & Interconnections networks	1
4.3	Permanently Programmed FPGAs	1
4.3.1	Antifuses	1
4.3.2	Flash configuration	1
4.3.3	Logic blocks and interconnections	1
4.3.4	Antifuse programming	1
4.4	Chip I/O	1
4.5	Circuit Design of FPGA Fabrics	1
5	**Design Techniques, Rules,and Guidelines**	
5.1	Basics of Hardware Description Language (Verilog)	1
5.1.1	Verilog Expressions	1
5.2	Top-Down Design	1
5.3	Synchronous Design	1
5.4	Floating Nodes and Bus Contention	1
5.5	One-Hot State Encoding	1
5.6	Design For Test and Testing Redundant Logic.	1
5.7	Initializing State Machines	1

5.8	Observable Nodes	1
	Total	44

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECG	3	-	-	3

ECG Power System Control 3:0

Preamble

Power system operators have the responsibility to ensure that adequate power is delivered to the load reliably and economically. To achieve this electric energy system must be maintained at the desired operating level characterized by nominal frequency, voltage profile and load flow configuration. The power system is kept in nominal state by close control of real and reactive power generated in the controllable sources of the system. Power system control is required to maintain continuous balance between electrical generation and a varying load demand while system frequency, voltage levels and security are maintained constant. As constancy of frequency and voltage are important factors in determining the quality of power supply, the control of active and reactive power is vital to the satisfactory performance of power system.

Programme outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science

b. An ability to design a system or component, or process to meet stated specifications

c. An ability to identify, formulate and solve engineering problems

d. An ability to consider issues from global and multilateral views

Competencies

After completion of the course the students will be able to:

1. Understand the principles of active and reactive power control and develop models for the control equipment.
2. Find static and dynamic response of two area system.
3. Determine the capacity of synchronous compensators and ratio of tap-changing transformers.
4. Understand role of information technology in energy management.
5. Determine various operating states of a power system and control actions required for secure operations.

6. Determine the contracts between different utilities forming a pool to include one or more items like emergency assistance, economy interchange etc.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	10	10	10
2	Understand	40	40	40
3	Apply	50	50	50
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. State the objectives of power system control.
2. What is the need for frequency constancy?
3. Distinguish between p-f and Q-V control.
4. Define control area, area control error.
5. List the advantages of pool operations.
6. Write the power balance equations.
7. Mention the advantages of state variable model.
8. List the source and sinks of reactive power.
9. What is SVC? Where and why is it used?
10. Draw the state transition diagram.

Understand

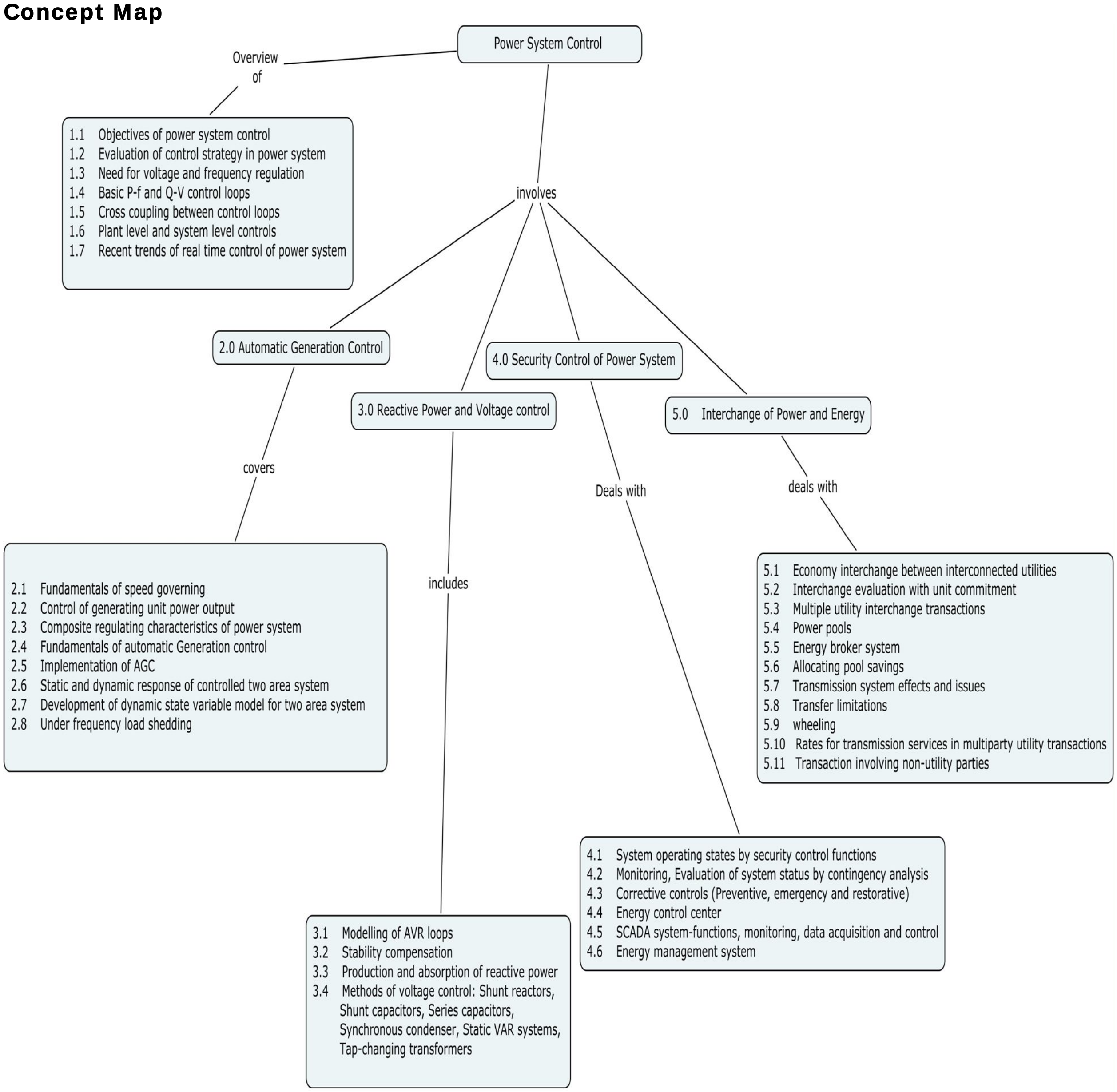
1. Draw the P-f and Q-V control channels of a synchronous generator and explain how voltage and frequency are maintained constant.
2. Draw the block diagram of the AVR loop and derive the transfer functions of each block. How stability compensation is provided in the system?
3. Discuss analytically the various methods of MVAr control provided in large power system.
4. Develop the state variable model for a two area system.
5. Draw the block diagram of two area system and discuss the salient features under static and dynamic conditions.
6. Explain the four operations status of a power system in the security perspective view with an example.

7. Briefly discuss the various functions of energy control center.
8. What is EMS? What are its major functions in power system operation and control?
9. Draw a block diagram to show the hardware components of a SCADA system for a power system and explain the applications of SCADA in monitoring and control of power system.
10. List the various contingencies that are generally considered for steady state security analysis.

Apply

1. For the two interconnected areas of capacity respectively 1500 MW and 500 MW, if the incremental regulation and damping torque coefficient for each area on its own base are equal to 0.1p.u and 1.0 p.u. respectively, following a 50 MW change in load of area 1, find the steady state change in system frequency from a nominal frequency of 50 Hz and the change in steady state tie-line power flow.
2. Two synchronous generators operating in parallel. Their capacities are 200 MW and 400 MW. The droop characteristics of their governor are 4% and 5% from no load to full load. Assuming that the generators are operating at 50 Hz at no load, how would be a load of 600 MW shared between them. What will be the system frequency at this load? Assume free governor action.
3. Two 1000 KW alternators operate in parallel. The speed regulation of first alternator is 100% to 103% from full load to no load and that of other 100% to 105%. How will the two alternators share a load of 1200 KW and at what load will one machine cease to supply any portion of the load?
4. A 132 kV line is fed through an 11/132 kV transformer from a constant 11 kV supply. At the load end of the line the voltage is reduced by another transformer of nominal ratio132/11kV. The total impedance of the line and transformers at 132 kV is (25+j66) ohms. Both transformers are equipped with tap-changing facilities which are so arranged that the product of the two off-nominal settings is unity. If the load on the system is 100 MW at 0.9 p.f. lagging, calculate the settings of the tap-changers required to maintain the voltage of the load busbar at 11 kV.
5. The load at the receiving end of a three phase, overhead line is 25 MW, 0.8 lagging PF, at a line voltage of 33 KV. A synchronous compensator is situated at the receiving end and the voltage at both ends of the line is maintained at 33 KV. Calculate the MVAR of the compensator. The line has 5 ohm resistance per phase and 20 ohm inductive reactance per phase.

Concept Map


Power System Control
Overview of
1.1 Objectives of power system control
1.2 Evaluation of control strategy in power system
1.3 Need for voltage and frequency regulation
1.4 Basic P-f and Q-V control loops
1.5 Cross coupling between control loops
1.6 Plant level and system level controls
1.7 Recent trends of real time control of power system
involves
2.0 Automatic Generation Control
3.0 Reactive Power and Voltage control
4.0 Security Control of Power System
5.0 Interchange of Power and Energy
covers
2.1 Fundamentals of speed governing
2.2 Control of generating unit power output
2.3 Composite regulating characteristics of power system
2.4 Fundamentals of automatic Generation control
2.5 Implementation of AGC
2.6 Static and dynamic response of controlled two area system
2.7 Development of dynamic state variable model for two area system
2.8 Under frequency load shedding
includes
3.1 Modelling of AVR loops
3.2 Stability compensation
3.3 Production and absorption of reactive power
3.4 Methods of voltage control: Shunt reactors, Shunt capacitors, Series capacitors, Synchronous condenser, Static VAR systems, Tap-changing transformers
Deals with
4.1 System operating states by security control functions
4.2 Monitoring, Evaluation of system status by contingency analysis
4.3 Corrective controls (Preventive, emergency and restorative)
4.4 Energy control center
4.5 SCADA system-functions, monitoring, data acquisition and control
4.6 Energy management system
deals with
5.1 Economy interchange between interconnected utilities
5.2 Interchange evaluation with unit commitment
5.3 Multiple utility interchange transactions
5.4 Power pools
5.5 Energy broker system
5.6 Allocating pool savings
5.7 Transmission system effects and issues
5.8 Transfer limitations
5.9 wheeling
5.10 Rates for transmission services in multiparty utility transactions
5.11 Transaction involving non-utility parties

Syllabus

Introduction: Objectives, Evaluation of control strategy, Need for voltage and frequency regulation, Basics and Assumptions of P-f and Q-V control loops, Cross coupling between control loops, Plant level and system level controls, Recent trends of real time control of power system.

Automatic Generation Control: Fundamentals of speed governing, Control of generating unit power output, Composite regulating characteristics of power system, Fundamentals of automatic Generation control, Implementation of AGC, Static and dynamic response of controlled two area system, Development of dynamic state variable model for two area system, Under frequency load shedding.

Reactive Power and Voltage control: Modelling of AVR loops, Stability compensation, Production and absorption of reactive power, Methods of voltage control, Shunt reactors, Shunt capacitors, Series capacitors, Synchronous condenser, Static VAR systems, Tap-changing transformers.

Security Control of Power System: System operating states by security control functions, Monitoring, Evaluation of system status by contingency analysis, Corrective controls (Preventive, emergency and restorative), Energy control center, SCADA system-functions, monitoring, data acquisition and control, Introduction to protocols, Energy management system.

Interchange of Power: Economy interchange between interconnected utilities, Interchange evaluation with unit commitment, Multiple utility interchange transactions, Power pools, Energy broker system, Allocating pool savings, Transmission system effects and issues, Transfer limitations, wheeling, Rates for transmission services in multiparty utility transactions, Transaction involving non-utility parties.

Text books

1. Prabha Kundur, 'Power System Stability and Control', McGraw-Hill, 2006.
2. B. M. Weedy and B. J. Cory, 'Electric Power Systems', Wiley, 4th Edition, 1998.
3. Allen J.Wood and Bruce F. Wollenberg, Power Generation, Operation and Control, Wiley, 1996.

Reference books

1. Olle I. Elgerd,' Electric Energy Systems Theory', McGraw-Hill, 2nd Edition, 1982.
2. V.Ramanathan and P.S.Manoharan, 'Power System Control and Operation', Charulatha Publications, 2009.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**Introduction**	
1.1	Objectives of power system control	1
1.2	Evaluation of control strategy in power system	2
1.3	Need for voltage and frequency regulation	1
1.4	Basics and assumption of P-f and Q-V control loops	1
1.5	Cross coupling between control loops	1
1.6	Plant level and system level controls	1
1.7	Recent trends of real time control of power system	1
2.0	**Automatic Generation Control**	
2.1	Fundamentals of speed governing	1
2.2	Control of generating unit power output	2
2.3	Composite regulating characteristics of power system	2
2.4	Fundamentals of automatic Generation control	2
2.5	Implementation of AGC	1
2.6	Static and dynamic response of controlled two area system	1
2.7	Development of dynamic state variable model for two area system	1
2.8	Under frequency load shedding	1
3.0	**Reactive Power and Voltage control**	
3.1	Modelling of AVR loops	2
3.2	Stability compensation	1
3.3	Production and absorption of reactive power	1
3.4	Methods of voltage control: Shunt reactors, Shunt capacitors, Series capacitors, Synchronous condenser, Static VAR systems, Tap-changing transformers	4
4.0	**Security Control of Power System**	
4.1	System operating states by security control functions	2
4.2	Monitoring, Evaluation of system status by contingency analysis	1
4.3	Corrective controls (Preventive, emergency and restorative)	1
4.4	Energy control center	1
4.5	SCADA system-functions, monitoring, data acquisition and control, Introduction to protocols.	2

4.6	Energy management system	1
5.0	**Interchange of Power**	
5.1	Economy interchange between interconnected utilities	1
5.2	Interchange evaluation with unit commitment	1
5.3	Multiple utility interchange transactions	2
5.4	Power pools	1
5.5	Energy broker system	2
5.6	Allocating pool savings	1
5.7	Transmission system effects and issues	1
5.8	Transfer limitations	1
5.9	wheeling	1
5.10	Rates for transmission services in multiparty utility transactions	1
5.11	Transaction involving non-utility parties	1
	Total	48

Course Designers

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Sub code	Lectures	Tutorial	Practical	Credit
ECH	3	0	-	3

ECH Robotics 3:0

Preamble

The field of Robotics finds many applications nowadays. This course mainly discusses about robot anatomy, coordinate frames, mapping and transforms, direct kinematic modeling of robots and inverse kinematics, dynamic modeling, trajectory planning, control of manipulators, robotic sensors and vision. 2-D planar robot alone is considered for quantitative analysis.

Program Outcomes addressed

a. An ability to apply knowledge of engineering, mathematics and science.

b. An ability to do kinematic modeling of robots and inverse kinematics

c. An ability to do dynamic modeling, trajectory planning and control of manipulators in robots

d. An ability to select suitable sensors for robots

Competencies

After completion of the course the students will be able to:

1. Understand the robot anatomy and coordinate frames, mapping and transforms
2. Develop the kinematic modeling and inverse kinematics
3. Develop dynamic modeling and trajectory planning of manipulator
4. Understand the control systems for manipulator control
5. Select suitable sensors based on the application

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	40	20	20
2	Understand	40	40	40
3	Apply	20	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

7. When a robot is preferred than human being to do a specific task?
8. What is meant by degrees of freedom?

9. What is meant by forward kinematics problem?
10. What is fundamental rotation matrix?
11. Define inverse kinematic problem.
12. Explain the workspace of a two-link planar manipulator with necessary diagrams.
13. What is the sufficient condition for a 6-DOF manipulator to possess closed form solution?
14. Explain the steps in trajectory planning in detail.
15. Explain the different categories of sensors used in robots.

Understand

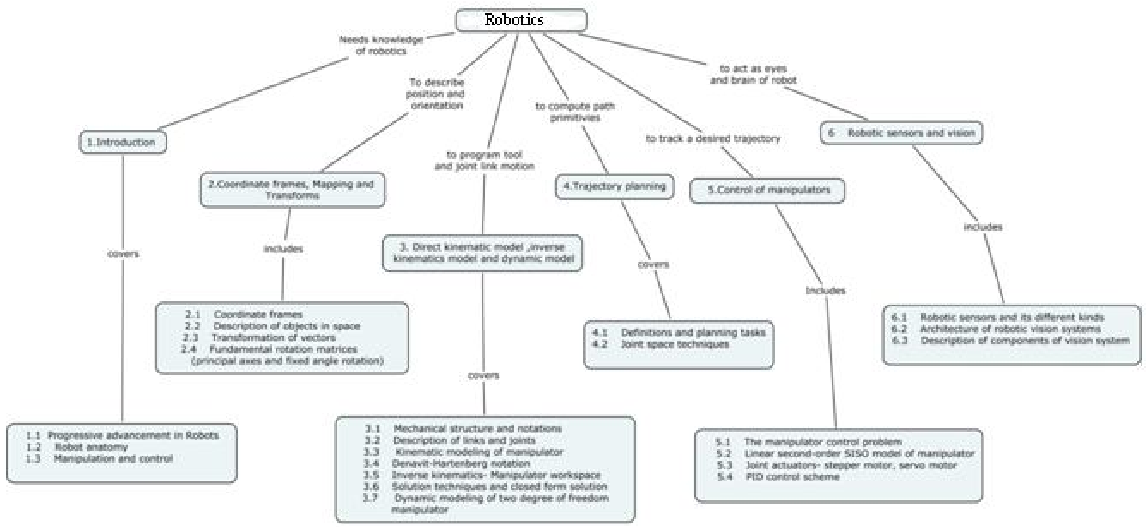
1. Why a frame is attached to the body in robot?
2. Why mapping is needed?
3. How mapping between rotated frames is done?
4. Why kinematic modeling of manipulator is needed?
5. What is the difference between closed form solution and numerical solution in inverse kinematics?
6. How the existence of solutions for inverse kinematic problem is found out?
7. Why closed loop control is preferred over open loop control?
8. With neat diagram, describe the development of second order SISO model for a manipulator joint.
9. Why electric actuators are preferred over hydraulic and pneumatic actuators?
10. With an example, explain the problem in robot sensing when compared with human sensing.

Apply

1. A point Q is located 8 units along the y-axis of moving frame. The mobile frame initially coincident with the fixed frame is rotated by $\Pi/3$ radians about the z-axis of fixed frame. Determine the coordinates of point Q in fixed coordinate frame. What are physical coordinates of point Q in fixed coordinate frame.
2. The end point of a link of a manipulator is at $P=[2\ 2\ 6\ 1]^T$. The link is rotated by 90° about x-axis, then by -180° about its own w-axis, and finally by -90° about its own v-axis. Find the resulting homogeneous transformation matrix and the final location of end-point.
3. Describe the local and global factors. When they are useful? Give three situations each where global scale factor is less than one and more than one.
4. A single cubic trajectory give by $q(t)=30+t^2-6t^3$ is used for a period of 3 seconds. Determine starting and goal position, velocity and accelerations of the end-effector.

5. Compute the joint trajectory for $q^s = 0$ and $q^g = 4$ with null initial and final velocities and accelerations. Assume $t_g = 1$.
6. A rotary joint moves from -15^o to $+45^o$ in 3 seconds. Determine the polynomial for a smooth trajectory, if the initial and final velocity and accelerations are zero.

Concept Map



Syllabus

Introduction to Robotics: Basics of Robots, Progressive advancement in Robots, Robot anatomy, Manipulation and Control

Coordinate frames, Mapping and Transforms: Coordinate frames, Description of objects in space, Transformation of vectors, Fundamental rotation matrices (principal axes and fixed angle rotation)

Direct kinematic model and inverse kinematics and dynamic modeling: Mechanical structure and notations, Description of links and joints, Kinematic modeling of manipulator, Denavit-Hartenberg notation, Inverse kinematics-Manipulator workspace, Solution techniques and closed form solution, Dynamic modeling of two degree of freedom manipulator

Trajectory planning: Definitions and planning tasks, Joint space techniques

Control of manipulators: The manipulator control problem, Linear second-order SISO model of manipulator, Joint actuators- stepper motor, servo motor, PID control scheme

Robotic sensors and vision: Robotic sensors and its different kinds, Architecture of robotic vision system, Description of components of vision system.

Robot Software: Introduction to robot programming languages.

Text books

1. R.K. Mittal, I.J. Nagrath, Robotics and control, Tata McGraw-Hill, 2003.
2. John J.Craig, Introduction to Robotics, Mechanics and control, third edition, Pearson education, 2005

Reference Books

1. Mark W.Sponge, M.Vidyasagar, Robot dynamics and control, Wiley India, 2009.
2. KS Fu, Ralph Gonzalez CSG Lee, Robotics, John wiley, 2002.

Course content and Lecture Schedule

S. No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Basics of Robotics, Progressive advancement in Robots	1
1.2	Robot anatomy	2
1.3	Manipulation and control	2
2	**Coordinate frames, Mapping and Transforms**	
2.1	Coordinate frames	2
2.2	Description of objects in space	2
2.3	Transformation of vectors	2
2.4	Fundamental rotation matrices (principal axes and fixed angle rotation)	2
3	**Direct kinematic model, inverse kinematics and dynamic modeling**	
3.1	Mechanical structure and notations	2
3.2	Description of links and joints	2
3.3	Kinematic modeling of manipulator	2
3.4	Denavit-Hartenberg notation	2
3.5	Inverse kinematics- Manipulator workspace	2
3.6	Solution techniques and closed form solution	2
3.7	Dynamic modeling of two degree of freedom manipulator	2
4	**Trajectory planning**	
4.1	Definitions and planning tasks	2
4.2	Joint space techniques	2
5	**Control of manipulators**	
5.1	The manipulator control problem	1
5.2	Linear second-order SISO model of manipulator	2
5.3	Joint actuators- stepper motor, servo motor	2

5.4	PID control scheme	2
6	**Robotic sensors and vision**	
6.1	Robotic sensors and its different kinds	2
6.2	Architecture of robotic vision system	2
6.3	Description of components of vision system	1
7	Robot software - Introduction to robot programming languages	2
	Total	45

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECJ	3	-	-	3

ECJ Operation and Maintenance of Electrical Equipment 3:0

Preamble

The objective of the subject is to operation and maintenance of electrical equipment in industries. This helps to increase the knowledge and skills in improving equipment productivity while reducing maintenance costs. The emphasis is on practical issues that go beyond typical electrical theory and focus on providing those that attend with the necessary toolbox of skills in solving electrical problems, ranging from generators to motors and illumination. The fundamental issues of troubleshooting electrical equipment of today which enable you to fix problems as quickly as possible are discussed.

Program outcomes addressed

a. An ability to Diagnose electrical problems ‘right-first-time’ and Minimize the expensive trial and error troubleshooting approach
b. An ability to analyze equipment problems, Determine causes of equipment failure and Troubleshoot electrical equipment and control circuits.
c. An ability to reduce unexpected downtime on electrical motors and other equipment
d. An ability to improve the efficiency of the plant
e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints
f. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the student should be able to:

1. Explain the basic principles and operation of electrical equipments including motors, generators, transformers, transmission lines and lighting systems
2. Explain the general procedure to maintain electrical equipments in any plant
3. Identify the possible cause for the observed faulty behavior of electrical equipment.
4. Explain how electrical equipment faults are rectified.
5. Apply the maintenance practices learnt in the shop floor.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Mention the types of Maintenance?
2. What precautions are required in paralleling two dc generators?
3. What is cyclic speed irregularity?
4. What are the good qualities of transformer oil?
5. What is meant by 'Basic Insulation level' of an apparatus?
6. What should be the breakdown value (BDV) for the oil?
7. What is meant by insulation co-ordination?
8. What are the various types of enclosures in which electric motors are available?
9. What is the maximum length of span permitted across the streets?
10. What is static balancing?

Understand

1. What are causes for accident?
2. How is the phase and neutral wires identified?
3. Why reverse current protection system is used in alternator?
4. What do you understand by low, medium and high voltages?
5. If the motor cannot start against its load, what will you do?
6. What are the points to be checked, when carrying out inspection of overhead lines?
7. What are the causes for failure of underground cable?
8. What precautions will you take to ensure safety, when using portable equipment?
9. Is fluorescent lamp light harmful to the eyes?
10. If a fluorescent lamp does not work, how would you proceed rectifying it?

Apply

1. Under which condition production maintenance is preferred?
2. Give the schematic of earthing for a power plant having three generating units.
3. Give the specimen layout of a register to record the maintenance carried out in a transformer.
4. What is to be done, if transformer oil shows a dielectric strength of 15 KV/cm during the test?
5. Give a scheme of laying underground cables in an industry.
6. Choose a suitable lighting for a packing area in an industry and justify your answer.
7. For a 10 HP, 3 phase, 440 Volts Induction motor, select a suitable starter.
8. If the value of resistance measured in a earth pit is 10 Ohms, what kind of maintenance is to be done?
9. For a sub station, 22 KV, 20 MVA rating, what kind of lightning arrestor do you suggest?
10. Give a suitable protective scheme, for two alternators running in parallel in a plant.

Syllabus

Maintenance: Importance of plant maintenance, Types - Preventive, Break down and Production maintenance, Maintenance records, Role of maintenance engineer, cause of accidents and prevention.

Building Electrical installations: Annual inspection, safe working of electrical equipment and safety, earthing arrangements.

Generator, Substation and Switch Gear: Operation procedure, Routine & Breakdown Maintenance, Causes of failure and Precautions measure.

Transformer: Insulation Co-ordination - Maintenance procedure, onload tap changer, loading of transformer, dissolved gas analysis, overhauling of transformers, Dryingout of transformers, Oil purification and Testing - maintenance and trouble shooting, Lightning arrester.

Transmission and Distribution: Rules for low, medium and high voltages, Factor of safety, Special precautions, Minimum clearance, Conductors, System protection, Lightning arrester, Methods of laying Underground cable and fault location.

Illumination: Special lighting applications, Installations, Trouble shooting, Modern developments.

DC & AC Motors & Starters: Routine & Breakdown Maintenance, Causes of failure - Precautions and Troubleshooting - Trouble shooting in pump motors.

Text Book

1. V. S. Rao - Operation & Maintenance of Electrical Equipment - Volume I & II, 1997 Edition, Media Promotors & Publishers Pvt. Ltd., Mumbai
2. TNEB Engineers Handbook, Published by TNEB Engineers Association, Chennai.

Reference Books

1. T. S Viswanathan & P Ramachandran - Control & Maintenance of Electrical Machines, 1998 Edition, Priya Publishers, Trichy
2. S. Rao - Testing Commissioning and Maintenance of Electrical Equipment, Fifth Edition, 1997, Khanna Publishers, Delhi - 6.

Course contents and Lecture schedule

S.No.	Topic	No of Lectures
1.0	**Maintenance**	
1.1	Importance of plant maintenance, Types - Preventive, Break down and Production maintenance	2
1.2	Maintenance records, Role of maintenance engineer, cause of accidents and prevention.	2
2.0	**Building Electrical installations**	
2.1	Annual inspection	2
2.2	Safe working of electrical equipment and safety, earthing arrangements.	2
3.0	**Generator, Substation and Switch Gear**	
3.1	Operation procedure	2
3.2	Routine & Breakdown Maintenance,	3
3.3	Causes of failure and Precautions measure.	3
4.0	**Transformer**	
4.1	Insulation Co-ordination - Maintenance procedure, onload tap changer, loading of transformer,	3
4.2	dissolved gas analysis, overhauling of transformers, Dryingout of transformers, Oil purification and Testing	3
4.3	maintenance and trouble shooting, Lightning arrester	3
5.0	**Transmission and Distribution**	
5.1	Rules for low, medium and high voltages, Factor of safety,	2

	Special precautions	
5.2	Minimum clearance, Conductors, System protection, Lightning arrester, Methods of laying Underground cable and fault location	3
6.0	**Illumination**	
6.1	Special lighting applications, Installations, Trouble shooting, Modern developments	3
7.0	**DC & AC Motors & Starters**	
7.1	Routine & Breakdown Maintenance	3
7.2	Causes of failure and Precautions and Trouble shooting	3
7.3	Trouble shooting in pump motors	2
Total		41

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECK	3	-	-	3

ECK Power Plant Economics 3:0

Preamble

The per capita consumption of electricity in any country is an index of the standard of living of the people in that country. A modern power system is invariably fed from a number of power plants. Research and development has led to efficient power plant equipment. A generating unit added to the system today is likely to be more efficient that the one added some time back. With a large number of generating units at hand, it is the job of the operating engineers to allocate the loads between the units such that the operating costs are the minimum. Based on this, the course aims at giving an adequate exposure in economic consideration of power plants, economic operation of thermal units, Hydro-thermal coordination and multi objective generator scheduling.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
d. Graduate will develop confidence for self education and ability for life-long learning.

Competencies

At the end of the course the student should be able to:

1. Understand the need of the power generation system operations in an economic mode.
2. Apply computing techniques, analytical skills and modern engineering tools for generation scheduling problems.
3. Analyze the plant requirements for base load and peak load operation.
4. Identify the suitable solution techniques to solve the economic dispatch problems.
5. Analyze the short term and long term hydro thermal co ordination.
6. Understand the operation of pumped storage hydro plants.

7. Formulate multi objective dispatch problems by considering economic operation and emission issues in thermal and hydel power plants.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	10
2	Understand	30	30	40
3	Apply	40	40	40
4	Analyze	10	10	10
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What are the components of operating cost of thermal power plant?
2. Define the Economic despatch problem?
3. Define the incremental production cost (IPC) of thermal units?
4. What is loss of economy?
5. Write down the co-ordination equations with transmission losses for solving ED problem?
6. What are the uses of B_{mn} loss coefficients?
7. List out the constraints involved in hydro thermal coordination problem?
8. Define `head' of hydel plant?
9. What is the need for emission despatch?
10. What are the advantages of hydro thermal coordination?

Understand

1. What is the impact of load diversity on power plant Economics?
2. What is the objective of automatic load dispatching?
3. If the real power generation limits are violated on scheduling, how will you handle the despatch problem?
4. What is piecewise linear cost characteristics of plants?
5. What do you mean by direct method of despatch of plants?
6. What do you understand from the co-ordination equations of plants?
7. How will you convert an ED problem into an OPF with cost minimization as objective?
8. How will you co-ordinate Economic and Emission dispatches?
9. What are online loss coefficients?
10. What are the control variables in OPF?

Apply

1. Assume that all three of the thermal units described below are running. Find the economic dispatch schedules as requested in each part. Use the method and starting conditions given.

Unit Data(MBTu/hr)	Minimum (MW)	Maximum (MW)	Fuel Cost (Rs/MBtu)
$H_1=225+8.4P_1+0.0025P_1^2$	45	350	0.80
$H_2=729+6.3P_2+0.0081P_2^2$	45	350	1.02
$H_3=400+7.5P_3+0.0025P_3^2$	47.5	450	0.90

a. Use the lambda-iteration method to find the economic dispatch for a total demand of 450MW.

b. Use the base-point and participation factor method to find the economic schedule for a demand of 495 MW. Start with the solution of part a.

2. A two-bus system is shown in Fig.1. If a load of 125 MW is transmitted from plant1 to the load, a loss of 15.625 MW is incurred. Determine the generation schedule and the load demand if the cost of received power is Rs. 24/MWhr. Solve the problem using coordination equations and the penalty factor method approach. The incremental production of the plants are

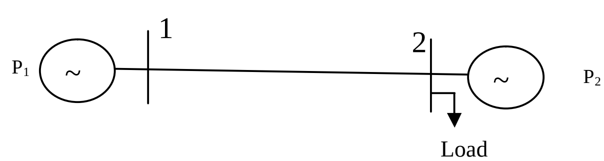


Figure 1

$$\frac{dF_1}{dP_1}=0.025P_1+15 \quad \text{Rs/MWhr}$$

$$\frac{dF_2}{dP_2}=0.05P_2+20 \quad \text{Rs/MWhr}$$

3. Figure 2 depicts a power system consisting of a hydro power station (1) and thermal power station (2) connected to bus A and bus B respectively. There are two loads, I_{L1} and I_{L2} supplied via transmission lines CF and DG. Bus C and bus D are joined up by an interconnecting line. Bus D is chosen as the reference bus at which V=1 p.u.

The impedances of and the currents in the lines are given below:

Line 1: Z_{AC} = 0.03+j0.12 p.u.

Line 2: Z_{BD} = 0.03+j0.12 p.u.

Line 3: Z_{CD} = 0.07+j0.28 p.u.

Line 4: Z_{CF} = 0.04+j0.16 p.u.

Line 5: Z_{DG} = 0.025+j0.10 p.u.

I_1 = 1.3-j0.50 p.u.

I_2 = 1.2-j0.25 p.u.

I_{L1} = I_4 = 1.0-j0.30 p.u.

I_{L2} = I_5 = 1.5-j0.45 p.u.

Determine the loss formula coefficients in p.u. and also in MW^{-1} taking a base of 100 MVA.

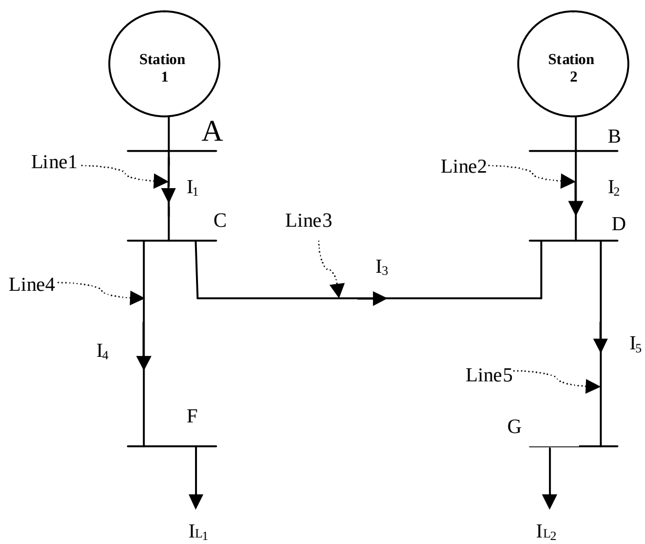


Figure 2

4. A power system consists of one steam plant and one hydro plant. In the hydro plant, 5500 million cubic meters of water is available for one day use. A total load of 220MW is in the system. Input to the plant is,

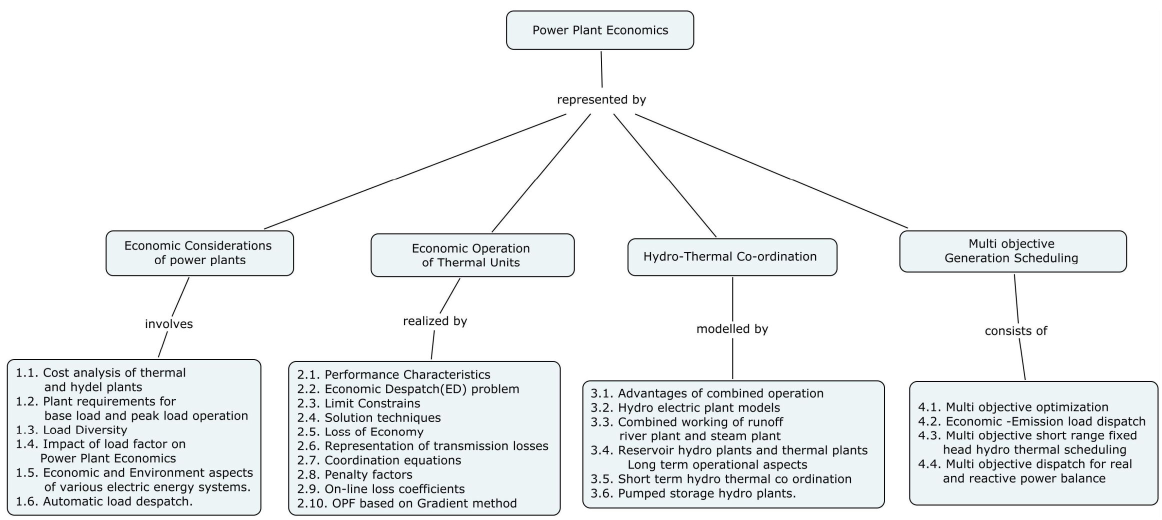
$F_s = 0.01\ P_s^2 + 20P_s + 100$ *Rs/hr*. Where P_s is in MW.

The rate of water input to the hydro plant is $W_H = 375P_H^2+1010P_H+700$ cubic mts/sec, where P_H is in MW. The transmission loss in the system can be neglected. Compute the optimum values of P_S, P_H, assuming the initial cost factor of the hydro plant is 2 paise/cubic-mt-hr.

Analyze

1. If there is error in the representation of IPC curves of thermal plants, analyze the economic consideration of the system.
2. Formulate the mathematical model of OPF problem with cost minimization as objective and analyze the application of gradient method for solving the same?
3. Analyze the necessity of operating run-off river plants in combination with the steam plant? How are they operated in rainy season and dry season?
4. Formulate the mathematical model of combined real and reactive power dispatch problem.

Concept Map



Syllabus

Economic Considerations of power plants – Cost analysis of thermal and hydel plants, Plant requirements for base load and peak load operation, Load diversity, Impact of load factor on power plant economics, Economic and Environmental aspects of various electric energy generation systems, Automatic load dispatch.

Economic Operation of Thermal Units – Performance Characteristics - Economic Dispatch(ED) problem – Limit constraints - Solution techniques – Lambda iteration method, Gradient search, ED with piecewise linear cost function, Base point and participation factor method, Direct methods – Loss of Economy – Representation of transmission losses – Coordination equations – Penalty factors – On-line loss coefficients – OPF based on Gradient method.

Hydro-Thermal Co-ordination– Advantages of combined operation – Hydro electric plant models- Combined working of runoff river plant and steam plant - Reservoir hydro plants and thermal plants – long term operational aspects – short term hydro thermal co ordination – Pumped storage hydro plants.

Multi objective Generation Scheduling – Multi objective optimization - Economic – Emission load dispatch – Multi objective short range fixed head hydro thermal scheduling – Multi objective dispatch for real and reactive power balance.

Text Books

1. Allen J. Wood, Bruce F. Wollenberg, 'Power Generation Operation and Control', Wiley India Pvt. Ltd., 2nd edition, New Delhi – 2007.
2. D.P. Kothari, J.S.Dhillon, 'Power System Optimization', Prentice-Hall of India Pvt. Ltd, 1st Edition, New Delhi – 2006.
3. L.K.Kirchmayer, 'Economic operation of Power systems', John Willy and sons, 1st Edition, 1958.
4. B.R. Gupta, 'Generation of Electrical Energy', Euresia Publishing House Pvt., Ltd., 1st Edition, New Delhi – 2003.

Reference Books

1. Gangadhar, 'Electric Power Systems: (Analysis, Stability and Protection)', Khanna Publishers, 2nd edition, New Delhi, 1992.
2. C.L. Wadhwa, 'Electrical Power Systems', New Age International Ltd. 6th Edition, New Delhi 2009.
3. O.I. Elgerd, 'Electric Energy Systems Theory- an Introduction', Tata McGraw Hill, 2nd edition - 1982.

Course contents and Lecture schedule

Sl.No.	Topic	No. of Lectures
1.0	**Economic Considerations**	
1.1	Cost analysis of thermal and hydel plants	1
1.2	Plant requirements for base load and peak load operation	1
1.3	Load diversity, Impact of load factor on power plant economics	1
1.4	Economic and Environmental aspects of wind and solar systems	2
1.5	Automatic load dispatch	1
2.0	**Economic Operation of Thermal Units**	
2.1	Performance Characteristics	1
2.2	Economic Dispatch (ED) problem, Limit constraints	2

2.3	Solution techniques – Lambda iteration method, Gradient search, ED with piecewise linear cost function, Base point and participation factor method, Direct methods	4
2.4	Loss of Economy	2
2.5	Representation of transmission losses	2
2.6	Coordination equations	3
2.7	Penalty factors	1
2.8	On-line loss coefficients	3
2.9	OPF based on Gradient method	2
3.0	**Hydro-Thermal Co-ordination**	
3.1	Advantages of combined operation	1
3.2	Hydro electric plant models	2
3.3	Combined working of runoff river plant and steam plant	1
3.4	Reservoir hydro plants and thermal plants - long term operational aspects	1
3.5	Short term hydro thermal co ordination	3
3.6	Pumped storage hydro plants	2
4.0	**Multi objective Generation Scheduling**	
4.1	Multi objective optimization, Economic – Emission load dispatch	3
4.2	Multi objective short range fixed head hydro thermal scheduling	3
4.3	Multi objective dispatch for real and reactive power balance	3
	Total	45

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECL	3	-	-	3

ECL Instrumentation systems 3:0

Prerequisites

1. The ability to understand various instruments used in measurement system
2. An understanding of the various principles of the common measuring instruments

Preamble

The Instrumentation Technology, being an inter-disciplinary branch of engineering, is heading towards development of new & intelligent sensors, smart transducers, MEMS Technology. The automation systems in the production are rapidly being enhanced and the demand for highly skilled instrumentation engineers is on the rise. In the instrumentation systems manufacturing sector, the demand for well trained process control engineering graduates is always present. Instrumentation students with sound theoretical & practical training in the operation and design of electronic instruments, digital logic systems, and computer based automatic process control & instrumentation, & automatic control system design, etc. To meet the industrial requirements of future, students are also made to become well versed with personal computer applications in Instrumentation, Process Control Systems Design, PLCs, DSP Architecture & Design, Microprocessors and Microcontroller System Design & Experimentation, Industrial Electronics & Applications.

Program outcomes addressed

a. An ability to apply knowledge of instrumentation engineering for doing electrical and electronic measurements.
b. An ability to prescribe instruments for measuring various physical quantities.
d. An ability to use techniques, skills and modern engineering tools to implement and organize instrumentation systems.

Competencies

After successfully completing the course, students should be able to:

1. Understand the working principle of various instruments.
2. know various latest instruments in the industries.

3. Enhance knowledge about various interfacing instruments in digital instrumentation.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End semester examination
1	Remember	10	10	30
2	Understand	30	30	50
3	Apply	10	10	20
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Draw then general block diagram of instrumentation system representing the Functional instruments.
2. Define strain with respect to strain gauge
3. Mention any four characteristics of operational amplifiers
4. Draw the general configuration of I to V & V to I converters.
5. Mention some interfaces used in GPIB bus (remember)
6. List some data presentation devices (remember)
7. List salient features of VXI modular instrumentation bus
8. With neat diagram explain the following encoders
   (a) Optical (b) resistance (c) shaft
9. Explain the following sensors with neat sketch
   (a)potentiometer (b)LVDT (c)strain gauge

Understand

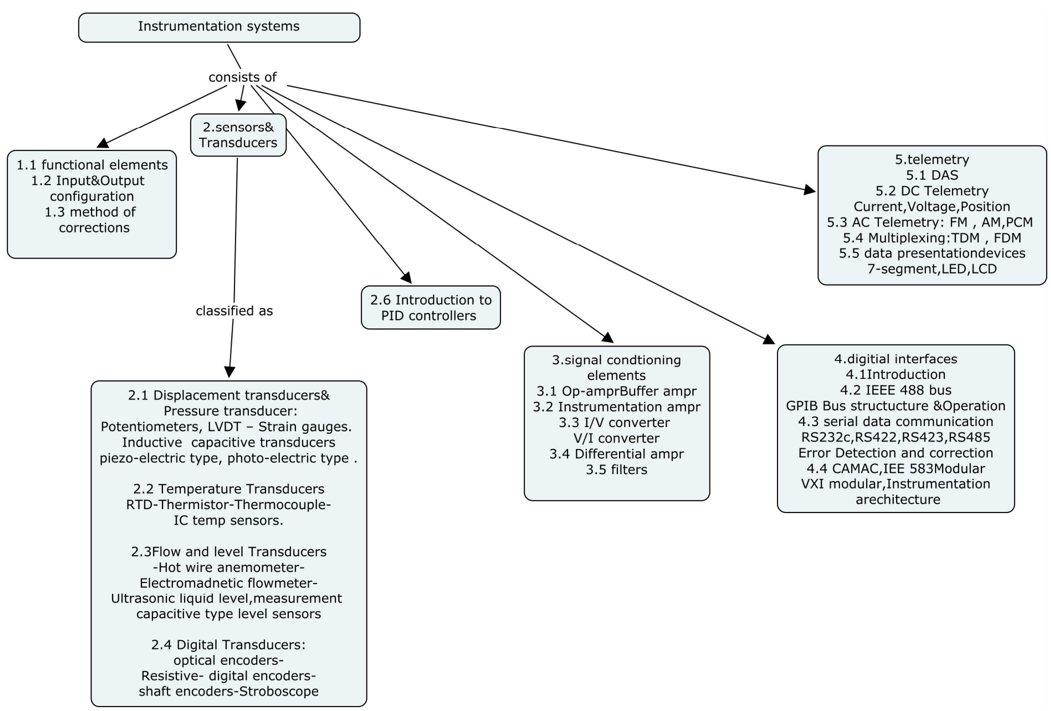
1. What is meant by Gauge factor?
2. State the working principle of digital encoder.
3. What is meant by stroboscope?
4. Classify the filters used in instrumentation system.
5. What is meant by GPIB?
6. What is meant by telemetry?
7. Classify telemetry system with respect to mode of communication?
8. What is meant by multiplexing?
9. Mention the salient features of IEEE 488 instrumentation bus.

10. With neat sketch, explain the functional elements of a measurement system.

Apply

1. Classify the instrument on the basis of working principle.
2. Mention the application of photovoltaic cells.
3. Write the method of corrections for interfering input.
4. Classify the instrument on the basis of working principle.
5. State the applications of lowpass , highpass,bandpass, band rejection filters.
6. Describe how liquid flow is measured using a suitable transducer?
7. Discuss the application of instrumentation amplifier.
8. Describe various applications of buffer amplifiers in instrumentation systems.
9. With neat sketch,explain the architecture of IEEE-488 Instrumentation bus(GPIB).
10. How interfacing is done using RS232c interface,RS422,RS485 serial data communication Links.

Concept Map



Syllabus

Introduction: Functional elements of an instrumentation system – classification of instruments – input and output configuration of instrument systems – methods of correction for interfering and modifying inputs.

SENSOR AND TRANSDUCERS:

Displacement and Pressure transducers: Potentiometers – LVDT – Strain gauges- Inductive and capacitive transducers – piezo-electric type – photo-electric type.

Temperature transducers: RTD – Thermistor – Thermocouple-IC based temperature measurements.

Flow and Level transducers:-Hot wire anemometer-Electromagnetic flow meter-Ultrasonic method measurement of liquid level -capacitive type level sensors.

Digital Transducers: Encoders: optical encoders-Resistive digital encoders-shaft encoders – stroboscope.

INTRODUCTION TO CONTROLLERS: P, PI and PID controllers

Signal Conditioning: Operational amplifiers – Buffer amplifiers Differential Amplifiers – common mode – differential mode. Instrumentation amplifiers – I to V converters – V to I converters. Types of filters –Low pass and High pass – Band pass – Band Rejection.

Digital Interfaces in Measurement System:-Introduction to digital instruments-IEEE 488 Instrumentation Bus(GPIB)-GPIB Bus structure-GPIB operation

Serial Data communication Links- RS232C Interface – RS422 – RS423 – RS485 Interfaces- Error Detection and correction

The CAMAC(IEEE 583) modular instrumentation standard – VXI modular instrumentation Architecture.

TELEMETRY AND DATA PRESENTATION DEVICES: Introduction to Data Acquisition System.

Telemetry: DC Telemetry **-** current, voltage and position telemetering system;
AC Telemetry- FM, AM and PCM. Multiplexing - TDM , FDM.

Data Presentation Devices- Visual display, Seven segment, LED , LCD.

Text book

A.K.Sawhney, 'A course in electrical and electronic measurements and instrumentation', Dhanpat Rai & sons 1995.

Reference Books

1. Ernest.O.Doebelin, 'Measurement systems applications and design', Tata McGrawhill, 2002.
2. Robert.B.Northrop, 'Introduction to instrumentation and measurements', Allied Publishers, 2002.
3. Kalsi Victoria , 'Electronic Instrumentation', Allied Publishers, 2002.
4. A.J.Bouwens,' Digital Instrumentation', ,Tata McGraw Hill,1999.

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0 INTRODUCTION		
1.1	Functional elements of an instrumentation system	1
1.2	Classification of instruments – input and output configuration of instrument systems	2
1.3	Methods of correction for interfering and modifying inputs.	2
2.0 SENSOR AND TRANSDUCERS		
2.1	**Displacement and pressure transducers:** potentiometers – LVDT – Strain gauges- Inductive and capacitive transducers –piezo-electric type – photo-electric type	3
2.2	**Temperature transducers:** RTD – Thermistor – Thermocouple- IC based temperature transducers	2
2.3	**Flow and Level transducers :**-Hot wire anemometer,- Electromagnetic flowmeter, Ultrasonic method measurement of liquid level -capacitive type level sensors.	3
2.4	**Digital Transducers:** Encoders :optical encoders-Resistive digital encoders-shaft encoders – stroboscope.	3
2.5	Introduction to controllers-P,PI and PID	2
3.0 SIGNAL CONDITIONING		
3.1	Operational amplifiers – Buffer amplifiers	2
3.2	Instrumentation amplifiers and its applications	1
3.3	I to V converters – V to I converters.	1
3.4	Differential Amplifiers – common mode – differential mode.	1
3.5	Types of filters –Low pass and High pass – Band pass – Band Rejection.	2
4.0 DIGITAL INTERFACES IN MEASUREMENT SYSTEM		
4.1	Introduction to digital instruments	1
4.2	IEEE 488 Instrumentation Bus(GPIB), GPIB Bus structure GPIB operation	3
4.3	**Serial Data communication Links**- RS232C Interface – RS422 – RS423 – RS485 Interfaces-error Detection and Correction	3
4.4	The CAMAC (IEEE 583) modular instrumentation standard – VXI modular instrumentation Architecture.	3
5.0 TELEMETRY AND DATA PRESENTATION DEVICES		
5.1	Introduction to Data Acquisition System.	1
5.2	**Telemetry:** **DC Telemetry:** current, voltage and position telemetering system.	2
5.3	**AC Telemetry:** FM , AM , PCM	3
5.4	Multiplexing: TDM, FDM.	2
5.5	**Data Presentation Devices :** **Visual display:** Seven segment , LED , LCD.	2
	Total	45

Course designers

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B.E. / B.Tech. DEGREE PROGRAM

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2008-2009 ONWARDS

General Electives

OFFERED BY THE EEE DEPARTMENT

FOR

OTHER BRANCH STUDENTS

Sub Code	Lectures	Tutorial	Practical	Credit
EGD	3	-	-	3

EGD Sensors and Transducers 3:0

Preamble

The proposed course offered as General elective and its main purpose is:

1. To elaborate on the Theoretical and practical aspects of transducers and their classifications and also the applications of transducers in real life and in industries.
2. To explain the static and dynamic characteristics of transducers.
3. Discuss on electrical, magnetic, piezoelectric, fiber optic transducers and their operation.
4. To impart knowledge about digital transducers and their applications.
5. In view of present day technologies fundamental concepts of some of the smart sensors in day to day applications and also in industries are included

Program Outcomes addressed

b. Graduates will demonstrate an ability to identify, formulate and solve engineering

Problems

c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

e. An ability to use techniques, skills and modern engineering tools to implement and Organize engineering works under given constraints

Competencies

At the end of the course students should be able to:

1. To explain the basic characteristics, types of transducers and their practical aspects in industries.
2. Explain the operation and application of digital transducers.
3. Explain the application of smart sensors.

Assessment Pattern

S.No	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	40	40	20
2	Understand	40	40	60
3	Apply	20	20	20
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is a transducer?
2. What is a thermistor?
3. Name some pressure Sensors
4. What is role of gray code in optical and shaft encoders?
5. Define stress and strain.
6. Recall Hall Effect principle
7. Give some real time application of strain gauge
8. Classify the different methods of measuring temperature
9. Write the relation for temperature coefficient of resistance for thermistor.
10. What is a load cell?

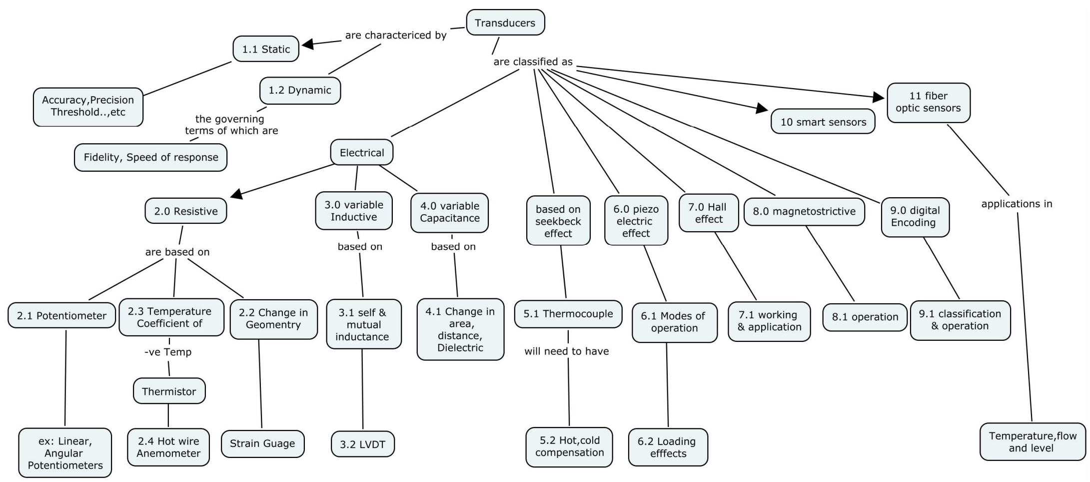
Understand

1. A digital meter has 10 bit accuracy. What is the resolution on the 16V range?
2. A liquid container has a total weight of 152 kN, and the container has 8.9 m^2 base. What is the pressure on the base?
3. Identify what pressure in psi corresponds to 98.5 kPa
4. State the three different temperature scales to measure relative hotness.
5. Write some applications of position sensors.(rolling mills, conveyors..,)
6. What is the change in resistance in a copper wire when the strain is 5500 micro strains? Assume the initial resistance of the wire is 275 ohms and the gauge factor is 2.7.
7. State the limitations of contact type shaft encoders.
8. Sketch the cross section of 3 wire RTD and explain its operation.
9. Describe about cold junction compensation of Thermocouple.
10. Illustrate in detail about three effects associated with Thermocouple

Apply

1. Illustrate the role of smart sensors in automated applications.
2. Develop a pressure sensor using capacitance principle and explain its operation
3. Explain how force is measured using Pressure transducer.
4. Describe the application of strain gauge as load sensor.

Concept Map



Syllabus

PERFORMANCE CHARACTERISTICS OF TRANSDUCERS

Static characteristics Meaning of static calibration, Accuracy, Precision, bias, Linearity, Threshold, Resolution, Hysteresis and Dead space, Scale readability and span.

Dynamic characteristics – Sinusoidal transfer function, zero order transducer, First order transducer, Step, Ramp, Frequency and Impulse response, Second order transducer, Step, Ramp Frequency and Impulse response.

VARIABLE RESISTANCE TRANSDUCERS

Potentiometers - Loading effect, Power rating of potentiometers, Linearity and Sensitivity, Construction of potentiometers, Non-linear potentiometers.

Strain gauges - Theory of Strain gauges, Types of strain gauges, Characteristics of strain gauges.

Resistance thermometers - Characteristics, Linear approximation, Quadratic approximation,

Thermistors - Resistance vs. Temperature characteristics, Voltage vs. current and Current vs. time characteristics.

Hot wire anemometers - Constant current mode and Constant resistance.

Variable Inductance transducers – Change of self-inductance, Change of mutual inductance, Production of eddy currents, Linear Variable Differential Transformer Construction, Working principle.

Variable capacitance transducers - Change in area of plates, Change in distance between the plates, Differential arrangement, Variation of dielectric constant, Frequency response.

Thermocouples – Construction, Measurement of thermocouple output, Compensating circuits, Reference junction compensation, Lead compensation

Piezoelectric transducers Modes of operation of piezoelectric crystals, Properties, Equivalent circuit of piezoelectric transducers, Loading effects and frequency response, Impulse response, **Hall effect transducers** working principle, application.

Magnetostrictive transducers principle of operation.

Digital encoding transducers – Classification of encoders, Construction of encoders, Brush type, Optical displacement transducers.

Smart sensors – Introduction, primary sensors, Excitation, Amplification, Filters, Convertors, Compensation, Information coding process, Data communication.

Fibre optic sensors – Temperature sensors, Liquid level sensing, Fluid flow sensing, Microbend sensors.

List of applications of various transducers.

Text Books

1. E.O.Doubelin, Measurement Systems, McGraw Hill Book Company, 2008.
2. A.K.Sawheney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpatrai & Co. Pvt. Ltd., 2007.
3. D. Patranabis, Sensors and Transducers, Wheeler Publishing, 2006.

Reference Books

1. Hermann, K.P. Neubert, Instrument Transducers, Oxford University Press, 1988.
2. S. Renganathan, Transducer Engineering, Allied Publishers, 1999
3. D.V.S. Murthy, Transducers and Instrumentation, Prentice Hall of India Pvt. Ltd., 2008.

Course contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1.0	**Performance characteristics of Transducers**	
1.1	**Static characteristics** Meaning of static calibration, Accuracy, Precision, bias, Linearity, Threshold, Resolution, Hysteresis and Dead space, Scale readability and span	3

1.2	**Dynamic characteristics –** Sinusoidal transfer function, zero order transducer, First order transducer, Step, Ramp, Frequency and Impulse response, Second order transducer, Step, Ramp Frequency and Impulse response	3
2.0	**Variable Resistance transducers**	
2.1	**Potentiometers -** Loading effect, Power rating of potentiometers, Linearity and Sensitivity, Construction of potentiometers, Non-linear potentiometers	2
2.2	**Strain gauges -** Theory of Strain gauges, Types of strain gauges, Characteristics of strain gauges, Resistance thermometers, Characteristics, Linear approximation, Quadratic approximation	2
2.3	**Thermistors** - Resistance vs. Temperature characteristics, Voltage vs. current and Current vs. time characteristics	2
2.4	**Hot wire anemometers**	
3.0	**Variable Inductance transducers**	
3.1	Change of self-inductance, Change of mutual inductance, Production of eddy currents	2
3.2	Linear Variable Differential Transformer Construction, Working principle	2
4.0	**Variable capacitance transducers**	
4.1	Change in area of plates, Change in distance between the plates, Differential arrangement, Variation of dielectric constant, Frequency response	3
5.0	**Thermocouples**	
5.1	Construction, Measurement of thermocouple output	2
5.2	Compensating circuits, Reference junction compensation, Lead compensation	2
6.0	**Piezoelectric transducers**	
6.1	Modes of operation of piezoelectric crystals, Properties, Equivalent circuit of piezoelectric transducers	2
6.2	Loading effects and frequency response, Impulse response	2
7.0.	**Hall effect transducers**	
7.1	working principle, application	2
8.0	**Magnetostrictive transducers**	
8.1	Principle of operation	2

9.0	**Digital encoding transducers**	
9.1	Classification of encoders, Construction of encoders, Brush type, Optical displacement transducers	3
10.	**Smart sensors**	
10.1	Introduction, primary sensors, Excitation, Amplification, Filters, Convertors, Compensation, Information coding process, Data communication	3
11.	Fibre Optic Sensors - Temperature sensors, Liquid level sensing, Fluid flow sensing, Microbend sensors	2
	List of applications of various transducers	1
	Total	40

Course designers

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2. B.Ashok kumar ashokudt@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
EGE	3	-	-	3

EGE Domestic and Industrial Electrical Installations 3:0

Preamble

Electricity becomes one of the essential commodities for the human beings on day to day activities. Hence it is necessary to educate an engineer in the aspects of Domestic and Industrial Electrical Installations. The idea of this subject is to educate the non-electrical engineers on the aspect of do's and don't in Electrical Installations. It will helpful to select a best electrical system for an establishment.

Programme Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

h. An ability to function on multidisciplinary teams

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the student should be able to:

1. Explain the basic Electrical Distribution systems
2. Design lighting system for domestic, commercial and industrial applications
3. Estimate the material requirements for a wiring work
4. Get familiar about the different types of wiring practice
5. To Carryout inspection accident analysis

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	50	50	40
3	Apply	30	30	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. When to go for a three phase power supply for domestic uses?
2. Specify the role of fuse.
3. Where to use FRLS wires?
4. Why switches should not be connected in neutral side?
5. Mention the energy efficient lamps used for domestic and industrial purpose.
6. Classify the different accidents
7. Specify the advantages of indirect lighting schemes.
8. What are the factors to be considered, while selecting the dimension of wire thickness for an application?
9. Mention the method of protecting electrical equipment in industry from over voltage.
10. List the safety precautions for operating high voltage equipment

Understand

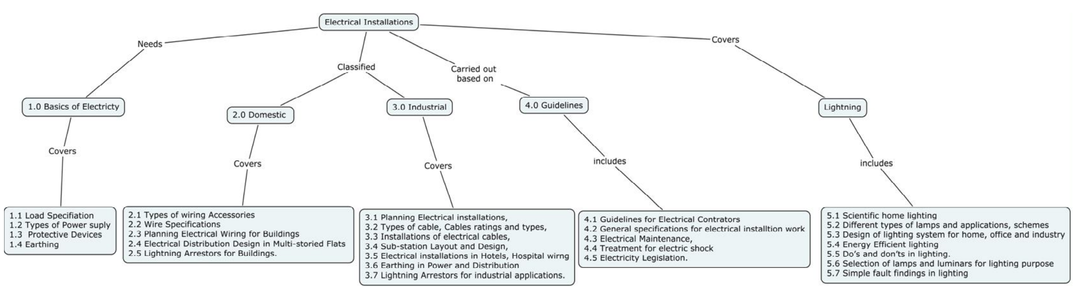
1. List the points to be checked in a single phase wiring.
2. How to check the electrical wiring in flats.
3. What are the factors to be considered while designing a lighting system for domestic purpose?
4. Explain the working principle of Residual Current circuit breakers.
5. List the major equipment used in a sub-station. Also specify the role of each.
6. Explain the plate earthing procedure as per the IS code of practice.
7. What are the points to be inspected, while carryout an annual inspection in a commercial complex?

8. Explain the various steps involved during planning electrical wiring for buildings.
9. Discuss the do's and don'ts in electrical wiring.
10. Explain the role of lightning arrestor in building and electrical systems.

Apply

1. Design a three phase power distribution system for a bungalow and draw the single line diagram of the same.
2. A 30meter X 50meter shop floor needs to be illuminated to a light level of 250Lux. The depreciation factor and utilization factor for the lighting system is 1.2 and 0.7 respectively. 400Watts Metal halide lamp is suggested for the illuminating purpose. The luminous efficacy of the Metal halide lamp is 105 Lumens per watt. Calculate the number of lamps required and the arrangements of lamps for even light distribution.
3. Design a complete protective system for an industrial units starting from the sub-station to the load. Also specify the role of each protective system.
4. Classify the lamps based on application. Also suggest suitable energy efficient lamps for Home and Shop floor lighting with justification.
5. Design a Distribution system for a hotel having a connected load of 100KW. The connected lighting load is 30KW and power load is 70KW. Assume other relevant data if necessary.

Concept Map



Syllabus

Introduction to Electricity –Connected load, Contracted demand, Maximum demand, Power factor, Single Phase Supply, Three phase supply, Three phase wiring, Protective devices in Electrical Installations – Fuse, MCB,MCCB's, RCCB, ELCB. Earthing for Electrical Safety.

Electrical Installations in Domestic Building - Types of wiring, Accessories used in Domestic wiring practice, wire ratings, FRLS type wires and PVC pipes, Planning Electrical Wiring for Buildings, Checking Electrical wiring in Flats, Electrical Distribution Design in Multi-storied Residential Flats and Commercial Buildings, Lightning Arrestors for Buildings.

Electrical Installation in Industry – Planning Electrical installations, Types of cable, Cables ratings and types, Installations of electrical cables, Sub-station Layout and Design, Electrical installations in Hotels, Hospital wiring, Earthing in Power and Distribution, Lightning Arrestors for industrial applications.

Do's and Don'ts in Electrical Wiring - Guidelines for Electrical Contractors. General specifications for electrical installation work, Electrical Maintenance, treatment for electric shock, Electricity Legislation. Points to be inspected, while carryout an Electrical Inspection.

Lighting – Scientific home lighting, Different types of lamps and applications, Various types of lighting schemes, design of lighting system for home, office and industrial work place, Energy Efficient lightings, Do's and don'ts in lighting. Selection of lamps and luminars for lighting purpose, Simple fault findings in lighting.

Text Book

B.Raja Rao, "Electricity for Architects, Project Consultants and Builders", B.Raja Rao Technical Books Publishers, Chennai.

Reference Book

V.S.Rao -Operation & Maintenance of Electrical Equipment - Volume I & II, 1997 Edition, Media Promoters & Publishers Pvt. Ltd., Mumbai.

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0	**Introduction to Electricity**	
1.1	Connected load, Contracted demand, Maximum demand, Power factor	2
1.2	Single Phase Supply, Three phase supply, Three phase wiring	2
1.3	Protective devices in Electrical Installations – Fuse, MCB, MCCB's, RCCB, ELCB	2
1.4	Earthing for Electrical Safety	1
2.0	**Electrical Installations in Domestic Building**	
2.1	Types of wiring, Accessories used in Domestic wiring	2

	practice	
2.2	wire ratings, FRLS type wires and PVC pipes	2
2.3	Planning Electrical Wiring for Buildings, Checking Electrical wiring in Flats	2
2.4	Electrical Distribution Design in Multi-storied Residential Flats and Commercial Buildings	2
2.5	Lightning Arrestors for Buildings	1
3.0	**Electrical Installation in Industry**	
3.1	Planning Electrical installations	1
3.2	Types of cable, Cables ratings and types	1
3.3	Installations of electrical cables	2
3.4	Sub-station Layout and Design	1
3.5	Electrical installations in Hotels, Hospital wiring	2
3.6	Earthing in Power and Distribution	1
3.7	Lightning Arrestors for industrial applications	1
4.0	**Do's and Don'ts in Electrical Wiring**	
4.1	Guidelines for Electrical Contractors	1
4.2	General specifications for electrical installation work	2
4.3	Electrical Maintenance	2
4.4	Treatment / First Aid for electric shock	1
4.5	Electricity Legislation. Points to be inspected, while carryout an Electrical Inspection	2
5.0	**Lighting**	
5.1	Scientific home lighting	1
5.2	Different types of lamps and applications, Various types of lighting schemes	1
5.3	Design of lighting system for home, office and industrial work place	3
5.4	Energy Efficient lightings	1
5.5	Do's and don'ts in lighting	1
5.6	Selection of lamps and luminars for lighting purpose	1
5.7	Simple fault findings in lighting	1
	Total	42

Course Designers

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E. DEGREE (Electrical and Electronics Engineering) PROGRAM

SEVENTH SEMESTER – CORE SUBJECTS

and

DEPARTMENTAL ELECTIVE & GENERAL ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2008-2009 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Govt. Aided ISO 9001-2008 certified Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU
Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Passed in BOS meeting on 30th April 2011 Academic Council meeting on 11th June 2011

Department of Electrical and Electronics Engineering

Graduating Students of B.E. program of EEE will be able to:

1. Specify, architect, design and analyze systems that efficiently generate, transmit, distribute and utilize electrical power
2. Specify, design, prototype and test modern electronic systems that perform analog and digital processing functions.
3. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015
Department of Electrical and Electronics Engineering
Scheduling of Courses

Sem	Theory Courses						Practical / Project		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0				E84 Project 0:12		
7th (21)	E71 Management Theory and Practice 3:0	E72 Protection and Switchgear 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		E77 Project 0:6		
6th (21)	E61 Accounting and Finance 3:0	E62 Power System Analysis 3:1	E63 Electric Drives 3:0	E64 VLSI design 3:0	Elective 1 3:0	Elective 2 3:0	E67 Power System Simulation Lab 0:1	E68 Power Electronics and Drives Lab 0:1	
5th (24)	E51 Numerical Methods 4:0	E52 Generation, Transmission and Distribution 4:0	E53 Power Electronics 3:0	E54 Embedded Systems 3:0	E55 Mixed Signal Circuits 3:0	E56 Design of Electrical Machines 4:0	E57 Digital Signal Processing Lab 0:1	E58 Microprocessor and Microcontroller Lab. 0:1	E59 Instrumenta tion and Control Lab 0:1
4th (25)	E41 Engineering Mathematics – IV 4:0	E42 AC Machines 4:0	E43 Microprocessors 4:0	E44 Thermal Engineering 3:0	E45 Digital Signal Processing 3:0	E46 Electrical & Electronic Measurements 3:0	E47 AC Machines Lab. 0:1	E48 Thermal Engineering Lab 0:1	E49 Professional Communicat ions 1:1
3rd (24)	E31 Engineering Mathematics – III 4:0	E32 Electromagnetics 4:0	E33 DC Machines and Transformers 4:0	E34 Digital Systems 3:0	E35 Data Structures 3:0	E36 Control Systems 4:0	E37 Digital Systems Lab 0:1	E38 DC Machines and Transformers Lab 0:1	
2nd (23)	E21 Engineering Mathematics – II 4:0	E22 Electric Circuit Analysis 4:0	E23 Analog Circuits and Systems 4:0	E24 Computers and Programming 3:0	E25 Material Science 3:0	E26 Environment and Ecology 2:0	E27 Analog Circuits and Systems Lab 0:1	E28 Computer Programming Lab 0:1	E29 Workshop 0:1
1st (25)	H11 Engineering Mathematics – I 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of M & CE 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab 0:1	H18 Chemistry Lab 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2008-2009 onwards)

SEVENTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
E71	Management Theory and Practice	HSS	3	-	-	3
E72	Protection and switch Gear	DC	3	-	-	3
ECX	Elective 1	DE	3	-	-	3
ECX	Elective 2	DE	3	-	-	3
xGx	Elective 3	GE	3	-	-	3
PRACTICAL						
E77	Project	DC	-	-	12	6
Total			**15**	**-**	**6**	**21**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DE : Departmental Elective
GE : General Elective

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2008-2009 onwards)

SEVENTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	E71	Management Theory and Practice	3	50	50	100	25	50
2	E72	Protection and Switch Gear	3	50	50	100	25	50
3	ECX	Elective 1	3	50	50	100	25	50
4	ECX	Elective 2	3	50	50	100	25	50
6	xGx	Elective 3	3	50	50	100	25	50
PRACTICAL								
7	E77	Project	--	150	150	300	75	150

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

LIST OF ELECTIVE SUBJECTS

Departmental Electives			
Sub. code	Subject Name	Pre/Co requisites	Credit
ECA	Special Machines	E33 , E42	3
ECB	Digital Control Systems	E36	3
ECC	High Voltage Engineering	E25, E46	3
ECD	Soft Computing	--	3
ECE	Analog Integrated Circuit Design	E23	3
ECF	Digital Systems Design with PLDs and FPGAs	E34	3
ECG	Power System Control	E62	3
ECH	Robotics	--	3
ECJ	Operation and Maintenance of Electrical Equipment	E33, E42	3
ECK	Power plant Economics	E62	3
ECL	Instrumentation Systems	E46	3
ECM	**Flexible AC Transmission Systems**	**E62**	**3**
ECN	**Power System Stability**	**E62**	**3**
ECO	**Electrical Power Quality**	**E52 , E53**	**3**
ECP	**Real Time Operating Systems**	**E54**	**3**
ECQ	**Computer Networks**	**--**	**3**
ECR	**Distributed Generation Systems**	**E52, E62**	**3**
ECS	**Automotive Electronics**	**E23, E34**	**3**
ECT	**Industrial Controllers**	**E36**	**3**
ECU	**Gas Insulated Sub Stations**	**E52**	**3**

General Electives (offered to other Branch students)			
Sub. code	Subject Name	Pre/Co requisites	Credit
EGA	Industrial Safety and Environment	--	3
EGB	Renewable Energy Sources	--	3
EGC	Soft Computing	--	3
EGD	Sensors and Transducers	--	3
EGE	Domestic and Industrial Electrical Installations	--	3
EGF	**Energy Conservation practices**	**--**	**3**

Sub Code	Lectures	Tutorial	Practical	Credit
E 71	3	-	-	3

E71 Management Theory and Practice 3:0

(common to G 71)

Preamble

Management is the science of managing operations for an enterprise or organization. It deals with managing men, material, machinery and money. It has become an essential need to analyze the basic concepts of management theory and to understand the ways and means of implementing them in practice. The course work highlights the systematic approach for the management of various departments in an organization.

Program outcomes addressed

b) Ability to identify, formulate and solve engineering problems
g) Ability to function on multidisciplinary teams
h) Ability to communicate effectively in both oral and written forms
i) Ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course, the student will be able to:

1. Manage the operations in total for an enterprise.
2. Work with team spirit and group coordination.
3. Ability to design Organizational Structure
4. To facilitate an effective communication both within and outside a firm.
5. Formulate the selection and recruitment procedures for a department
6. Evolve proper performance appraisal system
7. Analyze and identify an effective site selection and design a proper layout.
8. Prepare maintenance schedules for an organization.
9. Ability to measure overall productivity and suggest means to improve it
10. Plan the material handling systems for the organization.

Assessment Pattern

S.No.	Blooms Category	Test 1	Test 2	Test 3 / End semester Examination
1	Remember	10	10	20
2	Understand	10	10	40
3	Apply	30	30	40
4	Analyze	0	0	0
	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Define Management
2. What are the various functions of management?
3. Distinguish MBO and MBE.
4. Define Group Cohesiveness
5. What do you mean by semantic barrier of communication?
6. What type of industry requires process type layout?
7. Define Morale
8. Mention the significance of Market Research?
9. Give an example of centralized layout.
10. Mention the types of maintenance
11. What do you understand by the term Productivity?

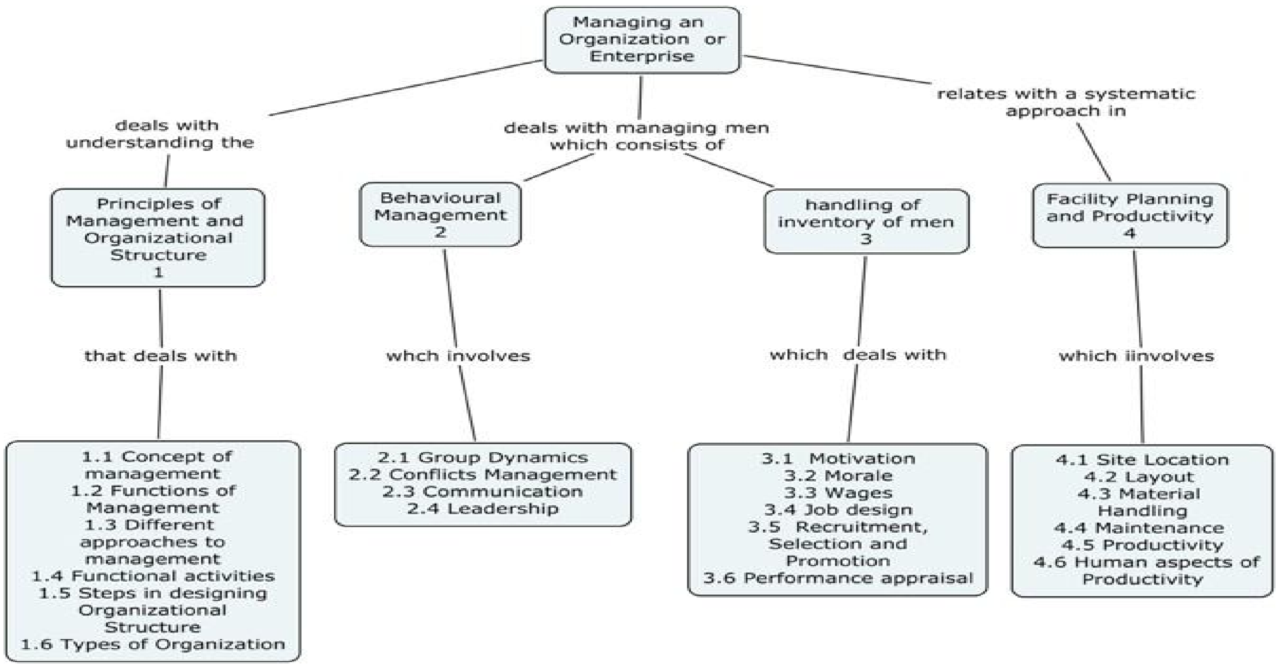
Understand

1. Briefly explain all the functions of Management
2. Explain various controlling techniques.
3. What are the merits of Modern Type of Organization?
4. List out all the stages of Group formation and explain
5. What are the barriers of communication?
6. What are the factors associated with morale?
7. Compare job enrichment and job enlargement
8. Compare the merits and demerits of product and process layouts
9. Enumerate all the human factors associated with productivity
10. Differentiate periodical and preventive maintenance
11. Enumerate all the ways of measuring productivity.
12. What are the requirements of an effective material handling system?

Apply

1. Bring out all the steps in the formation of a Quality Circle in an educational institution.
2. Suggest the modalities of selection of a trainee engineer to be recruited for a software firm
3. You as a manager prepare a proposal to locate a site to establish a telecommunication industry.
4. Suggest all the possible ways to increase the overall productivity of a manufacturing sector
5. Prepare a preventive maintenance schedule for an electronic equipment manufacturing company which operates for three shits in 24 hours for 8 hours per shift by 6.00 AM to 2.00 PM, 2.00 PM to 10.00 PM and 10.00 PM to 6.00 AM

Concept map



Syllabus

Management and Functions of Management

Concept of management, Management, organization, Administration-Management is Science or Art, Taylors Scientific Management – Henry Fayol's Principles of management -Functions of management, planning, Organizing, Staffing, Coordinating, Directing and Controlling, different approaches to management, various functional activities of different departments, Strategic planning, MBO, Management by exception, Organization Structure- Principles, Steps in designing an Organization-Types of Organization

Behavioural Management

Group dynamics, types of groups, formation of group, Group cohesiveness, conflicts management, Communication –meaning and types, barriers in communication, communication in Groups, Leadership styles

Human Resources Management

Objectives-employer-employee relations-Motivation-Morale-Ways of achieving high morale-collective bargaining-Wage and wage payments-incentives-job design, job analysis-job description, job rotation, job evaluation and merit rating-Recruitment, Selection and training of employees-Promotion-Performance appraisal-Outsourcing Management-issues.

Facility Planning and Productivity

Site location-Factors to be considered-layout-objectives, types, f factors influencing layout, layout procedure-Materials handling-principles, factors affecting the choice of materials handling, Materials handling equipment-Plant maintenance-need functions and types-

Productivity-definition and concept, measurement-techniques for productivity measurement-Human aspects of productivity

Text Books

1. Koontz O'donnel, "Essentials of Manangement",2004
2. O.P. Khanna, "Industrial Engineering and Management" , Khanna Publishers,2008

Reference Books

1. Chase, Jacobs, aquilano, "Production and Operations Management" 8th Edition, Tata McGraw Hil Companies Inc 1999
2. Fred Luthans "Organizational Behaviour", Tata McGraw Hill, 2005
3. Edwin Flippo, "Personnel Management", Tata McGraw Hill,2004
4. R.N. Gupta, "Principles of Management",S.Chand and Co Ltd, 2008

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**The Principles of Management**	
1.1	Concept of management, Organization, Administration, Management is science or art, Taylor's Scientific Management, Henry Fayol's Priniciples of management	3
1.2	Functions of management, Planning, organizing, Staffing, Coordinating, Directing and controlling	3
1.3	Different approaches to management	1
1.4	Functional activities, Strategic Planning, MBO, MBE	1
1.5	Principles and Steps Designing Organization structure	2
1.6	Types of Organization	1
2	**Behavioural Management**	
2.1	Group Dynamics, types of group, formation of group, group cohesiveness	3
2.2	Conflicts management	2
2.3	Communication, meaning and types, barriers in communication , communication in groups	3
2.4	Leadership styles	2
3	**Human Resources Management**	
3.1	Employer employee relations, Motivation	3
3.2	Morale, ways of achieving high morale, collective bargaining	1
3.3	Wages, wage and wage payments, incentives	1
3.4	Job Design, job analysis-job description, job rotation, job evaluation and merit rating	3
3.5	Recruitment, Selection and Promotion	3
3.6	Performance appraisal-Outsourcing Management-issues.	3
4	**Facility Planning and Productivity**	
5.1	Site Location , factors to be considered	1
5.2	Layout objectives, types , factors influencing layout, layout procedure	2
5.3	Material Handling, principles, factors affecting the choice of materials handling, materials handling equipments	2
5.4	Maintenance, need, functions and types	2

S.No.	Topic	No. of Lectures
5.5	Productivity, definition and concept, measurement-techniques for productivity measurement	1
5.6	Human aspects of Productivity	2
Total		**45**

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Sub Code	Lectures	Tutorial	Practical	Credit
E72	3	-	-	3

E72 Protection and Switchgear 3:0

Preamble

The importance of electric supply has constructed such circumstances that we must secure the Power system from large faults and provide protection to the machineries and devices used and to ensure maximum continuity of the power supply. For this purpose, machines such as generators and motors are needed to be switched on and off many times. Means provided to achieve this are called 'Switch Gear'. Based on this, the course aims at giving an adequate exposure in Power System Transient Protection, Circuit Breakers, Fuses, Protective Relays and Apparatus Protection.

Programme Outcomes addressed

a. Ability to apply knowledge of mathematics, science and engineering.
e. Ability to identify, formulate and solve engineering problems.
i. A recognition of the need for, and an ability to engage in life-long learning
j. A knowledge of contemporary issues
k. Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course the student should be able to:

1. Understand the causes of over voltages, transient currents in power system.
2. Understand the working principles of circuit breakers, fuses and its selection.
3. Selection of circuit breaker for various faults and overvoltages.
4. Identify and implement the suitable protective schemes for all types of faults.
5. Understand the operation of static relays.
6. Design and develop microprocessor based protective relays.
7. Understand the layout of a typical substation.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What are the causes of over voltages arising in Power System?
2. What are travelling waves?

3. Define insulation co-ordination.
4. Define protective angle of transmission lines.
5. What is high resistance interruption in Circuit Breakers?
6. What is re-striking voltage in Circuit Breaker?
7. What is an incipient fault?
8. What is meant by breaking capacity of a circuit breaker?
9. What is discrimination?
10. What are the advantages of digital relays?

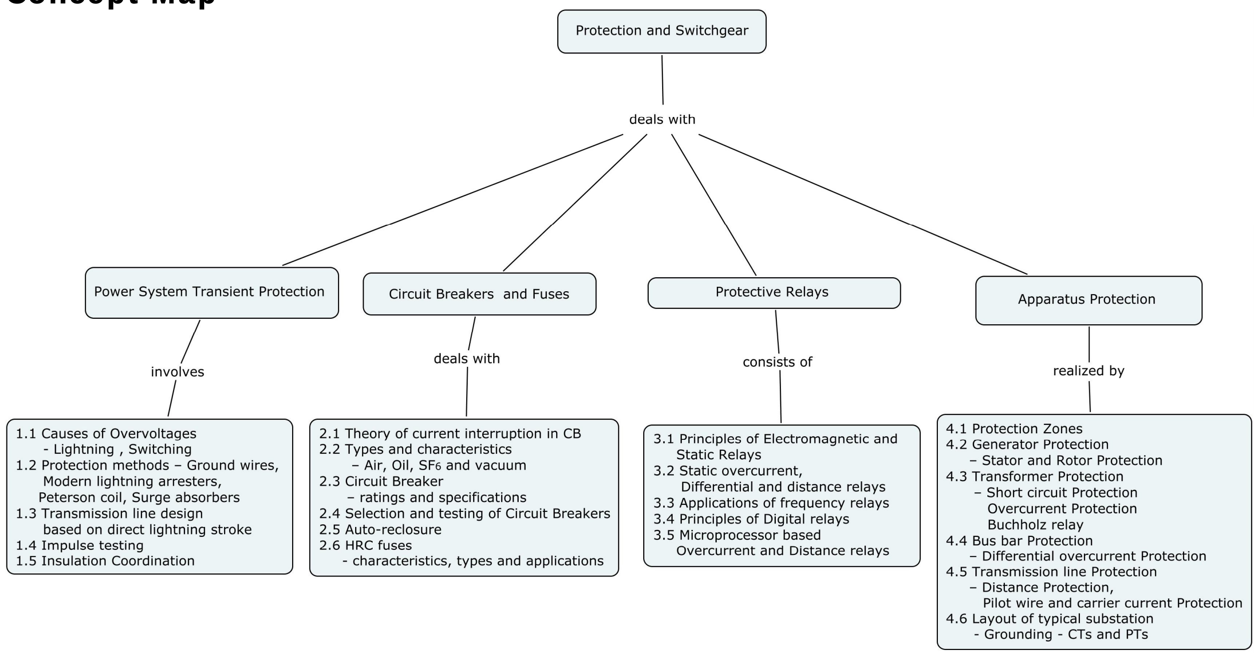
Understand

1. How does a circuit breaker differ from a switch?
2. Give the sequence of operation of isolator, CB and earthing switch, during opening of a circuit?
3. What is the principle of an impedance relay?
4. How to select a fuse for motor?
5. What is “field suppression” of Alternators?
6. What are the characteristics of non-linear surge diverter?
7. What is current chopping in Circuit Breakers?
8. Compare indoor and outdoor substations?
9. Explain how arc is initiated and sustained in a CB, when its contacts separate.
10. Compare the various types of HVAC circuit breakers?

Apply

1. How can the magnitude of overvoltages due to direct and indirect lightning strokes on overhead lines be calculated?
2. A 132kV, 3-phase, 50Hz transmission line 200km long contains three conductors of effective diameter 2.2 cm, arranged in a vertical plane with 4.5 m spacing and regularly transposed. Find the inductance and kVA rating of the Peterson coil in the system.
3. Explain the term insulation coordination. Describe the construction of volt-time curve and the terminology associated with impulse testing.
4. Explain the phenomenon of current chopping in a circuit breaker. What measures are taken to reduce it?
5. Discuss how breaking capacity and making capacity of a circuit breaker are tested in a laboratory type testing system.
6. Discuss why the ratio of reset to pick up should be high.
7. An 11kV, 100 MVA generator is grounded through a resistance of 6Ω. The C.T.s have a ratio of 1000/5. The relay is set to operate when there is an out of balance current of 1A. What percentage of the generator winding will be protected by the percentage differential scheme of protection?
8. How can R and X of the line as seen by the relay be calculated by using an algorithm based on the Discrete Fourier Transform (DFT)?

Concept Map



Syllabus

Power System Transient Protection

Causes of Over voltages - Lightning , Switching -Protection methods – Ground wires, Modern lightning arresters, Peterson coil, Surge absorbers - Transmission line design based on direct lightning stroke - Impulse testing – Insulation Coordination.

Circuit Breakers and Fuses

Theory of current interruption in circuit breaker - Types and characteristics – Air, Oil, SF_6 and vacuum - Circuit Breaker – ratings and specifications - Selection and testing of Circuit Breaker - Auto-reclosure - HRC fuses - characteristics, types and applications.

Protective Relays

Principles of Electromagnetic and Static Relays - Static over current, Differential and distance relays - Application of frequency relays - Principles of Digital relays - Microprocessor based Over current and Distance relays.

Apparatus Protection

Protection Zones - Generator Protection – Stator and Rotor Protection - Transformer Protection –Short circuit Protection. Over current Protection, Buchholz relay – Bus bar Protection – Differential over current Protection - Transmission line Protection – Distance Protection, Pilot wire and carrier current Protection - Layout of typical substation – Grounding- CTs and PTs.

Text Books

1. J.B.Gupta, "A course in Power Systems", S.K.Kataria and Sons Publications - 9th edition 2004.
2. Badri Ram and D.N. Vishwakarma, "Power System Protection and Switch Gear", Tata McGraw Hill 2nd edition - 2007.
3. T.S. Madhava Rao "Digital/Numerical Relays", Tata McGraw Hill 1st edition - 2005.

Reference Books

1. Sunil S. Rao, "Protection and Switch Gear", Khanna Publishers 4th edition, New Delhi, 1992.
2. B. Ravindranath and N.Chander, "Power System Protection and Switch Gear", New Age International Ltd., New Delhi, Reprint 2005.
3. Uppal, "Electrical Power" Khanna Publisher, 8th edition, 1981.
4. L. P. Singh, "Digital Protection Protective Relaying From Electromechanical To Microprocessor" New Age International Ltd., New Delhi, 2nd Edition, Reprint 2004.

Course contents and Lecture schedule

Sl.No.	Topic	No. of Lectures
1.0	**Power System Transient Protection**	**7**
1.1	Causes of Over voltage- Lightning , Switching	1
1.2	Protection methods – Ground wires, Modern lightning arresters, Peterson coil, Surge absorbers	2
1.3	Transmission line design based on direct lightning stroke	2
1.4	Impulse testing	1
1.5	Insulation Coordination	1
2.0	**Circuit Breakers and Fuses**	**11**
2.1	Theory of current interruption in circuit breaker	1
2.2	Types and characteristics – Air, Oil, SF_6 and vacuum	3
2.3	Circuit Breaker – ratings and specifications	2
2.4	Selection and testing of Circuit Breaker	2
2.5	Auto-reclosure	1
2.6	HRC fuses – characteristics, types and applications	2
3.0	**Protective Relays**	**14**
3.1	Principles of Electromagnetic and Static Relays	3
3.2	Static over current, Differential and distance relays	3
3.3	Applications of frequency relays	2
3.4	Principles of Digital relays	3
3.5	Microprocessor based Over current and Distance relays	3
4.0	**Apparatus Protection**	**13**
4.1	Protection Zones	1
4.2	Generator Protection – Stator and Rotor Protection	2
4.3	Transformer Protection –Short circuit Protection, Over current Protection, Buchholz relay	3
4.4	Bus bar Protection – Differential over current Protection	2

4.5	Transmission line Protection – Distance Protection, Pilot wire and carrier current Protection	3
4.6	Layout of typical substation, Grounding, CTs & PTs	2
	Total	**45**

Course Designers

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Sub code	Lectures	Tutorial	Practical	Credit
ECM	3	-	-	3

ECM Flexible AC Transmission Systems 3:0

Preamble

The field of Flexible AC Transmission Systems (FACTS) finds many applications nowadays. This course mainly discusses about different types of FACTS controllers, applications, stability of the power systems after introducing FACTS controllers.

Program Outcomes addressed

(a) An ability to apply knowledge of mathematics, science, and engineering
(b) An ability to design and conduct experiments, as well as to analyze and interpret data
(g) An ability to communicate effectively
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) A recognition of the need for, and an ability to engage in life-long learning
(j) A knowledge of contemporary issues
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course, the student will be able to:

1. Understand the operations of series, shunt compensators
2. Modelling of different FACTS controller
3. Understand the different types series and shunt compensators
4. Develop the control systems for FACTS devices.
5. Analyze the system to put proper FACTS controllers
6. Analyze the FACTS devices and to put proper controller
7. Analyze the stability of system after introducing the FACTS controllers

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test3 / End-semester examination
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	40	40	40
4	Analyze	40	40	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is meant by Saturated Reactor?

2. Define the term “TSSR
3. List the objective of shunt compensation
4. Define the term “TCSC”.
5. Define the term “Sub synchronous Resonance”.
6. What is meant by ASC?
7. What is the basic principle of NGH damping scheme?

understand

1. What is meant by Saturated Reactor?
2. Draw the schematic diagram of UPFC
3. Define the term “TSSR
4. Differentiate between TCR and TSR
5. List the objective of shunt compensation
6. Define the term “TCSC”
7. Define the term “Sub synchronous Resonance”.
8. What is meant by ASC.
9. Draw the impedance vs firing angle characteristic of TCSC.
10. What is the basic principle of NGH damping scheme
11. Why in TSC a small reactor is put in series with the capacitor

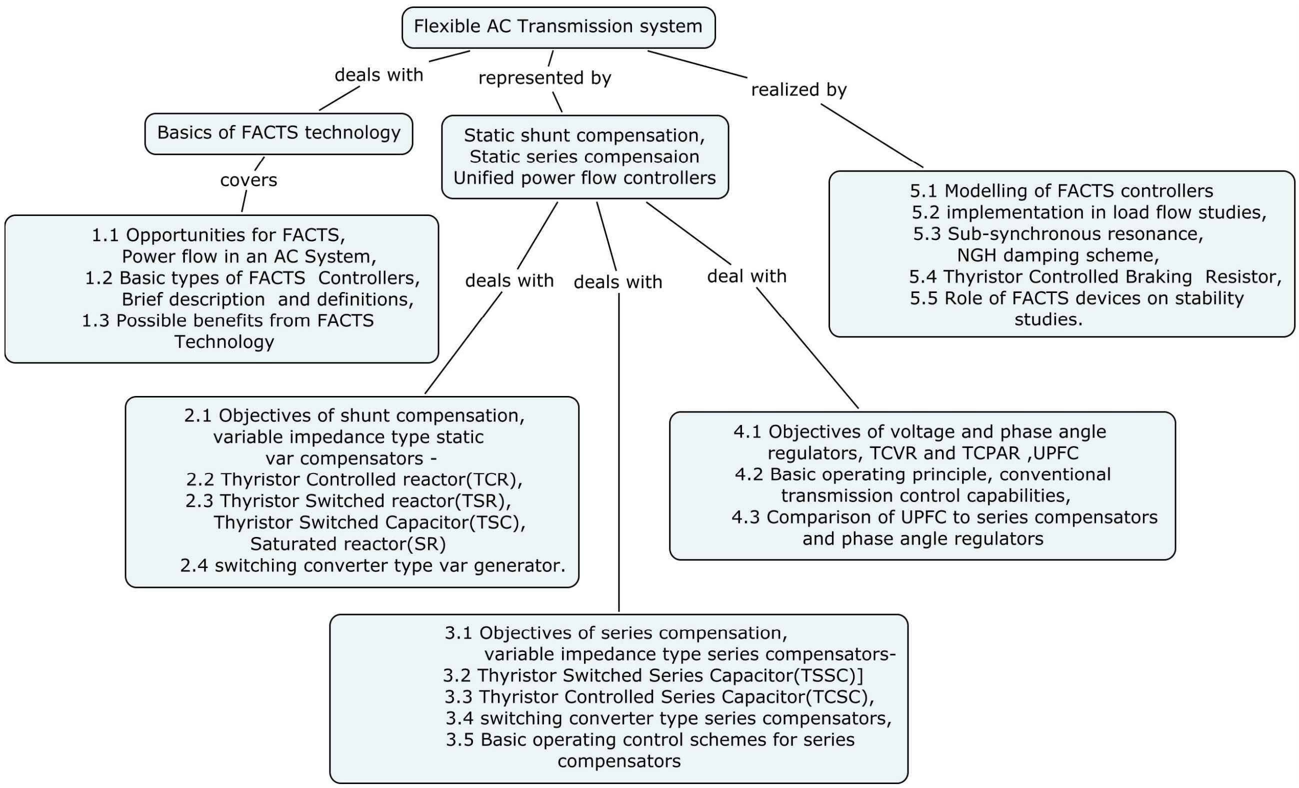
Apply

1. By applying Thyristor Controlled Series Capacitor explain how the power factor is improved when the load is of inductive in nature
2. By applying Thyristor controlled tap changers explain how the phase angle control is achieved
3. Explain the operation of UPFC with neat sketch and phasor diagrams
4. Explain how the multi-modal decomposition technique is applied in FACTS controller
5. By applying UPFC solve, when the voltage stability is poor
6. By applying the TCPAR solve, when the load voltage is suddenly decreased
7. By applying the Phase angle regulator solve, when the load is suddenly changing from Inductive to capacitive

Analyse

1. Analyze the working and the characteristics of TCSC with a neat sketch.
2. Analyze NGH damping scheme.
3. Analyze the ASC damping scheme
4. Analyze the Phase Angle Regulator with a neat sketch.
5. Analyze the VSC based UPFC which is connected at the middle of the transmission line
6. Analyze the SSSC which is connected at the load end of the transmission line
7. Analyze the STATCOM which is connected at the middle of the transmission line

Concept Map



Syllabus

INTRODUCTION

Opportunities for FACTS, Power flow in an AC System, Basic types of FACTS Controllers, Brief description and definitions, possible benefits from FACTS Technology.

STATIC SHUNT COMPENSATORS

Objectives of shunt compensation, variable impedance type static VAR compensators - Thyristor Controlled Reactor(TCR), Thyristor Switched Reactor(TSR), Thyristor Switched Capacitor(TSC), Saturated Reactor(SR) and switching converter type vAR generator.

STATIC SERIES COMPENSATORS

Objectives of series compensation, variable impedance type series compensators-Thyristor Switched Series Capacitor(TSSC), Thyristor Controlled Series Capacitor(TCSC), switching converter type series compensators, Basic operating control schemes for series compensators.

STATIC VOLTAGE AND PHASE ANGLE REGULATORS AND UNIFIED POWER FLOW CONTROLLER

Objectives of voltage and phase angle regulators, TCVR and TCPAR and UPFC-Basic operating principle, conventional transmission control capabilities, Comparison of UPFC to series compensators and phase angle regulators.

POWER FLOW CONTROL, STABILITY AND OSCILLATION DAMPING USING FACTS CONTROLLERS

Modelling of FACTS controllers and implementation in load flow studies, Sub-synchronous resonance, NGH damping scheme, Thyristor Controlled Braking Resistor, Role of FACTS devices on stability studies.

TEXT BOOKS

1. Narain G.Hingorani & L.Gyugyi "Understanding FACTS concepts and Technology of Flexible AC Transmission Systems", IEEE Press, 2000.

2. T.J.E.Miller "Reactive power control in electric systems", John Wiley & Sons Ltd, 1982.

REFERENCE BOOKS

1. R.M.Mathur & R.K.Varma, "Thyristor Based FACTS Controllers for Electrical Transmission Systems", IEEE Press, 2002.

2. E.Acha, et.al. "FACTS Modelling and Simulation in Power Networks." John Wiley & Sons Ltd, 2004.

Course content and lecture schedule

S.No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Opportunities for FACTS, Power flow in an AC System	2
1.2	Basic types of FACTS Controllers, Brief description and definitions	2
1.3	Possible benefits from FACTS Technology	2
2	**STATIC SHUNT COMPENSATORS**	
2.1	Objectives of shunt compensation and variable impedance type static VAR compensators	2
2.2	Thyristor Controlled Reactor(TCR) and Thyristor Switched Reactor(TSR)	2
2.3	Thyristor Switched Capacitor(TSC) and Saturated reactor(SR)	2
2.4	switching converter type vAR generator	2
3	**STATIC SERIES COMPENSATORS**	
3.1	Objectives of series compensation, variable impedance type series compensators	2
3.2	Thyristor Switched Series Capacitor(TSSC)	2
3.3	Thyristor Controlled Series Capacitor(TCSC)	2
3.5	switching converter type series compensators	2
3.6	Basic operating control schemes for series compensators	2
4	**STATIC VOLTAGE AND PHASE ANGLE REGULATORS AND UNIFIED POWER FLOW CONTROLLER**	
4.1	Objectives of voltage and phase angle regulators, TCVR and TCPAR	2
4.2	Basic operating principle and conventional transmission control capabilities of UPFC	2
4.3	Comparison of UPFC to series compensators and phase angle regulators	2

5	**POWER FLOW CONTROL, STABILITY AND OSCILLATION DAMPING USING FACTS CONTROLLERS**	
5.1	Modelling of FACTS controllers	2
5.2	Implementation in load flow studies	2
5.3	Sub-synchronous resonance and NGH damping scheme	2
5.4	Thyristor Controlled Braking Resistor	2
5.5	Role of FACTS devices on stability studies	2
	Total	**40**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECN	3	-	-	3

ECN Power System Stability 3:0

Preamble

This subject Power System Stability is concerned with understanding, modeling, analyzing and improving power system stability problems. These problems comprise important considerations in the planning, design and operation of modern power system. The complexity of power system is continually increasing because of growth in interconnected operations.

The robustness of a power system is measured by the ability of the system for operation in a state of equilibrium between normal and perturbed conditions. Power system stability deals with the study of behavior of power system under conditions such as sudden changing of load or generation or short circuit on transmission lines. A power system is said to be stable if the interconnected generating units remain in synchronism.

Programme outcomes addressed

a. Ability to apply knowledge of engineering, information technology, mathematics, and science
b. Ability to design and conduct experiments, as well as to analyze and interpret data
c. Ability to design a system or component, or process to meet stated specifications
d. Ability to identify, formulate and solve engineering problems
e. Ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints
j. Ability to consider issues from global and multilateral views.

Competencies

After completion of the course the students will be able to:

1. Understand the concept of transient, steady state and dynamic stability.
2. Find stability for power system by point-by point method.
3. Determine the critical clearing angle and clearing time for power system by equal area criterion.
4. Calculate the steady state stability limit for power system by construction of Clarke's diagram.
5. Describe the different types of modern excitation system and calculation of exciter response by graphical integration technique.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Define stability of a power system.
2. What do you understand by dynamic stability of a power system?
3. Distinguish between steady state and transient stability.
4. What is the need for reduced order model?
5. Write any two bad effects of instability
6. Name the various load models?
7. Define inertia constant H.
8. Write the swing equation taking the effect of damping with account.
9. List any two assumption made in stability studies.
10. Define infinite bus.
11. Define critical clearing angle.
12. State the unit of AVR.
13. Name little modern excitation system.
14. Give the characteristics of quick response excitation system.
15. How will you increase the excitation response?

Understand

1. Distinguish between transient steady state and dynamic stability of a power system. For a given power system which of the stability limit is higher and why?
2. Write a brief note on importance of stability for system operation and design.
3. What are the bad effects of instability?
4. How the following power system components are modeled in stability studies

i. Synchronous machine ii. Induction machine iii. Transformers iv. Loads

5. Describe the various part of the network analysis that can be implemented for power system calculation. How will you use it for transient stability studies?
6. Derive the power angle excitation of two machine system in polar and rectangular form.
7. Derive the swing equation from the basic principles and indicate the method of solving the same by point by point method.
8. With the help of a flowchart and algorithm explain the solution of swing equation by modified Euler's method.
9. Discuss the various factors affecting the transient stability of a power system and explain the method of improving it.
10. Explain the method of obtaining swing curve by graphical integration technique.
11. Discuss in detail the effect of inertia and governor action upon stability.
12. Illustrate using Clarke's diagram the method of determining steady state stability limit of a two machine system with resistance.
13. Draw the block diagram of an exciter control system and derive the transfer function of each block.

Apply

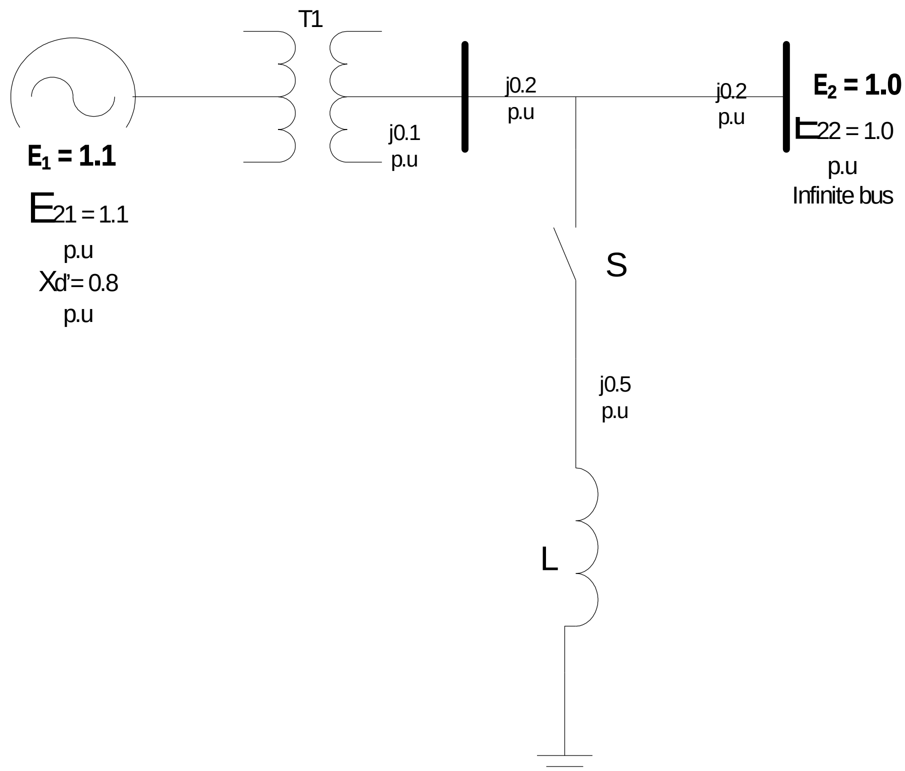
1. A 2 pole, 50 Hz, 11.5KV turbo generator has a rating of 60MW, 0.85 P.F lagging. Its rotor has moment of inertia of 8800kg-m^2 .Calculate its inertia constant in MJ/MVA and its momentum in MJ-sec/ elec.deg.

2. A cylindrical rotor generator is delivering 1.0.p.u power to an infinity bus through a lossless transmission network. The Maximum power which can be transferred for Perrault, during fault and post fault condition 1.8, 0.4 and 1.3 p.u. respectively. Find the critical clearing angle
3. Find the Steady state power limit of two synchronous machines having a resistance link of 0.5 p.u. The internal reactances of the machine are 0.6 p.u. and 0.7 p.u. respectively and the terminal voltages are held constant at 1.1 p.u. and 1.0 p.u. respectively.
4. A 3- ph 50hz, 50MVA synchronous generator has H=4.5MJ/MVA in steady state with input and output=0.7 p. u. and displacement angle of 30 deg(elec) w.r.t infinity bus. Consequent upon the occurrence of fault. The output power angle relation is given by P_u=1.0sinδ. Assume that its input power remains constant determine and draw the swing curve by step- step method II taking the time interval **Δt** = 0.05sec.
5. For the system shown below find the steady state stability limit for the following conditions:

a. when switch 'S' is open

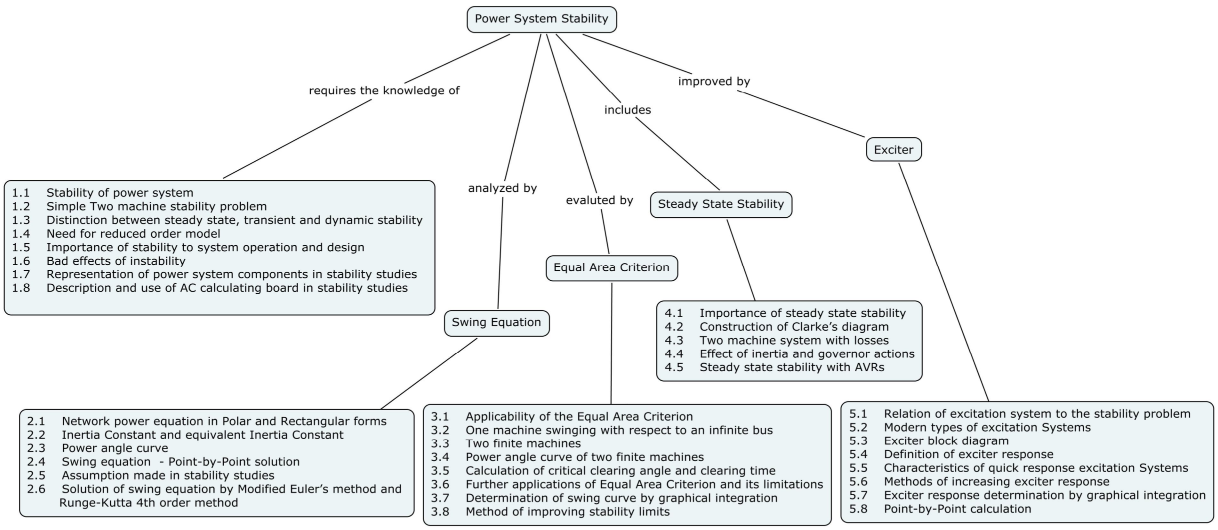
b. when switch 'S' is closed

c. Inductor is replaced by a capacitor of same p.u. reactance.



6. An industrial area receives 60MW over a transmission line from another area. The transmission system has a steady state stability limit of 120MW. What is the permissible maximum sudden load that can be switched ON Without loss of stability?

Concept Map



Syllabus

Introduction to Stability

Stability of power system, Simple Two machine stability problem, Distinction between steady state, transient and dynamic stability, Need for reduced order model, Importance of stability to system operation and design, Bad effects of instability, Representation of power system components in stability studies, Description and use of AC calculating board in stability studies.

Swing Equation and its solution

Network power equation in Polar and Rectangular forms, Inertia Constant and equivalent Inertia Constant, Power angle curve, Swing equation - Point-by-Point solution, Assumption made in stability studies, Solution of swing equation by Modified Euler's method and Runge-Kutta 4^{th} order method.

Equal Area Criterion for Stability

Applicability of the Equal Area Criterion, One machine swinging with respect to an infinite bus, Two finite machines, Power angle curve of two finite machines, Calculation of critical clearing angle and clearing time, Further applications of Equal Area Criterion and its limitations, Determination of swing curve by graphical integration, method of improving stability limits.

Steady State Stability

Importance of steady state stability, Construction of Clarke's diagram, two machine system with losses, Effect of inertia and governor action, Steady state stability with AVRs.

Excitation Systems

Relation of excitation system to the stability problem, Modern types of excitation Systems, Exciter block diagram, Definition of exciter response, Characteristics of quick response excitation Systems, Methods of increasing exciter response, Exciter response determination by graphical integration, Point-by-Point calculation.

Textbooks

1. E.W.Kimbark, Power system stability, Vol I & III, John Wiley & Sons, 2006
2. K.A. Gangadhar, "Power System Analysis and Stability", Khanna Publishers, New Delhi, 2004.
3. P.Kundur, "Power System Stability and Control", Tata McGraw Hill, 2007.
4. B.R.Gupta, "Power system Analysis and Design", S.Chand and Company, 2004.

Reference Book

1. Paul M.Anderson, A.A. Fouad, "Power System Control and Stability", Wiley-IEEE Press, 2^{nd} Edition, 2002.

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**Introduction to Stability**	
1.1	Stability of power system	1
1.2	Simple Two machine stability problem	1
1.3	Distinction between steady state, transient and dynamic stability	1
1.4	Need for reduced order model	1
1.5	Importance of stability to system operation and design	1
1.6	Bad effects of instability	1
1.7	Representation of power system components in stability studies	2
1.8	Description and use of AC calculating board in stability studies	1
2	**Swing Equation and its solution**	
2.1	Network power equation in Polar and Rectangular forms	2
2.2	Inertia Constant and equivalent Inertia Constant	1
2.3	Power angle curve	1
2.4	Swing equation - Point-by-Point solution	2
2.5	Assumption made in stability studies	1
2.6	Solution of swing equation by Modified Euler's method and Runge-Kutta 4^{th} order method	2
3	**Equal Area Criterion for Stability**	
3.1	Applicability of the Equal Area Criterion	2
3.2	One machine swinging with respect to an infinite bus	1
3.3	Two finite machines	2
3.4	Power angle curve of two finite machines	1
3.5	Calculation of critical clearing angle and clearing time	2
3.6	Further applications of Equal Area Criterion and its limitations	1
3.7	Determination of swing curve by graphical integration	1
3.8	Method of improving stability limits	1
4	**Steady State Stability**	
4.1	Importance of steady state stability	1
4.2	Construction of Clarke's diagram	2
4.3	Two machine system with losses	2
4.4	Effect of inertia and governor actions	1

4.5	Steady state stability with AVRs	2
5	**Excitation Systems**	
5.1	Relation of excitation system to the stability problem	1
5.2	Modern types of excitation Systems	1
5.3	Exciter block diagram	2
5.4	Definition of exciter response	1
5.5	Characteristics of quick response excitation Systems	1
5.6	Methods of increasing exciter response	2
5.7	Exciter response determination by graphical integration	2
5.8	Point-by-Point calculation	1
	Total	**48**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECO	3	-	-	3

ECO Electrical Power Quality **3:0**

Preamble

The main purpose of the course is to:

a. Address electrical power quality issues.
b. Address on power quality standards.
c. Address on mitigation techniques using Filters to overcome power quality issues.

Program Outcomes addressed

(a) Ability to apply knowledge of mathematics, science, and engineering
(b) Ability to design and conduct experiments, as well as to analyze and interpret data
(c) Ability to design a system, component, or process to meet desired needs
(e) Ability to identify, formulate, and solve engineering problems
(f) An understanding of professional ethical responsibility
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course students should be able to:

1. Familiarize with the power quality issues and perspectives.
2. Identify power quality problems.
3. Specify solution for a particular power quality problem.
4. Understand the cause and effect of harmonics to electrical system.
5. Identify the ways to mitigate the effect of harmonics.
6. Design a harmonic filter.
7. Understand the usage of power quality measuring equipments.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	60	40	40
2	Understand	40	50	40
3	Apply	0	10	20
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is Power Quality?
2. What is the most common power quality Problem? Why has power quality only become an issue in recent years?
3. What are harmonics?
4. Why noise or transients on the power line causing problems now**?**
5. Define total demand distortion
6. Define DC offset, Inter harmonics
7. Define voltage unbalance
8. Name any two IEEE standards that define power quality.
9. What are the importance of power quality monitoring?

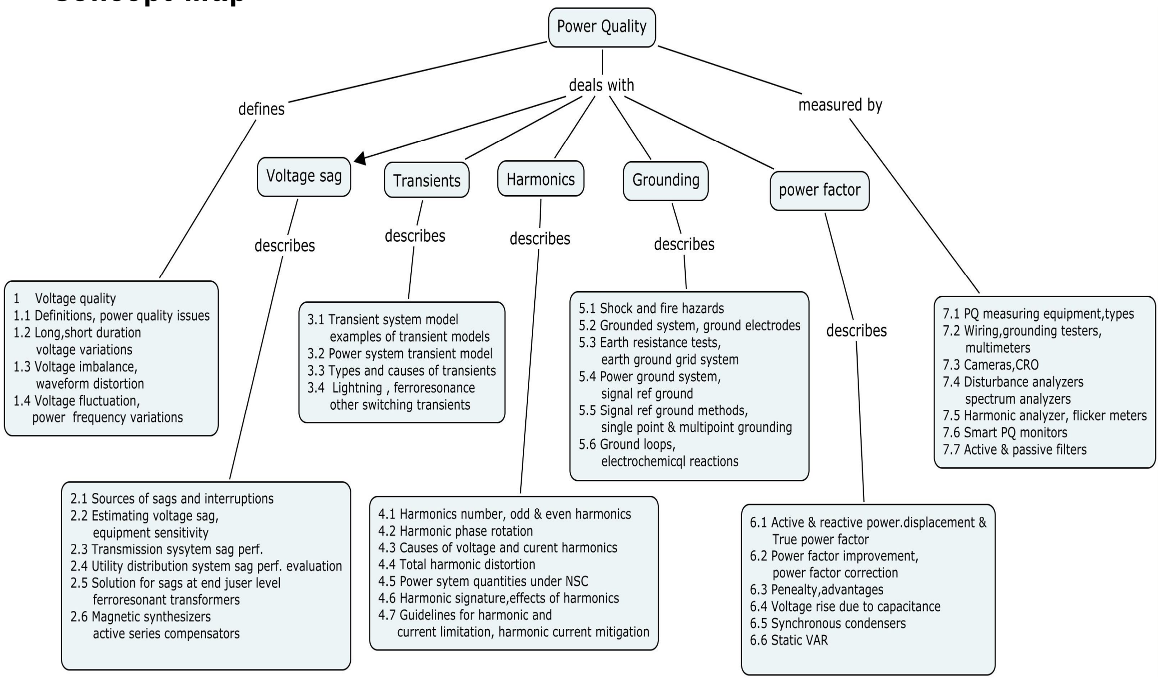
Understand

1. What are the major power quality issues? Explain in detail
2. Explain the various types of power quality disturbances and impacts of power quality.
3. Discuss about long and short duration voltage variations.
4. Discuss in detail about transients
5. Explain the following: a) Total harmonic distortion b) Total demand distortion
6. What is the need of estimating sag performance? Explain the different methods of estimating voltage sag performance.
7. What are the different voltage sag mitigation techniques? Explain in details.
8. What are transient over voltages? Explain the different types of transient over voltages.
9. Differentiate between power quality, voltage quality and current quality
10. Explain briefly about for the following harmonic filter.
    (i)Active filters (ii) Passive filters

Apply

1. Select capacitor bank to needed to improve the power factor from the present level to typically 0.9 to 0.95. Determine whether capacitor operating parameters fall within IEEE-18 maximum recommended limits.
2. Suppose that a capacitor bank installed for reactive power compensation at a six pulse power converter applications to be tuned to fifth harmonic. Determine the required reactor size and verify whether capacitor bank operation fall within IEEE 18 limits.
3. Design a filter to attenuate the 5th, 7th, and 11th harmonics. Also design such that each filter section is tuned 4 percent below the filtered harmonic.
4. Design a filter to attenuate harmonic currents drawn from the line to comply with IEEE-519, Where the source is 277 V, line-to-neutral. The fundamental load current at 60 Hz is IL _ 100 A. This load also draws fifth-harmonic current I_5 _ 20 A and seventh-harmonic current I_7 _ 15 A.

Concept map



Syllabus

Introduction

Voltage quality, terms and definitions, Power quality issues : Transients, long duration voltage variations, short duration voltage variations, voltage unbalance, waveform distortion, voltage fluctuation, power frequency variations.

Voltage Sags

Voltage sags sources of sags and interruptions, estimating voltage sag performance, equipment sensitivity to voltage sags, transmission system sag performance evaluation, utility distribution system sag performance evaluation, Solution for sags at end user level : ferro resonant transformers, magnetic synthesizers, active series compensators.

Transients

Transient system model, examples of transient models and their response, power system transient model, types and causes of transients, Ligntning, ferro resonance , other switching transients.

Harmonics

IEEE standards, Definition, harmonic number, odd and even harmonics , harmonic phase rotation and phase angle relationship, Causes of voltage and current harmonics, Individual and total harmonic distortion, power system quantities under non sinusoidal conditions, harmonic signatures, effects of harmonics on power system devices, guidelines for harmonics voltage and current limitation, harmonic current mitigation.

Grounding

shock and fire hazards, essential of a grounded system, ground electrodes, earth resistance tests, earth ground grid systems, power ground system, signal reference ground, signal reference ground methods, single point and multipoint grounding, ground loops, electrochemical reactions due to ground grids.

Power factor

Active and reactive power, displacement and true power factor, power factor improvement, power factor correction, power factor penalty, avantages of power factor correction, voltage rise due to capacitance, applications of synchronous condensers, static VAR compensators.

Measuring and solving power quality problems

Power quality measuring equipment :types of instruments, wiring and grounding testers, multimeters, , digital cameras, oscilloscopes, disturbance analysers, spectrum analyzers and harmonic analyzers, flicker meters, smart power quality monitors, Active and passive filters for harmonic reduction. Measuring and simulation techniques for Harmonics analysis and THD calculations.

Text Books

1. Roger .C. Dugan, Mark F.Mcgranaghan & H.Wayne Beaty," Electrical power system Quality" McGraw-Hill Newyork Second edition 2003
2. Sankaran C,"Power Quality", CRC press special Indian edition 2009

Reference Books

1. Barry W.Kennedy, "Power Quality Primer", McGraw-Hill, New York, 2000.
2. Math H.J.Bollen, « Understanding Power Quality Problems : Voltage Sags and Interruptions », IEEE Press, New York, 2000.
3. Arrillaga.J, Watson.N.R and Chen.S, « Power System Quality Assessment », John Wiley & Sons Ltd., England, 2000

Course contents and Lecture schedule

Sl No.	Topic	No.of lectures
1	**Introduction**	1
1.1	Voltage quality :Terms and definitions, Power quality issues	1
1.2	Transients, long duration, voltage variations, short duration voltage variations	1
1.3	Voltage unbalance, waveform distortion,	1
1.4	Voltage fluctuation, power frequency variations	1
2	**Voltage sag**	
2.1	Voltage sags , sources of sags and interruptions	1
2.2	Estimating voltgae sag performance, equipment sensitivity to voltage sags	1

2.3	Transmission system sag performance evaluation	1
2.4	Utility distribution system sag performance evaluation	1
2.5	Solution for sags at end user level, ferro resonaant transformers	1
2.6	Magnetic synthesizers, active series compensators	1
3	**Transients**	
3.1	Transient system model, examples of transient models	1
3.2	Transient model response, power system transient model	1
3.3	Types and causes of transients	1
3.4	Ligntning, ferri resonance , other switching transients	1
4	**Harmonics**	
4.1	IEEE standards, Definition, harmonic number, odd and even harmonics	2
4.2	Harmonic phase rotation and phase angle relationship	1
4.3	Causes of voltage and current harmonics	1
4.4	Individual and total harmonic distortion	1
4.5	Power system quantities under non sinusoidal conditions	1
4.6	Harmonic signatures, effects of harmonics on power system devices	1
4.7	Guidelines for harmonics voltage and current imitation,harmonic current mitigation	1
5	**Grounding**	
5.1	Shock and fire hazards	1
5.2	Essential of a grounded system, ground electrodes	1
5.3	Earth resistance tests,earth – groung grid systems	1
5.4	Power ground system, signal reference ground	1
5.5	Signal reference ground methods, single point and multipoint grounding	1
5.6	Ground loops, electrochemical reactions due to ground grids	1
6	**Power factor**	
6.1	Active and reactive power, displacement and true power factor	1
6.2	Power factor improvement, power factor correction,	1
6.3	Power factor penalty,advantages of power factor correction	1
6.4	Voltage rise due to capacitance, applications of synchronous condensers	1
6.5	Static VAR compensators.	1
7	**Measuring and solving power quality problems**	
7.1	Power quality measuring equipment,types	1
7.2	Wiring and grounding testers, multimeters	1
7.3	Digital cameras, oscilloscopes	1
7.4	Disturbance analysers, spectrum analyzers	1
7.5	Harmonic analyzers, flicker meters	1
7.6	Smart power quality monitors	1
7.7	Active and passive filters for harmonic reduction	2
7.8	Measuring and simulation techniques for Harmonics analysis and THD calculations.	2
	Total	**44**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECP	3	0	-	3

ECP Real Time Operating Systems 3:0

Preamble

Real-time systems play a crucial role in our society since an increasing number of complex embedded systems rely, in part or completely, on processor control. Examples of real-time applications include automotive electronics, air traffic control, and railway switching systems, nuclear power plants, telecommunications, and robotics. The RTOS determines which applications should run in what order and how much time should be allowed for each application before giving processor access to another process. The functions of the RTOS are to manage the sharing of internal memory among multiple tasks, to handle input and output to and from attached hardware devices such as serial ports, buses, and I/O device controllers and to send messages about the status of operation and any errors that may have occurred.

Program Outcomes Selected

(a) Ability to apply knowledge of mathematics, science, and engineering

(c) Ability to design a system, component, or process to meet desired needs

(d) Ability to function on multi-disciplinary teams

(e) Ability to identify, formulate, and solve engineering problems

(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course students should be able to:

1. understand basics of Embedded systems
2. understand about the Devices and Communication Buses for Devices Network
3. understand about the interrupt service mechanism in Embedded systems
4. know about RTOS and RTOS Programming Concepts
5. Able to design an Embedded System by programming using µCOS-II RTOS for various applications

Assessment pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	20
2	Understand	40	30	30
3	Apply	40	30	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	20	20

Course level Learning Objectives

Remember

1. Define a system and an embedded system.
2. When do we need an RTOS?
3. What are the internal serial-communication devices in (a) 8051 and (b) 68HC11? Compare the modes of working of each of these.
4. What do you mean by hot attachment and detachment? What are bus protocols of buses Bluetooth, UART, CAN, PCI and USB that support hot attachment and detachment?
5. Define context, interrupt latency and interrupt service deadline.
6. Define critical section of a task. What are the ways by which the critical sections run by blocking other process(es)?

Understand

1. Explain the need of watchdog timer and reset after the watched time.
2. Explain the advantages of internet-enabled systems. How is the internet-enabled device incorporated in the embedded system?
3. Explain use of each control bit of I^2C bus protocol.
4. Explain the importance of the following declarations: static, volatile and interrupt in embedded C.
5. Write a device driver for a COM serial line port in C including in-line assembly codes.
6. Explain with one example each, APEG, SDFG and HSDFG.
7. What are the_situations, which lead to priority inversion problems? How does an OS solve this problem by a priority inheritance mechanism?
8. How do you choose scheduling strategy for the periodic, aperiodic and sporadic tasks?
9. Explain the applications of simulation annealing method.

Apply

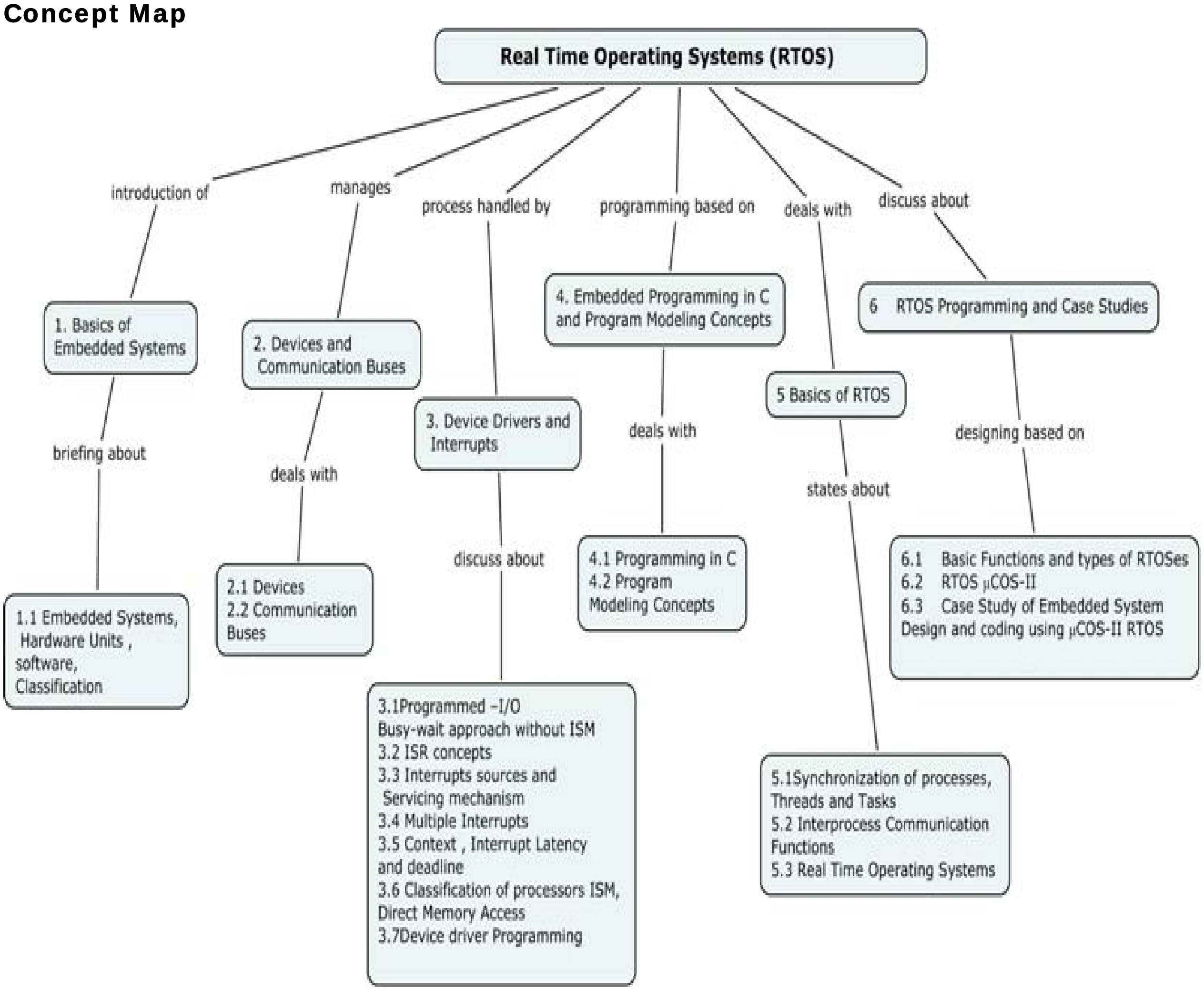
1. A 16-bit counter is getting inputs from an internal clock of 12 MHz. There is a prescaling circuit, which prescales by a factor of 16. What are the time intervals at which overflow interrupts occur from this timer? What will be period before which this interrupts must be serviced?
2. How do you initialize and configure a device? Take an example of serial-line driver at COM port of PC.
3. Draw an FSM model of an automatic chocolate-vending machine program. The machine permits only one type of coin, Rs. 1, one chocolate at a time and one chocolate is cost is Rs. 8.
4. Assume that four processes are scheduled to run on two processors. A program is partitioned in such a way that with each 10,000 ns each process schedules 10 times on each processor. What will be the minimum number of contexts switching/microsecond?
5. How will you create and display SMS message T9 keypad of a mobile phone? Use the states, FSM model and state tables for all keys 0, 1 to 9 with T9 keypad. Use suitable template.
6. List the processes in the smart mobile phone. The display process has multiple threats in the phone. List the threats. List the IPC functions required and their uses in the phone.

7. How do you set the priorities and parameters, OS_LOWEST_PRIO and OS_MAX_TASKS, for pre-emptive scheduling of the tasks using μCOS-II?

Create

1. Take a mobile smart phone with a T9 keypad. Write a table for the states of each key. Write another table for the new states generated by a combination of two keys.
2. Write program C codes for a loop for summing 10 integers with odd indices only. Each integer is 32 bits. Now unroll the loop and write C codes afresh. Compare the code length in both cases.
3. Draw the class diagram of Controller Tasks for a digital camera.
4. Draw the state diagram of ACVM functions and digital camera functions.
5. Develop the coding for an automatic chocolate vending machine using μCOS-II RTOS.
6. How do you set the priorities and parameters, OS_LOWEST_PRIO and OS_MAX_TASKS, for pre-emptive scheduling of the tasks using μCOS-II?

Concept Map



Syllabus

Basics of Embedded Systems
Embedded Systems, Hardware Units , software, Classification.

Devices and Communication Buses
Devices- I/O types, Serial and Parallel communication devices, Wireless Devices, Timer and Counting Devices, Watchdog Timer, Real Time Clock, Networked Embedded Systems. Communication Buses- Serial Bus Communication Protocols, Parallel Bus Device Protocols, Internet Enabled Systems, Wireless and Mobile System Protocols.

Device Drivers and Interrupts
Programmed –I/O Busy-wait approach without ISM, ISR concepts, Interrupts sources and Servicing mechanism, Multiple Interrupts,
Context, Interrupt Latency and deadline, Classification of processors ISM, Direct Memory Access, Device driver Programming.

Embedded Programming in C and Program Modeling Concepts
Programming in C :C Program Elements, Macros and Functions, Program Modeling Concepts- Program models, DFG models, State Machine Programming models.

Basics of RTOS
Synchronization of processes, Threads and Tasks - Multiple Processes, Multiple Threads in an application, Tasks, Task States and Data, Interprocess Communication Functions – Semaphores, Signal Function and Semaphore Functions, Message Queue Functions, Real Time Operating Systems - OS Services, Process Management, Timer and Event Functions, Memory, Device, File, I/O Subsystems Management, Interrupt routines in RTOS Environment, Basic Design Using an RTOS, RTOS Task Scheduling Models, Interrupt latency.

RTOS Programming and Case Studies
Basic Functions and types of RTOSes, RTOS µCOS-II, Case Study of Embedded System Design and coding using µCOS-II RTOS-Automatic Chocolate Vending Machine.

Text Book

1. Raj Kamal, “Embedded Systems- Architecture, Programming and Design” Second edition , Tata McGraw Hill, 2008.

Reference Books

1. David E.Simon, “An Embedded Software Primer”, Pearson Education, 2006
2. C.M. Krishna, Kang, G.Shin, “Real Time Systems”, McGraw Hill, 1997.
3. Phillip A. Laplante, Real Time Systems Design and Analysis, An Engineer’s Handbook, Second Edition, PHI India, 1997.
4. Charles Crowley, “Operating Systems-A Design Oriented approach” McGraw Hill,1997.
5. J. Archer Harris “Schaum's Outline of Operating Systems” Schaum's Outline Series, 2001.
6. www.micrium.com

Course Contents and lecture Schedule

S.No.	Topic	No. Of Lectures
1	**Basics of Embedded Systems**	
1.1	Embedded Systems, Hardware Units , software, Classification	2
2	**Devices and Communication Buses**	
2.1	Devices	
2.1.1	I/O types, Serial and Parallel communication devices	1
2.1.2	Wireless Devices	1
2.1.3	Timer and Counting Devices	1
2.1.4	Watchdog Timer, Real Time Clock	1
2.1.5	Networked Embedded Systems	1
2.2	Communication Buses	
2.2.1	Serial Bus Communication Protocols	1
2.2.2	Parallel Bus Device Protocols	1
2.2.3	Internet Enabled Systems	1
2.2.4	Wireless and Mobile System Protocols	1
3	**Device Drivers and Interrupts**	
3.1	Programmed –I/O Busy-wait approach without ISM	1
3.2	ISR concepts	1
3.3	Interrupts sources and Servicing mechanism	2
3.4	Multiple Interrupts	1
3.5	Context , Interrupt Latency and deadline	1
3.6	Classification of processors ISM, Direct Memory Access	1
3.7	Device driver Programming	1
4	**Embedded Programming in C and Program Modeling Concepts**	
4.1	Programming in C	
4.1.1	C Program Elements, Macros and Functions	1
4.2	Program Modeling Concepts	
4.2.1	Program models, DFG models	1
4.2.2	State Machine Programming models	1
5	**Basics of RTOS**	
5.1	Synchronization of processes, Threads and Tasks	
5.1.1	Multiple Processes, Multiple Threads in an application	1
5.1.2	Tasks, Task States and Data	1
5.2	Interprocess Communication Functions	
5.2.1	Semaphores	1
5.2.2	Signal Function and Semaphore Functions	1
5.2.3	Message Queue Functions	1
5.3	Real Time Operating Systems	
5.3.1	OS Services	2
5.3.2	Process Management	1
5.3.3	Timer and Event Functions	1
5.3.4	Memory, Device, File, I/O Subsystems Management	2
5.3.5	Interrupt routines in RTOS Environment	1
5.3.6	Basic Design Using an RTOS	2
5.3.7	RTOS Task Scheduling Models, Interrupt latency	2
6	**RTOS Programming and Case Studies**	
6.1	Basic Functions and types of RTOSes	2

6.2	RTOS µCOS-II	3
6.3	Case Study of Embedded System Design and coding using µCOS-II RTOS	
6.3.1	Automatic Chocolate Vending Machine	2
	Total	**45**

Course designers

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Sub code	Lectures	Tutorial	Practical	Credit
ECQ	3	-	-	3

ECQ Computer Networks 3:0

Preamble

Computer network is taught as an introductory course which contains all fundamental knowledge about networking. The course describes about network layers and its functions in networking. Various topologies and protocols are explained elaborately. Comparisons of several topologies are done for better understanding. The details about several applications and uses of networking are described.

Program Outcomes addressed

(a) Ability to apply knowledge of mathematics, science, and engineering
(d) Ability to function on multi-disciplinary teams
(e) Ability to identify, formulate, and solve engineering problems
(i) A recognition of the need for, and an ability to engage in life-long learning
(j) A knowledge of contemporary issues
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At end of the course the graduates will be able to :

1. Acquire knowledge about Networking and Engineering.
2. Determine the performance of a Computer network.
3. Synthesize Addressing mechanisms for Computer networks.
4. Design services based on Computer networks.
5. Able to design a secured network.
6. Able to build efficient network to all modern requirement.

Assessment pattern

S.No.	Bloom's category	Test1	Test2	Test3 / end semester Examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	30	30	30
4	Analyze	30	30	30
5	Evaluate	0	0	0
6	Create	0	0	0

Remember

1. What are the uses of Computer network?
2. Mention the services provided by the Physical Layer.
3. What is a peer to peer process?
4. Define FDDI.
5. Why we need IEEE 802.2?
6. What are the functions of medium access sub layer?
7. Define Internetworking.
8. Differentiate between TCP and UDP protocols.
9. Discuss the issues in transport layer.
10. Define File transfer protocol

Understand

1. Explain with a neat sketch, the functioning of each layer of the OSI model and illustrate how communication is taking place between two end systems.
2. Describe the basic services provided by ISDN.
3. What is the basic purpose of MAC sub layer protocols? Explain the features, functions and performance of IEEE 802.5 token ring protocol.
4. Explain in detail about the Standard Ethernet protocol with necessary cabling in physical layer.
5. Why do you need routing protocols? Explain the operation of distance vector routing algorithm.
6. Explain the features, functions and performance of IEEE 802.11 standard.
7. List the primitives for a simple transport service and explain the operation of simple connection management scheme with the state diagram.
8. What is network security? Illustrate the concept of Cryptography.
9. What is a proxy server and how is it related to HTTP?
10. Write short notes on: i) CSMA/CA ii) DNS

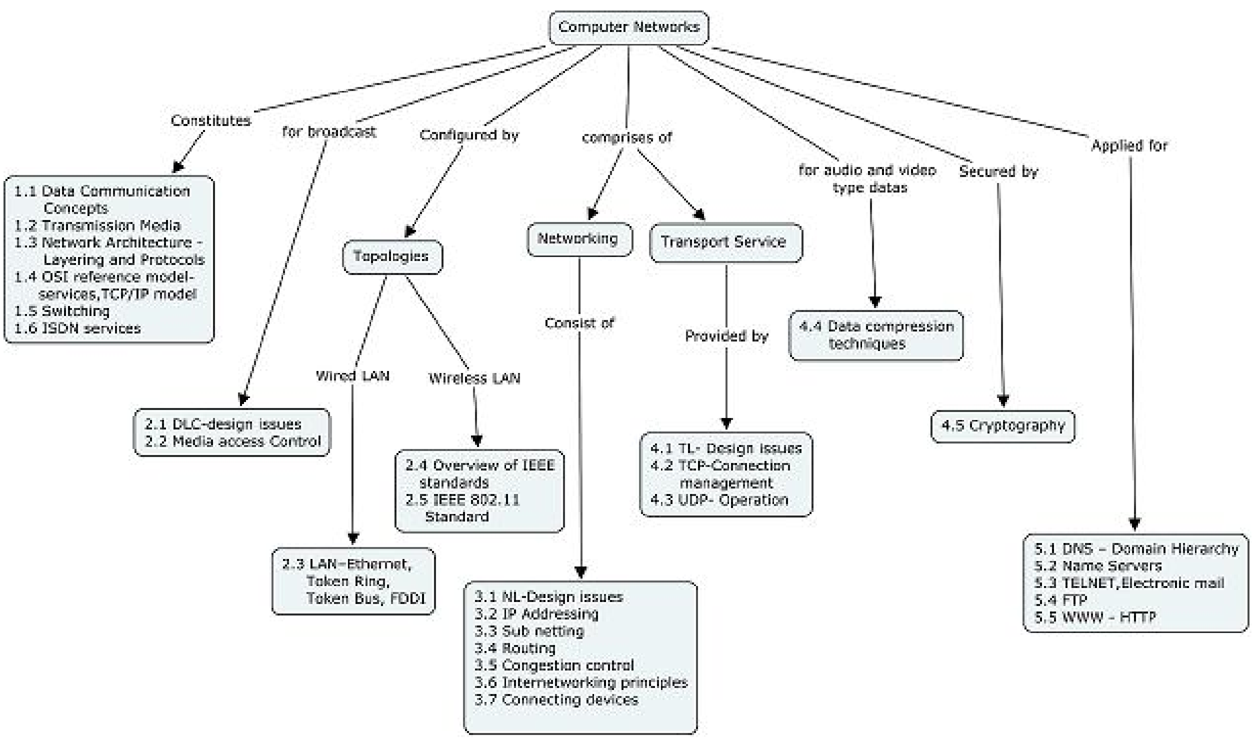
Apply

1. Show a routing table for a host that is connected to LAN without being connected to internet.
2. The internet is roughly doubling in size in every 18 months although no one really knows for sure, one estimate put the number of hosts on it at 7 million in January 1996. Use these data to compute the expected number of internet hosts in the year 2008
3. Change the following IP address from dotted decimal notation to binary notation
   a) 114.34.12.8 b) 127.24.6.8 c) 242.34.54.15
4. Consider building CSMA/CD network running at 1Gbps over a 1-km cable with no repeaters. The signal speed in the cable is 20,000 km/sec. What is the minimum frame size?
5. Sketch the Manchester and differential Manchester encoding foe the bit stream 0001110101. Assume the line is initially in the low state.
6. A 4 Mbps token ring has a token holding timer value of 10 msec. What is the longest frame that can be sent on this ring?

Analyze

1. Suppose a computer send a packet at the network layer to another computer somewhere in the network. The logical destination address of the packet is corrupted. Analyse what happens to the packet? How can the source computer are informed of the situation.
2. Why most of the addresses in class A are wasted. Analyse why a medium size or large size corporation does not want a block of class C addresses.
3. Investigate the following address 43:7B:6C: ED: 10:00 at a source address on Ethernet frame and check why it is discarded by the receiver.
4. In a token ring the sender removes the frame. What modification to the system would be needed to have the receiver remove the frame instead, and what would the consequences be?
5. Two networks each provide reliable connection-oriented service. One of them offers a reliable byte stream and the other offers a reliable message stream. Are these identical? If so, why is the distinction made? If not give an example of how they differ.
6. Assuming that all routers and hosts are working properly and that all software in both is free of all errors, is there any chance, however small, that a packet will be delivered to the wrong destination.

Concept Map



Syllabus

Fundamentals

Data Communication Concepts – Basics, Transmission Media, Network Architecture - Layering and Protocols, OSI reference model-services, TCP/IP model, Switching – Circuit Switching, Packet Switching, ISDN services.

Medium access sub layer / DLL
Data Link Control-design issues, Media access Control- CSMA/CD, CSMA/CA, Token passing method, LAN–Ethernet, Token Ring, Token Bus, FDDI, Overview of IEEE standards, Wireless LAN-IEEE 802.11.

Network Layer
NL-Design issues, IP Addressing, Sub netting, Routing – Distance Vector Routing, Link State Routing, Congestion control, Internetworking principles, Connecting devices – Hub, Repeaters, Bridges, Routers, Switches.

Transport layer
TL- Design issues, TCP-Connection management, UDP-Operation, Data compression techniques, Cryptography.

Applications and Uses
DNS – Domain Hierarchy, Name Servers, TELNET, Electronic mail, FTP, WWW – HTTP.

TEXT BOOK

1. Behrouz A.Forouzan, “Data Communication and Networking”, Tata McGraw-Hill, 2004.

REFERENCE BOOKS

1. Larry L.Peterson and Peter S.Davie, “Computer Networks”, Harcourt Asia Pvt.Ltd., Second Edition.
2. Andrew S.Tanenbaum,“Computer Networks”, PHI,Fourth Edition,2003.

Course content and Lecture Schedule

S. No.	Topics	No of lectures
1.	**Fundamentals**	
1.1	Data Communication Concepts - Basics.	1
1.2	Transmission Media	1
1.4	Network Architecture - Layering and Protocols	1
1.5	OSI reference model-services, TCP/IP model	2
1.6	Switching – Circuit Switching, Packet Switching	1
1.7	ISDN services	2
2	**Medium access sub layer / DLL**	
2.1	Data Link Control -design issues	1
2.2	Media access Control- CSMA/CD,CSMA/CA, Token passing method	2
2.3	LAN–Ethernet, Token Ring, Token Bus, FDDI	2
2.4	Overview of IEEE standards	1
2.5	Wireless LAN-IEEE 802.11	2
3	**Network Layer**	
3.1	NL-Design issues	1
3.2	IP Addressing	2
3.3	Sub netting	1
3.4	Routing – Distance Vector Routing - Link State Routing	2
3.5	Congestion control	2
3.6	Internetworking principles	1

3.7	Connecting devices – Hub, Repeaters, Bridges, Routers, Switches	1
4	**Transport layer**	
4.1	TL- Design issues	1
4.2	TCP-Connection management	2
4.3	UDP- Operation	2
4.4	Data compression techniques	2
4.5	Cryptography	1
5	**Applications**	
5.1	DNS – Domain Hierarchy	2
5.2	Name Servers	1
5.3	TELNET, Electronic mail	2
5.4	FTP	1
5.5	WWW - HTTP	2
	Total	**42**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECR	3	-	-	3

ECR Distributed Generation Systems 3:0

Preamble

Distributed Generation system would provide the platform for the use of renewable sources and adequate emergency power for major metropolitan load centers, remote villages and would safeguard in preventing the complete blackout of the interconnected power systems due to man-made events and environmental calamity and would provide the ability to break up the interconnected power systems into the cluster smaller regions. Based on this, the course aims at giving an adequate exposure in Distributed Generation system, Economics of Distributed Resources, Wind Power Systems, Photovoltaic Systems & State of the art of hybrid systems

Programme Outcomes addressed

a) Ability to apply knowledge of mathematics, science and engineering
c) Ability to design a system, component or process to meet desired needs
d) Ability to function on multi – disciplinary teams
e) Ability to identify, formulate and solve engineering problems
h) The broad education necessary to understand the impact of engineering solutions in a global and societal context

Competencies

At the end of the course the student should be able to:

1. Understand the need of Distributed Generation Systems.
2. Determine the economic attributes of the technologies that can most efficiently utilize Renewable resources.
3. Identify the suitable potential sources to develop Distributed Generation systems.
4. Do first-order calculations on how the Distributed generation systems will actually perform.
5. Understand the operation of Hybrid Systems.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What are advantages of Distributed Generation Systems?
2. What is mean by Micro Turbine?
3. What is mean by HHV and LHV?
4. What is mean by payback period?
5. What is mean by cost of conserved energy (CCE)?
6. What are the environmental impacts of wind turbines?
7. What is mean by Maximum power point trackers?
8. What are the main components of Hybrid systems?
9. What do you mean by Dump loads?
10. What is mean by super conducting magnetic energy storage?

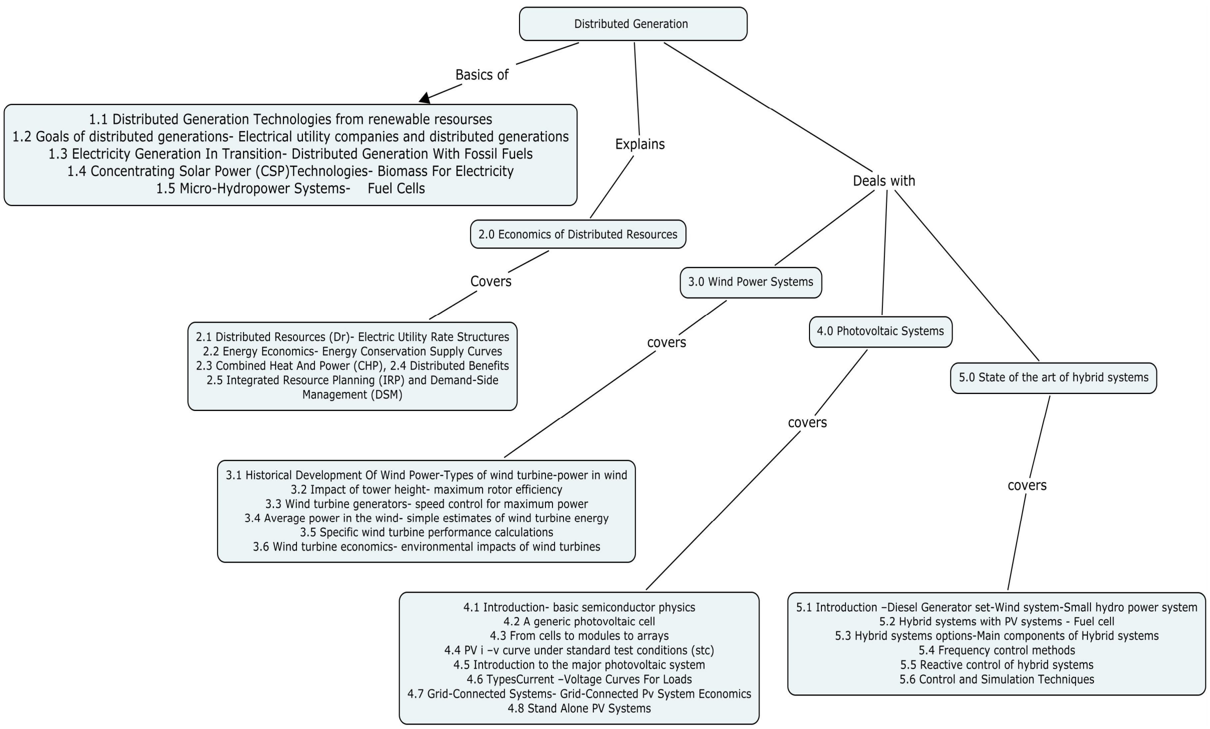
Understand

1. Explain the Bio mass Gasification process?
2. What are the goals of Goals of distributed generations?
3. What is the impact on power utility companies because of Distributed generation systems
4. What do you mean by real time pricing?
5. Explain the benefits of Distributed Generation Systems?
6. How will find the rotor maximum efficiency?
7. Consider a 100-cm^2 photovoltaic cell with reverse saturation current I_0=10 .12 A/cm^2. In full sun, it produces a short-circuit current of 40 mA/cm 2 at 25 degree C. Find the open-circuit voltage at full sun and again for 50%sunlight. Plot the results.
8. Explain the stand alone PV systems?
9. What are the various configurations in an autonomous hybrid system?
10. Why the reactive power is need to control in a hybrid systems?

Apply

1. A microturbine has a natural gas input of 13,700 Btu (LHV) per kWh of electricity generated. Find its LHV efficiency and its HHV efficiency?
2. A 3-kW photovoltaic system, which operates with a capacity factor (CF)of 0.25,costs $10,000 to install. There are no annual costs associated with the system other than the payments on a 6%, 20-year loan. Find the cost of electricity generated by the system. Take the capital recovery factor is 0.0872/yr.
3. How will you calculate the power in the wind?
4. Develop a simple equivalent circuit for PV cell.
5. How will you develop photovoltaic module from cells?
6. Explain how will you use a PV system to run a DC motor?
7. How will you use a Buck Boost converter as maximum power tracker for a PV system?
8. What procedure will you follow to calculate PV sizing for a particular applications?
9. Draw the schematic diagram for a general isolated wind –diesel hybrid power systems.
10. How will you control the reactive power of hybrid system using static synchronous compensator?

Concept Map



Syllabus

Distributed Generation

Introduction – Distributed Generation Technologies-Solar photovoltaic power-wind-fuel cells-Diesel Generator- hydro & Micro turbines **–** Goals of distributed generations-Electrical utility companies and distributed generations-Electricity Generation In Transition-Distributed Generation With Fossil Fuels- Concentrating Solar Power (CSP)Technologies-Biomass For Electricity **-** Micro-Hydropower Systems-Fuel Cells**. (Treatment as per text book 1)**

Economics of Distributed Resources

Distributed Resources (Dr)- Electric Utility Rate Structures- Energy Economics- Energy Conservation Supply Curves **–**Energy Economics- Energy Conservation Supply Curves-Combined Heat And Power (CHP)-Distributed Benefits Integrated Resource Planning (IRP) and Demand-Side Management (DSM). **(Treatment as per text book 1)**

Wind Power Systems

Historical Development Of Wind Power-Types of wind turbine-power in wind-Impact of tower height- maximum rotor efficiency-Wind turbine generators- speed control for maximum power-Average power in the wind- simple estimates of wind turbine energy-Specific wind turbine performance calculations-Wind turbine economics- environmental impacts of wind turbines. **(Treatment as per text book 1)**

Photovoltaic Systems

Introduction- basic semiconductor physics-A generic photovoltaic cell-From cells to modules to arrays-PV *i* –*v* curve under standard test conditions (stc) Introduction to the major photovoltaic system Types-Current –Voltage Curves For Loads Grid-Connected Systems-Grid-Connected PV System Economics-Stand Alone PV Systems **(Treatment as per text book 1)**

State of the art of hybrid systems

Introduction –Diesel Generator set-Wind system-Small hydro power system- Hybrid systems with PV Systems and Fuel cell-Hybrid systems options-Main components of Hybrid systems Frequency control methods-Reactive control of hybrid systems-Control and Simulation Techniques **(Treatment as per text book 2)**

Text Books

1. Gilbert M.Masters, "Renewable and Efficient Electric Power Systems", John Wiley & Sons,Inc.,Hoboken,New Jersey,2004.
2. Bansal.R, Bhatti.T.S, " Small signal Analysis of isolated Hybrid power systems", Narosa Publishing House Pvt.Ltd.New Delhi,2008.

Reference Books

1. Paul Breeze, "Power Generation Technologies", Newnes, An imprint of Elsevier, Linacre House, Jordan Hill, Oxford OX2 8DP,2005.
2. Lee willis .H, Walter G.Scott, " Distributed Power Generation", Marcel Dekker, Inc, USA, 2000
3. Sachin Jain, Vivek Agarwal, "An Integrated Hybrid Power Supply for Distributed Generation Applications Fed by Nonconventional Energy Sources", IEEE Transactions on Energy Conversion, vol. 23, no. 2, June 2008

Course contents and Lecture schedule

Sl.No.	Topic	No. of Lectures
1.0	**Distributed Generation**	**5**
1.1	Introduction – Distributed Generation Technologies-Solar photovoltaic power-wind-fuel cells-Diesel Generator- hydro & Micro turbines	1
1.2	Goals of distributed generations- Electrical utility companies and distributed generations	1
1.3	Electricity Generation In Transition- Distributed Generation With Fossil Fuels	1
1.4	Concentrating Solar Power (CSP) Technologies- Biomass For Electricity	1
1.5	Micro-Hydropower Systems- Fuel Cells	1
2.0	**Economics of Distributed Resources**	**6**
2.1	Distributed Resources (Dr)- Electric Utility Rate Structures	1

2.2	Energy Economics- Energy Conservation Supply Curves	2
2.3	Combined Heat And Power (CHP)	1
2.4	Distributed Benefits	1
2.5	Integrated Resource Planning (IRP) and Demand-Side Management (DSM)	1
3.0	**Wind Power Systems**	**12**
3.1	Historical Development Of Wind Power-Types of wind turbine-power in wind	2
3.2	Impact of tower height- maximum rotor efficiency	2
3.3	Wind turbine generators- speed control for maximum power	2
3.4	Average power in the wind- simple estimates of wind turbine energy	2
3.5	Specific wind turbine performance calculations	2
3.6	Wind turbine economics- environmental impacts of wind turbines	2
4.0	**Photovoltaic Systems**	**12**
4.1	Introduction- basic semiconductor physics	1
4.2	A generic photovoltaic cell	2
4.3	From cells to modules to arrays	2
4.4	PV *i* –*v* curve under standard test conditions (stc)	1
4.5	Introduction to the major photovoltaic system Types	1
4.6	Current –Voltage Curves For Loads	2
4.7	Grid-Connected Systems- Grid-Connected Pv System Economics	2
4.8	Stand Alone PV Systems	1
5.0	**State of the art of hybrid systems**	**10**
5.1	Introduction –Diesel Generator set-Wind system-Small hydro power system	2
5.2	Hybrid Systems with PV Systems and Fuel cell	2
5.3	Hybrid Systems options-Main components of Hybrid systems	2
5.4	Frequency control methods	2
5.5	Reactive control of hybrid systems	2
5.6	Control and Simulation Techniques	
	Total	**45**

Course Designers

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Sub code	Lectures	Tutorial	Practical	Credit
ECS	3	-	-	3

ECS Automotive Electronics 3:0

Preamble

This course unfolds the application of electronics engineering to vehicle motion control. This course mainly focuses on the engine control, various sensors and actuators employed for motion control, and automotive instrumentation.

Program Outcomes addressed

(a) Ability to apply knowledge of mathematics, science, and engineering
(b) Ability to design and conduct experiments, as well as to analyze and interpret data
(c) Ability to design a system, component, or process to meet desired needs
(d) Ability to function on multi-disciplinary teams
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course the students will be able to :

1. Identify the various components involved in vehicle motion.
2. Apply electronic principles for various measurements required in automotives.
3. Explain the working of different sensors and actuators employed in vehicles.
4. Evaluate various parameters of vechile engine.
5. Analyze the different techniques employed for engine control.
6. Explain the controls involved in vechile motion control

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test3 / End-semester examination
1	Remember	30	30	20
2	Understand	40	40	40
3	Apply	0	0	0
4	Analyze	10	10	20
5	Evaluate	20	20	20
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Draw the block diagrams for various system applications.
2. Define - brake-specific fuel consumption.
3. Define- Thermal efficiency.
4 .what is meant by airflow rate?

5. State the hall effect.
6. Write the desirable characteristics of Exhaust gas recirculation actuator.
7. Write short notes on electronic suspension system.
8. Name some of the sensors employed in vehicles.
9. Write brief notes on Brushless dc motor.

Understand

1. Explain the concept of analog and digital PID controller.
2. Explain the concept of electronic engine control system.
3. Describe the electronic fuel control configuration.
4. Discuss the working principle of throttle angle sensor.
5. Explain the typical cruise control configuration.
6. Discuss the working of vacuum-operated throttle actuator.

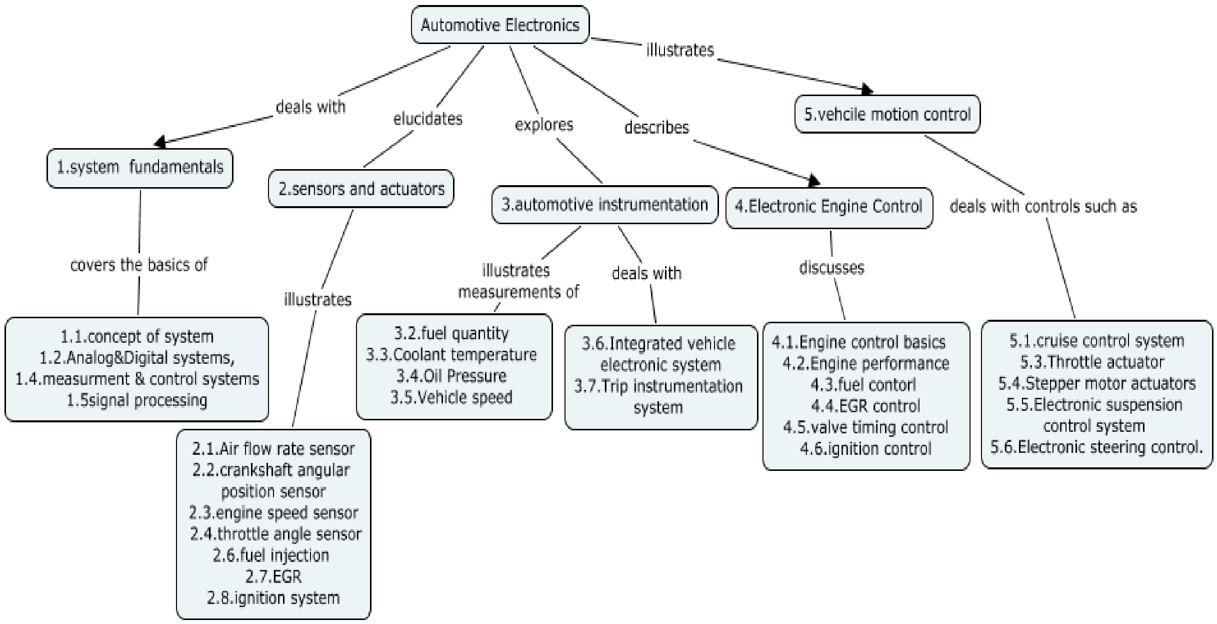
Analyze

1. Analyze the Exhaust gas recirculation actuator control.
2. Analyze the Electronic ignition control with neat diagram.
3. Compare different Position sensors for sensing the shaft position of the engine.
4. Investigate the difficulties occur during the fuel quantity measurement.
5. Differentiate the speed control methods used in Automotives.
6. Analyze the role of Brushless dc motor in vehicle motion control.

Evaluate

1. Justify the usage of Hall Effect in position sensing sensor.
2. Evaluate the open and closed loop control methods used in Automotives
3. Estimate the volumetric efficiency and thermal efficiency of the electrical engine
4. Compare conventional and power steering controls used in four wheel steering system.
5. Estimate the break-specific fuel consumption and torque of the electrical engine
6. Evaluate the effect of air/fuel ratio on performance of the engine

Concept map



Syllabus

System fundamentals

Review of automotives - representation of various systems – Analog systems – Digital systems – Electronic system performance – Measurement systems – Control systems – Signal processing.

Automotive Sensors and actuators

Air flow rate sensor - Engine crankshaft angular position sensor – Engine speed sensor – Hall Effect position sensor – Optical crankshaft position sensor – throttle angle sensor- Automotive engine control actuators – fuel injector – Pulse mode fuel control signal – EGR actuators - Ignition systems.

Automotive instrumentation

Computer based automotive instrumentation – input output signal conversion – fuel quantity measurement – Coolant temperature measurement – Oil Pressure measurement – Vehicle speed measurement – Integrated vehicle electronic system – Trip instrumentation system.

Electronic Engine control

Electronic engine control system – controller inputs from engine – controller outputs to engine – Engine performance – power, brake-specific fuel consumption , torque, volumetric efficiency, thermal efficiency, calibration – Electronic fuel control – open loop and closed loop control – Exhaust gas recirculation actuator control- Variable valve timing control- Electronic ignition control.

Vehicle Motion Control

Typical cruise control system – speed response curves - Digital cruise control system – Throttle actuator – stepper motor actuator for cruise control system – Electronic suspension control system – Electronic steering control.

Text Book

1. Understanding Automotive Electronics – William B.Ribbens – Elsevier publications-2003

Reference books

1. Automotive Electrics - Robert Bosch Gmbh – John Wiley & Sons – 2007
2. Automotive Electronics Handbook - Ronald K. Jurgen, McGraw-Hill, 1999.

Course content and Lecture schedule

S.No.	Topic	No. of Lectures
1.0	**System fundamentals**	
1.1	Review of automotives – representation of various systems	2
1.2	Analog systems - Digital systems	1
1.3	Electronic system performance	1
1.4	Measurement systems , Control systems	2
1.5	Signal processing	1
2.0	**Automotive Sensors and actuators**	
2.1	Air flow rate sensor	1
2.2	Engine crankshaft angular position sensor	1
2.3	Engine speed sensor , Hall Effect position sensor	1
2.4	Throttle angle sensor	1
2.5	Optical crankshaft position sensor	1
2.6	Fuel injector, Pulse mode fuel control signal	2
2.7	Exhaust gas recirculation actuator	1
2.8	Ignition systems	1
3.0	**Automotive instrumentation**	
3.1	Computer based automotive instrumentation – input output signal conversion	2
3.2	fuel quantity measurement	1
3.3	Coolant temperature measurement	1
3.4	Oil Pressure measurement	1
3.5	Vehicle speed measurement	1
3.6	Integrated vehicle electronic system	1

3.7	Trip instrumentation system	1
4.0	**Electronic Engine control**	
4.1	electronic engine control system	2
4.2	Engine performance – power, brake-specific fuel consumption , torque, volumetric efficiency, thermal efficiency, calibration	2
4.3	Electronic fuel control , open loop and closed loop control	2
4.4	EGR control	1
4.5	Variable valve timing control	1
4.6	Electronic ignition control	1
5.0	**Vehicle Motion Control**	
5.1	Typical cruise control system , speed response curves	2
5.2	Digital cruise control system	1
5.3	Throttle actuator	1
5.4	stepper motor actuator for cruise control system	1
5.5	Electronic suspension control system	1
5.6	Electronic steering control.	1
	Total	**40**

Course Designers

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Sub code	Lectures	Tutorial	Practical	Credit
ECT	3	0	-	3

ECT Industrial Controllers 3:0

Preamble

Knowledge of Linear control system is essential for studying this course. This course is designed to impart the knowledge of industrial grade PID controllers and their digital implementation, and design procedures. Emphasis is also given to distributed, programmable controllers and model- free controllers.

Program Outcomes addressed

a. Ability apply the knowledge of mathematics, science and engineering.
c. Ability to design a system, component or process as per needs and specifications.
e. Ability to identify, formulate and solve engineering problems.
k. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course the student should be able to:

1. Demonstrate about various processes and the controllers
2. Explain the design of industrial PID controller
3. Implement digital PID for real time industrial needs
4. Explain the commercial controllers
5. Apply the distributed and programmable controllers for industrial requirements
6. Identify the various intelligent controllers for different processes

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	0	0	0
4	Analyze	40	40	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. What are the modifications of PID control?
2. Name the major building blocks of automation systems.
3. Name some final control elements.
4. What are the typical quantities used to characterize the error?
5. Define model based controllers.

6. Draw the control valve characteristics.

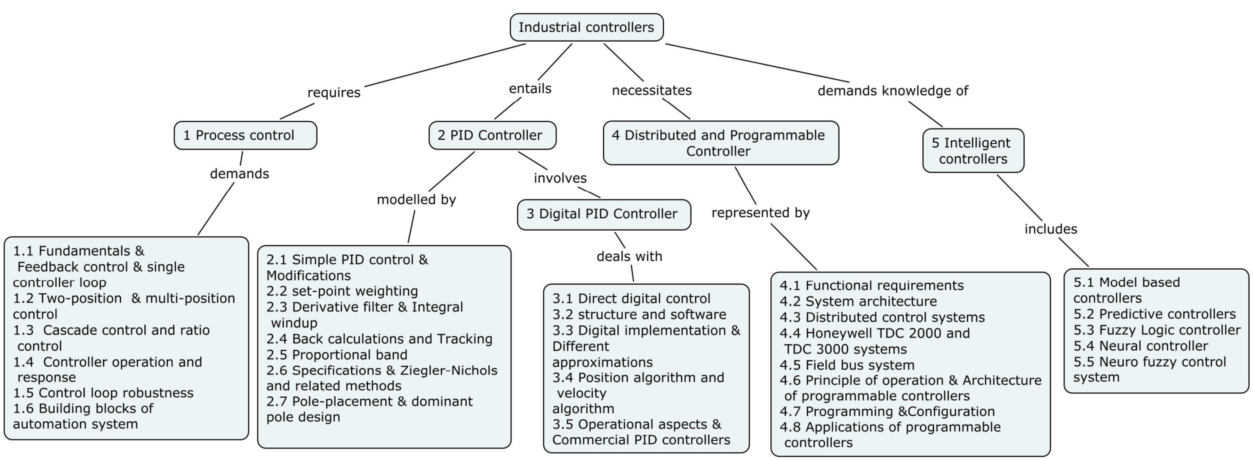
Understand

1. Differentiate between cascade control and ratio control.
2. What is Ethernet?
3. Discuss the working of some final control elements.
4. What do you understand by control loop robustness?
5. State the relations between Ziegler –Nichol's tuning methods.
6. Explain different PID tuning methods in detail.
7. Compare neural and fuzzy controllers.
8. What is the need for model-free controllers?

Analyze

1. Analyze the performance of due to various modifications of PID controller
2. Compare the performance of various intelligent controllers for any process control application.
3. Compare various discretization strategies used for digital PID controller
4. Develop PLC ladder program for ON/OFF control.
5. Analyze the advantage of distributed control over centralized control
6. Compare the various commercial PID controllers with respect to algorithm, tuning method and implementation

Concept Map



Syllabus

Process control fundamentals

Process fundamentals - Feedback control –single controller- loop-two-position control – multi-position control- cascade control-ratio control- controller operation-control system response-control loop robustness-Building blocks of automation system- Processing system - Multiprocessor systems-Analog and digital I/O modules- Supervisory control and data acquisition system- Remote terminal unit-final control element-control valve characteristics

PID Controller Design

Simple PID control-Modifications - set-point weighting- Derivative filter Integral windup- Back calculations and Tracking- Proportional Band - -Specifications-Ziegler-Nichols and related methods- pole-placement –dominant pole design

Digital PID Controller Implementation

Direct digital control – structure and software – digital implementation-different approximations- position algorithm -velocity algorithm- operational aspects -commercial PID controllers.

Distributed and Programmable Controller

Introduction to Distributed digital control- functional requirements-System architecture – Distributed control system-Honeywell TDC 2000 and TDC 3000 systems- Field bus system- Introduction to programmable controllers - Principle of operation-architecture of programmable controllers – Programming- configuration-Applications of programmable controllers

Intelligent Controllers

Introduction-Model based controllers –Predictive controller- Expert controller-Fuzzy Logic controller-Neural controller- Neuro-fuzzy control system

Text Books

1. Krishna kant, “Computer based industrial control”, PHI, second edition, 2010.
2. Karl J. Astrom, Tore Hagglund, “PID Controllers: Theory, design and Tuning”, 2nd Edition, Instrument Society of America, 1995

Reference Books

1. Krishna kant, “Digital control systems”, ISTE learning materials centre, First edition 2001
2. Sivanandham S.N, Deepa,S.N., Principles of Soft Computing, Wiley,2011.
3. Frank D. Petruzella, Programmable Logic Controllers, Tata McGraw Hill, Third Edition 2010

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**Process control**	
1.1	Fundamentals and Feedback control and single controller loop	1
1.2	Two-position and multi-position control	1
1.3	Cascade control and ratio control	1
1.4	Controller operation and response	1
1.5	Control loop robustness	1

1.6	Building blocks of automation system	
1.6.1	Processing system and Multiprocessor systems	1
1.6.2	Analog and digital I/O modules	1
1.6.3	Supervisory control and data acquisition system	1
1.6.4	Remote terminal unit and Final control element	1
1.6.5	Control valve characteristics	1
2	**PID controller design**	
2.1	Simple PID control & Modifications	1
2.2	Set-point weighting	1
2.3	Derivative filter & Integral windup	2
2.4	Back calculations and Tracking	1
2.5	Proportional band	1
2.6	Specifications and Ziegler-Nichols and related methods	1
2.7	Pole-placement & dominant pole design	1
3	**Digital PID controller implementation**	
3.1	Direct digital control	1
3.2	Structure and software	1
3.3	Digital implementation and Different approximations	2
3.4	Position algorithm and velocity algorithm	1
3.5	Operational aspects and Commercial PID controllers	2
4	**Distributed and Programmable Controller**	
4.1	Functional requirements of Distributed digital control	1
4.2	System architecture	1
4.3	Distributed control system	1
4.4	Honeywell TDC 2000 and TDC 3000 systems	1
4.5	Field bus system	1
4.6	Principle of operation and architecture of programmable controllers	2
4.7	Programming & Configuration	1
4.8	Applications of programmable controllers	1
5	**Intelligent controllers**	
5.1	Model based controllers	1
5.2	Predictive controller	1
5.3	Fuzzy Logic controller	3
5.4	Neural controller	3
5.5	Neuro-fuzzy control system	3
	Total	**45**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECU	3	-	-	3

ECU Gas Insulated Substations 3:0

Preamble

The increase in demand for electricity and the growing energy density in metropolitan cities have made it necessary to extend the existing high voltage network right up to the consumer. Stepping down the voltage from transmission to distribution level at the substation located near the actual consumers not only yield economic advantages, but also ensures reliable power supply. The development of completely enclosed substations or otherwise known as Gas Insulated Substations (GIS) and Gas Insulated Transmission Lines (GITL) towards the end of the last century has come as a boon to the power engineers. GIS of up to 800kV have been developed and are being widely used.

With ever increasing use of GIS, a student of Electrical Engineering is expected to possess knowledge of GIS. This subject is designed to give a comprehensive introduction to GIS.

Programme Outcomes addressed

(a) Ability to apply knowledge of mathematics, science, and engineering
(b) Ability to design and conduct experiments, as well as to analyze and interpret data
(c) Ability to design a system, component, or process to meet desired needs
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
(j) A knowledge of contemporary issues
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course the student should be able to:

1. Explain the properties of Gas insulations.
2. Understand the concept of components and its arrangements in GIS
3. Design a GIS Station
4. Explain the various tests to be carried on GIS
5. Understand the qualiy assurance during the testing of GIS components
6. Explain Various Problems in GIS and Diagnostics.

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	40	30	20
2	Understand	60	50	40
3	Apply	0	20	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What are the advantages of GIS?
2. Mention the important characteristics of SF_6 recycling unit?
3. List the major components of GIS.
4. What the are the major requirements for planning and Installation of GIS?
5. What are the various design features of GIS
6. What are the various type test involved in the testing of GIS?
7. Mention few Characteristic Imperfections in Insulation.
8. Define VFTO.
9. Give some reasons for the origin of VFTO.
10. Mention some special problems in GIS.

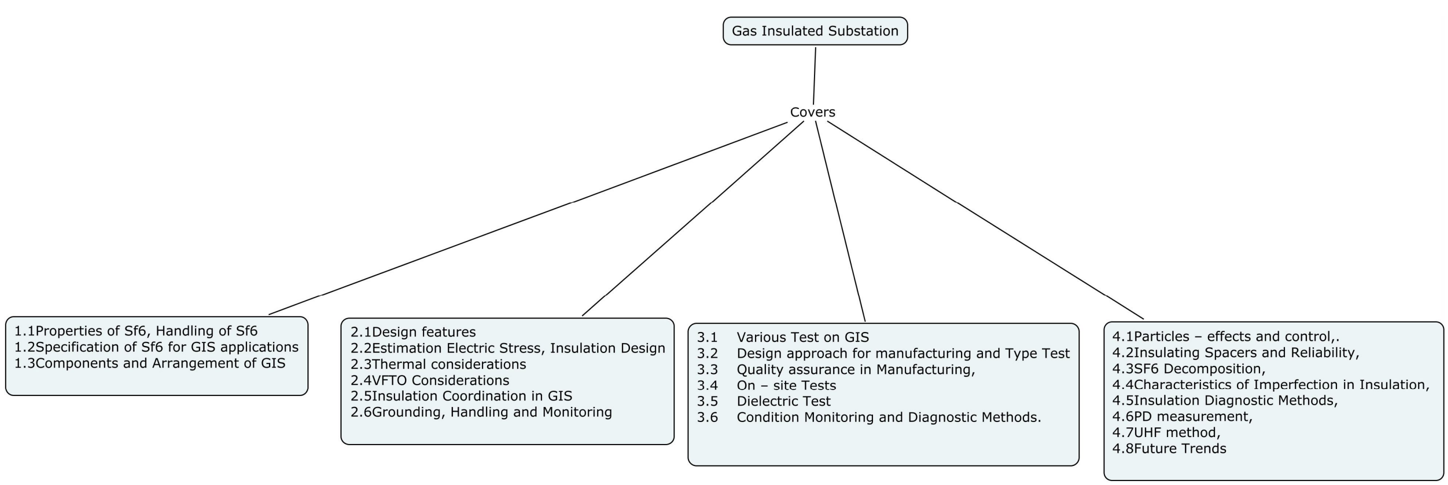
Understand

1. Justify SF_6 as a Green Gas.
2. Compare AIS and GIS.
3. Explain in detail the Basic requirement for the choice of Equipment.
4. Explain in detail the various components of GIS.
5. Briefly explain the various test carried out in GIS.
6. In detail explain the various causes for SF_6 decomposition.

Apply

1. Find the Insulation level between Breaker and LA using Insulation Co – ordination in a 400 KV GIS.
2. Give a schematic design of Gas Handling and Monitoring Systems of a GIS.
3. How do adopt Standards during the testing of GIS?
4. What kind of insulation Diagnostic Methods prefered for finding cavity in an Insulator ?
5. How do use VHF and UHF to detect the partial discharge signals ?

Concept Map



Syllabus

Introduction to GIS

Review and compariosn of Air Insulated Sub Station (AIS) and GIS, Properties of SF_6, Handling of SF_6, Specification of SF_6 for GIS applications. Components and Arrangement of GIS.

Design and Construction of GIS: Design features, Estimation Electric Stress, Insulation Design, Thermal considerations, VFTO Considerations, Insulation Coordination in GIS, Grounding, Handling and Monitoring.

Testing of GIS: Various Test on GIS, Design approach for manufacturing and Type Test, Quality assurance in Manufacturing, On – site Tests, Dielectric Tests, Condition Monitoring and Diagnostic Methods.

Problems in GIS and Diagnostics: Particles – effects and control, Insulating Spacers and Reliability, SF_6 Decomposition, Characteristics of Imperfection in Insulation, Insulation Diagnostic Methods, PD measurement, UHF method, Future Trends.

Text Book

1. M.S. Naidu, “Gas Insulated Substations”, I. K. International, New Delhi, 2008.

Reference Books

1. L.L. Alston, “High Voltage Insulation Technology”, Oxford university Press, London, 1996.

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0	**Introduction to GIS**	
1.1	Review and comparison of AIS and GISProperties of SF_6, Handling of SF_6	3
1.2	Specification of SF_6 for GIS applications	2
1.3	Components and Arrangement of GIS	2
2.0	**Design and Construction of GIS**	
2.1	Design features	1
2.2	Estimation Electric Stress, Insulation Design	2
2.3	Thermal considerations	1
2.4	VFTO Considerations	1
2.5	Insulation Coordination in GIS	1
2.6	Grounding, Handling and Monitoring	2
3.0	**Testing of GIS**	
3.1	Various Test on GIS	1
3.2	Design approach for manufacturing and Type Test	2
3.3	Quality assurance in Manufacturing	2
3.4	On – site Tests	2
3.5	Dielectric Test	2

3.6	Condition Monitoring and Diagnostic Methods	2
4.0	**Problems in GIS and Diagnostics**	
4.1	Particles – effects and control	2
4.2	Insulating Spacers and Reliability	2
4.3	SF_6 Decomposition,	2
4.4	Characteristics of Imperfection in Insulation	1
4.5	Insulation Diagnostic Methods	2
4.6	PD measurement	1
4.7	UHF method	2
4.8	Future Trends	2
	Total	**40**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
EGF	3	-	-	3

EGF Energy Conservation Practices 3:0

Preamble

Energy resource scarcity becomes one of the biggest issues in the world and leading to rise in cost. Effective utilization of Electrical energy is one of the key issues to minimize the rising cost of energy and to minimize the global warming. This course will educate the non-electrical engineers on the aspect of energy conservation in electrical equipment and Electrical Installations. It will helpful to select an energy efficient electrical system for an establishment.

Programme Outcomes addressed

(a) Ability to apply knowledge of mathematics, science, and engineering
(b) Ability to design and conduct experiments, as well as to analyze and interpret data
(c) Ability to design a system, component, or process to meet desired needs
(d) Ability to function on multi-disciplinary teams
(f) An understanding of professional ethical responsibility
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) A recognition of the need for, and an ability to engage in life-long learning
(j) A knowledge of contemporary issues
(k) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Competencies

At the end of the course the student should be able to:

1. Explain the basic principle of Energy Management and Conservation
2. Select Energy Efficient gadgets for domestic, commercial and industrial applications
3. Estimate the energy performance of Electrical Equipment
4. Get familiar about the energy conservation practices
5. Capable to carryout preliminary energy audit
6. Do energy audit in any process and manufacturing industries

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	60	60	60
3	Apply	20	20	20
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is an Energy audit?
2. List down the objective of energy management
3. Define contracted demand and billing demand.
4. Name three types of motors in industrial practice.
5. List the factors affecting energy efficiency in air compressors.
6. What are the types of commonly used lamps?
7. Specify the role of Turbo chargers.
8. What are the advantages of energy efficient motors?
9. Mention the role of demand controller in industrial plants.
10. What is the function of Automatic Power factor controller?

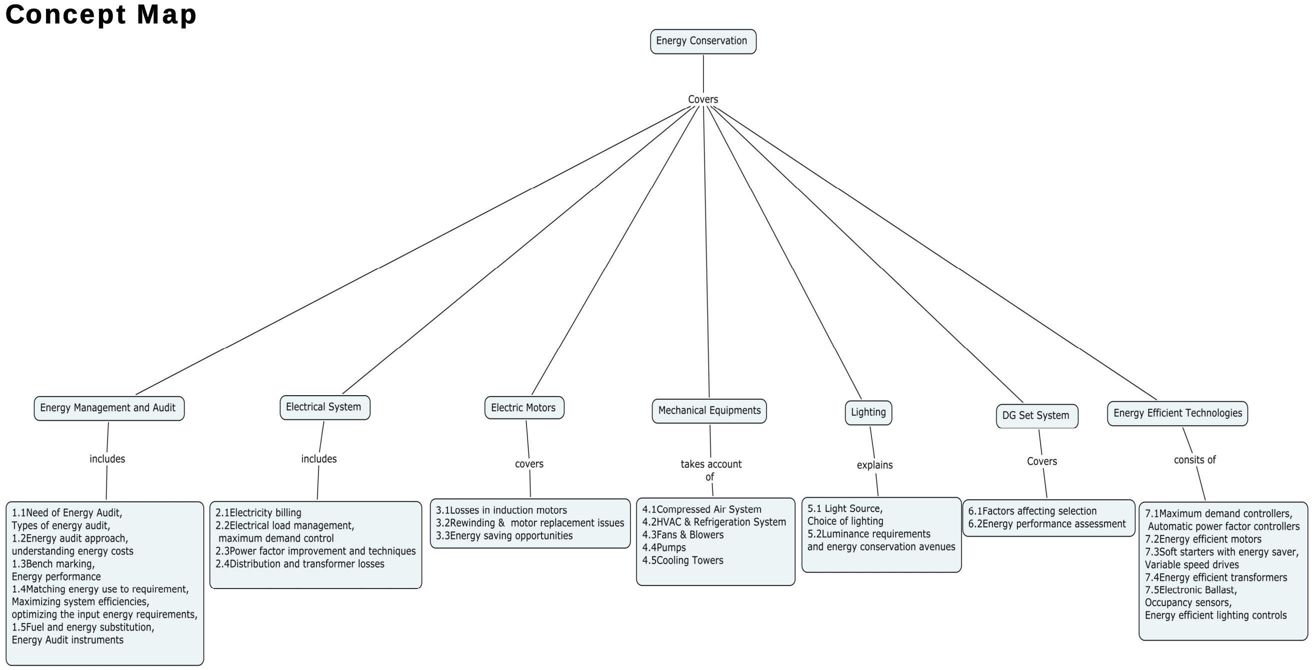
Understand

1. Explain the implications of part load operation of energy equipment with examples.
2. What are the effects of moisture on compressed air?
3. Discuss the various energy conservation opportunities in a refrigeration plant.
4. Explain what do you understand by static head and friction head.
5. What are the effects of over sizing a pump?
6. List down few energy conservation opportunities in pumping system.
7. List the energy conservation opportunities in a cooling tower system.
8. Describe the methodology of lightning energy audit in an industrial facility.
9. List the energy savings opportunities in an industrial DG Set plant.
10. Explain why centrifugal machines offer the greatest savings, when operating with Variable speed drives.

Apply

1. A 4 pole squirrel cage induction motor operates with 5% slip at full load. What is the full load RPM you may expect, if the frequency is changed by a V/F control to a)40 Hz b) 45 Hz and c) 35 Hz.
2. Slect a suitable Energy efficients light for the given working area :
    a. Packing places
    b. Cotton Stock godown
    c. Jwellery shop
    d. Manufacturing area
    e. Class rooms
3. Suggest a sutiable enegy efficent motor/drives for the given applications :
    a. Variable load (50% t0 80%)
    b. High starting torque
    c. Constant load
4. Suggest a way to improve efficiency of the transformers operating in parallel with variable loads.
5. How do select a AC system for a Computer hall having 100 computers with all accesories ?

Concept Map



Syllabus

Energy Management and Audit

Need of Energy Audit, Types of energy audit, Energy audit approach, understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, optimizing the input energy requirements, Fuel and energy substitution, Energy Audit instruments

Electrical System

Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefits, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses.

Electric Motors

Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors.

Mechanical Equipment

Compressed Air System - Efficient compressor operation, Leakage test, factors affecting performance and Efficiency. Heating Ventilating and Air-conditioning (HVAC) & Refrigeration System – Factors affecting system performance and energy savings opportunities. Fans & Blowers – Flow control strategies and energy conservation opportunities. Pumps – Flow control strategies and energy conservation opportunities. Cooling Towers– Flow control strategies and energy saving opportunities.

Lighting

Light Source-Types, Development, Applications and Limitations, Choice of lighting, Luminance requirements and energy conservation avenues.

DG Set System

Factors affecting selection, Energy performance and assessment of diesel conservation avenues.

Energy Efficient Technologies in Electrical Systems

Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic Ballast, Occupancy sensors, Energy efficient lighting controls.
Issues in new technologies used in Energy conservation pratices.

Text Books

1. Book I - General aspect of energy management and energy audit, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India
2. Book III - Energy efficiency in electrical utilities, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0	**Energy Management and Audit**	
1.1	Need of Energy Audit, Types of energy audit,	2
1.2	Energy audit approach, understanding energy costs	2
1.3	Bench marking, Energy performance	2
1.4	Matching energy use to requirement, Maximizing system efficiencies, optimizing the input energy requirements,	1
1.5	Fuel and energy substitution, Energy Audit instruments	1
2.0	**Electrical System**	
2.1	Electricity billing	1
2.2	Electrical load management and maximum demand control	2
2.3	Power factor improvement and its benefits, Selection and location of capacitors, Performance assessment of PF capacitors	2
2.4	Distribution and transformer losses	1
3.0	**Electric Motors**	
3.1	Losses in induction motors, Motor efficiency, Factors affecting motor performance	2
3.2	Rewinding and motor replacement issues	2
3.3	Energy saving opportunities with energy efficient motors	2
4.0	**Mechanical Equipments**	
4.1	Compressed Air System – Efficient compressor operation, Leakage test, factors affecting performance and Efficiency	1
4.2	Heating, Ventilating and Air-condionting & Refrigeration System – Factors affecting system performance and energy savings opportunities	2

4.3	Fans & Blowers – Flow control strategies and energy conservation opportunities	2
4.4	Pumps – Flow control strategies and energy conservation opportunities	1
4.5	Cooling Towers– Flow control strategies and energy saving opportunities	2
5.0	**Lighting**	
5.1	Light Source – Types, Development, Advantages and Limitations, Choice of lighting	1
5.2	Luminance requirements and energy conservation avenues	1
6.0	**DG Set System**	
6.1	Factors affecting selection	1
6.2	Energy performance and assessment of diesel conservation avenues	2
7.0	**Energy Efficient Technologies in Electrical Systems**	
7.1	Maximum demand controllers, Automatic power factor controllers	1
7.2	Energy efficient motors	2
7.3	Soft starters with energy saver, Variable speed drives	2
7.4	Energy efficient transformers	1
7.5	Electronic Ballast, Occupancy sensors, Energy efficient lighting controls	2
7.6	Issues in New technologies used in Energy conservation practices	2
	Total	**43**

Course Designers

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted in 2008 only)

EIGHTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
ECX	Elective 6	DE	3	-	-	3
ECX	Elective 7	DE	3	-	-	3
ECX	Elective 8	DE	3	-	-	3
PRACTICAL						
E84	Project	DC	-	-	24	12
	Total		**9**	**-**	**24**	**21**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
Dc :Departmental core
DE : Departmental Elective
GE : General Elective

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electrical and Electronics Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted in 2008 only)

EIGHTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	ECX	Elective 6	3	50	50	100	25	50
2	ECX	Elective 7	3	50	50	100	25	50
3	ECx	Elective 8	3	50	50	100	25	50
PRACTICAL								
4	E84	Project	-	150	150	300	75	150

* CA evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

Sub Code	Lectures	Tutorial	Practical	Credit
ECA	3	-	-	3

ECA Special Machines 3:0

Preamble

Usually the electronics needed for desired operation of special machines over its operating range are inseparable from the machine itself. The machines are normally used in low power applications, especially in control systems. Because of their low weight, it is used in aerospace applications. Further they produce low noise during their operation.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

k. Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course the student should be able to:

1. Do precise control of speed and position using special motors.
2. Know the Dynamic characteristics, Drive systems and circuit for open loop control in stepper motor.
3. Able to analyze the closed loop Characteristics and control for switched reluctance motor
4. Able to apply Microprocessors based controllers to special machines
5. Determine the control strategy in permanent magnet brushless machine
6. Explain self control and vector control operations of permanent magnet synchronous motors

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	10	10	10
2	Understand	40	40	40
3	Apply	50	50	50
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Mention the types of stepper motor.
2. Write the principle of operation of switched reluctance motor
3. Give the areas of application of stepping motor
4. What are the different types of permanent magnet materials used in brushless D.C. motor?
5. Write the advantages and disadvantages of brushless D.C machine
6. Write the function of a sensor

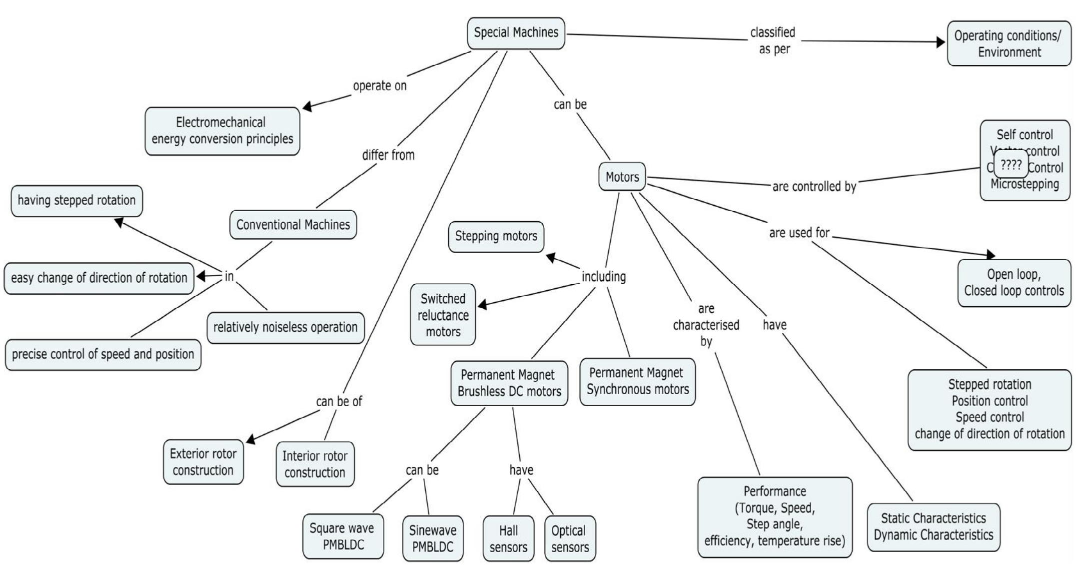
Understand

1. Give the difference between plain synchronous stepper motor and hybrid stepper motor
2. Write the difference between conventional reluctance motor and switched reluctance motor
3. Write the different types of Drive systems used for stepping motor
4. Derive the torque expression for switched reluctance motor
5. Discuss the torque speed characteristics of permanent magnet brushless D.C. machine
6. Describe the working of hall sensors and optical sensors.

Apply

1. Explain closed loop control of stepper motor.
2. Write about rotor sensing mechanism and switching operations in switched reluctance motor.
3. Discuss the control strategy in permanent magnet brushless machine.
4. With neat diagrams explain self control and vector control operations of permanent magnet synchronous motors.
5. Discuss a microprocessors based controller in switched reluctance motor?
6. Explain rotor position sensing and switching logic for a BLDM for forward and reverse rotation.

Concept Map



Syllabus

STEPPING MOTORS - Constructional features, Principle of operation, Modes of excitation torque production in Variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor.

SWITCHED RELUCTANCE MOTORS - Constructional features, Principle of operation, Torque equation, Power controllers, Characteristics and control Microprocessors based controller

PERMANENT MAGNET BRUSHLESS DC MOTORS - Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessors based controller

PERMANENT MAGNET SYNCHRONOUS MOTORS - Principle of operation, EMF, Power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes.

Text Books:

1. Miller, T.J.E. " Brushless permanent magnet and reluctance motor drives ", Clarendon Press, Oxford, 1989.
2. Kenjo, T and Naganori, S " Permanent Magnet and brushless DC motors ", Clarendon Press, Oxford, 1989.
3. Kenjo, T, " Stepping motors and their microprocessor control ", Clarendon Press, Oxford, 1989.
4. K. Venkataratnam, “Special electrical machines”, Universities Press, India

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**STEPPING MOTORS**	
1.1	Constructional features	2
1.2	Principle of operation	1
1.3	Modes of excitation torque production in Variable Reluctance(VR) stepping motor	2
1.4	Dynamic characteristics, Drive systems and circuit for open loop control	3
1.5	Closed loop control of stepping motor.	1
2.0	**SWITCHED RELUCTANCE MOTORS**	
2.1	Constructional features	1
2.2	Principle of operation	1
2.3	Torque equation	2
2.4	Power controllers	2
2.5	Characteristics and control Microprocessors based controller	2
3.0	**PERMANENT MAGNET BRUSHLESS DC MOTORS**	
3.1	Commutation in DC motors	1
3.2	Difference between mechanical and electronic commutators	1
3.3	Hall sensors	1
3.4	Optical sensors	2
3.5	Multiphase Brushless motor	2

3.6	Square wave permanent magnet brushless motor drives	1
3.7	Torque and emf equation	1
3.8	Torque-speed characteristics	1
3.9	Controllers-Microprocessors based controller	1
4.0	**PERMANENT MAGNET SYNCHRONOUS MOTORS**	
4.1	Principle of operation	1
4.2	EMF	1
4.3	Power input and torque expressions	2
4.4	Phasor diagram	1
4.5	Power controllers	1
4.6	Torque speed characteristics	1
4.7	Self control	1
4.8	Vector control	2
4.9	Current control schemes	1

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
ECB	3	-	-	3

ECB Digital control systems 3: 0

Prerequisites

1. The ability to analyze, design, and synthesize linear continuous-time feedback control systems using Laplace transform, frequency response, and state-space methods.
2. An understanding of the Z-transform and its application to solving difference equations, assessing system stability, and determining the frequency response of a system.

Preamble

Modern embedded solutions allow for better performance and lower costs of dynamic systems such as servomechanisms, chemical processes, and vehicles that move over water, land, air, or space. Digital control theory is here an enabling factor as it can exploit steadily increasing computational capabilities to shift emphasis from hardware to software and thus to take full advantage of modern embedded solutions. This course illustrates the main issues related to digital control theory. The aim is to provide basic notions required for the design and implementation of a digital control system. This knowledge is necessary for the selection of an appropriate microprocessor/DSP or for the correct design of a dedicated component.

Program outcomes addressed

a. An ability to apply knowledge of engineering, information technology, Mathematics and science
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to identify, formulate and solve engineering problems
d. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

Competencies

After successfully completing the course, students are able to:

1. Represent sampled-data systems using difference equations, transfer functions, All-delay blocks diagrams and state-space models.
2. Analyze digital control systems using transform techniques and state-space methods
3. Design, digital control systems using transform techniques and state-space methods

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End semester examination
1	Remember	20	20	20
2	Understand	40	40	20
3	Apply	0	0	0
4	Analyze	40	40	40
5	Evaluate	0	0	0
6	Create	0	0	20

Course level learning objectives

Remember

1. What is zero-order hold circuit in sampled data control system?
2. State sampling theorem.
3. List the methods of discritezation technique.
4. Define observability of a system.
5. Define controllability of a system.
6. What is aliasing?
7. What is state feedback controller?
8. What is reduced order observer?
9. What is meant by sampled data control system?
10. Define pulse transfer function with respect to sampled data control system.

Understand

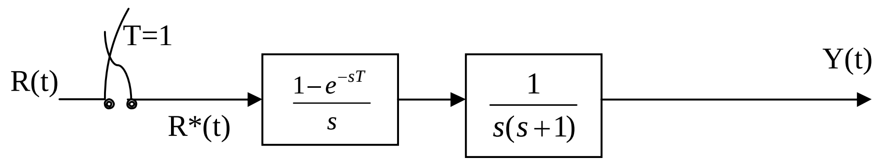
1. Write the condition of the sampling period for a signal to be reconstructed faithfully.
2. Discuss the effects of sampling?
3. What is purpose of hold circuit in sample data control system?
4. What are the effects of adding an observer on a closed loop system?
5. What is aliasing phenomena and how it can be corrected?
6. Compare between transform technique and frequency response method.
7. What are the problems encountered in the practical hold circuit?
8. State the necessary condition to be stable for a sampled data control system.
9. List the methods for analyzing the sampled data control system.
10. Outline a neat sketch and show the various components in the sampled data control system.

Analyze

1. Consider a discrete-time system described by the difference equation

$y(k+2)+\frac{1}{4}y(k+1)-\frac{1}{8}y(k)=3r(k+1)-r(k)$ .the system is initially relaxed $\left(y(k)=0\, for k<0\right)$ and is excited by the input $r(k)=(-1)^k\,\mu(k)$ .obtain the transfer function model of the discrete –time system and also find the output. $y(k); k\geq 0$

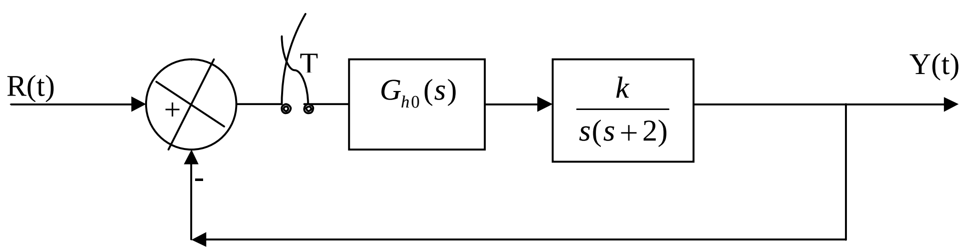
2. Find the response of the system to unit impulse input for the system shown in figure.



3. Examine if all the roots of the characteristic equation lie with in the unit circle.

$z^3 - 1.3z^2 - 0.08z + 0.24 = 0$

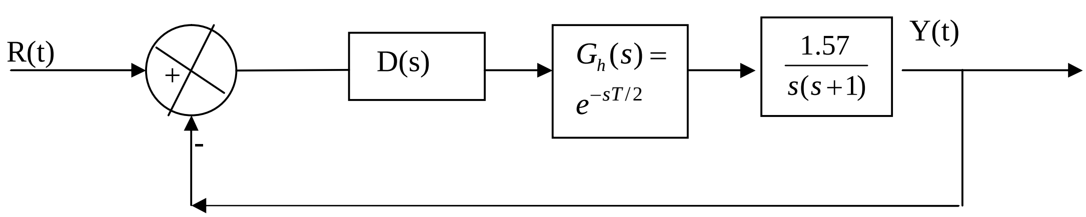
4. Compare the stability properties of the system shown in the figure with T=0.4sec,T=3sec, Assume K>0.



5. (i) discretize D(s)= $\frac{25s+1}{62.5s+1}$ using bilinear transformation.

(ii) Verify D(s) = $\frac{25s+1}{62.5s+1}$ meets thefollowing specfication so that closed loop

system acquires a damping ratio of 0.45 without loss of steady state accuracy .the sampling period T =1.57sec.



Create

1. A discrete –time regulator system has the plant

$$x(k+1)=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -4 & -2 & -1\end{bmatrix}x(k)+\begin{bmatrix}0\\0\\1\end{bmatrix}u(k)$$

Design a state –feedback controller which will place the closed loop poles at the $-\frac{1}{2}\pm j\frac{1}{2}$,0.

2.Consider a plant defined by the state model given below:

$$x(k+1)=Fx(k)+Gu(k);$$
$$y(k)=cx(k)+du(k)$$
$$where$$
$$F=\begin{bmatrix}0.5 & 1 & 0\\ -1 & 0 & 1\\ 0 & 0 & 0\end{bmatrix}G=\begin{bmatrix}1 & 4\\ 0 & 0\\ -3 & 2\end{bmatrix}C=\begin{bmatrix}1 & 0 & 0\end{bmatrix}d=\begin{bmatrix}0 & 4\end{bmatrix}$$

Design a prediction observer for the estimation of the error vector x,the observer error poles are required to lie at the $-\frac{1}{2}\pm j\frac{1}{4}$,0. $\longrightarrow$

3.consider the system

$$x(k+1)=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -0.5 & -0.2 & 1.1\end{bmatrix}x(k)+\begin{bmatrix}0\\0\\1\end{bmatrix}u(k)$$

Determine the state feed back gain matrix the eigen values of the controller lies at $0\pm j0,0$

4.A discrete –time regulator system plant has

$$x(k+1)=\begin{bmatrix}2 & -1\\ -1 & 1\end{bmatrix}x(k)+\begin{bmatrix}4\\3\end{bmatrix}u(k);$$

$y(k)=\begin{bmatrix}1 & 1\end{bmatrix}x(k)+7u(k)$ Design a state feedback control algorithm such that closed loop characteristic equation lies at $\pm j\frac{1}{2}$.

5. A discrete –time regulator system plant has

$$x(k+1)=\begin{bmatrix}2 & -1\\ -1 & 1\end{bmatrix}x(k)+\begin{bmatrix}4\\3\end{bmatrix}u(k);$$

$$y(k)=\begin{bmatrix}1 & 1\end{bmatrix}x(k)+7u(k)$$ Design a prediction observer such that closed loop characteristic equation lies at $0\pm j0$.

6. Consider a plant defined by the state model given below:

$$x(k+1)=Fx(k)+Gu(k);$$

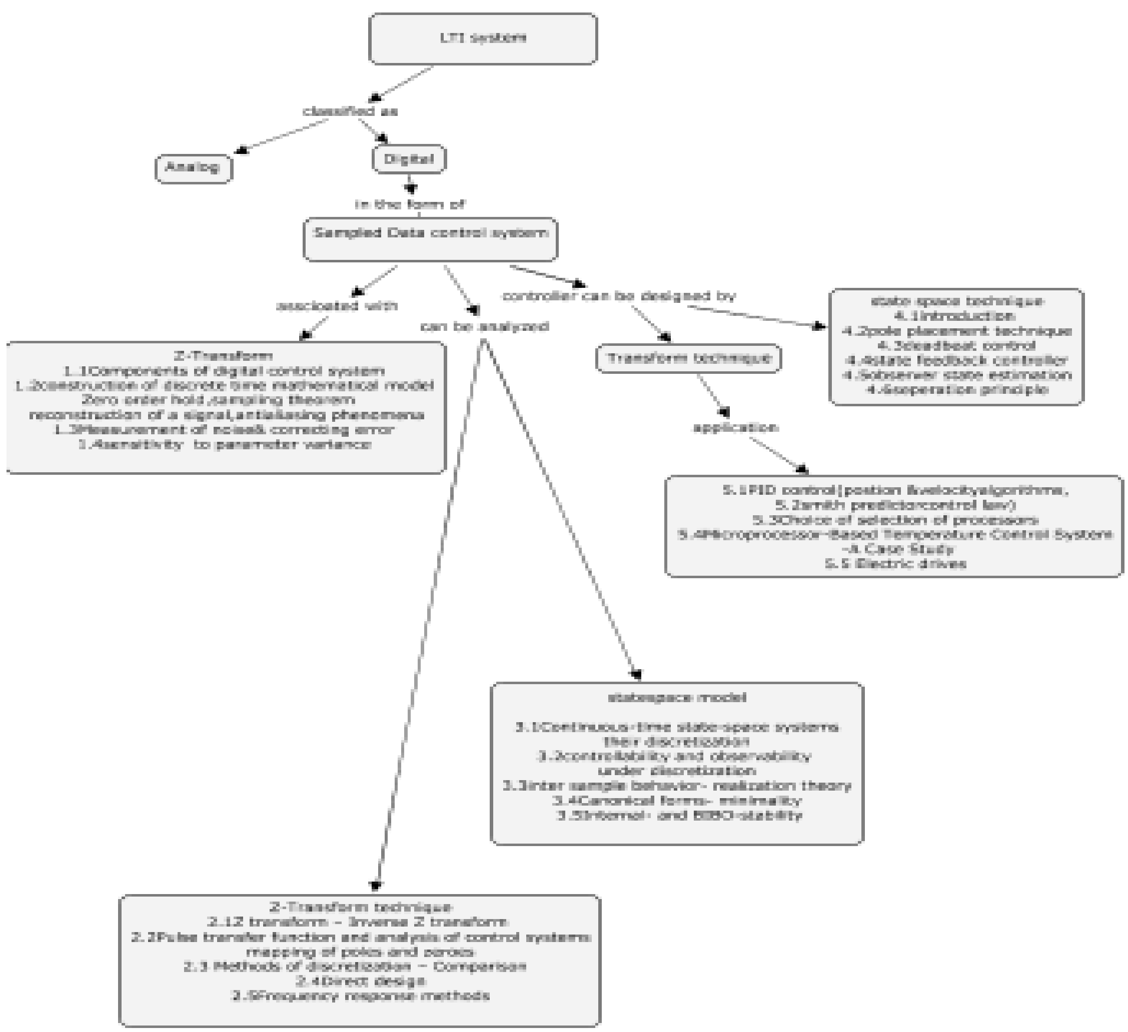
$$y(k)=cx(k)$$

where

$$F=\begin{bmatrix}0.16 & 2.16\\ -0.16 & -1.16\end{bmatrix} G=\begin{bmatrix}-1\\1\end{bmatrix} C=\begin{bmatrix}1 & 1\end{bmatrix}$$

Design a state feedback control algorithm such that closed loop characteristic equation lies at $0.6\pm j0.4$.

Concept Map



Syllabus

INTRODUCTION TO DIGITAL CONTROL

Digitization, sampling, effects of sampling, reconstruction of signals-zero order hold-Shannon's sampling theorem; aliasing and folding- choice of the sampling period-Analysis of round off error – Sensitivity to parameter variations – Measurement noise and antialising filter.

DISCRETE SYSTEM ANALYSIS

Linear difference **E**quations transform – Inverse Z transform – pulse transfer function and analysis of control systems-mapping of poles and zeroes- Methods of discretization-sampled data control systems , First order hold, sampled data control system, signal analysis of unit step ,unit pulse, exponential, data extrapolation, spectrum of sampled signal- System output between samples

DESIGN USING TRANSFORM TECHNIQUES

System specifications-design by emulation, discrete equivalent controllers, Evaluation of design, direct design by root locus in the Z-plane- Frequency response methods-Direct design method of Ragazzini

STATE SPACE REPRESEANTATION

Discrete –time state space equation – solution of discrete-time state space equation-Z-transfer function- Controllability-Observability-state space realizations –State and output feedback control

STATE SPACE DESIGN

Design of full state feedback controller - Pole placement technique- Estimator design –prediction estimators, current estimators, reduced order estimators- Pole placement using separation principle- reference input for full state feedback control – reference input with estimators.

Text book

Franklin, Powell, Workman, Digital Control of Dynamic Systems, Pearson Education, Third, 2006.

Reference Books

1. R. J. Vacaro, Digital Control: A State Space Approach, McGraw-Hill Higher Education, 1995
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publication Limited, 1997
3. Ogata, Discrete-time Control Systems, Prentice hall, Second edition, 2005.
4. M. Sami fadali,Antonio visioli, Digital Control Engineering, academic press,2009.

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**INTRODUCTION TO DIGITAL CONTROL**	
1.1	Digitization, sampling, effects of sampling, reconstruction of signals	2
1.2	Zero order hold- Shannon's sampling theorem; aliasing and folding	2
1.3	Choice of the sampling period in sampled-data control systems	1

1.4	Analysis of round off error – Sensitivity to parameter variations – Measurement noise and antialising filter	2
2.0	**DISCRETE SYSTEM ANALYSIS**	
2.1	Linear difference **E**quations transform – Inverse Z transform	2
2.2	pulse transfer function and analysis of control systems-mapping of poles and zeroes	2
2.3	Methods of discretization-sampled data control systems	2
2.4	First order hold, sampled data control system,	1
2.5	signal analysis of unit step ,unit pulse, exponential, data extrapolation	2
2.6	spectrum of sampled signal- System output between samples	1
3.0	**DESIGN USING TRANSFORM TECHNIQUES**	
3.1	System specifications-design by emulation	3
3.2	discrete equivalent controllers, Evaluation of design,	2
3.3	direct design by root locus in the Z-plane	2
3.4	Frequency response methods-Direct design method of Ragazzini	3
4.0	**STATE SPACE REPRESEANTATION**	
4.1	Introduction Discrete –time state space equation	1
4.2	solution of discrete-time state space equation-Z-transfer function	2
4.3	Controllability-Observability	2
4.4	state space realizations	2
4.5	State and output feedback control	2
5.0	**STATE SPACE DESIGN**	
5.1	Design of full state feedback controller	1
5.2	Pole placement technique- Estimator design	2
5.3	prediction estimators, current estimators, reduced order estimators	3
5.4	Pole placement using separation principle	2
5.5	reference input for full state feedback control – reference input with estimators	3

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Sub Code	Lectures	Tutorial	Practical	Credit
ECC	3	-	-	3

ECC High Voltage Engineering 3:0

Preamble

High Voltages are used in wide applications covering the power system, industry, medical and research laboratories. Such applications have become essential to sustain modern civilization. High Voltages are applied in nuclear research laboratories, Particle accelerators and Van de Graaff generators. For transmission of large bulk power over long distances, high voltages are indispensable. The diverse conditions under which a high voltage apparatus used necessitate careful design of its insulation and the electrostatic field profiles. The various types of insulation media used and their breakdown mechanisms are dealt in this course. The generation and measurement of High A.C., D.C., and impulse voltages are also discussed in this subject. Various procedures & standards adopted for the testing high voltage apparatus and analysis based on the testing are introduced.

Programme Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science

b. An ability to design and conduct experiments, as well as to analyze and interpret data

d. An ability to identify, formulate and solve engineering problems

e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

g. An ability to communicate effectively in English in both oral and written forms

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the student should be able to:

1. Explain the breakdown mechanisms in Solid Liquid and Gaseous Insulations.
2. Explain different methods of generating high voltages and large currents
3. Explain different methods of measuring high voltages and currents.
4. State standards for testing of high voltage equipments
5. Determine the suitability of a given insulation for a given high voltage application.
6. Select appropriate generating and measurement methods for testing a given high voltage apparatus

Assessment Pattern

No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	30	30	10
2	Understand	50	50	50
3	Apply	20	20	30
4	Analyze	0	0	0
5	Evaluate	0	0	10
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Name the four important properties of any Gaseous dielectric medium.
2. Define Townsend's primary and secondary ionization coefficients.
3. What are electronegative gases? Give example.
4. What is meant by "Tracking" in solid dielectric breakdown?
5. What are the causes for over voltages in a transmission line?
6. What is meant by insulation coordination?
7. What is Time lag in the break down of dielectrics?
8. State Paschen's Law.
9. What are the factors influencing the measurements using sphere gap?
10. What are the advantages of CVT measurement in HVAC?

Understand

1. Differentiate the terms Flashover and puncture
2. Deduce an expression for Townsend's criteria for breakdown of Gaseous medium.
3. With neat sketches explain the streamer theory of breakdown mechanism in gaseous dielectrics.
4. With neat sketches explain the breakdown mechanism in solid dielectrics due to "Internal discharges".
5. With a neat circuit explain the working principle of a Cockcroft –Walton voltage multiplier circuit.
6. With a neat sketch explain the working principle of Van de Graff Generator.
7. Give the Marx circuit – multistage impulse generator. How the basic arrangements are modified to accommodate the wave time control resistances?
8. With a neat sketch explain the working principle of Van de Graff Generator.
9. With a neat sketch explain the Sphere gap measurements for peak voltage measurement.
10. Explain the principle and importance of Power frequency tests carried out in a Power Transformer.

Apply

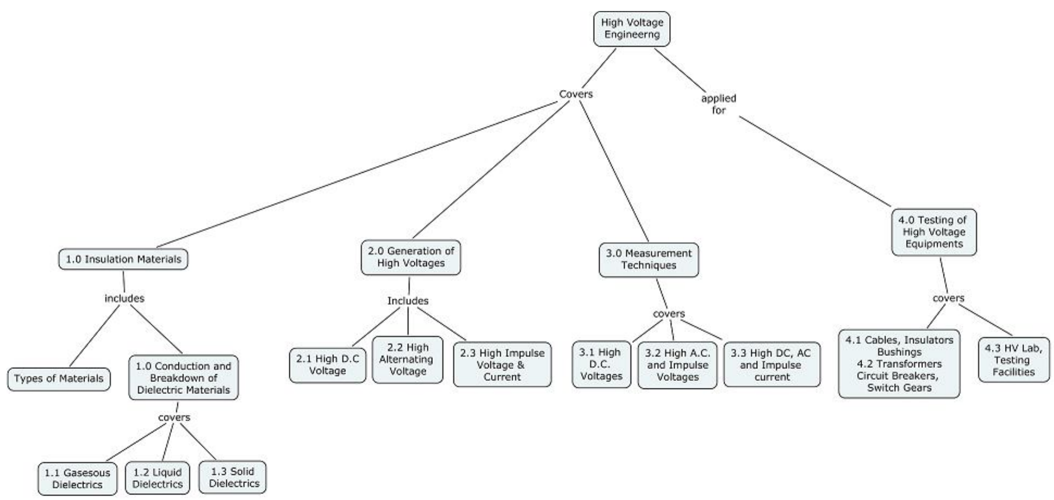
1. What are the various test conducted on a high voltage cable? Explain the necessity and the expected outcome of each tests. Also, explain the procedure to locate the fault.
2. Discuss in detail, how an RC Circuit can be used to measure impulse voltage.
3. Explain, the procedure to be adopted to measure peak AC and Impulse voltages using sphere gap.
4. A 8-stage impulse generator has 0.12 micro Farad capacitor rated for 167 KV. What is the maximum discharge energy? If it has to produce 1 / 50 micro second waveform across a load capacitor of 15000 pico Farad, find the value of front and tail timings.
5. A coaxial cylindrical capacitor of 1000 pF, 15 KV, 500 KHz, Єr = 2.3 and a length of 20 cm is to be designed. Find the dimensions of electrodes
6. A voltage doubler circuit has C1 = c2 = 0.01 micro farad and sis supplied form a voltage source of V 100 sin 314t, KV. If the d.c. output current is to be 4 mA, calculate the output voltage and ripple.

7. An electrostatic voltmeter has an effective plate diameter of 50 cm with a gap separation of 30 cm. Find the force between the plates when measuring a d.c. voltage of 100 KV. What is the maximum voltage that can be measured if the electric field E has to be not more than 5 KV/cm.

Evaluate

1. Sketch the insulation coordination scheme for the rod gap arrester and an insulator in a transmission line.
2. With suitable illustrations, explain how insulation level is chosen for various equipment in a 400/230 KV sub-station?
3. Explain in detail the high voltage and high current impulse testing of a 11kV surge diverter
4. An electrostatic voltmeter has an effective plate diameter of 50 cm with a gap separation of 30 cm. Find the force between the plates when measuring a d.c. voltage of 100 KV. What is the maximum voltage that can be measured if the electric field E has to be not more than 5 KV/cm.

Concept map



Syllabus

Conduction and Breakdown in Dielectric Materials:

Ionization process - Townsend's Criterion for breakdown - Electronegative gases - Time lag for breakdown – Streamer theory - Paschen's law - post breakdown phenomena and application – Vacuum insulation and breakdown.

Pure liquid - commercial liquid - conduction & breakdown in pure and commercial liquids.

Solid Dielectrics – Intrinsic break down – Electromechanical breakdown – Thermal breakdown – Breakdown in composite Dielectrics.

Generation of High voltages and currents :

Generation of DC voltage – High Alternating voltage – Impulse voltage – Impulse current – Tripping and control of Impulse generator.

Measurement of High voltage & Current :

Measurement of high DC voltage – High AC and Impulse voltage – High DC, AC and Impulse current – CRO for Impulse voltage and current measurements.

High voltage testing of electrical equipment:

Testing Standards

Testing of Insulators - Bushings - Isolators and Circuit Breakers – Cables – Transformers – Surge Diverters.

Test facilities – Activities – Classification – Grounding – Size – Ratings.

Text Book:

M.S.Naidu and V.Kamaraju - High voltage Engineering - Tata Mc.Graw hill Publishing company Limited, New Delhi, 3rd Edition, 2005.

Reference Book:

C.L.Wadhwa - High voltage engineering - Wiley eastern limited, New Delhi, 1st Edition, 1994.

Course Content and Lecture Schedule

S.No.	Topics	No. of Lectures
1.0	**Conduction and Breakdown in Dielectric Materials**	
1.1	Type of Gaseous insulating mediums Ionisation process, Townsend's Criterion for breakdown & Coefficients, Streamer theory Paschen's law, Vacuum insulation and it's breakdown	5
1.2	Types of liquid dielectrics and it's characteristics, Pure liquid and Commercial liquid Suspended Particle mechanism of Breakdown, Cavitation & Bubble theory & Stressed oil volume mechanism of Breakdown	4
1.3	Types of Solid Dielectrics and it's characteristics Ionic or Intrinsic & Electronic break down, Electromechanical breakdown, Thermal breakdown,– Electro chemical breakdown Breakdown due to internal discharges	4
2.0	**Generation of High voltages and currents**	
2.1	Generation of HV DC – Half and full wave rectifiers. Voltage Doubler circuits Voltage multiplier circuits & calculation of RF and Voltage regulation Van de Graff generator, Electrostatic Generator	4
2.2	Generation of HVAC – Cascade Transformers Resonant Transformer. Generation of High Frequency AC voltage	2
2.3	Generation of Impulse voltage : Standard Wave shapes. Circuits for producing impulse waves Marx circuit and components of multi stage generator Generation of switching surges & Impulse current	4
3.0	**Measurement of High voltage & Current**	

3.1	Measurement of high DC voltage – Series Resistance, Potential divider methods. Generating voltmeter, Measurement of High Direct Currents – Shunts & Hall Effect methods,	4
3.2	Measurement of High AC voltage – Series impedance, Potential divider measurement Sphere gap measurement and Factors influencing it. PT, CVT, Electrostatic Voltmeter measurements, AC high frequency voltage and Impulse voltage measurement – Potential divider with CRO	5
3.3	Magnetic Links. Measurement of High Alternating Currents – Shunts & CT High frequency AC impulse current measurement – Magnetic potentio meter or Rogowski coil, CRO for Impulse current measurement	4
4.0	**High voltage testing of Electrical Equipment**	
4.1	Testing Standards, Testing of Insulators and Bushings.	2
4.2	Testing of Isolators, circuit Breakers, Cables, Transformers,and Surge Diverters.	4
4.3	Design of High voltage laboratories: Size, Ratings, Test facilities, Grounding	3
Total		45

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Sub Code	Lectures	Tutorial	Practical	Credit
EGD	3	-	-	3

EGD Sensors and Transducers 3:0

Preamble

The proposed course offered as General elective and its main purpose is:

1. To elaborate on the Theoretical and practical aspects of transducers and their classifications and also the applications of transducers in real life and in industries.
2. To explain the static and dynamic characteristics of transducers.
3. Discuss on electrical, magnetic, piezoelectric, fiber optic transducers and their operation.
4. To impart knowledge about digital transducers and their applications.
5. In view of present day technologies fundamental concepts of some of the smart sensors in day to day applications and also in industries are included

Program Outcomes addressed

b. Graduates will demonstrate an ability to identify, formulate and solve engineering

Problems

c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

e. An ability to use techniques, skills and modern engineering tools to implement and Organize engineering works under given constraints

Competencies

At the end of the course students should be able to:

1. To explain the basic characteristics, types of transducers and their practical aspects in industries.
2. Explain the operation and application of digital transducers.
3. Explain the application of smart sensors.

Assessment Pattern

S.No	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	40	40	20
2	Understand	40	40	60
3	Apply	20	20	20
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is a transducer?
2. What is a thermistor?
3. Name some pressure Sensors
4. What is role of gray code in optical and shaft encoders?
5. Define stress and strain.
6. Recall Hall Effect principle
7. Give some real time application of strain gauge
8. Classify the different methods of measuring temperature
9. Write the relation for temperature coefficient of resistance for thermistor.
10. What is a load cell?

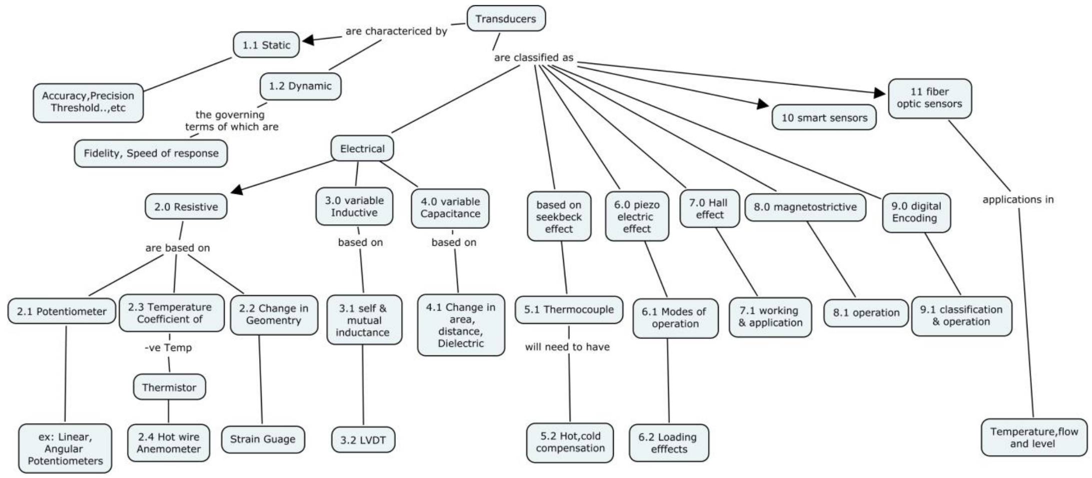
Understand

1. A digital meter has 10 bit accuracy. What is the resolution on the 16V range?
2. A liquid container has a total weight of 152 kN, and the container has 8.9 m^2 base. What is the pressure on the base?
3. Identify what pressure in psi corresponds to 98.5 kPa
4. State the three different temperature scales to measure relative hotness.
5. Write some applications of position sensors.(rolling mills, conveyors..,)
6. What is the change in resistance in a copper wire when the strain is 5500 micro strains? Assume the initial resistance of the wire is 275 ohms and the gauge factor is 2.7.
7. State the limitations of contact type shaft encoders.
8. Sketch the cross section of 3 wire RTD and explain its operation.
9. Describe about cold junction compensation of Thermocouple.
10. Illustrate in detail about three effects associated with Thermocouple

Apply

1. Illustrate the role of smart sensors in automated applications.
2. Develop a pressure sensor using capacitance principle and explain its operation
3. Explain how force is measured using Pressure transducer.
4. Describe the application of strain gauge as load sensor.

Concept Map



Syllabus

PERFORMANCE CHARACTERISTICS OF TRANSDUCERS

Static characteristics Meaning of static calibration, Accuracy, Precision, bias, Linearity, Threshold, Resolution, Hysteresis and Dead space, Scale readability and span

Dynamic characteristics – Sinusoidal transfer function, zero order transducer, First order transducer, Step, Ramp, Frequency and Impulse response, Second order transducer, Step, Ramp Frequency and Impulse response.

VARIABLE RESISTANCE TRANSDUCERS

Potentiometers - Loading effect, Power rating of potentiometers, Linearity and Sensitivity, Construction of potentiometers, Non-linear potentiometers,
Strain gauges - Theory of Strain gauges, Types of strain gauges, Characteristics of strain gauges
Resistance thermometers - Characteristics, Linear approximation, Quadratic approximation,
Thermistors - Resistance vs. Temperature characteristics, Voltage vs. current and Current vs. time characteristics,
Hot wire anemometers - Constant current mode and Constant resistance

Variable Inductance transducers – Change of self-inductance, Change of mutual inductance, Production of eddy currents, Linear Variable Differential Transformer Construction, Working principle

Variable capacitance transducers - Change in area of plates, Change in distance between the plates, Differential arrangement, Variation of dielectric constant, Frequency response.

Thermocouples – Construction, Measurement of thermocouple output, Compensating circuits, Reference junction compensation, Lead compensation
Piezoelectric transducers Modes of operation of piezoelectric crystals, Properties, Equivalent circuit of piezoelectric transducers, Loading effects and frequency response, Impulse response, **Hall effect transducers** working principle, application,
Magnetostrictive transducers principle of operation
Digital encoding transducers – Classification of encoders, Construction of encoders, Brush type, Optical displacement transducers

Smart sensors – Introduction, primary sensors, Excitation, Amplification, Filters, Convertors, Compensation, Information coding process, Data communication

Fibre optic sensors – Temperature sensors, Liquid level sensing, Fluid flow sensing, Microbend sensors
List of applications of various transducers

Text Books

1. E.O.Doubelin, Measurement Systems, McGraw Hill Book Company, 2008.
2. A.K.Sawheney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpatrai & Co. Pvt. Ltd., 2007.
3. D. Patranabis, Sensors and Transducers, Wheeler Publishing, 2006.

Reference Books

1. Hermann, K.P. Neubert, Instrument Transducers, Oxford University Press, 1988.
2. S. Renganathan, Transducer Engineering, Allied Publishers, 1999
3. D.V.S. Murthy, Transducers and Instrumentation, Prentice Hall of India Pvt. Ltd., 2008.

Course contents and Lecture Schedule

Sl. No.	Topic	No. of Lectures
1.0	**Performance characteristics of Transducers**	
1.1	**Static characteristics** Meaning of static calibration, Accuracy, Precision, bias, Linearity, Threshold, Resolution, Hysteresis and Dead space, Scale readability and span	3
1.2	**Dynamic characteristics –** Sinusoidal transfer function, zero order transducer, First order transducer, Step, Ramp, Frequency and Impulse response, Second order transducer, Step, Ramp Frequency and Impulse response	3
2.0	**Variable Resistance transducers**	
2.1	**Potentiometers -** Loading effect, Power rating of potentiometers, Linearity and Sensitivity, Construction of potentiometers, Non-linear potentiometers	2
2.2	**Strain gauges -** Theory of Strain gauges, Types of strain gauges, Characteristics of strain gauges, Resistance thermometers, Characteristics, Linear approximation, Quadratic approximation	2
2.3	**Thermistors** - Resistance vs. Temperature characteristics, Voltage vs. current and Current vs. time characteristics	2
2.4	**Hot wire anemometers**	
3.0	**Variable Inductance transducers**	
3.1	Change of self-inductance, Change of mutual inductance, Production of eddy currents	2
3.2	Linear Variable Differential Transformer Construction, Working principle	2
4.0	**Variable capacitance transducers**	
4.1	Change in area of plates, Change in distance between the plates, Differential arrangement, Variation of dielectric constant, Frequency response	3
5.0	**Thermocouples**	

5.1	Construction, Measurement of thermocouple output	2
5.2	Compensating circuits, Reference junction compensation, Lead compensation	2
6.0	**Piezoelectric transducers**	
6.1	Modes of operation of piezoelectric crystals, Properties, Equivalent circuit of piezoelectric transducers	2
6.2	Loading effects and frequency response, Impulse response	2
7.0.	**Hall effect transducers**	
7.1	working principle, application	2
8.0	**Magnetostrictive transducers**	
8.1	Principle of operation	2
9.0	**Digital encoding transducers**	
9.1	Classification of encoders, Construction of encoders, Brush type, Optical displacement transducers	3
10.	**Smart sensors**	
10.1	Introduction, primary sensors, Excitation, Amplification, Filters, Convertors, Compensation, Information coding process, Data communication	3
11.	Fibre Optic Sensors - Temperature sensors, Liquid level sensing, Fluid flow sensing, Microbend sensors	2
	List of applications of various transducers	1
	Total	40

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
EGE	3	-	-	3

EGE Domestic and Industrial Electrical Installations 3:0

Preamble

Electricity becomes one of the essential commodities for the human beings on day to day activities. Hence it is necessary to educate an engineer in the aspects of Domestic and Industrial Electrical Installations. The idea of this subject is to educate the non-electrical engineers on the aspect of do's and don't in Electrical Installations. It will helpful to select a best electrical system for an establishment.

Programme Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science
c. An ability to design a system or component, or process to meet stated specifications
d. An ability to identify, formulate and solve engineering problems
e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints
h. An ability to function on multidisciplinary teams
i. An ability to engage in life-long learning
j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the student should be able to:
1. Explain the basic Electrical Distribution systems
2. Design lighting system for domestic, commercial and industrial applications
3. Estimate the material requirements for a wiring work
4. Get familiar about the different types of wiring practice
5. To Carryout inspection accident analysis

Assessment Pattern

S.No.	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	50	50	40
3	Apply	30	30	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. When to go for a three phase power supply for domestic uses?
2. Specify the role of fuse.
3. Where to use FRLS wires?
4. Why switches should not be connected in neutral side?
5. Mention the energy efficient lamps used for domestic and industrial purpose.

6. Classify the different accidents
7. Specify the advantages of indirect lighting schemes.
8. What are the factors to be considered, while selecting the dimension of wire thickness for an application?
9. Mention the method of protecting electrical equipment in industry from over voltage.
10. List the safety precautions for operating high voltage equipment

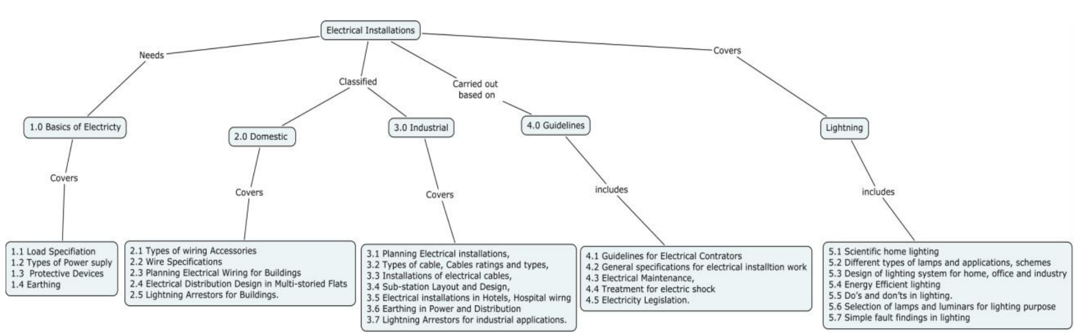
Understand

1. List the points to be checked in a single phase wiring.
2. How to check the electrical wiring in flats.
3. What are the factors to be considered while designing a lighting system for domestic purpose?
4. Explain the working principle of Residual Current circuit breakers.
5. List the major equipment used in a sub-station. Also specify the role of each.
6. Explain the plate earthing procedure as per the IS code of practice.
7. What are the points to be inspected, while carryout an annual inspection in a commercial complex?
8. Explain the various steps involved during planning electrical wiring for buildings.
9. Discuss the do's and don'ts in electrical wiring.
10. Explain the role of lightning arrestor in building and electrical systems.

Apply

1. Design a three phase power distribution system for a bungalow and draw the single line diagram of the same.
2. A 30meter X 50meter shop floor needs to be illuminated to a light level of 250Lux. The depreciation factor and utilization factor for the lighting system is 1.2 and 0.7 respectively. 400Watts Metal halide lamp is suggested for the illuminating purpose. The luminous efficacy of the Metal halide lamp is 105 Lumens per watt. Calculate the number of lamps required and the arrangements of lamps for even light distribution.
3. Design a complete protective system for an industrial units starting from the sub-station to the load. Also specify the role of each protective system.
4. Classify the lamps based on application. Also suggest suitable energy efficient lamps for Home and Shop floor lighting with justification.
5. Design a Distribution system for a hotel having a connected load of 100KW. The connected lighting load is 30KW and power load is 70KW. Assume other relevant data if necessary.

Concept Map



Syllabus

Introduction to Electricity –Connected load, Contracted demand, Maximum demand, Power factor, Single Phase Supply, Three phase supply, Three phase wiring, Protective devices in Electrical Installations – Fuse, MCB,MCCB's, RCCB, ELCB. Earthing for Electrical Safety.

Electrical Installations in Domestic Building - Types of wiring, Accessories used in Domestic wiring practice, wire ratings, FRLS type wires and PVC pipes, Planning Electrical Wiring for Buildings, Checking Electrical wiring in Flats, Electrical Distribution Design in Multi-storied Residential Flats and Commercial Buildings, Lightning Arrestors for Buildings.

Electrical Installation in Industry – Planning Electrical installations, Types of cable, Cables ratings and types, Installations of electrical cables, Sub-station Layout and Design, Electrical installations in Hotels, Hospital wiring, Earthing in Power and Distribution, Lightning Arrestors for industrial applications.

Do's and Don'ts in Electrical Wiring - Guidelines for Electrical Contractors. General specifications for electrical installation work, Electrical Maintenance, treatment for electric shock, Electricity Legislation. Points to be inspected, while carryout an Electrical Inspection.

Lighting – Scientific home lighting, Different types of lamps and applications, Various types of lighting schemes, design of lighting system for home, office and industrial work place, Energy Efficient lightings, Do's and don'ts in lighting. Selection of lamps and luminars for lighting purpose, Simple fault findings in lighting.

Text Book

B.Raja Rao, "Electricity for Architects, Project Consultants and Builders", B.Raja Rao Technical Books Publishers, Chennai.

Reference Book

V.S.Rao -Operation & Maintenance of Electrical Equipment - Volume I & II, 1997 Edition, Media Promoters & Publishers Pvt. Ltd., Mumbai.

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.0	**Introduction to Electricity**	
1.1	Connected load, Contracted demand, Maximum demand, Power factor	2
1.2	Single Phase Supply, Three phase supply, Three phase wiring	2
1.3	Protective devices in Electrical Installations – Fuse, MCB, MCCB's, RCCB, ELCB	2
1.4	Earthing for Electrical Safety	1
2.0	**Electrical Installations in Domestic Building**	
2.1	Types of wiring, Accessories used in Domestic wiring practice	2
2.2	wire ratings, FRLS type wires and PVC pipes	2
2.3	Planning Electrical Wiring for Buildings, Checking Electrical wiring in Flats	2
2.4	Electrical Distribution Design in Multi-storied Residential	2

	Flats and Commercial Buildings	
2.5	Lightning Arrestors for Buildings	1
3.0	**Electrical Installation in Industry**	
3.1	Planning Electrical installations	1
3.2	Types of cable, Cables ratings and types	1
3.3	Installations of electrical cables	2
3.4	Sub-station Layout and Design	1
3.5	Electrical installations in Hotels, Hospital wiring	2
3.6	Earthing in Power and Distribution	1
3.7	Lightning Arrestors for industrial applications	1
4.0	**Do's and Don'ts in Electrical Wiring**	
4.1	Guidelines for Electrical Contractors	1
4.2	General specifications for electrical installation work	2
4.3	Electrical Maintenance	2
4.4	Treatment / First Aid for electric shock	1
4.5	Electricity Legislation. Points to be inspected, while carryout an Electrical Inspection	2
5.0	**Lighting**	
5.1	Scientific home lighting	1
5.2	Different types of lamps and applications, Various types of lighting schemes	1
5.3	Design of lighting system for home, office and industrial work place	3
5.4	Energy Efficient lightings	1
5.5	Do's and don'ts in lighting	1
5.6	Selection of lamps and luminars for lighting purpose	1
5.7	Simple fault findings in lighting	1
	Total	42

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
EGF	3	-	-	3

EGF Energy Conservation Practices 3:0

Preamble

Energy resource scarcity becomes one of the biggest issues in the world and leading to rise in cost. Effective utilization of Electrical energy is one of the key issues to minimize the rising cost of energy and to minimize the global warming. This course will educate the non-electrical engineers on the aspect of energy conservation in electrical equipment and Electrical Installations. It will helpful to select an energy efficient electrical system for an establishment.

Programme Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

h. An ability to function on multidisciplinary teams

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the student should be able to:

6. Explain the basic principle of Energy Management and Conservation
7. Select Energy Efficient gadgets for domestic, commercial and industrial applications
8. Estimate the energy performance of Electrical Equipment
9. Get familiar about the energy conservation practice
10. Capable to carryout preliminary energy audit

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	60	60	60
3	Apply	20	20	20
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

11. What is an Energy audit?
12. List down the objective of energy management
13. Define contracted demand and billing demand.
14. Name three types of motors in industrial practice.
15. List the factors affecting energy efficiency in air compressors.
16. What are the types of commonly used lamps?
17. Specify the role of Turbo chargers.
18. What are the advantages of energy efficient motors?
19. Mention the role of demand controller in industrial plants.
20. What is the function of Automatic Power factor controller?

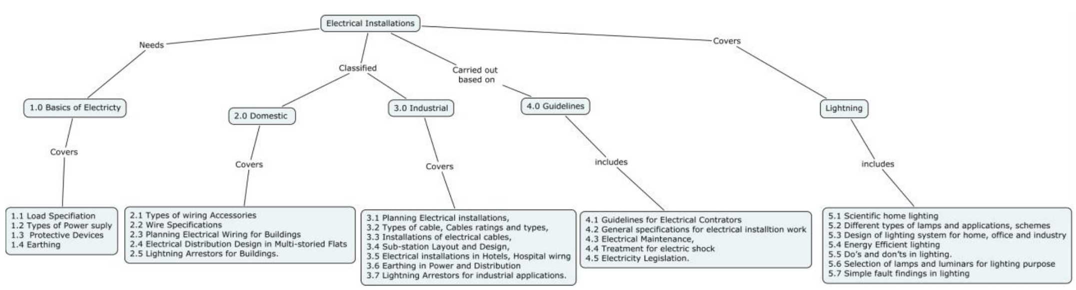
Understand

11. Explain the implications of part load operation of energy equipment with examples.
12. What are the effects of moisture on compressed air?
13. Discuss the various energy conservation opportunities in a refrigeration plant.
14. Explain what do you understand by static head and friction head.
15. What are the effects of over sizing a pump?
16. List down few energy conservation opportunities in pumping system.
17. List the energy conservation opportunities in a cooling tower system.
18. Describe the methodology of lightning energy audit in an industrial facility.
19. List the energy savings opportunities in an industrial DG Set plant.
20. Explain why centrifugal machines offer the greatest savings, when operating with Variable speed drives.

Apply

6. What is the percentage of loss reduction, if an 11KV supply line is converted into 33KV supply system for the same length and electrical load application?
7. A 4 pole squirrel cage induction motor operates with 5% slip at full load. What is the full load RPM you may expect, if the frequency is changed by a V/F control to a)40Hz b) 45Hz and c 35Hz.

Concept Map



Syllabus

Energy Management and Audit

Need of Energy Audit, Types of energy audit, Energy audit approach, understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, optimizing the input energy requirements, Fuel and energy substitution, Energy Audit instruments

Electrical System

Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefits, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses.

Electric Motors

Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors.

Mechanical Equipments

Compressed Air System - Efficient compressor operation, Leakage test, factors affecting performance and Efficiency. HVAC & Refrigeration System – Factors affecting system performance and energy savings opportunities. Fans & Blowers – Flow control strategies and energy conservation opportunities. Pumps – Flow control strategies and energy conservation opportunities. Cooling Towers– Flow control strategies and energy saving opportunities.

Lighting

Light Source, Choice of lighting, Luminance requirements and energy conservation avenues.

DG Set System

Factors affecting selection, Energy performance assessment of diesel conservation avenues.

Energy Efficient Technologies in Electrical Systems

Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic Ballast, Occupancy sensors, Energy efficient lighting controls.

Text Book

1. Book I - General aspect of energy management and energy audit, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India
2. Book III - Energy efficiency in electrical utilities, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**Energy Management and Audit**	
1.1	Need of Energy Audit, Types of energy audit,	2
1.2	Energy audit approach, understanding energy costs	2
1.3	Bench marking, Energy performance	2

1.4	Matching energy use to requirement, Maximizing system efficiencies, optimizing the input energy requirements,	1
1.5	Fuel and energy substitution, Energy Audit instruments	1
2.0	**Electrical System**	
2.1	Electricity billing	1
2.2	Electrical load management and maximum demand control	2
2.3	Power factor improvement and its benefits, Selection and location of capacitors, Performance assessment of PF capacitors	2
2.4	Distribution and transformer losses	1
3.0	**Electric Motors**	
3.1	Losses in induction motors, Motor efficiency, Factors affecting motor performance	2
3.2	Rewinding and motor replacement issues	2
3.3	Energy saving opportunities with energy efficient motors	2
4.0	**Mechanical Equipments**	
4.1	Compressed Air System – Efficient compressor operation, Leakage test, factors affecting performance and Efficiency	1
4.2	HVAC & Refrigeration System – Factors affecting system performance and energy savings opportunities	2
4.3	Fans & Blowers – Flow control strategies and energy conservation opportunities	2
4.4	Pumps – Flow control strategies and energy conservation opportunities	1
4.5	Cooling Towers– Flow control strategies and energy saving opportunities	2
5.0	**Lighting**	
5.1	Light Source, Choice of lighting	1
5.2	Luminance requirements and energy conservation avenues	1
6.0	**DG Set System**	
6.1	Factors affecting selection	1
6.2	Energy performance assessment of diesel conservation avenues	2
7.0	**Energy Efficient Technologies in Electrical Systems**	
7.1	Maximum demand controllers, Automatic power factor controllers	1
7.2	Energy efficient motors	2

7.3	Soft starters with energy saver, Variable speed drives	2
7.4	Energy efficient transformers	1
7.5	Electronic Ballast, Occupancy sensors, Energy efficient lighting controls	2

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Sub Code	Lectures	Tutorial	Practical	Credit
EGA	3	-	-	3

EGA Industrial Safety and Environment 3:0

Preamble

In India, efforts for control of major chemical plant accidents began in the aftermath of the Bhopal Gas tragedy in 1984. In 1989, the Ministry of Environment & Forest, Government of India formed the important MIHC (Manufacture & Import of Hazardous Chemicals) rules. Ministry of Labour, Government of India implemented an ILO (International Labour Organization) project to establish MAHC (Major Hazard Control) system to identify & assess hazards in MAH plants, to frame new legislation for MHC, etc. Over 1000 industrial plants have been identified as MH plants in India. Unlike natural hazards, chemical hazards can be prevented by proper planning & in case of accidents; the consequences can be minimized to the extent possible.

World wide, the total loss figure has doubled every 10 years despite increased efforts by the chemical process industry to improve safety. The increases are mostly due to an expansion in the number of chemical plants, an increase in chemical plant size, an increase in the use of more complicated & dangerous chemicals. Within the past 10 or 15 years, the chemical & petroleum industries have undergone considerable changes. Process conditions such as pressure & temperature have become more severe. Plants have grown in size & inventory. The scale of possible fire, explosion has grown & so has the area that might be affected by such events, especially outside the work boundary.

Programme Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

e. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

h. An ability to function on multidisciplinary teams

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the student should be able to:

1. Explain the basic principles of Safety practices
2. Estimate the risk level of a given hazardous area
3. Apply and adopt safety management and policy
4. Carryout accident analysis

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	30	30	20
2	Understand	50	50	30
3	Apply	20	20	30
4	Analyze	0	0	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What are the hazard identification techniques?
2. List the salient features of 3^{rd} factory act 1911
3. What are the sources that give information requirement on hazard evaluation?
4. List the methods of lessoning accidents
5. What are the obligations of an employer to prevent accident?
6. Classify the different accidents
7. What is HAZOP or hazard and operability study?
8. What are the advantages of Event Tree Analysis(ETA)?
9. List some of the risk zones regarding fire accidents
10. List the safety precautions for operating high voltage equipment

Understand

1. Explain the concept of risk tolerance matrix
2. Compare and contrast the relative ranking method of analysis and Preliminary hazard analysis (PHA)
3. Explain in detail the HAZOP Analysis
4. Explain FMEA, FTA, ETA, CCA, HRA Analysis
5. Explain the guidelines for accident investigations
6. Explain the procedure for HAZOP study
7. Explain the occurrence of shock due to flashover
8. Explain the grounding procedures

Apply

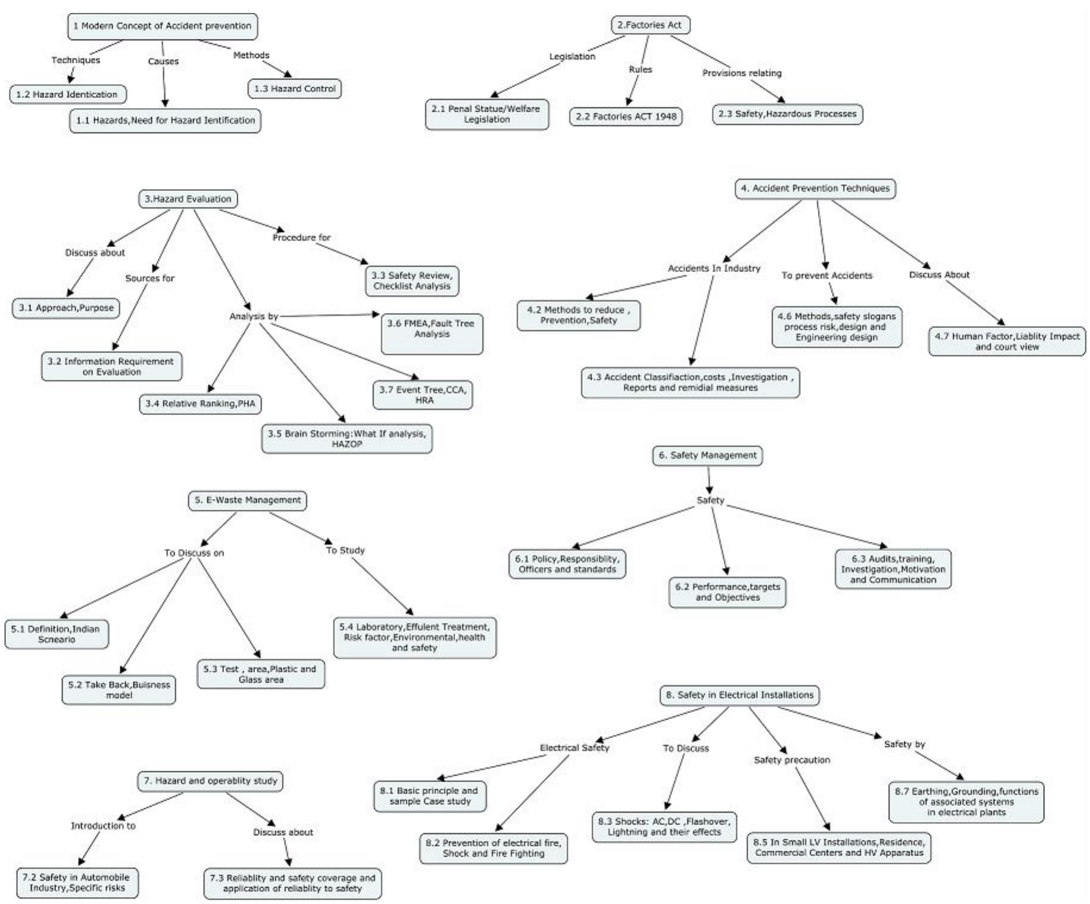
1. Specify the applications of Lockout and Tag out
2. What are the safety factors to be consider in a petrochemical industries
3. Discuss the precautionary measures to be consider in Textile industry to minimize hazards

Analyze

1. With any one case study explain the cause and effect of electric accident and the remedial measures to prevent it

2. Analyze the health risks in an automobile industry and suggest techniques to minimize?
3. Classify the risk zones regarding fire accidents in petrochemical industries. Also suggest suitable fire extinguishers for each area.

Concept Map



Syllabus

Modern Concept of Accident Prevention – Hazard, Hazard causes, Need for Hazard Identification, Hazard Identification Techniques, Reactive approach, Proactive approach, Hazard Control

Factories Act – Penal Statute / Welfare Legislation, The Factories Act 1948 and Tamil Nadu Factories Rules 1950, Safety Provisions, Provisions relating to Hazardous processes

Hazard Evaluation - Hazard Evaluation approach, Purpose, Sources for information requirement on hazard evaluation, Safety Review, Advantages, Method of checklist analysis, Relative ranking method of analysis, Preliminary Hazard Analysis (PHA), Brain Storming approach: What - if – analysis, Hazard and Operability Analysis (HAZOP), Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA), Cause-Consequence Analysis (CCA), Human Reliability Analysis (HRA)

Accident Prevention Techniques - safety precautions, Industrial Accidents, Methods of Lessening Accidents, Prevention of Accident, Safety Committee, Classification of Accidents, Accident Costs, Steps of Investigation, Accident Reports, Need for the analysis of accidents, Remedial Measures, Methods adopted for accident prevention, Methods of reducing accidents, Safety Slogans, Process risk, Design and engineering control, Human factor, Liability impacts of major disaster outside its premises, Court view

E-Waste Management - Suitable for Indian condition, Definition of e-waste, Indian Scenario, Take Back, Business Model, Test Area, Metals Area, Plastic Area, Glass Area, Laboratory, Effluent Treatment Plant, Risk factors, Environmental, Health and Safety

Safety Management – Introduction, Safety policy, Safety to be a Line Management Responsibility, Safety officers, Safety standards, Techniques to measure safety performance, Safety targets and objectives, Audits of safety standards and practices, Safety training, Investigation and follow up of injuries and incidents, Motivation and communication,

Hazard and Operability Study – Introduction, Principle, Procedure, Safety in Automobile Industry, Industry specific risks, Reliability & Safety - Coverage, Application of Reliability to Safety

Safety in Electrical Installations - Basic principles of electrical safety, A sample case study, Fire prevention and fire fighting, Electrical shocks and their prevention, Occurrence of shock, Shocks from AC, AC Shock versus DC shock, Effect of impulse discharge through body, Shocks due to flashover, Lightning and its effects, Safety precautions for small L-V installations, residential and commercial centers, Precautions to be taken before working on HV apparatus, Earthing and grounding, Equipment grounding, Safety systems in electrical installations, Functions of associated systems in electrical plants and substations

Text Book

B.Nedumaran, “Industrial Safety and Risk Management” Class notes,2004.

Reference Books

1. William Hammer, “Product Safety management and Engineering ", prentice Hall International Society, 1980.
2. Danier C. Peterson, “Techniques of Safety Management ", McGraw Hill Kogakisha Ltd.,Japan, 1971.
3. Check list for work place inspection for improving safety, " health and working condition ", International Labour Organization Geneva, 1987.
4. Safety and failure of components, " Proceedings of Mechanical Engineering ", London, Vol. 184, Part 38, 1974.

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**Modern Concept of Accident Prevention**	
1.1	Hazard, causes the hazards, Need for Hazard Identification	2
1.2	Hazard Identification Techniques	1
1.3	Hazard Control	2
2.0	**Factories Act**	

2.1	Penal Statute / Welfare Legislation	1
2.2	The Factories Act 1948 and Tamil Nadu Factories Rules 1950,	1
2.3	Safety Provisions, Provisions relating to Hazardous processes	1
3.0	**Hazard Evaluation**	
3.1	Hazard Evaluation approach, Purpose	1
3.2	Sources for information requirement on hazard evaluation,	1
3.3	Safety Review, Advantages, Method of checklist analysis	2
3.4	Relative ranking method of analysis, Preliminary Hazard Analysis (PHA)	1
3.5	Brain Storming approach: What - if – analysis, Hazard and Operability Analysis (HAZOP),	2
3.6	Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA)	1
3.7	Event Tree Analysis (ETA), Cause-Consequence Analysis (CCA), Human Reliability Analysis (HRA)	
4.0	**Accident Prevention Techniques**	
4.1	Safety precautions	1
4.2	Industrial Accidents, Methods of Lessening Accidents, Prevention of Accident, Safety Committee	2
4.3	Classification of Accidents, Accident Costs, Steps of Investigation	2
4.4	Accident Reports, Need for the analysis of accidents	1
4.5	Remedial Measures, Methods adopted for accident prevention,	2
4.6	Methods of reducing accidents, Safety Slogans, Process risk, Design and engineering control	1
4.7	Human factor, Liability impacts of major disaster outside its premises, Court view	2
5.0	**E-Waste Management**	
5.1	Definition of e-waste, Indian Scenario	1
5.2	Take Back, Business Model	1
5.3	Test Area, Metals Area, Plastic Area, Glass Area	1
5.4	Laboratory, Effluent Treatment Plant	1
5.5	Risk factors, Environmental, Health and Safety	1
6.0	**Safety Management**	
6.1	Safety policy, Safety to be a Line Management Responsibility, Safety officers, Safety standards	2
6.2	Techniques to measure safety performance, Safety targets and objectives	2

6.3	Audits of safety standards and practices, Safety training	1
6.4	Investigation and follow up of injuries and incidents, Motivation and communication	2
7.0	**Hazard and Operability Study**	
7.1	Introduction, Principle, Procedure	1
7.2	Safety in Automobile Industry, Industry specific risks	1
7.3	Reliability & Safety - Coverage, Application of Reliability to Safety	1
8.0	**Safety in Electrical Installations**	
8.1	Basic principles of electrical safety, A sample case study,	1
8.2	Fire prevention and fire fighting	1
8.3	Electrical shocks and their prevention, Occurrence of shock, Shocks from AC, AC Shock versus DC shock,	2
8.4	Effect of impulse discharge through body, Shocks due to flashover, Lightning and its effects,	1
8.5	Safety precautions for small L-V installations, residential and commercial centers,	2
8.6	Precautions to be taken before working on HV apparatus	1
8.7	Earthing and grounding, Equipment grounding, Safety systems in electrical installations,	1
8.8	Functions of associated systems in electrical plants and substations	1

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Sub Code	Lectures	Tutorial	Practical	Credit
EGB	3	-	-	3

EGB Renewable Energy Sources 3:0

Preamble

Renewable energy sources are gaining importance to minimize the global warming. Presently around 5% of total energy usage is met by Renewable Energy Sources. The renewable energy usage may be met up to 50% level in the end of this century to make the world green. Energy has become an important and one of the basic infrastructures required for the economic development of a country. Energy security is imperative for sustained growth of economy. The importance and role of renewable energy sources is stressed on the aspects of growing energy demand. The harnessing of energy through renewable resources, using efficient technologies is expected to play an important role of serving a clean energy source for mankind and for the mother earth.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of Renewable Energy Sources applications to real life energy requirements.

b. Graduates will able to select a right green energy source for a specify applications.

c. Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course the student should be able to:

1. Discuss the nature of renewable energy sources including solar, geothermal, wind, biomass, tidal and hydro paying attention to energy and environment payback.
2. Explain the basic principles of energy conversion from Renewable Energy Resources
3. Discuss the various viable option for the utilization of renewable energy resources
4. Design renewable energy system for given specification based on current commercially available technologies

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	10
2	Understand	50	50	40
3	Apply	30	30	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	20

Course Level Learning Objectives

Remember

1. Define the term Renewable energy source?
2. Mention the Coal, Gas & Fuel oil reserves of India at present rate of consumption in years?
3. Name the green house gases involved in global warming?
4. What is meant by Cut-in and Cut-out speed in wind turbine?
5. What are the factors to be considered while selecting a site for wind power plant?
6. Explain the working principle of a wind electric generator system with a block diagram?
7. Explain the various methods of tidal power generation with a conceptual diagram? What are the limitations?
8. What is meant by Energy Plantation?
9. What is meant by energy economy?
10. What are the factors governing global warming? How it can be minimized?

Understand

1. Specify the limitations of Renewable energy sources?
2. Why tracking/orientation is needed in concentrating type of solar collectors?
3. Specify the needs of energy storage devices? Discuss the various method of energy storage?
4. Explain the operation of binary cycle geothermal power plant?
5. Explain the Anaerobic digestion principle to convert Biomass into biogas?
6. What are the advantages of vertical axis turbine over to horizontal axis wind turbine?
7. List the advantages of biomass gasification compared to biomass combustion
8. Explain the process of pyrolysis to generate biogas from biomass? Also specify the advantages & disadvantages.
9. Why biomass is considered as a renewable energy sources?
10. What do you understand by the term mini hydro power plant?

Apply

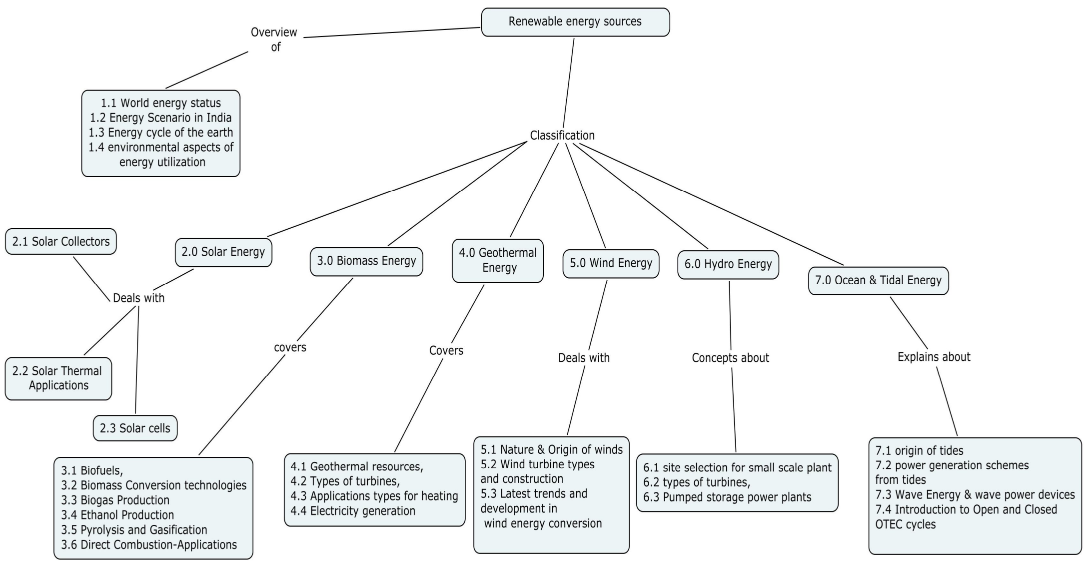
1. Draw the Energy Consumption pattern of India by using a bar chart graph and also discuss the ways and means to bridge the gap between Demand & Supply of Power in India?
2. List the commercial energy resources?
3. Suggest suitable solar collectors for solar furnace applications?
4. What are the main applications of solar dryer?
5. Discuss the various application of solar energy? Also specify its applicability with respect to economic operation?
6. Discuss the various application of geothermal energy for energy alternative?
7. List the procedure to select a site for wind electric generator installations? Also specify the different types of Wind Turbine along with its application.
8. What are the difficulties encountered in commercializing the renewable energy sources?

9. The ocean surface temperature at a location is 30C and bottom ocean temperature is 10C. Calculate the maximum theoretical efficiency of the OTEC system for energy conversion?

Create

1. Create a Renewable Energy System for an Tea industry energy applications
2. Create a Renewable energy model for preheating water for a power plant application.
3. Create a renewable energy system for desalination of Sea water.

Concept Map



Syllabus

Energy Overview: Classification of Energy Resources, World energy status, Energy Scenario in India-energy cycle of the earth-environmental aspects of energy utilization-renewable energy resources and their importance

Solar Energy: Solar collectors, Solar thermal applications, solar cells

Biomass Energy: Biofuels, Biomass Conversion technologies, Biogas Production-Ethanol Production-Pyrolysis and Gasification-Direct Combustion-Applications.

Geothermal Energy: Geothermal resources, basic theory-types of turbines-applications types, applications for heating and electricity generation

Wind Energy: Nature & Origin of winds, Wind turbine types and construction, Latest trends and development in wind energy conversion.

Hydro Energy: Basic concepts site selection and types of turbines for small scale hydropower, Pumped storage power plants

Ocean & Tidal Energy: origin of tides-power generation schemes-Wave Energy, wave power devices, Introduction to Open and Closed OTEC cycles

Environmental Aspects: Energy Payback and Environment Payback period. Potential impacts of harnessing the different renewable energy resources.

Text Book

B.H. Khan, “Non-Conventional Energy Resources” Tata McGraw-Hill Publishing Company Limited, 1st Edition, 2006.

Reference Books

1. Abbasi S.A, Abbasi Naseema, Renewable Energy Resources & Their Environmental Impact, Prentice Hall of India, 2001
2. G.D.Roy, Non-conventional Energy Sources, Khanna Publications, New Delhi, 2001
3. Ghosh.B.Saha, S.K.Basu, Sujay, Towards Clean Energy, Tata McGraw Hill, New Delhi, 1996
4. Garg.H.P, Prakash.J, Solar Energy, Tata McGraw Hill, New Delhi, 2000

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**Energy Overview:**	
1.1	Classification of Energy Resources, World energy status	2
1.2	Energy Scenario in India	1
1.3	Energy cycle of the earth	2
1.4	Environmental aspects of energy utilization	1
1.5	Renewable energy resources and their importance	1
2.0	**Solar Energy**	
2.1	Solar collectors	1
2.2	Solar thermal applications	1
2.3	solar cells	1
3.0	**Biomass Energy**	
3.1	Biofuels	1
3.2	Biomass Conversion technologies	1
3.3	Biogas Production	2
3.4	Ethanol Production	2
3.5	Pyrolysis and Gasification	2
3.6	Direct Combustion-Applications	1
4.0	**Geothermal Energy**	
4.1	Geothermal resources & basic theory	1
4.2	Types of turbines	1
4.3	Applications types for heating	1
4.4	Electricity generation	2
5.0	**Wind Energy**	
5.1	Nature & Origin of winds	1
5.2	Wind turbine types and construction	2

5.3	Latest trends and development in wind energy conversion	2
6.0	**Hydro Energy**	
6.1	Site selection for Small Scale Hydropower Plant	1
6.2	Turbines for Small Scale Hydro Plants	1
6.3	Pumped storage power plants	2
7.0	**Ocean & Tidal Energy**	
7.1	origin of tides	1
7.2	power generation schemes from tides	2
7.3	Wave Energy & wave power devices	2
7.4	Introduction to Open and Closed OTEC cycles	2
8.0	**Environmental Aspects:**	
8.1	Potential impacts of harnessing the different renewable energy resources	2

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Sub Code	Lectures	Tutorial	Practical	Credit
EGC	3	-	-	3

EGC Soft computing 3:0

Preamble

Soft computing is a discipline that deals with the design of intelligent systems, which is in contrast to classical hard computing technique. A consortium of computing methodologies that provides a foundation for the conception, design, and deployment of intelligent systems and aims to formalize the human ability to make rational decisions in an environment of uncertainty, imprecision, partial truth, and approximation. The main constituents of soft computing involve fuzzy logic, neuro computing, and genetic algorithms and its applications.

Students acquire knowledge of soft computing theories, fundamentals and so they will be able to design program systems using approaches of these theories for solving various real-world problems. Students also awake the importance of tolerance of imprecision and uncertainty for design of robust and low-cost intelligent machines.

Program outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to identify, formulate and solve engineering problems
d. An ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints

Competencies

After successfully completing the course, students are able to:

1. Acquire the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience
2. Acquire the knowledge of neural networks that can learn from available examples and generalize to form appropriate rules for inferencing systems
3. Provide the mathematical background for carrying out the optimization associated with neural network learning
4. Acquire knowledge of various optimization techniques and genetic algorithm procedures useful while seeking global optimum in self-learning situations
5. Detailed case studies utilizing the above and illustrate the intelligent behavior of programs based on soft computing

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End semester examination
1	Remember	20	20	10
2	Understand	40	40	30
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	20
6	Create	0	0	0

Course level learning objectives

Remember

1. What are the different paradigms of soft-computing?
2. Give some common applications of fuzzy logic?
3. What are the different methods of De-fuzzification?
4. What are the parameters to be considered for the design of membership function?
5. Define: optimization
6. Mention the different methods selection.
7. What are the genetic operators used in GA?
8. What are the types of learning?
9. Mention the linear and non-linear activation functions used in ANN.
10. What is perceptron?
11. What is feed forward networks? Give example.
12. How weights are initialized by BAM?
13. Mention the special features of Boltzman machine.

Understand

1. Explain Sugeno fuzzy model
2. Explain the construction of fuzzy model for a nonlinear equation
3. Explain Widrow-Hoff LMS Learning Algorithms.
4. Explain multilayer perceptron with its architecture. How is it used to solve XOR Problem?
5. What do you mean by supervised and unsupervised learning?
6. Explain back propagation algorithm in detail.
7. Describe the learning expressions in the back propagation network.
8. What is competitive learning? How does it differ from signal Hebbrian learning?
9. Explain the basic idea behind SVM with suitable illustrations
10. Explain the various steps involved in GA in detail

Apply and Evaluate

1. Compute the centroid defuzzifier for

$\overline{A}=\left\{\frac{0.9}{-3},\frac{0.7}{-2},\frac{0}{-1},\frac{0.3}{1},\frac{1}{2},\frac{0.2}{3}\right\}$

2. Let $X=\{0,1,2,3,4,5\}$ and $\overline{A}=\left\{\frac{0.9}{-3},\frac{0.7}{-2},\frac{0}{-1},\frac{0.3}{1},\frac{1}{2},\frac{0.2}{3}\right\}$, $\overline{B}=\left\{\frac{0.9}{-3},\frac{0.7}{-2},\frac{0}{-1},\frac{0.3}{1},\frac{1}{2},\frac{0.2}{3}\right\}$

Find the fuzzy max and fuzzy min of $\overline{A}$ and $\overline{B}$

3. Let A={(x1,0.2),(x2,0.7),(x3,0.4)} and B={(y1,0.5),(y2,0.6)} be two fuzzy sets defined on the universe of discourse X={x1,x2,x3} and Y={y1,y2,y3} respectively. Find the Cartesian product of the A and B and fuzzy relation R.

4. Describe the structure and operation of continuous Hopfield network. & Construct an auto associative BAM using the following training vectors. X1 = $(1,-1,-1,1,-1,1)^T$ and x2 = $(1,1,1,-1,-1,-1)^T$. Determine the output using xo $=(1,1,1,1,-1,1)^T$

5. Find the optimal layer associative memory (OLAM) matrix M for the association given below

A1 = $(1\ 2\ 3)^T$ B1 = $(4\ 3\ 2\ )^T$
A2 = $(2\ 3\ 4)^T$ B2 = $(3\ 5\ 2\ )^T$
A3 = $(3\ 4\ 6)^T$ B3 = $(2\ 2\ 1)^T$

Determining whether Ai= M - Bi

6. Perform two generations of simple binary coded genetic algorithm to solve the following optimization problem. Maximize $f(x) = x^2$ $0\le x\le 31$, x is an integer.

Use proportionate selection, single point crossover, binary mutation and population size of six.

7. Perform two generations of simple binary coded and real coded genetic algorithm to solve the following optimization problem.

Maximize $f(x) = |x| \sin(x)$ $-5\le x\le 5$, x is real number.

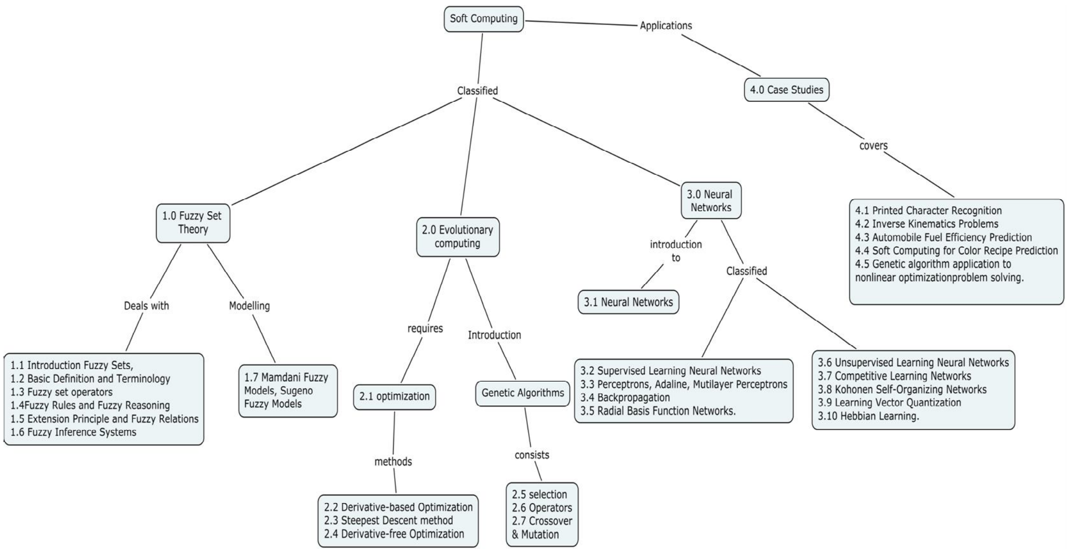
Use proportionate selection, single point crossover, and binary mutation for simple GA and proportionate selection, Arithmetic crossover, and Gaussian mutation for RGA .Use population size of six for both SGA and RGA. Evaluate the performance of SGA and RGA after two generations

8. For the following data set, generate a suitable simple fuzzy and perceptron neuron model

```
OriginalData = {{1, 20}, {2, 12}, {3, 9}, {4, 6},
  {5, 5}, {6, 4}, {7, 5}, {8, 6}, {9, 9}, {10, 12}, {11, 20}};
```

Evaluate their performance.

Concept Map



Syllabus

FUZZY SET THEORY

Introduction to Soft Computing – Fuzzy Sets – Basic Definition and Terminology – Fuzzy set operators – Fuzzy Rules and Fuzzy Reasoning – Extension Principle and Fuzzy Relations – Fuzzy Inference Systems – Mamdani Fuzzy Models – Sugeno Fuzzy Models – Fuzzy Modeling.

GENETIC ALGORITHMS

Introduction to optimization techniques - Derivative-based Optimization – Steepest Descent Method – Derivative-free Optimization – Genetic Algorithms - Selection, -Genetic operators- Crossover and Mutation –Simple binary coded GA- Real coded GA.

NEURAL NETWORKS

Introduction - Supervised Learning Neural Networks – Perceptrons - Adaline – Mutilayer Perceptrons – Back propagation - Radial Basis Function Networks – Unsupervised Learning Neural Networks – Competitive Learning Networks – Kohonen Self-Organizing Networks – Learning Vector Quantization – Hebbian Learning –Support vector Machines .

CASE STUDIES

Printed Character Recognition – Inverse Kinematics Problems – Automobile Fuel Efficiency Prediction – Soft Computing for Color Recipe Prediction- Genetic algorithm application to nonlinear optimization problem solving.

TEXT BOOK

J.S.R.Jang, C.T.Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI, 2004, Pearson Education 2004.

REFERENCE Books

1. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, McGraw-Hill, 1997.
2. Davis E.Goldberg, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y., 1989.

3. Simon Haykin, "Neural Networks A comprehensive foundation", PHI, Second Edition,1999

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0 FUZZY SET THEORY		
1.1	Introduction to Soft Computing	1
1.2	Fuzzy Sets, Basic Definition and Terminology	1
1.3	Fuzzy set operators	1
1.4	Fuzzy Rules and Fuzzy Reasoning	1
1.5	Extension Principle and Fuzzy Relations	1
1.6	Fuzzy Inference Systems	1
1.7	Mamdani Fuzzy Models Sugeno Fuzzy Models	2
2.0 GENETIC ALGORITHMS		
2.1	Introduction to optimization techniques	1
2.2	Derivative-based Optimization	1
2.3	Steepest Descent method and Derivative-free Optimization	1
2.4	Genetic Algorithms- Selection	1
2.5	Genetic operators	1
2.6	Crossover and Mutation schemes	1
2.7	Simple binary coded GA	2
2.8	Real coded GA	2
3.0 NEURAL NETWORKS		
3.1	Introduction	1
3.2	Supervised and unsupervised Learning Neural Networks	1
3.3	Perceptrons, Adaline, Mutilayer Perceptrons	2
3.4	Backpropagation	2
3.5	Radial Basis Function Networks	1
3.6	Competitive Learning Networks	1
3.7	Kohonen Self-Organizing Networks	1
3.8	Learning Vector Quantization	1
3.9	Hebbian Learning.	1
3.10	Support vector machines	2
4.0 CASE STUDIES		
4.1	Printed Character Recognition	1
4.2	Inverse Kinematics Problems	1
4.3	Automobile Fuel Efficiency Prediction	1
4.4	Soft Computing for Color Recipe Prediction	1

4.5	Genetic algorithm application to nonlinear optimization problem solving.	2

Course designers

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2. Dr.P.Venkatesh pveee@tce.edu
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Sub Code	Lectures	Tutorial	Practical	Credit
E 1B	14	0	0	1

E1B DESIGN OF ROBUST LV DISTRIBUTION SYSTEMS

Preamble

An Electrical Engineering Graduate should have Design knowledge on Low Voltage Distribution Systems. This course emphasizes the development of LV Distribution Products and its design issues. Also address the solving of different kinds of practical problems that occur in Distribution Side design, selection of equipment / switch gears, commissioning & testing and control of robust design of the LV distribution systems.

Programme Outcomes addressed

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

k. An ability to consider issues from global and multilateral views

Competencies

At the end of the course the student should be able to understand:

1. Design and challenges in LV distribution systems.
2. Selection of various switch gears for LV distribution.
3. Robust design Issues in Switch Gears & Protection of LV distribution.
4. Various Quality control methods for robust products

Assessment Pattern

	Bloom's Category	End-semester examination
1	Remember	0
2	Understand	30
3	Apply	30
4	Analyze	20
5	Evaluate	0
6	Create	20

Syllabus

Elements of LV distribution products: Range, functionality, and integration of products into system

Essentials of design: Domain & design tools knowledge, understand & use of design language.

Why robust design: safety of people & installation, regulations, assured life, user confidence

How of robust design: Quality, reliability, dfss, poka-yoke, design margin & trade-offs.

Testing & validation of robust design: Evaluation, certification, third party recognition, field performance.

Controls for robust products: Parts, processes, performance, qms, internal & external defect ppm

References

1. Lecture Notes Prepared by Course Designer.
2. www.ge.com

Course contents and Lecture schedule

Sl.No.	Topic	No. of Lectures
1.	**Elements of LV distribution products**	
1.1	Range, functionality, and integration of products into system	2
2	**Essentials of design**	
2.1	Domain & design tools knowledge, understand & use of design language.	3
3	**Why robust design**	
3.1	Safety of people & installation, regulations, assured life, user confidence	3
4	**How of robust design**	
4.1	Quality, reliability, dfss, poka-yoke, design margin & trade-offs.	2
5	**Testing & validation of robust design**	
5.1	Evaluation, certification, third party recognition, field performance	2
6	**Controls for robust products**	
6.1	Parts, processes, performance, qms, internal & external defect ppm	2
	TOTAL	**14**

Course Designer

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GE Energy - Industrial Solutions
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Sub Code	Lectures	Tutorial	Practical	Credit
E1J	**1**	**-**	**-**	**1**

E1J Micro Grid 1:0

Preamble

Nearly 60% of Grid Power in today's scenario is from Thermal Power Stations where we burn the fossil fuels to Generate Electric Power. Power Generation from fossil fuels is the major contributor to the carbon emissions which is in turn the major cause for Global worming issues what we face today.

The BEST solution to contain carbon emission is to monitor electric consumption, to optimize the energy consumption by adapting to best methods of energy efficiency, to integrate Renewables to the tail end of the Grid even if it is in a small way to begin with and also to introduce energy storage systems in the Grid.

To integrate energy efficiency, Renewable and energy storage systems, the best way is to have a SMART GRID without which this may not be possible.

This will also solve Power Quality issues to great extent.

Program outcomes addressed

a. An ability to design a system or component, or process to meet stated specifications
b. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints
c. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.
d. An ability to consider issues from global and multilateral views.

Competencies

At the end of the course the students will be able to:

1. Understand the aspects of planning, engineering, design and operation of SMART GRID
2. Understand the criteria involved in the selection of equipment involved in the development of SMART GRID.
3. Understand the steps involved with SMART GRID system.
4. Understand the concept of SMART METERING and implementation of this kind of Metering
5. Understand the aspects of Integration of Renewables, Energy Storage system in the MICRO GRID
6. Understand the aspects of selecting the right type of Renewables and right type of energy storage systems

Assessment Pattern

	Bloom's Category	End-semester examination
1	Remember	30
2	Understand	40
3	Apply	30
4	Analyze	0
5	Evaluate	0
6	Create	0

Course Level Learning Objectives

Remember

1. Define - Micro grid.
2. List the various mitigation methods of voltage regulation in micro grid.
3. Define – Fuel cell.
4. Write short notes on micro grid black start.
5. Describe the power quality enhanced operation of a micro grid.
6. State the methods of voltage mitigation in micro grids.

Understand

1. Explain the control operation of Interconnected Network Bulk Power Grids.

2. Explain the various emergency control strategies in micro grid.
3. Explain the dynamic modeling of a Hybrid Distributed Generation (HDG) System.
4. Describe the general requirements and sequence of actions for micro grid
5. What is the significance of droop setting in frequency control?
6. Discuss in detail the Neighborhood Area Communications and Home Area Network topology.

Apply

1. Illustrate the difference between conventional grid and smart grid.
2. Dramatize the system stability of micro grid with high droop gain.
3. Demonstrate the voltage regulation in micro grid and conventional distribution network.
4. Construct the different network topologies in smart micro grid.
5. Interpret the role of smart metering in micro grid.

Syllabus

Concept of MICRO Grid

General Back ground, Functions of a Micro Grid- Layouts, Essential features, functions of various elements in Micro Grid;

Renewables for Micro Grid

Basics of various Renewables, Integration of Renewables in the Micro Grid, Selection of Renewables and Commercial application;

Energy Storage Options

Basics of various Energy Storage options, Selection of Energy Storage Options;

Smart Metering Solutions

SMART metering concept, Advanced Metering Infrastructure, SCADA and application;

Distributed Generation

Concept of Distributed Generation and its application

Reference Books

1. Micro Grid Integration with Renewables in Indian context by S. S. Murthy, *Life Senior Member, IEEE*

2. Micro Grids and Active Distribution Networks by S. Chowdhury, S.P. Chowdhury and P. Crossley

3. Deployment of Micro Grids in India by V. S. K. Murthy Balijepalli, Student Member, IEEE , S. A. Khaparde, Senior Member, IEEE and C. V. Dobariya

Course content and Lecture Schedule

Sl No	Contents	Lecture Hours
1	**Concept of MICRO Grid**	
1.1	General Back ground, Functions of a Micro Grid	1
1.2	Layouts, Essential features, functions of various elements in Micro Grid	2
2	**Renewables for Micro Grid**	
2.1	Basics of various Renewables	1
2.2	Integration of Renewables in the Micro Grid	1
2.3	Selection of Renewables and Commercial application	2
3	**Energy Storage Options**	
3.1	Basics of various Energy Storage options	1
3.2	Selection of Energy Storage Options	1
4	**Smart Metering Solutions**	
4.1	SMART metering concept	1
4.2	Advanced Metering Infrastructure	1
4.3	SCADA and application	2
5	**Distributed Generation**	
5.1	Concept of Distributed Generation and its application	1
	Total Hours	14

Course designers

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BIO-DATA :

A.D.Thirumoorthy

Energy Consultant

Coimbatore

Basically an Electrical Engineer worked in Power Utility for the past 32 years. Most of the services in Technical field, handling metering area and Sub-station Protection area.

Worked in Renewable Energy Development Agency (IREDA).

Presented about 40 technical of papers in different National and International Conferences.

Presented a paper on Power Quality in Wind Mills in Asia International Conference 2010, Bangkok and October, 2012 in Malaysia, and listed as speaker for September conference in Macau, China.

Regular Guest Lecturer in Engineering colleges, and also handling ONE credit courses in Engineering Colleges, for the past THREE years especially in the areas of Sub Station Engineering, Renewables and Power Quality.

Presently undertaken Power Quality Survey in Wind Mill connected areas funded by Ministry of New and Renewable source of Energy.

Pursuing R&D Project along with Coimbatore Institute of Technology and M/S.CDAC, Trivandrum in designing an indigenous Dynamic Voltage Restorer,

funded by Ministry of Power through CPRI, Bangalore.

Presently undertaking Solar installation works on EPC from KW to MW size.

Sub Code	Lectures	Tutorial	Practical	Credit
E1K	1	-	-	1

E1K SAFETY ENGINEERING **1:0**

Preamble

The industrial processes are designed and developed with the prime focus to convert the raw material into usable products for the society. In order to make the final products commercially viable, the processes are fine tuned, modified or replaced from time to time. All industrial processes are built by integration of best suitable technologies in all fields of engineering and science. A large number of equipments are used and adequate manpower is deployed for operation and maintenance of various units within the industry.

Program outcomes addressed

c. An ability to design a system or component, or process to meet stated specifications
e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints
i. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the students should be able to:

1. understand the general process safety and safety procedures
2. understand the Fire properties of solid, liquid and gas and about the toxicity of products of combustion
3. understand the Explosion protection systems ,Explosion parameters and Explosion suppression systems
4. Understand Hazardous area classification and classification of electrical equipments for hazardous areas (IS, API and OSHA standards).
5. understand the Electrical Hazards and Electrical causes of fire and explosion
6. understand about National electrical Safety code, Statutory Rules and Techniques of fire fighting, Indian Explosive acts and rules
7. Apply the safety guidelines for working in electrical system

Assessment Pattern

S.No	Bloom's Category	End-semester examination
1	Remember	30
2	Understand	50
3	Apply	20
4	Analyze	-
5	Evaluate	-
6	Create	-

Course level Learning Objectives

Remember

1. How the risk and are defined?
2. What are the fire hazards and electrical hazards in industries?
3. What are the unsafe situations one has to encounter while working in industry?
4. How fire and explosions are caused in industries?
5. What is a standard and how it is useful to prevent accidents in industries?
6. What are the procedures to be followed to ensure safety in electrical HV system?

Understand

1. Discuss the different ways of classifying the hazards.
2. Explain Classification of fire hazards and about OHSAS18001
3. Develop and Explain the safe working procedure to take up work in industry
4. Predict the various types of unsafe acts possible to occur and gas safety in Steel Industry
5. Discuss the different types of work practices and equipments used in industries to prevent accidents.
6. Discuss the steps to be taken to ensure Safety in electrical HV system

Syllabus

Basics in Safety: Definitions- Hazards, risk, importance of safety in industries. General Aspects, Safety Culture
Fire Hazard: Fire chemistry, Dynamics of fire behavior, Fire properties of solid, liquid and gas, Fire spread, Toxicity of products of combustion. Classification of fire hazards, Indian Explosive acts and rules, OHSAS18001, Fire/Flame/Smoke detectors.
Electrical Safety: Hazards, Effects of current flow, Energy leakage Clearance and insulation , Excess energy, Current surges , Protective devices Electrical causes of fire and explosion.
Safety in electrical HV system: Hazards/Risks, Basic Work Practices, Clearances, Tools &Plants, Earthing, Safety Documents, Safety Precautions, Flash over, Hazards in TLM, Best practices-perspective.
Safety in Steel Plants: Processes, Hazards in Steel Plants, Gas Production, Gas Safety aspects, Steps taken at Tata Steel.
Case Studies: Gas exposure while working on gas lines and Developing work procedures for working in electrical system.

Reference Books

1. Fordham Cooper W., Electrical Safety Engineering, Butterworths, London, 1986.
2. McCornick, E.J., Human Factors in Engineering and Design, Tata McGraw-Hill, 1982.
3. Accident Prevention Manual for Industrial Operations, NSC, Chicago, 1982
4. Gupta R.S., Handbook of Fire Technology, Orient Longman, Bombay, 1997
5. James, D., Fire Prevention Handbook, Butterworths, London, 1986.

Course content and Lecture Schedule

Sl No	Contents	Lecture Hours
1	**Basics in Safety**	
1.1	Definitions- Hazards, risk; importance of safety in industries.	1.0
1.2	General Aspects, Safety Culture.	1.0
2	**Fire Hazard**	
2.1	Fire chemistry, Dynamics of fire behavior, Fire properties of solid, liquid and gas – Fire spread, Toxicity of products of combustion.	1.5
2.2	Classification of fire hazards, Indian Explosive acts and rules, OHSAS18001, Fire/Flame/Smoke detectors.	1.5
3	**Electrical Safety**	
3.1	Hazards, Effects of current flow, Energy leakage	1
3.2	Clearance and insulation, Excess energy, Current surges, Protective devices, Electrical causes of fire and explosion.	1
4	**Safety in electrical HV system**	
4.1	Hazards/Risks, Basic Work Practices, Clearances, Tools & Plants, Earthing.	1
4.2	Safety Documents, Safety Precautions, Flash over, Hazards in TLM, Best practices-perspective.	1
5	**Safety in Steel Plants**	
5.1	Processes, Hazards in Steel Plants, Gas Production.	2.0
5.2	Gas Safety aspects, Steps taken at Tata Steel.	1.0
6	**Case Studies**	
6.1	Gas exposure while working on gas lines.	1.0
6.2	Developing work procedures for working in electrical system.	1.0
	Total	**14.0**

Course designers

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E1L POWER GRID OPERATION
1:0

Preamble

This course gives an exposure to the Indian power scenario and current issues faced by the national grid. It describes the need for energy conservation in electrical systems and power factor improvement. It throws light on the present and future challenges in Renewable energy grid integration.

Program Outcomes addressed

a. Ability to apply the knowledge of mathematics, science, and engineering.
j. To possess the knowledge of contemporary issues in engineering..

Competencies

At the end of the course the students will know:

1. Present Indian power scenario
2. Current issues in national grid
3. Energy conservation concepts
4. Challenges in Renewable energy grid integration

Assessment Pattern

	Bloom's Category	End-semester examination
1	Remember	40
2	Understand	50
3	Apply	10
4	Analyze	0
5	Evaluate	0
6	Create	0

Syllabus

Indian Power Scenario: Evaluation of Power System in India - Isolated Systems - Grid Systems -National Grid - ATC (Aggregate Technical & Commercial Losses) - Role of NLDC, RLDC & SLDC - National Tariff Policy.

Energy Conservation in Electrical Systems: Electricity Billing - Electrical Load Management - Maximum Demand Control - Power Factor Improvement and its Benefit - Selection and Location of Capacitors - Performance Assessment of PF Capacitors - Distribution and Transformer Losses.

RE Grid Integration: RE Generation: the present, the future and integration challenges - Present: state of the art in integrating large capacity RE - Future: technical solutions for integrating more large - capacity RE - Application of large capacity EES (Electrical Energy Storage) to support RE integration - Standard for large capacity RE Integration.

Course content and Lecture schedule

No.	Topic	No. of Lectures
1.0	**Indian Power Scenario**	
1.1	Evaluation of Power System in India	1
1.2	Isolated Systems - Grid Systems	1
1.3	National Grid - ATC (Aggregate Technical & Commercial Losses)	1
1.4	Role of NLDC, RLDC & SLDC - National Tariff Policy.	1
2.0	**Energy Conservation in Electrical Systems**	
2.1	Electricity Billing - Electrical Load Management	1
2.2	Maximum Demand Control	1
2.3	Power Factor Improvement and its Benefits	1
2.4	Selection and Location of Capacitors - Performance Assessment of PF Capacitors	1
2.5	Distribution and Transformer Losses.	1
3.0	**RE Grid Integration**	
3.1	RE Generation: the present, the future and integration challenges -	1
3.2	Present: state of the art in integrating large capacity RE	1
3.3	Future: technical solutions for integrating more large capacity RE	1
3.4	Application of large capacity EES (Electrical Energy Storage) to support RE integration	1
3.5	Standard for large capacity RE Integration.	1
	Total	**14**

Course Designer:

V. Suresh Babu, Assistant Director, NPTI (PSTI), Ministry of Power, Govt. of India, Bangalore.
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Course Coordinator:

R.Medeswaran , AP/EEE, TCE
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Expert profile:

- Pursuing Ph.D. in the department of Electrical Engineering from Visvesvaraya Technological University, Belgaum, Karnataka

- Graduated Engineering in the department of Electrical and Electronics from Bharathiyar University, Coimbatore, Tamil Nadu

- Post Graduation in Energy Systems Engineering from Vellore Institute of Technology, Vellore, and Tamil Nadu and specialized in Wind Energy & Solar Energy.

- Initially worked in IT for around 2 years in EPL Systems, Chennai, Tamil Nadu

- Having around 6 years of experience in teaching profession for engineering graduates across various engineering colleges in Bangalore.

- Having 2 years of experience in R and D activities in the field of Power Electronics.

- Working past 5 years as an Assistant Director in NPTI (PSTI), Ministry of Power, Govt. of India.

Roles and Responsibilities in NPTI:

- Giving training and certification for electrical engineers from various electrical entities across the world and performing 3rd Party inspection of HV & EHV Electrical equipments.

- Involved as System Operation faculty for Load Dispatch Engineers across the country for past 5 years.

- Involved in testing of Relays like Electromechanical, Solid states and Numerical relays that includes the following protection schemes - Bus bar protection, Transformer Protection, Generator Protection and Line Protection.

- Involved in HV testing and this includes testing of HV equipments like Transformers, Insulators, Bushes and Lightning arrestors.

- Prepared two manuals for Power System Operation and the same have been published by NPTI.

Area of Research:

Power quality issues in Distributed Generation & Islanding

Sub Code	Lectures	Tutorial	Practical	Credit
E 1E	14	0	0	1

E1E Indian Electrical Standards

Preamble

An electrical engineering graduate should have the knowledge of Indian electrical standards. This course unfolds the electrical standards for cabels, motors and power transformers.

Program Outcomes addressed

a. Ability to engage in life long learning.
b. Ability to consider issues from global and multilateral views.

Competencies

At the end of the course the students will know:

5. Electrical standards for cables ,motors and power transformers.
6. Various types of tests done on above.

Assessment Pattern

	Bloom's Category	Test3 / End-semester examination
1	Remember	40
2	Understand	40
3	Apply	0
4	Analyze	20
5	Evaluate	0
6	Create	0

Syllabus

CABLES - IS 7098: Cross linked polyethylene insulated thermoplastic sheathed cables — Specification. Insulation Thickness- Properties of XLPE insulation – Filler and Inner sheath, IS 5831- Armoring –Outer sheath , IS 5831 – construction – Core identification – Laying up of cores – thickness of outer sheath - Special tests - Acceptance test - Type test - Routine test . **IS 3961-**Current Rating for cables of different categories and derating factors.

MOTORS -IS-325 : Scope - Site conditions - Introduction to enclosure-IS 4691 - Introduction to type of cooling-IS6362 - Standard voltage ranges - Standard Ratings -
Types of Duty-IS 4722 -Dimensions Frame no. and output relations - Values performance characteristics for energy efficient Motors-IS12 615

Introduction to vibration levels-IS 12075 - Introduction to noise levels-IS 12065 and Tolerances.

TESTING

Type tests - Measurement of resistance of windings of stator and wound rotor- No load test at rated voltage to determine input current power and speed - Open circuit voltage ratio of wound rotor motors (Slip ring motors) - Reduced voltage running up test at no load (for squirrel cage motors upto 37 Kw only)- Locked rotor readings of voltage, current and power input at a suitable reduced voltage - Full load test to determine efficiency power factor and slip -Temperature rise test - Momentary overload test - Insulation resistance test - High voltage test.

Routine Tests - Insulation resistance test - Measurement of resistance of windings of stator and wound rotor-No load test - Locked rotor readings of voltage, current and power input at a suitable reduced voltage - Reduced voltage running up test - Open circuit voltage ratio of stator and rotor windings (for slip ring motors rotor - High voltage test **.**

POWER TRANSFORMERS - IS 2026 : Definition for different terms used in transformers-Specifications – Service Conditions – Rating – Short Circuit apparent power of the system- Temperature Limits – Percentage Impedance Tolerances.

TESTING

Type Tests -IS 11171 Dry Type Transformers-IS 335 New oil specification: Characteristics, Requirement, Method of Tests -IS 1866 Code of Practice for Maintenance and Supervision of Mineral Insulating oil in Electrical Equipment Application and interpretation of results.

Routine Tests -Measurement of winding resistance-Measurement of voltage ratio and check of voltage vector relationship- Measurement of impedance voltage/short-circuit impedance-Principal tapping and load loss- Measurement of no-load loss and current-Measurement of insulation resistance- Dielectric tests - IS 2026 PART-III- Tests on on-load tap-changers

Course content and Lecture schedule

No.	**Topic**	**No. of Lectures**
1.0	**CABLES - IS 7098**	
1.1	Cross linked polyethylene insulated thermoplastic sheathed cables — Specification. Insulation Thickness- Properties of XLPE insulation – Filler and Inner sheath, IS 5831- Armoring –Outer sheath , IS 5831 – construction	1
1.2	Core identification – Laying up of cores – thickness of outer sheath - Special tests - Acceptance test - Type test - Routine test . **IS 3961-**Current Rating for cables of different categories and derating factors.	2
2.0	**MOTORS -IS-325**	
2.1	Scope - Site conditions - Introduction to enclosure-IS 4691 - Introduction to type of cooling-IS6362 - Standard voltage ranges - Standard Ratings - Types of Duty-IS 4722 -Dimensions Frame no. and output relations - Values performance characteristics for energy efficient Motors-IS12 615- Introduction to vibration levels-IS 12075 - Introduction to noise levels-IS 12065 and Tolerances	2
2.2	**Type tests** - Measurement of resistance of windings of stator and wound rotor- No load test at rated voltage to determine input	2

	current power and speed - Open circuit voltage ratio of wound rotor motors (Slip ring motors) - Reduced voltage running up test at no load (for squirrel cage motors upto 37 Kw only)- Locked rotor readings of voltage, current and power input at a suitable reduced voltage - Full load test to determine efficiency power factor and slip -Temperature rise test - Momentary overload test - Insulation resistance test - High voltage test	
2.3	**Routine Tests -** Insulation resistance test - Measurement of resistance of windings of stator and wound rotor-No load test - Locked rotor readings of voltage, current and power input at a suitable reduced voltage - Reduced voltage running up test -Open circuit voltage ratio of stator and rotor windings (for slip ring motors rotor - High voltage test **.**	2
3.0	**POWER TRANSFORMERS - IS 2026**	
3.1	Definition for different terms used in transformers-Specifications – Service Conditions – Rating – Short Circuit apparent power of the system- Temperature Limits – Percentage Impedance Tolerances	1
3.2	**Type Tests -**IS 11171 Dry Type Transformers-IS 335 New oil specification: Characteristics, Requirement, Method of Tests -IS 1866 Code of Practice for Maintenance and Supervision of Mineral Insulating oil in Electrical Equipment Application and interpretation of results.	2
3.3	**Routine Tests -**Measurement of winding resistance-Measurement of voltage ratio and check of voltage vector relationship-Measurement of impedance voltage/short-circuit impedance-Principal tapping and load loss- Measurement of no-load loss and current-Measurement of insulation resistance- Dielectric tests - IS 2026 PART-III- Tests on on-load tap-changers	2
	Total	14

Course Designers:

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Course Coordinator:

R.Medeswaran , AP/EEE
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Sub Code	Lectures	Tutorial	Practical	Credit
E1N	1	-	-	1

1:0

E1N SOLAR POWER PLANT

Preamble

Fossil fuels are the major energy source that is being used in the world today. But their over exploitation can lead to serious environmental issues such as environmental pollution. Further, power shortages in India making most of the commercial and office establishments to opt for diesel generator backup, which is neither cost nor environment friendly. Hence, the focus of many countries is to utilize renewable sources for power generation. Among all renewable energy, Solar Energy seems to be more green & economic alternative to the conventional source of energy. This course highlights the solar power plant and its associated equipments. This course also addresses the grid code requirements and power quality issues of solar power plant.

Program outcomes addressed

c. An ability to design a system or component, or process to meet stated specifications

e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

i. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.

j. An ability to consider issues from global and multilateral views.

Competencies

At the end of the course the students should be able to:

8. Explain the Solar power plant and its types.
9. Describe the inverter types used in solar power plant.
10. Explain the MPPT and control algorithms for the solar power plant.
11. Describe the Grid code and standards of solar power plant.
12. Explain the safety standards for solar power plant.
13. Describe the grid support requirements of solar power plant.

Assessment Pattern

S.No.	Bloom's Category	End-semester examination
1	Remember	30
2	Understand	30
3	Apply	40
4	Analyze	-
5	Evaluate	-
6	Create	-

Course level Learning Objectives

Remember

7. State the types of solar cell.
8. Write the need for MPPT algorithm in solar power plant.
9. List the any three grid codes for solar power plant.

Understand

7. Explain the operation of solar power plant with suitable sketch.
8. Describe the power quality issues in solar power plant.
9. Explain the need for ride through requirement for grid connected solar power plant.

Apply

1. Illustrate the equivalent circuit of PV module showing the diode and ground leakage currents.
2. Describe the difference between solar and Conventional Power Plants.
3. Explain the Factors Influencing Power and Energy Performance of solar power plant.

Syllabus
SOLAR POWER PLANT

Solar power plant- Solar Panels - Thin film, Csi- Solar Panel characteristics - Types of Inverters-Central, String, Micro-Inverters- Solar Power Plant - Layout and other equipments- PV Penetration level- Analysis of any power plant layout architecture

Inverters- Inverter Topology-DC Link reference, Switching Topologies, Over modulation strategy- Booster- Grid Synchronization - PLL, IN-rush current- MPPT Algorithms - P&0, Incremental conductance, Fast sweep- Current controller and Voltage feed forward- Stability Analysis.
Assignment - Analysis on topologies in drives / power modules from Infinion or vincotech in matlab

Grid Codes / Standards / Protection- Relay self test, PV Insulation Test, Residual current, ARC fault detection- Remote power-off for fireman's option- Power Quality- Harmonics, Flicker Test- V / F Disconnection for various countries- Anti-islanding- Grid support functionality-Ride-through, Reactive Power – Types, Active power derating with frequency.
Assignment - voltage harmonics / current harmonics using a power-meter.

Other Applications- PV Diesel, Island inverters - with external UPS.
Assignment - Analysis on Tesla Island Inverters

Reference Books

1. Remus Teodorescu, Marco Liserre, Pedro Rodríguez," **Grid Converters for Photovoltaic and Wind Power Systems**", Wiley publication, 2011

Course content and Lecture Schedule

Sl No	Contents	Lecture Hours
1:0	**Solar power plant**	
1.1	Solar Panels - Thin film, Csi	1
1.2	Solar Panel characteristics	
1.3	Types of Inverters-Central, String, Micro-Inverters	1
1.4	Solar Power Plant - Layout and other equipments	
1.5	PV Penetration level	1
1.6	Analysis of any power plant layout architecture	

2:0	**Inverters**	
2.1	Inverter Topology-DC Link reference, Switching Topologies, Over modulation strategy- Booster	1
2.2	Grid Synchronization - PLL, IN-rush current	1
2.3	MPPT Algorithms - P&0, Incremental conductance, Fast sweep	1
2.4	Current controller and Voltage feed forward	1
2.5	Stability Analysis	1
2.6	**Assignment** - Analysis on topologies in drives / power modules from Infinion or vincotech in matlab	1
3.0	**Grid Codes / Standards / Protection**	1
3.1	Relay self test, PV Insulation Test, Residual current, ARC fault detection	
3.2	Remote power-off for fireman's option	1
3.3	Power Quality- Harmonics, Flicker Test	
3.4	V / F Disconnection for various countries	
3.5	Anti-islanding	
3.6	Grid support functionality-Ride-through, Reactive Power – Types, Active power derating with frequency	1
3.7	**Assignment** - voltage harmonics / current harmonics using a power-meter	1
4.0	**Other Applications**	
4.1	PV Diesel, Island inverters - with external UPS,	1
4.2	**Assignment** - Analysis on Tesla Island Inverters	
	Total	**14**

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E1G	15	-	-	1

E1G ELECTRICAL SUBSTATION ENGINEERING 1:0

Preamble

The present day electrical power is generated, transmitted and distributed in the form of alternating current. The electric power is produced at the power stations which are located at favorable place, generally quite away from consumers. It is delivered to the consumers through a large network of transmission and distribution. At many places in the line of power system some of characteristics like voltage, ac to dc, frequency of electric supply are accomplished by suitable apparatus called sub station. Electrical substations are supplementary parts of electricity generation systems, where voltage is transformed from high to low and vice verse using transformers. Substations containing step-up transformers increase voltage and decrease current. If the transformer contained within the substation is a step-down, the voltage decreases, and the current increases. There are three main types of substation: transmission, distribution, and collector.

Program outcomes addressed

c. An ability to design a system or component, or process to meet stated specifications
e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints
i. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.
j. An ability to consider issues from global and multilateral views.

Competencies

At the end of the course students should be able to

7. Understand the aspects of planning, engineering, design and operation of substations.
8. Understand the criteria involved in the selection of equipment involved in the development of substation.
9. Understand the steps involved with substation earthing system.
10. Understand the protective relaying in substations
11. Understand the testing, commissioning and inspection standards of substations.

Assessment Pattern

	Bloom's Category	End-semester examination
1	Remember	30
2	Understand	70
3	Apply	0
4	Analyze	0
5	Evaluate	0
6	Create	0

Learning Objectives

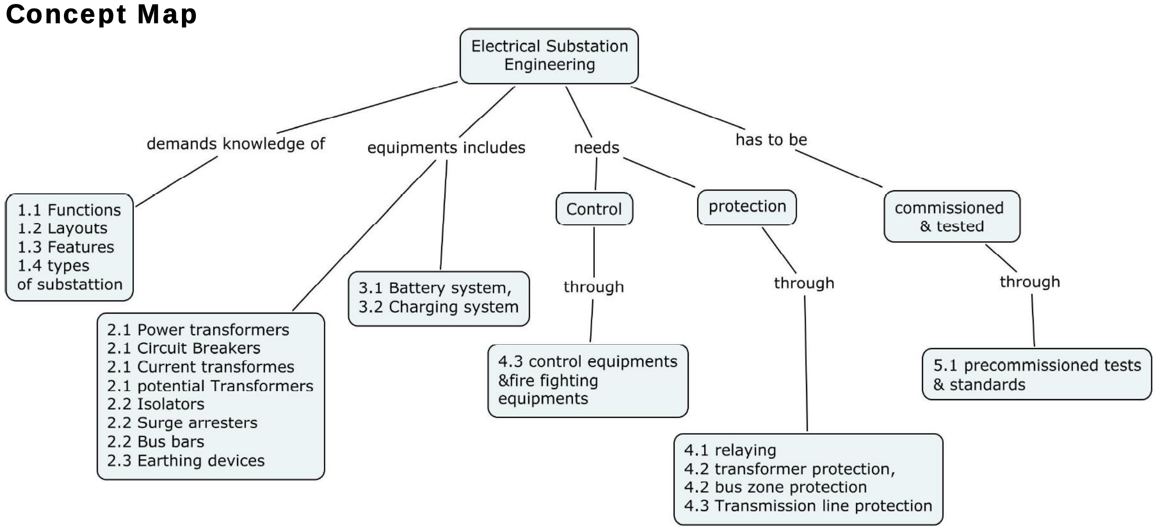
Remember

1. What is an electrical substation?
2. What are switching substations?
3. What are the dangers of living near a small electric substation?
4. How an electrical substation works?
5. Name the factors that should be taken care while designing and erecting the sub station.
6. What is the use of a reactor in an electrical substation?

Understand

1. Discuss the different ways of classifying the sub stations.
2. Explain the differences between Indoor and outdoor substations..
3. Explain the classifications of transformer sub stations.
4. Discuss the different types of equipments used in transformer sub station.
5. Draw and explain the typical layout of underground sub station
6. Explain the bus bar arrangements of sub stations.

Concept Map



Syllabus

Electrical Substation: General Back ground- Functions of substation- SS layouts – Essential features – Types of substation.

Major Substation equipments & Substation earthing : Power transformers – Circuit breakers – CTs & PTs- Isolators – Surge arresters – Busbars – Functional requirements of SS earthing – Description of an earthing system – Earth mat – resistance of earthing system & soil resistivity.

Battery system: Description of DC system – Battery AH capacity- specifications- Battery room – Battery charging system.

Protection & Control: Control room & control panels – Protective relaying – Power transformer protection – Bus zone protection – Protection of transmission lines – Substation control– fire fighting equipments.

Testing & commissioning: Details of pre-commissioning tests- standards

Reference Books

1. John D. McDonald "Electric Power Substations Engineering", Second Edition, CRC Press , 2003
2. V.K.Metha & Rohit Metha "Principles of power system", S. Chand & Company Ltd, 2007.
3. Sunil S.Rao, "Switchgear protection & power systems", thirteen edition Khanna Publishers 2008.

Course content and Lecture Schedule

Sl No	Contents	Lecture Hours
1	**Electrical Substation:**	
1.1	General Back ground, Functions of a substation	1
1.2	SS layouts , Essential features, Types of substation.	2
2	**Major Substation equipments & Substation earthing**	
2.1	Power transformers , Circuit breakers , CTs & PTs	1
2.2	Isolators , Surge arresters , Bus bars , Functional requirements of SS earthing	1
2.3	Description of an earthing system, resistance of earthing system & soil resistivity.	2
3	**Battery system**	
3.1	Description of DC system , Battery AH capacity, specifications	1
3.2	Battery room , Battery charging system	1
4	**Protection & Control**	
4.1	Control room & control panels , Protective relaying	1
4.2	Power transformer protection , Bus zone protection	1
4.3	Protection of transmission lines , Substation control, fire fighting equipments	2
5	**Testing & commissioning**	
5.1	Details of pre-commissioning tests, standards	2
	Total	15

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E 1A	14	0	0	1

E1A MANAGEMENT OF POWER SECTOR IN INDIA

Preamble

An engineering student needs to have basic knowledge on current affairs on Indian Power Sector and Ministry of Power's initiatives to develop the power sector. This emphasizes the development of logical thinking and analytical skills of the student and appraises him the complete methodology for solving different kinds of practical problems that occur in power industry. Based on this, the course aims at giving adequate exposure of the current Indian power sector challenges and analysis the issues and explores the solutions.

Programme Outcomes addressed

i. An ability to engage in life-long learning

j. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

k. An ability to consider issues from global and multilateral views

Competencies

At the end of the course the student should be able to:

5. Understand the Country's power position and power sector challenges
6. Develop various DSM Strategies to match with local requirements.
7. Implement Energy Conservation methods
8. Understand the application of Renewable Energy
9. Visualise the Smart Grid.

Assessment Pattern

	Bloom's Category	End-semester examination
1	Remember	0
2	Understand	60
3	Apply	30
4	Analyze	10
5	Evaluate	0
6	Create	0

Syllabus

Towards Powering India

Indian Electricity Scenario - Power for all – Objective of Reform - Managing Peak Hour Demand –ABT mechanism

Demand Side Management

Introduction – Demand side Management Strategies – Implementation Challenges - DSM for various end users – Case studies.

Energy Conservation

Introduction – Various initiatives of Ministry of Power –Standards & Labeling Programme – Energy Efficiency in Buildings and Establishments. Tips for Energy Conservation in various sectors.

Renewable Energy

Wind Power: Key Concerns and challenges- Renewable Energy for different applications .

Smart Grid

Overview and Background – Technology of Smart Grid – Challenges for the Smart Grid.

References

1. www.powermin.nic.in
2. "Towards Powering India" by R V Shahi, Excel Books, New Delhi 110 028.
3. www.mnre.gov.in
4. www.**bee**-india.nic.in

Course contents and Lecture schedule

Sl. No.	Topic	No. of Lectures
1.	**Towards Powering India**	
1.1	Indian Electricity Scenario - Power for all – Objective of Reform	2
1.2	Managing Peak Hour Demand –ABT mechanism	2
2	**Demand Side Management**	
2.1	Introduction – Demand side Management Strategies – Implementation Challenges -	2
2.2	DSM for various end users – Case studies	2
3	**Energy Conservation**	
3.1	Introduction – Various initiatives of Ministry of Power –Standards & Labeling Programme – Energy Efficiency in Buildings and Establishments. Tips for Energy Conservation in various sectors	2
4	**Renewable Energy**	
4.1	Wind Power: Key Concerns and challenges-	1
4.2	Renewable Energy for different applications	1
5	**Smart Grid**	
5.1	Overview and Background – Technology of Smart Grid	1
5.2	Challenges for the Smart Grid.	1
	TOTAL	**14**

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Sub Code	Lectures	Tutorial	Practical	Credit
E 1F	14	0	0	1

E1F Electrical and Electronics Engineering in Missile Technology

Preamble

This course unfolds the application of Electrical and Electronics Engineering to Missile Technology. It exposes the fundamentals of Missile technology, Power management in Missiles, Control and Instrumentation deployed in Missiles and , Testing and Safety aspects of Missiles.

Program Outcomes addressed

a. Ability to apply the knowledge of mathematics, science, and engineering.
b. To possess the knowledge of contemporary issues in engineering..

Competencies

At the end of the course the students will know:

7. Fundamentals of Missile Technology
8. Power management in Missiles.
9. Control and Instrumentation deployed in Missiles.
10. Various testing and safety measures in Missiles.

Assessment Pattern

	Bloom's Category	End-semester examination
1	Remember	40
2	Understand	40
3	Apply	0
4	Analyze	20
5	Evaluate	0
6	Create	0

Syllabus

OVERVIEW OF MISSILES: Satellite Launch Vehicles vs. Missiles - Space Vehicles-Interplanetary Missions - Classification of Missiles - Missiles developed at DRDO - Missile Stages - Rocket Motors - Elect/electronic systems - Control systems - Communication systems -Intelligent systems.
POWER SUPPLY AND MANAGEMENT : Primary batteries vs. Secondary batteries - Battery charging - Future trends in Battery design – Relays - Relay units- Electrical interconnectivity - DC/DC converters – SMPS.
CONTROL AND INSTRUMENTATION: Types of control in flight vehicles Control components - Closed loop control system - LVDT - Pressure - Temperature – vibration – Strain - Sound and acoustics - Signal Conditioning - Pulse code modulator - Transmitter / Ground receiving station – Transponder - Telecommand.

TESTING AND SAFETY : Testing electronic sub-systems - Environmental tests , AT/QT tests - Phase checks - Failures and Reliability - Shielding and grounding - Earthing - Static Discharge.

Course content and Lecture schedule

No.	Topic	No. of Lectures
1.0	**OVERVIEW OF MISSILES**	
1.1	Satellite Launch Vehicles vs. Missiles - Space Vehicles-Interplanetary Missions - Classification of Missiles -	1
1.2	Missiles developed at DRDO	1
1.3	Missile Stages - Rocket Motors - Elect/electronic systems - Control systems -	1
1.4	Communication systems -Intelligent systems	1
2.0	**POWER SUPPLY AND MANAGEMENT**	
2.1	Primary batteries vs. Secondary batteries - Battery charging - Future trends in Battery design	1
2.2	Relays-Relay units	1
2.3	Electrical interconnectivity - DC/DC converters – SMPS	1
3.0	**CONTROL AND INSTRUMENTATION**	
3.1	Types of control in flight vehicles Control components - Closed loop control system	1
3.2	LVDT-Pressure-Temperature	1
3.3	vibration – Strain - Sound and acoustics	1
3.4	Signal Conditioning - Pulse code modulator - Transmitter / Ground receiving station – Transponder - Telecommand	1
4.0	**TESTING AND SAFETY**	
4.1	Testing electronic sub-systems - Environmental tests	1
4.2	AT/QT tests - Phase checks	1
4.3	Failures and Reliability - Shielding and grounding - Earthing - Static Discharge.	1
	Total	14

Course Designer:

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Sub Code	Lectures	Tutorial	Practical	Credit
E1M	1	-	-	1

1:0

E1M LEAD ACID BATTERY TECHNOLOGY

Preamble

The Battery is the energy storage device that stores energy in the form of Chemical energy. It converts chemical energy into electrical energy as and when required. During this process, the initial chemical form [active chemical form] liberates energy and changes its chemical structure and forms a different chemical [spent chemical].

The battery is used as a singular power source in certain applications and as a back up or alternate power source in the event the main power source not powering the application. The battery finds its use in every application, be it in automotive four wheelers, two wheelers, aircrafts, rockets or in computers, emergency power back up, UPS, telecom, railways, and the list goes on….

The battery, based on chemistry, is classified into primary and secondary. Primary battery is one that is not amenable to charging, i.e., once the stored chemical energy is fully converted in to electrical energy, further reconverting the spent chemicals back into active chemicals is not possible. Secondary battery is one that can be recharged meaning, the spent chemicals can be converted back in to active chemicals.

The battery output voltage and power and other characteristics depend on the active chemicals and the chemistry.

Program outcomes addressed

c. An ability to design a system or component, or process to meet stated specifications
e. An ability to use techniques, skills, and modern engineering tools to implement and
organize engineering works under given constraints
i. An ability to consider social, environmental, economic and ethical impact of engineering
activities in a given context.
j. An ability to consider issues from global and multilateral views.

Competencies

At the end of the course the students should be able to:

14. Describe the various Lead acid battery technologies and its limitations.
15. Explain the Lead acid battery manufacturing process for different technologies.
16. Explain the application requirement of the Lead acid battery.
17. Describe the test equipment, test methods in evaluating the Lead acid battery systems.
18. Explain the Lead acid battery sizing with respect to applications.
19. Explain the safety requirement in handling lead acid battery systems and its raw materials and components through its life cycle.

Assessment Pattern

S.No.	Bloom's Category	End-semester examination
1	Remember	30
2	Understand	70
3	Apply	-
4	Analyze	-
5	Evaluate	-
6	Create	-

Course level Learning Objectives

Remember

10. State the chemistry principle of lead acid battery
11. List the components of Lead acid battery system.
12. List the applications of Lead acid battery
13. Define battery sizing.
14. State the safety issues in Lead acid battery system

Understand

10. Explain the lead acid battery standards – requirements, evaluation methods, test equipment and interpretation of results to assess the SOC and SOH
11. Describe the strengths and weakness of lead acid battery systems.
12. Explain the mechanism for sizing and selection of suitable battery for any given application
13. Explain the manufacturing processes for Lead acid batteries and the critical elements associated with it.
14. Illustrate the safety and environment related issues on battery recycling.

Syllabus

Introduction: Classification of batteries – Lead Acid, Nickel-Cadmium, Nickel-Hydrogen, Nickel-Metal Hydride, Lithium-Iron, Lithium –Polymer, Na/$NiCl_2$, NaS, Fuel cells.

Lead acid Battery - Fundamental: Definitions- basic chemistry, chemical reactions, acid characteristics, effect of temperature on specific gravity of acid, relationship between cell voltage and acid strength, battery standard ratings.

Lead acid Battery - Technology: Different types – manufacturing process, manufacturing equipment and their critical characteristics, process parameters, influence of process parameters, instruments and evaluation methods of process parameters.

Lead acid Battery – Charging & Evaluation: Different battery charging methods, chargers, charging systems vs applications, effect of overcharge and undercharge.
Lead acid battery charge and discharge characteristics – various standards, test instruments and equipment, test conditions, test results requirement, interpretation of test result, BMS, uses and limitations, battery failure modes.

Lead acid Battery - Applications: Different applications and their requirement for power and energy, duty cycles, selection of battery, effect of ambience on battery, use of design, life and temperature factors, battery replacement, on-site evaluation, cost of battery and Life cycle cost calculation, ventilation and floor loading requirement. Battery sizing as per IEEE 484.

Lead acid Battery – Safety and Hazards: chemicals and form – hazards, safety measures in manufacturing, handling and in actual application, Pollution control systems overview, Battery Management rules, battery recycling processes, battery recycling equipment and disposals.

Reference Books

1. TR Crompton, “ Battery Reference Book” third edition, Newness publishers , 2000
2. Thomas Reddy, “Linden's Handbook of Batteries”, Fourth edition, Mc Graw Hill, 2010
3. George W. Vinal,” Storage Batteries: A General Treatise on the Physics and Chemistry of Secondary Batteries and Their Engineering”, Fourth edition, John Wiley & Sons
4. H.A. Kiehne, "Battery Technology Handbook”, Second Edition, Markel Dekker, 2003.
5. Battery Council International - BATTERY SERVICE MANUAL, 13th Edition, 2010

Course content and Lecture Schedule

Sl No.	Contents	Lecture Hours
1.0	**Introduction:** Classification of batteries – Lead Acid, Nickel-Cadmium, Nickel-Hydrogen, Nickel-Metal Hydride, Lithium-Iron, Lithium –Polymer, $Na/NiCl_2$, NaS, Fuel cells.	1
	Lead acid battery fundamental	
1.1	Definitions- basic chemistry, chemical reactions, acid characteristics,	1
1.2	Effect of temperature on specific gravity of acid, relationship between cell voltage and acid strength, battery standard ratings.	1
2	**Lead acid Battery - Technology**	
2.1	Different types – manufacturing process, manufacturing equipment and their critical characteristics.	1.5
2.2	Process parameters, influence of process parameters, instruments and evaluation methods of in process parameters.	1.5
3	**Lead acid Battery – Charging & Evaluation**	
3.1	Different battery charging methods, chargers, charging systems vs applications, effect of overcharge and undercharge.	1
3.2	Lead acid battery charge and discharge characteristics – various standards, test instruments and equipment, test conditions, test results requirement, interpretation of test result test results requirement, interpretation of test result BMS, uses and limitation, Battery failure modes.	2
4	**Lead acid Battery - Applications**	
4.1	Different applications and their requirement for power and energy, duty cycles, selection of battery, effect of ambience on battery,	1
4.2	Use of design, life and temperature factors, battery replacement, on-site evaluation, cost of battery and Life cycle cost calculation, ventilation and floor loading requirement , Battery sizing as per IEEE 484.	1
5	**Lead acid Battery – Safety and Hazards**	
5.1	Chemicals and form – hazards, safety measures in manufacturing, handling and in actual application, Pollution control systems overview, Battery Management rules,	1

5.2	Battery recycling processes, battery recycling equipment and disposals.	
6	**Exercises**	
6.1	Selection of battery for a given application.	1
6.2	Determining test requirements and evaluation criteria.	1
	Total	**14**

Course designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
E1H	1	-	-	1

E1H Design Of Power Supplies 1:0

Preamble: Basics of semiconductors, Basics of Power supplies- LPS & SMPS, Basic topologies in SMPC, Control of power semiconductors, Basics of high frequency magnetic, Basics of EMC & any power simulation environment.

Program outcomes addressed:

1. An ability to design a system or component, or process to meet stated specifications
2. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints
3. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.
4. An ability to consider issues from global and multilateral views.

Competencies:

At the end of the course students should be able to

1. Understand the requirement of learning the manufacturer's details for proper design of any Power Electronic Equipment (PEE).
2. Systematic design and assembly of PEE.
3. Governing standards and certifications for PEE.

Assessment Pattern

	Bloom’s Category	End-semester examination
1	Remember	20
2	Understand	30
3	Apply	50
4	Analyze	-
5	Evaluate	-
6	Create	-

Learning Objectives

Remember

1. The MCT is a new device and has none/any/all of the following properties

    1. Low on state voltage drop at high currents
    2. gate latching
    3. Voltage controlled device

A. 1,2 and 3 are correct
B. 2,and 3 are correct
C. 1 and 2 are correct
D. None of the above

2. In buck boost converter the switch utilization is maximum at

A. D =0.5
B. D = 0.75
C. D = 0.25
D. None of the above

3. 3. Match the output voltage(Vo) equation of the corresponding dc-dc converters if input voltage is Vd and converter switching duty ratio is D

Name of the converter	***Output Voltage equation***
a. BUCK Converter b. BOOST Converter c. BUCK BOOST Converter d. Fly-back converter	1. Vo = -Vd D(1-D) 2. Vo = D.Vd 3. Vo = Vd.D/(1-D) 4. Vo = Vd/(1-D)

A. a-4 , b-2, c-1, d-3
B. a-4, b- 3, c-2, d-1
C. a-2, b-4, c-3, d-1
D. a-2 , b- 4, c-1, d-3

Understand (Questions)

1. Which of the following statements are correct

    1. BJT have low power losses than MOSFETs
    2. MOSFETs have low power losses than IGBTs
    3. SCRs has low power losses than MOSFETs

A. 1,2 and 3 are correct
B. 2 and 3 are correct
C. 1 and 3 are correct
D. 3 and 2 are correct

2. The correct sequence of given devices in the decreasing order of their speeds of operation is

A. PowerBJT, PowerMOSFET, IGBT, SCR
B. IGBT, PowerMOSFET, PowerBJT, SCR
C. SCR, PowerBJT, IGBT, PowerMOSFET
D. PowerMOSFET, IGBT, PowerBJT, SCR

3. Which one of the following controls reduces the size of the transformer in a switch mode ac power supply

A. Resonant control
B. Bidirectional control
C. PWM control
D. Phase control

Apply

1. In a dc-dc boost converter what will be the output voltage when the input is 100V and duty ratio is 40%

A. 166.67V
B. 133.33V
C. 25V
D. 40V

2. A step up chopper is fed from a 220V dc source to deliver a load voltage of 660 V. if the non conducting time of the switch is 100μs, the required pulse width will be

A. 100μs
B. 200μs
C. 220μs
D. 660μs

3. In a dc-dc buck converter what will be the output voltage when the input is 100V and duty ratio is 30%

A. 100V
B. 30V
C. 0V
D. 60V

Syllabus

Introduction of Available Sources & demanding loads: Sources - AC mains, Lab supplies, Batteries, Solar Cells Loads - Requirements of load, battery as load,

Selection of Topology : Step-Up / Step-Down, Multiple outputs, Continuous & discontinuous modes of operation, Isolated converters, Various configurations of Converters

Selection of Components: Selection of Resistors, Chokes, Capacitors, Diodes, MoSFETs & IGBTs, Connectors

Guide to Instrumentation: Basics of measurements using DMM, Oscilloscope, Electronic loads, etc.

Design of Magnetics: Fundamentals & ideal conditions, design of High frequency chokes & transformers, Selection of wire gauge, sealing of magnetics **.**

Design of Feedback circuits: Basic control requirements, Current & voltage mode control fundamentals & system stability conditions.

Design of Control and Monitoring circuits: Practical Control circuitry & Monitoring circuitry requirements.

Evaluations and Thermal management: Performance evaluations of SMPS & thermal loss calculations and cooling options & packaging of converter.

EMI control requirements: Overview of EMC, differentiating signal and noise, Layout concepts Low & High frequency filtering requirements, Optimal filter design

Worst case analysis: Introduction to datasheet reading, operation tuned to datasheet, typical worst case analysis

Simulation of particular application in PSIM: Simulation of simple BUCK, BOOST & BUCK BOOST, Typical discrete power factor corrector circuit.

Standards governing the power supplies: IEC standards for Electrical & Environmental testing, certification standards, Ingress protection standards.

Recent trend in Power supplies: Recent advancements in components, Recent advancements in topologies, Digital control of power supplies, Power Integration & its Low power applications.

Demonstration of Various SMPS & Its components- Practical design of a cell phone charger- a practical approach

Reference Books

1. Ned Mohan ,Undeland and Robbins,''Power Electronics Converters, Applications and Design'',John Wiley&sons ,1995 second edition
2. Abraham I Pressman, Keith Billings , Taylor Morey , " Switching Power Supply Design", 2009, 3rd Edition, McGraw-Hill.
3. L. Umanand and S R Bhat, "Design of Magnetic Components for Switched Mode Power Converters", Wiley Eastern Limited.
4. International Standard, IEC 60571 Edition 2.1 2006-12.

Course content and Lecture Schedule

S.No	Topic	Duration
1	**Introduction of Available Sources & demanding loads**	
1.1	Sources - AC mains, Lab supplies, Batteries, Solar Cells Loads - Requirements of load, battery as load	**1**
2	**Selection of Topology**	
2.1	Step-Up / Step-Down, Multiple outputs, Continuous & discontinuous modes of operation, Isolated converters, Various configurations of Converters	**1**
3	**Selection of Components**	
3.1	Selection of Resistors, Chokes, Capacitors, Diodes, MoSFETs & IGBTs, Connectors	**1**
4	**Guide to Instrumentation**	
4.1	Basics of measurements using DMM, Oscilloscope, Electronic loads, etc	**1**
5	**Design of Magnetics**	
5.1	Fundamentals & ideal conditions, design of High frequency chokes & transformers, Selection of wire gauge, sealing of magnetics	**1**
6	**Design of Feedback circuits**	
6.1	Basic control requirements, Current & voltage mode control fundamentals & system stability conditions	**1**
7	**Design of Control and Monitoring circuits**	
7.1	Practical Control circuitry & Monitoring circuitry requirements	**1**
8	**Evaluations and Thermal management**	

8.1	Performance evaluations of SMPS & thermal loss calculations and cooling options & packaging of converter	**1**
9	**EMI control requirements**	
9.1	Overview of EMC, differentiating signal and noise, Layout concepts Low & High frequency filtering requirements, Optimal filter design	**1**
10	**Worst case analysis**	
10.1	Introduction to datasheet reading, operation tuned to datasheet, typical worst case analysis	**1**
11	**Simulation of particular application in PSIM**	
11.1	Simulation of simple BUCK, BOOST & BUCK BOOST, Typical discrete power factor corrector circuit.	**1**
12	**Standards governing the power supplies**	
12.1	IEC standards for Electrical & Environmental testing, certification standards, Ingress protection standards	**1**
13	**Recent trend in Power supplies**	
13.1	Recent advancements in components Recent advancements in topologies Digital control of power supplies Power Integration & its Low power applications	**1**
14	**Demonstration of Various SMPS & Its components**	**1**
15	**Practical design of a cell phone charger**- a practical approach	**1**
	Total	**15**

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
E1D	14	0	0	1

E1D: Power Quality in Industries 1:0

Preamble: The proposed course offered as one credit course and its main purpose is to:

- Emphasize the various power quality problems due to advanced controllers.
- Address on mitigation techniques used to overcome power quality issues.

Program Outcomes addressed:

e. To demonstrate and ability to visualize and work on laboratory and multidisciplinary tasks.

g. Demonstrate knowledge of professional and ethical responsibilities.

i. Understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.

Competencies:

At the end of the course students should be able to:

1. Identify and classify various power quality issues.
2. Understand the various sources and effects of power quality disturbances.
3. Solve the practical power quality issues through case studies

Assessment Pattern

	Bloom's Category	End-semester examination
1	Remember	0
2	Understand	40
3	Apply	40
4	Analyze	20
5	Evaluate	0
6	Create	0

Syllabus

Power Quality : History, concern about power quality, Definition categories and characteristics of power system electromagnetic phenomenon.

Sources of power quality problem : Source of Power Supply & its saturation, Transformer & DG Environment, Sags , Dips & Interruptions & its effect on equipments , Capacitors & Resonance , Case Study – Ill effects of Capacitors. Switching, Non – Linear Loads & Harmonics , Case Study

Effects of power quality problems : On Maximum Demand , Contract Demand , Power Factor & Over all operation Case studies on Call Centre , Case Study on Drive based plastic & Printing industry, Case Study on Motors – LT & MV

Power Quality standards : IEEE 519 1991 STDS, EMC & ESD & IEC

Handling of Power Quality problems : Principles of mitigation of harmonics Passive & Active filter, Dynamic Voltage Regualtor & STATCOM.

Reference Books:

1. Roger .C. Dugan, Mark F.Mcgranaghan & H.Wayne Beaty," Electrical power system Quality" McGraw-Hill Newyork Second edition 2003
2. Math.H.J.Bollen, Understanding Power Quality Problems" Voltage sags & Interruptions" IEEE Press, Newyork 2000.
3. Sankaran C,"Power Quality", CRC press Wahington DC 2002

Lecture Schedule:

No.	**Topic**	**No. of Lectures**
1	**Power Quality,** History, concern about power quality	1
1.1	Definition	1
1.2	categories and characteristics of power system electromagnetic phenomenon.	1
2	**Sources of Power Quality Issues**	
2.1	Source of Power Supply & its saturation, Transformer & DG Environment, Sags , Dips & Interruptions & its effect on equipments	2
2.2	Capacitors & Resonance Case Study – Ill effects of Caps. switching	1
2.3	Non – Linear Loads & Harmonics Case Study	1
3	**Effects of power quality problems** On maximum Demand, Contract Demand, Power	1

	Factor & Over all operation	
3.1	Case studies on Call Centre	1
3.2	Case Study on Drive based plastic & Printing industry	1
3.3	Case Study on Motors – LT & MV	1
4	**Power Quality standards**	
4.1	IEEE 519 1991 STDS.	1
4.2	EMC & ESD & IEC	1
5	**Handling of Power Quality problems**	
5.1	Principles of mitigation of harmonics	1
5.2	Passive & Active filter, Dynamic Voltage Regualtor & STATCOM	1

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