CATEGORIZATION AND SCHEDULING OF COURSES

FOR

B.E. EEE DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided Autonomous Institution affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

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VISION

Transforming the individuals into globally competent electrical engineers to fulfill the technological needs of the society.

MISSION

Establishing world class infrastructure in Electrical Engineering.
Enhancing the knowledge of the faculty in cutting edge technologies through continuous improvement programmes.
Providing well balanced curriculum in graduate, postgraduate and doctoral programmes.
Adopting innovative content delivery, assessment and continuous improvement methods to achieve desired outcomes.
Facilitating industry institution interaction in teaching & learning, consultancy and research activities to accomplish the technological needs of the society.
Encouraging the faculty and students to carry out innovative research work.
Practicing ethical standards by the faculty and students.
Motivating the students for active participation in co-curricular and extracurricular activities.

Programme Educational Objectives (PEO's)

PEO1: Graduates of the programme will have successful career in chosen technical or professional fields.
PEO2: Graduates of the programme will have technical competency in solving challenging societal tasks in ethical and economical manner.
PEO3: Graduates of the programme will reveal lifelong learning and team work in their chosen profession.

Programme Outcomes (POs) for B.E. Electrical and Electronics Engineering

After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students should be able to:
PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 Conduct investigations of complex problems: The problems:

- That cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline.
- That may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions.
- That requires consideration of appropriate constraints/requirements not explicitly given in the problem statement. (like: cost, power requirement, durability, product life, etc.).
- Which need to be defined (modeled) within appropriate mathematical framework.
- That often requires use of modern computational concepts and tools.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering 21 activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
PEO1												
PEO2												
PEO3												

<u>Programme Specific Outcomes (PSO):</u>

After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students will be able to:

PSO1: Design and analyze components/ systems that effectively generate, transmit, distribute and utilize electrical power.

PSO2: Design and analyze modern industrial electronic systems/components to perform analog and digital processing and control functions

PEO- Mission mapping

PEO	M1	M2	M3	M4	M5	M6	M7	M8
PEO1	1	2	2	1	2	1	1	3
PEO2	1	2	2	2	2	2	1	3
PEO3	1	2	3	2	3	2	1	3

1 – Low; 2 – Medium; 3 – Strong

Credit Distribution

S.No	Category	Credits
A	**Foundation Courses (FC)**	**54-66**
	Humanities and Social Sciences including Management Courses (HSMC)	9-12
	Basic Science Courses (BSC)	24- 27
	Engineering Science Courses (ESC)	21 -27
B	**Professional Core Courses (PCC)**	**55**
C	**Professional Elective Courses (PEC)**	**24 - 39**
	Programme Specific Elective(PSE)	15 - 24
	Programme Elective for Expanded Scope (PEES)	9-15
D	**Open Elective Courses (OEC)**	**6-12**
	Interdisciplinary Elective (IE)	3-6
	Basic Science Elective (BSE)	3-6
E	**Project work**	**12**
F	Internship and Mandatory Audit Courses as per Regulatory authorities	**Non-Credit (Not included for CGPA)**
	Minimum Credits to be earned for the award of the Degree	**160 (from A to E) and the successful completion of Mandatory Courses**

- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College

SCHEDULING OF COURSES (B.E.EEE. Programme) – 2022-23 admitted Batch

Sem	Theory / Theory cum Practical / Practical								CDIO courses	Audit Courses (Mandatory Non- credit}	Credit
	1	2	3	4	5	6	7	8			
I	22MA110 Calculus for Engineers (BSC -4)	22PH120 Physics (BSC -3)	22CH130 Chemistry (BSC -3)	22EG140 English (HSMC-2)	22ME160 Engineering Graphics (ESC -4)	22EG170 English Lab. (HSMC -1)	22PH180 Physics Lab. (BSC -1)	22CH190 Chemistry Lab. (BSC -1)	20EE150 Engineering Exploration (EEE Specific) (ESC -2)		**21**
II	22EE210 Matrices and Ordinary Differential Equations (BSC -4)	22EE220 Materials Science for Electrical Engineering (ESC -3)	22EE230 Electric Circuit Analysis (PCC-3)	22EE240 Electromagnetic Fields (PCC-3)	22EE250 Digital Systems (PCC-3)	22EE260 Electronic devices and circuits (PCC-3)	22EE270 Electrical Workshop (ESC -1)	22EE280 Electronic Devices and Circuits (PCC Lab 1)		Audit Course 1	**21**
III	22EE310 Numerical methods and Complex variables (BSC -4)	22EE320 DC Machines and Transformers (PCC-3)	22EE330 Linear Integrated Circuits (PCC-3)	22EE340 Signals and Systems (PCC-3)	22EE350 Python Programming (ESC -3)		22EE370 DC Machines and Transformers Lab (PCC Lab 1)	22EE380 Integrated Circuits Lab (PCC Lab 1)	22ES390 Design Thinking (ESC -3)		**21**
IV	22EE410 Probability and Random Process (BSC -4)	22EE420 AC Machines (PCC-3)	22EE430 Measurements and Instrumentation (PCC-3)	22EE440 Control Systems (PCC-3)	22EE450 Power Electronics (PCC-3)	22EE460 Data Structures Elective (ESC - 3)	22EE470 Electrical Problem solving using computers (PCC Lab 1)	22EE480 AC Machines Lab (PCC Lab 1)	22EE490 Project Management (HSMC -3)	Audit Course 2	**24**
V	22EE510 Generation, Transmission and Distribution (PCC-3)	22EE520 Micro Controllers (PCC-3)	22EE530 Electric drives (PCC-3)	22EE540 Power System Analysis (PCC-3)	Interdisciplinary Elective (OE-3)	22EE550 OOPS & JAVA PE (ESC -3)	22EE570 Measurement & Control Lab (PCC Lab1)	22EE580 Microcontrollers lab (PCC Lab 1)	22EE590 Project -1 Electrical (P-3)		**23**
VI	22EE610 Accounting & Finance HSS-3	22EEPXX PEC-PSE-1 (3)	22EEPXX PEC-PSE -2 (3)	22EEPXX PEC-PSE -3 (3)	Basic Science Elective (OE-3)	22EG660 Professional Communication HSMC -2	22EE670 Power Electronics & Drives Lab (PCC Lab-1)(1)	22EE680 Electric Power Systems lab (PCC Lab 1)	22EE690 Project -2 Electronics (P-3)		**22**
VII	22EEPXX	22EEPXX	22EEPX	22EEPX	22EEPXX		22EE770		22EE790		**19**

	PEC-PSE - 4 (3)	PEC-PSE - 5 (3)	X PEC-PSE -6 (3)	X PEC-PSE -7 (3)	PEC-PEES-1 (3)		Energy Management System Laboratory (PCC Lab 1)		Project -3 Advanced Electrical /Advanced Electronics (P-3)		
VIII	22EEPXX PEC-PEES -2 (3)	22EEPXX PEC-PEES -3(3)							22EE890 Project -4 (P-3)		**9**

Total Credits: **160**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

FIRST SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22MA110	Calculus for Engineers	BSC	3	1	-	4
22PH120	Physics	BSC	3	-	-	3
22CH130	Chemistry	BSC	3	-	-	3
22EG140	English	HSMC	2	-	-	2
22EE150	Engineering Exploration	ESC	2	-	-	2
THEORY CUM PRACTICAL						
22ME160	Engineering Graphics	ESC	3	-	2	4
PRACTICAL						
22EG170	English Laboratory	HSMC	-	-	2	1
22PH180	Physics Laboratory	BSC	-	-	2	1
22CH190	Chemistry Laboratory	BSC	-	-	2	1
Total			**16**	**1**	**8**	**21**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical

Note :

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B.E. / B.Tech. Degree Programme

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2022-2023 onwards)

FIRST SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	22MA110	Calculus for Engineers	3	40	60	100	27	50
2	22PH120	Physics	3	40	60	100	27	50
3	22CH130	Chemistry	3	40	60	100	27	50
4	22EG140	Technical English	3	40	60	100	27	50
5	22EE150	Engineering Exploration	2	40	60	100	27	50
THEORY CUM PRACTICAL								
6	22ME160	Engineering Graphics	3	50	50	100	25	50
PRACTICAL								
7	22EG170	English Laboratory	3	60	40	100	18	50
8	22PH180	Physics Laboratory	3	60	40	100	18	50

9	22CH190	Chemistry Laboratory	3	60	40	100	18	50

* CA evaluation pattern will differ from course to course 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.

22MA110	CALCULUS FOR ENGINEERS

Category	L	T	P	Credit
BSC	3	1	0	4

Preamble

This course aims to provide technical competence of modeling engineering problems using calculus. This course is implements the calculus concepts geometrically, numerically, algebraically and verbally. Students will apply the main tools for analyzing and describing the behavior of functions of single and multi-variables: limits, derivatives, integrals of single and multi-variables to model and solve complex engineering problems using analytical methods and MATLAB.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO's	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Cognize the concept of functions, limits and continuity	TPS2	75	70
CO2	Compute derivatives and apply them in solving engineering problems	TPS3	70	65
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	TPS3	70	65
CO4	Demonstrate the techniques of integration to find the surface area of revolution of a curve.	TPS3	70	65
CO5	Utilizedouble integrals to evaluatearea enclosed between two curves.	TPS3	70	65
CO6	Apply triple integrals to find volume enclosed between surfaces	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	S	M	M					L		L	
CO2.	S	S	M	M					L		L	
CO3.	S	S	M	M					L		L	
CO4.	S	S	M	M					L		L	
CO5.	S	S	M	M					L		L	
CO6.	S	S	M	M					L		L	

S- Strong; M-Medium; L-Low

Assessment Pattern

<table>
<tr><th rowspan="2">CO</th><th colspan="6">Assessment 1</th><th colspan="6">Assessment 2</th><th colspan="4" rowspan="2">Terminal
(%)</th></tr>
<tr><th colspan="3">Written Test 1 (%)</th><th colspan="3">Assignment 1 (%)</th><th colspan="3">Written Test 2 (%)</th><th colspan="3">Assignment 2 (%)</th></tr>
<tr><th>TPS</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>1</th><th>2</th><th>3</th><th>TOTAL (%)</th></tr>
<tr><td>CO1</td><td colspan="3">20%</td><td colspan="3" rowspan="3">50%</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>10%</td><td>-</td><td>10%</td></tr>
<tr><td>CO2</td><td colspan="3">32%</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td>16%</td><td>16%</td></tr>
<tr><td>CO3</td><td colspan="3">36%</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td><td>-</td><td>18%</td><td>18%</td></tr>
<tr><td>CO4</td><td colspan="3">12%</td><td colspan="3">-</td><td colspan="3">39%</td><td colspan="3" rowspan="3">50%</td><td>-</td><td>-</td><td>25%</td><td>25%</td></tr>
<tr><td>CO5</td><td colspan="3">-</td><td colspan="3">-</td><td colspan="3">35%</td><td>-</td><td>-</td><td>17%</td><td>17%</td></tr>
<tr><td>CO6</td><td colspan="3">-</td><td colspan="3">-</td><td colspan="3">26%</td><td>-</td><td>-</td><td>14%</td><td>14%</td></tr>
<tr><td>MATLAB</td><td colspan="3">-</td><td colspan="3">50%</td><td colspan="3">-</td><td colspan="3">50%</td><td></td><td></td><td></td><td></td></tr>
<tr><td>TOTAL</td><td colspan="3">100%</td><td colspan="3">100%</td><td colspan="3">100%</td><td colspan="3">100%</td><td>-</td><td>10%</td><td>90%</td><td>100 %</td></tr>
</table>

* Assignment 1: (i)Application Problems in CO1, CO2 and CO3 (50%).
(ii) MATLAB Onramp & Introduction to symbolic Math with MATLAB (50%).
**Assignment 2: (i) Application Problems in CO4, CO5 and CO6 (50%).
(ii) Application problems using MATLAB. (50%).
***Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

DIFFERENTIAL CALCULUS
Functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Maxima and Minima of functions of one variable – Mean value theorem - Effect of derivatives on the shape of a graph- Application problems in engineering using MATLAB.

FUNCTIONS OF SEVERAL VARIABLES
Function of several variables- Level curves and level surfaces - Partial derivatives – Chain rule - Maxima and minima of functions of two variables –Method of Lagrange's Multipliers - Application problems in engineering using MATLAB.[9 hours]

INTEGRAL CALCULUS:
The definite integral – Fundamental theorem of Calculus – Indefinite integrals and the Net Change Theorem – Improper integrals – Area of surface of revolution - Volume of solid of revolution -Application problems in engineering using MATLAB.

MULTIPLE INTEGRALS:
Iterated integrals-Double integrals over general regions-Double integrals in polar coordinates-Applications of double integrals (density, mass, moments & moments of inertia problems only)-triple integrals- triple integrals in cylindrical coordinates- triple integrals in spherical coordinates-change of variables in multiple integrals - Application problems in engineering using MATLAB.

Text Books

1) James Stewart, "Calculus Early Transcendentals", 9e, Cengage Learning, New Delhi, 2019.

DIFFERENTIAL CALCULUS: [Sections: 1.3, 2.2, 2.5, 2,6,2.8, 4.1, 4.2 and 4.3.]

FUNCTIONS OF SEVERAL VARIABLES: [Sections: 14.1,14.3,14.5,14.7 and 14.8.]
INTEGRAL CALCULUS: [Sections: 5.2, 5.3, 5.4, 7.8, 8.2 and 6.2.]
MULTIPLE INTEGRAL: [Sections: 15.1-15.4, 15.6-15.9]
2) Lecture Notes on Calculus Through Engineering Application Problems and Solutions, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

Reference Books and web resources

1. George B. Thomas, "Thomas Calculus: early Transcendentals", 14th ,Pearson, New Delhi, 2018.
2. Howard Anton, Irl Bivens and Stephen Davis, "Calculus: Early Transcendentals", 12the, John Wiley & Sons, 2021.
3. Kuldeep Singh, "Engineering Mathematics Through Appplications",2nde, Blooms berry publishing, 2019,
4. Kuldip S. Rattan, Nathan W. Klingbeil, Introductory Mathematics for Engineering Applications, 2nd e John Wiley&Sons , 2021.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**DIFFERENTIAL CALCULUS**	
1.1	Functions and New functions from old functions	2
1.2	Limit of a function &Continuity of a function	1
	Tutorial	1
1.3	Limits at infinity	1
1.4	Derivative as a function	2
	Tutorial	1
1.5	Maxima and Minima of functions of single variable	2
1.6	The Mean value theorem and effect of derivatives on the shape of a graph of a function	1
	Tutorial	1
1.7	Application problems in engineering using MATLAB	1
2	**FUNCTIONS OF SEVERAL VARIABLES**	
2.1	Level curves and level surfaces	2
2.2	Partial derivatives – Chain rule	1
	Tutorial	1
2.3	Maxima and minima of functions of two variables	2
2.4	Method of Lagrange's Multipliers	1
	Tutorial	1
2.5	Application problems in engineering using MATLAB	1
3	**INTEGRAL CALCULUS**	
3.1	The definite integral	1
3.2	Fundamental theorem of Calculus	2
	Tutorial	1
3.3	Indefinite integrals and the Net Change Theorem	1
3.4	Improper integrals	2
	Tutorial	1
3.5	Area of surface of revolution	1
3.6	Volume of solid of revolution.	2
3.7	Application problems in engineering using MATLAB	1
4	**MULTIPLE INTEGRALS**	

Module No.	Topic	No. of Periods
4.1	Iterated integrals	1
4.2	Double integrals over general regions	2
	Tutorial	1
4.3	Double integrals in polar coordinates	1
4.4	Applications of double integrals (density, mass, moments & moments of inertia problems only)	2
	Tutorial	1
4.5	Triple integrals	1
4.6	Triple integrals in cylindrical coordinates	1
4.7	Triple integrals in spherical coordinates	1
	Tutorial	1
4.8	Change of variables in multiple integrals	1
4.9	Application problems in engineering using MATLAB	1
	Total	**48**

Course Designer(s):

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22PH120	PHYSICS (Common to all branches)

Category	L	T	P	Credit
BSC	3	0	0	3

Preamble

The course work aims in imparting fundamental knowledge of mechanics, oscillations and waves and optics, electromagnetism and quantum mechanics which are essential in understanding and explaining engineering devices.

Prerequisite

None

Course Outcomes

On the successful completion of the course, students will be able to

	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Apply the vector calculus approach and Newton's law in polar coordinates to solve problems in mechanics	TPS3	85	80
CO2	Solve for the solutions and describe the behaviour of a damped harmonic oscillator and waves.	TPS3	85	80
CO3	Introduce Schrodinger equation to arrive at the energy values of particle in a box and linear harmonic oscillator	TPS3	85	80
CO4	Use the principle of quantum mechanics for quantum mechanical tunnelling, quantum confinement and quantum computation	TPS2	85	80
CO5	Use the laws of electrostatics and magnetostatics to explain electromagnetic wave propagation	TPS3	85	80
CO6	Explain the fundamentals of optical phenomena and its applications	TPS2	85	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**S**	**M**	**L**	-	-	-	-	-	**L**	**L**	-	-
CO2	**S**	**M**	**L**	-	-	-	-	-	**L**	**L**	-	-
CO3	**S**	**M**	**L**	-	-	-	-	-	**L**	**L**	-	-
CO4	**M**	**L**		-	-	-	-	-	**L**	**L**	-	-
CO5	**S**	**M**	**L**	-	-	-	-	-	**L**	**L**	-	-
CO6	**M**	**L**										

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
TPS Scale / CO	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	8	15	22										6	6	10
CO2	8	10	15	100									4	3	10
CO3	4	5	13				-	-	15				-	2	15
CO4							4	15	-	100			4	6	-
CO5							-	-	35				-	3	15
CO6							16	15	-				6	10	-
Total	**20**	**30**	**50**	**100**			**20**	**30**	**50**	**100**			**20**	**30**	**50**

*Assignment I, II –Quiz/ Puzzle/ Case analysis/ Problem-solving/ Presentation/ Writing tasks

Syllabus

Mechanics of Particles:
Scalars and vectors under rotation transformation - Coordinate system - Cartesian, Polar, Spherical, Cylindrical - Newton's second law of motion - Forces in nature - Central forces - Conservative and non-conservative forces - Work - Energy theorem - Conservation of angular momentum - Satellite manoeuvres

Oscillations and Waves:
Simple harmonic oscillators - Energy decay in a Damped harmonic oscillator - Q factor-Impedance matching- Wave groups and group velocity - Non dispersive Transverse and Longitudinal waves - Waves with dispersion - Water waves - Acoustic waves - Earthquake and Tsunami waves

Quantum Mechanics:
Wave nature of particles - wave function - probability current density and expectation values - Schrodinger wave equation - Uncertainty principle - Particle in a box in 1D - Linear harmonic oscillator - Quantum tunnelling – Quantum confinement in 0D, 1D, 2D systems - Scanning tunnelling microscope - Quantum Cascade lasers - Quantum computation (qubit) - Entanglement - Teleportation

Electromagnetic Fields and Waves:
Electric potential and Electric field of a charged disc - Magnetic Vector potential - Maxwell's equation - Equation of continuity – Poynting Vector - Energy and momentum of EM waves - CT/MRI scan

Optics:
Ray paths in inhomogeneous medium and its solutions – Applications - Fibre optics - Numerical Aperture& Acceptance angle - Fibre optic sensors - Liquid Level & Medical Applications - Interference in non-reflecting films - Fabry-Perot interferometer - Diffraction - Fraunhofer diffraction due to double slit

Text Books

1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9thEdition, Wiley, 2011.
2. PaulA.TiplerandG.Mosca,PhysicsforScientistsandEngineers,6thEdition,Freeman,2008.

Reference Books

MECHANICS OF PARTICLES

1. Paul A.Tipler and GeneMosca, Physics for Scientists and Engineers, 6thEdition, Freeman, 2008 (Chapters– 4, 9 & 10).

2. Manoj K. Harbola, Engineering Mechanics, 2ndEdition, Cengage, 2018.

OSCILLATIONS AND WAVES

1. Paul ATipler, Gene Mosca, Physics for Scientists and Engineers, 6thEdition, Freeman, 2008 (Chapters– 14 & 15).
2. HJ Pain, The Physics of Vibrations&Waves,6thEd., John Wiley 2005 (Ch. 2, 5, 6).

ELECTROMAGNETIC FIELDS AND WAVES

1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9thEdition, Wiley, 2011 (Chapters - 23, 24, 32 & 33)
2. PMFishbane,Stephen G.Gasiorowicz, Stephen T Thornton, Physics for Scientists & Engineers with Modern Physics,3rdEdition,Pearson,2005(Chapters-26, 28, 31, 34).

OPTICS

1. Paul A.Tipler and Gene Mosca, Physics for Scientists and Engineers, 6thEdition, Freeman, 2008 (Chapters– 31 & 33).
2. Ajoy Ghatak, Optics, 5thEdition, Tata McGraw Hill, 2012 (Chapters – 3, 18, 20)

QUANTUM MECHANICS

1. Paul A.Tipler and GeneMosca, Physics for Scientists and Engineers, 6thEdition, Freeman, 2008 (Chapters– 34 & 35).
2. 2.StephenT.Thorntonand Andrew Rex, Modern Physics for Scientists and Engineers, 4th Edition, Cengage, 2013. (Chapters- 5 & 6).
3. R. Shankar, Fundamentals of Physics– I, II, Yale University Press, 2014, 2016.

Course Contents and Lecture Schedule

Module No.	**Topic**	**No. of Periods**
1	**Mechanics of Particles**	**8**
1.1	Scalars and vectors under rotation transformation	2
1.2	Coordinate system - Cartesian, Polar, Spherical, Cylindrical	2
1.3	Newton's second law of motion - Forces in nature - Central forces	2
1.4	Conservative and non-conservative forces - Work - Energy theorem - Conservation of angular momentum - Satellite manoeuvres	2
2	**Oscillations and Waves**	**6**
2.1	Simple harmonic oscillators - Energy decay in a Damped harmonic oscillator	2
2.2	Q factor- Impedance matching – Wave groups and group velocity	2
2.3	Non-dispersive transverse and Longitudinal waves	1
2.4	Waves with dispersion- Water waves -Acoustic waves – Earthquake and Tsunami waves	1
3	**Quantum Mechanics**	**10**
3.1	Wave nature of particles - wave function -probability current density and expectation values -Uncertainty principle - Schrodinger wave equation	4
	CAT-I after 18 contact hours	
3.2	Applications - Particle in a box in 1D – Linear harmonic oscillator	2
3.3	Quantum tunnelling – Quantum confinement in 0D, 1D, 2D systems - Scanning tunnelling microscope – Quantum Cascade lasers – Quantum computation (qubit) – Entanglement - Teleportation	4
4	**Electromagnetic Fields and Waves**	**6**
4.1	Electric potential and Electric field of a charged disc	1
4.2	Magnetic Vector potential – Maxwell's Equations	2
4.3	Equation of continuity- Poynting vector - Energy and momentum of EM waves	2

4.4	CT/MRI scan	1
5	**Optics**	**6**
5.1	Ray paths in inhomogeneous medium & its solutions –Applications – Fiber optics	2
5.2	Numerical Aperture& Acceptance angle - Fiber optic sensors - Liquid Level & Medical Applications	2
5.3	Interference in non-reflecting films - Fabry- Perot interferometer - Diffraction - Two slit Fraunhoffer diffraction	2
	CAT-II after 18 contact hours	
	Total	**36**

Course Designers:

1. Dr. M Mahendran, Professor, mahendran@tce.edu
2. Mr. V Veeraganesh, Assistant Professor, vvgphy@tce.edu
3. Dr. A LSubramaniyan, Assistant Professor, alsphy@tce.edu
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22CH130	CHEMISTRY

Category	L	T	P	Credit
BSC	3		0	3

Preamble

The objective of this course is to bestow basic concepts of chemistry and its applications in engineering domain. It imparts knowledge on properties and treatment methods of water, spectroscopic techniques and their applications. This course provides exposure on electrochemical techniques for corrosion control, surface coatings and energy storage devices and also emphasis the properties and applications of engineering materials.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the essential water quality parameters of water	TPS2	70	70
CO2	Determine hardness of water and identify suitable water treatment method	TPS3	70	70
CO3	Explain the electrochemical process involved in energy storage devices and corrosion of metals	TPS2	70	70
CO4	Interpret the electrochemical principles in modern energy storage devices and corrosion control methods	TPS3	70	70
CO5	Identify the appropriate spectroscopic techniquefor various applications	TPS3	70	70
CO6	Select the materials based on the properties for Engineering applications	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	M	L	-	-	-	-	-	-	-	-	-	-
CO2.	S	M	L	-	-	-	L	-	-	-	-	-
CO3.	M	L	-	-	-	-	-	-	-	-	-	-
CO4.	S	M	L	-	-	-	-	-	L	-	-	-
CO5.	S	M	L	-	-	-	L	-	L	-	-	-
CO6.	S	M	L	-	-	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Terminal					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	4	20	0										2	8				
CO2	4	0	20										2	4	10			
CO3	4	20	0										2	8				
CO4	8	0	20										2	4	10			
CO5							12	20	20				6	8	10			
CO6							8	20	20				6	8	10			

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

CO	Assignment 1*						Assignment 2*					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6
CO1												
CO2			20									
CO3												
CO4			20									
CO5									20			
CO6									20			

*Assessment type: Quiz / Test /Presentation

Syllabus

Water: Water-sources- physical - characteristics - alkalinity - hardness of water – types - determination of hardness by EDTA method. Boiler trouble-Softening of water: Internal and External treatment methods. Waste water treatment process. **Electrochemical technologies for energy storage and surface engineering:** Electrochemistry and Energy storage: Basics of electrochemistry. Batteries **-** Primary and Secondary batteries. Fuel cells.Hydrogen generation and storage. Corrosion and Surface Engineering–Basics –Corrosion - causes-factors- types - corrosion of metal and computer components- Corrosion control. Electroplating - Electroless process. **Spectroscopic technique and applications:** Principle, instrumentation, and applications: X-ray-diffraction - UV–Visible spectroscopy- Atomic Absorption Spectroscopy - Fluorescence spectroscopy - Inductively Coupled Plasma - Optical Emission Spectroscopy- Infra-red spectroscopy - Nuclear magnetic resonance spectroscopy**.** **Engineering materials:** Bonding and their influences on the property of materials - melting point - brittleness, ductility – thermal, electrical, and ionic conductivity - optical – magnetic properties, hydrophobic, hydrophilic. **Polymer composites** - structure and properties-applications.**Ceramics and advanced ceramics** - types-properties-applications-**Nano-materials** – Synthesis, structure, and properties –applications.

Text Book

1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16thedition, 2015.

Reference Books & web resources

1. S.S. Dara and S.S. Umare, "A Textbook of Engineering Chemistry", S.Chand& Company, 12thEdition, Reprint, 2013.

2. ShashiChawla, " A text book of Engineering Chemistry", DhanpatRai& Co.(pvt) ltd, 3rd edition, reprint 2011.
3. C. N. Banwell and E.M. McCash, "Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill (India), 5thEdition, 2013.
4. W.F. Smith, Principles of Materials Science and Engineering: An Introduction; Tata Mc-Graw Hill, 2008.
5. V. Raghavan, Introduction to Materials Science and Engineering; PHI, Delhi, 2005.
6. M. Akay, 2015, An introduction to polymer matrix composites,"
from: https://www.academia.edu/37778336/An_introduction_to_polymer_matrix_composites

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Water**	
1.1	Importance of water, sources, standards for drinking water, (WHO, BIS & ICMR standards) physical, chemical & biological characteristics, Alkalinity (principle only)	1
1.2	Hardness of water - types, units. Determination of hardness by EDTA method and numerical problems	2
1.3	**boiler trouble:** Scale and sludge formation, boiler corrosion, priming and foaming, caustic embrittlement	1
1.4	**Internal treatment methods:** Carbonate, Phosphate, Colloidal, Calgon conditioning	1
1.5	**softening of water:** External treatment methods:Lime-soda process (concept only), zeolite process,ion exchange process	2
1.6	Desalination- reverse osmosis, electro dialysis, solar and multistage flash distillation, nano-filtration	1
1.7	Waste water treatment – primary, secondary, and tertiary treatment	1
2	**Electrochemical technologies for energy storage and surface engineering**	
2.1	**Electrochemistry and Energy storage**: Introduction**–** Basics of electrochemistry – Redox process, EMF	1
2.2	**Energy storage** – Batteries, Battery quality parameters	1
2.3	Primary battery – Dry cell and Alkaline cell	1
2.4	Secondary battery – Lead-acid battery, Lithium-ion battery	1
2.5	Fuel cells – Fundamentals, types and applications. Hydrogen generation and storage	1
2.6	**Corrosion and Surface Engineering**- Basics – Corrosion - causes- factors- types	1
2.7	chemical, electrochemical corrosion (galvanic, differential aeration), corrosion of metal and computer components-	1
2.8	Corrosion control - material selection and design	1

Module No.	Topic	No. of Periods
	aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method	
2.9	Electroplating –Introduction, Process, Applications (Gold and nickel plating). Electroless plating – Principle, process, Applications (PCB manufacturing)	1
3	**Spectroscopic technique and applications**	
3.1	Introduction to Electromagnetic Radiation, Types of atomic and molecular spectra	1
3.2	***Principle, Instrumentation and Applications:*** X-ray-diffraction	1
3.3	UV–Visible spectroscopy,Atomic Absorption Spectroscopy	2
3.4	Fluorescence spectroscopy, Inductively Coupled Plasma - Optical Emission Spectroscopy	2
3.5	Infra-red spectroscopy	2
3.6	Nuclear magnetic resonance spectroscopy – Magnetic resonance imaging	1
4	**Engineering materials**	
4.1	Bonding and its influence on the property of materials	1
4.2	Properties of materials- melting point - brittleness, ductility - thermal, electrical and ionicconductivity	1
4.3	optical – magnetic properties, hydrophobic, hydrophilic	1
4.4	**Polymer composites** - structure and properties	1
4.5	applications -automotive, aerospace, marine, biomedical, and defense	1
4.6	**Ceramics and advanced ceramics** - types-properties	1
4.7	applications- medicine, electrical, electronics, space	1
4.8	**Nano-materials** – Synthesis, structure and properties	1
4.9	applications - sensors, drug delivery, photo and electro-catalysis, and pollution control	1
	Total	36

Course Designer(s):

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22EG140	TECHNICAL ENGLISH

Category	L	T	P	Credit
HSMC	2		0	2

Preamble

The course aims at fostering the students' ability to communicate effectively in various academic, professional, and social settings through oral and written forms. Besides imparting the basic skills such as Listening, Speaking, Reading and Writing (LSRW), significant emphasis is placed on enriching their analytical, descriptive, and creative skills, enabling them to develop and demonstrate a holistic English language proficiency.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	**Relate** the fundamentals of language in terms of vocabulary, grammar and pronunciation in technical communication.	TPS2	60%	70%
CO2	**Infer** ideas from technical and general contexts by identifying main ideas, specific details, predicting and note-making.	TPS2	60%	70%
CO3	**Make use of** language in professional and social contexts with clarity and conciseness.	TPS3	60%	70%
CO4	**Identify** specific contexts in technical writing, where appropriate lexical and grammatical functions are applied	TPS3	60%	70%
CO5	**Develop** the skills such as understanding, evaluating, analysing and summarising the text and graphical representations.	TPS3	60%	70%
CO6	**Organise** ideas with coherence, cohesion and precision in formal written communication	TPS3	70%	80%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									M	S		S
CO2									M	S		S
CO3								L	M	S		S
CO4									M	S		S
CO5									M	S		S
CO6								L	M	S		S
S- Strong; M-Medium; L-Low												

Assessment Pattern

CO	Assessment 1						Assessment 2						Terminal (%)		
	Written Test 1 (%)			Assignment 1 (%)			Written Test 2 (%)			Assignment 2 (%)					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1		24%									-		-	10%	-
CO2		34%			100%						-		-	20%	
CO3			14%						24%		-		-	-	20%
CO4			14%		-				34%				-	-	10%
CO5			14%		-						100%		-	-	20%
CO6					-				42%				-	-	20%
TOTAL	100%			100%			100%			100%			100%		

* Assignment 1:Speaking activities in CO1, CO2, and CO3 (100%).
**Assignment 2: Writing activities in CO4, CO5, and CO6 (100%).
***Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus:

MODULE- I - Basics of Language (CO1)
Vocabulary - Word Building, Prefix, Suffix and Root Words, Basics of Grammar – Parts of Speech, Tenses, Phonetics - Phonemes, Syllables and Stress.

MODULE- II – Reading (CO2)
Reading - Skimming and Scanning of Short Comprehension Passages and Answering Questions or Cloze exercises based on the text prescribed for extensive reading, Note-Making.

MODULE- III – Functional English (CO3)
Framing Questions (WH and Yes/No), Modals, Manual Writing, Recommendations Writing, Agenda and Minutes of Meeting.

MODULE-IV – Technical Notions (CO4)
Technical Notions - Subject-Verb Agreement, Relative Clause, Phrasal Verbs, Impersonal Passive Voice, Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives.

MODULE-V – Analytical Writing and Business Correspondence (CO5 & CO6)
Summary Writing, Interpretation of Graphics, Jumbled Sentences, Paragraph Writing, Formal Letters (Seeking Permission for Industrial Visit/internship/Bonafide), E-mail Writing (BEC Vantage Writing Task I)

Suggested Reading:

Books:

1. Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006
3. Brook-Hart,Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP,2013.
4. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.
5. Swan, Michael.Practical English Usage.4thEdn. OUP. 2017.
6. Elbow, Peter. Writing with Power: Techniques for Mastering the Writing Process. New York, Oxford University Press, 1998.

Extensive Reading:

1. Anthology of Select Five Short Stories
2. Tagore, Rabindranath. *Chitra, a Play in One Act.* London, Macmillan and Co., 1914

Websites:

1. www.englishclub.com
2. owl.english.purdue.edu
3. www.oxfordonlineenglish.com
4. www.bbclearningenglish.com
5. tcesrenglish.blogspot.com

Course Contents and Lecture Schedule

S.No	Topic	No. of Hours
1.	Word Building, Prefix, Suffix and Root Words	1
2.	Parts of Speech	1
3.	Tenses	1
4.	Skimming and Scanning of Short Comprehension Passages	1
5.	Manual Writing	1
6.	Recommendations	1
7.	Note-Making	1
8.	Subject-Verb Agreement	1
9.	Phonemes	1
10.	Syllables and Stress	1
11.	Answering Questions or Cloze exercises based on the text prescribed for extensive reading	1
12.	Noun Compounds, Classifications and Definitions	1
13.	Summary Writing	1
14.	Interpretation of Graphics	1
15.	Cause and Effect, Purpose and Function	1
16.	Jumbled Sentences	1
17.	Formal Letters (Seeking Permission for Industrial Visit/internship/ Bonafide)	1
18.	Phrasal Verbs and Impersonal Passive Voice	1
19.	Numerical Adjectives	1
20.	Framing Questions (WH and Yes/No) and Modals	1
21.	Agenda and Minutes of Meeting	1
22.	Relative Clause	1
23.	E-mail Writing (BEC Vantage Writing Task I)	1
24.	Paragraph Writing	1
	Total	**24**

Course Designers:

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Mrs. M. Sarpparaje mseeng@tce.edu

		Category	L	T	P	Credit
22EE150	**ENGINEERING EXPLORATION**	ESS	2	0	0	2

Preamble

The course Engineering Exploration provides an introduction to the engineering field. It is designed to help the student to learn about engineering and how it affects our everyday lives. On the successful completion of the course, students will be to explain how engineering is different from science and technology and how science, mathematics and technology are an integral part of engineering design.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO		TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain technological & engineering development, change and impacts of engineering	TPS2	80	70
CO2	Explain the Engineering Fundamentals	TPS2	80	70
CO3	Explain the Electrical Engineering practices	TPS2	80	70
CO4	Practice Safety in work place	TPS2	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**M**	**L**													
CO2	**M**	**L**													
CO3	**M**	**L**													
CO4	**M**	**L**													

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	**CAT1**						**CAT2**						**Terminal**					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	16	20											8	12				
CO2	24	40											16	24				
CO3							20	30					8	12				
CO4							20	30					8	12				

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Engineering Basics - Introduction to Engineering Profession; Preparing for an Engineering Career; Introduction to Engineering Design; Engineering Communication; Types of Drawing, Engineering Council of India (ECI) code of Ethic.

Engineering Fundamentals - Fundamental Dimensions and Systems of Units; Current and Voltage; Conductor, semiconductors and Insulators; sources of EMF, Resistance; Power and Energy calculation; Capacitance; Magnetism; Inductance; Alternating current; Peak, Average and RMS values; Reactance; vector algebra; Impedance; Power in alternating current circuits; Electrical Measurement.

Electrical Engineering - Symbols for Electrical Elements ;Electric Power Supply System and its components; Switches, contactors; Rating of Electrical Equipment;

Electrical Safety - Principles of Electrical Safety; Earthing, Types of Earthing, Fuse, Miniature Circuit Breakers, Earth Leakage Circuit Breakers, Rating of Protective Devices, First Aid, Fire Extinguishers, Personal Protective Devices.

Reference Books& web resources

1. Saeed Moaveni "Engineering Fundamentals- An Introduction to Engineering"- Cengage Learning- Fifth Edition- 2016
2. Herbert W. Jackson, Dale Temple, Brian Kelly, Karen Craigs, and Lauren Fuentes," Introduction to Electric Circuits" – Oxford University Press- Tenth Edition- 2019.
3. V.K.Metha “Principles of Power System”-S.Chand Publishers, 2006
4. International Copper Association India “Electricity in Buildings – Good Practice Guide” McGraw Hill Education (India) Private Limited, New Delhi, 1st Edition 2016,
5. S.Rao, R.K.jain, H.L.Saluja “Electrical Safety, Fire Safety Engineering and Safety Management”Khanna Publishers, New Delhi, Second Edition 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Engineering Basics**	
1.1	Introduction to Engineering Profession; Preparing for an Engineering Career	1
1.2	Introduction to Engineering Design	1
1.3	Engineering Communication; Types of Drawing	1
1.4	Engineering Council of India (ECI) code of Ethic	1
2	**Engineering Fundamentals**	
2.1	Fundamental Dimensions and Systems of Units;	1
2.2	Current and Voltage; Conductor, semiconductors and Insulators; sources of EMF	1
2.3	Resistance; Power and Energy calculation	1
2.4	Capacitance; Magnetism; Inductance	2
2.5	Alternating current; Peak, Average and RMS values	1
2.6	Reactance; vector algebra; Impedance	2

Module No.	Topic	No. of Periods
2.7	Power in alternating current circuits	1
2.8	Electrical Measurement.	1
3	**Electrical Engineering**	
3.1	Symbols for Electrical Elements	1
3.2	Electric Power Supply System and its components;	1
3.3	Switches, contactors	1
3.4	Rating of Electrical Equipment;	1
4	**Electrical Safety**	
4.1	Principles of Electrical Safety	1
4.2	Earthing, Types of Earthing	1
4.3	Fuse, Miniature Circuit Breakers, Earth Leakage Circuit Breakers	1
4.4	Rating of Protective Devices	1
4.5	First Aid, Fire Extinguishers	1
4.6	Personal Protective Devices.	1
	Total	24

Course Designer(s):

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2 Dr.V.Saravanan vseee@tce.edu

22ME160	ENGINEERING GRAPHICS	Category	L	T	P	Credit
		ESC	3	0	2	4

Preamble

Engineering Graphics is referred as language of engineers. An engineer needs to understand the geometry of any object through its orthographic or pictorial projections. The knowledge on engineering graphics is essential in proposing new product designs through drawings and in reading or understanding the existing drawings. This course covers orthographic and pictorial projections, sectional views, development of surfaces and use of computer aided drafting tools.

Prerequisite

- Basic knowledge about geometry of objects.

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
C01	Draw the orthographic views of objects from the given isometric views and draw the orthographic projections of points.	TPS 3	70	70
CO2	Draw the orthographic projections (Elevation and Plan) of straight lines inclined to both reference planes.	TPS 3	70	70
CO3	Draw the orthographic projections (Elevation and Plan) of plane surfaces inclined to both reference planes.	TPS 3	70	70
CO4	Draw the orthographic projections (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and Cone) with axis inclined to any one-reference plane.	TPS 3	70	70
CO5	Draw the orthographic projections (Elevation and Plan) of sectioned solids (Prisms, Pyramids, Cylinder and Cone) and true shape of the sections.	TPS 3	70	70
CO6	Draw the development of surfaces (base and lateral) of sectioned regular solids (Prisms, Pyramids, Cylinder and Cone).	TPS 3	70	70
CO7	Draw the isometric projections of regular solids and combined solids (Prisms, Pyramids, Cylinder, Cone and Sphere) and convert the orthographic projections into isometric views.	TPS 3	70	70
CO8	Create computer-aided 3D models for the given drawing (2D/3D) and draw orthographic views for the 3D model with appropriate dimensioning using CAD package (Continuous Assessment only).	TPS 3	Continuous Assessment only	

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO2.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO3.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO4.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO5.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO6.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
CO7.	S	M	S	M	M	_	_	_	M	M	_	_	M	_	_
C08.	S	M	S	M	S	_	_	_	M	M	_	_	M	_	_
Over all	3	2	3	2	2.13	0	0	0	2	2	0	0	2	0	0
	S	M	S	M	M	-	-	-	M	M	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category / TPS Scale	Continuous Assessment Test	Terminal Examination
Remember / 1		
Understand / 2		
Apply / 3	100	100
Analyse / 4		
Evaluate / 5		
Create / 6		

Syllabus

Introduction - Significance of engineering graphics, Use of drawing instruments, Standards, Lettering and dimensioning, Scales.

Orthographic Projection - Principles of orthographic projections, First angle projection, Orthographic projection of objects from pictorial views. Projection (Elevation and Plan) of points located in all quadrants.

Projection (Elevation and Plan) of straight lines in first quadrant, inclined to both reference planes by rotating line method.

Projection (Elevation and Plan) of plane surfaces in first quadrant, inclined to both reference planes by rotating object method.

Projection (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and cone) in first quadrant, by rotating object method when the axis is inclined to one of the reference planes.

Projection (Elevation and Plan) of sectioned solids (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.

Development of base and lateral surfaces of sectioned regular solids (Prisms, Pyramids, Cylinder and Cone) with cutting plane inclined to HP only.

Isometric projection – Principle, isometric scale, Isometric views and Isometric projections of single simple solids. Combination of solids (Prisms, Pyramids, Cylinder, Cone and sphere - in simple vertical positions only). Conversion of orthographic projections (Elevation, Plan and Side view) of solid parts / engineering components into isometric views.

Computer Aided Drafting (For Continuous Assessment only):

Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Cross hairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), Command Line, Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems. Orthographic and isometric views.

Practice on drawing of 2 dimensional geometric patterns consisting of entities such as lines, arcs and circles. Practice on creation of 3 dimensional wire-frame and shaded models. Dimensioning in isometric and orthographic views.

Text Book

1. Bhatt N.D., Panchal V.M. and Ingle P.R., (2014) "Engineering Drawing", Charotar Publishing House.

Reference Books

1. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2012.
2. Basant Agarwal and Agarwal C.M., "Engineering Drawing", Tata McGraw Hill Publishing Company Limited, New Delhi, 2019.
3. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age International (P) Limited, 2011.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Publications, Bangalore, 2017.
5. Shah M.B, and Rana B.C (2009) "Engineering Drawing and Computer Graphics", Pearson Education.
6. CAD Software Theory and User Manuals.

Course Contents and Lecture Schedule

Sl.No	Topic	Lecture Hours	Practice Hours
1	**Introduction**- Significance of engineering graphics, Use of drawing instruments –Standards, Lettering and dimensioning, Scales	2	1
2	**Orthographic Projection-** Principles of orthographic projections, First angle projection, **Orthographic projection of objects from pictorial views.**	2	2
3	**Projection (Elevation and Plan) of points** located in all quadrants.	2	1
4	**Projection (Elevation and Plan) of straight lines** in first quadrant, inclined to both reference planes by rotating line method.	4	2
5	**Projection (Elevation and Plan) of plane surfaces** in first quadrant, inclined to both reference planes by rotating object	5	3

	method.		
6	**Projection (Elevation and Plan) of regular solids** (Prisms, Pyramids, Cylinder and cone) in first quadrant, by rotating object method when the axis is inclined to one of the reference planes.	5	3
7	**Projection (Elevation and Plan) of sectioned solids** (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.	4	2
8	**Development of surfaces** (base and lateral) **of sectioned regular solids** (Prisms, Pyramids, Cylinder and Cone) with cutting plane inclined to HP only.	4	2
9	**Isometric projection** – Principle, isometric scale, Isometric views and Isometric projections of single simple solids. Combined solids (Prisms, Pyramids, Cylinder, Cone and sphere - in simple vertical positions only). **Conversion of orthographic projections** (Elevation, Plan and Side view) of solid parts / engineering components into isometric views.	4	2
10	**Computer Aided Drafting** (For Continuous Assessment only)**:** **10.1** Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Cross hairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line, The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems. Orthographic and isometric views.	1	1
	10.2 – Practice on drawing of 2 dimensional geometric patterns consisting of entities such as lines, arcs and circles. Practice on creation of 3 dimensional wire-frame and shaded models. Dimensioning in isometric and orthographic views.	3	5
	TOTAL	**36**	**24**

<u>Marks Allocation for Continuous Assessment:</u>

Sl. No	Description	Marks
1	Plates (Drawing sheets) submission	20
2	Computer Aided Drafting (CAD) Exercises	15
3	Continuous Assessment Test (CAT)	15
Total		**50**

Question Pattern for Terminal Examination:

Question Number	Description	Type	Marks
1	Orthographic views from isometric view Or Projection of Points	Either or type	10
2	Projection of lines	Either or type	15
3	Projection of planes	Either or type	15
4	Projection of solids	Either or type	15
5	Section of solids	Either or type	15
6	Development of surfaces	Either or type	15
7	Isometric projections of combined solids Or Conversion of orthographic views into isometric view	Either or type	15
Total			**100**

Note:

1. **One test or two tests will be conducted locally by respective Faculty In - charges during regular class hours to account for continuous assessment test (CAT) marks.**

2. **Terminal examination (3 hrs) will be conducted centrally by the office of controller of examinations.**

Course Designers:

1. Dr. B. Karthikeyan, Assistant Professor, Mechanical Engineering bkmech@tce.edu
2. Dr. M. Kannan, Assistant Professor, Mechanical Engineering mknmech@tce.edu

22EG170	ENGLISH LABORATORY	Category	L	T	P	Credit
		HSMC	0	0	2	1

Preamble

This practical course enables the students to develop and evaluate their basic English language skills through individualized learning process at the Language Lab, using English Software and online resources. In addition, it facilitates students with the need-based student-centric presentation sessions in a multi-media driven classroom environment.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale
CO1	Interpret words correctly through listening and watching general and technical online contents	Understand
CO2	Develop appropriate pronunciation skills through listening and speaking practices	Apply
CO3	Build and apply a wide range of lexicons in general and technical presentations	Apply
CO4	Identify and apply the key ideas and spoken English features learnt through auditory and visual listening tools	Apply
CO5	Experiment with inventiveness by creating a blog, vlog, or YouTube channel.	Apply
CO6	Prepare and deliver oral and written presentations using digital tools.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									M	S		S
CO2									M	S		M
CO3								L	M	S		S
CO4								L	M	S		M
CO5								L	M	S		S
CO6								L	S	S		S

Assessment Pattern

- Students' performance will be assessed in the language lab/ classroom as given below:
  - Spoken Task - General / Technical Presentation / Picture Description: 20 Marks
  - Listening Task –(MCQs, Gap Filling Exercises) : 10 Marks
  - Written Test - Phonetics, Grammar, Vocabulary, Reading : 20 Marks

External: Online Exam- Phonetics, Grammar, Vocabulary, Reading (45 Minutes): 50 Marks
Listening Test : 20 Marks
Submission of Students' Record on Practical Tasks in the Class and Lab :10 Marks
BEC Vantage Speaking Tasks I and II : 20 Marks

List of Experiments

S.No	Topic	Hours
	LAB ACTIVITIES (12 Hours)	
1	Listening to TED Talks/ Podcasts/ Product Advertisements/ NewsBulletins.	2
2	Phonetics – Tutorials through Online Repositories, English Movie Clips and Software in the Lab(S-net)	2
3	Vocabulary Development through Movies / Short Films/ Documentaries	2
4	Language Development through English softwareS-net and Online Content (Tens Voices, SV Agreement, Prepositions, Coherence Markers, Relative Clauses, Mod Punctuation)	2
5	Reading Comprehension – I (General / Technical, BEC Vantage Reading Task III	2
6	Creating a Blog/Vlog/YouTube Channel –Uploading MP3/MP4 – Practice (Movie/Book/ Gadget Review, General/Tech Talks, Interview with Celebrities)	1
7	Revision – Model Online Aptitude Test	1
	CLASSROOM ACTIVITIES (12 Hours)	
8	Introduction of Spoken English Features	1
9	Self-introduction and Introducing others	1
10	Video Comprehension – Brainstorming and Note-Taking	2
11	Role-Play, Picture/Movie Description	1
12	Reporting the events from Media / Newspapers – Discussion	1
13	Interactive Games for Language Development	1
14	Reading / Note Making (Extensive Reading – News Paper Reports)	1
15	Presentation – I (Book /Movie Review, Story Telling, General Presentations)	2
16	Presentation – II (Technical Presentations)	2
	Total	24

Software Used:

1. English Software S Net
2. Business English Certificate-Vantage- Practice Software

Teaching Resources and Websites:

1. Open Online Repositories from Oxford / Cambridge / British Council/ Voice of America
2. Free Video Downloads from YouTube
3. www.ted.com
4. tcesrenglish.blogspot.com

Course Designers:

1	Dr.A.Tamilselvi	tamilselvi@tce.edu
2	Dr. S. Rajaram	sreng@tce.edu
3	Dr.RS. Swarnalakshmi	rssleng@tce.edu
4	Mrs. M. Sarpparaje	mseeng@tce.edu

22PH180	PHYSICS LABORATORY

Category	L	T	P	Credit
BSC	0	0	2	1

Preamble

This course ensures that students are able to apply the basic physics concepts and carry out the experiments to determine the various physical parameters related to the material
• Learn the necessary theory to understand the concept involved in the experiment.
• Acquire the skills to carry out the experiment.
• Tabulate the observed data and use the formula to evaluate the required quantities.
• Plot the data in a graph and use it for calculation.

Prerequisite

- None

Course Outcomes

On the successful completion of the course, students will be able to

	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Analyze the mechanical & electrical oscillations and determine their resonance frequency	TPS3	85	90
CO2	Analyse the interference and diffraction patterns for micron sized objects	TPS3	85	90
CO3	Investigate the V-I characteristics of photodiode, phototransistor under dark and bright illumination conditions	TPS3	85	90
CO4	Determine the Planck's constant using LEDs	TPS3	85	90
CO5	Plot the VI characteristics of solar cell and find the fill factor	TPS3	85	90
CO6	Determine the reversibility of classical and quantum logic gates	TPS3	85	90
CO7	Identify the variation of magnetic field with distance for circular coils	TPS3	85	90

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO7.	**S**	**M**	**L**	**-**	**M**	**-**	**-**	**-**	**S**	**-**	**-**	**L**
CO8.	**S**	**M**	**L**	**-**	**M**	**-**	**-**	**-**	**S**	**-**	**-**	**L**
CO3	**S**	**M**	**L**	**-**	**M**	**-**	**-**	**-**	**S**	**-**	**-**	**L**
CO4	**S**	**M**	**L**	**-**	**M**	**-**	**-**	**-**	**S**	**-**	**-**	**L**
CO5	**S**	**M**	**L**	**-**	**M**	**-**	**-**	**-**	**S**	**-**	**-**	**L**
CO6	**S**	**M**	**L**	**-**	**M**	**-**	**-**	**-**	**S**	**-**	**-**	**L**
CO7	**S**	**M**	**L**	**-**	**M**	**-**	**-**	**-**	**S**	**-**	**-**	**L**

S- Strong; M-Medium; L-Low

LIST OF EXPERIMENTS

1. Quantum Logic Gate-Toffoli gate
2. Study of Optoelectronic Devices- Photodiode, Phototransistor.
3. Solar cell VI characteristics,fill factor & Optical fibre-Determination of numerical aperture.
4. Torsional pendulum – Determination of rigidity modulus of wire and moment of inertia of regular objects.
5. Laser Diffraction - Determination of wave length of the laser using grating and determination of micro particle size.(Observing diffraction pattern due to single and double slit)
6. Air wedge – Determination of thickness of a thin sheet/wire.
7. Determination of Planck’s constant through V-I characteristics of LED.
8. Determination of magnetic field-Stewart and Gees.
9. LCR Circuit – Determination of resonant frequency

Course Designer(s):

Dr. N. Sankarasubramanian nssphy@tce.edu
Dr. A.L .Subramaniyanalsphy@tce.edu
Dr.P.K.Kannan akphy@ce.edu

22CH190	CHEMISTRY LABORATORY (COMMON TO ALL BRANCHES)

Category	L	T	P	Credit
BSC	0	0	1	1

Preamble

This course aims to provide the students, a basic practical knowledge in chemistry. The objective of this course is to develop intellectual and psychomotor skills of the students by providing hands on experience in quantitative, electrochemical and photo-chemical analysis.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale
CO1	Estimate the chemical water quality parameters of sample water / effluent	TPS Apply
CO2	Demonstrate presence of calcium ions in milk sample	TPS Apply
CO3	Determine the surface tension of solvent mixtures	TPS Apply
CO4	Estimate pH and acid content of samples using pH metric and conductometric titrations	TPS Apply
CO5	Illustrate the strength of oxidisable materials present in given sample by potentiometric method	TPS Apply
CO6	Determine Fe^{2+} ion in effluent using colorimetric method	TPS Apply
CO7	Calculate the efficiency of electroplating	TPS Apply
CO8	Determine the rate of corrosion of metal & alloy using potentio-dynamic polarisation method	TPS Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO7.	S	M	L	-	M	-	-	-	L	-	-	-
CO8.	S	M	L	-	M	-	-	-	L	-	-	-
CO9.	S	M	L	-	M	-	-	-	L	-	-	-
CO10	S	M	L	-	M	-	-	-	L	-	-	-
CO11	S	M	L	-	M	-	-	-	L	-	-	-
CO12	S	M	L	-	M	-	-	-	L	-	-	-
CO13	S	M	L	-	M	-	-	-	L	-	-	-
CO14	S	M	L	-	M	-	-	-	L	-	-	-

S- Strong; M-Medium; L-Low

List of Experiments/Activities with CO Mapping

Experimental List	CO
Quantitative Analysis	
Estimation of total hardness of water sample	CO1
Estimation of COD of industrial effluent	CO1
Determination of calciumion inmilk sample	CO2

Determination of surface tension of solvent mixture	CO3
Electrochemical and Photochemical Analysis	
Determination of the Phosphoric acid content in soft drinks using conductometric titration	CO4
Determination of pH of soil by pH metric titration	CO4
Potentiometric redox titration ($K_2Cr_2O_7$vs FAS, $KMnO_4$vs FAS)	CO5
Estimation of iron content in water sample using colorimeter	CO6
Estimation of current density of electroplating process using Hull cell	CO7
Determination of rate of corrosion of metal and alloy using potentiodynamic polarisation technique (TAFEL)	CO8

Learning Resources

1. Vogel's Textbook of Quantitative Chemical Analysis (8^{TH}edition, 2014)
2. LaboratoryManual – Department of Chemistry, Thiagarajar College of Engineering (2022)

Course Designers:

1. Dr.M.Kottaisamy hodchem@tce.edu
2. Dr.S.Balaji sbalaji@tce.edu
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5. Dr.M.Velayudham mvchem@tce.edu
6. Dr.R.Kodi Pandyan rkp@tce.edu
7. Dr.A.Ramalinga chandrasekar arcchem@tce.edu
8. Dr. B. Shankar bsrchem@tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

B.E. EEE DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41

Fax: 0452 2483427

Passe

Web: www.tce.edu

VISION

Transforming the individuals into globally competent electrical engineers to fulfill the technological needs of the society.

MISSION

Establishing world class infrastructure in Electrical Engineering.

Enhancing the knowledge of the faculty in cutting edge technologies through continuous improvement programmes.

Providing well balanced curriculum in graduate, postgraduate and doctoral programmes.

Adopting innovative content delivery, assessment and continuous improvement methods to achieve desired outcomes.

Facilitating industry institution interaction in teaching & learning, consultancy and research activities to accomplish the technological needs of the society.

Encouraging the faculty and students to carry out innovative research work.

Practicing ethical standards by the faculty and students.

Motivating the students for active participation in co-curricular and extracurricular activities.

Programme Educational Objectives (PEO's)

PEO1: Graduates of the programme will have successful career in chosen technical or professional fields.

PEO2: Graduates of the programme will have technical competency in solving challenging societal tasks in ethical and economical manner.

PEO3: Graduates of the programme will reveal lifelong learning and team work in their chosen profession.

Programme Outcomes (POs) for B.E. Electrical and Electronics Engineering

After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students should be able to:

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 Conduct investigations of complex problems: The problems:

- That cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline.
- That may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions.
- That requires consideration of appropriate constraints/requirements not explicitly given in the problem statement. (Like: cost, power requirement, durability, product life, etc.).
- Which need to be defined (modeled) within appropriate mathematical framework.
- That often requires use of modern computational concepts and tools.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering 21 activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEO-PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
PEO 1												
PEO												

2												
PEO 3												

Programme Specific Outcomes (PSO):

After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students will be able to:

PSO1: Design and analyze components/ systems that effectively generate, transmit, distribute and utilize electrical power.

PSO2: Design and analyze modern industrial electronic systems/components to perform analog and digital processing and control functions

PEO- Mission mapping

PEO	M1	M2	M3	M4	M5	M6	M7	M8
PEO1	1	2	2	1	2	1	1	3
PEO2	1	2	2	2	2	2	1	3
PEO3	1	2	3	2	3	2	1	3

1 – Low; 2 – Medium; 3 – Strong

Credit Distribution

<table>
<tr><th rowspan="2">S. No</th><th rowspan="2" colspan="2">Category</th><th colspan="2">Credits</th></tr>
<tr><th>Regular Admission</th><th>Lateral Entry Admission</th></tr>
<tr><td rowspan="4">A</td><td colspan="2">Foundation Courses (FC)</td><td>54 – 66</td><td>24 - 36</td></tr>
<tr><td>a.</td><td>Humanities and Social Sciences including Management Courses (HSMC)</td><td>9- 12</td><td>09 - 12</td></tr>
<tr><td>b.</td><td>Basic Science Courses (BSC)</td><td>24 – 27</td><td>06 - 09</td></tr>
<tr><td>c.</td><td>Engineering Science Courses (ESC)</td><td>21 – 27</td><td>12 - 15</td></tr>
<tr><td>B</td><td colspan="2">Professional Core Courses (PCC)</td><td>55</td><td>45</td></tr>
<tr><td>C</td><td colspan="2">Professional Elective Courses (PEC)</td><td>24 – 39</td><td>24 - 39</td></tr>
<tr><td></td><td>a.</td><td>Programme Specific Electives (PSE)</td><td>15 – 24</td><td>15 – 24</td></tr>
<tr><td></td><td>b.</td><td>Programme Electives for Expanded Scope (PEES)</td><td>9 – 15</td><td>9 – 15</td></tr>
<tr><td>D</td><td colspan="2">Open Elective Courses (OEC)</td><td>6 – 12</td><td>6 – 12</td></tr>
<tr><td></td><td>a.</td><td>Interdisciplinary Elective (IE)</td><td>3 – 6</td><td>3 – 6</td></tr>
<tr><td></td><td>b.</td><td>Basic Science Elective (BSE)</td><td>3 – 6</td><td>3 – 6</td></tr>
<tr><td>E</td><td colspan="2">Project Work</td><td>12</td><td>12</td></tr>
<tr><td>F</td><td colspan="2">Internship and Mandatory Audit Courses as per Regulatory authorities</td><td colspan="2">Non-Credit
(Not included for CGPA)</td></tr>
<tr><td rowspan="2"></td><td rowspan="2" colspan="2">Minimum Credits to be earned for the award of the Degree</td><td>160</td><td>120</td></tr>
<tr><td colspan="2">From A to E and the successful completion of F</td></tr>
</table>

- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College

SCHEDULING OF COURSES (B.E.EEE. Programme) – 2022-23 admitted Batch

Sem	Theory / Theory cum Practical / Practical 1	2	3	4	5	6	7	8	CDIO courses	Audit Courses (Mandatory Non- credit}	Credit
I	22MA110 Calculus for Engineers (BSC-4)	22PH120 Physics (BSC-3)	22CH130 Chemistry (BSC-3)	22EG140 Technical English (HSMC-2)	22ME160 Engineering Graphics (ESC-4)	22EG170 English Lab. (HSMC-1)	22PH180 Physics Lab. (BSC-1)	22CH190 Chemistry Lab. (BSC-1)	22EE150 Engineering Exploration (EEE Specific) (ESC-2)		**21**
II	22EE210 Matrices and Transforms (BSC-4)	22EE220 Materials Science for Electrical Engineering (ESC-3)	22EE230 Electric Circuit Analysis (PCC-3)	22EE240 Electromagnetic Fields (PCC-3)	22EE250 Digital Systems (PCC-3)	22EE260 Electronic devices and circuits (PCC-3)	22EE270 Electrical Workshop (ESC-1)	22EE280 Electronic Devices and Circuits (PCC Lab 1)		Audit Course 1	**21**
III	22EE310 Numerical methods and Complex variables (BSC-4)	22EE320 DC Machines and Transformers (PCC-3)	22EE330 Linear Integrated Circuits (PCC-3)	22EE340 Signals and Systems (PCC-3)	22EE350 Problem Solving Using Computers (ESC-3)		22EE370 DC Machines and Transformers Lab (PCC Lab 1)	22EE380 Integrated Circuits Lab (PCC Lab 1)	22ES390 Design Thinking (ESC-3)		**21**
IV	22EE410 Probability Distribution and Random Process (BSC-4)	22EE420 AC Machines (PCC-3)	22EE430 Measurements and Instrumentation (PCC-3)	22EE440 Control Systems (PCC-3)	22EE450 Power Electronics (PCC-3)	22EE460 Data Structures Elective(ESC-3)	22EE470 Electrical Problem solving using computers (PCC Lab 1)	22EE480 AC Machines Lab (PCC Lab 1)	22EE490 Project Management (HSMC-3)	Audit Course 2	**24**
V	22EE510 Generation, Transmission and Distribution (PCC-3)	22EE520 Micro Controllers (PCC-3)	22EE530 Electric drives (PCC-3)	22EE540 Power System Analysis (PCC-3)	Interdisciplinary Elective (OE-3)	22EE550 Object Oriented Programming PE (ESC-3)	22EE570 Measurement and Control Lab (PCC Lab1)	22EE580 Microcontrollers lab (PCC Lab 1)	22EE590 Project -1 (P-3)		**23**

VI	22EE610 Accounting and Finance HSMC-3	22EEPXX PEC-PSE-1 (3)	22EEPXX PEC-PSE-2 (3)	22EEPXX PEC-PSE-3 (3)	Basic Science Elective (OE-3)	22EG660 Professional Communication HSMC-2	22EE670 Power Electronics and Drives Lab (PCC Lab-1)(1)	22EE680 Electric Power Systems lab (PCC Lab 1)	22EE690 Project -2 (P-3)		**22**
VII	22EEPXX PEC-PSE-4 (3)	22EEPXX PEC-PSE-5 (3)	22EEPXX PEC-PSE-6 (3)	22EEPXX PEC-PSE-7 (3)	22EEPXX PEC-PEES-1 (3)		22EE770 Energy Management System Lab (PCC Lab 1)		22EE790 Project -3 (P-3)		**19**
VIII	22EEPXX PEC-PEES -2 (3)	22EEPXX PEC-PEES -3(3)							22EE890 Project -4 (P-3)		**9**

Total Credits: **160**

THIAGARAJAR: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

COURSES OF STUDY
(For the candidates admitted from 2022-23 onwards)

SECOND SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE210	Matrices and Transforms	BSC	3	1	-	4
22EE220	Materials Science for Electrical Engineering	ESC	3	-	-	3
22EE230	Electric Circuit Analysis	PCC	3	-	-	3
22EE240	Electromagnetic Fields	PCC	2	1	-	3
22EE250	Digital Systems	PCC	3	-	-	3
22EE260	Electronic devices and circuits	PCC	3	-	-	3
22CHAA0	Environmental Science (Audit Course)					
THEORY CUM PRACTICAL Nil						
PRACTICAL						
22EE270	Electrical Workshop	ESC	-	-	2	1
22EE280	Electronic Devices and Circuits	PCC Lab	-	-	2	1
Total			**17**	**2**	**4**	**21**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses

L : Lecture , T : Tutorial ,P: Practical

Note :

1 Hour Lecture is equivalent to 1 credit

1 Hour Tutorial is equivalent to 1 credit 2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

THIRD SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE310	Numerical methods and Complex variables	BSC	3	1	-	4
22EE320	DC Machines and Transformers	PCC	2	1	-	3
22EE330	Linear Integrated Circuits	PCC	3	-	-	3
22EE340	Signals and Systems	PCC	3	-	-	3
22EE350	Problem Solving Using Computers	ESC	3	-	-	3
22ES390	Design Thinking	ESC	3	-	-	3
THEORY CUM PRACTICAL Nil						
PRACTICAL						
22EE370	DC Machines and Transformers Lab	PCC Lab	-	-	2	1
22EE380	Integrated Circuits Lab	PCC Lab	-	-	2	1
Total			**17**	**2**	**4**	**21**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical

Note :

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

FOURTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE410	Probability Distribution and Random Process	BSC	3	1	-	4
22EE420	AC Machines	PCC	2	1	-	3
22EE430	Measurements and Instrumentation	PCC	3	-	-	3
22EE440	Control Systems	PCC	2	1	-	3
22EE450	Power Electronics	PCC	3	-	-	3
22EE490	Project Management	HSMC	3	-	-	3
THEORY CUM PRACTICAL						
22EE460	Data Structures Elective	ESC	2		2	3
PRACTICAL						
22EE470	Electrical Problem solving using computers	PCC Lab	-	-	2	1
22EE480	AC Machines Lab	PCC Lab	-	-	2	1
Total			**18**	**4**	**4**	**24**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical

Note :

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

FIFTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE510	Generation, Transmission and Distribution	PCC	2	1	-	3
22EE520	Micro Controllers	PCC	2	1	-	3
22EE530	Electric drives	PCC	3	-	-	3
22EE540	Power System Analysis	PCC	3	-	-	3
	Interdisciplinary Elective	OE	3	-	-	3
22EE550	Object Oriented Programming	ESC	3	-	-	3
THEORY CUM PRACTICAL						
PRACTICAL						
22EE570	Measurement and Control Lab	PCC Lab	-	-	2	1
22EE580	Microcontrollers lab	PCC Lab	-	-	2	1
22EE590	Project -1	PCC	3	-	-	3
Total			**19**	**2**	**4**	**23**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical

Note :

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

SIXTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE610	Accounting and Finance	HSMC	3	-	-	3
22EEPXX	PEC-PSE-1 (3)	PEC-PSE-1 (3)	3	-	-	3
22EEPXX	PEC-PSE -2 (3)	PEC-PSE -2 (3)	3	-	-	3
22EEPXX	PEC-PSE -3 (3)	PEC-PSE -3 (3)	3	-	-	3
	Basic Science Elective	OE	3	-	-	3
22EG660	Professional Communication	HSMC		1	2	2
THEORY CUM PRACTICAL						
PRACTICAL						
22EE670	Power Electronics and Drives Lab	PCC Lab	-	-	2	1
22EE680	Electric Power Systems lab	PCC Lab	-	-	2	1
22EE690	Project -2	PCC	3	-	-	3
Total			**18**	**1**	**6**	**22**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical
Note :
1 Hour Lecture is equivalent to 1 credit
1 Hour Tutorial is equivalent to 1 credit
2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

SEVENTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEPXX	PEC-PSE -4 (3)	PEC-PSE -4 (3)	3	-	-	3
22EEPXX	PEC-PSE -5 (3)	PEC-PSE -5 (3)	3	-	-	3
22EEPXX	PEC-PSE -6 (3)	PEC-PSE -6 (3)	3	-	-	3
22EEPXX	PEC-PSE -7 (3)	PEC-PSE -7 (3)	3	-	-	3
22EEPXX	PEC-PEES-1 (3)	PEC-PEES-1 (3)	3	-	-	3
THEORY CUM PRACTICAL						
PRACTICAL						
22EE770	Energy Management System Lab	PCC Lab	-	-	2	1
22EE790	Project -3	PCC	-	-	-	3
Total			**15**	**-**	**2**	**19**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical

Note :

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

EIGHTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEPXX	PEC-PEES -2 (3)	PEC-PEES -2 (3)	3	-	-	3
22EEPXX	PEC-PEES -3(3)	PEC-PEES -3(3)	3	-	-	3
THEORY CUM PRACTICAL						
PRACTICAL						
22EE890	Project -4 (P-3)	PCC		-	-	3
Total			**6**	**-**	**-**	**9**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical
Note :
1 Hour Lecture is equivalent to 1 credit
1 Hour Tutorial is equivalent to 1 credit
2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B.E. / B.Tech. Degree Programme

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2022-2023 onwards)

SECOND SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE210	Matrices and Transforms	3	40	60	100	27	50
2	22EE220	Materials Science for Electrical Engineering	3	40	60	100	27	50
3	22EE230	Electric Circuit Analysis	3	40	60	100	27	50
4	22EE240	Electromagnetic Fields	3	40	60	100	27	50
5	22EE250	Digital Systems	3	40	60	100	27	50
6	22EE260	Electronic devices and circuits	3	40	60	100	27	50
THEORY CUM PRACTICAL Nil								
PRACTICAL								
7	22EE270	Electrical Workshop	3	60	40	100	18	50
8	22EE280	Electronic Devices and Circuits	3	60	40	100	18	50

THIRD SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE310	Numerical methods and Complex variables	3	40	60	100	27	50
2	22EE320	DC Machines and Transformers	3	40	60	100	27	50
3	22EE330	Linear Integrated Circuits	3	40	60	100	27	50
4	22EE340	Signals and Systems	3	40	60	100	27	50
5	22EE350	Problem Solving Using Computers	3	40	60	100	27	50
6	22ES390	Design Thinking						
THEORY CUM PRACTICAL Nil								
PRACTICAL								
7	22EE370	DC Machines and Transformers Lab	3	60	40	100	18	50
8	22EE380	Integrated Circuits Lab	3	60	40	100	18	50

FOURTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE410	Probability Distribution and Random Process	3	40	60	100	27	50
2	22EE420	AC Machines	3	40	60	100	27	50
3	22EE430	Measurements and Instrumentation	3	40	60	100	27	50
4	22EE440	Control Systems	3	40	60	100	27	50
5	22EE450	Power Electronics	3	40	60	100	27	50
6	22EE490	Project Management	3	40	60	100	27	50
THEORY CUM PRACTICAL								
7	22EE460	Data Structures Elective	3	50	50	100	25	50
PRACTICAL								
8	22EE470	Electrical Problem solving using computers	3	60	40	100	18	50
9	22EE480	AC Machines Lab	3	60	40	100	18	50

FIFTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE510	Generation, Transmission and Distribution	3	40	60	100	27	50
2	22EE520	Micro Controllers	3	40	60	100	27	50
3	22EE530	Electric drives	3	40	60	100	27	50
4	22EE540	Power System Analysis	3	40	60	100	27	50
5		Interdisciplinary Elective	3	40	60	100	27	50
6	22EE550	Object Oriented Programming	3	40	60	100	27	50
THEORY CUM PRACTICAL								
PRACTICAL								
7	22EE570	Measurement and Control Lab	3	60	40	100	18	50
8	22EE580	Microcontrollers lab	3	60	40	100	18	50
9	22EE590	Project -1	3					

SIXTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE610	Accounting and Finance	3	40	60	100	27	50
2	22EEPXX	PEC-PSE-1 (3)	3	40	60	100	27	50
3	22EEPXX	PEC-PSE -2 (3)	3	40	60	100	27	50
4	22EEPXX	PEC-PSE -3 (3)	3	40	60	100	27	50
5		Basic Science Elective	3	40	60	100	27	50
6	22EG660	Professional Communication	3	40	60	100	27	50
THEORY CUM PRACTICAL								
PRACTICAL								
7	22EE670	Power Electronics and Drives Lab	3	60	40	100	18	50
8	22EE680	Electric Power Systems lab	3	60	40	100	18	50
9	22EE690	Project -2						

SEVENTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEPXX	PEC-PSE -4 (3)	3	40	60	100	27	50
2	22EEPXX	PEC-PSE -5 (3)	3	40	60	100	27	50
3	22EEPXX	PEC-PSE -6 (3)	3	40	60	100	27	50
4	22EEPXX	PEC-PSE -7 (3)	3	40	60	100	27	50
5	22EEPXX	PEC-PEES-1 (3)	3	40	60	100	27	50
THEORY CUM PRACTICAL								
PRACTICAL								
6	22EE770	Energy Management System Lab	3	60	40	100	18	50
7	22EE790	Project -3						

EIGHTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEPXX	PEC-PEES - 2 (3)	3	40	60	100	27	50
2	22EEPXX	PEC-PEES -3(3)	3	40	60	100	27	50
THEORY CUM PRACTICAL								
PRACTICAL								
3	22EE890	Project -4 (P-3)						

Electives

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1.	22EEPA0	Power System Operation and Control	3	40	60	100	27	50
2.	22EEPB0	Electrical Machine Design	3	40	60	100	27	50
3.	22EEPC0	Switchgear and Protection	3	40	60	100	27	50
4.	22EEPD0	Wind and Solar Technology	3	40	60	100	27	50
5.	22EEPF0	Operation and Maintenance of Electrical equipment	3	40	60	100	27	50

6.	22EEPG0	Energy Audit and Management in Electric Utilities	3	40	60	100	27	50
7.	22EEPH0	Power System Stability	3	40	60	100	27	50
8.	22EEPJ0	VLSI Design	3	40	60	100	27	50
9.	22EEPK0	Computer Organization	3	40	60	100	27	50
10.	22EEPR0	Control System Design	3	40	60	100	27	50
11.	22EEPS0	Industrial Instrumentation	3	40	60	100	27	50
12.	22EEPU0	Flexible AC Transmission Systems	3	40	60	100	27	50
13.	22EEPV0	Power Quality	3	40	60	100	27	50
14.	22EEPW0	Power Electronics for Renewable Energy Systems	3	40	60	100	27	50

15.	22EERM0	Electric Vehicles	3	40	60	100	27	50
16.	22EEPY0	Design of Electrical Installations	3	40	60	100	27	50
17.	22EEPZ0	Smart Grid	3	40	60	100	27	50
18.	22EERA0	Thermal power plant instrumentat ion & control	3	40	60	100	27	50
19.	22EERB0	High Voltage Engineering	3	40	60	100	27	50
20.	22EERD0	Biomedical Instrumentat ion	3	40	60	100	27	50
21.	22EERG0	ASIC Design	3	40	60	100	27	50
22.	22EERJ0	Operation Research	3	40	60	100	27	50
23.	22EERK0	HVDC Transmissio n	3	40	60	100	27	50
THEORY CUM PRACTICAL								
24.	22EEPL0	Internet of Things	3	50	50	100	25	50

25.	22EEPM0	FPGA based System Design	3	50	50	100	25	50
26.	22EEPN0	Digital Signal Processing	3	50	50	100	25	50
27.	22EEPQ0	Embedded Systems Design	3	50	50	100	25	50
28.	22EEPT0	Soft Computing	3	50	50	100	25	50
29.	22EERF0	Real Time Operating System	3	50	50	100	25	50
30.	22EERH0	Machine Learning	3	50	50	100	25	50
31.	22EERL0	Simulation of Power Electronic Systems	3	50	50	100	25	50

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015

(A Govt. Aided Autonomous Institution affiliated to Anna University)

CHOICE BASED CREDIT SYSTEM

Categorization of Courses

Degree: B.E. **Programme: EEE** **Batch: 2022-23 onwards**

A. FOUNDATION COURSES: Total Credits to be earned: (53-58)

a. Humanities and Social Sciences including Management Courses (HSMC) **(09-12)**

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					
1.	22EG140	Technical English	2	-	-	2	Nil
2.	22EE610	Accounting and Finance	3	-	-	3	Nil
3.	22EE490	Project Management	3	-	-	3	Nil
		THEORY CUM PRACTICAL					
1.	22EG660	Professional Communication	-	1	2	2	Nil
		PRACTICALS					
1.	22EG170	English Laboratory	-	-	2	1	Nil

b. Basic Science Courses (BSC)**(24-27)**

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					
1.	22MA110	Calculus for Engineers	3	1	-	4	Nil
2.	22PH120	Physics	3	-	-	3	Nil

3.	22CH130	Chemistry	3	-	-	3	Nil
4.	22EE210	Matrices and Transforms	3	1	-	4	Nil
5.	22EE310	Numerical methods and Complex variables	3	1	-	4	Nil
6.	22EE410	Probability Distribution and Random process	3	1	-	4	Nil
		PRACTICALS					
1.	22PH180	Physics Laboratory	-	-	2	1	Nil
2.	22CH190	Chemistry Laboratory	-	-	2	1	Nil

c. Engineering Science Courses (ESC)**(21-27)**

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					
1.	22EE150	Engineering Exploration	2	-	-	2	Nil
2.	22EE220	Materials Science for Electrical Engineering	3	-	-	3	Nil
3.	22EE350	Problem Solving Using Computers	3	-	-	-	Nil
4.	22ES390	Design Thinking	3	-	-	3	Nil
5.	22EE460	Data Structures	2	-	2	3	22EE350
5.	22EE550	Object Oriented Programming	3	-	-	3	Nil
		THEORY CUM PRACTICAL					
1.	22ME160	Engineering Graphics	3	-	2	4	Nil
2.							

		PRACTICALS					
1.	22EE270	Electrical Workshop	-	-	2	1	Nil

B. PROFESSIONAL CORE COURSES(PCC) Credits to be earned: (55)

Course Code		Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					
1.	22EE230	Electric Circuit Analysis	3	-	-	3	Nil
2.	22EE240	Electromagnetic Fields	2	1	-	3	22PH120 22MA110
3.	22EE250	Digital Systems	3	-	-	3	Nil
4.	22EE260	Electronic devices and circuits	3	-	-	3	Nil
5.	22EE320	DC Machines and Transformers	2	1	-	3	22EE230
6.	22EE330	Linear Integrated Circuits	3	-	-	3	22EE260 22EE280
7.	22EE340	Signals and Systems	3	-	-	3	Nil
8.	22EE420	AC Machines	2	1	-	3	22EE230 22EE240
9.	22EE430	Measurements and Instrumentation	3	-	-	3	Nil
10.	22EE440	Control Systems	2	1	-	3	22EE230 22EE340 22EE210
11.	22EE510	Generation, Transmission and Distribution	2	1	-	3	22EE230 22EE240
12.	22EE520	Microcontrollers	2	1	-	3	22EE250

13.	22EE450	Power Electronics	3	-	-	3	Nil
14.	22EE530	Electric drives	3	-	-	3	Nil
15.	22EE540	Power System Analysis	3	-	-	3	Nil
		PRACTICALS					
16.	22EE280	Electronic Devices and Circuits Lab	-	-	2	1	Nil
17.	22EE370	DC Machines and Transformers Lab	-	-	2	1	Nil
18.	22EE380	Integrated Circuits Lab	-	-	2	1	22EE260, 22EE280
19.	22EE470	Electrical Problem solving using computers	-	-	2	1	Nil
20.	22EE480	AC Machines Lab	-	-	2	1	22EE320
21.	22EE570	Measurement and Control Lab	-	-	2	1	22EE440
22.	22EE580	Microcontrollers Lab	-	-	2	1	22EE250
23.	22EE670	Power Electronics and Drives Lab	-	-	2	1	22EE320 22EE420 22EE450
24.	22EE680	Electric Power Systems Lab	-	-	2	1	Nil
25.	22EE770	Energy Management System Lab	-	-	2	1	Nil

C. ELECTIVE COURSES: Credits to be earned: (24-39)

a. Programme Specific Electives (PSE) Credits to be earned:15-24

S.No.	Course code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		ELECTRICAL ENERGY SYSTEMS					

	THEORY						
1.	22EEPA0	Power System Operation and Control	3	-	-	3	Nil
2.	22EEPB0	Electrical Machine Design	2	1	-	3	Nil
3.	22EEPC0	Switchgear and Protection	3	-	-	3	Nil
4.	22EEPD0	Wind and Solar Technology	3	-	-	3	Nil
5.	22EEPF0	Operation and Maintenance of Electrical equipment	3	-	-	3	22EE320 22EE420 22EE510
6.	22EEPG0	Energy Audit and Management in Electric Utilities	2	1	-	3	NIL
7.	22EEPH0	Power System Stability	3	-	-	3	22EE230 22EE320 22EE420
		ANALOG AND DIGITAL ELECTRONIC SYSTEMS					
	THEORY						
1.	22EEPJ0	VLSI Design	2	1	-	3	22EE250
2.	22EEPK0	Computer Organization	3	-	-	3	22EE250
	THEORY CUM PRACTICAL						
1.	22EEPL0	Internet of Things	2	-	2	3	22EE520
2.	22EEPM0	FPGA based System Design	2	-	2	3	22EE250
3.	22EEPN0	Digital Signal Processing	2	-	2	3	22EE340
4.	22EEPQ0	Embedded Systems Design	2	-	2	3	22EE520 22EE580
		CONTROL AND AUTOMATION					
	THEORY						
1.	22EEPR0	Control System Design	2	1	-	3	22EE440
2.	22EEPS0	Industrial Instrumentation	3	-	-	3	Nil
	THEORY CUM PRACTICAL						
1.	22EEPT0	Soft Computing	2	-	2	3	Nil
		POWER ELECTRONICS AND DRIVES					

1.	22EEPU0	Flexible AC Transmission Systems	2	1	-	3	2EE450
2.	22EEPV0	Power Quality	3	-	-	3	Nil
3.	22EEPW0	Power Electronics for Renewable Energy Systems	3	-	-	3	22EE450
4.	22EERM0	Electric Vehicles	3	-	-	3	Nil

b. Programme Specific Elective for Expanded Scope (PEES) Credits to be earned: 09-15

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	
			L	T	P		
ELECTRICAL ENERGY SYSTEMS							
	THEORY						
1.	22EEPY0	Design of Electrical Installations	2	1	-	3	Nil
2.	22EEPZ0	Smart Grid	3	-	-	3	Nil
3.	22EERA0	Thermal power plant instrumentation & control	3	-	-	3	Nil
4.	22EERB0	High Voltage Engineering	3	-	-	3	Nil
5.	22EERC0	Energy Storage Systems	2	-	-	2	
		ANALOG AND DIGITAL ELECTRONIC SYSTEMS					
	THEORY						
1.	22EERD0	Bio-medical Instrumentation	3	-	-	3	Nil
2.	22EERG0	ASIC Design	3	-	-	3	22EE250
		THEORY CUM PRACTICAL					
1.	22EERF0	Real Time Operating System	2	-	2	3	22EE520
2.	22EERH0	Machine Learning	2	-	2	3	Nil

		CONTROL AND AUTOMATION					
	THEORY						
1.	22EERJ0	Operation Research	3	-	-	3	Nil
		POWER ELECTRONICS AND DRIVES					
		THEORY					
1.	22EERK0	HVDC Transmission	3	-	-	3	Nil
2.	22EE1A0	Battery Technology	1	-	-	1	Nil
		THEORY CUM PRACTICAL					
1.	22EERL0	Simulation of Power Electronic Systems	2	-	2	3	22EE450

c. General Elective Credits to be earned: 03-06

d. Electives from foundation courses- HSMC, BSC, ESC Credits to be earned: 03-06

D. Project Credits to be earned: 12

S.No	Course code	Course Name	Credits
1.	22EE590	Project -1	3
2.	22EE690	Project -2	3
3.	22EE790	Project -3	3
4.	22EE890	Project- 4	3

E. Mandatory Courses (Not included for CGPA)

Audit Course 1 , Audit Course 2 (as per UGC guideline)

Minimum credits to be earned for the award of the degree =160 (From A to D) for Regular students and 120 (From A to D) for Lateral entry students.

22EE210	MATRICES AND TRANSFORMS

Category	L	T	P	Credit
BSC	3	1	0	4

Preamble

An Electrical engineering student needs to know the concept of Eigen value problem for construction of engineering modelling. Also mathematical tools Laplace Transforms, Fourier Transforms are very much essential to solve ordinary differential equations, partial differential equations, integral equations and related initial and boundary value problems. The course is designed to impart the knowledge and understanding the concepts of Fourier series for approximation of periodic functions and apply them in their area of specialization.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Estimate the Eigen values and Eigen vectors of a square matrix	TPS3	75	70
CO2	Reduce the Quadratic form to Canonical Form using diagonalization.	TPS3	75	70
CO3	Determine Laplace Transform and Inverse Laplace Transform	TPS3	70	65
CO4	Solve initial value problem using Laplace transform.	TPS3	70	65
CO5	Represent the function into infinite Fourier trigonometric series.	TPS3	75	70
CO6	Determine the value of improper integrals and solve integral equation using Fourier Transform.	TPS3	75	70

Mapping with Programme Outcomes

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

CO 1	**S**	**S**		**S**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**S**	**S**	**S**
CO 2	**S**	**S**		**S**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**S**	**S**	**S**
CO 3	**S**	**M**			**-**	**-**	**-**	**-**		**-**	**-**		**S**	**S**
CO 4	**S**	**S**	**S**		**-**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**
CO 5	**S**	**S**	**S**		**M**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**
CO 6	**S**	**S**	**S**		**M**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Scale CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I (%)			CAT – II (%)			Assg. II (%)					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	4	-	13	-	-		-	-	-	-	-	-	-	-	8
CO2	3	10	20	-	-	100	-	-	-	-	-	-	-	5	11
CO3	3	10	25	-	-		-	-	-	-	-	-	-	5	13
CO4	-	-	12	-	-		-	-	-	-	-	-	-	-	8
CO5	-	-	-	-	-	-	5	10	35	-	-	100	-	10	15
CO6	-	-	-	-	-	-	5	10	35	-	-		-	10	15
Total	10	20	70	-	-	100	10	20	70	-	-	100	-	30	70

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

MATRIX EIGEN VALUE PROBLEM: Eigenvalues and Eigenvectors – Properties of Eigen values –Reduction to Diagonal form - Reduction of Quadratic forms to Canonical Form.

LAPLACE TRANSFROMS: Laplace transform -Properties –Transforms of Periodic Functions - Transforms of derivatives and integrals – Evaluations of integrals by Laplace Transform – Inverse Transform - Convolution – Application to Differential Equations

FOURIER SERIES: Fourier series in (0, 2π) –Even and Odd functions – Half-range Sine and Cosine series – Complex Form of Fourier Series - Harmonic Analysis.

FOURIER TRANSFORM: Fourier transform – Properties of Fourier Transforms – Fourier Sine and cosine transforms – Convolution theorem – Parseval's identity – Discrete Fourier Transform.

Text Book

1. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, New Delhi, 2012.

Reference Books& web resources

1. Erwin Kreszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
2. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, 4th Edition, New Delhi, 2011.
3. Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7th Edition, New Delhi, 2012.
4. John Bird, "Higher Engineering Mathematics", Fifth edition, Published by Elsevier Ltd., 2006.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**MATRIX EIGEN VALUE PROBLEM**	

Module No.	Topic	No. of Periods
1.1	Eigenvalues and Eigenvectors	2
1.2	Properties of Eigen values	1
	Tutorial	**1**
1.3	Reduction to Diagonal form	3
	Tutorial	**1**
1.4	Reduction of Quadratic forms to Canonical Form.	3
	Tutorial	**1**
2	**LAPLACE TRANSFROMS**	
2.1	Laplace transform -Properties	1
2.2	Transforms of Periodic Functions	1
2.3	Transforms of derivatives and integrals	2
	Tutorial	**1**
2.4	Evaluations of integrals by Laplace Transform	1
2.5	Inverse Transform	2
	Tutorial	**1**
2.6	Convolution	1
2.7	Application to Differential Equations	2
3	**FOURIER SERIES**	
3.1	Fourier series in (0, 2π)	2
3.2	Even and Odd functions	2
	Tutorial	**1**
3.3	Half-range Sine and Cosine series	2
3.4	Complex Form of Fourier Series	2
	Tutorial	**1**
3.5	Harmonic Analysis	2

Module No.	Topic	No. of Periods
4	**FOURIER TRANSFORM**	
4.1	Fourier transform	2
	Tutorial	**1**
4.2	Properties of Fourier Transforms	2
4.3	Fourier Sine and cosine transforms	1
	Tutorial	**1**
4.4	Convolution theorem	2
4.5	Parseval's identity	1
4.6	Discrete Fourier Transform	1
	Tutorial	**1**
	Total	48

Course Designer(s):

1. Dr. R. Rammohan, Professor ,Mathematics rr_maths@tce.edu
2. Dr. L. Muthusubramanian, Assistant Professor ,Mathematics lmsmat@tce.edu
3. Dr. S. Suriyakala, Assistant Professor ,Mathematics ssamat@tce.edu

22EE220	MATERIALS SCIENCE FOR ELECTRICAL ENGINEERS	Category	L	T	P	Credit
		ESC	3	0	0	3

Preamble

The course work aims in imparting fundamental knowledge of materials science required for electrical engineers. The course work will introduce engineers to different types of conductors, semiconductors and dielectrics. The recent magnetic materials, Solar cell materials, superconductors and smart materials will be discussed

Prerequisite

22PH120-Physics

Course Outcomes

On the successful completion of the course, students will be able to

	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Compute the electrical properties of metals based on classical, quantum and band theory of solids.	TPS3	80%	85%
CO2	Use the basic properties of semiconductor for fabrication of optoelectronic devices	TPS3	80%	85%
CO3	Calculate the various dielectric properties at a given frequency.	TPS 3	80%	85%
CO4	Compute the magnetic properties of different magnetic and magnetostrictive materials	TPS3	80%	85%
CO5	Explain the properties and application of metallic glasses, nano material, smart materials ,superconductors	TPS2	80%	85%
CO6	Explain the importance of solar cell materials Conducting polymers, Two dimensional materials ,Spintronics and QLED	TPS2	80%	85%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1.	**S**	**M**	**L**									**L**			
CO2.	**S**	**M**	**L**									**L**			
CO3.	**S**	**M**	**L**									**L**			
CO4.	**S**	**M**	**L**									**L**			
CO5.	**M**	**L**	**L**									**L**			
CO6.	**M**	**L**	**L**									**L**			

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**8**						50								2		10	
CO2	6	15	20				50								4		10	
CO3	6	15	30								50				4		15	
CO4				**6**		50					50				4		15	
CO5				8	15										2	15		
CO6				6	15										2	15		
	20	30	50	20	30	50									20	30	50	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Conducting Materials

Conduction in metals- Classical free electron theory of metals- Mobility and Conductivity- Thermal Conductivity of metals, polymers and ceramics-Widemaan Franz Law . Quantum free electron theory –Fermi function, Band theory of Solids Blochs theorem-Kronig-Penny model –Application of low and high resistivity materials.

Semiconducting Materials

Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature, Carrier generation and recombination, diffusion and drift current , p-n junction, Metal-semiconductor junction (Ohmic and Schottky), Semiconductor materials of interest for optoelectronic devices-Laser diode and photodiode.

Dielectric materials

Electric polarization-Different types of polarization- -Internal field-Claussius Mosotti Relation-Dielectric Loss-Dielectric Breakdown-Uses of dielectrics (Capacitors and Transformers) - Frequency and temperature dependence of Polarization - Ferroelectric materials piezoelectric materials.

Magnetic materials

Origin of magnetic moment - Wiess theory- Hysteresis- Hard and soft magnetic materials, Ferrites – properties & applications. Neodymium magnets- Magnetostrictive materials-CMR-GMR.

Advanced Engineering materials

Metallic Glasses-Types of metallic glasses- Properties and applications - Superconductors- Types of superconductor-Properties and Applications , Nano materials- Properties and Applications- Smart materials-Properties and Applications –Solar cell materials-Conducting polymer - Two dimensional materials- -Spintronics-QLED

Text Book

1. M.A.Wahab Solid State Physics - Structure and Properties of Materials, 3rd edition,Reprint, Narosa Publishers, 2020

Reference Books& web resources

1.. William D Callister Materials Science and Engineering – An introduction,10th edition, Wiley Publications, 2018

2. William F Smith, Javed Hashemi, Ravi Prakash Materials Science and Engineering 4th edition, Tata McGraw Hill, 2006

3. https://nptel.ac.in/courses/115102025/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.	**Conducting Materials**	
1.1	Conduction in metals - Classical free electron theory of metals - Mobility and Conductivity	2
1.2	Thermal Conductivity of metals, polymers and	1

Module No.	Topic	No. of Periods
	ceramics - Wiedemaan Franz Law	
1.3	Quantum free electron theory – Fermi function	1
1.4	Band theory of Solids - Bloch theorem - Kronig - Penny model	2
1.5	Application of low and high resistivity materials	1
2.	**Semiconducting Materials**	
2.1	Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier concentration and temperature	2
2.2	Carrier generation and recombination.	1
2.3	Diffusion and drift current , p-n junction	2
2.4	Metal-semiconductor junction (Ohmic and Schottky),	2
2.5	Semiconductor materials of interest for optoelectronic devices - Laser diode and photodiode	1
3.	**Dielectric materials**	
3.1	Electric polarisation - Different types of polarisation	2
3.2	Internal field - Claussius Mossotti Relation	1
3.3	Dielectric Loss - Dielectric Breakdown - Uses of dielectrics(Capacitors and Transformers)	2
3.4	Frequency and temperature dependence of Polarization	2
3.5	Ferroelectric materials & Piezoelectric materials	1
4.	**Magnetic materials**	
4.1	Origin of magnetic moment- Wiess theory	2
4.2	Hysteresis - Hard and soft magnetic materials- Ferrites – properties & applications	2
4.3	Neodymium magnets , Magnetostrictive materials-	2

Module No.	Topic	No. of Periods
	CMR-GMR.	
5.	**Advanced Engineering materials**	
5.1	Metallic Glasses – Types of metallic glasses – Properties and applications	1
5.2	Superconductors – Types of superconductor- Properties and Applications	1
5.3	Nano materials – Properties and Applications	1
5.4	Smart materials – Properties and Applications	1
5.5	Solar cell materials, Conducting polymers	2
5.6	Two dimensional materials - Spintronics-QLED	1
	Total number of hours	36

Course Designer(s):

1. Prof.V.Veeraganesh ,Assistant Professor, Physics vvgphy@tce.edu
2. Dr .A.L.Subramaniyan , Assistant Professor, Physics alsphy@tce.edu
3. Dr .M.Mahendran ,Professor, Physics mmphy@tce.edu

22EE230	**ELECTRIC CIRCUIT ANALYSIS**	Category	L	T	P	Credit
		PCC	3	0	0	3

Preamble

Electric circuit theory is the fundamental theory upon which all branches of electrical engineering are built. Many areas of electrical engineering, such as power, electric machines, control, electronics, communications, and instrumentation, are based on electric circuit theory. Therefore, the basic electric circuit theory course is the most important course for an electrical engineering student, and always an excellent starting point for a beginner in electrical engineering education. Circuit theory is also valuable to students specializing in other branches of the engineering because circuits are a good model for the study of energy systems in general, and because of the applied mathematics, physics, and topology involved.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamental components of Electric circuits	TPS1	80	75
CO2	Apply mesh analysis, nodal analysis and network theorems to interpret the behaviour of the given electrical circuit	TPS3	80	75
CO3	Demonstrate the resonance in series and parallel circuits.	TPS3	80	75
CO4	Find the transient response of the given RL,RC and RLC circuit	TPS3	80	75
CO5	Calculate Z, Y ,h, and t parameters of the given two-port network.	TPS3	80	75
CO6	Calculate three-phase quantities of the given three phase circuit and mutual inductance of a coupled circuit	TPS3	80	75

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4

CO1	10														5			
CO2		20	40				50									10	20	
CO3		10	20				50									10	20	
CO4					10	30					50					10	10	
CO5					10	20					50						10	
CO6					10	20									5			

Syllabus

Electric Circuits: Circuit laws, Sources, Resistance, inductance, capacitance Reactance, Impedance, Types of connections, Equivalent circuit, Phasors, Phasor diagram

Sinusoidal steady state analysis: Mesh and Nodal analysis, Thevenin's Theorem, Norton's Theorem, Superposition theorem, Source transformation theorem and maximum power transfer theorem and frequency response of the circuit – resonance.

Transient Analysis: Source free, Step and sinusoidal response for RL, RC & RLC circuits.

Two-port Networks: Impedance, admittance, Hybrid and Transmission parameter, Inter relation and interconnection of networks, Duality.

Three Phase Circuits: Balanced, unbalanced star – delta connections. Power measurement.

Coupled Circuits: Mutual Inductance, Dot rules, Energy in coupled circuits.

Reference Books and Web Resources

1. W.H. Hayt & J.K. Kemmerly and Steven M. Durbin, "Engineering circuit analysis", Tata McGraw Hill, 7th edition, New Delhi, 2007
2. Charles K. Alexander, Matthew N.O. Sadiku, "Fundamentals of Electric Circuits", Tata McGraw Hill, 5th edition, 2013
3. Mahmood Nahvi, Joseph A Edminister, "Electric Circuits", Tata McGraw - Hill Education, 5th Edition, 2010.
4. Sudhakar A and Shyam Mohan SP, "Electric Circuit Analysis", Tata McGraw Hill, New Delhi, 2008
5. NPTEL E-Learning Courses: Basic Electrical Circuits https://onlinecourses.nptel.ac.in/noc17_ee13
6. https://www.electrical4u.com

Course Contents and Lecture Schedule

Module	Topic	No. of	Course

No.		Hours	Outcome
1.0	**Electric Circuits**		
1.1	Circuit laws, Sources, Resistance, inductance, capacitance Reactance, Impedance	3	CO1
1.2	Types of connections, Equivalent circuit, Phasors, Phasor diagram, Power Triangle	3	CO1
2.0	Steady state analysis		
2.1	Mesh and Nodal analysis,.	2	CO2
2.2	Thevenin's Theorem, Norton's Theorem, Superposition theorem	2	CO2
2.2	Source transformation theorem and maximum power transfer theorem and frequency response of the circuit – resonance	2	CO2
2.3	Resonance	2	
4.0	**Transient Analysis**		
4.1	Source free response for RL, RC & RLC circuits.	2	CO4
4.2	Step response for RL, RC & RLC circuits.	2	CO4
4.3	Sinusoidal response for RL, RC & RLC circuits.	3	CO4
5.0	**Two-port Networks**		
5.1	Impedance and admittance parameters	3	CO5
5.1	Hybrid and Transmission parameters	2	CO5
5.2	Inter relation and interconnection of networks	2	CO5
5.3	Duality	2	CO5
6.0	**Three Phase Circuits**		
6.1	Balanced, unbalanced star – delta connections.	2	CO6
6.2	Power measurement	2	CO6
6.3	Mutual Inductance, Dot rule in coupled circuit	2	CO6
	TOTAL	36	

Course Designers:

1. Dr.C.K. Babulal   Professor,EEE   ckbeee@tce.edu
2. Dr.R. Rajan Prakash   Associate Professor,EEE   r_rajanprakash@tce.edu

22EE240	ELECTROMAGNETIC FIELDS	Category	L	T	P	Credit
		PCC	2	1	0	3

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 resistance, capacitance, and Inductance. Students will get an idea about behavior of field in materials (magnetic, conducting, insulating materials) at the interface of two different materials and their applications to Electrical Engineering. Force, torque, generator and transformer working principles are explained with Electromagnetic Fields.

Prerequisite

22PH120 : Physics
22MA110 : Calculus for Engineers

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the coordinate systems and vector calculus applicable to electric and magnetic fields.	TPS2	70	70
CO2	Compare the behavior of Electric and Magnetic field in free space and in material space using basic laws.	TPS2	70	70
CO3	Relate Voltage, Current and basic circuit laws using Electric fields	TPS3	70	70
CO4	Demonstrate Resistance, Inductance and capacitance with materials of different resistivity/Permeability /Permittivity and of different dimensions with the help of electric fields.	TPS3	70	70
CO5	Explain the force on a current carrying conductor and torque on a current loop subjected to magnetic fields	TPS2	70	70
CO6	Relate dynamic electric and magnetic fields with help of Faraday's Law and Maxwell's Equation, and, their applications to electrical machines	TPS3	70	70

*** Weightage depends on Bloom's Level, number of contact hours,

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	30													5			
CO2	10	30														10	20	
CO3			20				50									10	20	
CO4				10	20	20	50				50					10	10	
CO5				10	20						50						10	
CO6					10	10									5			

Syllabus

Mathematical Foundation

Scalar, Vector, Vector addition, Subtraction and Multiplication, Coordinate Systems, Differential elements, Del operator, Gradient, Divergence and Curl of a vector, Divergence and Stoke's Theorem.

Electrostatic Fields

Coulomb's Law, Charge density, Electric field intensity, Electric flux density, Gauss law, Potential, Potential Difference, Basic circuit laws - verifications.

Material Characteristics - Current, Current Density, Conductivity/ Resistance of materials. Continuity equation and time constant. Permittivity / Dielectric Strength of materials and application to capacitance & electrical insulation. Multiple Dielectrics and field behavior at the interfaces. Calculation of capacitance for various applications and energy storage. Capacitance of Transmission lines and cables. Simulation of Electric Fields using FEM packages.

Magneto static Fields

Biot – Savart's Law and Ampere's Law, Magnetic flux density and Magnetic field Intensity, Field behaviour at interface of magnetic materials, Inductance, application to Energy Storage and Magnetic Circuits. Inductance of Transmission lines and cables. Simulation of Magnetic Fields using FEM packages.

Force and Torque

Force on a current carrying conductor subjected to a magnetic field, Torque on a current loop subjected to a magnetic field and working principle of motor.

Dynamic Fields

Faraday's Law of Electromagnetic Induction, Principle of operation of generator and transformer, Displacement current , Maxwell's equations, Poynting Theorem.

ASSIGNMENTS

1. Simulation of Electrical and Magnetic Fields using FEM packages.
2. Demonstration of Electric and Magnetic fields using simple experiments
3. Seminar on practical applications of electric and magnetic fields like working of copier machine, MRI Scan .

Reference Books

1. William Hayt Jr. and John A. Buck , "Engineering Electromagnetics", TMH publishing co. ltd., 7th Edition, 2006.
2. John D. Kraus, "Electromagnetics", Mcgraw – Hill International Editions, 4th Edition, 1992.
3. Mathew N.O. Sadiku, "Principles of Electromagnetic Fields", 4th Edition, Oxford University Press, 2010.
4. K.A. Gangadhar and P.M. Ramanathan, "Electromagnetic Field Theory (Including Antennas and Wave Propagation)" Khanna Publishers– 2012

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lecture Hours	Course Outcome
1.0	**Vector Calculus**		
1.1	Scalar, Vector, Vector addition, Subtraction and Multiplication	2	CO1
1.2	Coordinate Systems, Differential elements	2	CO1
1.3	Del operator, Gradient, Divergence and Curl of a vector, Divergence and Stoke's Theorem.	3	CO1
2.0	**Electrostatic Field**		
2.1	Coulomb's Law, Charge density, Electric field intensity,	2	CO2
2.2	Electric flux density, Gauss law and its applications	2	CO2
2.3	Potential, Potential Difference, Basic circuit laws - verifications	2	CO3
2.4	Material Characteristics - Current, Current Density, Conductivity of materials	3	CO3
2.5	Permittivity, Dielectric Strength of materials and application to capacitance & insulation	3	CO4
2.6	Multiple Dielectrics and field behavior at the interfaces.	1	CO4
2.7	Calculation of capacitance for various application and energy storage. Simulation of electric fields	3	CO4
2.8	Calculation of capacitance of transmission lines and cables.	1	CO4
3.0	**Magneto static Fields**		
3.1	Biot – Savart's Law and Ampere's Law, Magnetic flux density and Magnetic field Intensity, Field behaviour at the interface of magnetic materials	3	CO2
3.2	Inductance, application to Energy Storage and Magnetic Circuits	2	CO4
3.3	Inductance of a Transmission line and Cable	1	CO4
3.4	Simulation of magnetic fields	1	CO6
4.0	**Force and Torque**		
4.1	Force on a Current carrying conductor subjected to magnetic field.	1	CO5
4.2	Torque on a current carrying loop subjected to magnetic field, working principle of a motor	1	CO5
5.0	**Dynamic Fields**		
5.1	Faraday's Law, Principle of operation of generator and transformer.	1	CO6
5.2	Displacement current and Maxwell's equations	1	CO6
5.3	Poynting Theorem	1	CO6
	Total	**36**	

Course Designers:

1. Prof. S. Sivakumar, Associate Professor, EEE siva@tce.edu
2. Dr.R. Rajan Prakash, Associate Professor, EEE r_rajanprakash@tce.edu

22EE250	DIGITAL SYSTEMS

Category	L	T	P	Credit
PCC	3	0	0	3

Preamble

Digital systems encompass the circuits, that process signals by discrete bands of analog levels, rather than by continuous ranges (as used in analog electronics). All levels within a band represent the same signal state. Digital systems are designed to store, process, and communicate information in digital form. They are found in a wide range of applications, including process control, communication systems, digital instruments, and consumer products

Prerequisite

- **NIL**

Course Outcomes

On the successful completion of the course, students will be able to :

CO Number	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain different number systems, codes, code converters and digital logic families	TPS2	80	80
CO2	Design combinational circuit for the given applications using logic gates and standard combinational circuits (multiplexers and de multiplexers ,adders, subtractors, Encoders and Decoders)	TPS3	80	80
CO3	Design synchronous sequential circuits for the given requirement including counters and sequence detectors	TPS3	80	80
CO4	Explain the characteristics and working of asynchronous sequential logic circuits	TPS2	80	80
CO5	Implement combinational and sequential circuits using verilog simulation tool	TPS3	80	80
CO6	Implement the given digital application using Programmable Logic Devices and illustrate the function of memories.	TPS3	80	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1.	M	L						M		M				M
CO2.	S	M	L					M		M				S
CO3	S	M	L					M		M				S
CO4	M	L						M		M				M
CO5.	S	M	L					M		M				S
CO6	S	M	L					M		M				S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	10													4	5		
CO2	5	20	40				100								4	5	15	
CO3	5		10	5	5	20					60				4	5	15	
CO4				**5**	15										4	5		
CO5				5	5	15					20				2	5	10	
CO6				5	5	15					20				2	5	10	

Syllabus

Review of Number systems & Boolean Algebra: Decimal, binary, signed binary, octal, hexadecimal number - Binary arithmetic, one's and two's complements arithmetic - Base conversions - C**odes:** BCD, Excess-3, Gray, ASCII codes, Code conversions, Boolean Algebra and laws- Simplification of Boolean expressions – Canonical and Standard forms.

Logic gates & Logic Families: Logic gates and their truth table**-** Characteristics of digital ICs- Digital Logic Families - Comparison of TTL, ECL and MOS families - Operation of CMOS logic gates- Examples of IC gates.

Combinational logic circuits: Introduction to sum of products (SOP) & product of sums (POS) forms- Logic Minimization using K-map and their realization using logic gates - Quine-McCluskey method of function realization- Don't care conditions- Multiplexer, De-Multiplexer, Decoders- Realization of Boolean functions using multiplexers- Adders, Subtractors, Basic ALU design - Magnitude comparator, parity checker/generator, code converters, priority encoder.

Sequential Logic circuits: Moore and Melay Machines, Latches and Flip-Flops(SR,JK,T,D), State Diagrams, Timing Diagrams and state Tables, Sequential Circuit Design, Shift Registers, Synchronous counters (up, down, up-down, Ring), Examples of Counter ICs –IC 7493, IC 74161.

Asynchronous Sequential Logic circuits: Characteristics- Racing and Glitches**,** Asynchronous Counters (up, down, Mod-N).

Introduction to Verilog simulation tool: Verilog code for basic combinational and sequential circuits.

Memory & Programmable logic devices: RAM (static and dynamic), ROM (EEPROM, FLASH), Programmable Logic Array (PLA), Programmable Array Logic (PAL), Introduction to CPLD and FPGA

Reference Books and Web Resources

1. M.Morris Mano and Michael D.Ciletti, Digital Design, Sixth Edition, Pearson Prentice Hall, 2019
2. RP Jain, Modern Digital Electronics,fourth edition, Tata Mcgraw Hill Publishers,2010
3. Floyd and Jain, Digital Fundamentals, 8th Edition, Pearson Education, 2009
4. Charles H.Roth and Lizy K.John, Digital system design using VHDL, 3rd edition, Cengage learning, 2017
5. Donald Leach, Albert Malvino and Goutam Saha, Digital Principles and Applications, 8th edition ,McGraw Hill Publishers,2015
6. J. F. Wakerly Digital Design Principles and Practices, 5th edition, Prentice Hall of India, 2021.
7. NPTEL course: https://onlinecourses.nptel.ac.in/noc18_ee33

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1	**Review of Number systems & Boolean Algebra:**	
1.1	Decimal, binary, signed binary, octal, hexadecimal number	1
1.2	binary arithmetic, one's and two's complements arithmetic - base conversions ,C**odes:** BCD, Excess-3, Gray, ASCII codes	2
1.3	Boolean Algebra and laws, Simplific ation of Boolean expressions	1
1.4	Canonical and Standard forms	2
2	**Logic gates & Logic Families:**	
2.1	Logic gates and their truth table**.** Characteristics of digital ICs, digital logic families, Comparison of TTL, ECL and MOS families	2
2.2	Operation of CMOS logic gates- Examples of IC gates.	1
3	**Combinational logic circuits:**	
3.1	Introduction to sum of products (SOP) & product of sums (POS) form- Logic Minimization using K-map and their realization using logic gates	2

3.2	**Quine-McCluskey** method of function realization. Don't care conditions, Multiplexer, De-Multiplexer,	3
3.3	Decoders, Realization of Boolean functions using multiplexers. Adders, Subtractors,	2
3.3	Magnitude comparator, parity checker/generator, code converters, priority encoder	2
4	**Sequential Logic circuits:**	
4.1	Moore and Melay Machines, Latches and Flip-Flops(SR,JK,T,D),	2
4.2	State Diagrams, Timing Diagrams and state Tables,	2
4.3	Sequential Circuit Design, Shift Registers, Synchronous counters (up, down, up-down, Ring).	3
4.4	Examples of Counter ICs –IC 7493, IC 74161.	1
5	**Asynchronous Sequential Logic circuits:**	
5.1	**C**haracteristics- Racing and Glitches	1
5.2	Asynchronous Counters (up, down, Mod-N)	2
6	**Introduction to Verilog simulation tool:**	
6.1	Verilog code for basic combinational and sequential circuits	2
7	**Memory & Programmable logic devices:**	
7.1	RAM (static and dynamic), ROM (EEPROM, FLASH)	2
7.2	Programmable Logic Array (PLA), Programmable Array Logic(PAL)	2
7.3	Introduction to CPLD and FPGA	1
	Total	**36**

Course Designers:

1. Dr.D.Kavitha, Assistant Professor, EEE dkavitha@tce.edu
2. Dr.B.Ashok Kumar, Assistant Professor, EEE ashokudt@tce.edu

22EE260 ELECTRONIC DEVICES AND CIRCUITS

Category	L	T	P	Credit
PCC	3	0	0	3

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 from the signal. This signal conditioning/processing is usually most conveniently performed by electronic systems. The signal conversion/conditioning/processing is done by using different semiconductor/signal conditioning devices like diodes, transistors and voltage regulator ICs, etc. These could involve rectification, filtering, regulation, amplification, modulation, demodulation, mixing, frequency synthesizing etc.

Course Outcomes

On the successful completion of the course, students will be able to

CO No.	COURSE OUTCOMES	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the characteristics and applications of diode, special diodes, BJTs and MOSFETs	TPS2	80	85
CO2	Design rectifier, clipper and clamper circuits for the given specifications	TPS3	80	85
CO3	Design BJT and MOSFET based amplifier for the given specifications	TPS3	80	85
CO4	Explain the operation of Class A,B,C and D power amplifiers	TPS2	80	85
CO5	Design feedback amplifiers and oscillators for the given specifications	TPS3	80	85
CO6	Explain the operation of Opto-electronic devices	TPS2	80	85

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L						M		M				M	
CO2	S	M	L	L				M		M				S	
CO3	S	M	L	L				M		M				S	
CO4	M	L						M		M				M	
CO5	S	M	L	L				M		M				S	
CO6	M	L						M		M				S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT1						CAT2						Assignment 1				Assignment 2				Terminal					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	10	10											20								5	10				
CO2	10	10	30										40										25			
CO3		10	20										40										20			
CO4							10	10									20				5	5				
CO5							5	15	40								60				5		15			
CO6							5	15									20				5	5				

Syllabus

Diode: Semiconductor – Types, Drift and Diffusion currents, Diode-Operation, V-I Characteristics, Current equation, Parameters and equivalent circuit, Load line analysis, Transition and Diffusion capacitance, Reverse recovery Characteristics, Application of Diodes – Wave shaping circuits: Rectifiers, Clippers and Clampers.

Special Diodes: Zener diode, Varactor diode, Schottky Diode and their application - Selection of diode using data sheets for the given application.

BJTs and UJT: Operation of NPN and PNP transistor, Characteristics of BJT in CB, CE and CC configurations, DC and AC load line, Fixed, Emitter feedback and Voltage divider bias, Stability factor, Application of BJT as amplifier, BJT as switch, Switching characteristics of BJT, Low frequency and high frequency hybrid model, AC analysis of BJT CE amplifier - Selection of BJT using data sheets for the given application - Working principle, operation and applications of UJT.

MOSFETs: Introduction to JFET, Construction, Operation, Characteristics and Parameters of MOSFET, MOSFET as a voltage controlled resistor, Voltage divider bias in MOSFET CS amplifier, Small signal model of MOSFET- AC analysis of MOSFET CS amplifier, Selection of MOSFET using data sheets for the given application-Introduction to FinFET.

Power Amplifiers: Construction and operation of Class A, B, C and D amplifiers.

Feedback amplifiers & Oscillators: Positive and negative feedback- Feedback amplifiers- Gain and frequency response - Oscillators – Colpitts, Hartley and Crystal oscillator

Opto-electronic Devices: Photo diode, Photo transistor, LED, LCD, Laser diode, Opto-couplers, IR Emitter and Detector.

Text Book

1. Robert Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory", 11th Edition, Pearson Education, 2013.

Reference Books & web resources

1. Floyd T.L," Electronic Devices", 10th Edition, Pearson Education, 2017.
2. David A. Bell, "Electronic Devices and Circuits", 5th Edition, Prentice Hall India, 2010.
3. Albert Malvino and David J.Bates, "Electronic Principles", 7th Edition, Tata Mc-Graw Hill, 2017.
4. Jacob Millman, Halkias C.C and Satyabrata Jit, "Electronic Devices and Circuits", 4th Edition, Tata Mc-Graw Hill, 2012.
5. Sedra A.S. and Smith K.C, "Microelectronic Circuits", 7th Edition, Oxford press, 2014.
6. Donald A.Neamen, "Electronic circuit analysis and design", Second edition, Tata Mc-Graw Hill, 2003.
7. VK.Mehta and Rohit Mehta, "Principles of Electronics", S.Chand and Company, 11th Edition, 2008.

Course Contents and Lecture Schedule

S.No.	Topics	No. of Lectures	CO
1.	**Diode**		
1.1	Semiconductor–Types, Drift and Diffusion currents	1	CO1
1.2	Operation, V-I Characteristics, Current equation, Parameters and equivalent circuit	1	CO1
1.2	Load line analysis, Transition and Diffusion capacitance, Reverse recovery Characteristics	1	CO1
1.3	Application of Diodes – Rectifiers	2	CO2
1.4	Clippers and Clampers	2	CO2
2.	**Special Diodes**		
2.1	Zener diode, Varactor diode, Schottky Diode and their application	1	CO1
2.2	Selection of diode using data sheets for the given application.	1	CO2
3.	**BJTs**		
3.1	Operation of NPN and PNP transistor, Characteristics of BJT in CB, CE and CC configurations	1	CO1
3.2	DC & AC load line, Fixed and Emitter feedback bias	2	CO3
3.3	Voltage divider bias, Stability factor	1	CO3
3.4	Application of BJT as amplifier and switch	1	CO2
3.5	Switching characteristics of BJT	1	CO1

3.6	Low frequency and high frequency hybrid model, AC analysis of BJT CE amplifier – Selection of BJT using data sheets for the given application	1	CO3
3.7	Characteristics and applications of UJT	2	CO1
4.	**MOSFETs**		
4.1	Introduction to JFET, Construction, Operation, Characteristics and Parameters of MOSFET	2	CO1
4.2	MOSFET as a voltage controlled resistor, Voltage divider bias in MOSFET CS amplifier	2	CO3
4.3	Small signal model of MOSFET- AC analysis of MOSFET CS amplifier	2	CO3
4.4	Selection of MOSFET using data sheets for the given application	1	CO1
4.5	Introduction to FinFET	1	CO1
5.	**Power Amplifiers**		
5.1	Construction and operation of Class A, B, C and D amplifiers	2	CO4
6.	**Feedback amplifiers & Oscillators**		
6.1	Positive and negative feedback	1	CO5
6.2	Feedback amplifiers- Gain and frequency response	1	CO5
6.3	Oscillators – Colpitts, Hartley and Crystal oscillator	1	CO5
6.4	Design of Oscillators	2	CO5
7.	**Opto-electronic Devices**		
7.1	LED, LCD	1	CO6
7.2	Laser diode, Photo-diode Photo-transistor	1	CO6
7.3	Opto-couplers, IR Emitter and Detector	1	CO6
	Total	36	

Course Designers

1. Dr. M.Saravanan, Professor, EEE mseee@tce.edu
2. Dr. V.Suresh Kumar, Professor, EEE vskeee@tce.edu

22EE270	**ELECTRICAL WORKSHOP**	Category L T P Credit	
		ESC 0 0 2 1	

Preamble

The course is designed to provide students a widespread knowledge and understanding of the basic Electrical Systems Components and Laws. The indispensable and pervasive knowledge of electrical wiring and the electronic circuits will give the students an insight to their practical approach in our daily life.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Analyze the resistance, inductance and capacitance of various dimensions/shapes of materials experimentally	TPS2	25	30
CO2	Analyze Electric field lines and equi-potential lines of different electrode configurations experimentally.	TPS2	25	30
CO3	Practice assembling, soldering and testing of the given simple electronic circuit using PCB	TPS3	25	30
CO4	Verify Electrical circuit laws, and theorems for the electric circuit using hardware and simulation software	TPS3	25	30
CO5	Verify series resonance phenomena in a RLC circuit experimentally	TPS4	40	50
CO6	Analyze the transient behavior of the given RL, RC, RLC circuits experimentally	TPS2	25	30

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	M	M	S			M	M	M				S	S
CO2	S	S	M	M	S			M	M	M				S	S
CO3	S	S	M	M	S			M	M	M				S	S
CO4	S	S	M	M	S			M	M	M				S	S
CO5	S	S	M	M	S			M	M	M				S	S
CO6	S	S	M	M	S			M	M	M				S	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	30	30
Analyse	40	40
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Mini project /Practical Component/Observation
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

Experiment	CO
Familiarization of magnetic and electric field lines. Familiarization of basic protective devices (fuse, MCB, ELCB) Familiarization of ammeter, voltmeter, wattmeter, rheostat , power supply	C01 to CO6
Design, Develop and Analyze the resistance of various dimensions with different resistivity, inductance of various core dimensions and winding configurations and capacitance of various shapes and materials experimentally	CO1
Plot and analyze Electric field lines and equipotential lines of different electrode configurations experimentally.	CO2
Assembling, Soldering and Testing of Simple electronic Circuit using PCB	CO3
Verification of Electrical laws and Superposition, Thevenin and Maximum power transfer theorems for the electric circuit using simulation software	CO4
Verification of Electrical laws and Superposition, Thevenin and Maximum power transfer theorems for the electric circuit using hardware	CO4
Verification of series resonance phenomena in a RLC circuit	CO5
Analyze the transient behaviour of the given RL ,RC,RLC circuits	CO6

Reference Book

1. Electrical Workshop Manual prepared by TCE Staff Members

Course Designers:

1. Dr.P.S.Manoharan,Professor,EEE psmeee@tce.edu
2. Dr.V.Saravanan, Professor,EEE vseee@tce.edu

22EE280 **ELECTRONIC DEVICES AND CIRCUITS LAB**

Category	L	T	P	Credit
PCC	0	0	2	1

Preamble

This laboratory gives a practical exposure to the students to learn the characteristics of various electronic devices such as diodes, BJT, and MOSFET that are used nowadays in most of the electronic circuits. The students also learn the design and the construction of different electronic circuits based on the above electronic devices. To validate the experimental results, the use of simulation tools for the performance analysis of the circuits is also introduced to the students

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome	Weightage in %
CO1	Determine the equivalent circuit parameters of the given Diode, BJT, and MOSFET	30
CO2	Design voltage regulator using Zener diode for the given specifications	10
CO3	Analyze the performance of the diode rectifier circuit designed for the given specifications	10
CO4	Analyze the performance of the wave shaping circuits (Clippers and Clampers) designed for the given specifications	20
CO5	Analyze the performance of the amplifier and oscillator designed for the given specifications	20
CO6	Analyze the performance of the analog device characteristics and analog circuits using simulation tools	10

*** Weightage depends on Bloom’s Level, number of contact hours

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	S			M	M	M				S	
CO2	S	M	L	L	S			M	M	M				S	
CO3	S	S	S	M	S			M	M	M				S	
CO4	S	S	S	M	S			M	M	M				S	

CO5	S	S	S	M	S			M	M	M				S	
CO6	S	S	S	M	S			M	M	M				S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	40	40
Analyse	30	30
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Mini project /Practical Component/Observation
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

No.	Name of the experiment	CO	No. of Sessions
1.	Characteristics of PN junction diode, Zener diode	CO1	1
2.	Characteristics of BJT and MOSFET	CO1	2
3.	Design of voltage regulator using zener diode	CO2	1
4.	Design of Full wave rectifier with and without filter	CO3	1
5.	Design of wave shaping circuits (clippers and clampers)	CO4	1
6.	Design of BJT-CE amplifier and LC Oscillator	CO5	2
7.	Characteristics of Opto-couplers	CO6	1
8.	Analyze the characteristics of analog devices and analog circuits using PSPICE/PSIM/Simulink/NI-MY DAQ	CO6	2

Reference Books & web resources

1. Robert Boylestad and Lowis Nashelsky, "Electronic Devices and Circuit Theory", 11th Edition, Pearson Education, 2013.
2. David A. Bell, "Electronic Devices and Circuits", 5th Edition, Prentice Hall India, 2010.
3. https://powersimtech.com/.
4. PSpice Technologies for Academic | PSpice.
5. Simulink - Simulation and Model-Based Design - MATLAB & Simulink.
6. https://www.ni.com/.

Course Designers

1. Dr. M.Saravanan Professor,EEE mseee@tce.edu
2. Dr. V.Suresh Kumar, Professor EEE vskeee@tce.edu

22EE310	Numerical Methods and Complex Variables

Category	L	T	P	Credit
BSC	3	1	0	4

Preamble

An Electrical engineering student needs to know sufficient numerical tools and techniques for solving engineering problems arises in their field. This course aims at developing the ability to formulate an engineering problem in a mathematical form appropriate for subsequent computational treatment and to choose an appropriate numerical approach. Analytic functions and Contour integration are extremely important while creating engineering models in control systems, communication systems, searching algorithms. The course is designed to impart the knowledge and understanding of the above concepts to Electrical Engineers and apply them in their areas of specialization.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Solve single non-linear algebraic, transcendental equation numerically.	TPS3	80	75
CO2	Solve system of linear equations numerically	TPS3	80	75
CO3	Solve the initial value problems in ODE numerically using single step and multi-step methods.	TPS3	80	75
CO4	Solve the boundary value problems in PDE using finite difference methods.	TPS3	80	75
CO5	Construct complex potential function and observe the behaviour using conformal mapping.	TPS3	75	70
CO6	Determine the value of integrals of functions of complex variable .	TPS3	75	70

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2

CO1	**S**	**S**	**M**	**M**	**-**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**
CO2	**S**	**S**	**M**	**M**	**-**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**
CO3	**S**	**S**	**M**	**M**	**-**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**
CO4	**S**	**M**	**M**	**-**	**-**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**
CO5	**S**	**M**	**M**	**-**	**-**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**
CO6	**S**	**M**	**M**	**-**	**-**	**-**	**-**	**-**	**M**	**-**	**-**	**M**	**S**	**S**

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Scale CO	**Assessment - I**						**Assessment - II**						**Terminal Exam (%)**		
	CAT – I (%)			**Assg. I** (%)			**CAT – II** (%)			**Assg. II** (%)					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	3	-	18	-	-	100	-	-	-	-	-	-	-	3	7
CO2	-	-	22	-	-		-	-	-	-	-	-	-	3	7
CO3	3	10	20	-	-		-	-	-	-	-	-	-	6	11
CO4	4	10	10	-	-		-	-	-	-	-	-	-	3	10
CO5	-	-	-	-	-	-	7	10	33	-	-	100	-	9	16
CO6	-	-	-	-	-	-	3	10	37	-	-		-	6	19
Total	10	20	70	-	-	100	10	20	70	-	-	100	-	30	70

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Solution to a Single Non-linear Equation and a System of Linear Equations: Introduction to Numerical Solution – The Bisection Method - Fixed point iteration method – Newton Raphson method – Crout's Decomposition Method - Gauss Jacobi Method – Gauss Seidel methods

Numerical Solution of ODEs: Euler's method – Modified Euler's method – Taylor's Method-Runge-Kutta methods of order 4 – Predictor corrector methods – Adam's predictor corrector formula – Milne's Predictor corrector formula. **Numerical Solution of PDEs:** Classification of Second order equation - Solution to Elliptic, Parabolic and Hyperbolic PDEs

Complex Differentiation: Functions of complex variable – Analytic functions – C-R equations – Conjugate harmonics – Standard Transformations – Conformal Transformations – z^2, 1/z, az+b – Bilinear Transformations

Complex Integration: Cauchy's Theorem - Cauchy's integral formula – Taylor's Series - Laurent's series – Zeros of Analytic function – Singularities - Residues –– Cauchy's residue theorem – Contour Integration.

Text Books

1. Steven C. Chapra, Raymond P. Canale, "Numerical Methods for Engineers", 7th Edition, McGrawHill Higher Education,2016.
2. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, New Delhi, 2012.

Reference Books & web resources

1. Richard L Burden and Douglas J Faires, "Numerical Analysis", Thomas Learning, New York, 2017.
2. Ward Cheney and David Kincaid, "Numerical Mathematics and Computing", Cengage Learning, USA, 2018.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley, 10th Edition, 2017
4. Mathews J. H. and Howell R. W, "Complex Analysis for Mathematics and Engineering", Narosa Publishing House, New Delhi, 2012

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Solution to a Single Non-linear Equation and a System of Linear Equations**	
1.1	Introduction to Numerical Solution	1
1.2	The Bisection Method	1
1.3	Fixed point iteration method	1
	Tutorial	**1**
1.4	Newton Raphson method	1
1.5	Crout's Decomposition Method	2

Module No.	Topic	No. of Periods
	Tutorial	**1**
1.6	Gauss Jacobi Method	1
1.7	Gauss Seidel methods	1
2	**Numerical Solution of ODEs and PDEs**	
2.1	**Numerical Solution of ODEs** : Euler's method and Modified Euler's method	1
	Tutorial	**1**
2.2	Taylor's Method	1
2.3	Runge-Kutta methods of order 4	2
	Tutorial	**1**
2.4	Predictor corrector methods	1
2.5	Adam's and Milne's predictor corrector formula	1
2.6	**Numerical Solution of PDEs:** Classification of Second order equation	1
	Tutorial	**1**
2.7	Solution to Elliptic PDEs	2
2.8	Solution to Parabolic PDEs	1
	Tutorial	**1**
3	**Complex Differentiation**	
3.1	**Complex Differentiation** Functions of complex variable	1
3.2	Analytic functions – C-R equations	2
	Tutorial	**1**
3.3	Conjugate harmonics	1
3.4	Standard Transformations	1
	Tutorial	**1**
3.5	Conformal Transformations – z^2, 1/z, az+b	2
3.6	Bilinear Transformations	2
	Tutorial	**1**

Module No.	Topic	No. of Periods
4	**Complex Integration**	
4.1	**Complex Integration:** Cauchy's Theorem and Cauchy's integral formula	2
4.2	Taylor's Series - Laurent's series	2
	Tutorial	**1**
4.3	Zeros of Analytic function and Singularities - Residues	1
4.4	Cauchy's residue theorem	2
	Tutorial	**1**
4.5	Contour Integration	3
	Total	48

Course Designer(s):

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3. Dr. S. Suriyakala, Assistant Professor, Mathematics ssamat@tce.edu

22EE320	DC MACHINES AND TRANSFORMERS	Category	L	T	P	Credit
		PCC	2	1	0	3

Preamble

The course aims in imparting fundamental knowledge of construction, types, Operation of Transformers and Direct current (DC) machines. DC machine is a highly versatile energy converting device. They can be designed to give a wide variety of voltage-current or speed- torque characteristics for both dynamic and steady-state operation. Due to their flexibility in speed control, DC motors are widely used in applications requiring a wide range of motor speeds or precise control of motor output. A transformer is a device used to transfer electrical energy from one circuit to another. It changes electricity from one level to other level of voltage using the properties of electricity.

Prerequisite

22EE230 : Electric Circuit Analysis

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome (CO)	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the construction, principle of operation and various types of DC machines.	TPS2	80%	70%
CO2	Determine the characteristics and performance of DC machines at loaded conditions.	TPS3	70%	60%
CO3	Choose the starting methods, speed control, and testing methods DC Motors.	TPS3	80%	70%
CO4	Explain the basic principles and construction of single phase, three phase transformer and application specific transformers	TPS2	80%	70%
CO5	Illustrate the operation of transformer at no load and loaded conditions	TPS3	80%	70%
CO6	Determine the performance of the given single transformer using equivalent circuit diagram and testing methods	TPS3	70%	60%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO7.	**M**	**L**						**M**		**M**			**M**		
CO8.	**M**	**L**						**M**		**M**			**M**		
CO 3	**S**	**M**	**L**	**L**				**M**		**M**			**S**		
CO 4	**S**	**M**	**L**	**L**				**M**		**M**			**S**		
CO 5	**M**	**L**						**M**		**M**			**M**		
CO 6	**S**	**M**	**L**	**L**				**M**		**M**			**S**		

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**8**	16													4	8		
CO2	6	8	20				50								4	8	10	
CO3	6	16	20				50								2		10	
CO4				**8**	16										4	8		
CO5				6	8	20					50				4	8	10	
CO6				6	16	20					50				2	8	10	
	20	40	40	20	40	40									20	40	40	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

DC Generators

Construction-Principle of operation, Emf equation-types, Armature reaction-commutation, Characteristics of generators, Losses & efficiency, Regulation, parallel operation, Applications

DC Motors

Principle of operation, Torque equation, Types-characteristics, Losses-Efficiency, Speed control and starters, Swinburne's Test , Heat run Test ,Hopkinson's Test

Transformers

Transformer construction and principle, Ideal Transformer, EMF equation, Transformer on no load & load Losses, efficiency and regulation, All day efficiency, Auto transformer, three phase transformer connections, Parallel operation of Transformers, Welding transformers, Tap changers on load & off load , OC&SC Test on transformers, Sumpners Test

Text Book

1. D.P.Kothari & I.J.Nagrath, “ Electrical Machines”, Tata-McGrawhill, Newdelhi, 5th Edition, 2010.

Reference Books& web resources

1. R.K.Rajput, “ Electrical Technology”, Laxmi Publications, 3rd edition, 2005.
2. Vincent Deldoro ,“ Electromechanical Energy Conversion ” PHI III edition,
3. M.G.Say, Theory and performance of electrical machines, Tata-Mcgraw hill

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**DC Generators**	
1.1	Construction- Principle of operation	2
1.2	EMF equation	1
1.3	Types & Characteristics of generators	1
1.4	Armature reaction-commutation	1
1.5	Losses & efficiency, Condition for Maximum Efficiency	2
1.6	Regulation,	1
1.7	Parallel operation, Applications	2
2	**DC Motors**	
2.1	Principle of operation	1
2.2	Torque equation	1
2.3	Types-characteristics	2
2.4	Losses-Efficiency	2
3	**Control & Testing of DC Machines**	
3.1	Speed control and starters	2
3.2	Swinburne’s Test , Heat run Test ,Hopkinson’s Test	2
4	**Transformer**	
4.1	Transformer construction and principle	2
4.2	Ideal Transformer	1

Module No.	Topic	No. of Periods
4.3	EMF equation	1
4.4	Auto transformer, three phase transformer connections, , Welding transformers	2
5	**Transformer Performance**	
5.1	Transformer on no-load & load Losses	2
5.2	Voltage Regulation, Tap changers on load & off load	2
5.3	Efficiency and All day efficiency	2
5.4	Parallel operation of Transformers	1
6	**Transformer Modelling & Testing**	
6.1	OC&SC Test on transformers,	1
6.2	Transformer Equivalent Circuit	1
6.3	Sumpners Test	1
	Total	36

Course Designer(s):

1. Dr.V.Saravanan, Professor, EEE vseee@tce.edu
2. Dr.S.Latha, Professor, EEE sleee@tce.edu

22EE330	LINEAR INTEGRATED CIRCUITS

Category	L	T	P	Credit
PCC	3	-	-	3

Preamble

A linear integrated circuit is a solid-state analog device characterized by a theoretically infinite number of possible operating states. It operates over a continuous range of input levels. Linear ICs are employed in audio amplifiers, Analog to Digital converters, averaging amplifiers, differentiators, DC amplifiers, integrators, multivibrators, oscillators, audio filters, and sweep generators. Some devices contain several amplifiers within a single housing.

Prerequisite

22EE260 - Electronics devices and Circuits

22EE280- Electronics devices and Circuits lab

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the Linear Integrated Circuits fabrication techniques	TPS2	70	70
CO2	Explain the working of operation amplifier and its characteristics.	TPS2	70	70
CO3	Design linear circuits using operational amplifiers for the given specifications	TPS3	70	70
CO4	Design Multivibrator circuits using 555 timer IC	TPS3	70	70
CO5	Design voltage regulators, Analog to digital converters and Digital to Analog converters for the given specifications	TPS3	70	70
CO6	Explain the operation of Phase Locked Loop	TPS2	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M				M
CO2	M	L						M		M				M
CO3	S	M	L	L				M		M				S
CO4	S	M	L	L				M		M				S
CO5	S	M	L	L				M		M				S
CO6	M	L						M		M				M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**8**	16													4	8		
CO2	6	8	20				50								4	8	10	
CO3	6	16	20				50								2		10	
CO4				**8**	16										4	8		
CO5				6	8	20					50				4	8	10	
CO6				6	16	20					50				2	8	10	
	20	40	40	20	40	40									20	40	40	

Syllabus

Introduction: Integrated circuits – Classification, Thin and thick film techniques, SMT(Surface Mount Technology) Monolithic technique - wafer preparation, Epitaxial growth, Oxidation, Photolithography, Diffusion, Ion Implantation, Isolation, Metallization and Packaging, Fabrication of Integrated resistors, capacitors and inductors - Bipolar and MOSFET devices fabrication techniques.

Operational amplifier: Basic concepts - differential amplifiers - block diagram-ideal op-amp parameters - Basic op-amp applications Scale changer, Inverting and non-inverting amplifiers, summer and subtractor, Log and antilog amplifiers - multiplier, Divider, differentiator, Integrator. Instrumentation amplifier

Op-amp circuits: V to I and I to V converters- Precision rectifier- Clipper and clamper- Sample and hold circuits - Active filters: first order and second order LPF and HPF- Comparators - Regenerative comparator (Schmitt Trigger)- Square wave and Triangular wave generators- Sine wave generators: RC Phase shift and Wein bridge oscillators.

Other Linear ICs: IC voltage regulators – Fixed and Variable voltage regulators-78XX and 79XX series regulators, LM317 voltage regulator -Switching Regulator- 555 timer IC: Astable and Monostable modes - Phase locked loop and its applications- D/A converters: weighted resistor and R-2R ladder- A/D converters: Successive approximation, Counter type, Flash type and Delta-sigma.

Text Book

1. Roy choudhury and shall B.Jain, Linear Integrated circuits, Wiley Eastern Ltd, 5th edition, 2018.

Reference Books & Web Resources

1. Ramakant A. Gayakwad, Op-amps and Linear Integrated Circuits, Pearson Education; Fourth edition, 2015
2. K.R.Botkar, Integrated Circuits, Hanna Publishers, 2008
3. Jacob Millman & Christos C.Halkias- Integrated electronics, McGraw Hill Education; 2 edition ,2017.
4. Fred F. Driscoll and Robert F. Coughlin , Operational Amplifiers and Linear Integrated Circuits, Pearson; 4 edition 1997.
5. NPTEL courses web:http://nptel.ac.in/courses/108106068/
6. MOOCs course link: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/

Course Contents and Lecture Schedule

Module No.	Topics	No. of Periods
1	**Introduction**	
1.1	Integrated circuits – Classification	1
1.2	Thin and thick film techniques, SMT(Surface Mount Technology)	1
1.3	Monolithic technique - wafer preparation, Epitaxial growth, Oxidation	1
1.4	Photolithography, Diffusion, Ion Implantation, Isolation, Metallization and Packaging	1
1.5	Fabrication of Integrated resistors	1
1.6	Fabrication of Integrated capacitors and inductors	1
1.7	Bipolar and MOSFET devices fabrication techniques	1
2	**Operational amplifier**	
2.1	Basic concepts - differential amplifiers - block diagram-	2
2.2	ideal op-amp parameters	1
2.3	Basic op-amp applications Scale changer, Inverting and non-inverting amplifiers, summer and subtractor	1
2.4	Log and antilog amplifiers	1
2.5	multiplier, Divider,	1
2.6	differentiator, Integrator	2
2.7	Instrumentation amplifier	1
3	**Op-amp circuits**	
3.1	V to I and I to V converters	1
3.2	Precision rectifier	1
3.3	Clipper and clamper, Sample and hold circuits	1
3.4	Active filters: first order and second order LPF and HPF	2
3.5	Comparators - Regenerative comparator(Schmitt Trigger)-	1
3.6	Square wave and Triangular wave generators-	2
3.7	Sine wave generators: RC Phase shift and Wein bridge oscillators.	1
4	**Other Linear ICs**	
4.1	IC voltage regulators – Fixed and Variable voltage regulators- 78XX and 79XX series regulators,	1

4.2	LM317 voltage regulator -Switching Regulator-	2
4.3	555 timer IC - Astable and Monostable modes	2
5	**Applications**	
5.1	Phase locked loop and its applications	2
5.2	D/A converters: weighted resistor and R-2R ladder-	2
5.3	A/D converters: Successive approximation, Counter type, Flash type and Delta-sigma	2
	Total	36

Course Designers:

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2. Dr.S.Arockia Edwin Xavier, Associate Professor, EEE - saexeee@tce.edu

22EE340	SIGNALS AND SYSTEMS

Category	L	T	P	Credit
PCC	3	-	-	3

Preamble

This course deals the fundamentals of signal and system analysis, focusing on representations of discrete-time and continuous-time signals (singularity functions, complex exponentials and geometrics, Fourier representations, Laplace and Z transforms, sampling) and representations of linear, time-invariant systems (difference and differential equations, block diagrams, system functions, poles and zeros, convolution, impulse and step responses, frequency responses). Applications are drawn broadly from engineering, including feedback and control, communications, and signal processing.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Identify the type of given signals and systems.	TPS2	70%	60%
CO2	Analyze the Time domain behaviour of a given Continuous time LTI system using Laplace Transform.	TPS4	70%	60%
CO3	Analyze the Time domain behaviour of a given Discrete Time LTI system using Z-Transform.	TPS4	70%	60%
CO4	Apply Fourier transform for frequency domain analysis of a given Continuous time LTI system	TPS3	70%	60%
CO5	Apply Fourier transform for frequency domain analysis of a given Discrete time LTI system	TPS3	70%	60%
CO6	Apply Discrete Fourier transform for frequency domain analysis of a given Discrete time LTI system	TPS3	70%	60%

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M				M
CO2	S	M	L	L	L			M		M				S
CO3	S	M	L	L	L			M		M				S

CO4	S	M	L	L				M		M				S
CO5	S	M	L	L				M		M				S
CO6	S	M	L	L				M		M				**S**

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	8	20													4	10		
CO2	8	10	20					50							4	10	8	
CO3	5	10	20					50							2		8	
CO4				8	10	15					40				4	5	8	
CO5				8	15	10					30				4	5	8	
CO6				4	15	15					30				2	10	8	

Syllabus

Introduction to Signals and Systems:

Classification of Signals and systems- Signal properties: periodicity, absolute integrability, determinism and stochastic character. Test signals: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, reliability. Examples.

Time domain behavior of continuous and discrete time LTI systems

Impulse response and step response, convolution, correlation, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

Laplace and z- Transforms

Laplace Transform for continuous time signals and systems, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.

Fourier Transforms

Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response. The Discrete Time Fourier Transform (DTFT), the Discrete Fourier Transform (DFT) its properties. Parseval's Theorem, Fast Fourier Transform (FFT) - radix 2

Reference Book & Web Resources

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and Systems", Pearson India Education Services Pvt. Ltd, 2016.
2. H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education, 2010.
3. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, nd Applications", Pearson, Fourth Edition 2006.
4. S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons, 2007.
5. https://nptel.ac.in/courses/117101055/
6. https://www.edx.org/course/signals-and-systems

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Introduction to Signals and Systems**		
1.1	Classification of Signals and systems	2	CO1
1.2	Signal properties: periodicity, absolute integrability, determinism and stochastic character	2	CO1
1.3	Test signals: The unit step, the unit impulse, the sinusoid, the complex exponential signals	1	CO1
1.4	Time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals	1	CO1
1.5	System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, reliability. Examples.	2	CO1
2	**Time domain behaviour of continuous and discrete time LTI systems**		
2.1	Impulse response and step response	1	CO2 &CO3
2.2	Convolution	1	CO2 &CO3
2.3	Input-output behaviour with aperiodic convergent inputs, cascade interconnections.	1	CO2 &CO3
2.4	Characterization of causality and stability of LTI systems.	1	CO2 &CO3
2.5	System representation through differential equations and difference equations	2	CO2 &CO3
2.6	Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.	2	CO4
3	**Laplace and z- Transforms**		
3.1	The Laplace Transform for continuous time signals and systems,	2	CO2
3.2	System functions, poles and zeros of system functions and signals,	2	CO2
3.3	Laplace domain analysis, solution to differential equations and system behaviour	2	CO2
3.4	The z-Transform for discrete time signals and systems	2	CO3

3.5	System functions, poles and zeros of systems and sequences, z-domain analysis	2	CO3
4	**Fourier Transform**		
4.1	Continuous Time Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients	2	CO4
4.2	Discrete Time Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients	2	CO5
4.3	Continuous Time Fourier Transform (CTFT), convolution/multiplication and their effect in the frequency domain, magnitude and phase response	2	CO4
4.4	The Discrete Time Fourier Transform (DTFT) and its properties	2	CO5
4.5	The Discrete FourierTransform (DFT) and its properties ,	2	CO6
4.6	Fast Fourier Transform - radix 2	3	CO6
4.7	Parseval's Theorem	1	CO6
	Total	40	

Course Designers:

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22EE350	PROBLEM SOLVING USINGCOMPUTERS

Category	L	T	P	Credit
ESC	3	0	0	3

Preamble

The course on problem solving using computers is intended to introduce the students about the different problem solving strategies with emphasis on python coding. Upon completion of the course, the students would be able to master the principles of interpreted high-level programming and demonstrate significant experience in problem solving.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the problem solving strategies and the key terms related to problem solving using computers	TPS2	80	70
CO2	Solve the given problem statement using python programming concepts such as objects, data types, expression , statements, looping.	TPS3	80	70
CO3	Apply the concepts of tuples, list, dictionary and string in design of simple applications	TPS3	80	70
CO4	Make use of functions while developing python scripts.	TPS3	80	70
CO5	Develop coding based on file I/O and exception handling in python.	TPS3	80	70
CO6	Apply the concepts of classes and objects in solving the problem using python programming.	TPS3	80	70

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L										M	M	M
CO2	S	M	L		M							M	S	S
CO3	S	M	L		M							M	S	S

CO4	S	M	L		M							M	S	S
CO5	S	M	L		M							M	S	S
CO6	S	M	L		M			S	S	S	L	M	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**5**	10													2	5		
CO2	3	10	30				50									5	15	
CO3	2	10	30				50								2	5	15	
CO4				**5**	10	20					40				2	5	10	
CO5				3	10	20					30				2	5	10	
CO6				2	10	20					30				2	5	10	

Assignment marks are based on python programming

Syllabus

Introduction to Problem Solving: Problem Analysis - Algorithms - Flowcharts, Verifying Algorithms - Comparison of Algorithm - Coding - Problem solving strategies - High level languages, syntax, semantics, compilation and execution, Debugging

Introduction to Python : Introduction - Python Overview - Comments - Python Identifiers - Reserved Keywords -Variables - Standard Data Types - Operators - Statement and Expression - Boolean Expressions - Control Statements - Iteration – while Statement - Input from Keyboard - Basic programming examples

Strings - Lists - Tuples - Dictionaries - Mutability - Development of simple applications

Functions : Introduction - Built-in Functions - Composition of Functions - User Defined Functions - Parameters and Arguments - Function Calls - The return Statement - Python Recursive Function - The Anonymous Functions - Writing Python Scripts

Files and Exceptions: Text Files - Directories - Exceptions - Exception with Arguments -- User-Defined Exceptions

Classes and Objects : Overview of OOP (Object-Oriented Programming) - Class Definition - Creating Objects - Objects as Arguments - Objects as Return Values - Built-in Class Attributes - Inheritance - Method Overriding - Data Encapsulation - Data Hiding

Reference Books

1. John V.Guttag, " Introduction to Computation and Programming Using Python : With Application to Understanding Data", Prentice-Hall International publishers, Second Edition, 2017.
2. E. Bala gurusamy, "Introduction to Computing and Problem Solving using Python", Mcgraw Higher Ed, First Edition, 2016.
3. ReemaThareja, "Python Programming using problem solving Approach", Oxford University, Higher Education Oxford University Press, First edition, 2017.
4. R.G.Dromey, "How to solve it by Computers", Pearson Education India , First Edition, 2008
5. NPTEL course "A joy of computing using python" , https://nptel.ac.in/courses/106106182/
6. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", Updated for Python 3, Shroff/O„Reilly Publishers, Second Edition, 2016.
7. Robert Sedgewick, Kevin Wayne, Robert Dondero, "Introduction to Programming in Python: An Inter-disciplinary Approach", Pearson India Education Services Pvt. Ltd., First Edition, 2016.
8. Mark Pilgrim, "Dive into Python 3", Apress, 2009

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**Introduction to Problem Solving**		
1.1	Problem Analysis	**1**	**CO1**
1.2	Algorithms - Flowcharts	**1**	**CO1**
1.3	Verifying Algorithms - Comparison of Algorithm - Coding	**1**	**CO1**
1.4	Problem solving strategies	**2**	**CO1**
1.5	High level languages, syntax, semantics,	**1**	**CO1**

1.6	Compilation and execution, Debugging	**1**	**CO1**
2	**Introduction to Python**		
2.1	Introduction - Python Overview	**1**	**CO2**
2.2	Comments - Python Identifiers - Reserved Keywords	**1**	**CO2**
2.3	Variables - Standard Data Types - Operators	**1**	**CO2**
2.4	Statement and Expression	**1**	**CO2**
2.5	Boolean Expressions - Control Statements	**1**	**CO2**
2.6	Iteration – while Statement - Input from Keyboard	**1**	**CO2**
2.7	Basic programming examples	**3**	**CO2**
2.8	Strings	**1**	**CO3**
2.9	Lists - Tuples	**1**	**CO3**
2.10	Dictionaries - Mutability	**1**	**CO3**
2.11	Development of simple applications	**3**	**CO3**
3	**Functions**		
3.1	Introduction - Built-in Functions - Composition of Functions	**1**	**CO4**
3.2	User Defined Functions - Parameters and Arguments	**1**	**CO4**
3.3	Function Calls - The return Statement - Python Recursive Function	**2**	**CO4**
3.4	The Anonymous Functions - Writing Python Scripts	**1**	**CO4**
4	**Files and Exceptions**:		
4.1	Text Files - Directories	**1**	**CO5**
4.2	Exceptions - Exception with Arguments	**1**	**CO5**
4.3	User-Defined Exceptions	**1**	**CO5**
4.4	**Classes and Objects**		

4.5	Overview of OOP (Object-Oriented Programming)	**1**	**CO6**
4.6	Class Definition - Creating Objects	**1**	**CO6**
4.7	Objects as Arguments - Objects as Return Values	**1**	**CO6**
4.8	Built-in Class Attributes - Inheritance	**2**	**CO6**
4.9	Method Overriding - Data Encapsulation - Data Hiding	**1**	**CO6**
Total Lecture Hours		**36**	

Course Designers:

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22EE370	DC MACHINES AND TRANSFORMERS LAB

Category	L	T	P	Credit
PCC	-	-	2	1

Preamble

This laboratory gives a practical exposure to the students to learn the characteristics of Transformers and DC Machines that are used nowadays in Electrical Systems. The students also learn to select the suitable DC Electrical Machines for an application based on its characteristics. To familiarize the standard testing procedures of DC Machines and Transformers.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Obtain the characteristics of DC Generator (Shunt, Series & Compound) independently	20
CO2	Obtain the characteristics of DC Motor (Shunt & Series) independently	20
CO3	Determine the Efficiency of DC Machine and calculate the maximum efficiency	10
CO4	Obtain the Voltage Regulation and Efficiency characteristics of Transformer independently	20
CO5	Sketch the Circuit Model of Transformer	20
CO6	Obtain the Thermal & Vibration characteristics of DC Machines and Transformers	10

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	M	M	S				S	S				S	
CO2	S	S	M	M	S				S	S				S	
CO3	S	M	L	L	S				S	S				S	
CO4	S	M	L	L	S				S	S				S	

CO5	S	S	M	M	S				S	S				S	
CO6	S	S	M	M	S				S	S				S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand	10	10
Apply	40	40
Analyse	20	20
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Practical Component/Observation
Perception	
Set	
Guided Response	10
Mechanism	20
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

Exp.No	Name	CO
DC Machine		
1	Load characteristics of DC Generators	CO1
2	Methods of Excitation and Voltage Control of DC Generators	CO1
3	Measuring the resistance of Armature and Field Windings	CO1
4	Methods of Starting and Speed Control of DC Motors	CO2
5	Load Characteristics of DC Motors	CO2
6	Swinburne's & Hopkinson's tests	CO3
7	Thermal and Vibration Study of DC Machines	CO6
Transformer		
8	Performance estimation using various load	CO4
9	Performance calculation using equivalent circuit	CO4
10	Measurement of Winding Resistance and Inductance	CO5
11	Sumpner's test / Polarity Test	CO5
12	Thermal and Vibration Study of Transformer	CO6

Reference Books

1. D.P.Kothari & I.J.Nagrath, " Electrical Machines", Tata-McGrawhill, Newdelhi, 5th Edition, 2010.
2. R.K.Rajput, " Electrical Technology", Laxmi Publications, 3rd edition, 2005.
3. Vincent Deldoro ," Electromechanical Energy Conversion " PHI III edition,
4. M.G.Say, Theory and performance of electrical machines, Tata-Mcgraw hill LR2

Course Designers:

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Category	L	T	P	Credit
PCC	-	-	2	1

22EE380 INTEGRATED CIRCUITS LAB

Preamble

This laboratory gives a practical exposure to the students to learn the characteristics of analog and digital ICs that are used in most of the electronic circuits. Student can also conceive ideas on different electronics circuits have analog and digital ICs and can be able to design and implement it for particular applications.

Prerequisite

22EE260 - Electronics devices and Circuits

22EE280 - Electronics devices and Circuits Lab

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Analyze the performance of the designed circuits like amplifier, filters using operational amplifier for the given applications.	30
CO2	Design the Multivibrator circuits using 555 timers for the given specifications.	5
CO3	Design the voltage regulators using linear Regulator ICs for the given specifications.	5
CO4	Design the Combinational digital circuits for the given requirements using suitable digital ICs.	20
CO5	Design the Digital sequential circuits for the given requirements using suitable digital ICs.	20
CO6	Develop IC based electronic system for a real-world applications	20

*** Weightage depends on Bloom's Level, number of contact hours

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	M	S	M		M	M	M				S
CO2	S	S	M	M	S	M		M	M	M				S

CO 3	S	S	M	M	S	M		M	M	M				S
CO 4	S	S	M	M	S	M		M	M	M				S
CO 5	S	S	M	M	S	M		M	M	M				S
CO 6	S	S	M	M	S	M		M	M	M				S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	50	50
Analyze	20	20
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	~~Miniproject~~ /Practical Component/~~Observation~~
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	10
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

E.No	Name of the experiment	CO	No. of sessions
1.	Characteristics of given Operational Amplifier	CO1	1
2.	Design of Comparator, Amplifier, Integrator, differentiator and Precision rectifiers using OP-AMP	CO1	1

	(Hardware /Simulation)		
3.	Design of Instrumentation Amplifier, Second order active filters using OP AMP/ FPAA (Hardware /Simulation)	CO1	1
4.	Design of V to I , I to V converter, and Oscillator circuits using OP AMP/FPAA (Hardware /Simulation)	CO1	1
5.	Design of Multivibrator circuits using 555 Timer ICs (Hardware /Simulation)	CO2	1
6.	Design of Voltage Regulator for given specification	CO3	1
7.	Realization of Boolean expression using universal gates.	CO4	1
8.	Realization of Full adder, Subtractor, Multiplexer, Demultiplexer, code converters, Decoder and encoder using suitable Digital ICs.(Hardware/ verilog simulation)	CO4	1
9.	Realization of shift Registers and counters using suitable Digital ICs. (Hardware/ verilog simulation)	CO5	1
10	Development of IC based electronic system for a real-world applications (selected by group of students)	CO6	2

Reference Books

1. Roy Choudhury and shall B.Jain, Linear Integrated circuits, Wiley Eastern Ltd, 5th edition, 2018
2. Jacob Millman & Christos C.Halkias- Integrated electronics, McGraw Hill Education; 2 edition ,2017
3. M.Morris Mano and Michael D.Ciletti, Digital Design, Sixth Edition, Pearson Prentice Hall, 2018

Course Designers:

1. Dr.R.Helen , Assistant Professor,EEE rheee@tce.edu
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3. Dr.B.Ashok Kumar, Assistant Professor,EEE ashokudt@tce.edu

22EE410	Probability Distribution and Random Process

Category	L	T	P	Credit
BSC	3	1	0	4

Preamble

An electrical engineering student needs to have some basic statistical tools and techniques to apply in diverse applications in digital signal processing communications systems and networks, radar systems, power systems that requires an understanding of Probability distributions, and Testing of Hypotheses and random process. The course is designed to impart the knowledge and understanding of the above concepts to Electrical Engineers and apply them in their areas of specialization.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

Cos	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Use standard distributions to find the expected life time of electrical components.	TPS3	75	70
CO2	Apply the concept of Joint Probability Distributions and random samples	TPS3	75	70
CO3	Apply the concept of testing the hypotheses for single samples by using various tests for difference of proportions and means.	TPS3	75	70
CO4	Apply the concept of testing the hypotheses for two samples by using various tests for difference of proportions and means.	TPS3	75	70
CO5	Estimate the statistical measures of random processes.	TPS3	70	65
CO6	Estimate the power spectral density of random processes.	TPS3	70	65

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	**S**	**M**	**L**	**L**	**-**	**-**	**-**	**M**	**M**	**M**	**-**	**M**	**S**	**S**

CO2	**S**	**M**	**L**	**L**	**-**	**-**	**-**	**M**	**M**	**M**	**-**	**M**	**S**	**S**
CO3	**S**	**M**	**L**	**L**	**-**	**-**	**-**	**M**	**M**	**M**	**-**	**M**	**S**	**S**
CO4	**S**	**M**	**L**	**L**	**-**	**-**	**-**	**M**	**M**	**M**	**-**	**M**	**S**	**S**
CO5	**S**	**M**	**L**	**L**	**-**	**-**	**-**	**M**	**M**	**M**	**-**	**M**	**S**	**S**
CO6	**S**	**M**	**L**	**L**	**-**	**-**	**-**	**M**	**M**	**M**	**-**	**M**	**S**	**S**

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Scale CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I (%)			CAT – II (%)			Assg. II (%)					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	3	10	20	-	-	100	-	-	-	-	-	-	-	6	10
CO2	4	10	28	-	-		-	-	-	-	-	-	-	6	15
CO3	3	-	22	-	-		-	-	8	-	-	-	-	6	11
CO4	-	-	-	-	-		3	10	25	-	-	-	-	6	13
CO5	-	-	-	-	-	-	3	10	20	-	-	100	-	6	11
CO6	-	-	-	-	-	-	4	-	17	-	-		-	-	10
Total	10	20	70	-	-	100	10	20	70	-	-	100	-	30	70

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Probability Distributions: Random Variables – Discrete Probability distribution: Binomial Distribution - Poisson distribution – Continuous Probability distribution: Normal and Exponential Distributions.

Joint Probability Distributions: Jointly distributed Random Variables – Two Discrete Random Variables -Two Continuous Random Variables –Independent Random Variables –Conditional Distributions – Expected Values, Covariance and Correlation: Covariance – Correlation.

Tests of Hypothesis Based on a Single Sample: Hypotheses and Test Procedures – z-Tests for Hypotheses about a Population Mean – The One Sample t test – Test Concerning a Population Proportion.

Inferences Based on Two Samples: zTests and Confidence Intervals for a Difference between Two Population Means – The Two Sample t-test and Confidence Interval – Inferences Concerning a Difference Between Population Proportions – Chi-square Tests - Goodness of Fit –Two Way Contingency Tables.

Random Processes: Introduction – Classification of Random Process – Characterizing a Random Process – Cross Correlation and Cross Covariance of Functions – Stationary Random Processes – Power Spectral Density.

Text Books

1. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 9th Edition, Cengage Learning India Pvt Ltd, New Delhi, 2014.
2. Oliver C. Ibe, Fundamentals of Applied Probability and Random Processes, Elsevier, 2015.

Reference Books

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, "Probability & Statistics for Engineers & Scientists", Pearson, New Delhi, 2016.
2. Richard A. Johnson, "Miller & Freund's, Probability and Statistics for Engineers", Prentice Hall, New Delhi, 2017.
3. John Bird, "Higher Engineering Mathematics", Fifth edition, Published by Elsevier Ltd., 2006.
4. Douglas C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", Wiley India, New Delhi, 2018.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Probability Distributions**	
1.1	Random Variables	1
1.2	Discrete Probability distribution: Binomial Distribution	1

Module No.	Topic	No. of Periods
1.3	Poisson Distribution	1
	Tutorial	**1**
1.4	Continuous Probability distribution: Normal Distributions	2
1.5	Exponential Distributions	1
	Tutorial	**1**
2	**Joint Probability Distributions**	
2.1	Jointly distributed Random Variables – Two Discrete Random Variables	2
2.2	Two Continuous Random Variables - Independent Random Variables	1
	Tutorial	**1**
2.3	Conditional Distributions	2
2.4	Expected Values, Covariance	1
	Tutorial	**1**
2.5	Correlation	2
3	**Tests of Hypothesis Based on a Single Sample**	
3.1	Hypotheses and Test Procedures	1
3.2	z-Tests for Hypotheses about a Population Mean	2
	Tutorial	**1**
3.3	The One Sample t test	2
3.4	Test Concerning a Population Proportion.	1
	Tutorial	**1**
4	**Inferences Based on Two Samples**	
4.1	Z Tests and Confidence Intervals for a Difference between Two Population Means	2
4.2	The Two Sample t-test and Confidence Interval	1
	Tutorial	**1**
4.3	Inferences Concerning a Difference Between Population Proportions	2

Module No.	Topic	No. of Periods
4.4	Chi-square Tests - Goodness of Fit	1
	Tutorial	**1**
4.5	Two Way Contingency Tables.	1
5	**Random Processes**	
5.1	Introduction	1
5.2	Classification of Random Process	2
	Tutorial	**1**
5.3	Characterizing a Random Process	1
5.4	Cross Correlation and Cross Covariance of Functions	2
	Tutorial	**1**
5.5	Stationary Random Processes	2
5.6	Power Spectral Density.	2
	Tutorial	**1**
	Total	48

Course Designer(s):

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		Category	L	T	P	Credit
22EE420	**AC MACHINES**	PCC	2	1	0	3

Preamble

Rotating electrical machines are widely used for the purpose of converting energy from one form to another. Alternating Current (AC) machines are becoming more and more attractive in many applications such as those requiring variable speed and flexible control. Also, AC machines are the most preferred for generation of electric power. AC motors are the commonly used in industry for motive power for applications. 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. Due to their low cost and economic advantages, AC motors are widely used in applications requiring a wide range of speeds or precise control of output.

Prerequisite

- 22EE230: Electric Circuit Analysis
- 22EE240: Electromagnetic Fields

Course Outcomes

On the successful completion of the course, students will be able to

CO NOs	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the construction and working principles of Synchronous machine	TPS2	80	80
CO2	Explain the construction and working principles of Asynchronous machine	TPS2	80	80
CO3	Obtain the performance of AC Generators	TPS3	80	80
CO4	Obtain the performance of AC Motors using equivalent circuit	TPS3	80	80
CO5	Explain the Operation and Control of AC Machines	TPS2	80	80

CO6	Apply the testing procedures for AC Machines as per the standard practice	TPS3	80	80

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L						M		M			M		
CO2	M	L						M		M			M		
CO3	S	M	L	L				M		M			S		
CO4	S	M	L	L				M		M			S		
CO5	M	L						M		M			M		
CO6	S	M	L	L				M		M			S		

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Assignment 1				Assignment 2				Terminal Examination					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	10	10																			2	5				
CO2							10	15													2	5				
CO3	6	10	35										60								2	5	20			
CO4							8	15	35								60				2		15			
CO5	2	5																			2	5				
CO6	2	5	15				2		15				40				40					5	15			

Syllabus

SYNCHRONOUS MACHINE

Alternator: Types, Construction, working principle, Characteristics, Applications, Performance Analysis, Testing, Parallel operation, Voltage & Frequency control

Synchronous Motor: Starting Methods, Working Principles, Characteristics, Applications, Voltage and Power Factor control.

ASYNCHRONOUS MACHINE

Three Phase Induction Motor: Types, Construction, Working Principle, Characteristics, Applications, Performance Analysis, Types of losses and efficiency calculations, Equivalent Circuit, Circle Diagram, Starting Methods and Speed Control.

Single Phase Induction Motor: Types, Construction, Working principle, Applications, AC Series Motor.

SPECIAL MACHINES

Special Machines: Linear Induction Motor, Hysteresis Motor, Eddy Current Motor,

Brushless DC motor, Stepper motor, Induction Generator.

Text Book

1. H.Wayne Beaty & James. L.Kirtley. Jr "Electric Motor Handbook", McGraw-Hill, USA, 1st Edition, 1998.

Reference Books

1. A.K.Sawhney and A.Chakrabarti, "A course in Electrical Machine Design",6th Edition, Dhanpat Rai & Co (P) Ltd., 2006.

2. P. S. Bimbhra, "Electrical machinery", Seventh Edition, Khanna Publications, 2014.
3. Gupta.J.B,"Theory of Performances of Electrical Machines' Katson, 7th Edition, 1987
4. Stephen J.Chapman, "Electric Machinery Fundamentals', "McGraw Hill Intl. Edition, New Delhi, 6 th Edition, 2012.
5. Vincent Deldoro ," Electromechanical Energy Conversion " PHI III edition,
6. M.G.Say, The Performance and Design of Alternating Current machines, Tata-McGraw Hill.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
	SYNCHRONOUS MACHINE	
1	**Alternator**	
1.1	Types, working principle	2

Module No.	Topic	No. of Periods
1.2	Construction, Characteristics, Applications	2
1.3	Performance Analysis: Determination of Voltage regulation by EMF, MMF and ZPF	3
1.4	Blondel two reaction Theory for salient pole machine, Phasor diagram using Xd, Xq, Testing	3
1.5	Parallel operation, Voltage & Frequency control	2
2	**Synchronous Motor**	
2.1	Working Principles, Starting Methods	2
2.2	Characteristics & Applications	2
2.3	Voltage and Power Factor control	2
ASYNCHRONOUS MACHINE		
3	**Three Phase Induction Motor**	
3.1	Types, working Principle	2
3.2	Construction, Characteristics, Applications	2
3.3	Types of losses and efficiency calculations	1
3.4	Performance Analysis, Equivalent Circuit	3
3.5	Starting Methods, Speed Control	2
4	**Single Phase Induction Motor**	
4.1	Types, Construction, Working principle	2
4.5	Applications, AC Series Motor	2
5	**Special Machines**	
5.1	Linear Induction Motor, Hysteresis Motor	1
5.2	Eddy Current Motor, Stepper Motor	1
5.3	Brushless DC motor, Induction Generator	1
5.4	Testing, Standards, Specifications	1
	Total	36

Course Designer(s):

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22EE430	**MEASUREMENTS AND INSTRUMENTATION**	Category L T P Credit PCC 3 0 0 3

Preamble

The rapid development of new and exciting means of measurement using new technologies, the adoption of new standards give us a path way to the state of "Classic Electrical Measurements". However, knowledge of these subjects is important to understand the principles of modern measuring instruments. Instrumentation systems help to create, construct and maintain measuring devices and systems found in manufacturing plants and research institutions. Its main objective is to ensure that systems and processes operate safely and efficiently. This course is designed to impart fundamental knowledge of analog and digital measuring instruments.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course students will be able to

CO	Course Outcome Statement	TPS Scale	Expected Proficiency %	Expected Attainment %
CO1	Explain the fundamental art of measurement in Engineering	TPS2	70	75
CO2	Apply suitable analog instrument to measure the various electrical parameters (current, voltage, power and energy)	TPS3	70	70
CO3	Use potentiometers for calibration of meters	TPS3	70	70
CO4	Apply suitable DC bridge circuit to measure Resistance and suitable AC bridge circuit to measure Inductance, Capacitance and frequency.	TPS3	70	70
CO5	Apply suitable transducers for the measurement of various non-electrical parameters	TPS3	70	70
CO6	Explain the working principle of various Digital instruments.	TPS2	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M					M	M	M		M			M	M
CO2	M	L						M		M	L		M	M
CO3	S	M	L	L				M		M	L		S	S
CO4	S	M	L	L				M		M	L		S	S
CO5	S	M	L	L				M		M	L		S	S
CO6	M	L			M		S	M		M			M	M

S- Strong; M-Medium; L-Low

Assessment Pattern:

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	10													5	5		
CO2	5	20	15				50									10	10	
CO3	5	20	15				50									10	5	
CO4				5	20	15					50				5	10	10	
CO5				5	20	15					50				5	10	5	
CO6				10	10										5	5		

SYLLABUS

CONCEPTS OF MEASUREMENTS

Classification of Instruments – Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement - Statistical evaluation of measurement data - Standards and Calibration

ANALOG INSTRUMENTS FOR MEASUREMENT OF ELECTRICAL PARAMETERS

Introduction and Classification of analog measuring instruments —Construction, operating principle and applications of : Moving coil and Moving iron meters –Dynamometer type watt meters - Single phase Induction type Energy meter - Instrument Transformers (CT & PT) - Measurement of power in a single phase circuit using CT & PT.

POTENTIOMETERS

Basic potentiometer circuit–Multi range potentiometer- Volt-Ratio box- Applications of DC and AC potentiometers -Self balancing potentiometer.

DC & AC BRIDGES

Wheatstone bridge - cable fault location, Kelvin double bridge - Maxwell, Hay, Wien and Schering bridges and their applications - Sources of errors in bridges.

TRANSDUCERS FOR MEASUREMENT OF NON - ELECTRICAL PARAMETERS

Classification of transducers – **Temperature transducers-** RTD, thermistor, Thermocouple – **Displacement transducer -** Inductive, capacitive, LVDT, **Pressure transducer –** Bourdon tube- **Speed transducer -** Digital Encoders – **Flow transducer –** Electromagnetic flow meter .Strain gauges – Piezo electric and Hall Effect transducers- Concept of MEMS based smart sensors.

DIGITAL INSTRUMENTS

Working Principles and applications: Digital Voltmeter- Digital Multimeter - Digital Frequency Meter - Digital measurement of phase and time interval - Digital Storage Oscilloscope - Harmonic analyzer - Concept of Smart meters.

Text Books

1. H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw-Hill, New Delhi, 2010.

2. A.K. Sawhney, Puneet Sawhney 'A Course in Electrical & Electronic Measurements & Instrumentation', Dhanpat Rai and Co, New Delhi, Edition 2011.

Reference Books

1. M.M.S. Anand, 'Electronics Instruments and Instrumentation Technology', Prentice Hall India, New Delhi, 2009

2. J.J. Carr, 'Elements of Electronic Instrumentation and Measurement', Pearson Education India, New Delhi, 2011

3. R.B. Northrop, 'Introduction to Instrumentation and Measurements', Taylor & Francis, New Delhi, 3 rd Edition 2014.

4. E. O. Doebelin and D. N. Manik, "Measurement Systems – Application and Design", Tata McGraw-Hill, New Delhi, 6th Edition 2017.

5. R. K. Rajput, “Electrical and Electronics Measurements and Instrumentation”, Chand Pub, 2016.

LECTURE SCHEDULE

Mo. No.	Topic	No. of Lecture Hours
1	**CONCEPTS OF MEASUREMENTS**	
1.1	Classification of Instruments – Elements of a generalized measurement system	1
1.2	Static and dynamic characteristics – Errors in measurement	2
1.3	Statistical evaluation of measurement data,	1
1.4	Standards and Calibration	1
2	**ANALOG INSTRUMENTS FOR MEASUREMENT OF ELECTRICAL PARAMETERS**	
2.1	Introduction and Classification of analog measuring instruments – moving coil and moving iron meters	2
2.2	Dynamometer type watt meters - Single phase Induction type Energy meter	2
2.3	Instrument transformers (CT & PT)- Measurement of power using CT & PT.	2
3	**POTENTIOMETERS**	
3.1	Basic potentiometer circuit–Multi range potentiometer	2
3.2	Volt-Ratio box- Applications of DC and AC potentiometers	2
3.3	Self-balancing potentiometer	1
4	**DC & AC BRIDGES**	
4.1	Wheatstone bridge, cable fault location - Kelvin double bridge	2
4.2	Maxwell, Hay, Wien and Schering bridges and their applications	3
4.3	Sources of errors in bridge circuits	1
5	**TRANSDUCERS FOR MEASUREMENT OF NON- ELECTRICAL PARAMETERS**	
5.1	Classification of transducers – **Temperature transducers-** RTD, thermistor, Thermocouple	2
5.2	**Displacement transducer –** Inductive, capacitive, LVDT	2
5.3	**Pressure transducer –** Bourdon tube-	1
5.4	**Speed transducers-** Digital Encoders	1
5.5	**Flow transducer –** Electromagnetic flow meter	1
5.6	Strain gauges Piezo electric and Hall Effect transducers	1
5.7	Concept of MEMS based smart sensors	1
6	**DIGITAL INSTRUMENTS**	
6.1	Digital Voltmeter-Digital Multimeter	2
6.2	Digital Frequency Meter – Digital measurement of phase and time interval	1

6.3	Digital Storage Oscilloscope, Harmonic analyzer	1
6.4	Concept of Smart meters.	1
	Total	**36**

COURSE DESIGNERS:

1.	Dr.K.Selvi,Professor,EEE	kseee@tce.edu
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		Category	L	T	P	Credit
22EE440	**CONTROL SYSTEMS**	PCC	2	1	0	3

Preamble

This course is to impart students the knowledge of fundamental principles in control engineering. The course includes: Mathematical Modeling of Linear Continuous Time Invariant Single Input - Single Output Dynamical Systems, Transfer Functions and State Space Models, Performance Specifications, and Analysis of Closed Loop Control Systems using time domain and frequency domain approaches.

Prerequisite

- 22EE230 : Electric Circuit Analysis
- 22EE340 : Signals and Systems
- 22EE210: Matrices and Transforms

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome 1 (CO1)	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment %
CO1	Determine the transfer function and state space model of the given electrical, mechanical and electro-mechanical system	TPS3	70%	70%
CO2	Analyze the time response characteristics of a given transfer function model	TPS4	70%	70%
CO3	Analyze the frequency response characteristics of a given transfer function model	TPS4	70%	70%
CO4	Analyze the closed loop characteristics of a given transfer function model using root locus	TPS4	70%	70%
CO5	Explain the effects of compensators in improving the performance of the system	TPS2	80%	80%
CO6	Determine the stability, controllability and observability of the given dynamical system	TPS3	70%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**	**1**						**2**					
CO2	**3**	**3**	**2**	**2**						**2**		**2**			
CO3	**3**	**3**	**2**	**2**						**2**		**2**			
CO4	**3**	**3**	**2**	**2**						**2**		**2**			
CO5	**2**	**1**								**2**					
CO6	**3**	**2**	**1**	**1**						**2**					

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1				CAT 2				ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	4	1	2	3	4	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	10	30						40								2	6	15	
CO2	5	10	10	30					60								2		6	7
CO3					2	10	10	10					50				2		7	6
CO4					2		10	10					50				2		7	7
CO5					4	10												8		
CO6					2	10	20										2	6	15	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Modeling:

Industrial control examples, Feedback control: Open loop and Closed loop systems, Benefits of feedback, Transfer function models of linear time invariant systems. Concept of state variable, state space model. Mathematical models of electrical, mechanical and electromechanical systems, Block diagram reduction, signal flow graphs and Mason gain formula.

Time domain analysis and stability:

Test Signals, Steady state errors, Time response of First order and second order systems- Dominant pole approximation of higher order systems, Concept of Stability and Characteristic equation, Routh-Hurwitz criteria- Root-locus construction and interpretation, closed loop analysis using root locus, Time domain and root locus analysis using MATLAB.

Frequency-domain analysis:

Frequency responses and Frequency domain specifications, Bode plot, polar plot, construction and interpretation, Nyquist stability criterion- Gain and phase margin, Frequency domain analysis using MATLAB.

Compensation:

Types of compensators, characteristics and effects of lead, lag, lag-lead compensators and P, PI and PID controllers.

State Variable Analysis:

Relation between state space and transfer functions, canonical forms, solution of state equation, Eigen values and stability analysis, Controllability and Observability.

Text Book

1.Norman S. Nise, Control Systems Engineering, 6th edition, John Wiley, 2010. (Indian edition)

Reference Books& web resources

1. I.J. Nagrath and M Gopal, Control Systems engineering, 5th Edition, New Age International, 2007
2. Robert H Bishop and Richard C Dorf, Modern Control Systems, 12th Edition, Pearson Education, 2010
3. John JD Azzo, Constantine H Houpis, and Stuart N Sheldon, Linear Control Systems: Analysis and Design with MATLAB, 5th Edition, Taylor and Francis, 2003
4. B.C. Kuo, and F.Golnaraghi, Automatic Control Systems, 9th Edition. Wiley India Pvt limited 2014. (Student edition)
5. Katsuhiko Ogata, Modern Control Engineering, 5th edition, PHI, 2010
6. M Gopal, Control Systems-Principles and Design, 4th Edition, McGraw Hill India, 2012
7. NPTEL Online Course: Control Systems, URL: https://nptel.ac.in/courses/107106081/72

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods

Module No.	Topic	No. of Periods
1	**Modeling**	
1.1	Industrial control examples, Feedback control: Open loop and Closed loop systems, Benefits of feedback	2
1.2	Transfer function models of linear time invariant systems	1
1.3	Mathematical models of electrical, mechanical and electromechanical systems	3
1.4	Block Diagram reduction	1
1.5	Signal flow graph and mason gain formula	2
1.6	Concept of state variable, state space model	2
2	**Time domain analysis and stability**	
2.1	Test Signals, Time response of First order systems	1
2.2	Time response of second order systems	2
2.3	Dominant pole approximation of higher order systems,	1
2.4	Steady state errors	1
2.5	Concept of Stability and Characteristic equation, Routh-Hurwitz criteria	2
2.6	Root-locus construction and interpretation, closed loop analysis using root locus,	2
2.7	Time domain and root locus analysis using MATLAB	1
3	**Frequency-domain analysis**	
3.1	Frequency responses and Frequency domain specifications,	1
3.2	Bode plot, construction and interpretation,	2
3.3	polar plot ,construction and interpretation	2
3.3	Nyquist stability criterion- Gain and phase margin	2
3.4	Frequency domain analysis using MATLAB.	1
4	**Compensation**	
4.1	Types of compensators, Characteristics and effects of lead, lag, lag-lead compensators	2
4.2	Characteristics of P, PI and PID controllers	1
5	**State Variable Analysis**	

Module No.	Topic	No. of Periods
5.1	Relation between state space and transfer functions, canonical forms	1
5.2	Solution of state equation, Eigen values and stability analysis,	2
5.3	Controllability and Observability	1
	Total	36

Course Designer(s):

1. Dr. S. Baskar, , Professor,EEEsbeee@tce.edu
2. Prof. S.Sivakumar, Associate Professor, siva@tce.edu

22EE450	POWER ELECTRONICS

Category	L	T	P	Credit
PCC	3	0	0	3

Preamble

Power Electronics can be defined as the application of solid state electronics for the control, conversion and transmission of electric power. Power electronic circuits convert electrical energy from one form to another form required by the load in an efficient and effective way. They find applications in industrial motor control, power supplies, vehicle propulsion systems, high voltage direct current (HVDC) systems, flexible AC transmissions (FACTs), heat controls and light controls.

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain steady state characteristics and applications of Power diode, Power transistor, Power MOSFET, IGBT, SCR, TRIAC, Silicon carbide devices and GaN devices.	TPS2	75	80
CO2	Design SCR triggering circuits, protection circuits and commutation circuits for the given requirements.	TPS3	75	80
CO3	Design controlled single phase and three phase rectifiers for the given specifications	TPS3	75	80
CO4	Design single phase and three phase voltage source inverters for the given specifications	TPS3	75	80
CO5	Design buck, boost and buck-boost DC-DC converters for the given specifications	TPS3	75	80
CO6	Explain the SMPS topologies, single phase and three phase AC voltage controllers.	TPS2	75	80
CO7	Analyze the performance of the given power converter and gate drive circuits using PLECS /PSPICE / MATLAB /PSIM software.	TPS4	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M			M	M
CO2	S	M	L					M		M			S	S
CO3	S	M	L					M		M			S	S
CO4	S	M	L					M		M			S	S
CO5	S	M	L					M		M			S	S
CO6	M	L						M		M			M	M
CO7	S	S	M	L	M			M		M			S	S

S- Strong; M-Medium; L-Low

Assessment Pattern:

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	10													5	5		
CO2	5	15	20												5	5	10	
CO3	5	15	20				40									10	10	
CO4				5	15	20	20								5	5	10	
CO5				5	15	20	40									10	10	
CO6				10	10										5	5		
CO7											50	50						

Note: Simulation of power converters as per CO7 will be given as assignments.

Syllabus

Power Semiconductor Devices

Principle of operation & static V-I Characteristics of power diode, power transistor, MOSFET, IGBT, SCR and TRIAC, merits of silicon carbide devices and GaN devices, **SCR:** Triggering circuits, protection circuits and commutation circuits.

AC to DC Converters

Review of uncontrolled rectifiers, Controlled Rectifiers: Half wave, half controlled, fully controlled single phase and three phase controlled rectifiers, performance parameters.

DC to AC Converters

Single phase and three phase voltage source inverter, frequency and voltage control, PWM schemes, harmonic distortion.

DC-DC & AC-AC Converters

Principle of working: Step-down, step-up, voltage commutated, current commutated chopper, switching regulators: buck, boost & buck-boost, SMPS topologies, single phase and three phase ac voltage controller.

Applications

Electric Drives, uninterruptible power supply, HVDC transmission, FACTS, distributed generation, custom power devices.

Simulation of Power Converters

Performance analysis of the power converters and gate drive circuits using PLECS /PSPICE / MATLAB /PSIM software.

Text Book

1. Muhammad H.Rashid, Power Electronics Devices, Circuits & Applications, Fourth Edition, Pearson Education India Publication, New Delhi, 7th Impression, 2019.

Reference Books& web resources

1. M.D.Singh & K.B.Khanchandani, Power Electronics – Tata Mc Graw Hill publishing company Ltd, New Delhi, 2008.
2. Ned Mohan, Tore Undeland & William Robbins, Power Electronics:Converters, Applications and Design-John Willey and sons, 3rd Edition, 2003.

3. P.S. Bimbhra, Power Electronics- Khanna Publishers, Sixth Edition, 2018.
4. John G.Kassakian, Martin F.Schlecht, George C.Verghese, Principles of Power Electronics, Pearson Education, 12th Impression, 2014.
5. Daniel W.Hart, Introduction to Power Electronics, First Edition, Prentice Hall International Inc.,1996.
6. L. Umanand, Power Electronics: Essentials and Applications- Wiley India, 2009.
7. Marty Brown, Power Sources and Supplies, ELSEVIER, 2008.
8. https://ocw.mit.edu/courses/electrical-engineering.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Power Semiconductor Devices**		
1.1	Principle of operation & Static V-I Characteristics: Power Diode & Power Transistor, MOSFET, IGBT	2	CO1
1.2	SCR, TRIAC, Merits of Silicon carbide devices GaN devices	2	CO1
1.3	Device specifications, Switching characteristics	2	CO1
1.4	SCR triggering circuits, Protection circuits	2	CO2
1.5	Commutation circuits	2	CO2
2.	**AC to DC Converters**		
2.1	Review of Uncontrolled Rectifiers	1	CO3
2.2	Controlled Rectifier: Half-wave, Half-controlled, Fully-controlled Single phase Rectifiers	2	CO3
2.3	Half-wave, Half-controlled, Fully-controlled Three phase Rectifiers	2	CO3
2.4	Performance parameters of uncontrolled& Controlled Rectifiers	2	CO3
3.	**DC to AC Converters**		
3.1	Single phase Voltage source Inverters	1	CO4
3.2	Three phase Voltage source Inverters	2	CO4
3.3	Current source Inverters	1	CO4
3.4	Frequency and Voltage Control, PWM Schemes	2	CO4
3.5	Harmonic Distortion	1	CO4
4.	**DC-DC & AC-AC Converters**		
4.1	Principle of working: Step-down, Step-up, Voltage commutated, Current commutated Chopper	2	CO5
4.2	Buck, Boost Switching Regulator	2	CO5
4.3	Buck-Boost Switching Regulator	1	CO5
4.4	SMPS Topologies	1	CO6
4.5	Single phase and Three phase AC voltage controller	2	CO6
5.	**Applications**		
5.1	Electric Drives, Uninterruptible Power Supply, HVDC Transmission	1	CO1
5.2	FACTS, Distributed Generation, Custom Power Devices	1	CO1
5.3	Performance analysis of the power converters and gate drive circuits using PLECS /PSPICE / MATLAB /PSIM software	2	CO7
	Total	36	

Course Designers:

1. Dr. S. Arockia Edwin Xavier Associate Professor,EEE - saexeee@tce.edu
2. Dr. G. Sivasankar Assistant Professor,EEE - gsivasankar@tce.edu

22EE460	DATA STRUCTURES	Category	L	T	P	Credit
		ESC	2	1	0	3

Preamble

This course will cover various data structures and their operations for manipulating them. Students will learn how to organize the data so that, the data can be accessed and updated efficiently using computer programs.

Prerequisite

- 22EE350 Problem Solving using Computers

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Use suitable linear data structures and their operations for solving a given problem	TPS3	80	85
CO2	Use suitable non-linear data structures like Trees and their operations for solving a given problem	TPS3	80	85
CO3	Use suitable non-linear data structures like Hash Table, Graph and their operations for solving a given problem	TPS3	80	85
CO4	Compute space and time complexity of a given problem	TPS3	80	85
CO5	Interpret computational efficiency of searching and sorting algorithms	TPS3	80	85
CO6	Formulate solutions by identifying suitable ADTs for solving problems using suitable programming languages	TPS3	80	85

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L					L				M			
CO2	S	M	L					L				M			
CO3	S	M	L					L				M			
CO4	S	M	L					L				M			
CO5	S	M	L					L				M			
CO6	S	M	L		M			L				M			

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Terminal					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
CO1	10	15	25										6	10	10			
CO2							5	10	20				6	10	10			
CO3							5	10	10				2	5	5			
CO4	5		10										2		8			
CO5		5	10						10				4	5	5			
CO6			20						30						12			

Assignments include solving worksheets, quiz, problem solving using Programming languages.

Syllabus

Data Abstraction: Data Representation - Types of Data Structures - Abstract Data Type

Linear ADTs: List - Arrays - Matrix - String - Applications –Array Problems,Matrix Problems, Strings problems

Stack - Queue - Circular Queue - Linked List - Singly Linked List, Doubly Linked List, Circular Linked List - Applications - Expression evaluation, Polynomial Evaluation, Josephus Problem, Middle Number, Palindrome checking – Recursion – Fibonacci, GCD

Non-linear ADTs: Tree Terminology - Binary tree - Tree traversals - Expression Tree – Binary Search Tree - AVL Tree - B-tree - Binary Heap - Applications – Dictionary, kth smallest element, Hash Table – Hashing Techniques, Rehashing–Graphs –Graph Terminology – Graph Representation – Graph traversals – Applications –Shortest path algorithm, Minimum Spanning Tree

Algorithm Analysis: Asymptotic Measures – Space Complexity – Time Complexity

Searching and Sorting: Searching Techniques - Sequential Search, Binary Search, Search trees – Sorting Techniques – Bubble Sort, Insertion Sort, Selection Sort, Shell Sort, Quick Sort, Merge Sort, Heap Sort

Text Book

1. M. A. Weiss, “Data Structures and Algorithm Analysis in C”, Second Edition, Pearson Education, 2012.
2. Richard Gilberg, Behrouz A. Forouzan, “Data Structures: A Pseudo code Approach with C”, Second edition, India Edition 2007.

Reference Books& web resources

1. M. A. Weiss, “Data Structures and Algorithm Analysis in Java”, Second Edition, Pearson Education, 2014
2. Aho, J.E. Hopcroft and J.D. Ullman, “Data Structures and Algorithms”, Pearson Education, 1983.
3. BasantAgarwal, BejaminBaka, “Hands-On Data Structures and Algorithms with Python: Write complex and powerful code using the latest features of Python 3.7, 2nd Edition, 2018
4. SWAYAM / NPTEL’s Course for Data Structures – http://nptel.ac.in/courses/Webcourse-contents/IIT-%20Guwahati/data_str_algo/frameset.htm
5. Web Reference for Data Structures – https://www.geeksforgeeks.org/data-structures
6. Web Reference for Data Structures –https://www.hackerrank.com/domains/data-structures
7. Web Reference for Data Structures – www.leetcode.com/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Data Abstraction**	
1.1	Data Representation	1
1.2	Types of Data Structures	
1.3	Abstract Data Type (ADT)	
2	**Linear ADTs**	
2.1	List – Arrays, Matrix, String	2
2.2	Applications– Array Problems, Matrix Problems, Strings problems	1
2.3	Stack ADT	2
2.4	Queue ADT	1
2.5	Circular Queue ADT	1
2.6	Linked List – Singly, Double, Circular Lists	3
2.7	Applications – Expression evaluation, Polynomial Evaluation, Josephus Problem, Middle Number, Palindrome checking	2
2.8	Recursion – Fibonacci, GCD	1
3	**Non-linear ADTs:** - Graphs –Graph Terminology –	
3.1	Trees	
3.1.1	Trees Terminology	1
3.1.2	Binary Tree traversals	1
3.1.3	Expression Tree	1
3.1.4	Binary Search Tree	2
3.1.5	AVL Tree	2
3.1.6	B-tree	2
3.1.7	Binary Heap	2
3.1.8	Applications – Dictionary, kth smallest element	1
3.2	Hash Table	
3.2.1	Hashing Techniques	2
3.2.2	Rehashing	

Module No.	Topic	No. of Periods
3.3	Graph	
3.3.1	Graph Terminology	1
3.3.2	Graph Representation	
3.3.3	Graph traversals	
3.3.4	Applications – Shortest path algorithm, Minimum Spanning Tree	2
4	**Algorithm Analysis:**	
4.1	Asymptotic Measures	1
4.2	Space Complexity	
4.3	Time Complexity	
5	**Searching and Sorting**	
5.1	Searching Techniques	
5.1.1	Sequential Search	1
5.1.2	Binary Search	
5.1.3	Search trees	
5.2	Sorting Techniques	
5.2.1	Bubble Sort	1
5.2.2	Insertion Sort	
5.2.3	Selection Sort	
5.2.4	Shell Sort	1
5.2.5	Quick Sort	
5.2.6	Merge Sort	1
5.2.7	Heap Sort	
	Total Lecture Hours	36

Course Designer(s):

A.M. Abirami, Associate Professor, Information Technology, abiramiam@tce.edu

22EE470	ELECTRICAL PROBLEM SOLVING USING COMPUTERS

Category	L	T	P	Credit
PCC	0	0	2	1

Preamble

The purpose of this course is to introduce to students to the field of programming using Python language. The students will be able to enhance their analyzing and problem solving skills and use the same for writing programs in Python. The programming will be done for electrical applications.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Solve the given problem statement using python programming concepts such as objects, data types, expression , statements, looping and	TPS3	80	70
CO2	Apply the concepts of functions, tuples, list, dictionary and string in design of simple applications	TPS3	80	70
CO3	Apply structured types, and file handling to design a solution for a problem of moderate complexity.	TPS3	80	70
CO4	Use packages and libraries in python programming for problem solving by reducing time and space complexity	TPS4	80	70
CO5	Apply the concepts of classes and objects in solving the problem using python programming.	TPS3	80	70
CO6	Develop a Python program for the given electrical problem / tasks	TPS4	80	70

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	S	M	L		S							M	S	S
CO 2	S	M	L		S							M	S	S

CO 3	S	M	L		S							M	S	S
CO 4	S	S	M	L	S							M	S	S
CO 5	S	M	L		S							M	S	S
CO 6	S	S	M	L	S			M	M	M		M	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	**Model Examination**	**Terminal Examination**
Remember		
Understand		
Apply	30	30
Analyse	40	40
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	**Mini project /Practical Component/Observation**
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

Experiment	CO
Simple Programs including print, input and computations	C01
Branching Programs	CO1
Looping Programs	CO1
String Programs	CO2
Programs handling functions	CO2
File handling with exceptions	CO3
Python programs to solve electrical engineering problems using libraries and packages	CO4

Programs including object oriented concepts	CO5
Mini-Project	CO6

Sample problems:

1. Determine the value of inductance / resistance / capacitance for the given specifications of materials.
2. Determine electric potential/electrical field / flux density for the given charge information.
3. Calculate energy stored in inductor/capacitor
4. Obtain the value of resistance for the given colour coding.
5. Solve the mesh/nodal equations of the given electrical circuit
6. Obtain the rating of fuse to be used in the mains for the given set of domestic loads.
7. Compute electric bill for a residential building.
8. Compute transient value of current/voltage in an electrical network at time "t".
9. Create a database of EB customer's data and retrieve necessary data.
10. Calculate the efficiency of a transformer/motor.
11. Obtain the voltage regulation for the given generator specifications.
12. Obtain the characteristics curve of diode/BJT/MOSFET.
13. Calculate the gain of electronics circuit including transistors/opamps
14. Calculate the equivalent Digital value of the analog input.

Reference Book & Web Resources

1. E. Bala gurusamy, "Introduction to Computing and Problem Solving using Python", Mcgraw Higher Ed, First Edition, 2016.
2. John V.Guttag, " Introduction to Computation and Programming Using Python : With Application to Understanding Data", Prentice-Hall International publishers, Second Edition, 2017.
3. ReemaThareja, "Python Programming using problem solving Approach", Oxford University, Higher Education Oxford University Press, First edition, 2017.
4. R.G.Dromey, "How to solve it by Computers", Pearson Education India , First Edition, 2008
5. NPTEL course "A joy of computing using python" , https://nptel.ac.in/courses/106106182/

Course Designers:

1. Dr.C.K.Babulal, Professor,EEE ckbeee@tce.edu
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3. Dr.S.Charles Raja, Associate Professor,EEE charlesrajas@tce.edu

22EE480	AC MACHINES LAB	Category	L	T	P	Credit
		PCC	0	0	2	1

Preamble

This laboratory gives a practical exposure to the students to fundamental concepts regarding AC Machines that are currently used in Electrical Systems. The students also learn to select the suitable AC Electrical Machines for an application based on its characteristics, perform suitable capacitor additions to improve power factor and to familiarize the standard testing procedures of AC Machines. The students can also perform evaluation of efficiency improvement by switching over to Adjustable speed drives.

Prerequisite

22EE320 DC Machines and Transformers

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Predetermination of efficiency of three phase Induction Motor	20
CO2	Obtain the performance characteristics of Induction Motor (Squirrel Cage, Slip ring, Single Phase)	20
CO3	Obtain the characteristics of Synchronous Motor	10
CO4	Obtain the voltage regulation of AC Generator (Salient Pole & Cylindrical Rotor type) by direct loading	20
CO5	Obtain the voltage regulation of AC Generators by indirect methods (EMF, MMF and ZPF) and by slip test.	20
CO6	Demonstrate experimentally synchronisation of alternator with busbar and the generator action of induction machine	10

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L		M	M	M	S	M			S		
CO2	S	M	L	L				M	S	M			S		

CO3	S	M	L	L				M	S	M			S		
CO4	S	M	L	L				M	S	M			S		
CO5	S	M	L	L		M	M	M	S	M			S		
CO6	M	L				M	S	M	S	M			M		

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand	10	10
Apply	40	40
Analyse	20	20
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject/Practical Component/Observation
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

E.No	Name of the experiment	CO	No. of sessions
Three Phase Induction Motor			
1.	Predetermination of Three-Phase Induction Motor efficiency using circuit model and circle diagram	CO1	1
2.	Performance Characteristics of Three-Phase Induction Motor by actual loading (squirrel cage, slip ring)	CO2	1
3.	Speed control of Three-Phase Induction Motor with VFD	CO2	1
Single Phase Induction Motor			
4.	Performance Characteristics of Single-Phase Induction Motor by actual loading	CO2	1
Synchronous Machines			
5.	V and inverted V curves of Synchronous Motor	CO3	1
6.	Voltage Regulation Characteristics of Alternators by direct load test	CO4	1
7.	Voltage Regulation characteristics of cylindrical rotor Alternator by indirect methods	CO5	1
8.	Slip test on Salient Pole Synchronous generator	CO5	1
9.	Synchronization of Alternators	CO6	1
Induction Generator			
10.	Load Characteristics of Induction Generator	CO6	1

Reference Books

1. H.Wayne Beaty & Jame. L.Kirtley.Jr " Electric Motor Handbook", McGraw-Hill, USA, 1st Edition, 1998.
2. A.K.Sawhney and A.Chakrabarti, "A course in Electrical Machine Design",6th Edition, Dhanpat Rai & Co (P) Ltd., 2006.
3. Gupta.J.B,"Theory of Performances of Electrical Machines' Katson, 7th Edition, 1987

Course Designer(s):

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Dr.D.Nelson Jayakumar, Asst Professor, EEE – dnjayakumar@tce.edu

22EE490	**PROJECT MANAGEMENT**		Category	L	T	P	Credit
			HSMC	3	0	0	3

Preamble

Project management has been proven to be the most effective method of delivering products within cost, schedule, and resource constraints. It provides the skills to ensure that the projects are completed on time and on budget while giving the user the product, they expect. This course gives strong working knowledge of the basics of project management and be able to immediately use that knowledge to effectively manage work projects.

Prerequisite

- **NIL**

Course Outcomes

On the successful completion of the course, students will be able to :

CO Number	Course Outcome	TPS	Expect Proficiency	Expected Level of Attainment
CO1	Explain the importance of project management and methodologies	TPS2	80	80
CO2	Prepare a project proposal and apply methods for project planning and analysis	TPS3	80	80
CO3	Apply methods to examine the risk and social cost benefit while implementing a project	TPS3	80	80
CO4	Identify the critical path and time in scheduling a set of project-activities	TPS3	80	80
CO5	Explain resource allocation and levelling and the use of PM software	TPS2	80	80
CO6	Outline the importance and various activities during project closure and prepare a project report	TPS3	80	80

Mapping with Programme Outcomes

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO1.	M	L						M		M				M
CO2.	S	M	L					M		M				S

CO3	S	M	L					M		M				S
CO4	S	M	L					M		M				S
CO5 .	M	L						M		M				M
CO6	S	M	L					M		M				S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5														10			
CO2	5	20	10				50								10			
CO3	10	30	20				50									20	10	
CO4				5	10	10					50						20	
CO5				5	20	20					50					20		
CO6				10	20											10		

Syllabus

Understanding Projects and Project management: Definition of Project & Project Management. Life cycle of Project. Project Management Methodologies and tools.

Project Selection & Appraisal: Project ideas generation, Pre-Feasibility Analysis -SWOT Feasibility Analysis-Market& Demand appraisal, Technical appraisal, Risk analysis Sensitivity analysis & Scenario Analysis. Economic Feasibility -SCBA-UNIDO approach. Preparing a detailed Project Proposal (Executive Summary).

Project Planning& Execution: Attributes & Definition of planning. WBS. Time Planning - PERT/CPM/Trade off. Material Planning - Procurement logistics & storage. Machines & Technology planning. Human Resource Planning in Project Organization. Quality Assurance Plan. Planning of Risk Management. Resource Allocation & Resource Levelling. Introduction & use of PM software.

Project Closure & Termination: Inspection. Testing. Transportation. Commissioning. Trial Run. Documentation required for Project Handover. Preparing a Project Report for Future Reference, Templates.

Reference Books

1. Prasanna Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review,Mc Graw Hill, 8th edition, 2015

2. Project planning and control using PERT and CPM, Dr.P.C.Punmia, Lakshmi publications, 2006
3. Project Management- A Managerial Approach to Planning, Scheduling, and Controlling Harold Kerzner, 10th edition John Wiley & Sons, Inc.
4. Project Management Institute (PMBOK) Guide, 5th Edition

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1	**Understanding Projects and Project management**:.	
1.1	Definition of Project & Project Management.	2
1.2	Life cycle of Project.	2
1.3	Project Management Methodologies and tools	2
2	**Project Selection & Appraisal:**	
2.1	Project ideas generation, Pre-Feasibility Analysis -	2
2.2	SWOT Feasibility Analysis-Market& Demand appraisal, Technical appraisal,	2
2.3	Risk analysis, Sensitivity analysis & Scenario Analysis.	2
2.4	Economic Feasibility -SCBA-UNIDO approach.	2
2.5	Preparing a detailed Project Proposal	2
3	**Project Planning& Execution:**	
3.1	Attributes & Definition of planning. WBS.	2
3.2	Time Planning - PERT/CPM/Trade off.	3
3.3	Material Planning - Procurement logistics & storage..	2
3.3	Machines & Technology planning. Human Resource Planning in Project Organization.	2
3.4	Quality Assurance Plan. Planning of Risk Management.	2
3.5	Resource Allocation & Resource Levelling. Introduction & use of PM software	2
4	**Project Closure & Termination:**	
4.1	Inspection. Testing. Transportation.	2
4.2	Commissioning. Trial Run.	2
4.3	Documentation required for Project Handover.	3
4.4	Preparing a Project Report for Future Reference, Templates	2
	Total	**36**

Course Designers:

1. Dr.D.Kavitha, Assistant Professor,EEE dkavitha@tce.edu

2. Dr.B.Ashok Kumar ,Assistant Professor,EEE ashokudt@tce.edu

		Category	L	T	P	Credit
22EE510	**GENERATION, TRANSMISSION AND DISTRIBUTION**	PCC	2	1	0	3

Preamble

This course introduces the overview of power generation from renewable and non-renewable energy sources. The determination of network parameters, modeling and performance analysis of transmission lines are included. The performance of insulators and underground cables, voltage and current calculation in distribution lines are also included.

Prerequisite

22EE230 : Electric Circuit Analysis

22EE240 : Electromagnetic Fields

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the generation of electric power using renewable and non-renewable energy sources.	TPS2	75	85
CO2	Calculate the line parameters of overhead transmission lines.	TPS3	75	85
CO3	Calculate the performance indices of transmission lines using nominal-T, π, rigorous methods and Power circle diagram.	TPS3	75	85
CO4	Explain the construction and performance of various types of insulators and underground cables.	TPS2	75	85
CO5	Calculate the string efficiency of suspension insulators.	TPS3	75	85
CO6	Calculate the voltage gradient of Underground cables.	TPS3	75	85
CO7	Calculate the voltages and currents for the given distribution System	TPS3	75	85

Mapping with Programme Outcome

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	**M**	**L**						**M**		**M**			**M**	
CO2	**S**	**M**	**L**					**M**		**M**			**S**	
CO3	**S**	**M**	**L**					**M**		**M**			**S**	
CO4	**M**	**L**						**M**		**M**			**M**	
CO5	**S**	**M**	**L**					**M**		**M**			**S**	
CO6	**S**	**M**	**L**					**M**		**M**			**S**	
CO7	**S**	**M**	**L**					**M**		**M**			**S**	

S-Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	10													2	10		
CO2	5	10	20				50								2		10	
CO3	5	10	20												2	5	10	
CO4	5	10					50								2	10		
CO5				2	10	10					25					5	10	
CO6				3	20	20					25				2	5	10	
CO7				5	10	20					50					5	10	
	20	40	40	10	40	50	100				100				10	40	50	

Syllabus

Generation of electrical power : Renewable and non-renewable energy sources - Schematic arrangement and operation of Thermal, Nuclear, Gas, Diesel, Hydro Electric, Wind, Solar, Geothermal and tidal power plants - Advantages and disadvantages

Modeling of Transmission lines - AC and DC transmission systems - Inductance and Capacitance Calculations - Single phase transmission lines - two wire system and composite conductors - Three phase transmission lines with unsymmetrical spacing, transposition of conductors, double circuit line – Bundled conductors - Skin effect, Proximity effect - Effect of earth on transmission line capacitance.

Performance of transmission lines – Performance of Short, Medium and Long transmission lines with Nominal-T, π and rigorous methods - ABCD constants - Power Circle diagram, Ferranti effect, Effect of Corona, Compensators - Series and Shunt.

Insulators and Cables - Overhead line insulators -Types of Insulators – Potential distribution over insulator string – Methods of Improving String Efficiency .

Underground cables - Construction and types - Single core and multi core cables - Capacitance, Insulation resistance, Electric stresses and Dielectric loss – Grading of Cables-Capacitance Grading and Inter-sheath Grading.

Distribution systems - AC and DC Distribution Systems – Feeders, distributors and service mains- Radial and ring main systems- Calculation of voltage and current in distributors fed at both ends with concentrated and distributed loads.

Text Books

1. C.L. Wadhwa - "Electrical Power system", New Age International-6th Edition – 2010.
2. C.L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", New Age International Publishers, Second Edition, 2006.

Reference Books& web resources

1. S.N. Singh, Electric Power Generation, Transmission and Distribution, Prentice Hall of India, ISBN – (978-81-203-36508), Second edition 2008.

2. Chetan Singh Solanki, Renewable Energy Technologies, PHI Learning Private Limited, New Delhi, 5th Printing, 2013.

3. B.R.Gupta, "Power System Analysis and Design", S.Chand& Co. pvt.ltd.,2015 Edition.
4. H. Cotton and H. Barber - Transmission and distribution of electrical energy – BI, New Delhi -1992.
5. S.L. Uppal - Electrical power, Khanna Publishers, 1996.
6. Soni ML and Gupta PV - A Textbook on Power Systems Engineering – Dhanpath Rai 1st Edition-1998.
7. IS 12360:1988 - Voltage Bands For Electrical Installations Including Preferred Voltages And Frequency
8. T.S.M. Rao - Principles and practice of electric power transfer systems, 1994.
9. 141-1993 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants.
10. http://nptel.ac.in/courses

Course Contents and Lecture Schedule

Module No.	Topic	No. Hours	Course Outcome
1.0	**Generation of electrical power**		
1.1	Renewable and non-renewable energy sources	1	CO1
1.2	Schematic arrangement and operation of the following power plants :		
	Thermal, Nuclear, Gas, Diesel, Hydro Electric	2	CO1
	Wind, Solar, Geothermal, tidal	2	CO1
1.3	Advantages and disadvantages	1	CO1
2.0	**Modeling of Transmission lines**		
2.1	AC and DC transmission systems	1	CO2
2.2	Inductance and Capacitance calculations of	2	CO2
2.3	Single phase transmission lines - two wire system, and composite conductors	2	CO2
2.4	Three phase transmission lines - unsymmetrical spacing, transposition of conductors	3	CO2
2.5	Double circuit line, Bundled conductors	2	CO2
2.6	Skin effect, Proximity effect, Effect of earth on transmission line capacitance.	1	CO2
3.0	**Performance of transmission lines**		
3.1	Performance of Short, Medium and Long transmission lines with Nominal-T, π and rigorous methods - Generalized (ABCD) constants	3	CO3
3.2	Power Circle diagram	1	CO3
3.3	Ferranti effect, Effect of Corona	2	CO3
3.4	Compensators -Series and Shunt	1	CO3
4.0	**Insulators and Cables**		
4.1	Overhead line insulators -Types of Insulators	1	CO4
4.2	Potential distribution over insulator string – Methods of Improving String Efficiency.	2	CO5
4.3	Underground cables - Construction and types - Single core and multi core cables.	2	CO4
4.4	Capacitance, Insulation resistance, Electric stresses and Dielectric loss	2	CO4
4.5	Grading of Cables - Capacitance Grading and Inter-sheath Grading	2	CO6
5.0	**Distribution systems**		
5.1	AC and DC Distribution Systems - Feeders, distributors and service mains- Radial and ring main systems	1	CO7
5.2	Calculation of Voltage and current in distributors fed at two ends with concentrated and distributed loads	2	CO7
	TOTAL	**36**	

Course Designers:

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22EE520	**MICROCONTROLLERS**	Category	L	T	P	Credit
		PCC	2	1	0	3

Preamble

Microprocessors are the predecessors to Microcontrollers, and they are mainly used as CPU in the desktop computers and laptops nowadays and they are also used for measurement and control applications in the past few decades. Due to the development in VLSI technology, microcontrollers evolve which function similar to Microprocessors, but they have most of the peripherals built on-chip. Microcontroller is used as the main controller in most of the embedded systems nowadays. This course makes the students to be familiar with the architecture and programming of Microcontrollers. Introduction to Microprocessors and their evolution is also given. This course provides a detailed study of architecture, assembly language & embedded 'C' language programming of Intel 8051 Microcontroller and interfacing various peripherals with 8051 and ATmega328 Microcontroller architecture.

Prerequisite

- 22EE250 – Digital Systems

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the evolution and architecture of microprocessors and microcontrollers.	TPS2	70	60
CO2	Explain the architecture and the function of on-chip hardware units in 8051 Microcontroller.	TPS2	70	60
CO3	Develop 8051 Assembly Language programs for data manipulations.	TPS3	70	60
CO4	Explain the architecture and hardware features of ATmega328p Microcontroller	TPS2	70	60
CO5	Develop 8051 based embedded C programs for interfacing LED, Matrix Keyboard, LCD, DAC, ADC, 7 segment LED Display and Stepper/DC Motors.	TPS3	70	60
CO6	Develop 8051 based embedded C programs for real time applications	TPS3	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L						M		M				M	
CO2	M	L						M		M				M	
CO3	S	M	L					M		M				S	
CO4	M	L						M		M				M	
CO5	S	M	L					M		M				S	
CO6	S	M	L					M		M				S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	10													4			
CO2	20	40													4	10		
CO3			20			25									4	10	10	
CO4				**10**	20										4	10		
CO5				10	5	15									4		30	
CO6					5	10	100				100						10	
	30	50	20	20	30	50									20	30	50	

Syllabus

Introduction: Introduction to Microprocessor and Microcontroller – Evolution – Architecture of Microprocessor -Von Neumann and Harvard architecture – CISC and RISC — Comparison of Microprocessor and Microcontroller – Overview of 8/16/32/64-bit Microprocessors and Microcontrollers, GPUs, and Mobile Processors – Introduction to ARM Microcontroller family, Applications of Microprocessors and Microcontrollers - Selection of Microcontroller for an application.

8051 Microcontroller:8051 Architecture – Pin details- Timing Diagram - Memory - Parallel Ports - Counters/Timers – Interrupts - Serial port.

8051 Assembly Language Programming: Addressing modes, Instruction set of 8051, Basic Assembly language Programming – Arithmetic operations – Code conversions –Look up tables – subroutines

Embedded 'C' Programming: Introduction to Schematic based Simulators and IDE – Embedded C Data Types-Program structure

8051 Interfacing with Peripherals using Embedded 'C': LED - Matrix Keyboard – LCD – DAC – ADC – 7-segment LED Display – Stepper Motor, DC Motor - Real time applications – Measurement of Weight, Temperature and Motor Speed - Case Studies: Washing Machine Control and Elevator Control.

ATmega328p Microcontroller: Architecture- I/O Ports - Watchdog timer-Fast PWM generation using Output Compare unit and Input Capture unit in 16 bit Timer1-On chip ADC.

Text Book

1. Muhammad Ali Mazidi, Janice GillispieMazidi, and Rolin D. McKinlay,The 8051 Microcontroller and Embedded Systems, (second edition), 2006 Pearson Education, Inc.
2. Thomas Grace, Programming and Interfacing ATMEL® AVR® Microcontrollers, Cengage Learning PTR, 2016.

Reference Books& web resources

1. Ajay V.Deshmukh, Microcontrollers- Theory and applications, Tata McGraw-Hill, publisher,2005.
2. N.Senthilkumar, M.Saravanan, S.Jeevanandhan, Microprocessors and Microcontrollers, Oxford university press, 2010.
3. P.S.Manoharan, P.S.Kannan, Microcontroller based system design, ScitechPublications Pvt. Ltd., Chennai, 2007.
4. Kenneth .J. Ayala, The 8051 Microcontroller, Architecture, Programming & Applications (third edition), Penram International, India (2004).
5. René Beuchat, Florian Depraz, Andrea Guerrieri, SahandKashani, Fundamentals of System-on-Chip Design on Arm® Cortex®-M Microcontrollers, Arm Education Media , 2021.
6. http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf
7. B. Kanta Rao,Embedded Systems, PHI Learning Pvt. Ltd., Second Printing, 2013.
8. https://nptel.ac.in/courses/108105102/ (Microprocessors and Microcontrollers)
9. https://www.arm.com/resources/education/books
10. https://www.instructables.com/circuits/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Introduction**		
1.1	Introduction to Microprocessor and Microcontroller– Evolution - Architecture of Microprocessor	1	CO1
1.2	VonNeuman and Harvard architecture – CISC- RISC	1	CO1
1.3	Comparison of Microprocessor and Microcontroller	1	CO1
1.4	Overview of 8/16/32/64-bit Microprocessors and Microcontrollers	1	CO1
1.5	GPUs and Mobile Processors, Introduction to ARM Microcontroller family	1	CO1

1.6	Application of Microprocessors and Microcontrollers - Selection of Microprocessors for an application	1	CO1
2.	**8051 Microcontroller**		
2.1	8051 Architecture, Pin details	1	CO2
2.2	Timing diagram, Memory	1	CO2
2.3	Parallel Ports	1	CO2
2.4	Counters/Timers	1	CO2
2.5	Interrupts	1	CO2
2.6	Serial port	1	CO2
3.	**8051 ALP Programming**		
3.1	Addressing modes	1	CO3
3.2	Instruction set of 8051	2	CO3
3.3	Basic Assembly language Programming – Arithmetic operations	1	CO3
3.4	Code conversions - Sorting	1	CO3
3.5	Look up tables – Subroutines	1	CO3
4	**Embedded 'C' Programming**		
4.1	Introduction to Schematic based Simulators and IDE	1	CO5
4.2	Embedded C Data Types-Program structure	1	CO5
5	**8051 Interfacing with Peripherals using Embedded 'C'**		
5.1	LED, Matrix Keyboard	2	CO5
5.2	Liquid Crystal Display	1	CO5
5.3	DAC	1	CO5
5.4	ADC	1	CO5
5.5	7 segment LED Display	1	CO5
5.6	Stepper Motor/DC Motor.	2	CO5
5.7	Real time applications - Measurement of Weight, Temperature and Motor Speed	1	CO6
5.8	Case Studies: Washing Machine Control and Elevator Control.	1	CO6
6.	**ATmega328p Microcontroller**		
6.1	Architecture- I/O Ports- Watchdog timer	1	CO4
6.2	Fast PWM generation using Output Compare unit and Input Capture unit in 16-bit Timer1	2	CO4
6.3	On chip ADC	1	CO4
	Total	**36**	

Course Designer(s):

1. Dr.L.Jessi Sahaya Shanthi, Associate Professor,EEE ljseee@tce.edu

2.Dr.P.S.Manoharan Professor,EEE psmeee@tce.edu

		Category	L	T	P	Credit
22EE530	**ELECTRIC DRIVES**	PCC	3	0	0	3

Preamble

Electric Drives are designed to control the motion of electrical machines. It is considered an important component of various industrial processes equipment as it helps in easy optimization of motion controlling**.** Electric Drives, both ac and dc types, come in many shapes and sizes. Some drives 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 the rating. 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.

Course Outcomes

On the successful completion of the course, students will be able to

CO No.	**COURSE OUTCOMES**	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Make a drive for particular applications	TPS3	75	80
CO2	Design controlled rectifier based dc drive	TPS3	75	80
CO3	Design various dc to dc converter topology based dc drive	TPS3	75	80
CO4	Explain speed control of inverter fed induction motor and synchronous motor drives	TPS2	75	80
CO5	Explain speed control of traction drives, solar and battery powered drives	TPS2	75	80
CO6	Analyze different electric drives using MATLAB/Simulink, PLECS and PSIM	TPS4	75	80

Mapping with Programme Outcomes and Programme specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L					M		M				S	
CO2	S	M	L					M		M				S	
CO3	S	M	L					M		M				S	
CO4	M	L						M		M				M	
CO5	M	L						M		M				S	
CO6	S	S	M	L	S			M		M				L	

S- Strong; M-Medium; L-Low

Assessment pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	15	25				20								5	5	10	
CO2	10	15	25				40								5	5	10	
CO3				5	5	50	40								5	5	30	
CO4				**5**	15										5	5		
CO5				10	10											10		
CO6											50	50						

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- Speed Estimation methods

Synchronous Motor Drives - Speed control - Inverter fed synchronous motors – Vector control of Synchronous motor

Traction and Solar powered Drives - Speed control of Traction drives - Solar and battery powered drives

Simulation of Electrical Drive Systems: DC motor drives- Induction motor drives.

Text Book

1. 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. Muhammad H.Rashid, Power Electronics Circuits, Devices & Applications - Pearson Education India Publication, New Delhi, 11th Edition, 2007.
3. Ned Mohan, Tore Undeland & William Robbins, Power Electronics: converters Applications and Design-John Willey and sons 2003.
4. R.Krishnan - Electric motor drives – Modeling, analysis and control, Pearson Education, New Delhi, 2003.
5. Peter Vas - Sensorless, Vector and Direct Torque Control, Oxford University Press, 1998.

Course Contents and Lecture Schedule

S.No.	Topic	Duration (Hours)	CO
1.	**Electric Drives**		
1.1	Advantage of Electric Drives - Parts and choice of Electrical Drives	1	CO1
1.2	DC and AC drives	1	CO1
1.3	Torque-speed characteristics of motor and load - Selection of Motor power rating	2	CO1
1.4	Thermal model of motor for heating and cooling - Classes of duty cycle - Determination of motor rating	2	CO1
1.5	Control of Electric drives - Modes of operation - Speed control and drive classifications	2	CO1
1.6	Closed loop control of drives	1	CO1
2.	**DC Motor Drives**		
2.1	DC motor and their performance	1	CO2
2.2	Speed control and Braking methods	2	CO2
2.3	Controlled rectifier fed DC drives	2	CO2
2.4	Chopper controlled DC drives	2	CO3
3.	**Induction Motor Drives**		
3.1	Speed control	2	CO4
3.2	VSI fed induction motor drives	2	CO4
3.3	Rotor resistance control and slip power recovery scheme - Static control of rotor resistance using DC	2	CO4

	chopper		
3.4	Vector control of induction motor	2	CO4
3.5	Speed Estimation methods	1	CO4
4.	**Synchronous Motor Drives**		
4.1	Speed control of three phase synchronous motors	1	CO1
4.2	VSI fed synchronous motors	2	CO6
4.3	Vector control of Synchronous motor	1	CO6
5.	**Traction and Solar powered Drives**		
5.1	Speed control of Traction drives	2	CO5
5.2	Solar powered drives	1	CO5
5.3	Battery powered drives	1	CO5
6.	**Simulation of Electrical Drive Systems**		
6.1	DC motor drive systems	1	CO6
6.2	Induction motor drive systems	2	CO6
	Total	36	

Course designers

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22EE540	POWER SYSTEM ANALYSIS	Category	L	T	P	Credit
		PCC	3	0	0	3

Preamble

The objective of the course is to instil confidence and understanding of the fundamental concepts of power system analysis. This course provides an exposure of representation of power system, formulation of network matrices, methods of solving power flow equations, symmetrical fault analysis, and symmetrical component method of unsymmetrical fault analysis and stability studies.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Develop a mathematical model of a power system under steady state operating condition by single line diagram and per unit notations.	TPS3	70	85
CO2	Apply direct inspection and singular transformation methods to determine Y-bus matrix of the given system.	TPS3	70	85
CO3	Describe the concept of load flow problem formulation and various numerical methods of solution.	TPS2	80	80
CO4	Calculate the fault current for various types of symmetrical faults on the given power system.	TPS3	70	85
CO5	Calculate the fault current for various types of unsymmetrical faults on the given power system.	TPS3	70	85
CO6	Explain the role of stability, swing equation and equal area criterion.	TPS2	80	80

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	L						M			M	
CO2	S	M	L	L						M			M	
CO3	M	L								M			M	
CO4	S	M	L	L						M			M	
CO5	S	M	L							M			M	
CO6	M	L								M			M	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	4	10	20	--	--	--	--	--	--	--	--	--	--	--	10		10	
CO2	6	10	30	--	--	--	50	--	--	--	--	--	--	--			15	
CO3	10	10	--	--	--	--	50	--	--	--	--	--	--	--		30		
CO4	--	--	--	4	10	25	--	--	--	--	50	--	--	--	10		15	
CO5	--	--	--	6	10	25	--	--	--	--	50	--	--	--			10	
CO6	--	--	--	10	10	--	--	--	--	--		--	--	--		30		
	20	30	50	20	30	50	100				100				20	30	50	

Syllabus

An Overview and Modelling of the Power System: Introduction - Structure of Electric Power System - Modelling of Power System Components - Single line diagram - Impedance Diagram - Reactance Diagram - Per unit System - Network Modelling - Bus Frame Network - Primitive Network - Incident Matrices - Formation of bus admittance matrix (Y_{BUS}) - Direct Inspection method and Singular transformation methods - Formation of bus impedance matrix (Z_{BUS}) without mutual coupling.

Power Flow Analysis: Introduction – Bus Classification – Load Flow Equations – Load flow methods – Gauss-Seidel Method – Newton-Raphson Method – Fast Decoupled Method – Computation of slack bus power and transmission line losses – Comparison of above methods.

Symmetrical Fault Analysis: Introduction – Types of Faults – Short circuit analysis of power system components: Synchronous Machine and Transmission Line – Short circuit current calculation using Thevenin's theorem and Bus Impedance Matrix – Short circuit capacity – Selection of circuit breakers.

Unsymmetrical Fault Analysis: Introduction – Symmetrical Components – Sequence Impedances – Sequence Network of power system components: Synchronous Machines, Transmission Line, Transformer and Loads – Single Line to Ground Fault – Line to line Fault – Double Line to Ground Fault – Unsymmetrical fault analysis using bus impedance matrix. Indian Standards for Short Circuit analysis IS-13234.

Power System Stability: Introduction – Classification of Power System Stability – Power Angle Equations – Swing Equation – Transient Stability – Assumptions in transient stability analysis – Equal Area Criterion – Solution of Swing Equation: Step By Step Methods, Euler's method, Modified Euler's Method and Runge – Kutta Method – Critical clearing angle and time.

Reference Books & Web Resources

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. P. Venkatesh, B. V. Manikandan, S. Charles Raja and A. Srinivasan, 'Electrical Power Systems: Analysis, Security and Deregulation', PHI Learning Pvt. Ltd., First Edition, 2012.
4. Hadi Saadat., 'Power System Analysis' Tata McGraw Hill Publishing Company, New Delhi, 2002.
5. E.W.Kimbark, Power system stability, Vol I & III, John Wiley & Sons, 2006
6. **Stagg**, *G.W. and* **El-Abiad**, A.H., Computer Methods in **Power System** Analysis", McGraw-Hill **Book** Co. 1968
7. K.A. Gangadhar., 'Electric Power Systems (Analysis, Stability and Protection)', Khanna Publishers Second Edition, 1992.
8. J. Duncan Glover, Thomas Overbye, Mulukutla S. Sarma,'Power System Analysis and Design' Cengage learning, 5th edition, 2016.
9. www.schneider-electric.com
10. NPTEL courses web: nptel.ac.in/courses/108105067/
11. MOOCs course link:https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods

1	**An Overview and Modelling of the Power System**	
1.1	Structure of Electric Power System – Modeling of Power System Components.	1
1.2	Single line diagram – Impedance Diagram – Reactance Diagram.	1
1.3	Per unit System – Network Modeling – Bus Frame Network – Primitive Network – Incident Matrices.	2
1.4	Formation of bus admittance matrix (Y_{BUS}) – Direct Inspection method and Singular transformation method.	2
1.5	Formation of bus impedance matrix (Z_{BUS}) without mutual coupling	1
2.	**Power Flow Analysis**	
2.1	Bus Classification, Load Flow Equations	2
2.2	Load flow methods: Gauss-Seidel Method, Newton Raphson Method and Fast Decoupled Method	4
2.3	Computation of slack bus power and transmission line losses, Comparison of above methods	2
3	**Symmetrical Fault Analysis**	
3.1	Types of Faults, Short circuit analysis of power system components: Synchronous Machines and Transmission Line	2
3.2	Short circuit current calculation using Thevenin's theorem and Bus Impedance Matrix	2
3.3	Short circuit capacity, Selection of circuit breakers.	2
4	**Unsymmetrical Fault Analysis**	
4.1	Symmetrical Components, Sequence Impedances, Sequence Network of power system components: Synchronous Machines, Transmission Line, Transformer and Loads	2
4.2	Single Line to Ground Fault, Line to line Fault, Double Line to Ground Fault	3
4.3	Unsymmetrical fault analysis using bus impedance matrix. Indian Standards for Short Circuit analysis IS-13234.	2
5	**Power System Stability**	
5.1	Classification of Power System Stability, Power Angle Equations, Swing Equation.	2
5.2	Transient Stability, Assumptions in transient stability analysis, Equal Area Criterion	2
5.3	Solution of Swing Equation: Step By Step Methods, Euler's method, Modified Euler's Method and Runge - Kutta Method	3
5.4	Critical clearing angle and time	1
	Total	**36**

Course Designers:

1. Dr. P. Venkatesh,Professor,EEE pveee@tce.edu
2. Dr. C.K. Babulal ,Professor,EEE ckbeee@tce.edu
3. Dr. S. Charles Raja,Associate Professor,EEE charlesrajas@tce.edu

22EE550	OBJECT ORIENTED PROGRAMMING

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

This syllabus is intended for Electrical Engineering students and enables them to learn Object Oriented Programming and the design of computer solutions in a precise manner. The syllabus emphasizes OOP concepts, Functions, Polymorphism, Inheritance and I/O. The intention is to provide sufficient depth in these topics to enable students to apply Object Oriented approach to programming. The modules in the syllabus reflect solving general problems via programming solutions. Thus, modules collectively focus on programming concepts, strategies and techniques; and the application of these toward the development of programming solutions.

Prerequisite

Programming fundamentals

Course Outcomes

Upon the successful completion of the course, the students will be able to

CO. No	Course Outcomes (COs)	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Construct Object-oriented programs using methods and passing arrays, objects, and an array of objects to them	TPS1	70	85
CO2	Demonstrate Compile-time and Run-time polymorphism using object-oriented programs	TPS2	70	85
CO3	Illustrate the relationships between objects using inheritance	TPS3	70	85
CO4	Develop Object Oriented programs to handle data using Files	TPS3	70	85
CO5	Develop Object Oriented programs to handle exceptions	TPS3	70	85
CO6	Develop Object Oriented programs to demonstrate event-driven programming, concurrent programming and network programming.	TPS3	70	80

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			Assignment 1				Assignment 2				Terminal Examination		
TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**1**	**2**	**3**
CO1	10	10	10	-	-	-	30	-	-	-	-	-	-	-	3	6	6
CO2	10	10	10	-	-	-	30	-	-	-	-	-	-	-	3	6	6
CO3	10	10	20	-	-	-	40	-	-	-	-	-	-	-	3	7	7
CO4	-	-	-	6	10	10	-	-	-	-	30	-	-	-	3	7	7
CO5	-	-	-	7	15	15	-	-	-	-	30	-	-	-	4	7	7
CO6	-	-	-	7	15	15	-	-	-	-	40	-	-	-	4	7	7

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	L	-	-	L	L	L	L	L	M	L	L
CO2.	S	M	L	L	L	-	-	L	L	L	L	L	M	L	L
CO3	S	M	L	L	L	-	-	L	L	L	L	L	M	L	L
CO4	S	M	L	L	L	-	-	L	L	L	L	L	M	L	L
CO5	S	M	L	L	L	-	-	L	L	L	L	L	M	L	L
CO6	S	M	L	L	L	-	-	L	L	L	L	L	M	L	L

S- Strong; M-Medium; L-Low

Syllabus

Object Oriented Programming Concepts: Introduction to Object-oriented programming and concepts - Instance fields and Member function - Access modifiers.

Classes and Objects: Constructors – Passing arguments to a method – Returning value from a method – Passing arrays as arguments to methods – Passing objects to methods - Returning objects from methods.

Polymorphism: Overloading & Overriding.

Inheritance: Base and derived classes - Access control and inheritance - Types of inheritance - Multiple inheritance.

Data Abstraction: Interface - Abstract class.

File Handling: Java I\O classes and interfaces – Directories – Streams – Serialization. **Exception Handling:** Improper termination of a program – Introduction to exception handling - Exception class and types of exception - exception handling.

Event-Driven Programming, Concurrent and Network programming: Text-related GUI components – other GUI components – Handling mouse events and button events – Thread life cycle and methods – Runnable interface – Thread synchronization – Basics of network programming.

Reference Books

1. Tony Gaddis, “Starting Out with Java: From Control Structures through Objects”, Sixth edition, Pearson Education Limited, 2016.
2. Bart Baesens, Aimee Backiel, SeppevandenBroucke, “Beginning Java Programming: The Object-Oriented Approach”, John Wiley & Sons, 2015.
3. Herbert Schildt: “Java: The Complete Reference”, Tenth Edition, McGraw-Hill, 2017.
4. Kenneth L. Calvert and Michael J. Donahoo, “TCP/IP Sockets in Java: Practical Guide for Programmers”, 2nd Edition. Elsevier, 2011.
5. Grady Booch, Robert Maksimchuk, Michael Engel, Bobbi Young, Jim Conallen, Kelli Houston“ Object Oriented Analysis and Design with Applications”, Third Edition, 2012

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**Object-Oriented Programming Concepts (5)**		
1.1	Introduction to Object-oriented programming	1	CO1
1.2	Object-oriented programming concepts	2	CO1, CO2
1.3	Instance fields and member function	1	CO1
1.4	Access modifiers	1	CO1
2	**Classes and Objects (5)**		
2.1	Constructors	1	CO1
2.2	Function prototype(s)	1	CO1
2.3	Passing arguments to a Method – Returning value from a method	1	CO2

2.4	Passing arrays as arguments to methods	1	CO1
2.5	Passing objects to methods - Returning objects from methods	1	CO1
3	**Polymorphism (3)**		
3.1	Introduction to polymorphism	1	CO2
3.2	Function overloading	1	CO2
3.3	Function overriding and super keyword	1	CO2
4	**Inheritance (3)**		
4.1	Base and derived classes	1	CO3
4.2	Access control and types of inheritance	1	CO3
4.3	How to handle multiple inheritance	1	CO3
5	**Data Abstraction (3)**		
5.1	Interface	1	CO3
5.2	Handling multiple inheritance through an interface	1	CO3
5.3	Abstract class – Declaration and definition – Difference between interface and abstract class	1	CO3
Continuous Assessment Test - I			
6	**File Handling and Exception Handling (9)**		
6.1	The Java I/O classes and interfaces	1	CO4
6.2	Files - Directories - Using FilenameFilter - The listFiles( ) alternative - Creating Directories	1	CO4
6.3	The Stream classes	1	CO4
6.4	Serialization	1	CO4
6.5	Improper termination of a program – Introduction to exception handling	1	CO5
6.6	Exception class and types of exception	2	CO5
6.7	try, throw, throws, catch and finally keyword	2	CO5
7	**Event-Driven Programming, Concurrent and Network programming (8)**		
7.1	GUI components – Text and other components	1	CO6
7.2	Button and mouse event handling	2	CO6
7.3	Thread life cycle and methods	1	CO6
7.4	Runnable interface	1	CO6
7.5	Thread synchronization	2	CO6
7.6	Basics of network programming	1	CO6
Continuous Assessment Test - II			

Course Designers:

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2. Mr S.Santhana Hari, Assistant Professor ,EEE sshcse@tce.edu

		Category	L	T	P	Credit
22EE570	**MEASUREMENT AND CONTROL LAB**	PCC	-	-	2	1

Preamble

This course includes the measurement of electric and non electric parameters such as voltage, current, power, energy, temperature and displacement using Sensors/Meters. The characteristics of Sensors/Transducers and RLC measurement using bridges are included. This course also introduces the computer based design, implementation and analysis of compensators and controllers for the given control system. Exposure to PLC based control of sequential processes is also included.

Prerequisite

22EE440 Control Systems

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale
CO1	Measure Voltage, Current, Power and Energy using Sensors/Meters by Direct Data Acquisition.	TPS3
CO2	Obtain the static and dynamic characteristics of the given Sensor/Transducer.	TPS3
CO3	Measure Resistance, Inductance and Capacitance using bridge circuits.	TPS3
CO4	Analyze the time and frequency responses of the given system using simulation tools.	TPS4
CO5	Analyze the performance of the given control system with cascade compensators using simulation tools.	TPS4
CO6	Analyze the performance of the given tank level control system with PID controller.	TPS4
CO7	Develop the PLC based Ladder logic diagram to control the sequential operations of the given hardware system.	TPS3

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	L	S			M		M			S	S	
CO2	S	M	L	L				M		M			S	S	
CO3	S	M	L	L				M		M			S	S	
CO4	S	S	M	L	M			M		M			S	S	
CO5	S	S	M	L	M			M		M			S	S	
CO6	S	M	L		M			M		M			S	S	
CO7	S	M	L		M			M		M			S	S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	35	35
Analyse	35	35
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Practical Component/Observation
Perception	
Set	
Guided Response	

Mechanism	
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

Experiments on Measurements:

1. (a) Measurement of True RMS and Average values of AC quantities using LabVIEW. CO1

   (b) Calculation of Peak factor and Form factor. CO1

2. Measurement of power using CT- PT. CO1

3. Measurement of Energy using Net metering mechanism. CO1

4. (a) Measurement of displacement using LVDT. CO2

   (b) Measurement of Temperature using RTD/Thermistor. CO2

5. Measurement of R L C using bridge circuits. CO3

Experiments on Control:

1. a)Obtain the Transfer function for the given Electrical network. CO4

   b)Time response and Frequency response Analysis using MATLAB. CO4

2. Design and implementation of compensator for a closed loop control system. CO5

3. Design and implementation of PID controller for a LabVIEW based tank level control system. CO6

4. Sequential control of processes using PLC(Elevator Control Systems, Dozing pump control system. CO7

Text Books

1. A.K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co, 2012.

2. Norman S. Nise, Control Systems Engineering, 6th edition, John Wiley,2010. (Indian edition).

3.J Nagrath and M Gopal, Control Systems engineering, 5th Edition, New Age International, 2007.

Reference Books& web resources

1. E.O. Doebelin, Measurement Systems – Application and Design, Tata McGraw Hill publishing company, 2003.

2. Kalsi H.S, Electronic Instrumentation , Tata McGraw-Hill 2003 LR2.

3. Robert H Bishop and Richard C Dorf, Modern Control Systems, 12th Edition, Pearson Education, 2010.

4. B.C. Kuo, and F.Golnaraghi, Automatic Control Systems, 9th Edition. Wiley India Pvt limited 2014. (Student edition)

5. Katsuhiko Ogata, Modern Control Engineering, 5th edition, PHI, 2010

Course Designers:

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3. Dr.N.Shanmuga Vadivoo, Professor,EEE nsveee@tce.edu

		Category	L	T	P	Credit
22EE580	**MICROCONTROLLERS LAB**	PCC	0	0	2	1

Preamble

Microcontroller is used as the main controller in most of the embedded systems nowadays. This course makes the students to be familiar with the assembly language and Embedded 'C' language programming of 8051 and ATmega328P microcontroller for interfacing various peripherals and for performing them through simulation using software tools.

Prerequisite

22EE250-Digital Systems

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage
CO1	Analyze 8051 microcontroller-based assembly language programs and embedded 'C' programs to implement basic operations by software tools.	20
CO2	Analyze 8051 embedded 'C' programs for accessing on-chip hardware units such as timer/counter, interrupts and serial communication.	15
CO3	Analyze 8051microcontroller based embedded 'C' programs for Keyboard and display interface.	15
CO4	Analyze 8051 based embedded 'C' programs for ADC and DAC interfacing and Motor control,	10
CO5	Analyze 8051 microcontroller based embedded 'C' programs to implement the given application through simulation by software tools.	20
CO6	Develop 8051/ATmega328P microcontroller based system for real world applications.	20

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	S	M	L					M		M				S	
CO2	S	M	L					M		M				S	
CO3	S	M	L					M		M				S	
CO4	S	M	L					M		M				S	
CO5	S	S	M	L	S			M		M				S	
CO6	S	S	M	L	S			M		M				S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	45	45
Analyse	30	30
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	~~Miniproject~~/Practical Component/~~Observation~~
Perception	
Set	
Guided Response	
Mechanism	25
Complex Overt Responses	

Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

List of Experiments:

Module – 1 (CO1)

- Use of software simulation tools
- Evaluation of arithmetic expressions

Module -2 (CO2)

- Timer/Counter applications with and without interrupts: (i) square wave generation (ii) Frequency measurement
- Serial communication (I^2C, UART) and Parallel communication.

Module - 3 (CO3 &CO4)

- Control of illumination of LED string / Traffic light
- Keyboard and Seven segment LED interfacing
- ADC and DAC interfacing
- Speed control of DC motor / Stepper motor

Module - 4 (Applications/Product) (CO5 & CO6)

- Automatic Toll gate
- Smart Energy meter
- PWM generator
- Smart Voltmeter/ Power meter /Power factor meter
- IoT applications such as Smart home, Smart grid, Smart city, Agriculture, Health care, Security applications

Reference Books & Web Resources

1. Ajay V.Deshmukh, “Microcontrollers- Theory and applications”, Tata McGraw-Hill, publisher,2005.
2. The 8051 Microcontroller and Embedded Systems, (second edition). By Muhammad Ali Mazidi, Janice GillispieMazidi, and Rolin D. McKinlay © 2005 Pearson Education, Inc
3. N.Senthilkumar, M.Saravanan, S.Jeevanandhan, “Microprocessors and Microcontrollers”, Oxford university press, 2010.
4. P.S.Manoharan, P.S.Kannan, “Microcontroller based system design”, ScitechPublicationsPvt. Ltd., Chennai, 2007.
5. http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf
6. https://nptel.ac.in/courses/108105102/ (Microprocessors and Microcontrollers)
7. UNIVERSAL EMBEDDED TRAINER (VUET-REV0) – Manual
8. https://www.instructables.com/circuits/

Course Designers:

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22EE610	ACCOUNTING AND FINANCE

Category	L	T	P	C	Terminal Exam Type
HSMC	3	-	-	3	Theory

Preamble

The engineering profession involves lots of decision-making. The decisions may range from operation to non-operation. For making decisions of these kinds, an engineer needs other data about the organization's routine and non-routine operations. Accounting is a science that provides all the data by recording, classifying, summarizing, and interpreting the various transactions taking place in an organization and thereby helps an engineer in effectively taking vital decisions. Finance is an allied but separate field relying on accounting and enables engineers to taking useful financial and cost-related decisions by providing well-defined concepts, tools, and techniques

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency	Expected Attainment
CO1	Prepare accounting financial statements and analyze them.	TPS4	70	70
CO2	Perform cost sheet, depreciation, and its applications in Electrical appliances.	TPS3	70	70
CO3	Compute various types of budgets in an organization	TPS3	70	70
CO4	Compute break-even analysis and activity-based costing systems for business applications.	TPS3	70	70
CO5	Compute working capital requirements and long-term investment decisions.	TPS3	70	70
CO6	Apply the appropriate sources of finance and mobilize the right quantum of finance and use them in the most profitable investment avenues	TPS3	70	70

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L	-	-	L	L	M	M	S	S	S	--	--
CO2	S	M	L	-	-	-	L	M	M	S	S	M	M	--
CO3	S	M	L	-	-	-	-	M	M	S	S	S	--	--
CO4	S	M	L	-	M	L	L	M	M	S	S	M	--	--
CO5	S	M	L	-	S	L	M	M	M	S	M	M	--	--
CO6	S	M	L	-	-	L	L	M	M	S	S	S	--	--

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory								Theory						Theory			
	Assessment-1								Assessment-2						Terminal Examination			
	Assignment-1				CAT-1				Assignment-2			CAT-2						
TPS / COs	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2	3	4
CO1				20		10		20							-	5		10
CO2			40		5	10	20								2	5	10	
CO3			40		5	10	20								2	5	10	
CO4											35	4	10	20	2	5	10	
CO5											35	4	10	20	2	5	10	
CO6											30	2	10	20	2	5	10	

Syllabus

Accounting – Introduction, definition, accounting principles-functions of accounting -– Preparation of Financial statements and their analysis.

Cost Accounting - Meaning and importance -Elements of cost- classification of cost- Cost center, Preparation of cost sheet for electrical components and their applications. Depreciation – meaning and causes of depreciation, Methods to find out the depreciation

Budget and Budgetary control- Introduction- Meaning -objectives of budgetary control –Budget-Types of budgets and their preparation.

Marginal costing- Introduction, Break-even analysis – Managerial of break-even analysis. Activity-based Costing

Capital budgeting- Meaning and features, capital budgeting decisions, Methods of evaluating capital budgeting decisions by traditional and modern methods. Working capital management - concept, classification, Estimation of working capital requirements.

Finance: Functions, Objectives of financial management and Source of finance and financial institutions, Venture capital.

Reference Books

1. M.C.Shukla,T.S.Grewal,"Advanced Accounts-Volume-I,2010 Reprint, S. Chand &Company Ltd.,2010.
2. Prasanna Chandra, "Financial Management-Theory and practice" seventh Reprint,Tata McGraw-Hill publishing company Limited,2010.
3. P.S.BoopathiManickam "Financial and Management Accounting" PSG publications 2009.
4. Don R. Hansen and Maryanne M. Mowen "Cost Management: Accounting and Control, Fifth Edition" Thomson, 2006.
5. Michael C . Ehrhardt and Eugene F . Brigham, "Financial Management: Theory and Practice -thirteenth edition" South-Western Cengage learning, 2011
6. Pandey, "Financial Management", Vikas Publishing House Pvt. Ltd., 2007
7. Paramasivan.C, Subramanian.T, "Financial management" New Age international Publishers, 2014.

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures
1	**Accounting**	
1.1	Introduction, Definition, and Functions of Accounting	1
1.2	Accounting principles	1
1.3	Preparation of Financial statements	3
1.4	Common size statement analysis	1

1.5	Comparative statement analysis	1
2	**Cost Accounting**	
2.1	Meaning,importance, and Elements of cost	1
2.2	classification of cost and meaning of Cost center,	1
2.3	Preparation of Cost sheet for electrical components and their applications	3
2.4	Depreciation – meaning and causes of depreciation	1
2.5	Methods to find out the depreciation	2
3	**Budget and Budgetary control**	
3.1	Introduction- Meaning -objectives of budgetary control –	1
3.2	Budget- Types of budgets and their preparation	4
4	**Marginal costing**	
4.1	Introduction, Break-even analysis	2
4.2	Managerial uses of breakeven analysis.	1
4.3	Activity Based Costing	2
5	**Capital budgeting**	
5.1	Meaning and features, capital budgeting decisions	1
5.2	Methods of evaluating capital budgeting decisions by traditional and modern methods	4
5.3	Working capital management – concept, classification,	1
5.4	Estimation of working capital requirements.	1
6	**Finance**	
6.1	Functions and Objectives of Financial management	1
6.2	Source of finance and financial institutions	3
6.3	Venture capital.	1
	Total	**36 hrs**

Course Designers:

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22EG660 PROFESSIONAL COMMUNICATION

Category	L	T	P	Credit
HSS	0	1	2	2

Terminal Exam Type-Lab

Preamble

The prime focus of this course is to enhance the employability and career skills of students with an emphasis on grooming them as value-driven professionals. The practice of essential language skills improves their ability to communicate persuasively and ensures their industry-readiness to face real-life challenges.

Prerequisite

Basics of Technical English

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate adequate soft skills relevant for workplace	TPS3	70%	70%
CO2	Listen and respond to native and non-native accented delivery	TPS3	65%	65%
CO3	Interpret general/technical topics in group discussion	TPS3	70%	70%
CO4	Present effectively both in general and technical contexts and interviews	TPS3	70%	70%
CO5	Exhibit verbal aptitude skills through reading and writing	TPS3	70%	70%
CO6	Write error-free business correspondence	TPS3	70%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										**S**		**M**
CO2								**L**	**S**	**S**		**S**
CO3								**L**	**M**	**S**		**S**
CO4								**L**	**M**	**S**		**S**

CO5								**L**	**M**	**S**		**S**
CO6								**M**	**S**	**S**		**M**
S- Strong; M-Medium; L-Low												

Internal Assessment

Students' performance will be continuously assessed in various classroom activities that include Listening, Speaking, Reading and Writing components for 50 marks as detailed below:

Listening Test **- 10**

Speaking Test (Group Discussion, Mock interview and Technical Presentation) **- 25**

Reading and Writing Test **- 15**

Total **- 50**

End Semester Assessment (LAB):

Listening Test **- 20**

Group Discussion **- 20**

Self-introduction and Personal Interview / BEC - Vantage speaking Task 2 **- 20**

General Aptitude Test **- 30**

Resume submission **- 10**

Total **-100**

List of Experiments/Activities with CO Mapping

S.No	Activities	Hours		CO Mapping
		T	P	
1	1.1. Introduction to soft skills 1.2. Hard skills vs soft skills	2		CO1
2	Listening Practice and Test		2	CO2
3	Reading and reasoning practice from Technical passages/articles/dailies	1		CO5
4	1-minute Self-Introduction (based on interview style)	1		CO4
5	GD Techniques	1		CO3
6	GD Practice		3	CO3
7	Interview Techniques	1		CO4

8	Mock interview		3	CO4
9	Presentation skills	1		CO4
10	Technical presentation		3	CO4
11	General Aptitude Practice and test – Vocabulary Development / Sentence completion / Error spotting /Analogy		3	CO5
12	Business Correspondence – BEC - Vantage speaking Task II	1		CO6
13	Basics of Technical Writing	1		CO5
14	Preparation of Resume	1		CO4

Text Book:

Work book prepared by the Faculty of Dept. of English.

Reference Books & Web Resources:

1. Brooks, Margret. Skills for Success. Listening and Speaking. Level 4 Oxford University Press, Oxford: 2011.
2. Brook-Hart, Guy. Business Benchmark. Upper-intermediate: Student's book, Volume 1. Cambridge University Press: 2013.
3. Patnaik, Priyadarshi. Group Discussion and Interview Skills - Cambridge University Press India; Second edition (1 September 2015).
4. Hughes, Glyn and Josephine Moate. Practical English Classroom. Oxford University Press: Oxford, 2014.
5. www.cambridgeenglish.org (BEC - LSRW)
6. www.examenglish.com (Online Exams for international ESL Exams)
7. www.testpreppractice.net (GRE Tests -Vocabulary /Analogy / Sentence Completion / Reading)
8. https://www.freshersworld.com (Placement Papers)

Extensive Reading:

Who Moved My Cheese? - Spencer Johnson, Ebury Publishing, 2002.

Course Designers:

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		Category	L	T	P	Credit
22EE670	**POWER ELECTRONICS AND DRIVES LAB**	PCC	0	0	2	1

Preamble

This laboratory gives a practical exposure to the students to learn the power electronics and drives. The students will be able to design and analyze power converters such as AC-DC converters, DC-DC converters, DC-AC converters, AC- to AC converters and their control circuits for real world applications.

Prerequisite

- 22EE320: DC Machines
- 22EE420: AC Machines
- 22EE450: Power Electronics

Course Outcomes

CO No.	**Course outcomes**	**Weightage in %**
CO1	Analyze the performance of driver circuits for SCR/MOSFET/IGBT experimentally	15
CO2	Analyze the performance of the SCR commutation circuits designed for the given specifications experimentally	10
CO3	Analyze the performance of the designed controlled rectifiers with 'R' and 'RL' loads experimentally	10
CO4	Analyze the performance of the DC chopper and static circuit breakers designed for the given specifications experimentally	10
CO5	Analyze the performance characteristics of the given DC and AC drive by conducting suitable experiments	20
CO6	Develop a power electronic circuit for the given design specifications	20
CO7	Analyze the performance of the given Power electronic circuit using PSIM/ MATLAB-Simulink/ PSPICE/ PLECS/ VSIM/ PSCAD simulation tool	10
CO8	Demonstrate the working of Battery simulator, Mixed domain oscilloscope, Programmable AC /DC Power supplies and Picoscope.	5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S	M	L	S			M		M			S	S
CO2	S	S	M	L	S			M		M			S	S
CO3	S	S	M	L	S			M		M			S	S
CO4	S	M	L		S			M		M			S	S
CO5	S	S	M	L	S			M		M			S	S
CO6	S	S	M	L	S			M		M			S	S
CO7	S	S	S	M	S			M		M			S	S
CO8	M	L			M			M		M			M	M

S- Strong; M-Medium; L-Low

Assessment Pattern: cognitive domain:

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	30	30
Analyze	50	50
Evaluate		
Create		-

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Practical Component/Observation
Perception	
Set	
Guided Response	
Mechanism	
Complex Overt Responses	20
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. 'R' and RC triggering circuits for half wave controlled rectifiers (CO1)
2. UJT triggering circuit for half wave controlled rectifier (CO1)
3. Voltage, current and complementary commutation techniques(CO2)
4. Half controlled and fully controlled rectifier with 'R' and 'RL' loads(CO3)
5. Static DC and AC circuit breakers(CO4)
6. Single quadrant DC chopper(CO4)
7. Half controlled rectifier fed DC motor(CO5)
8. Voltage commutated chopper fed DC motor(CO5)
9. AC voltage controller fed single phase induction motor(CO5)
10. PLC/DSP based 3 phase induction motor drive(CO5)
11. BLDC motor drive(CO5)
12. Simulation of power electronic converter circuits using PSIM/ MATLAB-Simulink/ PSPICE/PLECS/VSIM/PSCAD (CO7)
13. Study of Battery simulator, Mixed domain oscilloscope, Programmable AC /DC Power supplies and Picoscope.(CO8)
14. Design, implementation and operation of the power electronic circuits for the given design specifications.(CO6)

Reference Books & Web Resources

1. Muhammad H.Rashid, Power Electronics Circuits, Devices & Applications - Pearson Education India Publication, New Delhi, 7th Impression, 2009.

2. M.D.Singh & K.B.Khanchandani, Power Electronics – Tata Mc Graw Hill publishing company Ltd, New Delhi, 2008.
3. Ned Mohan, Tore Undeland & William Robbins, Power Electronics : converters Applications and Design-John Willey and sons, 3rd Edition, 2003.
4. P.S. Bimbra, Power Electronics- Khanna Publishers, 3rd Edition, 2004.
5. Daniel W.Hart, Introduction to power Electronics – Prentice Hall International Inc., 1997.
6. L. Umanand, Power Electronics: Essentials and Applications- Wiley India, 2009.
7. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-334-power-electronics-spring-2007/

Course designers

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2. Dr. G. Sivasankar, Assistant Professor, EEE - gsivasankar@tce.edu

22EE680	ELECTRIC POWER SYSTEMS LAB

Category	L	T	P	Credit
PCC	0	0	2	1

Preamble

The aim of this course is to train the students for solving the power system problems using MATLAB coding. The formation of bus admittance matrix followed by power flow solutions using various numerical methods is introduced. Students get the exposure in short circuit analysis and stability analysis under steady state and transient state. Economic load dispatch problem is also performed using MATLAB coding.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Analyze the performance of direct inspection and singular transformation methods for determining Y-bus matrix of the given system	20
CO2	Analyse the computational performance of Gauss-Seidel and Newton-Raphson methods for solving non-linear Equations.	10
CO3	Analyse the computational performance of Gauss-Seidel and Newton-Raphson methods for solving power flow problems.	20
CO4	Calculate the fault current for various types of faults both symmetrical and unsymmetrical on the given power system.	20
CO5	Analyze the transient stability by applying different fault clearing time to the circuit breakers of the given problem	15
CO6	Compute the optimal dispatch of the given power system using Lagrange Multiplier method	15

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomesand Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	M	M	S				S	S				S	

CO2	S	S	M	M	S				S	S				S	
CO3	S	M	L	L	S				S	S				S	
CO4	S	M	L	L	S				S	S				S	
CO5	S	S	M	M	S				S	S				S	
CO6	S	S	M	M	S				S	S				S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	**Model Examination**	**Terminal Examination**
Remember		
Understand		
Apply	30	30
Analyze	40	40
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	**Miniproject/Practical Component/Observation**
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	

Origination	

List of Experiments/Activities with CO Mapping

1. Formation of bus admittance matrix by direct inspection method and singular transformation method (CO1).
2. Analysis of Gauss-Seidal and Newton-Raphson methods for solving non-linear equation (CO2).
3. Analysis of Gauss-Seidal and Newton-Raphson methods for solving power flow equation (CO3).
4. Symmetrical and unsymmetrical fault analysis in Power System (CO4).
5. Power System Transient Stability problem (CO5).
6. Economic load dispatch (CO6).

Reference Books & Web Resources

1. HadiSaadat., ‘Power System Analysis’ Tata McGraw Hill Publishing Company, New Delhi, 2002.
2. P. Venkatesh, B. V. Manikandan, S. Charles Raja and A. Srinivasan, ‘Electrical Power Systems: Analysis, Security and Deregulation’, PHI Learning Pvt. Ltd., Second Edition, 2017.
3. J. Duncan Glover, Mulukutla S. Sarma, Thomas Overbye,‘Power System Analysis and Design’, Cengage Learning, Fifth Edition, 2011.
4. MOOCs course link:https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/

Course Designers:

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22EE770	ENERGY MANAGEMENT SYSTEM LAB	Category	L	T	P	Credit
		PCC	0	0	2	1

Preamble

The aim of this lab course is to train the students in modelling, designing and analysing solar systems, analyzing the various characteristics of solar system and performance of various converters used in solar systems using various state of the art hardware setup.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Perform simulation studies for analysing the characteristics of solar system	40
CO2	Analyze the performance of PWM charge controller used in solar system module.	10
CO3	Perform simulation studies for analysing the characteristics of different Technologies of Solar PV system	20
CO4	Analyze various operating parameters of PV array at different tilt angle.	10
CO5	Apply various wavelengths of light to find the power output of solar panel and compare spectral response for different wave lengths of light using spectral response training system module.	10
CO6	Measure minority carrier life time in solar cell using carrier life time measurement system	10

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	M	M	S				S	S				S	
CO2	S	S	M	M	S				S	S				S	
CO3	S	M	L	L	S				S	S				S	
CO4	S	M	L	L	S				S	S				S	
CO5	S	S	M	M	S				S	S				S	
CO6	S	S	M	M	S				S	S				S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	30	30
Analyze	40	40
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Mini project/Practical Component/Observation
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. Draw I-V and P-V characteristics of solar cell at different series/parallel configurations using solar simulation system module. (CO1)
2. Draw I-V and P-V characteristics of solar cell at different series/parallel configurations using solar simulation system module with change in illumination. (CO1)

3. Compare and analyze the performance of PWM charge controllerusing solar charge controller module (CO2)
4. Draw I-V and P-V characteristics of various solar modules such as mono crystalline, multi crystalline and thin film module using solar PV module technologies training system module. (CO3)
5. Measurement of operating parameters i.e. current and voltage of PV array at different tilt angle using solar PV tracking system module. (CO4)
6. Find the variation of power output of solar panel with the various wavelengths of light. (CO5)
7. Measurement of minority carrier life time in solar cell using carrier life time measurement system module. (CO6)
8. Measurement and comparison of spectral response for different wave lengths of light and obtain spectral response curve using spectral response training system module. (CO5)
9. Interfacing with laptop to obtain I-V and P-V characteristics of technologies training system for larger number of data.(CO3)
10. Study of wind solar hybrid system with DC microgrid.

Web Resources

1. https://www.kwattsolutions.com
2. Solar Training Manuals prepared by kWatt Solutions Private Limited, Mumbai
3. Ecosense manual

Course Designers:

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ELECTIVES

22EEPA0	POWER SYSTEM OPERATION AND CONTROL	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

The primary aim of a power system is to provide adequate uninterrupted supply of power of certain quality to meet all the demands of customers. The quality of the supply depends on the constancy of frequency and voltage and continuity of supply. This means that the generation must be adjusted, in real time, to match prevailing demand. The second objective, to be achieved as long as it is consistent with continuity of service and dependable operation, is to generate the required total output at minimum overall cost.

Course Outcomes

On the successful completion of the course, students will be able to:

COs No.	Course outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Find the load factor and diversity factor for the consumer load.	TPS3	70	85
CO2	Find the change in real power and frequency for the variation in load.	TPS3	70	85
CO3	Find the change in reactive power for the variation in load.	TPS3	70	85
CO4	Describe the various voltage control methods.	TPS2	80	80
CO5	Find the optimum unit commitment for a power system.	TPS3	70	85
CO6	Estimate the economic load dispatch for a system comprising of ‘n’ thermal plants	TPS3	70	85
CO7	Explain the various operating states of a power system and control actions required to obtain secured operation	TPS2	80	80

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	**S**	**M**	**L**					**M**		**M**				**M**
CO2	**M**	**L**						**M**		**M**				**M**
CO3	**M**	**L**						**M**		**M**				**S**
CO4	**M**	**L**						**M**		**M**				**S**
CO5	**S**	**M**	**L**					**M**		**M**				**S**
CO6	**S**	**M**	**L**					**M**		**M**				**M**
CO7	**M**	**L**						**M**		**M**				**S**

S- Strong; **M**-Medium; **L**-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	20	10	--	--	--	50	--	--	--	--	--	--	--	--	--	10	
CO2	5	10	15	--	--	--	25	--	--	--	--	--	--	--	--	--	10	
CO3	5	10	15	--	--	--	25	--	--	--	--	--	--	--	--	--	10	
CO4	--	--	--	5	10	--	--	--	--	--	--	--	--	--	10	10	--	
CO5	--	--	--	5	10	20	--	--	--	--	50	--	--	--	--	--	10	
CO6	--	--	--	5	10	20	--	--	--	--	50	--	--	--	--	--	10	
CO7	--	--	--	5	10	--	--	--	--	--	--	--	--	--	10	10	--	
	20	40	40	20	40	40	100				100				20	30	50	

Syllabus

Introduction: System load – variation - load characteristics - load curves and load-duration curve (daily, weekly and annual) - load factor - diversity factor - Importance of load forecasting and simple techniques of forecasting - An overview of power system operation and control and the role of computers in the implementation.

Real Power – Frequency Control: Basics of speed governing mechanism and modelling - speed-load characteristics – load sharing between two synchronous machines in parallel - Control area concept LFC control of a single area system - Static and dynamic analysis of uncontrolled and controlled cases - Integration of economic dispatch control with LFC - Two-area system – modelling - static analysis of uncontrolled case - tie line with frequency bias control of two-area system - state variable model.

Reactive Power – Voltage Control: Basics of reactive power control - Excitation systems – modelling - Static and dynamic analysis - stability compensation - generation and absorption of reactive power - Relation between voltage, power and reactive power at a node - method of voltage control - tap-changing transformer - System level control using generator voltage magnitude setting - tap setting of OLTC transformer and MVAR injection of switched capacitors to maintain acceptable voltage profile and to minimize transmission loss.

Unit Commitment: Statement of Unit Commitment problem – constraints – spinning Reserve - thermal unit constraints - hydro constraints, fuel constraints and other constraints - Solution methods - Priority-list methods - forward dynamic programming approach - Numerical problems only in priority-list method using full-load average production cost.

Economic Dispatch: Statement of economic dispatch problem – cost of generation – incremental cost curve co-ordination equations without loss and with loss - solution by direct method and λ-iteration method. (No derivation of loss coefficients).

Energy Management System: Need of computer control of power systems - Concept of energy control centre (or) load dispatch centre and the functions - system monitoring - data acquisition and control. SCADA and EMS functions - Network topology - state estimation - security analysis and control - Various operating states (Normal, alert, emergency, in-extremis and restorative) - State transition diagram showing various state transitions and control strategies.

Text Books

1. Allen. J. Wood and Bruce F. Wollenberg, 'Power Generation, Operation and Control', John Wiley & Sons, Inc., 2003.
2. V.Ramanathan, P.S.Manoharan, 'Power System Operation and Control' Third Edition, 2015, Charulatha Publications, Chennai.

3. Chakrabarti & Halder, "Power System Analysis: Operation and Control", Prentice Hall of India, 2004 Edition.
4. Haadi Sadat, "Power System Analysis", TATA McGraw hill, 2002 Edition.

Reference Books

1. P.Kundur, 'Power System Stability and Control' MC Craw Hill Publisher, USA, 1994.
2. Olle.I.Elgerd, 'Electric Energy Systems theory an introduction' Tata McGraw Hill Publishing Company Ltd. New Delhi, Second Edition 2003.
3. Leon K. Kirchmayer, 'Economic operation of power systems' Wiley, 2008.
4. D.P. Kothari and I.J. Nagrath, 'Modern Power System Analysis', Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.

Course Contents and Lecture Schedule

Module No	Topic	No. of Lecture Hours	COs
1	**Introduction**		
1.1	System load – variation, load characteristics, load curves and load-duration curve (daily, weekly and annual), load factor, diversity factor	1	CO1
1.2	Importance of load forecasting and simple techniques of forecasting	1	CO1
1.3	An overview of power system operation and control and the role of computers in the implementation.	1	CO1
2	**Real Power–Frequency Control**		
2.1	Basics of speed governing mechanism and modelling Speed-load characteristics	1	CO2
2.2	Load sharing between two synchronous machines in parallel	1	CO2
2.3	Control area concept LFC control of a single area system	1	CO2
2.4	Static and dynamic analysis of uncontrolled and controlled cases	1	CO2
2.5	Integration of economic dispatch control with LFC	1	CO2
2.6	Two area system – modelling		CO2
2.7	Static analysis of uncontrolled case	1	CO2
2.8	Tie line with frequency bias control of two-area system	1	CO2
2.9	State variable model	1	CO2
3	**Reactive Power–Voltage Control**		
3.1	Basics of reactive power control	1	CO3
3.2	Excitation systems – modelling	1	CO3
3.3	Static and dynamic analysis, Stability compensation	1	CO3
3.4	Generation and absorption of reactive power	1	CO3
3.5	Relation between voltage, power and reactive power at a node	1	CO3
3.6	Method of voltage control	1	CO4
3.7	Tap-changing transformer	1	CO4
3.8	System level control using generator voltage magnitude setting	1	CO4
3.9	Tap setting of OLTC transformer and MVAR injection of switched	1	CO4

	capacitors to maintain acceptable voltage profile and to minimize transmission loss.		
4	**Unit Commitment**		
4.1	Statement of Unit Commitment problem, constraints, spinning Reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints	1	CO5
4.2	Solution methods, Priority-list methods	1	CO5
4.3	Forward dynamic programming approach	1	CO5
4.4	Numerical problems only in priority-list method using full-load average production cost	1	CO5
5	**Economic Dispatch**		
5.1	Statement of economic dispatch problem, cost of generation, incremental cost curve	1	CO6
5.2	Co-ordination equations without loss and with loss	1	CO6
5.3	Solution by direct method and λ-iteration method. (No derivation of loss coefficients).	1	CO6
6	**Computer Control of Power Systems**		
6.1	Need of computer control of power systems	1	CO7
6.2	Concept of energy control centre (or) load dispatch centre and the functions	1	CO7
6.3	System monitoring, Data acquisition and control	1	CO7
6.4	System hardware configuration	1	CO7
6.5	SCADA and EMS functions, Network topology, State estimation	1	CO7
6.6	Security analysis and control	1	CO7
6.7	Various operating states (Normal, alert, emergency, in-extremis and restorative)	1	CO7
6.8	State transition diagram showing various state transitions and control strategies	1	CO7
	TOTAL	36	

Course Designers:

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22EEPB0	**ELECTRICAL MACHINE DESIGN**	Category	L	T	P	Credit
		PSE	2	1	0	3

Preamble

This course furnishes the primary knowledge to design the main dimension and other major parts of Transformer, DC and AC rotating machines. The basic design of an electrical machine involves the dimensioning of the magnetic circuit, electrical circuit, insulation system etc., and is carried out by applying analytical equations

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the properties of various magnetic materials, conducting materials & insulating materials to fulfil the design requirements of electrical machines.	TPS3	75	85
CO2	Calculate the mmf required for the given air gap and armature teeth.	TPS3	75	85
CO3	Design the overall dimensions of transformer along with tank and cooling tubes for the given specifications	TPS3	75	85
CO4	Design the main dimensions, winding details and field parameters of a DC machine for the given specifications	TPS3	75	85
CO5	Design the main dimensions and winding details of induction machines for the given specifications	TPS3	75	85
CO6	Design the main dimensions, winding details and field parameters of synchronous machine for the given specifications	TPS3	75	85

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M			M	
CO2	S	M	L					M		M			S	
CO3	S	M	L					M		M			S	
CO4	S	M	L					M		M			S	
CO5	S	M	L					M		M			S	
CO6	S	M	L					M		M			S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT1						CAT2						ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL					
TPS SCALE	1	2	3	4	5	6	1	2	3	4	5	6	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	5	10																			5					
CO2	5	10	30										50								5	10				
CO3		10	30										50									10	10			
CO4							5	10									50					10	10			
CO5							5	10	30								50						20			
CO6								10	30														20			

Syllabus

Introduction: Performance Specifications, Standard specifications, Duty Cycle, Design factors and Limitations, Thermal and mechanical design aspects.

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.

Design of Three Phase & Single-Phase Induction Motors: Design of Stator core & Rotor core. Design of Stator & Rotor windings, Insulation specifications, Performance calculations of No-load current, Losses and Efficiency.

Design of Synchronous machines: Design of Stator core & Rotor core. Design of Stator and Rotor windings. Performance calculations

Text Book

1 Sawhney A.K. ‘A course in Electrical Machine Design’, Dhanpath rai &sons publications, 6th Edition 2010.

Reference Books& web resources

1. Rai, H.M. ‘Principles of Electrical machine design’ Satya Prakashan Publication New Delhi, 5th edition 2008Book2 (Author(s), Title, edition, publisher, year of publication)
2. S.K.Sen, ‘Principles of Electrical Machine Design with Computer Programs’, Oxford & IBH Publishing Co. Pvt Ltd. 2rd edition 2006.
3. Say. M.G.,’ The Performance and Design of Alternating Current Machines’, CBC Publishers and Distributers. Pvt Ltd. E book Edition 2017.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.0	**Introduction**		
1.1	Performance Specifications Design Factors, Duty Cycle,	1	CO1
1.2	Limitations, Thermal and mechanical design aspects	1	CO1
2.0	**Materials**		
2.1	Magnetic materials	1	CO1
2.2	Conducting materials & Insulating materials	1	CO1
3.0	**Design of Magnetic Circuits**		
3.1	MMF calculation for Air gap	2	CO2
3.2	MMF calculation for Teeth	1	CO2
3.3	Performance: Iron losses and Magnetizing current	1	CO2
4.0	**Design of Transformers**		
4.1	Design of Core and Overall dimensions	2	CO3
4.2	Types of Windings	1	CO3
4.3	Design of Tank and cooling tubes	2	CO3
4.4	Performance: No load current, Losses and Efficiency	1	CO3
5.0	**Design of DC machines**		
5.1	Design of Armature core	2	CO4
5.2	Design of Armature windings	2	CO4

5.3	Design of Poles and filed windings	2	CO4
5.4	Design of Yoke	1	CO4
5.5	Performance: Voltage Regulation, losses and Efficiency	1	CO4
6.0	**Design of Three Phase &Single-Phase Induction Motors**		
6.1	Design of Stator core	2	CO5
6.2	Design of Rotor core	2	CO5
6.3	Design of Stator & Rotor windings	2	CO5
6.4	Performance calculations of No-load current, Losses and Efficiency.	1	CO5
7.0.	**Design of Synchronous machines**		
7.1	Design of Stator core	2	CO6
7.2	Design of Rotor core	2	CO6
7.3	Design of stator & rotor windings	1	CO6
7.4	Design of field systems	1	CO6
7.5	Performance calculations	1	CO6
	Total	36	

Course Designer:

1 Dr. S. Latha, Professor, EEE – sleee@tce.edu

22EEPC0	SWITCHGEAR AND PROTECTION

Category	L	T	P	Credit
PSE	3	0	0	3

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'. Power system switchgear and protection is a subject which touches our lives every day, in a very non-intrusive manner. Reliable protection of electric energy systems against faults like short circuits is in fact, the cornerstone of power system reliability. Based on this, the course aims at giving an adequate exposure in Switchgear equipment and protection schemes for various apparatus.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course students will be able to:

CO	Course Outcome Statement	TPS Scale	Expected Proficiency %	Expected Attainment %
CO1	Explain the layout of a typical substation and discuss its components	TPS2	70	70
CO2	Select Circuit breakers and Fuses for a given requirement	TPS3	70	70
CO3	Explain the principles of different types of protective relays	TPS2	70	70
CO4	Select a suitable protective scheme for specific faults in generatorand transformers	TPS3	70	70
CO5	Explain the principles of various protective schemes of bus bars andfeeders.	TPS2	70	70
CO6	Select a suitable protection method for lines and apparatus against over voltages in Power Systems	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M					M	M	M		M			M	M
CO2	M	L						M		M	L		M	M
CO3	S	M	L	L				M		M	L		S	S
CO4	S	M	L	L				M		M	L		S	S
CO5	S	M	L	L				M		M	L		S	S
CO6	M	L			M		S	M		M			M	M

S- Strong; M-Medium; L-Low

Assessment Pattern:

CO	CAT1-			CAT2-								Assignment 1					Assignment 2				Terminal					
TPS Scale	1	2	3	4	~~5~~	~~6~~	1	2	3	4	~~5~~	~~6~~	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	10	10																			5	5				
CO2		20	40										100									5	15			
CO3	10	10																			10	10				
CO4							5	15	20								50					10	10			
CO5							10	10													5	5				
CO6							5	15	20								50					5	15			

Syllabus

Introduction

Switchgear - essential features - Substations — Types — Equipment - Layout of a typical substation- Current and voltage transformers for protection.

Circuit Breakers and Fuses

Circuit Breakers **-** Arc phenomenon - Restriking and Recovery voltage – resistance switching- auto re-closure. Types — air, oil, SF6 and vacuum circuit breakers — ELCB - Selection of circuit breakers for a specific requirement-Testing of circuit breakers according to IS/IEC codes. Fuses - Types - HRC Fuses – Characteristics and applications.

Protective relays

Need for protective systems– Protection Zones– Essential qualities of protection — Basic relay terminology - Classification of protective relays based on technology and their operating principles - Components of a protection system- Classification of protective schemes.

Apparatus Protection

Generator - stator and rotor protection - **Transformer** –protection against internal faults - **Bus bar** protection - differential current protection -**Feeder protection** — Over-current, Distance, Pilot wire and Carrier current protection. Selection of protective devices for a specific requirement.

Protection against over-voltages

Causes of over voltages — Protection of Transmission lines, Stations and Sub-Stations against direct lightning stroke - Protection against travelling waves - -Surge Protective Devices (MOV, Thyrite Arrester, MCB type surge protector)-Peterson coil - Insulation coordination.

Reference Books

1. Badri Ram and D.N. Vishwakarma, "Power System Protection and Switch Gear",Tata McGraw Hill 2nd edition — 2011
2. Lewis Blackburn, J., Thomas J. Domin, Protective Relaying — Principles and Applications", 3rd edition, CRC Press, , New York, 2006.
3. B. Ravindranath and N.Chander, "Power System Protection and Switch Gear", New Age International Ltd., New Delhi, Reprint 2005.
4. Y.G Paithankar and S.R Bhide, "Fundamentals of power system protection", Prentice-Hall of india, 2003.
5. Oza, Nair, Mehta and Makwana, — "Power System Protection and Switchgear",
   Tata McGraw- Hill. Revised edition,2010.
6. ABB Electrical installation handbook volume 2 – Electrical devices 3rd edition, June2005 published by ABB SACE via Baioni, 35-24123, Bergamo (Italy).
7. Sunil S. Rao, "Protection and Switch Gear", Khanna Publishers- Revised edition, New Delhi, 2011.

Lecture Schedule

Module.No.	Topic	No. of Hours	Course Outcome
1.0	**Introduction**		
1.1	Introduction to Switchgear - essential features	1	CO1
1.2	Substations –Types of substations - Equipment-Layout of a typical substation	3	CO1
1.3	Importance of Current and Potential Transformers in protection schemes	1	CO1
2.0	**Circuit Breakers and Fuses**		

2.1	Arc phenomenon and principles of arc interruption - restriking voltage and recovery voltage — resistance switching– auto re-closure	3	CO2
2.2	Types of Circuit breakers — air blast, air break, oil, SF6 and vacuum circuit breakers — ELCB (Earth Leakage circuit breaker)	3	CO2
2.3	Selection of circuit breakers for a specific requirement-Testing of circuit breakers according to IS/IEC codes.	1	CO2
2.4	Fuses-Types of Fuses - HRC Fuses – Characteristics and applications	2	CO2
3.0	**Protective relays**		
3.1	Need for protective systems– Protection Zones– Essential qualities of protection — Basic relay terminology	2	CO3
3.2	Classification of protective relays based on technology and their operating principles	3	CO3
3.3	Components of a protection system- Classification of protective schemes.	2	CO3
4.0	**Apparatus Protection**		
4.1	Generator - stator and rotor protection Transformer – protection against internal faults	4	CO4
4.2	Bus bar protection - differential current protection - Feeder protection –Over-Current, distance, pilot wire and carrier current protection.	3	CO5
5.0	**Protection against over-voltages**		
5.1	Causes of over voltages	2	CO6
5.2	Protection of Transmission lines, Stations and Sub-Stations against direct lightning stroke	2	CO6
5.3	Protection against travelling waves- Surge Protective Devices(MOV, Thyrite Arrester, MCB type SPD)	2	CO6
5.4	Peterson coil - Insulation coordination.	2	CO6
	Total	**36**	

Course Designers

Dr. K. Selvi, Professor,EEE kseee@tce.edu

Dr. M. Geethanjali,Professor,EEE mgeee@tce.edu

		Category	L	T	P	Credit
22EEPD0	**WIND AND SOLAR TECHNOLOGY**	PSE	3	0	0	3

Preamble

Wind energy is the fast renewable source for the electricity generation. The course presents broad overview of wind energy technology. Due to the growing demand for renewable energy resource especially harnessing power from sun it is felt essential to offer a course on solar photovoltaic technology and systems.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Demonstrate the power produced in wind turbine, types of wind turbine and its effect on tower height, maximum rotor efficiency.	TPS3	70	85
CO2	Explain the different types of wind Electric generators such as Asynchronous (induction) generator and synchronous generator.	TPS2	80	80
CO3	Derive the average power, energy produced in the wind turbine, wind farms and wind turbine economics.	TPS3	70	85
CO4	Determine the fill factor and efficiency of photo voltaic cell and construct the simple and accurate equivalent circuit.	TPS3	70	85
CO5	Determine the effect of irradiation in Photovoltaic cells, module, and arrays and also study the impact of temperature and shading effect on a PV	TPS3	70	85

	module.			
CO6	Explain simplified grid connected PV system, Current voltage curves for loads, DC motor IV curves, Battery IV curves, maximum power point trackers, hourly IV curves, and Grid connected systems.	TPS2	80	80

Mapping with Programme Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	S	M	L	L				M		M			S	
CO2	M	L						M		M			M	
CO3	S	M						M		M			S	
CO4	S	M	L	L				M		M			S	
CO5	S	M	L	L				M		M			S	
CO6	S	M	L	L				M		M			S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	10					50								10			
CO2	5	10	20													20		
CO3	10	20	20				50										20	
CO4				5	10	20					30				10			
CO5				5	10	20					30					20		
CO6				10	20						40						20	

Syllabus

Wind Power Systems

Historical Development of Wind Power, Types of wind turbines, Power in the wind, Impact of tower height, Maximum rotor efficiency.

Wind Turbine Generators

Asynchronous (Induction) generator- Squirrel cage Induction generator, Wound rotor Induction generator- Optislip Induction generator- Doubly-fed Induction generator.

Synchronous generator- Wound rotor generator- Permanent magnet generator, Indian standards.

Wind Turbine performance evaluations

Average power in a wind, Simple estimates of wind turbine energy, Wind farms, Specific wind turbine performance calculations, Wind turbine economics – Capital cost and Annual cost.

A Generic Photovoltaic Cell

Simplest equivalent circuit for a photovoltaic cell – A More equivalent circuit for a PV cell, Solar cells to modules, Solar cells to arrays, PV – IV curve under standard test conditions, Impacts of temperature and insulation on IV curves, Shading impacts on IV curves.

Performance of Solar cells

Parameters of solar cells, solar cell technologies – Factors affecting electricity generated by a solar cell, Solar PV module, Standard PV module parameters, IV and PV characteristics of SPV module, Solar PV modules arrays – connection of modules in series and parallel.

Photovoltaic Systems

Introduction to Simplified grid connected PV systems, Current voltage curves for loads - DC motor IV curves - Battery IV curves – maximum power point trackers – hourly IV curves, grid connected systems.

Text Books

1. Non-Conventional Energy resources – G.S Sawhney – PHI 2012.
2. Solar Photovoltaic Technology and Systems – Chetan Singh Solanki – PHI 2018.

Reference Books & Web Resources

1. Solar Photovoltaics Third edition - Chetan Singh Solanki – PHI 2017.

2. Renewable and Efficient electric power systems – Gilbert M Masters – John Wiley & Sons Inc. 2004.
3. Course material on 20th National Training course on wind energy technology organized by NIWE, Chennai.
4. On line courses organized by Udemy, course era, edx, MOOC, NPTEL and SWAYAM in the area of renewable energy.
5. https://www.hindawi.com/journals/ijp/2014/763106/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours	Course Outcome
1.0 WIND POWER SYSTEMS			
1.1	Historical Development of Wind Power	1	CO1
1.2	Types of wind turbines	1	CO1
1.3	Power in the wind	1	CO1
1.4	Impact of tower height	1	CO1
1.5	Maximum rotor efficiency	1	CO1
2.0 WIND TURBINE GENERATORS			
2.1	Asynchronous (Induction) generators	1	CO2
2.2	Squirrel cage Induction generator	1	CO2
2.3	Wound rotor Induction generator	1	CO2
2.4	Optislip Induction generator, Doubly-fed Induction generator	1	CO2
2.5	Synchronous generator	1	CO2
2.6	Wound rotor generator, Permanent magnet generator	1	CO2
3.0 WIND TURBINE PERFORMANCE EVALUATIONS			
3.1	Speed control for maximum power	1	CO3

3.2	Average power in a wind	1	CO3
3.3	Simple estimates of wind turbine energy	1	CO3
3.4	Wind farms	1	CO3
3.5	Specific wind turbine performance calculations	1	CO3
3.6	Wind turbine economics	1	CO3
4.0 A GENERIC PHTOTOVOLTAIC CELL			
4.1	Simplest equivalent circuit for an photovoltaic cell	1	CO4
4.2	A More equivalent circuit for a PV cell	1	CO4
4.3	Solar cells to modules	1	CO4
4.4	Solar modules to arrays	1	CO4
4.5	PV – IV curve and standard test conditions	1	CO4
4.6	Impact of temperature and insulation on IV curves	1	CO4
4.7	Shading impacts on IV curves.	1	CO4
5.0 PERFORMANCE OF SOLAR CELLS			
5.1	Parameters of solar cells	1	CO5
5.2	Solar cell technologies	1	CO5
5.3	Factors affecting electricity generated by a solar cell	1	CO5
5.4	Standard PV module parameters	1	CO5
5.5	IV and PV characteristics of SPV module	1	CO5
5.6	Solar PV modules arrays	1	CO5
5.7	connection of modules in series and parallel	1	
6.0 Photovoltaic Systems			
6.1	Introduction	1	CO6
6.2	Simplified grid connected PV systems	1	CO6

6.3	Current voltage curves for loads	1	CO6
6.4	Maximum powerpoint trackers	1	CO6
6.5	Grid connected systems	1	CO6
	Total	**36**	

Course Designers:

1. Dr. P. Venkatesh, Professor, EEE, pveee@tce.edu
2. Dr. M. Meenakshi Devi, Assistant Professor,EEE, mmdeee@tce.edu

22EEPF0	OPERATION AND MAINTENANCE OF ELECTRICAL EQUIPMENT

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

This course will provide the technical and practical information required for ensuring correct operation, maintenance and troubleshooting of electrical equipment and systems such as transformer, motor, generator, substation, switchgear and transmission and distribution system.

Prerequisite

- 22EE320: DC Machines & Transformers
- 22EE420: AC Machines
- 22EE510: Generation, Transmission and Distribution

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the types, procedures and records of maintenance.	TPS2	75%	85%
CO2	Explain the causes of electrical accidents, safety measures, regulations and annual inspection methods of electrical installation.	TPS2	75%	85%
CO3	Calculate the earth resistance for a given electric system with suitable method of earthling.	TPS3	75%	85%
CO4	Explain the general procedure to maintain electrical equipment's in any point.	TPS2	75%	85%
CO5	Identify the possible cause for the faulty behavior of the given Electrical equipment.	TPS3	75%	85%
CO6	Explain the method of rectification of fault in the given Electrical equipment.	TPS2	75%	85%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M			M	
CO2	M	L						M		M			M	

CO3	S	M	L					M		M			S	
CO4	S	M	L					M		M			S	
CO5	S	M	L					M		M			S	
CO6	S	M	L					M		M			S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**8**	20													4	10		
CO2	6	30													4	10		
CO3	6	0	30				100								2	0	15	
CO4				**8**	20										4	10		
CO5				6	0	30					100				2	10	15	
CO6				6	30										4	10		
	20	50	30	20	50	30									20	50	30	

Syllabus

Maintenance: Importance of Plant maintenance, Types of maintenance - Preventive, Breakdown and Production maintenance, Need, classification, advantages, activities and frequency of maintenance, Maintenance Records, Role of Maintenance Engineer.

Electrical Accidents and Safety: Causes of electrical accidents, Electrical shock - Factors of severity, Actions to be taken, Safety regulations and safety measures, Indian electricity supply act 1948-1956, Factory Act -1948, Safe working of Electrical Equipments, Electrical inspectorate's rules for operation and maintenance, Annual Inspection, Internal Electrical Installation in Buildings, Fire extinguishers.

Earthing: Necessity, Types and Methods of earthing, Earth electrodes, plate, pipe and coil earthing, Earth resistance - factors affecting, Maximum permissible resistance of earthing system, Equipment earthing and system grounding, Earthing of Building installation, Domestic appliances, Industrial premises, Extra high voltage and underground cable, substation, generating station and overhead line.

Generator, Substation and Switchgears: Operation procedure, Routine and breakdown Maintenance, Causes of Failure and Precautions measure of Generator. Sub-station shut down procedure - certificate of requisition for shut down; certificate of Permit to work and certificate of Line clear, Maintenance of Lightning Arrestor and circuit breakers.

Transformer, Motors and Starters:, On-load tap changer, Dissolved gas analysis, Overhauling and Drying out of transformer, Oil Purification and Impulse voltage testing on transformer. Maintenance schedule, Routine and Breakdown Maintenance, Causes of failure, Precautions and Trouble-shooting methods of transformer, Motors and starters.

Transmission and Distribution system: Rules for Low, Medium and High voltages, Factor of safety, Special precautions, Minimum Clearance of Conductors, Laying of underground cable and Fault location.

Text Book

1. B.V.S.Rao, "Operation and Maintenance of Electrical Equipment", Volume I & II, 2008 Edition, Media Promoters & Publishers Pvt. Ltd., Mumbai.
2. S. Rao, "Testing Commissioning Operation and Maintenance of Electrical Equipments", Sixth Edition, Khanna Publishers, New Delhi, 2010.

Reference Books& web resources

1. Tarlok Singh, "Installation Commissioning and Maintenance of Electrical Equipments", First Edition, S. K. Kataria & Sons, 2013.
2. Paul Gill, "Electrical Power Equipment Maintenance and Testing", Second Edition, CRC Press, 2013.
3. https://www.weschler.com/wp-content/uploads/2020/01/gettingdown toearth.pdf

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours	Course Outcome
1.	**Maintenance**		
1.1	Importance of Plant maintenance, Types of maintenance - Preventive, Breakdown and Production maintenance, Need, classification, advantages, activities and frequency of maintenance	3	CO1
1.2	Maintenance Records, Role of Maintenance Engineer	2	CO1
2	**Electrical Accidents and Safety**		
2.1	Causes of electrical accidents, Electrical shock - Factors of severity, Actions to be taken,	1	CO2
2.2	Safety regulations and safety measures, Indian electricity supply act 1948-1956, Factory Act - 1948, Safe working of Electrical Equipment, Electrical inspectorate's rules for operation and maintenance,	2	CO2
2.3	Annual Inspection, Internal Electrical Installations in Buildings, Fire extinguishers.	3	CO2
3.	**Earthing**		
3.1	Necessity, Types and Methods of earthing - Earth electrodes, plate, pipe and coil earthing.	1	CO3
3.2	Earth resistance - factors affecting, Determination of maximum permissible resistance of the earthing system.	1	CO3
3.3	Comparison between equipment earthing and system grounding	1	CO3
3.4	Earthing of Building installation, Domestic appliances, Industrial premises, Extra high voltage and underground cable, substation, generating station and overhead line.	2	CO3
4.	**Generator, Substation and Switchgears**		
4.1	Operation procedure, Routine and breakdown Maintenance	2	CO4
4.2	Causes of Failure and Precautions measure on Generators.	1	CO5
4.3	Sub-station shut down procedure - certificate of requisition for shut down; certificate of Permit to work and certificate of Line clear.	3	CO4

4.4	Maintenance of Lightning Arrestor and circuit breakers	1	CO4
5.	**Transformer, Motors and Starters**		
5.1	On-load tap changer, Dissolved gas analysis, Overhauling and Drying out of transformer	2	CO5
5.2	Oil Purification and Impulse voltage testing on transformer.	2	CO6
5.3	Maintenance schedule, Routine and Breakdown Maintenance	1	CO4
5.4	Causes of failure and Precautions on the operation of transformer, Motors and starters.	1	CO5
5.5	Trouble-shooting methods of transformer, Motors and starters.	1	CO6
6	**Transmission and Distribution system**		
6.1	Rules for Low, Medium and High voltage Transmission systems, Factor of safety	2	CO4
6.2	Special precautions, Minimum Clearance of Conductors	2	CO5
6.3	Laying of underground cable and Fault location	2	CO6
	Total	36	

Course Designer:

1. Dr. N. Shanmuga Vadivoo, Professor, EEE – nsveee@tce.edu

22EEPG0	ENERGY AUDIT AND MANAGEMENT IN ELECTRIC UTILITIES

	L	T	P	Credit
PSE	2	1	0	3

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. The objective of the course is to provide an introduction to principles of Energy Conservation in Electrical System. This course will educate the power system 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.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the principles of Energy Audit, Management and Conservation	TPS2	80%	70%
CO2	Estimate the energy performance of Electrical System	TPS3	80%	70%
CO3	Estimate the energy performance of Electrical Motors	TPS3	80%	70%
CO4	Estimate the energy performance of Lighting System	TPS3	80%	70%
CO5	Selection and Operation aspects of DG Set for Energy Efficiency	TPS2	80%	70%
CO6	Identify the Energy Efficient gadgets for domestic, commercial and industrial applications	TPS3	80%	70%

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO9.	M	L						M		M			M		
CO10.	S	M	L	L				M		M			S		
CO11.	S	M	L	L				M		M			S		
CO12.	M	L						M		M			M		
CO13.	S	M	L	L				M		M			S		
CO14.	M	L						M		M			S		

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**8**	20													2	10		
CO2	6	15	15				50								4	5	7	
CO3	6	15	15				50								4	5	8	
CO4				**6**	15	15									4	5	7	
CO5				8	20						50				2	10		
CO6				6	15	15									2	5	8	
	20	50	30	20	50	30					50				20	50	30	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Energy Management and Audit: Need of Energy Conservation, Energy Star Rating/Green Labeling, Energy Audit objective, 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, Simple Payback calculation, Energy Audit instruments, Role of Energy Manager

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. (Case Studies)

Electric Motors: Types, Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors. (Case Studies)

Lighting: Light Source, Choice of lighting, Luminance requirements and energy conservation avenues. (Case Studies)

DG Set System: Factors affecting selection, Energy performance assessment of diesel conservation avenues. (Case Studies)

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. Checklist & Tips for Energy Efficiency in Electrical System.

Reference Books& web resources

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

Module No.	Topic	No. of Periods
1	**Energy Management and Audit**:	
1.1	Need for Energy Conservation, Energy Star Rating, Energy Audit objective, Types of energy audit,	2

Module No.	Topic	No. of Periods
1.2	Energy audit approach, understanding energy costs	2
1.3	Bench marking, Energy performance	1
1.4	Matching energy use to requirement, Maximizing system efficiencies, optimizing the input energy requirements, Role of Energy Manager	2
1.5	Fuel and energy substitution, Simple Payback calculation Energy Audit instruments	2
2	**Electrical System**	
2.1	Electricity billing	2
2.2	Electrical load management and maximum demand control	1
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	2
3	**Electric Motors**	
3.1	Losses in induction motors, efficiency, Factors affecting motor performance	2
3.2	Rewinding and motor replacement issues	2
3.3	Energy saving opportunities with energy efficient motors	1
4	**Lighting**	
4.1	Light Source, Choice of lighting	1
4.2	Luminance requirements and energy conservation avenues	2
5	**DG Set System**	
5.1	Factors affecting selection	1
5.2	Energy performance assessment of diesel conservation avenues	1
6	**Energy Efficient Technologies in Electrical Systems**	
6.1	Maximum demand controllers, Automatic power factor controllers	2

Module No.	Topic	No. of Periods
6.2	Energy efficient motors	2
6.3	Soft starters with energy saver, Variable speed drives	1
6.4	Energy efficient transformers	2
6.5	Electronic Ballast, Occupancy sensors, Energy efficient lighting controls	1
6.6	Checklist & Tips for Energy Efficiency in Electrical System.	2
	Total	36

Course Designer(s):

1. Dr.V.Saravanan, Professor, EEE – vseee@tce.edu
2. Dr.D.Nelson Jayakumar, Asst Professor, EEE – dnjayakumar@tce.edu

22EEPH0	**POWER SYSTEM STABILITY**	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

The largest man-made system in the world is the power system. It is challenging to maintain and operate the power system against failure. This course is aimed at understanding the basic modelling requirement of various power system components and operations, different types of stability problems and analytical methods for assessment.

Prerequisite

- 22EE230 Electric circuit analysis
- 22EE320 DC Machines and Transformers
- 22EE420 AC Machines

Course Outcomes

On the successful completion of the course, students will be able to

Course Outcome No.	**Course Outcomes**	**TCE Proficiency Scale**	**Expected Proficiency %**	**Expected Attainment Level %**
CO1	Explain the modelling of power system components in stability studies	TPS2	80	70
CO2	Assess the stability of the power system using Point by point, Modified Euler's and Runke-Kutta methods	TPS3	60	60
CO3	Find the critical clearing angle and time from equal area criterion	TPS3	70	70
CO4	Explain the modelling of the excitation system	TPS2	60	60
CO5	Describe the small signal stability of SMIB and multi-machine systems.	TPS2	60	60
CO6	Explain voltage collapse and voltage stability assessment methods	TPS2	60	60

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
CO1	M	L										

CO2	M	L										
CO3	S	M	L	L								
CO4	S	M	L	L								
CO5	M	L										
CO6	M	L										
	M	L										

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	20													5	10		
CO2	5	10	25				100								2	5	30	
CO3	5	10	20								100				3	5	30	
CO4	-			10	20										3	10		
CO5	-			10	25										2	10		
CO6	-			10	25										5	10		

Syllabus

Introduction to Power system Stability

Modelling of power system components in stability studies (Synchronous machine, Induction machine, Transformer and Load) – definition and illustrations of various terms in power system stability – bad effects of instability – the importance of stability in system operation and design – simple two machine system – power angle equation – methods of improving stability limits

Transient Stability

Inertia constant and equivalent inertia constant – Swing equation – Point by point solution, numerical methods (Modified Euler’s method and Runke-Kutta 4th order method) – Assumptions made in stability studies- Equal area criterion to test the transient stability of power systems – Calculation of critical clearing angle and clearing time – Further applications of the equal area criterion and its limitations.

Excitation Systems

Elements of an excitation system – types of excitation system – dynamic performance measure – control and protective functions – modelling of excitation system

Small Signal Stability

Small signal stability of a SMIB system – power system stabilizer – small signal stability of multi machine system.

Voltage Stability

Introduction – comparison of angle and voltage stability – reactive power flow and voltage collapse – voltage stability analysis – prevention of voltage collapse

Text Books

1. E.W.Kimbark, Power System Stability, Vol.1, John Wiley, 1995.
2. Prabha Kundur, Power System Stability and Control, Tata McGraw Hill, 2006.
3. B.R.Gupta, Power System Analysis and Design, S.Chand Ltd., 2008
4. D.P.Kothari and I.J.Nagrath, Modern Power System Analysis, 4th Edition, Tata McGraw Hill, 2011.

Reference Books

1. P.M.Anderson and A.A.Fouad, Power System Control and Stability, 2nd Edition, WileyIndia Pvt.Ltd., 2008.
2. P.W.Sauer and M.A.Pai, Power System Dynamics and Stability, Pearson Education,2007.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction to Power system Stability**	
1.1	Introduction - Modelling of power system components in stability studies (Synchronous machine, Induction machine, Transformer and Load)	3
1.2	Definition and illustrations of various terms in power system stability	2
1.3	bad effects of instability – importance of stability in system operation and design	2
1.4	simple two machine system – power angle equation – methods of improving stability limits	2
2.	**Transient Stability**	
2.1	Inertia constant and equivalent inertia constant	2
2.2	Swing equation – Point by point solution	2
2.3	Modified Euler's method and Runke-Kutta 4th order method – Assumptions made in stability studies	3
2.4	Equal area criterion – Calculation of critical clearing angle and clearing time – Further applications of the EAC and its limitations.	3
3	**Excitation Systems**	
3.1	Elements of an excitation system – types of excitation system –	2
3.2	dynamic performance measure – control and protective functions	2
3.3	modelling of excitation system	2
4	**Small Signal Stability**	
4.1	Small signal stability of a SMIB system	2

4.2	power system stabilizer	2
4.3	Small signal stability of multi-machine system.	2
5	**Voltage Stability**	
5.1	Introduction – comparison of angle and voltage stability	2
5.2	reactive power flow and voltage collapse	2
5.3	voltage stability analysis – prevention of voltage collapse	1
	Total	**36**

Course Designers:

1. Dr. C.K. Babulal, Professor, EEE, ckbeee@tce.edu

22EEPJ0 VLSI DESIGN

Category	L	T	P	Credit
PSE	2	1	0	3

Preamble

Very Large Scale Integrated Circuits (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.

Prerequisite

- 22EE250- Digital Systems

Course Outcomes

On the successful completion of the course, students will be able to:

Cos	**Course outcomes**	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the concept of MOS transistors theory and its characteristics.	TPS2	70%	80%
CO2	Describe the basics of CMOS fabrication techniques(n well, p well, Twin tub, SOI)	TPS2	70%	80%
CO3	Apply CMOS technology for specific layout rules in the placement, routing and interconnect of transistors, and to verify the functionality, timing, power, and parasitic effects of VLSI circuits.	TPS3	70%	80%
CO4	Construct combinational logic circuits using static CMOS Logic, Pseudo NMOS, Ratioed circuits, C^2MOS, Dynamic CMOS, Domino logic.	TPS3	70%	80%
CO5	Apply various Clocking schemes, I/O structure, and testing methods in VLSI circuits.	TPS3	70%	80%
CO6	Simulate the model for given digital system using Hardware Description Language(VHDL)	TPS3	70%	80%

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L												M
CO2	M	L												M
CO3	S	M	L	L										S
CO4	S	M	L	L										S
CO5	S	M	L	L										S
CO6	S	M	L	L	S									S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	20													4	10		
CO2	5	20													4	10		
CO3	5		40				100								2	10	10	
CO4				8	10	15					30				4	5	10	
CO5				8	15	10					30				4	5	10	
CO6				4	15	15					40				2		10	

Syllabus

An overview of VLSI: Complexity and Design, Basic Concepts

MOS Transistor Theory: nMOS and pMOS Enhancement Transistor-Threshold Voltage and Body Effect-MOS Device Design Equation -Second Order Effects-DC Transfer Characteristics- The Complementary CMOS Inverter-Beta Ratio- Noise Margin-Ratioed Inverter Transfer function-Pass Transistor-Tristate Inverter

CMOS Processing Technology:

Silicon Semiconductor Technology- Basic CMOS Technology (N-well, P-well, Twin Tub, SOI)- Inter connect, Circuit Elements - **Performance Estimation:** Delay Estimation-Transistor Sizing-Power Dissipation-Interconnect-Design Margin, Static Timing Analysis (STA).

CMOS Logic: Fan in & Fan out-Transistor Sizing-Basic physical Design of Simple Logic Gates: and Compound gates -Multiplexers and Flip flops-Pass Transistor and Transmission Gate-Layout Design Rules and Stick diagrams.

Advanced Techniques in CMOS Logic gates : Pseudo nMOS, Ratioed circuits, Tri-state Circuits, Clocked circuits, Dynamic CMOS Logic Circuits and Domino Logic Circuits.

VLSI I/O Structures Clocking and Testing of VLSI Circuits : I/O Structures, Clocked Flip Flops, 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 - Synthesis and Entity, Behavioral description and sequential description, Data flow description.

Reference Books

1. Neil H.E. Weste, David Harris & Ayan Banerjee, "CMOS VLSI Design- A Circuits and Systems Perspective", Third Edition, Pearson education, 2008.
2. John P. Uyemura "Introduction to VLSI Circuits and systems" – John Wiley & Sons, Inc., 2008
3. Wayne Wolf, "Modern VLSI Design," 2nd edition, Prentice Hall PTR, 2000.
4. Sung – Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated circuits, Analysis & Design", 3rd edition, Tata Mcgrew – Hill Publishing, 2003.
5. J. Bhaskar, "A VHDL Primer", Third Edition, Addition Wesley, 1999.

Course Contents and Lecture Schedule

SNo.	**Topic**	**No. of Lecture Hours**	**Course Outcome**
1	**An overview of VLSI**		
1.1	Complexity and Design, Basic Concepts	1	CO1
2	**MOS Transistor Theory**:		CO1
2.1	nMOS and pMOS Enhancement Transistor	1	CO1
2.2	Threshold Voltage and Body Effect	1	CO1
2.3	MOS Device Design Equation	1	CO1
2.4	Second Order Effects	1	CO1
2.5	DC Transfer Characteristics: The Complementary CMOS Inverter-Beta Ratio- Noise Margin - Ratioed Inverter Transfer function - Pass Transistor - Tristate Inverter	2	CO1

3	**CMOS Processing Technology**		
3.1	Silicon Semiconductor Technology	**1**	CO2
3.2	Basic CMOS Technology (N-well, P-well, Twin Tub, SOI)	2	CO2
3.3	Inter connect, Circuit Elements	1	CO2
4	**CMOS Logic**		
4.1	Fan in & Fan out-Transistor Sizing	1	CO3
4.2	Basic physical Design of Simple Logic and Compound gates	2	CO4
4.3	Multiplexers and Flip flops	1	CO3
4.4	Pass Transistor and Transmission Gate	1	CO3
4.5	Layout Design Rules and Stick diagrams	2	CO3
5	**Performance Estimation:**		
5.1	Delay Estimation, STA	1	CO3
5.2	Transistor Sizing	1	CO3
5.3	Power Dissipation	1	CO3
5.4	Interconnect & Design Margin	1	CO3
6	**Advanced Techniques in CMOS Logic gates**		
6.1	Pseudo nMOS, Ratioed Circuits	1	CO4
6.2	Tri-state Circuits, Clocked circuits	1	CO4
6.3	Dynamic CMOS Logic Circuits	1	CO4
6.4	Dynamic CMOS and Domino Logic Circuits	1	CO4
7	**VLSI I/O Structures, Clocking and Testing of VLSI Circuits**		
7.1	I/O Structures	1	CO5
7.1	Clocked FlipFlops & CMOS Clocking Styles	1	CO5
7.2	Pipelined Systems	1	CO5
7.3	Clock Generation and Distribution	1	CO5
7.4	Testing of VLSI Circuits - General Concepts,	1	CO5

	CMOS Testing, Test Generation Methods.		
8	**VHDL**		
8.1	VHDL Terms- Synthesis and Entity	1	CO6
8.2	Behavioral and sequential description	2	CO6
8.3	Data flow description	1	CO6
	Total	35	

Course Designers:

1. Dr.R.Helen, Assistant Professor, EEE, rheee@tce.edu

22EEPK0 **COMPUTER ORGANIZATION**

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Computers find lot of applications in most of the fields in the present day world. Due to the continuous technological developments taking place in the field of semiconductor, the modern day computers are equipped with high performance processors (CPUs) which have multi cores, on-chip cache memories, on-chip floating point units and can perform superscalar pipeline execution of instructions. Developments in the field of semiconductor memory technology lead to availability of high speed and high density memories with lower cost nowadays which are used in present day computers.

Prerequisite

- 22EE250- Digital Systems

Course Outcomes

On the successful completion of the course, students will be able to

CO No.	COURSE OUTCOMES	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the basic structure of computers	TPS2	70	70
CO2	Develop assembly language programs for solving the given problems in computers	TPS3	70	70
CO3	Explain the Input/Output organization in computers	TPS2	70	70
CO4	Determine the performance parameters of different memories used in computers	TPS3	70	70
CO5	Explain the operation of basic processing unit (CPU) in computers	TPS2	70	70
CO6	Determine the performance parameters of the processor due to the pipeline execution of instructions	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M									M					
CO2	S	M	L					M		M					
CO3	M									M					
CO4	S	M						M		M					
CO5	M									M					
CO6	S	M	L					M		M					

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT1						CAT2						Assignment 1				Assignment 2				Terminal					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	10	20																			4	10				
CO2		10	30										100								4		15			
CO3	10	20																			4	10				
CO4							6	10	30								50					5	15			
CO5							6	20													4	10				
CO6							8	10	10								50				4	5	10			

Syllabus

Basic Structure of Computers: Computer types-Functional units-Basic operational concepts- Bus structures- Software-Performance- Multiprocessors and Multicomputers.

Machine Instructions and Programs: Numbers, arithmetic operations and characters-Memory locations and addresses-Memory operations-Instructions and instruction sequencing-Addressing modes- Assembly language- Basic input/output operations- Stacks and Queues- Subroutines- Encoding of machine instructions- Assembly language Programs.

Input/Output Organization: Accessing I/O devices-Interrupts- Direct memory access (DMA)- Buses- Interface circuits – Standard I/O interfaces: PCI bus, USB and HDMI.

The Memory System: Semiconductor RAM memories- Read only memories- Speed, size and cost -Cache memories- Performance considerations- Virtual memories- Memory management requirements- Secondary storage: Magnetic hard disks and Solid State Drive (SSD).

Basic Processing Unit (CPU): Fundamental concepts- Execution of a complete instruction- Multiple bus organization- Hardwired control- Introduction to Microprogrammed control.

Pipelining: Basic concepts- Pipeline organization- Pipelining issues-Data dependencies-Memory delays-Branch delays- Resource limitations- Performance evaluation- - Superscalar operation.

Text Book

1. Carl Hamacher, Zvonko Vranesic and Safwat Zaky, Computer Organization and Embedded systems, 6th Edition, McGraw Hill, 2012.

Reference Books & web resources

1. Shuangbao Paul Wang, Computer Architecture and Organization, Springer publishing, 2021.
2. Jim Ledin, Modern Computer architecture and Organization, Packt Publishing, 2022.
3. David A. Patterson and John L.Hennessy, Computer organization and design- Elsevier Publishing,5th edition,2016.

Course Contents and Lecture Schedule

S.No.	Topics	No. of Lectures	CO
1.	**Basic Structure of Computers:**		
1.1	Computer types, Functional units	1	CO1
1.2	Basic operational concepts, Bus structures	1	CO1
1.2	Software, Performance	1	CO1
1.3	Multiprocessors and Multicomputers	1	CO1
2.	**Machine Instructions and Programs:**		
2.1	Numbers, arithmetic operations and characters	2	CO2
2.2	Memory locations and addresses, Memory operations	1	CO2
2.3	Instructions and instruction sequencing, Addressing modes	2	CO2
2.4	Assembly language, Basic input/output operations	1	CO2
2.5	Stacks and Queues, Subroutines	1	CO2
2.6	Encoding of machine instructions- Assembly language Programs	2	CO2
3.	**Input/Output Organization:**		
3.1	Accessing I/O devices	1	CO3
3.2	Interrupts	1	CO3
3.3	Direct memory access	1	CO3
3.4	Buses- Interface circuits	2	CO3
3.5	PCI bus, USB and HDMI	2	CO3
4.	**The Memory System:**		
4.1	Semiconductor RAM memories	1	CO4
4.2	Read only memories, Speed, size and cost	1	CO4
4.3	Cache memories, Performance considerations	2	CO4
4.4	Virtual memories, Memory management requirements	2	CO4
4.5	Magnetic hard disks and Solid State Drive (SSD)	1	CO4

5.	**Basic Processing Unit (CPU):**		
5.1	Fundamental concepts, Execution of a complete instruction	2	CO5
5.2	Multiple bus organization	1	CO5
5.3	Hardwired control- Introduction to Microprogrammed control	2	CO5
6.	**Pipelining:**		
6.1	Basic concepts, Pipeline organization	1	CO6
6.2	Pipelining issues, Data dependencies, Memory delays	1	CO6
6.3	Branch delays, Resource limitations	1	CO6
6.4	Performance evaluation, Superscalar operation	1	CO6
	Total	36	

Course Designer

1. Prof. M.Saravanan, Professor, EEE, mseee@tce.edu

22EEPL0	INTERNET OF THINGS (THEORY CUM PRACTICAL)

Category	L	T	P	Credit
PSE	2	0	2	3

Preamble

Internet of Things (IoT) refers to things that can be connected to internet and can send or receive data through internet for sensing/monitoring and/or control purposes. IoT consists of combination of Hardware and Software. IoT systems are used in realization of smart appliances, smart home, smart city, smart grid, smart irrigation and smart transportation etc. Microcontrollers, sensors and/or actuators and communication modules are the major components of IoT system. Programming the microcontrollers in the IoT system is essential to implement the given IoT application. In this course, programming Arduino, ESP32 and Raspberry Pi for various IoT applications is covered.

Prerequisite

- 22EE520 – Microcontrollers

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the basics of IoT and the major components of IoT System	TPS2	70	70
CO2	Explain the working principle of various sensors, Communication modules and communication technologies used in IoT System	TPS2	70	70
CO3	Develop programs for Arduino based IoT Applications	TPS3	70	70
CO4	Develop programs for ESP32 based IoT Applications	TPS3	70	70
CO5	Develop programs for Raspberry Pi based IoT Applications	TPS3	70	70
CO6	Explain the Cloud computing and Cloud Computing Services	TPS2	70	70

Mapping with Programme Outcomes

COs	PO	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

	1													
CO1	M							M		M				M
CO2	M							M		M		M		M
CO3	S	M	M		M	M	M	M	M	M		M		S
CO4	S	M	M		M	M	M	M	M	M		M		S
CO5	S	M	M		M	M	M	M	M	M		M		S
CO6	M							M		M		M		M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			PRACTICAL				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	1	2	3	4
CO1	10	10									4	10		
CO2	10	30									6	20		
CO3			40				30				2		15	
CO4	-			5	10	20	20				2		10	
CO5	-			5	10	20	30				2		15	
CO6	-			10	20						4	10		

***GUIDED MECHANISM: 20 MARKS**

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	
Adaptation	
Origination	

Syllabus

Introduction: Definition and Characteristics of Internet of Things- Physical design of IoT:Things in IoT- IoT Protocols used in link layer, network layer, transport layer and application layer.

Major Components of IoT System: Hardware: Microcontrollers – The Basics of Arduino, Raspberry pi and ESP32- Sensors and Actuators - Examples with their working principles - Communication Technologies-RFID-Bluetooth-Zigbee-WiFi-RF Links-Cellular Networks-Wired communication

Logical Design of IoT- IoT functional blocks- IoT Communication models - IoT Communication APIs- Introduction to Software, Middleware, Operating Systems, Firmware, Development tools and Open source framework for IoT implementation- Introduction to APIs and Device Interfacing components and Platforms and Integration tools for IoT- Programming Arduino and ESP32 for the applications of IoT- Programming Raspberry Pi for the applications of IoT.

Introduction to Cloud computing and Cloud Services: Basic services and Architectures: Cloud computing Components, Models and Architectures, Benefits of Cloud computing – Communicating with the Cloud using Web services-SOAP and REST-Cloud computing and IoT- Introduction to open cloud computing services for sensor management- Thingspeak.

List of Experiments: (24 hours)

1. Programming Arduino and ESP32 for basic operations (Digital I/O, Handling Analog Inputs, PWM)
2. Talking to Android mobile with the Arduino and ESP32
3 Reading data from Sensors using Arduino and ESP32
4. Programming Arduino for IoT applications (smart home, smart city, smart grid, smart irrigation, smart appliances)
5. Programming ESP32 for IoT applications
6. Programming Raspberry pi for IoT applications

Text Book

1.ArshdeepBahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015.

2.Charalampos Doukas, “Building Internet of Things with the Arduino”,Barcode Books International,2012.

Reference Books& web resources

1.Raj Kamal, “Internet of Things-Architecture and Design Principles”, MC Graw Hill Education,2017.

2. Donald Norris, “The Internet of Things-Do -It-Yourself at Home Projects for Arduino, Raspberry Pi, and BeagleBone Black”, MC Graw Hill Education,2015.

3. . Dragan Ibrahim, The complete ESP32 Projects Guide, Elektor Publishers, 2019.

4. Peter Waher “Learning Internet of Things”, PacktPublishing,UK, 2015.

5. Miguel de Sousa”,Internet of Things with Intel Galileo” ”, PacktPublishing,UK, 2015

6. Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014

7. Adrian McEwen, Hakim Cassimally “Designing the Internet of Things”,WileyPublishing, 2015

8. https://nptel.ac.in/courses/106105166- Introduction to Internet of Things

9.https://www.coursera.org/specializations/iot

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Introduction**		
1.1	Definition and Characteristics of Internet of Things	1	CO1
1.2	Physical design of IoT-Things in IoT- IoT Protocols used in link layer, network layer, transport layer and application layer	2	CO1
2.	**Major Components of IoT System**		
2.1	Hardware: Microcontrollers – The Basics of Arduino, Raspberry pi and ESP32	2	CO1
2.2	Sensors and Actuators- Examples with their working principles	2	CO2
2.3	Communication Technologies-RFID-Bluetooth-Zigbee-WiFi-RF Links-Cellular Networks—Wired communication	2	CO2
2.4	Logical Design of IoT- IoT functional blocks- IoT Communication models - IoT Communication APIs	1	CO2
2.5	Introduction to Software, Middleware, Operating Systems, Firmware, Development tools and Open source framework for IoT implementation	1	CO2
2.6	Introduction to APIs and Device Interfacing components and Platforms and Integration tools for IoT	1	CO2
2.7	Programming Arduino and ESP32 for the applications of IoT	2+2	CO3 & CO4
2.8	Programming Raspberry Pi for the applications of IoT	2	CO5
4	**Introduction to Cloud computing and Cloud Services:–**		

4.1	Basic services and Architectures: Cloud computing Components, Models and Architectures, Benefits of Cloud computing	2	CO6
4.2	Communicating with the Cloud using Web services-SOAP and REST	2	CO6
4.3	Cloud computing and IoT- Introduction to open cloud computing services for sensor management -Thingspeak	2	CO6
	Total	**24**	

Course Designer(s):

1. Dr.M.Saravanan, Professor, EEE, mseee@tce.edu
2. Dr.L.Jessi Sahaya Shanthi, Professor, EEE, ljseee@tce.edu

22EEPM0	FPGA BASED SYSTEM DESIGN (THEORY CUM PRACTICAL)

Category	L	T	P	Credit
PSE	2	-	2	3

Preamble

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.

Prerequisite

18EE250 –Digital Systems

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Design digital circuits using PROMs and SPLDs (PLA,PAL)	TPS3	80	70
CO2	Describe the architecture and features of XILINX XC9500 CPLD IC	TPS2	80	70
CO3	Explain architecture and features of SRAM, Flash and antifuse based FPGA	TPS2	80	70
CO4	Design synchronous circuit with the same functionality of the given asynchronous circuit	TPS3	80	70
CO5	Implement the given digital circuits in Xilinx FPGA processor using Hardware description Language experimentally	TPS3	80	70
CO6	Develop the specific digital applications in Xilinx FPGA processor using Hardware description Language experimentally	TPS3	80	70

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level		
		Cognitive	Affective	Psychomotor
CO1	TPS3	Apply	Value	

CO2	TPS2	Understand	Respond	
CO3	TPS2	Understand	Respond	
CO4	TPS3	Apply	Value	
CO5	TPS3	Apply	Value	Mechanism
CO6	TPS3	Apply	Value	Mechanism

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	S	M	L											S
CO 2	M	L												M
CO 3	M	L												M
CO 4	S	M	L											S
CO 5	S	M	L		S			M		M				S
CO 6	S	M	L		S			M		M				S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			PRACTICAL				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	20	40												5	10	20	
CO2	10	20													5	10		
CO3				10	20										5	10		

CO4				10	20	40									5	10	20	
CO5							40*											
CO6							40*											

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	
Adaptation	
Origination	

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, Logic elements & Interconnections networks, Permanently Programmed FPGAs , Antifuse programming, Flash configuration, Logic blocks and interconnections, , Chip I/O, Circuit Design of FPGA Fabrics.

Hardware Description Language: VHDL and Verilog programming.

Design Techniques, Rules, and Guidelines : 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.

Reference Books and Web Resources

1. Wayne Wolf “FPGA –Based System Design” Pearson Education, 2004.
2. Bob Zeidman, “Designing with FPGAs and CPLDs”, Elsevier, CMP Books, 2002.
3. M. Morris Mano and Michael D. Ciletti, “Digital Design”, PHI, fourth edition, 2008
4. R.F.Tinder: Engineering Digital Design, (2/e), Academic Press, 2000
5. Digital Electronics Principles, Devices and Applications Anil K. Maini – Wiley 2007
6. Samir Palnitkar, ”Verilog HDL”, Pearson Education, 2nd Edition, 2004.
7. Stephen Brown Zvonko Vranesic “Fundamentals of Digital Logic with VHDL Design” Tata McGraw- Hill Edition.
8. www.xilinx.com

9. www.acctel.com

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures	**Course Outcome**
1	**Programmable Logic to ASICs**		
1.1	Programmable Read Only Memories (PROMs).	1	CO1
1.2	Programmable Logic Arrays (PLAs)	2	CO1
1.3	Programmable Array Logic (PALs)	2	CO1
1.4	The Masked Gate Array ASIC	1	CO1
2	**Complex Programmable Logic Devices (CPLDs)**		
2.1	CPLD Architectures, Function Blocks, I/O Blocks	1	CO2
2.2	Clock Drivers, Interconnect, CPLD Technology and Programmable Elements	1	CO2
3	**FPGA-Based Systems**		CO2
3.1	Introduction- Basic Concepts, Digital Design and FPGAs, The roles of FPGAs and FPGA types	1	CO2
3.2	FPGA Based System Design- Design, Goals & techniques, Hierarchical design, Design abstraction, Methodologies	1	CO2
4	**FPGA Fabrics**		
4.1	FPGA Architectures	1	CO3
4.2	SRAM-Based FPGAs	1	CO3
4.2.1	Characteristics of SRAM-Based FPGAs	1	CO3
4.2.2	Logic elements & Interconnections networks	1	CO3
4.3	Permanently Programmed FPGAs	1	CO3
4.3.1	Flash configuration, Antifuse programming	1	CO3
4.3.2	Logic blocks and interconnections	1	CO3
4.4	Chip I/O, Circuit Design of FPGA Fabrics	1	CO3
5	**Design Techniques, Rules,and Guidelines**		
5.1	Basics of Hardware Description Language (Verilog) and Expressions	1	CO4
5.2	Top-Down Design	1	CO4

5.3	Synchronous Design	1	CO4
5.4	Floating Nodes, Bus Contention and One-Hot State Encoding	1	CO4
5.5	Design For Test and Testing Redundant Logic.	1	CO4
5.6	Initializing State Machines, Observable Nodes	1	CO4
	Total	24	

Tentative List of Experiments (24 Hours)

1. Construct digital circuits such as, (CO5)
    a. Synchronous Counters
    b. Ripple counters
    c. 4 –Bit adder and Subtractor
    d. Code Converters
    e. MUX, DEMUX, Encoder and decoder
2. Design FPGA based (CO6)
    a. Digital signal processing
    b. Motor Control

Course Designers:

1. Dr.R.Helen , Assistant Professor, EEE rheee@tce.edu

2. Dr.D.Kavitha ,Assistant Professor, EEE dkavitha@tce.edu

22EEPN0	DIGITAL SIGNAL PROCESSING (THEORY CUM PRACTICAL)

Category	L	T	P	Credit
PSE	2	-	2	3

Preamble

Digital processing of a signal has major advantage over analog techniques. With digital filters, linear phase characteristics can be achieved; Filters can be made to work over a wide range of frequencies. Storage of digital data is very easy. Digital processing is more suited for low frequency signals like seismic signals, bio signals.

Prerequisite

22EE340 –Signals and Systems

Course Outcomes

On the successful completion of the course, students will be able to

COs	**Course outcomes**	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the functional blocks of Digital Signal Processing system.	TPS2	70	70
CO2	Design FIR filter using windowing techniques for the given specifications.	TPS3	70	70
CO3	Design IIR filter using bilinear and impulse invariance transformation for the given specifications.	TPS3	70	70
CO4	Explain the architecture of TMS320F67XX Digital Signal Processor.	TPS2	70	70
CO5	Simulate the given Digital Signal Processing problems(like signal generations, transformations, operations, convolution, correlation) using matlab /CCS	TPS3	70	70
CO6	Design FIR and IIR filters using Matlab, CCS and DSP processor (TMS320F67XX) for the given specifications.	TPS3	70	70

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	M	L												M

CO 2	S	M	L	L										S
CO 3	S	M	L	L										S
CO 4	M	L												M
CO 5	S	M	L	L	M					M				S
CO 6	S	M	L	L	M					M				S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			PRACTICAL				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	20													5	10		
CO2	10	20	40												5	10	20	
CO3				10	20	40									5	10	20	
CO4				10	20										5	10		
CO5							40											
CO6							40											

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	
Adaptation	
Origination	

Syllabus

Introduction: Basic elements of a digital signal processing system – Advantages of digital over analog signal processing – Continuous time verses discrete time signals – Sampling of analog signals –Quantization of continuous amplitude signals –Introduction on CODEC.

Digital Filters Design: Properties and Structures of FIR and IIR filter – Design of FIR filter using windows – Design of IIR filter from analog filters using bilinear and impulse invariance transformation.

Realization of Digital Filters: Realization of FIR filters (Direct Form, Cascade Form, Linear-Phase FIR structures)and IIR filters(Direct Form I, Direct Form II, Cascade and Parallel Form) - Applications
Architecture: TMS320F67XX floating point DSP architectures, CPU, memory, buses and peripherals. Addressing modes, instruction sets, control operations, interrupts.

List of Experiments:

1. Discrete Time Sequences - Generation, Concept of Aliasing and operations using CCS and Matlab (CO5)
2. Convolution and Correlation using CCS and Matlab (CO5)
3. FIR Filter Design using CCS and Matlab (CO5)
4. IIR Filter Design using CCS and Matlab (CO5)
5. Implementation of FIR and IIR filters on TMS320C67XX (CO6)

Reference Books

1. John G.Proakis & Dimitris G.Manolakis, - Digital Signal Processing Principles, Algorithm and Applications – Pearson Education, New Delhi, 4th Edition, 2006.
2. P.Ramesh Babu - Digital Signal Processing, Scitech Publications of India, 2012.
3. Emmanuel C. Ifeachor & Barrie W. Jervis - Digital Signal Processing - A practical approach, Pearson Education, New Delhi, 2004.
4. A.V. Oppenheim and R.W.Schafer - Digital Signal Processing, Prentice Hall of India, 2001.
5. Sanjit K.Mishra – Digital Signal Processing-A computer based approach, Tata McGraw-Hill, New Delhi, 2004.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours	**Course Outcome**
1	**Introduction**		
1.1	Basic elements of a digital signal processing system	1	CO1
1.2	Advantages of digital over analog signal processing	1	CO1
1.3	Continuous time verses discrete time signals	1	CO1
1.4	Sampling of analog signals	1	CO1
1.5	Quantization of continuous amplitude signals	2	CO1

2	**Digital Filters**		
2.1	Properties and Structures of FIR and IIR filter	1	CO2
2.2	Design of FIR filter using windows	3	CO2
2.3	Design of IIR filter from analog filters using bilinear and impulse invariance transformation	3	CO3
2.4	**Realization of Digital Filters**		
2.4.1	Realization of FIR (Direct form I, Direct form II, Cascade and parallel form)	2	CO2
2.4.2	Realization of IIR filters(Direct form I, Direct form II, Cascade and parallel form)	2	CO3
2.4.3	**Applications**	1	CO3
3	**Architecture of TMS320F67XX**		
3.1	TMS320F67XX floating point DSP architectures,	2	CO4
3.2	CPU, memory, buses and peripherals.	2	CO4
3.3	Addressing modes, instruction sets, control operations, interrupts.	2	CO4
	Total	**24**	

Course Designers:

1. Dr.L.Jessi Sahaya Shanthi, Associate Professor, EEE ljseee@tce.edu
2. Dr.R.Helen, Assistant Professor, EEE rheee@tce.edu

22EEPQ0	EMBEDDED SYSTEMS DESIGN (THEORY CUM PRACTICAL)	Category	L	T	P	Credit
		PSE	2	0	2	3

Preamble

An embedded system is a computer system with a dedicated function within a larger electrical or mechanical system, often with real-time computing constraints. An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular function. Industrial machines, automobiles, medical equipment, digital cameras, household appliances, airplanes, vending machines, toys, cellular phone and PDA are among the numerous possible hosts of an embedded system. Embedded systems that are programmable are provided with programming interfaces. In order to meet real time constraints, most of the embedded systems use a real-time operating system (RTOS). This course introduces the architecture, design and development process of embedded systems. The architecture and programming of ARM Cortex M4 microcontrollers (STM32407xx, TM4C123)are also covered in this course.

Prerequisite

- 22EE520 –Microcontrollers
- 22EE580 -Microcontrollers Lab

Course Outcomes

On the successful completion of the course, students will be able to:

COs No.	Course outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain embedded system architecture and applications	TPS2	70	60
CO2	Explain the Characteristics and Quality attributes of Embedded System	TPS2	70	60
CO3	Explain the architecture of STM32407xx Microcontroller and the function of on-chip peripherals (GPIOs, I²C, USART, SPI , SDIO ,ADC)	TPS3	70	60
CO4	Explain the architecture of TM4C123 Microcontroller and the function of on-chip peripherals (DMA, interrupt controllers, Timers and watchdogs, CAN,	TPS3	70	60

	USB, PWM, QEI)			
CO5	Design and develop STM32407XX microcontroller based embedded systems for DC motor / stepper motor speed control and display of speed, Temperature measurement and display, data communication using Ethernet/ USB/ CAN and wireless data communication using Bluetooth and Zigbee	TPS3	70	60
CO6	Design and develop TM4C123 Microcontroller based embedded systems for DC motor / stepper motor speed control and display of speed, Temperature measurement and display, data communication using Ethernet/ USB/ CAN and wireless data communication using Bluetooth and Zigbee.	TPS3	70	60

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	L						M		M				M	
CO2	M	L						M		M				M	
CO3	S	M	L					M		M				S	
CO4	S	M	L					M		M				S	
CO5	S	M	L					M		M				S	
CO6	S	M	L					M		M				S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			PRACTICAL				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	1	2	3	4

CO1	20	20									4	10		
CO2	20	20									6	20		
CO3			20				30				2		15	
CO4	-			5	10	20	20				2		10	
CO5	-			5	10	20	30				2		15	
CO6	-			10	20						4	10		

***GUIDED MECHANISM: 20 MARKS**

**Terminal examination covers theory part only.

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	
Adaptation	
Origination	

Syllabus:

Introduction to Embedded Systems: Introduction-History of Embedded Systems – Classification of Embedded Systems - Major Application Areas – Purpose-Wearable Devices - The Typical Embedded System: Core of the Embedded System – Memory – Sensors and Actuators –Communication Interface – Embedded Firmware – Reset, Brown-out Protection circuit – Oscillator – Real-time clock – Watchdog Timer.

Characteristics and Quality Attributes of Embedded Systems:

Characteristics of an Embedded System - Quality Attributes of Embedded Systems – Examples for Application specific and Domain-Specific Embedded Systems.

ARM Cortex M4 Microcontroller:

STM32407xx -Architecture Memory Organization, Low Power modes- GPIOs: Registers- System Configuration Controller- I²C - USART - SPI - SDIO -ADC-Main features- ADC Registers -Single Conversion mode, Continuous Conversion mode, Fast Conversion mode.

TM4C123 Microcontroller: ARM Cortex-M4F Processor Core - Architecture – Memory - DMA - Interrupt controllers - Timers and watchdogs - PWM - QEI - CAN - USB.

Design of Embedded Systems using STM32407XX / TM4C123 microcontroller:

LED illumination control using PWM - Measurement of position and pressure - Temperature measurement and Display- Measurement of power and energy -DC motor's speed control and display of speed - Stepper motor's speed control and display of speed- Data communication using ethernet / USB/ CAN - Wireless data communication using Bluetooth / Zigbee module.

Text Books

1. Shibu K V, 'Introduction to Embedded Systems', Second Edition. Tata McGraw Hill Education Pvt.Ltd.,2017.
2. D.P.Kothari, Shriram K.Vasudevan, Embedded Systems, New Age International Publishers, 2012.
3. ARM Cortex M4 (STM32407xx)Data sheet, ST Microelectronics.
4. ARM Cortex M4 (TM4C123) Data sheet, Texas Instruments.

Reference Books

1. Raj Kamal, 'Embedded Systems, Architecture, Programming and Design', Tata McGraw-Hill, second edition 2010.
2. Tammy Noergaard, Embedded systems Architecture, Second edition, Newnes-Elsevier,2013.
3. Frank Vahid and Tony Givargis, 'Embedded System Design: A Unified Hardware/Software Introduction', John Wiley & Sons, Inc. 2002.
4. Steve Heath, Embedded Systems Design, Second Edition, Elsevier, 2003.

Course Contents and Lecture Schedule

Module No	Topic	No.of Lecture Hours	Course Outcome
1.	**Introduction to Embedded Systems:**		
1.1	History of Embedded Systems –Classification of Embedded Systems - Major Application Areas – Purpose - Wearable Devices	1	CO1
1.2	The Typical Embedded System: Core of the Embedded	1	CO1

	System – Memory – Sensors and Actuators – Communication Interface – Embedded Firmware		
1.3	Reset, Brown-out Protection circuit – Oscillator – Real-time clock – Watchdog Timer	1	CO1
2	**Characteristics and Quality Attributes of Embedded Systems:**		
2.1	Characteristics of an Embedded System	1	CO2
2.2	Quality Attributes of Embedded Systems	1	CO2
2.3	Examples for Application specific and Domain-Specific Embedded Systems.	1	CO2
3.	**ARM Cortex M4 Microcontrollers**		
3.1	STM32407xx –Architecture- Memory Organization, Low Power modes-	1	CO3
3.2	GPIOs: Registers– System Configuration Controller	1	CO3
3.3	I²C - USART - SPI - SDIO	2	CO3
3.4	ADC-Main features- ADC Registers -Single Conversion mode, Continuous Conversion mode, Fast Conversion mode	1	CO3
3.5	Advanced Control Timers (TIM1 and TIM8)-PWM mode	1	CO3
4	**TM4C123 Microcontroller**		
4.1	Architecture- Memory - DMA- GPIOs	1	CO4
4.2	General Purpose Timers	1	CO4
4.3	PWM, QEI	1	CO4
4.4	CAN, USB	1	CO4
5	**Embedded Applications based on STM32407XX Microcontroller**		
5.1	LED illumination control using PWM	1	CO5
5.2	Speed control of DC motor, Stepper motor	1	CO1
5.3	Data communication using ethernet / USB/ CAN	1	CO1
5.4	Wireless data communication using Bluetooth / Zigbee module	1	CO1
6	**TM4C123 Microcontroller Applications**		
6.1	LED illumination control using PWM	1	CO5
6.2	Speed control of DC motor, Stepper motor	1	CO1
6.3	Data communication using ethernet / USB/ CAN	1	CO1
6.4	Wireless data communication using Bluetooth / Zigbee module	1	CO1

List of Experiments (24 Hours)

Design of Embedded Systems using STM32407XX / TM4C123 microcontroller:

1. DC motor's speed control and display of speed

2. Stepper motor's speed control and display of speed
3. Temperature measurement and Display
4. Measurement of power and energy
5. LED illumination control using PWM
6. Data communication using ethernet / USB/ CAN
7. Wireless data communication using Bluetooth / Zigbee module
8. Measurement of position and pressure

Course Designers:

1. Dr.L.Jessi Sahaya Shanthi, Professor, EEE, ljseee@tce.edu
2. Dr.P.S.Manoharan, Associate Professor, EEE,psmeee@tce.edu.

22EEPR0	CONTROL SYTEMS DESIGN	Category	L	T	P	Credit
		PSE	2	1	0	3

Preamble

This course is to impart in students a good understanding of fundamental design principles in control engineering. The course covers design of continuous time and sampled data control systems using transfer function and state space based methods.

Prerequisite

- 22EE440 : Control systems

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment %
CO1	Design compensators using Root locus and Bode plot for continuous time system to achieve the given specifications	TPS3	70%	70%
CO2	Analyse the time domain and frequency domain characteristics of a given discrete time system	TPS4	70%	70%
CO3	Design digital controllers/compensators using root locus and Bode plot for a discrete time system to achieve given specifications	TPS3	70%	70%
CO4	Design state feedback controller and observer using pole placement technique for continuous and discrete time systems	TPS3	70%	70%
CO5	Explain the effects of word length in the characteristics of a discrete time control system	TPS2	75%	80%
CO6	Analyze the compensators/controllers designed for the given system using MATLAB control system design tool	TPS4	70%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**	**1**						**2**					
CO2	**3**	**3**	**2**	**2**						**2**		**2**			
CO3	**3**	**3**	**2**	**2**						**2**					
CO4	**3**	**3**	**2**	**2**						**2**					
CO5	**2**	**1**								**2**					
CO6	**3**	**3**	**2**	**2**	**3**					**2**		**2**			

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Assignment 1				Assignment 2				Terminal					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	5	10	15																		2	4	15			
CO2	5	10	20	20									100								2		10	20		
CO3			15				5		20												2	4	15			
CO4							5	10	40												2	4	10			
CO5								20													2	8				
CO6																				100						

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.
CO6 is will be evaluated only using Assignment 1 and Assignment 2

Syllabus

Design of continuous systems using Transfer function:

Design problem – Preliminary consideration of classical design – Realization of lag, lead and lag-lead compensators – Root locus based design of cascade compensators - Frequency domain design of cascade compensators – Feedback compensation - PID controller Analysis & Design - Design using MATLAB

Discrete Control Systems Analysis & Design:

Introduction to Sample data control systems, Z and S domain Relationship- Effect of sampling on poles and zeros, Stability analysis. State space analysis of discrete systems Z-plane specifications of control system design, Digital compensator design using Root locusplots, Digital compensator Design using frequency response plots, Z-plane synthesis- Design using MATLAB

Design in State Space [Continuous & Discrete Systems]:

Introduction to state space model, Discretization of state space models, State transition matrix, Solution of state equations, Effect of word length and sampling period on Controllability and observability, Stability improvement by pole placement, pole placement by state feedback, Pole placement by output feedback, Full order observers- Reduced order observers- Separation principle - dead beat control using state feedback – State space design using MATLAB.

Text Book

1. B.C. Kuo, and F.Golnaraghi, Automatic Control Systems, 9th Edition. Wiley India Pvt limited 2014.

2. Norman.S.Nise, "Control System Engineering", 7th edition, John Wiley And Sons, 2014

3. M. Gopal, "Digital Control and State Variable Methods –Conventional and Intelligent Control Systems", 4th Edition, Tata McGraw Hill Education, 2017.

4. Katsuhiko Ogata, "Discrete Time Control Systems", 2nd edition, PHI Learning Pvt. Ltd, 2009.
5. Kannan M. Moudgalya, "Digital Control", John Wiley & Sons,2009

Reference Books

1. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Pearson, 12th Edition, 2010
2 Jacqueline wilkie, Michael Johnson and Reza Katebi," Control Engineering: An Introductory Course ", Palgrave Publishers, 2003

Course Contents and Lecture Schedule

Module No.	**Topic**	**No. of Periods**
1	**Design of continuous systems using Transfer function:**	

Module No.	Topic	No. of Periods
1.1	Design problem – Preliminary consideration of classical design	1
1.2	Realization of lag, lead and lag-lead compensators	1
1.3	Root locus based design of cascade compensators	2
1.4	Frequency domain design of cascade compensators	2
1.5	Feedback compensation	1
1.6	PID controller analysis and design	1
1.7	Design using MATLAB	2
2	**Discrete Control System Analysis & Design**	
2.1	Sampling, Structure of discrete control system,	1
2.2	Discretization of continuous systems	1
2.3	Effect of sampling on poles and zeros, Stability Analysis using Jury's Stability Criterion	1
2.4	Discrete Root locus and Bode plots	2
2.5	Z-plane specifications of control system design	1
2.6	Digital compensator design using Root locus plots	2
2.7	Digital compensator Design using frequency response plots and Z-plane synthesis	2
2.8	Design using MATLAB	2
3	**Design in State Space [Continuous & Discrete Systems]**	
3.1	State space models- Discretization of state space models	1
3.2	State transition matrix, Solution of state equations	1
3.3	Effect of word length and sampling period on controllability and observability	1
3.4	Stability improvement by pole placement	1

Module No.	Topic	No. of Periods
3.5	Pole placement by state feedback	2
3.6	Full order Observers	2
3.7	Reduced order observers	2
3.8	Dead beat response in discrete systems	1
3.9	State Space design using MATLAB	2
	Total	36

Course Designer(s):

1. Dr. S. Baskar, Porfessor,EEE, sbeee@tce.edu

2. Prof. S.Sivakumar, Associate Professor, siva@tce.edu

22EEPS0 INDUSTRIAL INSTRUMENTATION

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Instrumentation is the science of automated measurement and control. The process of measuring and controlling various quantities in industries by utilizing various industrial instruments is called as industrial instrumentation. It is a collective term for measuring instruments used for indicating, measuring and recording physical quantities. For controlling any quantity, primarily that particular quantity has to be measured Applications of this science abound in modern research, industry, and even in household. From automobile engine control systems to home thermostats to aircraft autopilots to the manufacture of pharmaceutical drugs, automation surrounds us. This course covers some of the fundamental principles of industrial instrumentation

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO No	Course Outcome	TPS Scale	Expected Proficiency (%)	Expected attainment level(%)
CO1	Explain the principle and operating characteristics of Force and torque measuring techniques	TPS2	75	70
CO2	Apply suitable technique for measurement Acceleration and Vibration for a given application	TPS3	75	70
CO3	Apply suitable technique for measurement of Flow and Level for a given application	TPS3	75	70
CO4	Explain the principle and operating characteristics of Viscosity measuring techniques	TPS2	75	70
CO5	Apply suitable technique for measurement of high temperature for a given application	TPS3	75	70
CO6	Apply suitable technique for measurement of Pressure for a given application	TPS3	75	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO15.	M	**L**						**M**		**M**				**M**

CO16.	S	**M**	**L**					**M**		**M**				**S**
CO3	S	**M**	**L**					**M**		**M**				**S**
CO4	M	**L**						**M**		**M**				**M**
CO5	S	**M**	**L**					**M**		**M**				**S**
CO6	S	**M**	**L**					**M**		**M**				**S**

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	10													10			
CO2	5	20	10				50								10			
CO3	10	20	20				50									20	20	
CO4				5	10	10												
CO5				5	20	20					50					20		
CO6				10	20						50					10	10	

Syllabus

MEASUREMENT OF FORCE, TORQUE

Different types of load cells - Hydraulic, Pneumatic, strain gauge-Magnetoelastic and Piezoelectric load cells - Different methods of torque measurement:- Strain gauge-Relative angular twist

MEASUREMENT OF ACCELERATION, VIBRATION

Accelerometers LVDT, Piezoelectric, Strain gauge and Variable reluctance type accelerometers - Mechanical type vibration instruments - Seismic instruments as accelerometer - Vibration sensor - Calibration of vibration pickups

FLOW MEASUREMENTS

Orifice plate different types of orifice plates , Difference between area flow and mass flow meters, Venturi tube — Flow nozzle -Electromagnetic flow meter — Ultrasonic flow meters

LEVEL MEASUREMENT

Float gauges - Electrical types: Conductivity sensors, Differential pressure level measurement

MEASUREMENT OF VISCOSITY

Viscosity — Saybolt viscometer-Rotameter type viscometer

HIGH TEMPERATURE MEASUREMENTS

Special techniques for measuring high temperature using thermocouple -Radiation fundamentals - Radiation methods of temperature measurement - Total radiation pyrometers -Optical pyrometers

PRESSURE MEASUREMENT

Units of pressure - Manometers, different types, Elastic type pressure gauges, capacitive type pressure gauge

Text Book

1. Patranabis, D. Principles of Industrial Instrumentation, 3rd Edition, Tata McGraw Hill, New Delhi, 2017.
2. Doebelin, E.O.and Manik,D.N., Measurement Systems Application and Design, Special Indian Edition, Tata McGraw Hill Education Pvt. Ltd., 2007

Reference Books

1. Liptak, B.C., Instrumentation Engineers Handbook (Measurement), CRC Press, 2013.
2. Singh,S.K., Industrial Instrumentation and Control, Tata McGrawHill Education Pvt. Ltd., New Delhi, 2009.
3. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 2017

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures

Module No.	Topic	No. of Lectures
1	**MEASUREMENT OF FORCE, TORQUE:**	
1.1	Different types of load cells Hydraulic, Pneumatic, strain gauge	1
1.2	Magnetoelastic and Piezoelectric load cells	2
1.3	Different methods of torque measurement:- Strain gauge-Relative angular twist	2
2	**MEASUREMENT OF ACCELERATION, VIBRATION**	
2.1	Accelerometers LVDT, Piezoelectric	1
2.2	Strain gauge and Variable reluctance type accelerometers	1
2.3	Mechanical type vibration instruments - Seismic instruments as accelerometer	2
2.4	Vibration sensor - Calibration of vibration pickups	1
3	**FLOW MEASUREMENTS**	1
3.1	Orifice plate different types of orifice plates	2
3.2	Difference between area flow and mass flow meters	1
3.3	Venturi tube — Flow nozzle	1
3.4	Electromagnetic flow meter — Ultrasonic flow meters	2
4	**LEVEL MEASUREMENT**	
4.1	Float gauges - Displacer type, DIP methods	1
4.2	Bubbler system-Load cell Electrical types: Conductivity sensors	1
4.3	Boiler drum level measurement - Differential pressure level measurement	2
5	**MEASUREMENT OF VISCOSITY, HUMIDITY AND MOISTURE:**	1
5.1	Viscosity — Saybolt viscometer-Rotameter type viscometer	2
6	**HIGH TEMPERATURE MEASUREMENTS:**	
6.1	Special techniques for measuring high temperature using thermocouple	2
6.2	Radiation fundamentals - Radiation methods of temperature measurement	2
6.3	Total radiation pyrometers- Optical pyrometers -	2
7	**PRESSURE MEASUREMENT :**	2
7.1	Units of pressure - Manometers, different types, gauges	2
7.2	Elastic type pressure gauges, Capacitive type pressure gauge	2
	Total	36

Course Designers:

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22EEPT0	SOFT COMPUTING (THEORY CUM PRACTICAL)	Category	L	T	P	Credit
		PSE	2	0	2	3

Preamble

The objective of this course is to introduce basic concepts and applications of soft computing tools such as neural networks, fuzzy logic systems, and genetic algorithms. Also it covers soft computing based solutions for real-world Electrical Engineering problems.

Prerequisite

- Prior knowledge of MATLAB software is required.

Course Outcomes

On the successful completion of the course, students will be able to

		TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the role of various soft computing techniques in building intelligent systems	TPS2	85	80
CO2	Explain fuzzy logic operations, relations and inference system	TPS2	85	80
CO3	Develop the fuzzy logic controller for the given electrical system	TPS4	80	75
CO4	Explain the architecture and learning methodologies of perceptron, and back propagation neural networks	TPS2	85	80
CO5	Apply back propagation neural network for modelling and control of the given electrical engineering system	TPS4	80	75
CO6	Apply genetic algorithm to solve the given optimization problem using hand calculations	TPS4	80	75
CO7	Use MATLAB Fuzzy logic, Neural network and GA toolboxes effectively to solve a given electrical engineering problem	TPS4	80	75

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO 1	M	L						M		M			M	M	
CO 2	M	L						M		M			M	M	
CO 3	S	M	L					M		M			S	S	
CO 4	M	L						M		M			M	M	
CO 5	S	M	L					M		M			S	S	
CO 6	S	M	L					M		M			S	S	
CO 7	S	S	M	L	S			M		M			S	S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Practical				Terminal				
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**2**	**3**	**4**	**5**	**6**
CO1	20																				
CO2		40															20				
CO3			40															20			
CO4							20														
CO5								40									20				
CO6									40									20			
CO7													50	50							

Syllabus

Introduction to soft computing - Fuzzy logic, Neural Network and Genetic algorithm

Fuzzy Logic: Fuzzy sets, logic operations, and relations; Fuzzy decision-making; fuzzy inference systems; design steps in fuzzy logic controller; application of fuzzy logic controller in Electrical engineering.

Neural networks: Basic concepts and major classes of neural networks, supervised and unsupervised learning, Single-layer perceptron, Multi-layer perceptron, Back Propagation Neural network, RBF networks. Application of neural network modelling / control problems in Electrical engineering

Genetic algorithms: Introduction - genetic algorithm steps-Selection, Crossover and Mutation; Application of GA to Electrical engineering problems.

Use of MATLAB Fuzzy logic, Neural network and GA toolboxes to solve electrical engineering problems.

List of Experiments:

- Fuzzy logic based modelling
- Fuzzy logic based control
- Neural network based Classification
- Neural network based Regression
- Neural network based control
- GA based optimization of unconstrained Nonlinear optimization problem
- GA based optimization of constrained Nonlinear optimization problem
- GA based optimization of Economic Dispatch

Text Book

1. S.N.Sivanandam, and S.N.Deepa, Principles of Soft computing, Second Edition, Wiley India Pvt. Ltd, 2013.
2. N.P.Padhy and S.P.Simon, Soft computing with MATLAB programming, Oxford publishers, 2015.

Reference Books& web resources

1. George J.Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic, Second Edition, PHI, 2006
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Third Edition, John Wiley and Sons Ltd., 2010.
3. J.M.Zurada, Introduction to artificial neural systems, Jaico Publishing House, 2006
4. D.E. Goldberg, Genetic algorithms in search, optimization, and machine learning, Addison-Wesley.1989.
5. http://nptel.ac.in/courses/106106046/41
6. https://www.coursera.org/learn/neural-networks
7. http://www.iitk.ac.in/kangal/deb.shtml

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course Outcome

1	**Introduction to soft computing**		
1.1	Basics of Fuzzy logic, Neural network, and Genetic algorithm	2	CO1
2.	**Fuzzy Logic**		
2.1	Fuzzy sets	1	CO2
2.2	Fuzzy logic operations	1	CO2
2.3	Fuzzy relations	1	CO2
2.4	Fuzzy decision-making	1	CO2
2.5	fuzzy inference systems	1	CO2
2.6	Design steps in fuzzy logic controller;	1	CO3
2.7	Application of fuzzy logic controller in electrical engineering.	2	CO3
3	**Neural networks**		
3.1	Neural networks: Basic concepts	1	CO4
3.2	Classification, architecture and algorithm of ANN	2	CO4
3.3	Supervised and unsupervised learning	1	CO4
3.4	Single-layer Perceptron and Multi-layer Perceptron	2	CO4
3.5	Back Propagation Neural networks	1	CO5
3.6	Application of neural network in solving electrical engineering problem	2	CO5
4	**Genetic algorithms**		
4.1	Conventional optimization methods	1	CO6
4.2	Genetic algorithm steps - Selection, Crossover and Mutation	2	CO6
4.3	Application of GA in solving optimization problem	2	CO6
5	Use of MATLAB Fuzzy logic, Neural network and GA toolboxes to solve electrical engineering problems.	24	CO7

	Total	**48**	

Course Designers:

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22EEPU0	FLEXIBLE AC TRANSMISSION SYSTEMS	Category	L	T	P	Credit
		PSE	2	1	0	3

Preamble

FACTS devices are power electronics based system that provides control of AC transmission system parameters to enhance controllability and increase power transfer capability. Rising energy costs and a greater sensitivity to environmental impact of new transmission lines necessitated the application of FACTS controllers to minimize losses and maximize the stable power-transmission capacity of existing lines.

Prerequisite

22EE450 Power Electronics

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the need for reactive power control, types of reactive power compensations and need for FACTS controllers.	TPS2	85	80
CO2	Analyse the performance of various shunt type FACTS controllers	TPS3	80	75
CO3	Analyse the performance of various series type FACTS controllers	TPS3	80	75
CO4	Describe the performance and applications of UPFC.	TPS2	85	80
CO5	Model a FACTS controller for the given network configuration with respect stability.	TPS3	80	75
CO6	Model a FACTS controller for the given network configuration based on load flows.	TPS3	80	75

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	M	L						M		M			M	M	
CO 2	M	L						M		M			M	M	

CO3	M	L						M		M			M	M	
CO4	M	L						M		M			M	M	
CO5	S	M	L					M		M			S	S	
CO6	S	M	L					M		M			S	S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Assignment 1				Assignment 2				Terminal					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	20																				10					
CO2		50											50									25				
CO3			30										50										15			
CO4							20														10					
CO5								50									50					25				
CO6									30								50						15			

Syllabus

Introduction

Reactive power control in electrical power transmission lines -Uncompensated transmission line – Fixed series and shunt compensation – Basic types of FACTS controllers – Brief description and definitions of FACTS controllers.

Static Shunt Compensation

Static Shunt Compensators - SVC and STATCOM - operation and control of TSC, TCR, STATCOM - Compensator Control – Comparison between SVC and STATCOM – Applications of shunt compensators and TCBR.

Static Series Compensation

TSSC, TCSC and SSSC - operation and control – Control schemes for series compensators - SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control

Unified Power Flow Control

Introduction, Implementation of power flow control using conventional thyristors, Unified power flow concept, Implementation of unified power flow controller.

Modelling of FACTS Controllers

Modelling of Shunt and Series Controllers for Power Flow and Transient stability, Modelling of UPFC.

Text Book

1. N.G. Hingorani & L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Wiley; IEEE Press, 2000.
2. R. Mohan Mathur, Rajiv K. Varma. Thyristor-Based FACTS Controllers for Electrical Transmission Systems, Wiley & IEEE Press, 2002.

Reference Books

1. T.J.E Miller, Reactive Power Control in Electric Systems, New Age International, New Delhi, 1994.
2. K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International Publishers, 2nd Edition, 2016.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Reactive power control in electrical power transmission lines	1
1.2	Uncompensated transmission line – Fixed series and shunt compensation – Basic types of FACTS controllers	2
1.3	Brief description and definitions of FACTS controllers	2
2	**Static Shunt Compensation**	
2.1	Static Shunt Compensators	1
2.2	SVC and STATCOM	2
2.3	Operation and control of TSC, TCR, STATCOM	2
2.4	Compensator Control	1
2.5	Comparison between SVC and STATCOM –	1
2.6	Applications of shunt compensator	1
2.7	TCBR	1
3	**Static Series Compensation**	
3.1	TSSC, TCSC and SSSC - operation and control	2

3.2	Control schemes for series compensators	2
3.3	SSR and its damping	2
3.4	Static voltage and phase angle regulators	2
3.5	TCVR and TCPAR - operation and control	2
4	**UPFC**	
4.1	Implementation of power flow control using conventional thyristors	2
4.2	Unified power flow concept	2
4.3	Implementation of unified power flow controller	2
5	**Modelling of FACTS Controllers**	
5.1	Modelling of Shunt and Series Controllers for Power Flow	2
5.2	Modelling of Shunt and Series Controllers for Transient stability	2
5.3	Modelling of UPFC	2
	Total	**36**

Course Designer(s):

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22EEPV0	POWER QUALITY	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

This course imparts knowledge about various electrical power quality issues and their origin and addresses the effects of power quality problems on electrical power system. It also emphasis need for PQ monitoring and measurement. The study on transient and power factor enables students to understand the characteristics and performance of the real system. The topic on introduction to mitigation devices gives solution for solving various PQ issues.

Course Outcomes

Course Outcome No.	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain various power quality problems	TPS2	80	85
CO2	Discuss the root cause of power quality problems	TPS2	80	85
CO3	Determine the PQ indices in the given electrical system	TPS3	80	85
CO4	Assess the severity of PQ problems in distribution system	TPS3	80	85
CO5	Analyze various power quality issues and their solutions in residential / commercial / industrial facilities	TPS4	80	85
CO6	Develop an ability to analyse the measured data	TPS3	80	85

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M			M	M

CO2	M	L						M		M			M	M
CO3	S	M	L					M		M			M	M
CO4	S	M	L					M		M			M	M
CO5	S	M	M					M		M			M	M
CO6	S	M	M					M		M			M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2				ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	4	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	10														10	10		
CO2	10	10	20													10	10		
CO3		20	20														5	10	
CO4				**5**	15	10											5	10	
CO5				5	15	20		50	50								5	10	10
CO6				10	10	10	10					50	50				5		

Syllabus

Introduction

Power quality - Impact of PQ on end users, Need for PQ monitoring, Various PQ problems

Voltage disturbances

Voltage dips, over voltages, short supply interruptions, voltage fluctuations and flicker **-** sources, effects, measurement and mitigation

Harmonics

Definition, odd and even harmonics, harmonic phase sequence, voltage and current harmonics, individual and total harmonic distortion, harmonic standards, sources, effects on various electrical components, measurements and mitigation, passive and active filters (Case Studies)

Power factor

Active and reactive power flow with nonlinear load, displacement and distortion power factor, power factor penalty, power factor improvement, applications of synchronous condensers and static VAR compensators, automatic power factor controller (Case Studies)

Transients

Transient system model, examples of transient models and their response, power system transient model, types and causes of transients, lightning, other switching transients.

Voltage and Current Unbalance

Symmetrical components of currents and voltages, sources, effects, measurements and mitigation

Effect of Grounding

Shock and fire hazards, essential of a grounded system, earth resistance tests, methods of grounding, effect of poor grounding on power quality.

Solving PQ problems using CPD and PQ Measurement

Introduction to custom power devices (CPD) – STATCOM, DVR, UPQC - Power quality measuring equipment-Smart power quality analysers.

Text Book

1. Sankaran C, "Power Quality", CRC Press special Indian edition 2009.

Reference Books

1. Angelo Baggini, "Handbook of Power Quality" John Wiley & Sons Ltd, 2008.
2. Roger .C. Dugan, Mark F.Mcgranaghan&H.Wayne Beaty," Electrical power system Quality" McGraw-Hill Newyork Second edition 2003.
3. Barry W.Kennedy, "Power Quality Primer", McGraw-Hill, New York, 2000.
4. Math H.J.Bollen, « Understanding Power Quality Problems : Voltage Sags and Interruptions », IEEE Press, New York, 2000.
5. Arrillaga.J, Watson.N.R and Chen.S, « Power System Quality Assessment », John Wiley & Sons Ltd., England, 2000
6. Bhim Singh, Ambrish Chandraand Kamal Al-Haddad: Power Quality: Problems and Mitigation Technique, Wiley Publications, 2015
7. Arindam Ghosh and Gerald Ledwich: Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002.
8. G.T.Heydt: Electric Power Quality, 2nd edition, Stars in a Circle Publications, 1994.
9. Math H.J.Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", IEEE Press, New York, 2000.

Course contents and Lecture schedule

Sl No.	Topic	No. of Hours	Course Outcome
1	**Introduction**		
1.1	Power quality	1	CO1
1.2	Impact of PQ on end users	1	CO2
1.3	Need for PQ monitoring	1	CO6
2	**Voltage disturbances**		
2.1	Voltage dips	1	CO3
2.2	Over voltages	1	CO3
2.3	Short supply interruptions	1	CO2
2.4	Voltage fluctuations and flicker	1	CO2
3	**Harmonics**		
3.1	Definition, odd and even harmonics, harmonic phase sequence	1	CO1
3.2	Voltage and current harmonics	1	CO1
3.3	Individual and total harmonic distortion	1	CO4
3.4	Harmonic standards	1	CO4
3.5	Sources, effects on various electrical components	1	CO2
3.6	Measurements and mitigation	1	CO6
3.7	Passive and Active filter	1	CO5
4	**Power factor**		
4.1	Active and reactive power flow with nonlinear load	1	CO2
4.2	Displacement and distortion power factor	1	CO2
4.3	Power factor penalty, power factor improvement	1	CO5
4.4	Applications of synchronous condensers	1	CO5

4.5	Static VAR compensators, automatic power factor controller	2	CO5
5	**Transients**		
5.1	Transient system model, examples of transient models and their response, power system transient model	2	CO1
5.2	Types and causes of transients	1	CO1
5.3	Lightning, other switching transients	1	CO2
6	**Voltage and Current Unbalance**		
6.1	Symmetrical components of currents and voltages,	1	CO3
6.2	Sources & effects	1	CO2
6.3	Measurements and mitigation	1	CO3
7	**Grounding**		
7.1	Essential of grounding, Earth resistance tests	1	CO1
7.2	Methods of grounding	1	CO5
7.3	Effect of poor grounding on power quality	1	CO5
8	**Solving power quality problems using CPD**		
8.1	Introduction to custom power devices – STATCOM	2	CO6
8.2	DVR, UPQC	1	
8.3	Power quality measuring equipment, Smart power quality analyzer	2	CO5
	Total	**36**	

Course Designers:

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22EEPW0	**POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

This course will cover the applications of power electronics for the control and conversion of electrical power with emphasis on renewable energy systems.

Prerequisite

- 22EE450 : Power Electronics

Course Outcomes

On the successful completion of the course, students will be able to

Course Outcome NO.	**Course Outcomes**	Bloom's Level	**Expected Proficiency (%)**	**Expected Attainment Level (%)**
CO1	Explain contribution and impact of renewable energy sources	Understand	70	70
CO2	Describe the features of power electronics and their role in renewable energy system	Understand	70	70
CO3	Design appropriate converter for renewable energy systems	Apply	70	70
CO4	Categorize various issues experienced during grid connection of wind generators	Apply	70	70
CO5	Categorize various issues experienced during grid connection of PV systems	Apply	70	70
CO6	Demonstrate the control aspects of converters used in wind generators and PV systems	Apply	70	70

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO 12**	**PSO 1**	**PSO 2**

CO1	**M**	**L**						M		M			M	M
CO2	**M**	**L**						M		M			S	S
C03	**S**	**M**	**L**	**L**				M		M			S	S
CO4	**S**	**S**	**M**	**M**				M		M			S	S
CO5	**S**	**S**	**M**	**M**				M		M			S	S
CO6	**S**	**M**	**L**	**L**				M		M			M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	10													5	5		
CO2	5	15	20												5	5	10	
CO3	5	15	20													10	10	
CO4				5	15	20									5	5	10	
CO5				5	15	20										10	10	
CO6				10	10										5	5		
CO7							50	50			50	50						

Syllabus

Introduction

Environmental Pollution: Global Warming Problem, Impact of Power Electronics on Energy Systems, Challenges of the Current Energy Scenario: The Power Electronics Contribution, Renewable Energy Systems

Class of Power Converters for Renewable Energy

Introduction, Hard Switching AC-Link Universal Power Converter, Soft Switching AC-Link Universal Power Converter, Principle of Operation of the Soft Switching AC-Link Universal Power Converter

Key Technology for Wind Turbines

Introduction, Development of Wind Power Generation, Power Converters for Wind Turbines, Controls and Grid Requirements for Modern Wind Turbines, Emerging Reliability Issues for Wind Power System.

Photovoltaic Energy Conversion Systems

Introduction, Power Curves and Maximum Power Point of PV Systems, Grid-Connected PV System Configurations, Control of Grid-Connected PV Systems – Converters for domestic applications

Hybrid Renewable Energy System

Converters for hybrid renewable energy system - Recent Developments in Multilevel converters

Text Book

1. Haitham Abu-Rub, Mariusz Malinowski & Hamal Al Haddad, “Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications”, IEEE Press and John Wiley Publications, First Edition, 2014.

Reference Books

1. Muhammad H.Rashid, “Power Electronics Circuits, Devices & Applications”, Pearson Education India Publication, New Delhi, 7th Impression, 2009.
2. Ned Mohan, Tore Undeland & William Robbins, “Power Electronics: converters Applications and Design”, John Willey and sons, 3rd Edition, 2003.
3. Ali Keyhani, M.N.Marwali & Min Dai, “Integration of green and renewable energy in electrical power systems”, Wiley and sons, 2010.
4. Ewald F. Fuchs & Mohammad A.S. Masoum, “Power Conversion of Renewable Energy Systems” Springer New York Dordrecht Heidelberg London, 2011.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.	**Introduction**	
1.1	Global Warming and need of Renewable Energy Systems	1
1.2	Various types of Renewable Energy Systems	2

Module No.	Topic	No. of Lectures
1.3	Impact of Power Electronics on Energy Systems	1
2.	**Class of Power Converters for Renewable Energy**	
2.1	Hard Switching AC-Link Universal Power Converter	2
2.2	Soft Switching AC-Link Universal Power Converter	1
2.3	Principle of Operation of the Soft Switching AC-Link Universal Power Converter	2
2.3.1	Design Procedure and Analysis	2
2.4	AC–AC,DC–AC and AC–DC Power Conversion	2
3.	**Key Technology for Wind Turbines**	
3.1	Development of Wind Power Generation	2
3.2	Wind Generator Technologies	1
3.3	Power Converters for Wind Turbines	2
3.4	Controls and Grid Requirements for Modern Wind Turbines	2
3.5	Emerging Reliability Issues for Wind Power System	2
4.	**Photovoltaic Energy Conversion Systems**	
4.1	Development of Solar Power Generation	1
4.2	Power Curves and Maximum Power Point of PV Systems	2
4.3	Grid-Connected PV System Configurations	2
4.4	Control of Grid-Connected PV Systems	2
4.5	Recent Developments in PV Systems	2
4.6	Converters for domestic applications	1
5.	**Hybrid Renewable Energy System**	
5.1	Converters for hybrid renewable energy system	2
5.2	Recent Developments in Multilevel converters	2
	TOTAL	36

Course Designers:

1.	Dr.V.SureshKumar, Professor, EEE	vskeee@tce.edu
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22EERM0 ELECTRIC VEHICLES

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

In the future transportation sector, electric vehicles (EV) and hybrid electric vehicles (HEV) will play a significant role. Because it has more advantages than internal combustion engine (ICE) based vehicles. This course introduces the fundamental concepts, analysis and design of hybrid electric and electric vehicles. The students learn about the various aspects of hybrid and electric vehicles such as their configuration, powertrain sizing, types of electric machines and their control, and energy storage devices, etc.

Prerequisite

-NIL

Course outcomes

COs	**Course outcomes**	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the basic concepts of Electric vehicle (EV) and hybrid electric vehicles(HEV)	TPS2	70	70
CO2	Calculate the tractive force, tractive power and energy required for the given road, acceleration and velocity profile condition in a vehicle	TPS3	70	70
CO3	Calculate the power rating of motor and ICE and battery energy requirements for the given EV and HEV specifications	TPS3	70	70
CO4	Analyze the performance of EV / HEV using simulation software	TPS4	70	70
CO5	Explain the different energy storage systems, their characteristics and charging methods	TPS2	70	70
CO6	Calculate the different parameters in the DC drives and AC drives used for motor control in EV and HEV	TPS3	70	70

apping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	M	L						M		M			S	
CO2.	S	M	L	L				M		M			S	
CO3.	S	M	L	L				M		M			S	
CO4.	S	S	M	M				M		M			S	
CO5.	M	L						M		M			S	
CO6.	M	L						M		M			S	

S- Strong; M-Medium; L-Low

***CO4 will be assessed using an assignment on simulation of some part of EV/HEV.**

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	20	20	-	-	-	-								5	10	10	
CO2	5	10	20												2	5	10	
CO3	5	10													3	5		
CO4	-			10	20	20	100				100				5	10	10	
CO5	-			5	10	20									2	5	10	
CO6	-			5	10										3	5		

Syllabus

Introduction History of Electric vehicles (EV) and Hybrid electric vehicles (HEV)-EV and HEV components-Vehicle mass and performance-Electric motor and engine ratings- Well to wheel analysis- EV and Conventional Vehicle comparison

Vehicle Mechanics

Roadway fundamentals-Laws of motion-Vehicle kinetics-Dynamics of vehicle motion-Propulsion power-Velocity and acceleration

EV and HEV architectures and power train component sizing

Architecture of EV, HEV and PHEV- Powertrain component sizing for EV, HEV- Mass analysis and Packaging – Vehicle simulation- V2G and G2V – Fuel cell vehicles.

Energy storage systems

Battery energy storage- Batteries in EV and HEV-Battery basics-Battery parameters-Battery modeling- Traction batteries-Battery pack management-SOC and Fast Charging-Ultra capacitors

Electric motor drives

Electric drive components- DC drives- AC drives-Control of AC machines-Induction machine vector control- PM machine vector control – SRM drives

References Books:

1. Iqbal Husain, Electric and hybrid vehicles-Design fundamentals, Second edition, CRC Press,2011
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, ’Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives’, Wiley, 2011.
3. Mehr Ehsani, Yimin Gao, Sebestien E. Gay and Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
4. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
5 T. Denton, “Electric and Hybrid Vehicles”, Routledge Pub., 2016.
6. Ion Boldea and S.A Nasar, ‘Electric drives’, CRC Press, 2005.
7. James Larminie & amp; John Lowry "Electric Vehicle Technology Explained ", John Wiley & sons, 2012

Course Contents and Lecture Schedule

S. No.	Topics	No. of Lectures
1.	**Introduction**	
1.1	History of hybrid and electric vehicles, EV and HEV components	2
1.2	Vehicle mass and performance	1
1.3	Electric motor and engine ratings	2
1.4	Well to wheel analysis, EV and Conventional Vehicle comparison	1
2	**Vehicle Mechanics**	
2.1	Roadway fundamentals, Laws of motion	2
2.2	Vehicle kinetics, Dynamics of vehicle motion	2

2.3	Propulsion power, Velocity and acceleration	2
3.	**EV and HEV architectures and powertrain component sizing**	
3.1	Architecture of EV, HEV and PHEV	1
3.2	Powertrain component sizing for EV	1
3.3	Powertrain component sizing for HEV	1
3.4	Mass analysis and Packaging,Vehicle simulation- PHEV-V2G and G2V - Fuelcell vehicles	2
4.	**Energy storage systems**	
4.1	Battery energy storage- Batteries in EV and HEV, Battery basics	2
4.2	Battery parameters-Battery modeling	2
4.3	Traction batteries-Battery pack management	2
4.4	SOC and Fast charging	2
4.5	Ultra capacitors	1
5	**Electric motor drives**	
5.1	Electric drive components, DC drives	2
5.2	AC drives	2
5.3	Control of AC machines, Induction machine vector control	2
5.4	PM machine vector control	2
5.5	SRM drives	2
	Total	**36**

Course Designers:

1. Dr.S.Arockia Edwin Xavier, Associate Professor, EEE saexeee@tce.edu
2. Mr.C.Balasundar, Assistant Professor, EEE cbreee@tce.edu

22EEPY0	**DESIGN OF ELECTRICAL INSTALLATION**	Category	L	T	P	Credit
		PEES	2	1	0	3

Preamble

This course illustrates the procedure for the design of installations from initial assessment to final commissioning. The Electrical Installation must be primarily concerned with the safety of persons, property and livestock. The selection of appropriate systems and associated equipment and accessories is an integral part of the design procedure. The types of earthing schemes, choice of a transformer, protective device and the calculation of cable size under normal and fault conditions are included.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the General rules and standards of Electrical Installations design.	TPS2	85	80
CO2	Design of Electrical Installations based on equipment ratings.	TPS3	80	80
CO3	Explain the steps involved in the establishment of Sub-stations.	TPS2	80	80
CO4	Calculate the Size of LV Distribution System Components for a specified Electrical System	TPS3	85	80
CO5	Choose the type and rating of electrical safety devices in an installation.	TPS3	85	80
CO6	Draw the Electrical Plan for the given specification of Residential Electrical Installations.	TPS3	85	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M							S				
CO2	S	M	L									L
CO3	M	M	L	L								

CO4	**S**	**M**	**L**									**L**
CO5	**S**	**M**				**L**	**L**	**L**				
CO6	**S**	**M**				**L**						**L**

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	20													6	10		
CO2	5		20				50								2	5	10	
CO3	5	20													4	10		
CO4	5		20				50								2	5	10	
CO5				10	20	20					50				2	5	10	
CO6				10	20	20					50				4	5	10	
Total	20	40	40	20	40	40	100				100				20	40	40	

Assessment Pattern: Psychomotor

Psychomotor Skill	**Miniproject/Assignment/Practical Component**
Perception	
Set	
Guided Response	100
Mechanism	
Complex Overt Responses	
Adaptation	
Origination	

Syllabus

General rules of electrical installation design: Methodology - Rules and statutory regulations- Voltage Ranges, Standards, Quality & Safety of an electrical installation, Initial Testing of Installation, Periodic Check& Testing of Installation– Characteristics of Installed power loads - Induction motors, Induction Furnace, Resistive type heating applications, Lamps.

Power loading of an installation: Installed Power & Apparent Power, Estimation of Actual Maximum KVA Demand, Application of factors Ku and Ks, Choice of Transformer rating, Choice of power supply sources, Power factor improvement.

Sub-station: Establishment of a new sub-station, information & requirement provided by utility, Commissioning, Testing, Energizing -Different types of sub-station, Generators in stand-alone operation, Generators in parallel operation mode, Protection of Transformer, Interlocks & conditioned operations.

LV Utility Distribution Network: Low voltage consumers, Low voltage networks, Consumer service connection, Quality of supply voltage, Tariff and metering, Earthing connections, Standardized earthing schemes, Installation and measurements of earth electrodes, Distribution Switchboards, Cables & Bus ways.

Sizing and Protection of Conductors: Recommended simplified approach for cables, Sizing of bus bar trunking systems, Maximum voltage drop limit, Calculation of voltage drop in steady load conditions, Short circuit current, Calculation of minimum levels of short circuit current, Conductor Choice & Sizing, Sizing of Neutral conductor, Examples of cable calculation.

Protection against Electric Shock and Electric Fires – Electric shock, Direct & Indirect contact, Measures of protection against direct contact, Measures of protection against indirect contact, Residual Current Devices, Arc Fault Detection Devices, Selection of Ratings.

Residential Installations: Planning of Electrical Installations, Distribution board components selection, Protection of People, Circuits, Protection against over voltages and Lightning, Equi-potential Bonding.

Text Book

1. Schneider Electric "Electrical Installation Guide", Schneider Electric Industries - SAS, 2016 Year Edition, 2016.
2. BUREAU OF INDIAN STANDARDS, "National Electrical Code 2011", Government of India, 1st Revision 2011.

Reference Books& web resources

1. A.J.Watkins, C.Kitcher, " Electrical Installation Calculations - Basics", Elsevier Publications, 8th edition, 2009.
2. Brian Scadden," IEE Wiring Regulation : Design and Verification of Electrical Installations" Elsevier Publications, 6th edition,
3. Paul Cook, "Electrical Installation Design Guide", The Institution of Engineering & Technology, UK, 2nd Edition, 2013.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1	**General rules of electrical installation design**	
1.1	Methodology & Characteristics of Installed power loads, Rules and statutory regulations	3
1.2	Voltage Ranges, Standards, Quality & Safety of an electrical installation, Initial Testing of Installation, Periodic Check& Testing of Installation	2
1.3	Induction motors, Induction Furnace, Resistive type heating applications, Lamps	2
2.	**Power loading of an installation**	
2.1	Installed Power & Apparent Power, Estimation of Actual Maximum KVA Demand, Application of factors Ku and Ks	3
2.2	Choice of Transformer rating, Choice of power supply sources, Power factor improvement.	3
3	**Sub-station** :	
3.1	Establishment of a new sub-station, Different types of sub-station	2
3.2	Protection of Transformer, Interlocks & conditioned operations, information & requirement provided by utility.	2
3.3	Generators in stand-alone operation, Generators in parallel operation mode, Commissioning, Testing, Energizing.	2

Module No.	Topic	No. of Lecture Hours
4	**Sizing and Protection of Conductors**	
4.1	Recommended simplified approach for cables, Sizing of bus bar trunking systems, Maximum voltage drop limit, Calculation of voltage drop in steady load conditions	3
4.2	Short circuit current, Calculation of minimum levels of short circuit current	2
4.3	Conductor Choice & Sizing, Sizing of Neutral conductor, Examples of cable calculation.	2
5.	**Residential Installations**	
5.1	Planning of Electrical Installations, Distribution board components, Protection of People, Circuits	3
5.2	Protection against over voltages & Lightning, Equipotential Bonding.	2
6.	**Protection against Electric Shock and Electric Fires**	
6.1	Electric shock, Direct & Indirect contact, Measures of protection against direct contact, Measures of protection against indirect contact,	3
6.2	Residual Current Devices, Arc Fault Detection Devices.	2
	Total	**36**

Course Designer:

1. Dr. N. Shanmuga Vadivoo, Professor, EEE – nsveee@tce.edu

		Category	L	T	P	Credit
22EEPZ0	**SMART GRID**	PEES	3	0	0	3

Preamble

The course content is designed to study about smart grid technologies, distribution automation, information and communication Technologies, and operation of transmission system operation. It is used to get familiarized with smart metering and demand side integration.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

		TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamentals of smart power grids and its international & Indian scenarios.	TPS2	85	80
CO2	Calculate voltage and power loss for the given distribution system.	TPS3	80	75
CO3	Apply demand side management concept in advanced metering infrastructure system.	TPS3	80	75
CO4	Apply synchrophasor measurement technology in the operation of transmission system.	TPS3	80	75
CO5	Explain the data communication and technology used in smart grid.	TPS2	85	80
CO6	Explain the communication standard protocols used in smart grid.	TPS2	85	80

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO	M	L								M			M		

1															
CO 2	S	M	L	L						M			M		
CO 3	S	M	L							M			M		
CO 4	S	M	L							M			M		
CO 5	M	L								M					
CO 6	M	L								M					

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1						CAT2						Assignment 1				Assignment 2				Terminal					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO1	20																				10					
CO2		40																				20				
CO3			40																				20			
CO4							20														10					
CO5								40														20				
CO6									40														20			
CO7													50	50			50	50								

Syllabus

INTRODUCTION TO SMART GRID

Need for smart grid - Smart Grid definitions - Benefits of smart grid - Overview of enabling technologies in smart grid - vision of smart grid - International experience - smart grid demonstration and deployment efforts - Puducherry smart grid pilot project

DISTRIBUTION AUTOMATION EQUIPMENT

Introduction – Substation automation equipment: Current Transformers - Voltage Transformers - Intelligent Electronic Devices - Faults in the distribution system: Components for fault isolation and restoration – Fault location, isolation and restoration - Distribution network: forward update equation-Backward update equation- Determination of voltage, power loss, network reconfiguration for 16 bus standard distribution system

SMART METERING AND DEMAND SIDE INTEGRATION

Introduction –Smart metering: Evolution - Key components – Smart meters: over view of the hardware used - Communications infrastructure and protocols for smart metering- Demand-side integration (DSI): services - Implementations - Hardware support – Flexibility.

TRANSMISSION SYSTEM OPERATION

Introduction – Data sources: IEDs and SCADA- Phasor measurement units - Wide area applications: On-line transient stability controller-Pole-slipping preventive controller - Visualization techniques: Visual 2-D presentation-Visual 3-D presentation - Synchrophasor deployment in India

DATA COMMUNICATION

Introduction-Dedicated and shared communication channels - switching techniques: circuit switching - Message Switching- Packet switching - Communication channels - wired communication - Optical fibre- Radio communication – Cellular mobile communication - Satellite communication - Layered architecture and protocols: The ISO/OSI model-TCP/IP

COMMUNICATION TECHNOLOGIES FOR THE SMART GRID

Introduction- Communication technologies: IEEE 802 series – Mobile communications- Multi protocol label switching - Standards for information exchange: Standards for smart metering -Modbus-DNP3-IEC 61850

Text Book

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley & Sons Ltd., February 2012.

Reference Books& web resources

1. “Smart Grid primer”, Published by Power grid Corporation of India limited, September 2013
2. Stuart Borlase, “Smart Grid: Infrastructure, Technology and Solutions”, CRC Press 2012.
3. James Momoh, “Smart Grid Fundamentals of Design and Analysis”, IEEE Press, 2012.
4. Tony Flick, Justin morehouse, “Securing the smart grid: Next generation power grid security”, Elsevier, 2010.
5. MOOCs course link: https://www.edx.org/course/smart-grids-electricity-future-ieeex-smartgrid-x-0

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome

1.0	**INTRODUCTION TO SMART GRID**		
1.1	Need For Smart Grid - Smart Grid Definitions - Benefits of Smart Grid	1	CO1
1.2	Overview of Enabling Technologies In Smart Grid	1	CO1
1.3	Vision of Smart Grid	1	CO1
1.4	International Experience: Smart Grid Demonstration And Deployment Efforts - Tailoring Smart Grids to Developing Countries and Emerging Economies	1	CO1
1.5	Puducherry Smart Grid Pilot Project	1	CO1
2.0	**DISTRIBUTION AUTOMATION EQUIPMENT**		
2.1	Introduction	1	CO2
2.2	Substation Automation Equipment: Current Transformers-Voltage Transformers- Intelligent Electronic Devices	2	CO2
2.3	Faults in the Distribution System: Components for fault isolation and restoration – Fault location, isolation and restoration	2	CO2
2.4	Distribution Network: forward update equation-Backward update equation- Determination of voltage, power loss, network reconfiguration for 16 bus standard distribution system	2	CO2
3.0	**SMART METERING AND DEMAND SIDE INTEGRATION**		
3.1	Introduction	1	CO3
3.2	Smart metering: Evolution - Key components	1	CO3
3.3	Smart meters: over view of the hardware used	2	CO3
3.4	Communications Infrastructure And Protocols For Smart Metering	1	CO3
3.5	Demand-side integration (DSI): services - Implementations - Hardware support – Flexibility	2	CO3
4.0	**TRANSMISSION SYSTEM OPERATION**		

4.1	Introduction	1	CO4
4.2	Data Sources: IEDs and SCADA- Phasor measurement units	1	CO4
4.3	Wide Area Applications: On-line transient stability controller-Pole-slipping preventive controller	1	CO4
4.4	Visualization Techniques: Visual 2-D presentation-Visual 3-D presentation	1	CO4
4.5	Synchrophasor deployment in India	1	CO4
5.0	**DATA COMMUNICATION**		
5.1	Introduction	1	CO5
5.2	Dedicated And Shared Communication Channels	1	CO5
5.3	Switching Techniques: circuit switching-Message Switching- Packet switching	1	CO5
5.4	Communication Channels: wired communication-Optical fibre- Radio communication – Cellular mobile communication- Satellite communication	1	CO5
5.5	Layered Architecture And Protocols: The ISO/OSI model-TCP/IP	1	CO5
6.0	**COMMUNICATION TECHNOLOGIES FOR THE SMART GRID**		
6.1	Introduction	1	CO6
6.2	Communication Technologies: IEEE 802 series – Mobile communications- Multi protocol label switching	2	CO6
6.3	Standards For Information Exchange: Standards for smart metering -Modbus-DNP3-IEC 61850	1	CO6
	Total	**36**	

Course Designers:

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2. Dr.S.Charles Raja Associate Professor, EEE charlesrajas@tce.edu

22EERA0	THERMAL POWER PLANT INSTRUMENTATION AND CONTROL	Category	L	T	P	Credit
		PEES	3	0	0	3

Preamble

This course aims to give the fundamental concepts and practical aspects of thermal power plant instrumentation and control. A power station is a complex entity. It involves a wide range of engineering disciplines. The basic principles of steam and water cycles, fuel, air and flue gas circuits are discussed. Also the steam generator, boiler drum and circulation, water treatment and various types of controls in a steam power plant has been discussed. It includes the compression and draught control, feed water control, steam temperature control and control equipment have been discussed. The updated information on combined cycle generation is also provided.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the basic principles of power system instrumentation and control.	TPS2	70	70
CO2	Describe the operation of water circuit and its control in a thermal power plant.	TPS2	70	70
CO3	Interpret the performance of power plant instrumentation and control systems.	TPS3	70	70
CO4	Demonstrate the control equipment Practices in boiler and turbine power plant.	TPS3	70	70
CO5	Estimate the demand for the steam Generator.	TPS2	70	70
CO6	Choose suitable instrumentation system for power plant management.	TPS3	70	70

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PS O 2	PS O 3
CO1.	M			L		L		M	M						
CO2.	M					L	L	M		M					
CO3.	S	S		M			L	M	M	M					
CO4.	S	S		M			M	M	M	M					
CO5.	S	M													
CO6	S	M													

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT1						CAT2						Assignment 1				Assignment 2				Terminal					
TPS Scale	1	2	3	4	5	6	1	2	3	4	5	6	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	10	10											20								5	5				
CO2	10	10											20								5	5				
CO3		30	30										60									15	15			
CO4										5	20	15					40				2.5	10	7.5			
CO5										10	10						20				5	5				
CO6										5	20	15					40				2.5	10	7.5			

Syllabus

Introduction: Importance of instrumentation and control in Power plants-Piping and Instrumentation Diagram (P and I diagram).Process of power generation in coal-fired and oil fired in thermal power plants-Nature of steam-Thermal efficiency-Gas turbine and combined cycle plants.

Instrumentation and Control schemes in Water Circuit: Water circuit-Measurements in water circuits-controls in water circuits-impurities in water and steam.

Instrumentation and Control schemes in Air- Fuel Circuit: Air-Fuel Circuit-measurements in Air-Fuel circuit – Controls in Air- Fuel Circuit-Analytical Measurements-Oxygen measurement in flue gas- Carbon-di-oxide measurement in flue gas-Infra red flue gas analysis-Smoke detector-dust monitor-chromatography-pollution monitoring instruments

Control aspects in Boiler and Turbine: The principles of compression control-Draught control-The principles of feed water control-One, two and three elements feed water control. Drum level control-Steam temperature control-Spray-water attemperator-Temperature control with tilting burners-Gas Recycling.

Turbine steam Inlet System- Turbine Measurements-Turbine Control system- Turbo-alternator Cooling system.

Control aspects in setting the demand for the steam generator: Nature of the demand-Setting the demand in power stations applications-Master demand in power station applications-Load demand in combined heat and power plants-Waste to energy plants

Power Plant Management: Introduction-Master control-combustion process-boiler efficiency-maintenance of measuring instruments-intrinsic and electrical safety-interlocks for boiler operation-computer based control and data acquisition system-distributed control system (DCS).

Text Books

1. David Lindsley, "Thermal Power Plant Control & Instrumentation" second edition,IET Publications, London, UK (2018).

Reference Books

2. Sam G.Dukelow, The control of Boilers, Instrument Society of America, 1991.
3. Elonka, S.M. and KohalA.L.Standard Boiler Operations, McGraw Hill, New Delhi, 1994.
4. R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1995.
5. P.K.Nag, "Power Plant Engineering" Tata McGraw-Hill, New Delhi, 2005.
6. A.K.Mahalanbias-"Power System Instrumentation"-Tata McGraw Hill.
7. K.KrishnaswamyansM.PonniBala-"Power Plant Instrumentation-" – PHI Learning Pvt. Ltd., New delhi, 2015.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours	Course Outcome
1.0 Introduction			
1.1	Importance of instrumentation and control in Power plants	1	CO1
1.2	Piping and Instrumentation Diagram (P and I diagram)	1	CO1
1.3	Process of power generation in coal-fired and oil fired in thermal power plants	1	CO1
1.4	Nature of steam	1	CO1

1.5	Thermal efficiency	1	CO1
1.6	Gas turbine and combined cycle plants	1	CO1
2.0 Instrumentation and Control schemes in Water Circuit			
2.1	Water circuit	1	CO2
2.2	Measurements in water circuits	1	CO2
2.3	controls in water circuits	1	CO2
2.4	Impurities in water and steam	1	CO2
3.0 Instrumentation and Control schemes Air- Fuel Circuit			
3.1	Air-Fuel Circuit	1	CO3
3.2	measurements in Air-Fuel circuit	1	CO3
3.3	Controls in Air- Fuel Circuit-Analytical Measurements	1	CO3
3.4	Oxygen measurement in flue gas- Carbon-di-oxide measurement in flue gas	1	CO3
3.5	Infra-red flue gas analysis-Smoke detector-dust monitor	1	CO3
3.6	Chromatography-pollution monitoring instruments	1	CO3
4.0 Control aspects in Boiler and Turbine			
4.1	The principles of compression control, Draught control	2	CO4
4.2	The principles of feed water control	1	CO4
4.3	One, two and three elements feed water control	2	CO4
4.4	Drum level control, Steam temperature control	1	CO4
4.5	Spray-water attemperator, Temperature control with tilting burners	1	CO4
4.6	Gas Recycling	1	CO4
4.7	Turbine steam Inlet System-Turbine Measurements	1	CO4
4.8	Turbine Control system- Turbo-alternator Cooling system	1	CO4
5.0 Control aspects in setting the demand for the steam generator			
5.1	Nature of the demand	1	CO5
5.2	Setting the demand in power station applications	1	CO5
5.3	Master demand in power station applications	1	CO5
5.4	Load demand in combined heat and power plants	1	CO5
5.5	Waste to energy plants	1	CO5
6.0 Power Plant Management			
6.1	Master control-combustion process	1	CO6
6.2	Boiler efficiency-maintenance of measuring instruments	1	CO6
6.3	Intrinsic and electrical safety	1	CO6
6.4	Interlocks for boiler operation	1	CO6
6.5	Computer based control and data acquisition system, DCS	1	CO6
	Total	**36**	

Course Designers:

1. Dr. M. Meenakshi Devi, Assistant Professor, EEE mmdeee@tce.edu

22EERB0	HIGH VOLTAGE ENGINEERING

Category	L	T	P	Credit
PEES	3	-	-	3

Preamble

High Voltages are used in wide applications covering the power system, industry, medical and research laboratories with 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 and currents are included in this course. High voltage testing methods and standards are introduced.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the breakdown mechanisms of Gaseous, Liquid and Solid dielectrics.	TPS2	85	80
CO2	Design the generating arrangements of high voltages and high currents.	TPS3	80	80
CO3	Apply suitable method and device to measure high voltages and currents.	TPS3	80	80
CO4	Explain the methods and standards for testing high voltage apparatus.	TPS2	85	80
CO5	Describe the various Non – Destructive Testing methods.	TPS2	85	80
CO6	Design a High voltage laboratory for testing the given power apparatus.	TPS3	85	80

*** Weightage depends on Bloom's Level, number of contact hours,

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	M	L						M		M			M	
CO 2	S	M	L					M		M			S	
CO 3	S	M	L					M		M			S	
CO 4	M	L						M		M			M	
CO 5	M	L						M		M			M	
CO 6	S	M	L					M		M			S	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	20													10	10		
CO2		10	20													10	10	
CO3		20	20				100				100					10	10	
CO4				10	20										05	10		
CO5				10	30										05	10		
CO6					10	20											10	

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	

Set	
Guided Response	100
Mechanism	
Complex Overt Responses	
Adaptation	
Origination	

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Syllabus

Conduction and Breakdown in Dielectric Materials:

Gaseous Dielectrics: 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.

Liquid Dielectrics: Pure liquid - commercial liquid - Conduction and 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 voltages and currents :

Measurement of high DC voltage – High AC and Impulse voltages – High DC, AC and Impulse currents – CRO for Impulse voltage and current measurements.

High voltage testing of electrical equipment:

Non – Destructive Testing methods – High voltage Schering bridge- Partial Discharge measurement.

Testing Standards - Testing of Insulators and Bushings - Isolators and Circuit Breakers – Cables – Transformers – Surge Diverters.

Test facilities in HV Laboratories– Activities – Classification – Grounding – Size – Ratings.

Text Books

1. M.S.Naidu and V.Kamaraju - High voltage Engineering - Tata Mc.Graw hill Publishing company Limited, New Delhi, 5th Edition, 2013.

Reference Books

1. C.L.Wadhwa - High voltage engineering - Wiley eastern limited, New Delhi,3rd Edition, 2012.
2. E. Kuffel, W.S.Zaengl, J. Kuffel – High Voltage Engineering – Newness Pvt Ltd. 2nd Edition, 2000

Course Contents 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,post breakdown phenomena and application, Vacuum insulation and it's breakdown	4
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	3
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	3
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	3
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	3
3.0	**Measurement of High voltages and currents**	

3.1	Measurement of high DC voltage – Series Resistance, Potential divider methods. Generating voltmeter, Measurement of High Direct Currents – Shunts & Hall Effect methods,	3
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	4
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	3
4.0	**High voltage testing of Electrical Apparatus**	
4.1	Non – Destructive Testing methods – Measurement of Dielectric Constant, Loss and capacitance using High voltage schering bridge, Partial Discharge measurement.	3
4.2	Testing Standards, Testing of Insulators and Bushings. Testing of Isolators, circuit Breakers, Cables, Transformers,and Surge Diverters.	3
4.3	Design of High voltage laboratories: Size, Ratings, Test facilities, Grounding	2
Total		36

Course Designers:

1. Dr. N. Shanmuga Vadivoo, Professor, EEE nsveee@tce.edu
2. Dr. R. Rajan Prakash, Associate Professor, EEE r_rajanprakash@tce.edu

22EERC0	**ENERGY STORAGE SYSTEMS**	Category	L	T	P	Credit
		PEES	2	0	0	2

Preamble

Electrical energy storage is the ability to capture energy at one time for use at a later time. Storage devices can save energy in many forms (e.g., chemical, kinetic, or thermal) and convert them back to useful forms of energy like electricity. Energy storage can also contribute to meeting electricity demand during peak times. Utilities, grid system operators and regulators benefit from it as switching to storage mechanism to strengthen grid resiliency and reliability. This course will give an overview on energy storage systems.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	TPS	Expected Proficiency	Expected Attainment
CO1	Explain the types of Energy and their significance	TPS2	80%	70%
CO2	Describe the types of energy storage technologies	TPS2	80%	70%
CO3	Design a typical storage system for a given application	TPS3	80%	70%
CO4	Explain the fundamentals of power electronics for storage systems	TPS2	80%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M			M	L
CO1	M	L						M		M			M	L

CO1	S	S	M	L				M		M			M	M
CO2	M	L						M		M			M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	TERMINAL			
TPS SCALE	1	2	3	4
CO1	10	10		
CO2		10		
CO3		10	20	
CO4		10	30	

Syllabus

Energy Storage Systems

Introduction: Types of Energy and need for their storage-Fundamentals of Energy Storage-Quantity of stored energy, Rate of charging, Rate of Discharging, Analysis of additional benefits to the energy storage system

Introduction to Energy Storage Technologies :Pumped Hydro

Battery Energy Storage (BESS) : Lead Acid Batteries, Lithium Batteries, Lithium chemistries – LFP / NMC / LTO / Flow Batteries

Other technologies: Zinc Air / Na-S etc, Rotary UPS – Kinetic energy, Compressed Air – CAES, Thermal energy storage, Chemical Storage, Green Hydrogen, Green Ammonia, Introduction to energy storage system- Ultra capacitors

Design of a typical storage system: PHC, BESS, Thermal energy, Optimizing the storage (electrically / mechanically / functionally)

Fundamentals of Power Electronics for Storage Systems: BMS, EMS, Basics of inverter Control.

Simplified system design: Solar with Storage (Off Grid / ON Grid),Wind with Storage, Wind Solar HYBRID systems with storage

Text Book

1. Alfred Rufer," Energy Storage Systems and Components ", CRC Press, 2018

Reference Books

1. Kim, Hee-Je," Solar power and energy storage systems", CRC Press 2019
2. Díaz-González, Francisco, Gomis-Bellmunt, Oriol, Sumper, Andreas," Energy storage in power systems", John Wiley & Sons, 2016
3. Hand Book On Battery Energy Storage System, Asian Development Bank,2018

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction**: Types of Energy and need for their storage	2
1.1	Fundamentals of Energy Storage, Quantity of stored energy Rate of charging, Rate of Discharging	1
1.2	Analysis of additional benefits to the energy storage system	1
2	**Introduction to Energy Storage Technologies** :	1
2.1	Pumped Hydro	1
2.2	**Battery Energy Storage (BESS)** : Lead Acid Batteries, Lithium Batteries, Flow Batteries	1
2.2.1	Lithium chemistries – LFP / NMC / LTO /	1
2.3	**Other technologies**: Zinc Air / Na-S etc, Rotary UPS	1
2.3.1	Kinetic energy, Compressed Air	1
2.3.2	CAES, Thermal energy storage, Chemical Storage	1
2.3.3	Green Hydrogen, Green Ammonia	1
2.3.4	Introduction to energy storage system- Ultra capacitors	2
3	**Design of a typical storage system**: PHC, BESS,	2
3.1	Thermal energy, Optimizing the storage (electrically / mechanically / functionally)	2
4	**Fundamentals of Power Electronics for Storage Systems**: BMS, EMS, Basics of inverter Control.	2
5	**Simplified system design**: Solar with Storage (Off Grid / ON Grid)	2
5.1	Wind with Storage, Wind Solar HYBRID systems with storage	2

Course Designers:

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   Country Manager(Energy Solutions) Wartsila India
2. R.RajanPrakash, Associate Professor, EEE r_rajanprakash@tce.edu
3. Dr.B.Ashok Kumar Assistant Professor, EEE ashokudt@tce.edu

		Category	L	T	P	Credit
22EERD0	**BIO-MEDICAL INSTRUMENTATION**	**PEES**	**3**	**0**	**0**	**3**

Preamble

Biomedical instrumentation is the application of engineering principles and design concepts to medicine and biology. This field seeks to close the gap between engineering and medicine: It combines the design and problem solving skills of engineering with medical and biological sciences to improve healthcare diagnosis, monitoring and therapy. This subject will enable the students to learn the basic principles of different instruments/equipment used in the health care industry.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

Cos	**Course outcomes**	**TCE Proficiency Scale**	Expected Proficiency	Expected outcome Level
CO1	Explain the principles of biomedical measurement systems and its characteristics.	TPS2	70%	70%
CO2	Describe the medical standards, safety and regulation	TPS2	70%	70%
CO3	Discuss the origin and acquisition of bio potentials and bioelectric signals.	TPS2	70%	70%
CO4	Select suitable systems to measure Blood Flow, Blood Pressure, Heart sound, and Blood cell counters for specific situation.	TPS3	60%	60%
CO5	Select suitable therapeutic devices for specific situation.	TPS3	60%	60%
CO6	Explain the construction and operation of medical imaging systems(X ray machine, computer tomography, MRI, Ultrasound)	TPS2	70%	60%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO21.	M	**L**										
CO22.	**M**	**L**										

C03	**M**	**L**										
C04	**S**	**M**	L	L								
C05	**S**	**M**	L	L								
C06	**M**	**L**										

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	10													4	5		
CO2	5	20													2	10		
CO3	10	30													4	10		
CO4			20	5	10	20	100								4		20	
CO5				5	10	20					100				4		20	
CO6				10	20										2	15		

Syllabus

BASIC CONCEPTS OF BIO MEDICAL INSTRUMENTATION

Terminology – Generalized medical instrumentation system, characteristics – Measurement constrains – Bio statistics– Regulation and standards of medical devices – Electrical safety in medical environment.

BIO POTENTIALS AND MEASUREMENTS

Electric activity and excitable cells – Functional organization of peripheral nervous system. EMG, ECG, EEG and recording systems – Bio-potential electrodes – Electrolyte interface. Polarization – Body surface recording electrodes -microelectrodes– Electrodes for electric simulation of tissues – Practical hints for using electrodes.

BLOOD FLOW, PRESSURE, HEART SOUND, CELL COUNTERS MEASUREMENT

Blood Flow- Electromagnetic blood flow meter, ultrasonic blood flow meter, Doppler blood flow meter, NMR blood flow meter, cardiac output measurement – indicator dilution methods and impedance technique. **Blood pressure and heart sound measurement**: Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, Heart sound measurement – stethoscope, phonocardiograph. **Blood cell counters**: Different methods for cell counting, Coulter Counters, automatic recognition and differential counting of cells.

THERAPEUTIC DEVICES

Cardiac pacemakers, defibrillators, Hemodialysis, ventilators, infant incubators, drug delivery devices, therapeutic applications of the laser, diathermy

MEDICAL IMAGING SYSTEMS

X ray machine, computer tomography, ultrasonic imaging system, magnetic resonance imaging system.

Text Book

1. R. S. Khandpur "Handbook of Bio-Medical Instrumentation", MC GRAW HILL INDIA; 3rd Revised edition (January 1, 2014)

Reference Books

1. J.Webster, "Medical Instrumentation application and design", Fifth edition Wiley & Sons 2020.
2. Carr & Brown, "Introduction to Biomedical Equipment Technology" Fourth Edition, Pearson Education, Asia.
3. Leslie, Fred Weibell and Erich Cromwell " Biomedical Instrumentation and Measurements" Prentice Hall Of India, 2001

Course Contents and Lecture Schedule

SL. No.	Topics	No of lectures	**Course Outcome**
1	**BASIC CONCEPTS OF BIO MEDICAL INSTRUMENTATION**		
1.1	ıology, Generalized medical instrumentation system and Characteristics	1	CO1
1.2	Measurement constrains	1	CO1
1.5	Regulation and standards of medical devices & Electrical safety in medical environment	2	CO2
2	**BIO POTENTIALS AND MEASUREMENTS**		
2.1	c activity and excitable cells – Functional organization of peripheral nervous system	2	CO3
2..2	EMG, ECG	2	CO3
2.3	& MEG and recording systems – Bio-potential electrodes –	2	CO3

	Practical hints for using electrodes		
2.4	lyte interface. Polarization – Body surface recording electrodes	1	CO3
2.5	lectrodes, Electrodes for electric simulation of tissues	1	CO3
3	**D FLOW, PRESSURE, SOUND, CELL COUNTERS MEASUREMENT**		
3.1	**Blood Flow**		
3.1.1	Electromagnetic blood flow meter, ultrasonic blood flow meter.	2	CO4
3.1.2	Doppler blood flow meter, NMR blood flow meter.	1	CO4
3.1.3	Cardiac output measurement – indicator dilution methods and impedance technique	2	CO4
3.2	**Blood pressure and heart sound measurement**		
3.2.1	Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound	1	CO4
3.2.2	Indirect measurement of blood pressure	1	CO4
3.2.3	Heart sound measurement – stethoscope, phonocardiograph.	1	CO4
3.3	**Blood cell counters**		
3.3.1	Different methods for cell counting, Coulter Counters,	1	CO4
3.3.2	Automatic recognition and differential counting of cells.	1	CO4
4	**THERAPEUTIC DEVICES**		
4.1	Cardiac pacemakers, defibrillators	2	CO5
4.2	Haemodialysis, ventilators,	2	CO5
4.4	Therapeutic applications of the laser	1	CO5
4.5	Diathermy	2	CO5
5	**MEDICAL IMAGING SYSTEMS**		

5.1	X ray machine	1	CO6
5.2	computer tomography	1	CO6
5.3	Ultrasonic imaging system	2	CO6
5.4	magnetic resonance imaging system	2	CO6
Total		36	

Course Designers:

1. Dr.R.Helen Assistant Professor, EEE rheee@tce.edu

22EERF0	REAL TIME OPERATING SYSTEM (THEORY CUM PRACTICAL)

Category	L	T	P	Credit
PEES	2	0	2	3

Preamble

Real-time systems are complex embedded systems that operate with real time constraints. Real time systems include automotive electronics, air traffic control, nuclear power plants, telecommunications, and robotics and they use a real time operating system (RTOS) that determines which applications should run in what order and how much time should be allowed for each application before giving processor's 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.

Prerequisite

- 22EE520 – Microcontrollers

Course Outcomes

On the successful completion of the course, students will be able to

COs No.	Course outcomes	Blooms level	Expected Proficiency in %	Expected Attainment Level in %
CO1	Explain the concept of real-time systems	TPS2	70	70
CO2	Describe the various functional blocks of real-time operating system	TPS2	70	70
CO3	Develop the RTOS µC/OS-II Programs for the given tasks	TPS3	70	70
CO4	Develop RTOS program for an automatic chocolate vending machine using µC/OS-II	TPS3	70	70
CO5	Develop RTOS program for a digital camera using µC/OS-II	TPS3	70	70
CO6	Develop RTOS programs for the given applications	TPS3	70	70

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2

CO1	M													
CO 2	M													
CO 3	S	M	M		M			M	M	M				M
CO 4	S	M	M		M			M	M	M				M
CO 5	S	M	M		M			M	M	M				M
CO 6	S				M			M	M	M		M		M

S- Strong; **M**-Medium; **L**-Low

Assessment Pattern

CO	CAT 1			CAT 2			PRACTICAL				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	10													4	10		
CO2	10	20													10	10		
CO3		10	40												6	10		
CO4				**10**	15	25											25	
CO5				10	15	25											25	
CO6							80*				80*							
	20	40	40	20	30	50									20	30	50	

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	

Adaptation	
Origination	

Syllabus

Introduction: Real-time system concepts – Difference between OS and RTOS - Foreground/background systems - Critical section of code - Resource - Shared resource - Multitasking - Task - Context switch - Kernel - Scheduler - Non preemptive kernel - Preemptive kernel - Reentrancy - Round Robin scheduling

Priority concepts: Task, Static, Dynamic - Priority inversions - Assigning task priorities - Mutual exclusion - Deadlock - Synchronization - Event flags - Intertask communication - Message queues - Interrupt concepts: Latency, Response, Recovery, ISR processing time, Non-maskable Interrupts (NMIs) - Clock tick - Memory requirements - Real time kernel: Advantage and disadvantages.

RTOS programming: Basic functions and types of RTOSes - RTOS µC/OSII basics - Functions in µC/OSII - OSInit() - OSSemCreate() - OSSemPend() - OSSemPost() - OStart()-OSStartInit()-OSTaskCreate()- OSTaskCreateExt()- OSTimeDly()- OSTimeDlyHMSM() - OSVersion() - OS_ENTER_CRITICAL() and OS_EXIT_CRITICAL().

Design examples with µC/OSII: Automatic chocolate vending machine - Tasks - Requirements - Specifications Modeling using UML - Class diagram - State diagram - Synchronization diagram - Software architecture - µC/OSII program for ACVM-Development of µC/OSII program for Digital Camera.

List of Experiments (24 hours)

Develop embedded "C' program with RTOS for the following applications:

- Elevator control
- Motor control
- Real time power and energy measurement
- Speed measurement
- PWM signals generation
- Sensors interfacing

Text Books

1. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" Second edition , Tata McGraw Hill, 2008.

Reference Books

1. K.V.K.Prasad, Embedded /ReaL-Time Systems: Concepts, Design and Programming, Wiley India Publisher, Jan 2003.
2. Jean J.Labrosse, MicroC/OS II, Second edition, McGraw Hill Publisher,2002.
3. David E.Simon, "An Embedded Software Primer", Pearson Education, 2006

4. C.M. Krishna, Kang, G.Shin, “Real Time Systems”, McGraw Hill, 1997.
5. Phillip A. Laplante, Real Time Systems Design and Analysis, An Engineer’s Handbook, Second Edition, PHI India, 1997.

Course Contents and Lecture Schedule

S.No.	Topics	No. of Lectures
1.	**Introduction**	
1.1	Real-time system concepts - Difference between OS and RTOS- Foreground/background systems - Critical section of code - Resource - Shared resource - Multitasking - Task	2
1.2	Context switch - Kernel - Scheduler - Non pre-emptive kernel - Pre-emptive kernel - Re-entrancy	2
1.3	Round Robin scheduling - Priority concepts: Task, Static, Dynamic - Priority inversions - Assigning task priorities	2
1.4	Mutual exclusion - Deadlock - Synchronization - Event flags - Intertask communication - Message queues	2
1.5	Interrupt concepts: Latency, Response, Recovery, ISR processing time, NMIs	2
1.6	Clock tick - Memory requirements - Real time kernel: Advantage and disadvantages	1
2	**RTOS programming**	
2.1	Basic functions and types of RTOSes, RTOS μC/OSII – basics	1
2.2	Functions in μCOS-II - OSInit() - OSSemCreate() - OSSemPend() - OSSemPost()-OStart() - OSStartInit()	1
2.3	OSTaskCreate() - OSTaskCreateExt()-OSTimeDly() - OSTimeDlyHMSM() - OSVersion() - OS_ENTER_CRITICAL() and OS_EXIT_CRITICAL()	2
3	**Design examples with μC/OSII**	
3.1	Automatic chocolate vending machine	1
3.2	Tasks, Requirements	1
3.3	Specifications Modeling using UML	1
3.4	Class diagram, State diagram, Synchronization diagram	2

3.5	Software architecture, µC/OSII program for ACVM	1
3.6	Development of µC/OSII program for Digital Camera	3
	Total	**24**

Course Designers:

1. Dr.M.Saravanan Professor, EEE mseee@tce.edu
2. Dr.P.S.Manoharan Professor, EEE psmeee@tce.edu

	Category	L	T	P	Credit
22EERG0 ASIC DESIGN	PEES	3	0	0	3

Preamble

An application-specific integrated circuit (ASIC) is an integrated circuit customized for a specific use, rather than intended for general-purpose use. This course discusses the design of ASIC chips.

Prerequisite

- **22EE250 DIGITAL SYSTEMS**

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the design flow of different types of ASIC.	TPS2	80	70
CO2	Illustrate the programming of logic cells and logic expander	TPS3	80	70
CO3	Develop physical design of ASIC for specific applications using CAD tool.	TPS3	80	70
CO4	Describe partitioning, floor planning, placement and routing including circuit extraction of ASIC	TPS2	80	70
CO5	Perform the timing analysis, logic synthesis and testing of systems	TPS3	80	70
CO6	Explain the low power design techniques and tools	TPS2	80	70

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	M	L												M
CO 2	S	M	L					M		M				S
CO 3	S	M	L					M		M				S
CO 4	M	L												M
CO 5	S	M	L					M		M				S
CO 6	M	L												M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	**10**	20													4	5		
CO2	5	10	20				50								2	5	15	
CO3	5	10	20				50								4	5	10	
CO4				10	20										4	10		
CO5				5		40					100				2	5	15	
CO6				5	20										4	10		

Syllabus

INTRODUCTION TO ASICS, CMOS LOGIC, ASIC LIBRARY DESIGN :

Types of ASICs - Design flow – CMOS transistors- CMOS Design rules –Combinational logic Cell Sequential logic cell - Transistor as Resistors - Transistor parasitic capacitance – Logical effort - Library cell design – Library architecture.

PROGRAMMABLE ASICS -LOGIC CELLS

MUX as Boolean function generators, Acted ACT: ACT 1, ACT 2 and ACT 3 Logic Modules, Xilinx LCA: XC3000 CLB, Altera FLEX and MAX, Programmable ASIC I/O Cells: Xilinx and Altera I/O Block.

PROGRAMMABLE ASIC DESIGN SOFTWARE AND LOW LEVEL DESIGN ENTRY

Logic Synthesis - Half gate ASIC - Schematic entry -Low level design language - PLA tools -EDIF-CFI design representation – **ASIC Construction:** Physical Design, CAD Tools System partitioning : Constructive Partitioning, Iterative Partitioning Improvement, KL, FM and Look Ahead algorithms., Estimating ASIC size

ASIC Design flow: Introduction, design methodology, technology updatability and layout verification. Floor planning & placement: Floor Planning Goals and Objectives, Measurement of Delay in floor planning, Floor planning tools ,I/O and Power planning, Clock planning , timing analysis - Placement Algorithms. Routing: Global routing, Detailed routing ,Special routing. circuit extraction – Design Rule Check

PHYSICAL AND LOW POWER DESIGN

Overview of physical design flow- tips and guideline for physical design- modern physical design techniques- power dissipation-low power design techniques and methodologies-low power design tools- tips and guideline for low power design.

Text Book

1. J.S.Smith,. Application-specific integrated circuits. Addison-Wesley, 2010
2. Weste, Neil HE, and David Harris. CMOS VLSI design: a circuits and systems perspective. Pearson Education India, 2015.

Course Designers:

1. Dr.R.Helen, Assistant Professor, EEE, rheee@tce.edu
2. Dr.D.Kavitha, Assistant Professor, EEE, dkavitha@tce.edu
3. Mr.R.Ramesh , Design Engineer , Managing the Physical Design team in Microchip, Chennai, rameshramal@gmail.com

22EERH0 **MACHINE LEARNING (THEORY CUM PRACTICAL)**

Category	L	T	P	Credit
PEES	2	0	2	3

Preamble

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves. This course covers the fundamentals of machine learning, supervised and unsupervised learning.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO No	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the various steps involved in the Data pre-processing.	TPS2	80	80
CO2	Develop a Linear Multivariate Regression model for an available dataset	TPS3	80	80
CO3	Develop a NN Model and SVM classifier for multiclass classification problem	TPS3	80	80
CO4	Explain about the evaluation of algorithms	TPS2	80	80
CO5	Develop a k-mean clustering algorithm for an unsupervised learning problem	TPS3	80	80
CO6	Use multivariate Gaussian distribution for detection of anomaly	TPS3	80	80

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L												M
CO2	S	M	L		S			M		M				S
CO3	S	M	L		S			M		M				S

CO4	M	L												M
CO5	S	M	L		S			M		M				S
CO6	S	M	L		S			M		M				S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			PRACTICAL				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	5	20													4	10		
CO2	5	10	20				20								2	5	10	
CO3	10	10	20				20								4	5	10	
CO4				5	20										4	10		
CO5				10	10	20	20								4	5	10	
CO6				5	10	20	20								2	5	10	

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	
Adaptation	
Origination	

Syllabus

Introduction to Machine Learning:

Introduction to Machine learning – Types of Machine Learning – Supervised Learning – Unsupervised Learning – Reinforced Learning – Evolutionary Learning – Regression

Data pre-processing:

Data preprocessing – Data cleaning – Handling missing data and noisy data – Data integration – Redundancy and correlational analysis – Data Reduction – Linear Discriminant analysis - PCA – Factor analysis – Independent components analysis – Numerosity Reduction – Data compression – Data Normalization and Data Discretization.

Linear multivariate Regression

Introduction – Model Representation – Cost Function –Multiple features - Gradient Descent – polynomial regression

Non-Linear Regression:

Introduction – Non-linear Hypothesis – Neural network model representation – Multiclass classifications using NN - cost function – Back propagation algorithm – Gradient checking – Random initialization – SVM - common kernel function – classification using SVM.

Classification

Introduction – Hypothesis Representation – Decision Boundary – Logistic Regression model – simplified cost function and gradient descent – Multiclass classification –Redefined cost function with Regularization.

Learning Algorithm Evaluation:

Evaluating the Hypothesis – Model selection and Train/validation/Test sets – Diagnosing Bias and Variance – choosing regularization parameter - Learning curve analysis – Error metrics for skewed classes – Trading off precision and recall

Unsupervised Learning:

Introduction – K-means algorithm – Objectives – clusters formation –Anomaly Detection algorithm: Density Estimation - Building an anomaly detection system

Reference Books and Web Resources

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, 2011.
2. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier, 2011
3. Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques: Concepts and Techniques, Elsevier, 2011.
4. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification, Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB, John Wiley & Sons, 2005.
5. https://www.coursera.org/learn/machine-learning

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1	**Introduction to Machine Learning**	
1.1	Machine Learning Definition – Types of Machine Learning	1
2	**Data preprocessing**	
2.1	Data cleaning – Handling missing data and noisy data – Data integration	1
2.2	Redundancy and correlational analysis	1
2.3	Data Reduction – Linear Discriminant analysis – PCA	1
2.4	Factor analysis – Independent components analysis	2
2.5	Numerosity Reduction – Data compression	1
2.6	Data Normalization and Data Discretization	1
3	**Linear multivariate Regression**	
3.1	Introduction – Model Representation	1
3.2	Cost Function – Gradient Descent	1
4	**Non-Linear Regression**	
4.1	Introduction – Non-linear Hypothesis	1
4.3	Neural network model representation - Cost function – Back propagation algorithm	1
4.4	SVM - common kernel function	2
5	**Supervised Learning –Classification**	
5.1	Introduction – Hypothesis Representation	1
5.2	Decision Boundary – Logistic Regression model	1
6	**Learning Algorithm Evaluation:**	

6.1	Evaluating the Hypothesis – Model selection and Train/validation/Test sets	1
6.2	Diagnosing Bias and Variance – choosing regularization parameter	1
6.3	Learning curve analysis – Error metrics for skewed classes	1
6.4	Trading off precision and recall	1
7	**Unsupervised Learning:**	
7.1	Introduction – K-means algorithm– Objectives - clusters formation	2
7.2	Anomaly Detection algorithm: Density Estimation	1
7.3	Building an anomaly detection system	1
	Total	**24**

Lab Experiments: 24 hours (Python/MATLAB programming)

1. Develop a Linear Multivariate Regression model for an available dataset.
2. Develop a NN Model for multiclass classification problem
3. Develop an SVM classifier for a given classification problem
4. Develop a k-mean clustering algorithm for an unsupervised learning problem
5. Develop an Anomaly Detection algorithm for the given datasets.

Mini project:

Students should develop machine learning algorithms for the given Electrical problems using python/Matlab programming

Course Designers:

1. Dr.D.Kavitha, Assistant Professor, EEE dkavitha@tce.edu

2. Dr.S.Charles Raja, Associate Professor, EEE charlesrajas@tce.edu

		Category	L	T	P	Credit
22EERJ0	**OPERATIONS RESEARCH**	PEES	3	0	0	3

Preamble

Operations Research (OR) is a course to aid decision making and improving efficiency of the system by applying advanced analytical methods. It becomes a professional course that deals with the application of scientific methods for decision-making, and especially to the allocation of scare resources.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Formulate real-world problems as a programming model	TPS3	70	70
CO2	Solve linear programming problems using graphical and simplex methods and perform sensitivity analysis	TPS3	70	70
CO3	Solve transportation by MODI method	TPS3	70	70
CO4	Formulate deterministic inventory models and make optimal decisions	TPS3	70	70
CO5	Develop dynamic programming stages for real world problems and find optimal solution.	TPS3	70	70
CO6	Solve Single server Queuing models with infinite population	TPS3	70	70
CO7	Solver integer programming problems	TPS3	70	70

Mapping with Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**S**	**M**	**L**					**M**		**M**			**S**	**S**	

CO 2	**S**	**M**	**L**					**M**		**M**			**S**	**S**	
CO 3	**S**	**M**	**L**					**M**		**M**			**M**	**S**	
CO 4	**S**	**M**	**L**					**M**		**M**			**S**	**S**	
CO 5	**S**	**M**	**L**					**M**		**M**			**S**	**S**	
CO 6	**S**	**M**	**L**					**M**		**M**			**S**	**S**	
CO 7	**S**	**M**	**L**					**M**		**M**			**S**	**S**	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	**CAT1**						**CAT2**						**Assignment 1**				**Assignment 2**				**Terminal**					
TPS Scale	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
CO 1	5		20																		5		10			
CO 2	5	10	20							50											5	10	10			
CO 3		10	30							50												10	10			
CO 4							5		20														10			
CO 5							5	10	20								50						20			
CO 6								10	30								50						10			

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Introduction to Operations Research.

Linear Programming

Linear Programming (LP): Formulation; Graphical Method of solution for LP problems;

Simplex and Dual Simplex Methods for LP problems; Sensitivity Analysis

Transportation Problems

Transportation Problem(TP) Formulation; Initial Basic Feasible solutions; Optimal solution for TP using Modified Distribution Method.

Inventory Models

Purchase Model (with and without shortages); Production Model (with and without shortages); P-System and Q-System

Dynamic Programming

Concepts – Terminology – Bellman's Principle of optimality; Application in Network, Allocation and Inventory by Tabulation methods

Queuing Models

General concepts of a queueing system - Classification of Queues; Markovian queues-M/M/1 with infinite waiting space

Integer Programming Graphical Representation-Gomory's cutting Plane Method- Bala's algorithm for Zero-One programming problems

Text Books

1. ”Engineering Optimization-Theory and Practice”, by Singiresu S.Rao, New Age International,
2. "Operations Research- An Introduction" Hamdy A Taha- 8th Edition-Pearson Prentice Hall – 2007
3. "Introduction to Operations Research" by Frederick S Hillier and Gerald J Liberman-10th Edition- McGraw Hill Higher Education - 2010

Reference Books

1. Introduction to Operations Research" Kauffman A and Faure R - 47th Volume in the series “Mathematics in Science and Engineering” - Academic Press, Newyork -1968

2. “Principles of Operations Research” Harvey M Wagner-Prentice Hall of India-1974

Course Contents and Lecture Schedule

Module No.		No. of Hours
Module	Topic	Hrs
0	Introduction: Operations Research	1
1	Linear Programming	
1.1	Linear Programming (LP): Formulation	2
1.2	Graphical Method for LP problems	2
1.3	Simplex and Dual Simplex Methods for LP problems	5
1.4	Sensitivity Analysis	3
2.	Transportation Problems	
2.1	Transportation Problem(TP): LP Formulation	1
2.2	Initial Basic Feasible solutions	1
2.3	Optimal solution for TP using Modified Distribution Method	2
3	Inventory Models	
3.1	Inventory models	1
3.2	Purchase Model (with and without shortages)	2
3.3	Production Model (with and without shortages)	2
3.4	Inventory Control Models	2
4	Dynamic Programming	
4.1	Concepts – Terminology – Bellman's Principle of optimality	1
4.2	Application in Network, Allocation and Inventory by Tabulation methods	3
5	Queueing Models	
5.1	General concepts of a queueing system - Classification of Queues	1
5.2	Markovian queues- M/M/1 with infinite waiting space	2
6	Integer Programming	
6.1	Graphical representation and Solving by Gomory's method	3
6.2	Bala's algorithm for Zero-One programming problems	2

	Total	36

Course Designer(s):

1. Prof S.Sivakumar, Associate Professor , EEE siva@tce.edu

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22EERK0	HVDC TRANSMISSION

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

High voltage direct current transmission has advantages over ac transmission in special situations. With the advent of thyristor valve converters, HVDC transmission became even more attractive. This course deals with the operation, modelling and control of HVDC link in power system. Also, trends for HVDC applications and practical examples are discussed in this course.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

Course Outcome No.	Course Outcome	TCE Proficiency scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Design HVDC system for given specifications	TPS3	70	80
CO2	Design power converters for HVDC system	TPS3	70	80
CO3	Explain the requirement of appropriate control strategies and stability techniques used in HVDC system	TPS2	70	80
CO4	Design suitable controller for HVDC converters	TPS3	70	80
CO5	Design harmonic filters for given specifications	TPS3	70	80
CO6	Explain the recent trends of HVDC system	TPS2	70	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	**M**	**L**					M		M		M			S
CO2	**M**	**L**					M		M		M			S
CO3	**S**	**M**					M		M		M			M
CO4	**S**	**M**	**L**				M		M		M			M
CO5	**S**	**M**	**L**				M		M		M			M
CO6	**M**	**L**					M		M		M			M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	20	20				50								5	10	10	
CO2	5	10	20				50								2	5	10	
CO3	5	10													3	5		
CO4				10	20	20					50				5	10	10	
CO5				5	10	20					50				2	5	10	
CO6				5	10										3	5		
Total	20	40	40	20	40	40	100				100				20	40	40	

Syllabus

Introduction to HVDC transmission: Comparison between HVAC and HVDC systems - economic, technical and reliability, limitations, Types of HVDC links - monopolar, bipolar and homopolar links, Components of HVDC transmission system

Analysis of HVDC Converters: Rectifier and Inverter operation, Output voltage waveforms and DC voltage in both rectifier and inverter operation, Equivalent circuit of HVDC link

Basic means of HVDC system control: Desired features, power reversal, Basic controllers - constant ignition angle, constant current and constant extinction/ advance angle control, power control-Interaction between AC and DC systems

Harmonics in HVDC system: Characteristic and uncharacteristic harmonics - troubles due to harmonics – harmonic filters - active and passive filters - Reactive power control of converters

Recent trends in HVDC transmission: VSC based HVDC system – Multi-terminal HVDC systems and HVDC system applications in wind power generation

Text Book

1. Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.

Reference Books

1. Kamakshaiah, S and Kamaraju, V, 'HVDC Transmission', 1st Edition, Tata McGraw Hill Education (India), Newdelhi 2011.
2. Arrilaga, J., 'High Voltage Direct Current Transmission', 2nd Edition, Institution of Engineering and Technology, London, 1998.
3. Vijay K. Sood, 'HVDC and FACTS Controllers', Kluwer Academic Publishers, New York, 2004.
4. Kimbark, E.W., 'Direct Current Transmission-vol.1', Wiley Inter science, New York, 1971.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction:**	
1.1	Comparison between HVAC and HVDC systems	1
1.2	economic, technical and reliability, limitations	2
1.3	Types of HVDC links - monopolar, bipolar and homopolar links	1
1.4	Components of HVDC transmission system	2
2.	**Analysis of HVDC Converters:**	
2.1	Rectifier and Inverter operation	2
2.2	Output voltage waveforms and DC voltage in both rectifier and inverter operation	2
2.3	Equivalent circuit of HVDC link	2
3	**Basic means of HVDC system control**	
3.1	Desired features, power reversal	2
3.2	Basic controllers - constant ignition angle	2
3.3	constant current control	2

3.4	constant extinction/ advance angle control,	2
3.5	power control-Interaction between AC and DC systems	2
4	**Harmonics in HVDC system:**	
4.1	Characteristic and uncharacteristic harmonics	2
4.2	troubles due to harmonics – harmonic filters	2
4.3	active and passive filters	2
4.4	Reactive power control of converters	2
5	**Recent trends in HVDC transmission:**	
5.1	VSC based HVDC system	2
5.2	Multi-terminal HVDC systems	2
5.3	HVDC system applications in wind power generation	2
	TOTAL	36

Course Designers:

1. Dr. S.Arockia Edwin Xavier, Associate Professor, EEE, saexeee@tce.edu
2. Dr. M.Meenakshi Devi, Assistant Professor, EEE, mmdeee@tce.edu

22EE1A0	BATTERY TECHNOLOGY

Category	L	T	P	Credit
PEES	1	-	-	1

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. 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.

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Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TPS	Expected Proficiency	Expected Attainment
CO1	Explain the Lead acid battery manufacturing process for different technologies along with its application	TPS2	80%	70%
CO2	Explain the test equipment, test methods in evaluating the Lead acid battery systems	TPS2	80%	70%
CO3	Explain the safety requirement in handling lead acid battery systems and its raw materials and components through its life cycle.	TPS2	80%	70%
CO4	Apply Lead acid battery sizing with respect to applications	TPS3	80%	70%

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L						M		M			M	M
CO2	M	L						M		M			M	M
CO3	M	L						M		M			M	M
CO4	S	M	L	L				M		M			S	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	TERMINAL			
TPS SCALE	1	2	3	4
CO1	10	10		
CO2	10	20		
CO3		20		
CO4		10	20	

Syllabus

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

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
2.2	Process parameters, influence of process parameters, instruments and evaluation methods of in process parameters.	1
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	**13**

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 designers

1. T. S. Srinath, MD,SANKALP Batteries tssrinath@ibattech.com

2. R.RajanPrakash Associate Professor,EEE r_rajanprakash@tce.edu

3. B. Ashok Kumar Assistant Professor,EEE ashokudt@tce.edu

22EERL0	**SIMULATION OF POWER ELECTRONIC SYSTEMS (THEORY CUM PRACTICAL)**	Category	L	T	P	Credit
		PEES	2	0	2	3

Preamble

This Course enhances the students to analyze on various aspects of Power Electronic systems. The simulation of fundamental Power electronic circuits using simulation software is discussed. Using various simulation techniques, the output response of the systems for different conditions can be easily analyzed. The real power, reactive power, power factor & efficiency calculations are simplified using the simulation software. The Static, dynamic models and performance analysis of power electronics rectifier, inverter, chopper circuits and AC and DC motor drives are discussed.

Prerequisite

- 22EE450: Power Electronics

Course Outcomes

On the successful completion of the course, students will be able to

Course Outcome No.	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the applications of simulation tools	TPS2	75	80
CO2	Design diode rectifiers and phase-controlled rectifiers using simulation tools	TPS4	75	80
CO3	Design DC-DC converters using simulation tools	TPS4	75	80
CO4	Analyze DC-AC converters using simulation tools	TPS4	75	80
CO5	Analyze DC and AC motor drives using simulation tools	TPS4	75	80
CO6	Design power converters for solar, wind and battery powered system using simulation tools	TPS4	75	80

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	L	L		S			M		M		L		S
CO2	S	S	S	M	S			M	L	M		L		S
CO3	S	S	S	M	S			M	L	M		L		S
CO4	S	S	S	M	S			M	L	M		L		S
CO5	S	S	S	M	S			M	L	M		L		S
CO6	S	S	S	M	S			M	L	M		L		S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT 1				CAT 2				PRACTICAL				TERMINAL			
TPS SCALE	1	2	3	4	1	2	3	4	3	4	5	6	1	2	3	4
CO1	**5**	10														
CO2	5	5	20	15												
CO3		5	20	15												
CO4					**5**	5	10									
CO5					5	10	10	15								
CO6						5	20	15	50	50						

Practical test using Simulation software

Syllabus

SIMULATION OF POWER COMPUTATIONS AND RECTIFIER CIRCUITS
Simulation of Power electronic circuits - Power Computations in Linear-Nonlinear-Sinusoidal- Non sinusoidal circuits- Real Power, Reactive Power, Displacement factor, Distortion factor & Power factor- Diode Rectifier Circuits -Phase Controlled Rectifier Circuits.

SIMULATION OF DC-DC AND DC-AC CONVERTERS
Buck, Boost, Buck-Boost Converters Analysis- Power device dissipation, Component losses & efficiency calculation, Dynamic Simulation-Simulation of State space models-Simulating Inverters-Square wave Inverter, PWM Inverter Power device dissipation, efficiency & Harmonics calculation – Response with Filter

SIMULATION OF CONVERTERS

Single phase bridge rectifier, Three phase bridge rectifier, DC-DC Converters- Buck, Boost, Buck-Boost Converters,-Single phase bridge inverter with SPWM- Three phase bridge inverter

SIMULATION OF DC MOTOR, AC MOTOR DRIVES: Simulation of DC and AC motor drives using MATLAB, PLECS, etc

Text Book

1. Muhammad H. Rashid and Hasan M. Rashid., "SPICE for Power Electronics and Electric Power" CRC Press 2006.

Reference Books& web resources

1. Randall Shaffer., "Fundamentals of Power Electronics with MATLAB" Charles River Media Boston Massachusetts, 2007.
2. Rao V.Dukkipati,"Analysis and Design of Control Systems using MATLAB" New age international, 2006.
3. Chee-Mun Ong, "Dynamic Simulation of Electric Machinery: Using MATLAB/ Simulink", Prentice Hall PTR, New Jersey, 1998.
4. Ned Mohan, "Power Electronics: Computer Simulation Analysis and Education using PSPICE", Minnesota Power Electronics Research and Education, USA, 1992.
5. Ramshaw E., Schuuram D. C., "PSpice Simulation of Power Electronics Circuits – An Introductory Guide", Springer, New York, 1996.
6. http://www.plexim.com/plecs

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course Outcome
1.	**SIMULATION OF POWER COMPUTATIONS AND RECTIFIER CIRCUITS**		
1.1	Simulation of Power Electronics circuits	1	CO1
1.2	Power Computations in Linear	1	CO1
1.3	Nonlinear-Sinusoidal, Non-sinusoidal circuits	1	CO2
1.4	Real Power, Reactive Power, Displacement factor, Distortion factor & Power factor- Diode Rectifier Circuits -Phase Controlled Rectifier Circuits	2	CO2
2.	**SIMULATION OF DC-DC AND DC-AC CONVERTERS**		
2.1	Buck, Boost, Buck-Boost Converters Analysis, Power device dissipation, Component losses & efficiency calculation	2	CO3
2.2	Dynamic Simulation	1	CO5
2.3	Simulating Inverters Square wave Inverter, PWM Inverter	1	CO4

Module No.	Topic	No. of Lectures	Course Outcome
2.4	Power device dissipation, Efficiency & Harmonics calculation – Response with Filter	2	CO3
3	**SIMULATION OF CONVERTERS**		
3.1	Single phase bridge rectifier, Three phase bridge rectifier	1	CO2
3.2	DC-DC Converters- Buck, Boost, Buck-Boost Converters	1	CO3
3.3	Single phase bridge inverter with SPWM	1	CO4
3.4	Three phase bridge inverters	2	CO4
4	**SIMULATION OF DC MOTOR, AC MOTOR DRIVES**		
4.1	Simulation of DC and AC motor drives using PSpice, Matlab etc	4	CO6
	Total	20	

Tentative List of Experiments (24 Hours)

1. Simulation of Diode Rectifier Circuits: Half wave, Full wave circuits with R, RL, RC loads and Battery charger applications.

2. Simulation of Phase Controlled Rectifier Circuits:Half wave phase controlled, Full wave phase controlled circuits with R, RL, RC loads &Battery charger applications.

3. Performance Analysis and Thermal Analysis of single phase and three phase Diode Rectifier Circuits, Phase Controlled Rectifier Circuits with filter –Analysis of Fourier coefficients of output voltage- Effects of Filter Capacitance.

4. Dynamic Simulation, Performance Analysis and Thermal Analysis:Simulating Buck,Boost,Buck-Boost chopper circuits.

5. Dynamic Simulation, Performance Analysis and Thermal Analysis: Square wave Inverters-Single phase bridge inverter -Three phase bridge inverter- PWM Inverters with SPWM - Power device dissipation, efficiency and Harmonics calculation.

6. Transient response analysis of DC motor and AC motor drives.

7. Modelling and simulation of power converters for solar energy conversion.

8. Modelling and simulation of power converters for wind energy conversion.

9. Modelling and simulation of battery powered drive system.

Course designers

1. Dr.V.Suresh Kumar, , vskeee@tce.edu
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HONORS

FOR

B.E. EEE DEGREE PROGRAMME

AND

MINORS

FOR

B.E./B.TECH DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR FROM 2022-23 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41

Fax: 0452 2483427

Web: www.tce.edu

VISION

Transforming the individuals into globally competent electrical engineers to fulfill the technological needs of the society.

MISSION

Establishing world class infrastructure in Electrical Engineering.

Enhancing the knowledge of the faculty in cutting edge technologies through continuous improvement programmes.

Providing well balanced curriculum in graduate, postgraduate and doctoral programmes.

Adopting innovative content delivery, assessment and continuous improvement methods to achieve desired outcomes.

Facilitating industry institution interaction in teaching & learning, consultancy and research activities to accomplish the technological needs of the society.

Encouraging the faculty and students to carry out innovative research work.

Practicing ethical standards by the faculty and students.

Motivating the students for active participation in co-curricular and extracurricular activities.

Programme Educational Objectives (PEO's)

PEO1: Graduates of the programme will have successful career in chosen technical or professional fields.
PEO2: Graduates of the programme will have technical competency in solving challenging societal tasks in ethical and economical manner.
PEO3: Graduates of the programme will reveal lifelong learning and team work in their chosen profession.

Programme Outcomes (POs) for B.E. Electrical and Electronics Engineering

After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students should be able to:

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 Conduct investigations of complex problems: The problems:

- That cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline.
- That may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions.
- That requires consideration of appropriate constraints/requirements not explicitly given in the problem statement. (Like: cost, power requirement, durability, product life, etc.).
- Which need to be defined (modeled) within appropriate mathematical framework.
- That often requires use of modern computational concepts and tools.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering 21 activities with an understanding of the limitations.
PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO1												
PEO2												
PEO3												

Programme Specific Outcomes (PSO):
After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students will be able to:
PSO1: Design and analyze components/ systems that effectively generate, transmit, distribute and utilize electrical power.

PSO2: Design and analyze modern industrial electronic systems/components to perform analog and digital processing and control functions

PEO- Mission mapping

PEO	M1	M2	M3	M4	M5	M6	M7	M8
PEO1	1	2	2	1	2	1	1	3
PEO2	1	2	2	2	2	2	1	3
PEO3	1	2	3	2	3	2	1	3

1 – Low; 2 – Medium; 3 – Strong

Credit Distribution

<table>
<tr><th rowspan="2">S. No</th><th rowspan="2" colspan="2">Category</th><th colspan="2">Credits</th></tr>
<tr><th>Regular Admission</th><th>Lateral Entry Admission</th></tr>
<tr><td rowspan="4">A</td><td colspan="2">Foundation Courses (FC)</td><td>54 – 66</td><td>24 - 36</td></tr>
<tr><td>a.</td><td>Humanities and Social Sciences including Management Courses (HSMC)</td><td>9- 12</td><td>08- 11</td></tr>
<tr><td>b.</td><td>Basic Science Courses (BSC)</td><td>24 – 27</td><td>06 - 09</td></tr>
<tr><td>c.</td><td>Engineering Science Courses (ESC)</td><td>21 – 27</td><td>08 - 15</td></tr>
<tr><td>B</td><td colspan="2">Professional Core Courses (PCC)</td><td>55</td><td>45</td></tr>
<tr><td>C</td><td colspan="2">Professional Elective Courses (PEC)</td><td>24 – 39</td><td>24 - 39</td></tr>
<tr><td></td><td>a.</td><td>Programme Specific Electives (PSE)</td><td>15 – 24</td><td>15 – 24</td></tr>
<tr><td></td><td>b.</td><td>Programme Electives for Expanded Scope (PEES)</td><td>9 – 15</td><td>9 – 15</td></tr>
<tr><td>D</td><td colspan="2">Open Elective Courses (OEC)</td><td>6 – 12</td><td>6 – 12</td></tr>
<tr><td></td><td>a.</td><td>Interdisciplinary Elective (IE)</td><td>3 – 6</td><td>3 – 6</td></tr>
<tr><td></td><td>b.</td><td>Basic Science Elective (BSE)</td><td>3 – 6</td><td>3 – 6</td></tr>
<tr><td>E</td><td colspan="2">Project Work</td><td>12</td><td>12</td></tr>
<tr><td>F</td><td colspan="2">Internship and Mandatory Audit Courses as per Regulatory authorities</td><td colspan="2">Non-Credit
(Not included for CGPA)</td></tr>
<tr><td rowspan="2"></td><td rowspan="2" colspan="2">Minimum Credits to be earned for the award of the Degree</td><td>160</td><td>120</td></tr>
<tr><td colspan="2">From A to E and the successful completion of F</td></tr>
</table>

- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, and participation in identified activities that promote the growth of Departments and the College

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SCHEDULING OF COURSES (B.E.EEE. Programme) – 2022-23 admitted Batch

Sem	Theory / Theory cum Practical / Practical								CDIO courses	Audit Courses (Mandatory Non-credit}	Credit
	1	2	3	4	5	6	7	8			
I	22MA110 Calculus for Engineers (BSC-4)	22PH120 Physics (BSC-3)	22CH130Chemistry (BSC-3)	22EG140TechnicalEnglish (HSMC-2)	22ME160 Engineering Graphics (ESC-4)	22EG170 English Lab. (HSMC-1)	22PH180 Physics Lab. (BSC-1)	22CH190 Chemistry Lab. (BSC-1)	22EE150 Engineering Exploration (EEE Specific) (ESC-2)		21
II	22EE210 Matrices and Transforms (BSC-4)	22EE220 Materials Science for Electrical Engineering (ESC-3)	22EE230Electric Circuit Analysis (PCC-3)	22EE240Electromagnetic Fields (PCC-3)	22EE250 Digital Systems (PCC-3)	22EE260 Electronic devices and circuits (PCC-3)	22EE270 Electrical Workshop (ESC-1)	22EE280 Electronic Devices and Circuits (PCC Lab 1)		Audit Course 1	21
III	22EE310 Numerical methods and Complex variables (BSC-4)	22EE320 DC Machines and Transformers (PCC-3)	22EE330Linear Integrated Circuits (PCC-3)	22EE340Signals and Systems (PCC-3)	22EE350 Problem Solving Using Computers (ESC-3)		22EE370 DC Machines and Transformers Lab (PCC Lab 1)	22EE380 Integrated Circuits Lab (PCC Lab 1)	22ES390 Design Thinking (ESC-3)		21

IV	22EE410 Probability Distribution and Random Process (BSC-4)	22EE420 AC Machines (PCC-3)	22EE430Measurements and Instrumentation (PCC-)	22EE440Control Systems (PCC-3)	22EE450 Power Electronics (PCC-3)	22EE460 Data Structures Elective(ESC-3)	22EE470 Electrical Problem solving using computers (PCC Lab1)	22EE480 AC Machines Lab (PCC Lab 1)	22EE490 Project Management (HSMC-3)	Audit Course 2	**24**
V	22EE510 Generation, Transmission and Distribution (PCC-3)	22EE520 Micro Controllers (PCC-3)	22EE530 Electric drives (PCC-3)	22EE540 Power System Analysis (PCC-3)	Interdisciplinary Elective (OE-3)	22EE550 Object Oriented Programming PE (ESC-3)	22EE570 Measurement and Control Lab (PCC Lab1)	22EE580 Microcontrollers lab (PCC Lab 1)	22EE590 Project -I (P-3)		**23**
VI	22EE610 Accounting and Finance HSMC-3	22EEPXX PEC- 1 (3)	22EEPXX PEC-2 (3)	22EEPXX PEC-3 (3)	Basic Science Elective (OE-3)	22EG660 Professional Communication HSMC-2	22EE670 Power Electronics and Drives Lab (PCC Lab-1)(1)	22EE680 Electric Power Systems lab (PCC Lab 1)	22EE690 Project -II (P-3)		**22**
VII	22EEPXX PEC- 4 (3)	22EEPXX PEC--5 (3)	22EEPXX PEC--6 (3)	22EEPXX PEC-7 (3)	22EEPXX PEC-8 (3)		22EE770 Energy Management System Lab (PCCLab1)		22EE790 Project -II (P-3)		**19**
VIII	22EEPXX PEC-9 (3)	22EEPXX PEC-10(3)							22EE890 Project -IV (P-3)		**9**

Total Credits: **160**

Thiagarajar College of Engineering: Madurai – 625 015
B.E. / B.Tech. Degree Programmes

COURSES OF STUDY
(For the candidates admitted from 2022-23 onwards)

B.E EEE (HONORS and MINORS)

The academic council of our institution has approved the implementation of the following, for the students admitted from the academic year 2022-23 onwards:

I. B.E./B.Tech. (Honors) in the same discipline
II. B.E./B.Tech. (Honors)
III. B.E./B.Tech. Minor in other specialization

As per our regulations, a student has to earn 160 credits for the award of B.E./B.Tech. degree. An additional 18 credits have to be earned for the award of B.E./B. Tech. degree with Minor/Honors.

Out of the additional 18 credits, a student can earn a maximum of 12 credits through online platforms with proctored examinations. Out of which, 6 credits shall be earned through NPTEL/SWAYAM and the other 6 credits through the TCE MOOC platform.

Vertical is a particular area of specialization with a group of elective courses offered by the respective department.

I. B.E./B.Tech. (Honors) in the same discipline
A student has to complete additional elective courses (18 credits) from one vertical of the same discipline of their study

II. B.E./B.Tech. (Honors)
A student has to complete additional elective courses (18 credits) from more than one vertical of the same discipline of their study

III. B.E./B.Tech. (Minor) in other Specialization
A student has to complete additional elective courses (18 credits) from One vertical of other B.E./B.Tech. Programme

Smart Grid	**Electric Vehicle**	**Internet of Things**	**Industry Automation and Control**	**Artificial Intelligence**	**Minor - Electrical & Electronics**
Power system restructuring	Power Electronics interface for EV	Programming for IoT Boards	System Theory	An Introduction to Artificial Intelligence	Electric Circuit Theory
Substation automation	Battery Management System	Cloud computing	Digital Control System	Fuzzy logic and Neural networks	Electrical Machines Performance and Application
Operation and planning of	Electric Vehicle Charging	Sensors and Actuators (TCE	Sensors and actuators (TCE MOOC)	Evolutionary computation Techniques	22EEPD0 Wind and Solar

power distribution system	Infrastructure	MOOC)			Technology
Digital protection of power system	Fuel Cell Technology	Wireless Ad-hoc and Sensor Networks (Nptel)	Process Control - Design, Analysis and Assessment (Nptel)	Artificial Intelligence: Knowledge Representation and Reasoning (Nptel)	Sensors and actuators (TCE MOOC)
Smart grid operation and planning (TCE MOOC)	Electro-chemical Energy Storage (Nptel)	Introduction to Internet of Things (Nptel)	Intelligent Systems and Control (Nptel)	Artificial Intelligence Search Methods for Problem Solving (Nptel)	Energy Efficiency, Acoustics and Day lighting in Building (Nptel)
		Introduction to Embedded System Design (Nptel)	Energy Management Systems and SCADA (Nptel)	Machine Learning for Engineering and Science Applications (Nptel)	Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems (Nptel)
		Introduction to Industry 4.0 and Industrial Internet of Things (Nptel)	Industrial Automation And Control (Nptel)	Deep Learning	
				Block Chain Technology (Nptel)	

SMART GRID VERTICAL

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEZA0	Power system restructuring	PSE	2	1	-	3
22EEZB0	Substation automation	PSE	3	-	-	3
22EEZC0	Operation and planning of power distribution system	PSE	3	-	-	3

22EEZD0	Digital protection of power system	PSE	2	1	-	3
22EEZF0	Smart grid operation and planning	PSE	3	-	-	3
Total			**13**	**2**	**-**	**15**

Programme Specific Electives (PSE)
L : Lecture , T : Tutorial ,P: Practical
Note : 1 Hour Lecture is equivalent to 1 credit , 1 Hour Tutorial is equivalent to 1 credit 2 Hours Practical is equivalent to 1 credit

ELECTRIC VEHICLE VERTICAL

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEZG0	Power Electronics interface for Electric Vehicle	PSE	3	-	-	3
22EEZH0	Battery Management System	PSE	2	-	2	3
22EEZJ0	Electric Vehicle Charging Infrastructure	PSE	3	-	-	3
22EEZK0	Fuel Cell Technology	PSE	2	1	-	3
Total			**10**	**1**	**2**	**12**

Internet Of Things VERTICAL

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEZL0	Programming for IoT Boards	PSE	2	-	2	3
22EEZM0	Cloud computing	PSE	3	-	-	3
22EEZN0	Sensors and Actuators	PSE	3	-	-	3
Total			8	**-**	**2**	**9**

INDUSTRY AUTOMATION AND CONTROL VERTICAL

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEZP0	Systems Theory	PSE	3	-	-	3
22EEZQ0	Digital Control System	PSE	3	-	-	3
Total			06	**-**	**-**	**06**

ARTIFICIAL INTELLIGENCE VERTICAL

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEZR0	An Introduction to Artificial Intelligence	PSE	3	-	-	3
22EEZS0	Fuzzy logic and Neural networks	PSE	3	-	-	3
22EEZT0	Evolutionary computation Techniques	PSE	3	-	-	3
Total			9	**-**	**-**	9

MINOR - ELECTRICAL & ELECTRONICS VERTICAL

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEQA0	Circuits and networks	PSE	2	1	-	3
22EEQB0	Electrical Machines Performance and Application	PSE	3	-	-	3
	Wind and Solar Technology	PSE	3	-	-	3
Total			8	**1**	**-**	**9**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B.E. / B.Tech. Degree Programme

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2021-2022, 2022-2023 onwards)

SMART GRID VERTICAL

S.No.	Course Code	Name of the course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEZA0	Power system restructuring	3	40	60	100	27	50
2	22EEZB0	Substation automation	3	40	60	100	27	50
3	22EEZC0	Operation and planning of power distribution system	3	40	60	100	27	50
5	22EEZD0	Digital protection of power system	3	40	60	100	27	50
6	22EEZF0	Smart grid operation and planning	3	40	60	100	27	50

ELECTRIC VEHICLE VERTICAL

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								

1	22EEZG0	Power Electronics interface for Electric Vehicle	3	40	60	100	27	50
2	22EEZH0	Battery Management System	3	40	60	100	27	50
3	22EEZJ0	Electric Vehicle Charging Infrastructure	3	40	60	100	27	50
4	22EEZK0	Fuel Cell Technology	3	40	60	100	27	50

Internet Of Things VERTICAL

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEZL0	Programming for IoT Boards	3	40	60	100	27	50
2	22EEZM0	Cloud computing	3	40	60	100	27	50
3	22EEZN0	Sensors and Actuators	3	40	60	100	27	50

INDUSTRY AUTOMATION AND CONTROL VERTICAL

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total

THEORY								
1	22EEZP0	Systems Theory	3	40	60	100	27	50
2	22EEZQ0	Digital Control System	3	40	60	100	27	50

ARTIFICIAL INTELLIGENCE VERTICAL

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEZR0	An Introduction to Artificial Intelligence	3	40	60	100	27	50
2	22EEZS0	Fuzzy logic and Neural networks	3	40	60	100	27	50
3	22EEZT0	Evolutionary computation Techniques	3	40	60	100	27	50

MINOR - ELECTRICAL & ELECTRONICS VERTICAL

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEQA0	Circuits and Networks	3	40	60	100	27	50

2	22EEQB0	Electrical Machines Performance and Application	3	40	60	100	27	50
3		Wind and Solar Technology	3	40	60	100	27	50

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015

(A Govt. Aided Autonomous Institution affiliated to Anna University)

CHOICE BASED CREDIT SYSTEM

Categorization of Courses

Degree: B.E. **Programme: EEE** **Batch: 2021-2022, 2022-23 onwards**

ELECTIVE COURSES:

S.No.	Course code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		SMART GRID VERTICAL					
	THEORY						
1.	22EEZA0	Power system restructuring	2	1	-	3	Nil
2.	22EEZB0	Substation automation	3	-	-	3	Nil
3.	22EEZC0	Operation and planning of power distribution system	3	-	-	3	Nil
4.	22EEZD0	Digital protection of power system	2	1	-	3	Nil
5.	22EEZF0	Smart grid operation and planning	3	-	-	3	NIL
		ELECTRIC VEHICLE VERTICAL					
	THEORY						
1.	22EEZG0	Power Electronics interface for Electric Vehicle	3	-	-	3	Nil
2.	22EEZH0	Battery Management System	2	2	-	3	22PH120: Physics 22CH130: Chemistry Basic Electrical Engineering
3.	22EEZJ0	Electric Vehicle Charging Infrastructure	3	-	-	3	Nil
4.	22EEZK0	Fuel Cell Technology	2	1	-	3	Engineering Materials

							Basic Electronics
		Internet Of Things VERTICAL					
	THEORY						
1.	22EEZL0	Programming for IoT Boards	3	-	-	3	22EERZ0
2.	22EEZM0	Cloud computing	3	-	-	3	Nil
3.	22EEZN0	Sensors and Actuators	3	-	-	3	Nil
		INDUSTRY AUTOMATION AND CONTROL VERTICAL					
1.	22EEZP0	Systems Theory	3	-	-	3	22EE440
2.	22EEZQ0	Digital Control System	3	-	-	3	Nil
		ARTIFICIAL INTELLIGENCE VERTICAL					
1.	22EEZR0	An Introduction to Artificial Intelligence	3	-	-	3	Nil
2.	22EEZS0	Fuzzy logic and Neural networks	3	-	-	3	Nil
3.	22EEZT0	Evolutionary computation Techniques	3	-	-	3	Nil
		MINOR - ELECTRICAL & ELECTRONICS VERTICAL					
1.	22EEQA0	Circuits and networks	3	-	-	3	Nil
2.	22EEQB0	Electrical Machines Performance and Application	2	1	-	3	Nil

22EEZA0	POWER SYSTEM RESTRUCTURING

Category	L	T	P	Credit
PSE	2	1	0	3

Preamble

The electricity industry throughout the world, which has long been dominated by vertically integrated utilities, is undergoing enormous changes. Deregulation is a fairly new paradigm and just as in the case of other industries where it has been introduced, the goal of deregulation is to enhance competition and bring consumers new choices and economic benefits.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcome 1 (CO1)	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the restructuring process, new entities in power market and benefits.	TPS2	85	80
CO2	Apply the concepts and terminologies used in interchange evaluation, power pools and transaction issues.	TPS3	80	85
CO3	Explain the Indian power system, issues, regulatory and policy developments and facts.	TPS2	85	80
CO4	Demonstrate the transmission open access, congestion management and pricing issues.	TPS3	80	85
CO5	Determine available transfer capability in the restructured environment.	TPS3	80	85
CO6	Apply the concepts to relieve congestion in the transmission system	TPS3	80	85

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S			M						L					
CO2	S	M	M	M											
CO	S									M					

3															
CO 4	M		M	S	S		L								
CO 5			M	M	S					M					
CO 6	M		M	S	S										

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1			Assignment1			CAT2			Assignment2			Terminal					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	4	5	6
CO1	10	20											5	5				
CO2			40										5	10	10			
CO3	10	20				100							5	5				
CO4							10	10	10			30	5	5	10			
CO5							10	10	20			30		5	10			
CO6								10	20			40		10	10			

Syllabus

POWER SYSTEM RESTRUCTURING: AN OVERVIEW

Introduction- Motivation for Restructuring of Power System- Electricity Market Entities and Model-Milestones of Deregulation-International Scenario –Industrialized countries - In the US- The Scene in Europe- The British power pool-Nordic Deregulation process-Developing countries - Benefits of deregulation- Basic Terminologies

POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT

Introduction-Role of Independent system operator - Structure of UK and Nordic Electricity sector market operations –power pools – explanation of single auction power pool & double auction power pool with supply bid and demand - Two bus power system – four utility joint dispatch- Transmission networks and bilateral Electricity markets- bilateral trading in a two bus power system- three bus power system with feasible transactions

TRANSMISSION OPEN ACCESS AND PRICING ISSUES

Introduction-power wheeling -Transmission open access- Types of Transmission services in open access – cost components in transmission – Pricing of power transactions – Embedded cost based Transmission pricing - Postage stamp method - contract path method-MW Mile method – Marginal participation method – Incremental cost based transmission pricing –SRMC and LRMC based pricing

AVAILABLE TRANSFER CAPABILITY & CONGESTION MANAGEMENT

Introduction-Definition - Methods of Static ATC Determination - Method based on multiple load flow and continuation power flow - Method based on optimization power flow- method based on linear sensitivity factors. Congestion management –congestion management methods: An overview: Cluster/zone based method – Rescheduling of generation-LMP based congestion management.

INDIAN POWER MARKET

Introduction –Indian power sector past and present status-growth of power sector in India - overview - Time line of Indian power sector- Players in the Indian power sector - Availability based tariff - Necessity- working mechanism- Beneficiaries-Day Scheduling process- Deviation from Schedule- unscheduled interchange rate-system marginal rate- trading surplus generation- applications – Indian energy exchange

Text Book

1. P.Venkatesh, B.V.Manikandan, S.Charles Raja and A.Srinivasan , " Electrical power systems analysis, Security and Deregulation", PHI 2012.

Reference Books & web resources

1. Kankar Bhattacharya Maath H.J. Bollen and Jaap E.Daalder, "Operation of restructured power systems", Kluwer academic publishers, USA ,first edition, 2001.
2. Daniel Kirschen and Goran Strbac ,"Fundamentals of power system economics", John Wiley sons, 2004.
3. Loi Lei Lai, "Power system Restructuring and regulation" John Wiley sons, 2001.
4. M.Shahidepour, Hatim Tamin and Zuyi Li, "Market operations in electric power system forecasting, scheduling and risk management", John Wiley sons, 2002.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**POWER SYSTEM RESTRUCTURING: AN OVERVIEW**	
1.1	Introduction- motivation of restructuring	1
1.2	Structure – Entities - Deregulated Markets, Milestones of Deregulation	2
1.3	US Electricity market, European market	1
1.4	British power pool, Nordic Power market	1
1.5	Deregulation in Developing countries	1
1.6	Benefits of Deregulation & Basic Terminologies	1
2	**POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT**	
2.1	Introduction – Role of ISO	1
2.2	Structure of UK and Nordic Electricity sector market operation	1
2.3	Operation of Power pool	1
2.4	Single auction and double auction power pool	1
2.5	Two bus power systems and four utility joint dispatch	1
2.6	Transmission network and bilateral trading with simple power systems	2
3	**TRANSMISSION OPEN ACCESS AND PRICING ISSUES**	

Module No.	Topic	No. of Periods
3.1	Introduction – power wheeling-Transmission open access	1
3.2	Types of Transmission services in open access and cost components in transmission	1
3.3	Introduction to Transmission pricing and methods	1
3.4	Embedded cost-based transmission pricing - Postage stamp method - contract path method	2
3.5	MW Mile method – Marginal participation method	2
3.6	Incremental cost-based transmission pricing –SRMC and LRMC based pricing	1
4	**AVAILABLE TRANSFER CAPABILITY & CONGESTION MANAGEMENT**	
4.1	Introduction to ATC and Related terms & Definition	1
4.2	Methods of Static ATC Determination-Method based on multiple load flow and continuation power flow - Method based on optimization power flow-	1
4.3	Method based on linear sensitivity factors.	2
4.4	Introduction to Congestion management	1
4.5	congestion management methods: An overview: Cluster/zone-based method	1
4.6	LMP based congestion management	1
4.7	Rescheduling of generation	1
5	**INDIAN POWER MARKET**	
5.1	Introduction to Indian power market- Past and present status	1
5.2	Growth of power sector in India – overview -	1
5.3	Time line of Indian power sector- Players in the Indian power sector	1
5.4	Availability based tariff – Necessity – Working Mechanism – Beneficiaries – Day Scheduling Process – Deviation from Schedule	1
5.5	Unscheduled Interchange Rate – System Marginal Rate	1
5.6	Trading Surplus Generation – Applications.	1
	Total	**36**

Course Designer(s):

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22EEZB0	SUBSTATION AUTOMATION

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Substation automation is a rapidly increasing area of interest and benefit to utilities. Substation automation goes beyond traditional SCADA to provide added capability and information that can further improve operations and maintenance, increase system and staff efficiencies, and leverage and defer major capital investments. Substation Automation System provides protection, control, automation, monitoring, and communication capabilities as a part of a comprehensive substation control and monitoring solution. Substation automation is the cutting edge technology in electrical engineering. It means having an intelligent, interactive power distribution network.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the operational and physical separation among switchyard level, bay level and station level.	TPS2	70	70
CO2	Describe the protection and interoperability standards of the power system	TPS2	70	70
CO3	Explain the fundamental requirements and architecture of SCADA for Substation operation and its automation in electric Power system.	TPS2	70	70
CO4	Explain the features of RTU, interfaces and other functions of SCADA.	TPS2	70	70
CO5	Select appropriate monitoring and control instruments to improve power system functionality and performance.	TPS3	70	70
CO6	Design a complete SCADA equipped monitoring and control setup for substation automation.	TPS3	70	70

Mapping with Programme Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	S	M	L	L				M		M			S	

CO2	M	L						M		M			M	
CO3	S	M						M		M			S	
CO4	S	M	L	L				M		M			S	
CO5	S	M	L	L				M		M			S	
CO6	S	M	L	L				M		M			S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1			Assignment 1			CAT2			Assignment 2			Terminal					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	4	5	6
CO1	10	20	10		30								5	15				
CO2	10	20			30								5	10				
CO3	10	20			40								5	15				
CO4							10	10					5	15				
CO5							10	10	40			50		5	10			
CO6								10	10			50			10			

Syllabus

UNIT I INTRODUCTION TO SUBSTATION AUTOMATION SYSTEMS & COMMUNICATION PROTOCOLS

Evolution of SAS – Emerging Communication Technologies – IED's – Networking Mediums – Communication Standards-Structure of a SCADA. Communications Protocol - IEC61850 based communication architecture, Communication media like Fiber optic & PLCC.

UNIT II SUBSTATION AUTOMATION USING SCADA

Evolution of SCADA, SCADA definitions, SCADA Functional requirements and Components, SCADA Hierarchical concept, SCADA architecture, General features, SCADA Applications, Benefits.

UNIT III SCADA SYSTEM COMPONENTS

Remote Terminal Unit (RTU), Interface units, Human- Machine Interface Units (HMI), Display Monitors/ Data Logger Systems, Intelligent Electronic Devices(IED), Communication Network, SCADA Server.

UNIT IV SWITCHYARD LEVEL: EQUIPMENT & SYSTEM FUNCTIONALITIES

Primary Equipment–Instrument Transformers–Power Transformers–Electrical Connections – Bay Concept - Substation Physical Layout – System Functionalities – Control Function –Monitoring Function – Measuring & Metering function – Protection Function –Report Generation & Device Parameterization Function.

UNIT V BAYLEVEL & STATION LEVEL: FUNCTIONALITIES

Switchyard Control Rooms- Attributes of Control Cubicles-The Bay Controller- Other Bay Level Components- Main Control House- Station Controller- Human Machine Interface HMI- External Alarming-Time Synchronization Facility-Protocol Conversion Task-Station Bus-Station LAN.

CASE STUDIES:
SAS Design for 220/132 kV or 132/66 KV any utility Substation and IEC 61850 based SCADA Implementation issues in utility Substations.

Text Book

2. Grigsby L.L,“Electric Power Engineering Handbook”,2nd Ed., CRC Press,2007.
3. Substation Automation Systems–Design & Implementation –By Evillo Padilla–Wiley & Sons–2016

Reference Books

1. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 2004.
2. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3,60870.5 and Related Systems, Newnes Publications, Oxford, UK, 2004.
3. WilliamT. Shaw, Cyber security for SCADA systems, PennWell Books,2006.
4. David Bailey, EdwinWright, Practical SCADA for industry, Newnes, 2003.
5. DieterK. Hammer, Lonnie R.Welch, Dieter K.Hammer, “Engineering of Distributed Control Systems”, Nova Science Publishers, USA,1st Edition, 2001.
6. https://new.siemens.com/global/en/products/automation/industry-software/ automation-software/scada.html
7. https://electrical-engineering-portal.com/download-center/books-and-guides/ electricity-generation-t-d/scada-applications-tpps

Course Contents and Lecture Schedule

Sl.No.	Topic	No. of Lectures
1.0	**INTRODUCTION TO SUBSTATION AUTOMATION SYSTEMS & COMMUNICATION PROTOCOLS**	
1.1	Evolution of SAS	1
1.2	Emerging Communication Technologies	1
1.3	IED’s–Networking Mediums	1
1.4	Communication Standards – Structure of a SCADA	1
1.5	Communications Protocol-IEC61850 based communication architecture	2
1.6	Communication media like Fiber optic &PLCC	1
2.0	**SUBSTATION AUTOMATION USING SCADA**	
2.1	Evolution of SCADA	1
2.2	SCADA definitions, SCADA Functional requirements and Components	1
2.3	SCADA Hierarchical concept	1
2.4	SCADA architecture-General features	1
2.5	SCADA Applications	2
2.6	Benefits of SCADA	1
3.0	**SCADA SYSTEM COMPONENTS**	
3.1	Remote Terminal Unit (RTU)	1
3.2	Interface units	1
3.3	Human-Machine Interface Units(HMI)	1
3.4	Display Monitors/ Data Logger Systems	1
3.5	Intelligent Electronic Devices(IED)	1
3.6	Communication Network, SCADA Server	1
4.0	**SWITCHYARD LEVEL: EQUIPMENT & SYSTEM FUNCTIONALITIES**	
4.1	Primary Equipment	1
4.2	Instrument Transformers –Power Transformers	2

4.3	Electrical Connections–Bay Concept- Substation Physical Layout	1
4.4	System Functionalities –Control Function	1
4.5	Monitoring Function– Measuring & Metering function –Protection Function	1
4.6	Report Generation & Device Parameterization Function	1
5.0	**BAY LEVEL & STATION LEVEL: FUNCTIONALITIES**	
5.1	Switchyard Control Rooms	1
5.2	Attributes of Control Cubicles	1
5.3	The Bay Controller-Other Bay Level Components	1
5.4	Main Control House- Station Controller- Human Machine Interface HMI	1
5.5	External Alarming-Time Synchronization Facility	1
5.6	Protocol Conversion Task	2
5.7	Station Bus-Station LAN	2
6.0	**CASE STUDIES**	
	Total	**36**

Course Designers:

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22EEZC0	OPERATION AND PLANNING OF POWER DISTRIBUTION SYSTEMS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

The economic importance of the distribution system is very high, and the amount of investment involved dictates careful planning, design, construction, and operation. This course includes the operation concepts of distribution transformer, subtransmission lines, distribution substations, primary and secondary networks. Application and location of capacitors, Voltage-drop, Power-loss and voltage regulation calculation of distribution substations and overhead/underground distribution systems are also included.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

Course Outcome NO.	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the selection of Distribution transformer for the given condition.	TPS2	85	80
CO2	Specify the arrangements of substation with primary and secondary feeders.	TPS3	80	85
CO3	Design the primary distribution system for a given condition.	TPS3	80	85
CO4	Describe the Secondary distribution system networks.	TPS2	85	80
CO5	Select and locate the capacitor for a given application.	TPS3	80	85
CO6	Calculate voltage regulation of the given feeder.	TPS2	85	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	M	L						M		M	
CO2.	S	M	L	L				M		M	
CO3.	S	M	L	L				M		M	
CO4.	M	L						M		M	
CO5.	S	M	L	L				M		M	
CO6.	M	L						M		M	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory	Theory	Theory
	Assessment-1	**Assessment-2**	**Terminal**

	Assignment-1				CAT-1				Assignment-2			CAT-2			Examination			
TPS COs	1	2	3		1	2	3	4	1	2	3	1	2	3	1	2	3	
CO1					10										6	5		
CO2			50		5	20	20								2	5	10	
CO3			50		5	20	20								2	5	15	
CO4												10			6	5		
CO5											50	5	20	20	2	5	10	
CO6											50	5	20	20	2	20		

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Application of Distribution Transformers

Types of Distribution transformers - Regulation - Efficiency -Terminal Markings - Polarity - Distribution Transformer Loading Guides - Equivalent Circuits - Single-phase transformer-3 phase transformers - Autotransformers- Booster transformers - Amorphous Metal, Energy efficient transformers.

Design of Subtransmission Lines and Distribution Substations

Subtransmission- Line Costs - Distribution Substations - Substation Costs- Substation Bus Schemes- Location -Rating of Distribution Substation - Substation service area with n Primary Feeders -Comparison of Four and Six-Feeder patterns- Substation Grounding.

Design Considerations of Primary and Secondary Systems

Primary System – Primary Feeders - Radial and Loop types - Primary Network- Primary Feeder voltage levels - loading -Tie Lines - Distribution feeder Exit -Rectangular and Radial type development -Radial Feeders with Uniformly and Non-Uniformly distributed load -General circuit constants of Radial feeders - Design of Radial Primary Distribution Systems -Overhead and Underground - Primary System Costs – **Secondary System**-Secondary Voltage Levels - Present Design Practice - Secondary Banking -Secondary Networks - Spot Networks.

Applications of Capacitors to Distribution Systems

Power Capacitors - Effects of Series and Shunt Capacitors - Power Factor Correction - Application of Capacitors - Economic Justification for Capacitors - Best Capacitor Location- A Practical procedure- Optimum Capacitor Allocation-A Mathematical Procedure.

Distribution System Voltage Regulation

Quality of Service and Voltage standards - Voltage control - Feeder Voltage Regulators - Introduction to Line Drop Compensation - Distribution Capacitor Automation - Calculation of Voltage fluctuations.

Text Book

1. Electric Power Distribution System Engineering, Second Edition, TuranGonen, CRC Press, Taylor&Francis Group, Boca Raton, 2008 ISBN: 13:978-1-4200-6200-7

Reference Books and Web Resources

1. Gonen, T. (2011). Electrical power transmission system engineering: analysis and design. CRC press.
2. Grigsby, Leonard L. The electric power engineering handbook-five volume set. CRC press, 2018.
3. Padilla, E. (2015). Substation automation systems: design and implementation. John Wiley & Sons.
4. Edited by B. Das, Power Distribution Automation, IET Power and Energy Series, 75, London, 2016.
5. A. A. Sallam and O. P. Malik, Electric Distribution System, IEEE Press, Piscataway, NJ, 2011.
6. NPTEL course on Electrical Distribution System Analysis, By Prof.G. B. Kumbhar, IIT Roorkee. https://onlinecourses.nptel.ac.in/noc19_ee61/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1.0	**Application of Distribution Transformers**	
1.1	Types of Distribution transformers - Regulation - Efficiency	1
1.2	Terminal Markings - Polarity -Distribution Transformer Loading Guides - Equivalent Circuits	1
1.3	Single-phase transformer-3 phase transformers	2
1.4	Autotransformers- Booster transformers - Amorphous Metal, Energy efficient transformers.	2
2.0	**Design of Subtransmission Lines and Distribution Substations**	
2.1	Subtransmission- Line Costs - Distribution Substations - Substation Costs	2
2.2	Substation Bus Schemes- Location -Rating of Distribution Substation	2
2.3	Substation service area with n Primary Feeders -Comparison of Four and Six-Feeder patterns	2
2.5	Substation Grounding.	1
3.0	**Design Considerations of Primary and Secondary Systems**	
3.1	**Primary Feeders** - Radial and Loop types - Primary Network-Primary Feeder voltage levels - loading	2
3.2	Tie Lines - Distribution feeder Exit	2
3.3	Rectangular and Radial type development -Radial Feeders with Uniformly and Non-Uniformly distributed load, General circuit constants of Radial feeders	2
3.4	Design of Radial Primary Distribution Systems -Overhead and Underground- Primary System Costs	2
3.5	**Secondary Feeders** -Secondary Voltage Levels - Present Design Practice	1
3.6	Secondary Banking -Secondary Networks - Spot Networks	1
4.0	**Applications of Capacitors to Distribution Systems**	
4.1	Effects of Series and Shunt Capacitors - Power Factor Correction	2
4.2	Application of Capacitors	1
4.3	Economic Justification for Capacitors - Best Capacitor Location	2
4.4	A Practical procedure- Optimum Capacitor Allocation-A Mathematical Procedure	2
5.0	**Distribution System Voltage Regulation**	
5.1	Quality of Service and Voltage standards	1
5.2	Voltage control - Feeder Voltage Regulators	1
5.3	Introduction to Line Drop Compensation	2
5.4	Distribution Capacitor Automation - Calculation of Voltage fluctuations.	2
	Total	36

Course Designers:

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22EEZD0	DIGITAL PROTECTION OF POWER SYSTEM	Category	L	T	P	Credit
		PSE	2	1	0	3

Preamble

Power system protection and switchgear is a subject which touches our lives every day, in a very non-intrusive manner. Reliable protection of electric energy systems against faults like short circuits is in fact, the cornerstone of power system reliability. In turn, it is one of the important reasons for electricity having been accepted as a cost-effective and efficient medium for transmission of energy (or power) over large distances. The technology of power system protection has evolved a lot since the era of electromechanical type to use digital signal processing techniques. Thus, the requirement of learning this subject has changed significantly over a period of time and in fact, this subject addresses this need in a comprehensive manner.

Prerequisite

- Protection and Switchgear

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course outcomes (COs)	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Discuss the principles of time-overcurrent relays.	TPS 3	70	70
CO2	Explain the different types of faults and protection schemes of synchronous generators.	TPS 2	70	70
CO3	Explain the different types of faults and protective schemes of transformers.	TPS 2	70	70
CO4	Identify the different types of protective schemes for transmission lines.	TPS 3	70	70
CO5	Discuss the basic components of a digital relay.	TPS 2	70	70
CO6	Realization of different digital relay characteristics using microprocessor	TPS 3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	M									
CO2.	S	M									
CO3.	S		S						S		
CO4.	S		M								
CO5.	S		S								
CO6	S		M								
CO7	S										
CO8	S			M					M	S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal

TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	4	5	6
CO1	10	20	10			100							5	5	10			
CO2	10	20											5	10				
CO3	10	20											10	10				
CO4							10	10	40			50		10	10			
CO5							10	10					5	10				
CO6								10	10			50			10			

Syllabus

Introduction and Philosophy of a Protective Relaying System

Characteristic functions of protective relays- basic relay terminology.

Over current Protection

Introduction to over current relays – Basic principles and different types of time-over current relays - Introduction to Relay Co-ordination- Co-ordination of over current relays in an Interconnected power system.

Generator Protection

Different types of faults and different types of Protective schemes in Synchronous generators – Generator differential protection, Merz-Price protection, Stator earth fault protection, Stator inter-turn fault protection, Rotor earth fault protection.

Transformer Protection

Different types of faults and different types of Protective schemes in transformers -Percentage differential protection, Protection against magnetizing in-rush current, incipient fault protection (Buchholz relay), Over-fluxing protection, High resistance ground fault in transformers.

Transmission Line Protection

Types of line protection and selection criteria, Introduction to distance protection, Impedance relay, reactance relay, mho(admittance) relay, off-set mho relay, comparison of distance relays– Pilot wire protection- carrier current protection.

Digital/ Numerical Protection

Introduction to Digital protective relays - over current relay, impedance relay, Generalized mathematical expression for distance relays - mho relay, off-set mho, Quadrilateral relay characteristic realization, generalized interfacing for distance relays.

Block diagram of numerical relay, Sampling theorem, correlation with a reference wave, digital filtering, numerical over current protection, numerical transformer differential protection, numerical distance protection of transmission lines, Introduction to Fast Fourier Transform (FFT) and Discrete Wavelet Transform (DWT) to digital protection Overview of different algorithms for digital protection - Application of artificial intelligence (AI) in digital relaying.

Reference Books

1. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", Prentice-Hall of India, 2003.
2. S.R.Bhide "Digital Power System Protection" PHI Learning Pvt. Ltd.2014.
3. Sunil S.Rao, "Protection and switchgear", Khanna Publishers-IV th Edition.
4. T.S. Madhava Rao, "Digital/Numerical Relays", Tata McGraw- Hill Publishing Company, 2005.
5. Badri Ram and D.N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw- Hill Publishing Company, 2002.
6. P.Kundur, "Power System Stability and Control", McGraw-Hill, 1993.

7. L.P.Singh, "Digital Protection –Protective Relaying from Electromechanical to microprocessor", New Age International (P) Limited Publishers – 2nd Edition, 1997.
8. A.T.Johns&S.K.Salman "Digital Protection for power systems", IEE Power Engg. Series 15, 1995.
9. Batra, Basu and Chowdry, "Power System Protection", Oxford and IPH Publishing Company.
10. Oza, Nair, Mehta and Makwana, "Power System Protection and Switchgear", Tata McGraw-Hill.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1.0	**Introduction and Philosophy of a Protective Relaying System**	
1.1	Characteristic functions of protective relays- basic relay terminology	2
2.0	**Over current Protection**	
2.1	Introduction to over current relays – Basic principles and different types of time-over current relays	3
2.3	Introduction to Relay Co-ordination, Co-ordination of over current relays in an Interconnected power system.	3
3.0	**Generator Protection**	
3.1	Different types of faults and different types of Protective schemes used for Synchronous generators	2
3.2	Generator differential protection, Merz-Price protection, Stator earth fault protection, Stator inter-turn fault protection, Rotor earth fault protection.	3
4.0	**Transformer Protection**	
4.1	Different types of faults and different types of Protective schemes in transformers	2
4.2	Percentage differential protection, Protection against magnetizing in-rush current, incipient fault protection (Buchholz relay)	2
4.3	Over-fluxing protection, High resistance ground fault in transformers.	2
5.0	**Transmission Line Protection**	
5.1	Types of line protection and selection criteria, Introduction to distance protection	1
5.2	Impedance, reactance, mho(admittance), off-set mho relay,	2
5.3	Comparison of distance relays –Pilot wire and carrier current protection, numerical example for a typical distance protection scheme for a transmission line.	3
6.0	**Digital / Numerical Protection**	
6.1	Introduction to Digital protective relays - over current relay, impedance relay	2
6.2	Generalized mathematical expression for distance relays - mho relay, off-set mho, Quadrilateral relay characteristics realization, generalized interfacing for distance relays.	3
6.3	Block diagram of numerical relay, Sampling theorem, correlation with a reference wave, digital filtering	2
6.4	Numerical over current protection, numerical transformer differential protection, numerical distance protection of transmission lines, Introduction to Fast Fourier Transform(FFT) and Discrete Wavelet Transform(DWT) to digital protection	3
6.5	Overview of different algorithms for digital protection- Application of artificial intelligence (AI) in digital relaying.	1
	Total	**36**

Course Designers:

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22EEZF0	SMART GRID OPERATION AND PLANNING

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Electric power systems throughout the world are facing radical change stimulated by the pressing need to decarbonise electricity supply, to replace ageing assets and to make effective use of rapidly developing information and communication technologies. These aims all converge in the Smart Grid. This course is designed to study about smart grid technologies, wide area monitoring, phasor measurement unit, smart metering and integration of renewable energy sources in smart grid and related case studies.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

Course Outcome NO.	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the concepts and technologies of infrastructure in the Smart Power Grid architecture.	TPS2	85	80
CO2	Develop Wide Area monitoring and Control system using PMU technologies	TPS3	80	85
CO3	Explain the Communication, Measurement and Computing Technologies in the smart grid.	TPS2	85	80
CO4	Apply the Smart metering concepts in demand management for the given applications.	TPS3	80	85
CO5	Design various renewable sources and PHEVs in the given sample grid system.	TPS3	80	85
CO6	Explain substation automation process and its protocols	TPS2	85	80

Mapping with Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L							L		L	
CO2	S	L	M	M	L	L		L	L	L		L
CO3	S	S							M		M	
CO4	S	S	M	M	L	L		L		L	M	L
CO5	S	L	M	M	L	L			L		L	
CO6	S	S							M		M	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1								Theory Assessment-2						Theory Terminal Examination			
	Assignment-1				CAT-1				Assignment-2			CAT-2						
TPS / COs	1	2	3		1	2	3	4	1	2	3	1	2	3	1	2	3	
CO1					20										10			
CO2			50			50										10	15	
CO3			50				30									15		
CO4												20					10	
CO5											50		50			10	15	
CO6											50			30		15		

Syllabus

Module 1: INTRODUCTION TO SMART GRID: Need for smart grid - Smart Grid definitions - Benefits of smart grid - Overview of enabling technologies in smart grid - vision of smart grid - International experience - smart grid demonstration and deployment efforts

Module 2: SUBSTATION AUTOMATION SYSTEM: Evolution of SAS, Structure of a SCADA, SCADA System Components, Emerging Communication Technologies, Introduction to IEC 61850 based Communication Protocol, Comparison of SCADA and PMU's.

Module 3: WIDE AREA MEASUREMENT SYSTEM TECHNOLOGY (WAMS) USING PMU: Introduction to PMU, Components and Operation of PMU, Optimal placement of PMU, Application of PMU in Wide Area Protection, Application of PMU in Penetration of Renewable Energies, Advantages of PMU

Module 4: SMART METERING TECHNOLOGY: Introduction –Smart metering: Evolution - Key components – Smart meters: over view of the hardware used - Communications infrastructure and protocols for smart metering, smart metering infrastructure - Educational institution case study.

Module 5: SMART METERING INFRASTRUCTURE APPLICATIONS: Demand-side management and demand response, Distributed energy resource and energy storage, Smart homes with home energy management systems, missing value detection, outlier identification, Case studies in smart grid, Puducherry Smart Grid Pilot Project

Module 6: RENEWABLE ENERGY RESOURCES: Solar PV, Wind system, Small Hydro, Plugged hybrid electric vehicles and storage devices – optimal placement of PHEV and renewable energy resources, case studies

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1.0	**INTRODUCTION TO SMART GRID**	
1.1	Need For Smart Grid - Smart Grid Definitions - Benefits of Smart Grid	1
1.2	Overview of Enabling Technologies In Smart Grid	1
1.3	Vision of Smart Grid	1
1.4	International Experience: Smart Grid Demonstration And Deployment Efforts	2
2.0	**SUBSTATION AUTOMATION SYSTEM**	
2.1	Evolution of SAS	1
2.2	Structure of a SCADA, SCADA System Components	1
2.3	Emerging Communication Technologies, Introduction to IEC 61850 based Communication Protocol	2

2.4	Comparison of SCADA and PMU's	2
3.0	**WIDE AREA MEASUREMENT SYSTEM TECHNOLOGY (WAMS) USING PMU:**	
3.1	Introduction to PMU, Components and Operation of PMU	2
3.2	Optimal placement of PMU	2
3.3	Application of PMU in Wide Area Protection,	1
3.4	Application of PMU in Penetration of Renewable Energies, Advantages of PMU	1
4.0	**SMART METERING TECHNOLOGY:**	
4.1	Introduction	1
4.2	Smart metering: Evolution - Key components	1
4.3	Smart meters: over view of the hardware used	2
4.4	Communications Infrastructure And Protocols For Smart Metering	2
4.5	Smart metering infrastructure - Educational institution case study	2
5.0	**SMART METERING INFRASTRUCTURE APPLICATIONS:**	
5.1	Demand-side management and demand response,	1
5.2	Distributed energy resource and energy storage,	1
5.3	Smart homes with home energy management systems,	1
5.4	Missing value detection, outlier identification,	1
5.5	Case studies in smart grid, Puducherry Smart Grid Pilot Project	1
6.0	**RENEWABLE ENERGY RESOURCES:**	
6.1	Solar PV, Wind system, Small Hydro	2
6.2	Plugged hybrid electric vehicles and storage devices	2
6.3	Optimal placement of PHEV and renewable energy resources, case studies	2
	Total	**36**

Course Designers:

1.	Dr. P. Venkatesh Professor EEE	pveee@tce.edu
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22EEZG0 POWER ELECTRONICS AND MOTORS FOR ELECTRIC VEHICLE

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

In this course, students can learn how power converters are utilized for motor drive applications and build familiarity with various types of dc-dc converters, inverters, gate drivers, and more for electric vehicles. Students can explore the key design elements of power converters for high-speed motor for increased power density and gain insight into the techniques required to optimize for performance.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO No.	COURSE OUTCOMES	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain need of Power Electronics and Drives in Electric Vehicles	TPS2	70	85
CO2	Choose the motors for Electric Vehicles	TPS3	70	85
CO3	Design DC-DC converters in context of Electric Vehicles	TPS3	70	85
CO4	Design high power density inverters for Electric Vehicles	TPS3	70	85
CO5	Design thermal models for motors	TPS3	70	85
CO6	Discuss digital control of power electronics	TPS2	70	85

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L						M		M				M	
CO2	S	M	L	L				M		M				S	
CO3	S	M	L	L				M		M				S	
CO4	M	L						M		M				M	
CO5	S	M	L	L				M		M				S	
CO6	M	L						M		M				S	

S- Strong; M-Medium; L-Low

Assessment Pattern:

CO	CAT1			CAT2			Assignment 1				Assignment 2				Terminal					
TPS Scale	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	10	10					20								5	10				
CO2	10	10	30				40										25			
CO3		10	20				40										20			
CO4				10	10						20						10			
CO5				5	15	40					60				5		15			
CO6				5	15						20				5	5				

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Power Electronics Interface- Role of power electronics in EVs- Selection of dc-dc and dc-ac converters for EVs.

Motor topologies and design choices-Characteristics of EV motors-Drive train architecture-Peak ratings and performance calculations-Design of BLDC, PMSM and IM.

Design of DC-DC converters- Types-Principles of operation – Continuous conduction mode-Analysis and design based on steady-state relationships – Introduction to discontinuous conduction mode.

Design of Inverters- High power density inverters-oOn-board chargers- multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters -Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters -Digital control of power electronics.

Motor Drives and Thermal Design-Motor control algorithms-Combined simulations-Thermal design of power electronics and machines.

Reference Books

1. Ali Emadi_"Handbook of Automotive Power Electronics and Motor Drives" (Electrical and Computer Engineering) 1st Edition.
2. john G.Hayes and Abas goodarzi, "Electric Powertrain - Energy Systems, Power Electronics & Drives for Hybrid, Electric & Fuel Cell Vehicles: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles" John Wiley & Sons.

Course Contents and Lecture Schedule

S.No.	Topics	No. of Lectures	CO
1.	**Power Electronics Interface**		
1.1	Role of power electronics in EVs	1	CO1
1.2	Selection of dc-dc and dc-ac converters for EVs	1	CO1
2	**Motor topologies and design choices**		
2.1	Characteristics of EV motors-	2	CO2
2.2	Drive train architecture -	2	CO2
2.3	Peak ratings and performance calculations	1	CO2
2.4	Design of BLDC, PMSM and IM	3	CO2
3	**Design of DC-DC converters**		
3.1	DC-DC converters types and Principles of operation	2	CO3
3.2	Continuous conduction mode	1	CO3
3.3	Analysis and design based on steady-state relationships	2	CO3
3.4	discontinuous conduction mode	1	CO3
4	**Design of Inverters**		
4.1	High power density inverters-On-board chargers	2	CO4
4.2	Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters	2	CO4
4.3	Comparison of multilevel inverters	2	CO4
4.4	application of multilevel inverters	2	CO4
4.5	PWM techniques for MLI	2	CO4
4.6	Single phase &Three phase Impedance source inverters	2	CO4
4.7	Digital control of power electronics	2	CO6
5	**Motor Drives and Thermal Design**		CO5
5.1	Motor control algorithms	2	CO5
5.2	Combined simulations	2	CO5

5.3	Thermal design of power electronics and machines	2	CO5
		36	

Course Designers

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22EEZH0	BATTERYMANAGEMENT SYSTEM(THEORY CUM PRACTICAL)	Category	L	T	P	Credit
		PSE	2	0	2	3

Preamble

The aim of this course is to introduce learner to batteries, its parameters, modelling and charging requirements. Also, the course will help learner to develop battery management algorithms for batteries

Prerequisite

- 22PH120: Physics
- 22CH130: Chemistry
- Basic Electrical Engineering

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe various parameters and processes related to battery	TPS2	70	75
CO2	Choose appropriate battery charging and discharging methods	TPS3	70	75
CO3	Explain roles and requirements of battery management system	TPS2	70	75
CO4	Find suitable electronic components to provide protection for battery	TPS3	70	75
CO5	Calculate various parameters of battery and design battery management system	TPS3	70	75
CO6	Design battery management systems and execute battery testing & performance verification	TPS3	70	75

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L					M		M			M	L	
CO2	S	S	M					M		M			M	M	
CO3	S	M	L					M		M			S	M	
CO4	S	S	M					M		M			S	M	
CO5	S	M	L					M		M			S	S	
CO6	S	S	M					M		M			S	S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1	CAT2	Practical	Terminal

TPS Scale	1	2	3	4	5	6	1	2	3	1	2	3	1	2	3	4	5	6
CO1	10	15											5	7				
CO2	6	10	40										3	5	20			
CO3	4	15											2	8				
CO4							6	15	10				2	5	5			
CO5							10	15	10			50	5	10	5			
CO6							4	10	20			50	3	5	10			

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Introduction

Introduction to Battery Management System-Cells & Batteries-Nominal voltage and capacity- Crate, Energy and power-Cells connected in series-Cells connected in parallel, Electrochemical and lithium-ion cells-Rechargeable cell-Charging and Discharging Process, Overcharge and Undercharge-Modes of Charging.

Battery Management System Requirement

Introduction-Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation, Cell total energy and cell total power.

Battery Parameter Estimation and Modelling

Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation, Battery Health Estimation, Lithium-ion aging: Negative electrode, Positive electrode, Cell Balancing, Causes of imbalance, Circuits for balancing- Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach.

Design of BMS

Design principles of BMS, Effect of distance, load, and force on battery life-energy balancing with multi-battery system- Battery module and pack design -BMS topologies-Thermal management-active and passive-Packaging of battery pack and battery testing: material selection, sealing of enclosure-degradation and safety issues of Li ion rechargeable cells.

Battery Testing & Safety

Battery power testing for various vehicles Battery testing for urban and highway driving cycles, dynamic stress test, Ingress Protection test, Safety Considerations.

Text Book

1. Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
2. Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.
3. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L “Battery Management Systems -Design by Modelling” Philips Research Book Series 2002.
4. Davide Andrea,” Battery Management Systems for Large Lithium-ion Battery Packs” Artech House, 2010
5. Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.

Reference Books& web resources

1. Jiang, Jiuchun, and Caiping Zhang. Fundamentals and applications of lithium-ion batteries in electric drive vehicles. John Wiley & Sons, 2015.
2. Weicker, Phil. A systems approach to lithium-ion battery management. Artech house, 2013.
3. https://nptel.ac.in/courses/113105102

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction**	
1.1	Introduction to Battery Management System	1
1.2	Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power	1
1.3	Cells connected in series and parallel	1
1.4	Electrochemical and lithium-ion cells, Rechargeable cell	1
1.5	Charging and Discharging Process, Overcharge and Undercharge	1
1.6	Modes of Charging	1
2	**Battery Management System Requirement**	
2.1	Introduction to Battery pack topology	1
2.2	BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing	1
2.3	High-voltage contactor control, Isolation sensing	1
2.4	Thermal control and Protection	1
2.5	Communication Interface	1
2.6	Range estimation and State-of charge estimation	1
2.7	Cell total energy and cell total power	1
3	**Battery Parameter Estimation and modelling**	
3.1	Battery state of charge estimation (SOC), voltage-based methods to estimate SOC, Model-based state estimation	3
3.2	Battery Health Estimation, Lithium-ion aging: Negative electrode, Positive electrode	2
3.3	Cell Balancing, Causes of imbalance, Circuits for balancing	2
3.4	Equivalent-circuit models (ECMs)	1
3.5	Physics-based models (PBMs)	1
3.6	Empirical modelling approach	1
4	**Design of BMS**	
4.1	Design principles of BMS	1
4.2	Effect of distance, load, and force on battery life	1
4.3	Energy balancing with multi-battery system	1
4.4	Battery module and pack design	1

Module No.	Topic	No. of Periods
4.5	BMS topologies	1
4.6	Thermal management- active and passive	1
4.7	Packaging of battery pack and battery testing	1
4.8	Material selection, sealing of enclosure	1
4.9	Degradation and safety issues of Li ion rechargeable cells	1
5	**Battery Testing & Safety**	
5.1	Battery power testing for various vehicles Battery testing for urban and highway driving cycles	2
5.2	Dynamic stress test, Ingress Protection test	1
5.3	Safety Considerations	1
	Total	**36**

List of Experiments (CO5 & CO6)

1. Study the basic parameters of battery
2. Measure the charging voltage and current of given battery.
3. Demonstrate various charging techniques of lead acid battery/ Lithium Ion battery.
4. Demonstrate the discharging process of battery using various values of C-rate and compare it.
5. Selection and sizing of batteries for required specification.
6. Battery pack design with BMS for given EV specifications.
7. Demonstrate urban and highway drive cycle testing
8. Demonstrate battery dynamic stress test (DST)

Course Designer(s):

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22EEZJ0	ELECTRIC VEHICLE CHARGING INFRASTRUCTURE	Category	L	T	P	Credit
		PSE	3	0	1	3

Preamble

Electric vehicles are the future of transportation. Electric mobility has become an essential part of the energy transition strategy and will result in significant changes for vehicle manufacturers, governments, companies and individuals. In this course, students will gain comprehensive knowledge on electric vehicle charging infrastructure. It will help engineers and managers to choose and design appropriate charging infrastructure for their electric vehicle products and their implications.

Course Outcomes

On the successful completion of the course, students will be able to

CO No.	COURSE OUTCOMES	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the concept of electric vehicle charging technologies	TPS2	80	85
CO2	Identify the challenges and impacts of electric vehicle on grid	TPS3	80	85
CO3	Design a wireless charging infrastructure for electric vehicles	TPS3	80	85

CO4	Design distributed generation based smart microgrid for autonomous charging station	TPS3	80	85
CO5	Explain the need of monitoring and control of the Smart Grid with EVs	TPS2	80	85
CO6	Explain the economic, Social and environmental dimensions of EV in the Smart Grid	TPS2	80	85

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L						M		M				M	
CO2	S	M	L	L				M		M				S	
CO3	S	M	L	L				M		M				S	
CO4	S	M	L	L				M		M				S	
CO5	M	L						M		M				M	
CO6	M	L						M		M				M	

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

CO	CAT1			CAT2			Assignment 1				Assignment 2				Terminal					
TPS Scale	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4	5	6
CO1	10	10					20								5	10				
CO2	10	10	30				40										25			
CO3		10	20				40										20			
CO4				5	15	40					60						10			
CO5				5	5	10					20				5	15				
CO6				5	15						20				5	5				

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Introduction

Introduction to Charging Infrastructure – Roles and requirements- charging technologies-Classification-Wired charging- on board and off board charging- AC and DC charging-unidirectional and Bi-directional charging- private, semi-public, and public charging-slow, medium and fast charging-Wireless charging-inductive and capacitive and battery swapping- Manual and automatic-Charging Standards-Charging power levels-Charging connectors

Challenges and impacts of EV

Basics of grid to vehicle (G2V), Vehicle to grid (V2G), Vehicle to home (V2H), Vehicle to vehicle (V2V) operations- EV penetration level-EV power demand-EV power quality impacts on power system- positive, negative impacts and transformer aging- Time of use pricing- charge scheduling-impacts of grid issues on EV charging

Wireless Charging Systems

Wireless Power Characteristics, Methods of Wireless Power Transfer, Standards of Wireless Charging Systems for PEVs, Application of Wireless Charging Systems for PEVs, Wireless Safety Considerations

Autonomous Charging Infrastructure

Sources for autonomous charging infrastructure- DC & AC based for Charging Infrastructure, Hybridgrid CI- Smart and microgrid CI

Monitoring and Control of the Smart Grid with EVs

Introduction, Impacts of EV Penetration on Grid Power Profile and Requirements of Its Monitoring and Control, V2G Communication System, Contact Charging Safety Considerations

Economic, Social and Environmental Dimensions of PHEV in the Smart Grid
Introduction, Economic Dimension, Social Dimension, Environmental Dimension, General Method for Developing PHEV Scheduling Systems

Reference Books& web resources

1. Junwei Lu and Jahangir HossainVehicle-to-Grid: Linking ElectricVehicles to the Smart Grid, The Institution of Engineering and Technology, 2015
2. Sumedha Rajakaruna, Arindam Ghosh, Farhad Shahnia,Plug In Electric Vehicles in Smart Grids, Springer, 2015.
3. Ottorino Veneri, Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles
4. Prof. Zakir Rather, Prof. Rangan Banerjee, Mr. Angshu Nath and Ms. Payal Dahiwale, Integration of electric vehicles charging infrastructure with distribution grid, Available: https://changing-transport.org/wp-content/uploads/Report-1-Fundamentals-of-Electric-Vehicle-Charging-Technology-and-its-Grid-Integration_GIZ-IITB.pdf
5. Amitabh K, Randheer S, anjeev KK, et. al. Handbook of electric vehicle charging infrastructure implementation. 2021. Available: https://www.niti.gov.in/sites/default/files/2021- 0/EV_Handbook_Final_14Oct.pdf.
6. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003
7. H. A. Kiehne, “Battery Technology Handbook,” Marcel Dekker, NYC, 2003.
8. James Larminie and John Lowry, “Electric Vehicle Technology Explained,” John Wiley, 2003.

Course Contents and Lecture Schedule

S.No.	Topics	No. of Lectures	COs
1.	**Introduction**		
1.1	Introduction to Charging Infrastructure	1	CO1
1.2	Roles and requirements- charging technologies	1	CO1
1.3	Classification-Wired charging- on board and off board charging	1	CO1
1.4	AC and DC charging-unidirectional and Bi-directional charging	1	CO1
1.5	private, semi-public, and public charging-slow, medium and fast charging	1	CO1
1.6	Wireless charging-inductive and capacitive and battery swapping	1	CO1
1.7	Manual and automatic-Charging Standards-Charging power levels-Charging connectors	1	CO1
2	**Challenges and impacts of EV**		
2.1	Basics of grid to vehicle (G2V)	2	CO2
2.2	Vehicle to grid (V2G), Vehicle to home (V2H), Vehicle to vehicle (V2V) operations	1	CO2
2.3	EV penetration level-EV power demand-EV power quality impacts on power system	2	CO2
2.4	positive, negative impacts and transformer aging- Time of use pricing	2	CO2
2.5	charge scheduling-impacts of grid issues on EV charging	2	
3.	**Wireless Charging Systems**		
3.1	Wireless Power Characteristics	2	CO3
3.2	Methods of Wireless Power Transfer	2	CO3
3.3	Standards of Wireless Charging Systems for PEVs	1	CO3
3.4	Application of Wireless Charging Systems for PEVs	1	CO3
3.5	Wireless Safety Considerations	1	
4.	**Autonomous Charging Infrastructure**		
4.1	Sources for autonomous charging infrastructure	2	CO4

4.2	DC & AC based for Charging Infrastructure	2	CO4
4.3	Hybrid grid Charging Infrastructure		
4.4	Smart and microgrid Charging Infrastructure		
5.	**Monitoring and Control of the Smart Grid with EVs**		
5.1	Impacts of EV Penetration on Grid Power Profile and Requirements of Its Monitoring and Control	2	CO5
5.2	V2G Communication System, Contact Charging Safety Considerations	3	CO5
6	**Economic, Social and Environmental Dimensions of PHEV in the Smart Grid**		
6.1	Economic Dimension	1	CO6
6.2	Social Dimension, Environmental Dimension	2	CO6
6.3	General Method for Developing PHEV Scheduling Systems	1	CO6
	Total	36	

Course Designers

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22EEZK0	FUEL CELL TECHNOLOGY	Category	L	T	P	Credit
		PSE	2	1	0	3

Preamble

The aim of this course is to understand the basic principles involved in various fuel cells and their specific operating principles. Also, the course will help learner to understand the research and development challenges in various types of fuel cells.

Prerequisite

1. Engineering Materials
2. Basic Electronics

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain basic concepts and reaction kinetics of fuel cell technology	TPS2	85	80
CO2	Evaluate performance characteristics of fuel cell for various fuels	TPS3	80	75
CO3	Compare various types of fuel cells	TPS2	80	75
CO4	Design stack and integration system of the fuel cell	TPS3	85	80
CO5	Calculate various performance parameters of the fuel cell	TPS3	80	75
CO6	Apply fuel cell technologies to automotive applications	TPS3	80	75

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L					M		M			M	L	
CO2	S	S	M					M		M			M	M	
CO3	S	M	L					M		M			S	M	
CO4	S	S	M					M		M			S	M	
CO5	S	M	L					M		M			S	S	
CO6	S	M	L					M		M			M	L	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1			Assignment 1			CAT2			Assignment 2			Terminal					
TPS Scale	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	4	5	6
CO1	10	15											5	7				
CO2	6	10	40										3	5	20			
CO3	4	15			100								2	8				
CO4							6	15	10			40	2	5	5			
CO5							10	15	10			40	5	10	5			
CO6							4	10	20			20	3	5	10			

Syllabus

Introduction to fuel cell

Fuel cell- Fuel cell thermodynamics-Heat and work potentials -Prediction of reversible voltage -Fuel cell reaction kinetics - electrode kinetics - overvoltage - Tafel equation-charge transfer reaction-exchange currents - electro catalysis design - activation kinetics- Fuel cell problems- crossover, contamination, leakage currents, partial reactions - Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte- Fuel cell efficiency.

Fuels and Types of Fuel Cell

Hydrogen storage technology – pressure cylinders, liquid hydrogen, metal hydrides, carbon fibers – Reformer technology – steam reforming, partial oxidation, auto thermal reforming – CO removal, fuel cell technology based on removal like bio-mass. Low and high temperature fuel cells- Proton Exchange Membrane Fuel Cell (PEMFC) –Direct Methanol Fuel Cell (DMFC) - Phosphoric Acid Fuel Cell (PAFC) - Alkaline Fuel Cell (AFC) – Molten Carbonate Fuel Cell (MCFC) – Solid Oxide Fuel Cell (SOFC).

Electrode Models

Fuel utilization and the envelope of polarization curves - Influence of the Nernst equation (concentration polarization) - Mass balance on SOFC electrode – Energy balance on SOFC electrode - Multiple reactions in fuel cells: reforming, water gas shift, coking - Temperature profiles.

Stack Design, System Integration and Life cycle Analysis

Basic geometry approaches: flat plate vs. tubular - Flow field plate and interconnect design - Fluid mechanics: manifolding, pressure drop - Fuel utilization, efficiency, and current distribution - Internal heat exchange and recovery, internal reforming – Seals and insulation – Safety, cost estimation and lifecycle analyses of fuel cell.

Fuel cells for automotive applications

Fuel cells for automotive applications – technology advances in fuel cell vehicle systems – onboard hydrogen storage – liquid hydrogen and compressed hydrogen – metal hydrides, fuel cell control system – alkaline fuel cell – road map to market.

Text Book

1. Pukushpan, J.T., Stctanopoulon, A.G., Peng, H., "Fuel Cell Power Systems", Springer, 2006.
2. Viswanathan, B., and Aulice Scibioh, M., "Fuel Cells Principles and Applications", Universities Press (India) Pvt. Ltd., Hyderabad, 2006.
3. Fuel Cells for automotive applications – professional engineering publishing UK. ISBN 1-86058 4233, 2004.

Reference Books

1. Larminie.J and Dicks.A, "Fuel Systems Explained", John Wiley & Sons, Ltd., New York, 2001.
2. O'Hayre.R, Suk-Woncha, Whitney Colella, Prinz, F.B., "Fuel Cell Fundamentals", John Wiley & Sons, New York, 2006.
3. Hoogers.G. Edr, "Fuel Cell Technology Handbook", CRC Press, Washington D.C., 2013.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Introduction to fuel cell**	
1.1	Introduction to Fuel cell Technology	1
1.2	Fuel cell thermodynamics	1
1.3	Heat and work potentials and reversible voltage in fuel cell	1
1.4	Fuel cell reaction kinetics	2
1.5	Fuel cell problems	1
1.6	Fuel cell charge and mass transport	1
1.7	Flow field, transport in electrode and electrolyte	1
1.8	Fuel cell efficiency	1
2	**Fuels and Types of Fuel Cell**	
2.1	Hydrogen storage technology	2
2.2	Reformer technology	2
2.3	Types of Fuel Cell	3
3	**Electrode Models**	
3.1	Fuel utilization and the envelope of polarization curves	1
3.2	Influence of the Nernst equation	1
3.3	Mass balance on SOFC electrode	1
3.4	Energy balance on SOFC electrode	1
3.5	Multiple reactions in fuel cells: reforming, water gas shift, coking	2
3.6	Temperature profiles.	1
4	**Stack Design, System Integration and Life cycle Analysis**	
4.1	Basic geometry approaches: flat plate vs. tubular	1
4.2	Flow field plate and interconnect design	1
4.3	Fluid mechanics	2
4.4	Seals and insulation of fuel cell	1
4.5	Safety, cost estimation and lifecycle analyses of fuel cell	2
5	**Fuel cells for automotive applications**	
5.1	Fuel cells for automotive applications	1
5.2	Technology advances in fuel cell vehicle systems	3
5.3	Fuel cell control system	1
5.4	Road map to market	1
	Total	**36**

Course Designer(s):

1. Dr. S. Arockia Edwin Xavier Associate Professor EEE	saexeee@tce.edu
2. Dr. C. Balasundar Assistant Professor EEE	cbreee@tce.edu

22EEZL0	PROGRAMMING FOR INTERNET OFTHINGS	Category	L	T	P	Credit
		PSE	3	0	3	3

Preamble

This course aims at providing basic knowledge and skills to engage in innovative design and development of IoT solutions. The IoT encompasses broader spectrum of technologies, It is not only to identify the things, rather than they participate in computations, connections and also sense the environment to react with the real world. It also aims at giving the students a view, connect and actuate the sensor through powerful interfaces and programs.

Prerequisite

- Sensors and Actuators

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Examine the evolution of IoT, IoT Architectures,Protocols, Applications and Security	TPS2	70	70
CO2	Identify Scheduling Process and Validating Applications in Open-Source Semantic Web Infrastructure	TPS2	70	70
CO3	Examine Programming Frameworks for IoT.	TPS3	70	70
CO4	Apply logical design using pragmatic techniques for designing an IoT System	TPS3	70	70
CO5	Recommend cloud offerings and data analytics on IoT using case studies	TPS4	70	70
CO6	Build state of the art IoT architecture to solve the real-world constraints.	TPS5	70	70

Mapping with Programme Outcomesand Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L											L		
CO2	M	L											L		
CO3	S	M	M	M	S								M	S	
CO4	S	M	M	M	S								M	S	
CO5	S	S	M	L	M	S	S	S	S	S	S	S	M	L	M
CO6	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

S- Strong; M-Medium; L-Low

AssessmentPattern:

- *Assignment-1 and Assignment-2 marks are assessed from Mini Project.

Mini Project Details

- Team formation (Team size: 3)
- Problem identification on various IT, societal, business and environmental needs
- Identify the appropriate components needed to build the microcontroller board.
- Assemble the components and program the board.
- Test the board with sample input.

Syllabus

TPS	CAT 1			CAT 2			MINI PROJECT		TERMINAL		
	1	2	3	1	2	3	4	5	1	2	3
CO1	10	20							4	5	
CO2	5	20							4	5	
CO3	5	10	30						4	10	10
CO4				10	10				4		15
CO5				10	10	20	50		4	10	10
CO6				10	10	20		50			15

Internet of Things - Concept and Architecture: Internet of Things-Definition-Evolution-IoT Architectures-Resource Partitioning-IoT Data Management and Analytics- Communication Protocols- IoT Applications-IoT Security-Identity Management and Authentication- Privacy-Standardization and Regulatory Limitations.

Open-Source Semantic Web Infrastructure: Open IoT Architecture for IoT/Cloud convergence-Scheduling Process and IoT Services Lifecycle - Validating Applications and Use Cases.

Programming Frameworks for IoT: Embedded Device Programming Languages-Message Passing in Devices-Coordination Languages- Polyglot Programming-Survey of IoT Programming Framework.

Interfacing the Sensors and Actuators: Microcontrollers : Programming the Arduino, Microprocessors : Python Programming for Raspberry Pi, Case Study: Programming Matrix Creator Board, Communication Devices : Bluetooth, Wifi , Zigbee , GSM, Interfacing with Mobile Application, IoT Gateways.

Data acquisition: Data collection using sensors, Data Processing, Data Analytics

IoT Application and Design: IoT Platforms: IBM Bluemix, Microsoft Azure, AWS, Case Studies :Industrial Revolution 4,Smart Energy Systems ,Digital Food ,Smart Entertainment, Smart Manufacturing, Mini Project

Text Books

1.Rajkumar Buyya, Amir Vahid Dastjerdi, "Internet of Things Principles and Paradigms", Elsevier , First edition ,2016

2.Yamanoor, Sai, and Srihari Yamanoor. Python Programming with Raspberry Pi, 1st edition, Packt Publishing Ltd, 2017.

References:

1. Donald Norris, The Internet of Things: Do-It-Yourself Projects with Arduino, Raspberry Pi, and BeagleBone Black, 1 st edition, McGraw Hill Education, 2015
2. Marco Schwartz, Home Automation with Arduino, 3rd edition, Open Home Automation 2014.
3. Schwartz, Marco. Internet of Things with Arduino Cookbook, 1st edition, Packt Publishing Ltd, 2016.
4. Kooijman, Matthijs. Building Wireless Sensor Networks Using Arduino, 1st edition, Packt Publishing Ltd, 2015.
5. Adrian McEwen, Hakim Cassimally "Designing the Internet of Things",WileyPublishing, 2015

6. ArshdeepBahga, Vijay Madisetti, “Internet of Things – A hands-on approach”,Universities Press, 2015.

Web Resources:

- https://www.edx.org/course/introduction-to-the-internet-of-things-iot
- http://www.instructables.com/technology/
- https://aws.amazon.com/iot/
- https://azure.microsoft.com/en-in/services/iot-hub/
- https://www.ibm.com/cloud/internet-of-things

Course Contents and Lecture Schedule

Module No	Topic	No. of Lecture Hours
1	**Internet of Things - Concept and Architecture**	
1.1	Internet of Things-Definition-Evolution	1
1.2	IoT Architectures	1
1.3	Resource Partitioning	1
1.4	IoT Data Management and Analytics	1
1.5	Communication Protocols	1
1.6	IoT Applications	1
1.7	IoT Security-Identity Management and Authentication	1
1.8	Privacy- Standardization and Regulatory Limitations	1
2	**Open-Source Semantic Web Infrastructure**	
2.1	Open IoT Architecture for IoT/Cloud convergence	1
2.2	Scheduling Process and IoT Services Lifecycle	1
2.3	Validating Applications and Use Cases	1
3	**Programming Frameworks for IoT**	
3.1	Embedded Device Programming Languages	1
3.2	Message Passing in Devices	1
3.3	Coordination Languages	1
3.4	Polyglot Programming	1
3.5	Survey of IoT Programming Framework	2
4	**Interfacing the Sensors and Actuators**	
4.1	Microcontrollers : Programming the Arduino	2
4.2	Microprocessors : Python Programming for Raspberry Pi	2
4.3	Case Study: Programming Matrix Creator Board	1
4.4	Communication Devices : Bluetooth, Wifi , Zigbee , GSM	2
4.5	Interfacing with Mobile Application	2
4.6	IoT Gateways	1
5	**Data acquisition**	
5.1	Data collection using sensors	2
5.2	Data Processing	1
5.3	Data Analytics	1
6	**IoT Application and Design**	
6.1	IoT Platforms: IBM Bluemix, Microsoft Azure, AWS	2
6.2	Case Study : Industrial Revolution 4,Smart Energy systems, Digital Food, Smart Entertainment, Smart Manufacturing	3
	Total	**36**

Course Designers:

1. Dr.L.Jessi Sahaya Shanthi
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2. Dr.P.S.Manoharan Professor,EEE psmeee@tce.edu

22EEZM0	CLOUD COMPUTING	Category	L	T	P	Credit
		PSE	3	-	-	3

Preamble

Cloud computing paradigm covers a range of distributed computing, hosting and access solutions, including service-based computing. The objective of the course is to provide comprehensive view of cloud computing concepts, technologies, architecture, security breaches, corrective measures, deploying applications and researching state-of-the-art in Cloud Computing fundamental issues, technologies, applications and deployments

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the basic concept of cloud computing and the various cloud service types	TPS2	70	70
CO2	Identify suitable virtualization concept for the given scenario	TPS3	70	70
CO3	Identify the necessity, appropriate cloud architecture/model for deploying an application in a cloud environment based on the given requirements	TPS3	70	70
CO4	Explain the security and standards of cloud computing	TPS2	70	70
CO5	Develop a cloud application with a user interface and diagnose the suitable data components	TPS3	70	70
CO6	Outline the emerging technologies in cloud computingplatforms	TPS2	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L												M
CO2	S	M	L		S			M		M				S
CO3	S	M	L		S			M		M				S
CO	M	L												M

4														
CO 5	S	M	L		S			M		M				S
CO 6	M	L												M

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	20													5	10		
CO2	5	15	15				50									5	10	
CO3	5	15	15				50								5	5	15	
CO4				5	15										5	10		
CO5				10	15	30					100				5		15	
CO6				10	15											10		

Syllabus

Basics of Cloud computing: Introduction – Key Characteristics - Hardware evolution **-** Internet Software Evolution - Server Virtualization

Cloud services : Communication-as-a-Service (CaaS) - Infrastructure-as-a-Service (IaaS) - Monitoring-as-a-Service (MaaS) - Platform-as-a-Service (PaaS) - Software-as-a-Service (SaaS)

Virtualization: Need for Virtualization, Pros and cons of Virtualization, Types of Virtualization, Virtual Machine monitor, Virtual machine properties, Interpretation and binary translation, Types of VM: System VM, Process VM, , HLL VM, Hypervisors : Xen, KVM , VMWare, Virtual Box, Hyper-V.

Cloud architecture

Three layer cloud architecture-market oriented cloud architecture,SLA (Service Level Agreements) - billing and Accounting, challenges of big data analytics in cloud- Case study : Openstack -Managing Data: Looking at Data, Scalability & Cloud Services-Database & Data Stores in Cloud-Large Scale Data Processing- cloud programming and software environments- Hadoop, GFS, Spark, map reduce, Big Table, Hbase, Libvirt ,openVswitch

Security and Standards in the Cloud computing: Cloud Security Challenges - Software-as-a-Service Security - Standards for Application Developers - Standards for Messaging - Standards for Security - End-User Access to Cloud Computing

Cloud applications and development: Cloud Economics-Harnessing cloud characteristics in application design- Cloud Economics of choosing a Cloud platform for an organization, based on application requirements, economic constraints and business needs-Service creation environments to develop cloud based application-Case study: Meghdoot, Amazon, Azure, Google App, Docker, IBM, Sales force.

Emerging technologies: Grid of Clouds, Green Cloud- Mobile cloud Computing, Cloud in IoT applications, Fog and Edge computing

Text Book

1. John Rittinghouse& James Ransome, ―Cloud Computing, Implementation, Management and Strategy‖, CRC Press, 2010.
2. Cloud Computing Principles and Paradigms, Rajkumar Buyya, James Broberg, Andrzej Goscinski, Wiley Publishers,2011

Reference Books & web resources

1. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, SubraKumaraswamy, ShahedLatif,O'Reill,2010.
2. RajkumarBuyya, Christian Vecchiola, S.ThamaraiSelvi, ―Mastering cloud computing‖, Morgan Kaufman, 2013.

3. Dr. Kris Jamsa, —Cloud Computing: SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile, Security and More‖, Jones and Bartlett learning, First edition, 2013.
4. ArshdeepBahga, Vijay Madisetti, —Cloud Computing: A Hands-On Approach‖, CreateSpace Independent Publishing Platform, 1st edition, 2013.
5. Massimo Cafaro (Editor), Giovanni Aloisio (Editor), —Grids, Clouds and Virtualization‖ Springer; edition, 2011.
6. GautamShroff, —Enterprise Cloud Computing Technology Architecture Applications‖, Cambridge University Press; 1 edition, 2010.
7. Barrie Sosinsky, — Cloud Computing Bible‖ John Wiley & Sons, 2010
8. Cloud Security Alliance, —Security Guidance for Critical Areas of Focus in Cloud Computing‖ 2011
9. Cloud Security Alliance, —Top Threats to Cloud Computing‖, 2013.
10. http://nptel.ac.in/courses/106105167/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods	CO
1	**Basics of Cloud computing:**		
1.1	Introduction – Key Characteristics - Hardware evolution	1	CO1
1.2	Internet Software Evolution - Server Virtualization	1	CO1
2	**Cloud services :**		
2.1	Communication-as-a-Service (CaaS) - Infrastructure-as-a-Service (IaaS)	2	CO1
2.2	Monitoring-as-a-Service (MaaS) - Platform-as-a-Service (PaaS)	1	CO1
	Software-as-a-Service (SaaS)	1	CO1
3	**Virtualization:**		
3.1	Need for Virtualization, Pros and cons of Virtualization, Types of Virtualization	1	CO2
	Virtual Machine monitor, Virtual machine properties, Interpretation and binary translation	2	CO2
	Types of VM: System VM, Process VM, , HLL VM	2	CO2
	Hypervisors : Xen, KVM , VMWare, Virtual Box, Hyper-V.	1	CO2
4	**Cloud architecture:**		
4.1	Three layer cloud architecture-market oriented cloud architecture	1	CO3
4.2	SLA (Service Level Agreements) -billing and Accounting, challenges of big data analytics in cloud	2	CO3
4.3	Case study : Openstack -Managing Data: Looking at Data, Scalability & Cloud Services- Database & Data Stores in Cloud-Large Scale Data Processing	2	CO3
4.4	cloud programming and software environments- Hadoop, GFS, Spark, map reduce, Big Table, Hbase, Libvirt ,openVswitch	2	CO3
5	**Security and Standards in the Cloud computing:**		

Module No.	Topic	No. of Periods	CO
5.1	Cloud Security Challenges - Software-as-a-Service Security	2	CO4
5.2	Standards for Application Developers - Standards for Messaging	2	CO4
5.3	Standards for Security - End-User Access to Cloud Computing	2	CO4
6	**Cloud applications and development:**		
6.1	Cloud Economics-Harnessing cloud characteristics in application design	2	CO5
6.2	Cloud Economics of choosing a Cloud platform for an organization, based on application requirements	2	CO5
6.3	Economic constraints and business needs-Service creation environments to develop cloud based application	1	CO5
6.4	Case study: Meghdoot, Amazon, Azure, Google App, Docker, IBM, Sales force.	2	CO5
7	**Emerging technologies:**		
7.1	Grid of Clouds, Green Cloud- Mobile cloud Computing	2	CO6
7.2	Cloud in IoT applications, Fog and Edge computing	2	CO6
	Total	36	

Course Designer(s):

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2. Dr.D.Kavitha Assistant Professor EEE dkavitha@tce.edu

22EEZN0	SENSORS AND ACTUATORS	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

Sensors are used to measure the various physical parameters such as temperature, pressure, flow, speed, position and humidity, etc. which are needed in various applications in industries and in our day to day life. Sensors are also needed for implementing various IoT applications. Actuators are used to control physical devices in the real world and examples of actuator are solenoid valves, control valves, DC motors, Servo motors and switches, etc.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE	Expected	Expected

		Proficiency Scale	Proficiency in %	Attainment Level %
CO1	Explain the Communication Protocols, Sensor Networks	TPS2	80	80
CO2	Explain the principle and working of piezo-electric, ultrasonic and accelerometer type sensors.	TPS2	80	80
CO3	Select sensors to measure illumination, speed, Magnetostrictive and environmental monitoring sensors	TPS3	80	80
CO4	Explain the principle and fabrication of semiconductor sensors	TPS2	80	80
CO5	Explain the principle and working of various actuators	TPS2	80	80
CO6	Design signal conditioning circuit for various sensors	TPS3	80	80

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1.	M	L						M		M			M	M
CO2.	M	L						M		M			M	M
CO3	M	L						M		M			M	M
CO4	M	L						M		M			M	M
CO5	M	L						M		M			M	M
CO6	S	M	L					M		M			S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10														10			
CO2	10	30					50								10			
CO3	10	20	20				50										20	
CO4				10												20		
CO5				10	30											20		
CO6				10	20	20					100						20	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Introduction to Sensing, Actuation, Basics of Networking - Sensor Networks- Machine-to-Machine Communications

Piezoelectric sensors and their signal conditioning, Ultrasonic sensors, Seismic transducer and its dynamic response, seismic accelerometers, Force-Balance transducers: Theory-servo systems for measurement of non-electrical quantities.

Photoelectric sensors, Digital displacement sensors: Position Encoders, Variable frequency sensors, Tacho-generators and stroboscope, Hall effect sensors, Magnetostrictive sensors. Smoke and gas sensors, humidity and temperature sensors

Introduction to semiconductor sensor, materials, scaling issues and basics of micro fabrication. Smart sensors. Introduction to flexible sensors and sensor fusion.
Actuators: solenoid valves, control valves, DC motors, Servo motors, Solid state Relays, and switches, Hydraulic actuators, Pneumatic actuators.
Case study : Integration of Sensors and Actuators with Arduino.

Text Book

1. John P. Bentley, Principles of Measurement Systems, Pearson Education, 4 th Edition, 2005.
2. Doebelin E.0, Measurement Systems - Application and Design, McGraw-Hill, 4th Edition, 2004.
3. S.M. Sze, Semiconductor sensors, John Wiley & Sons Inc., 3rd edition, 2006.

Reference Books& web resources

1. John G. Webster, Sensors and Signal Conditioning, Wiley Inter Science, 2nd edition,2008
2. Patranabis, Sensors and Transducers, Prentice Hall, 2nd edition,2003.
3. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd,2011.
4. Murthy D. V. S, Transducers and Instrumentation, Prentice Hall, 2nd Edition,2011

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1.1	Introduction Sensing, Actuation,	2
1.2	Basics of Networking	1
1.3	Sensor Networks- Machine-to-Machine Communications	2
2.1	Piezoelectric sensors and their signal conditioning,	1
2.2	Ultrasonic sensors, Seismic transducer and its dynamic response,	2
2.3	seismic accelerometers, Force-Balance transducers:	2
2.4	Theory-servo systems for measurement of non-electrical quantities	2
3.1	Photoelectric sensors	1
3.2	, Digital displacement sensors: Position Encoders,	2
3.3	Variable frequency sensors, Tacho-generators and stroboscope	2
3.4	Hall effect sensors, Magnetostrictive sensors, Smoke and gas sensors, humidity and temperature sensors	4
4.1	Introduction to semiconductor sensor,	1
4.2	Materials, scaling issues and basics of micro fabrication.	2
4.3	Smart sensors.	2
4.4	Introduction to flexible sensors and sensor fusion	2
5.1	Actuators: solenoid valves, control valves,	2
5.2	DC motors, Servo motors, Solid state Relays, and switches.	2
5.3	Hydraulic actuators, Pneumatic actuators.	2
5.4	Integration of Sensors and Actuators with controllers	2
	Total	36

Course Designer(s):

1. Dr.L.Jessi Sahaya shanthi Associate Professor EEE ljseee@tce.edu
2. Dr.P.S.Manoharan Professor EEE psmeee@tce.edu
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22EEZP0	SYSTEMS THEORY

Category	L	T	P	Credit
PSE	2	1	0	3

Preamble

Modern control theory is a powerful technique for the analysis and design of linear and nonlinear, time-invariant or time varying MIMO systems. The classical design methods suffer from certain limitations due to the fact that the transfer function model is applicable only to linear time invariant systems, and that there too it is generally restricted to single-input, single-output (SISO) systems. This course aims at giving an adequate exposure in state space analysis, state space controller design, MIMO system, Non-linear system, stability analysis.

Prerequisite

Control Systems

Course Outcomes

After successful completion of the course, students will be able to:

CO	Course Outcomes	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
1	Analyze the characteristics of the developed state space model for the given electrical (or) electromechanical system	TPS4	70%	70%
2	Design a pole placement controller with or without observer for the given system to achieve desired specifications	TPS3	70%	70%
3	Design an optimal state regulator / stochastic optimal regulator for the given system	TPS3	70%	70%
4	Explain the characteristics of MIMO system	TPS2	70%	70%
5	Develop the phase plane trajectories of the given nonlinear system	TPS3	70%	70%
6	Analyze the stability of the given nonlinear system using describing function method	TPS4	70%	70%
7	Analyze the stability of the given linear and nonlinear system using Lyapunov stability theory	TPS4	70%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	**S**	**S**	**M**	**M**							**M**		
CO2	**S**	**M**	**M**	**M**							**M**		
CO3	**S**	**M**	**M**										
CO4	**M**	**L**	**L**										
CO5	**S**	**M**	**M**	**M**							**M**		
CO6	**S**	**S**	**M**	**M**							**M**		
CO7	**S**	**S**	**M**	**M**							**M**		

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS SCALE	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4
CO1	10	10	20					30							2	4	10	
CO2	05	10	20				30								2	4	10	
CO3		05	20				40									4	10	
CO4				05	10											6		
CO5				05	05	20									2	4	10	
CO6				05	05	20						40			2	4	10	
C07				05	05	15						60			2	4	10	

Syllabus

State Space Analysis

Introduction - Concept of state space model for dynamic systems – Time invariance and Linearity- Non-uniqueness - Minimal realization – Canonical state models - Solution of state equations – State transition matrix - Free and forced responses – Controllability and observability

State Space Controller Design

Introduction – State Feedback control – Pole Placement by State Feedback – Full Order and Reduced Order Observers – Separation principle –Optimal linear state regulator – Stochastic optimal linear estimator.

MIMO Systems

Properties of transfer functions Matrix – Impulse response matrices – Poles and zeros of transfer function matrices – Critical frequencies – Resonance – Steady state and dynamic response – Bandwidth- Nyquist plots – Singular value analysis.

Non-Linear Systems

Types of non-linearity – Typical examples – Equivalent linearization – Phase plane analysis – Limit cycles – Describing functions- Analysis using Describing functions – Jump resonance.

Stability

Introduction – Equilibrium Points – Stability in the sense of Lyapunov – BIBO Stability – Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems – The Direct Method of Lyapunov and the Linear Continuous Time Autonomous Systems – Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems – , Krasovskii and Variable-Gradient Method.

Text Book

1. M. Gopal, ―Modern Control System Theory‖, New Age International Publications, revised 2nd edition, 2005

Reference Books

1. K. Ogatta, ―Modern Control Engineering‖, PHI Publications, 2002.
2. I.J.Nagarath , M. Gopal, ―Control Systems Engineering‖, New Age International Publications, 4th edition, New Delhi, 2006.
3. M.Gopal, ―Digital Control and state variable methods – conventional and intelligent control systems‖, Tata Mcgraw Hill 3rd edition, New Delhi, 2008.
4. Stanley M. Shinners, ―Modern control system theory and design‖ Wiley-IEEE 2nd edition, 1998.

Course Contents and Lecture Schedule

Sl.No.	Topic	No. of Lecture Hours
1.0	**State Space Analysis**	

1.1	Introduction - Concept of state space model for dynamic systems	1
1.2	Time invariance and Linearity, Non-uniqueness, Minimal realization, Canonical state models	2
1.3	Solution of state equations – State transition matrix	2
1.4	Free and forced responses	1
1.5	Controllability and Observability	1
2.0	**State Space Controller Design**	
2.1	Introduction – State Feedback control	1
2.2	Pole Placement by State Feedback	2
2.3	Full Order and Reduced Order Observers	1
2.4	Separation principle	1
2.5	Optimal linear state regulator	1
2.6	Stochastic optimal linear estimator	1
3.0	**MIMO Systems**	
3.1	Properties of transfer functions Matrix	1
3.2	Impulse response matrices	1
3.3	Poles and zeros of transfer function matrices	1
3.4	Critical frequencies, Resonance, Steady state and dynamic response, Bandwidth	1
3.5	Nyquist plots	1
3.6	Singular value analysis	1
4.0	**Non-Linear Systems**	
4.1	Types of non-linearity – Typical examples	1
4.2	Equivalent linearization	1
4.3	Phase plane analysis	2
4.4	Limit cycles	1
4.5	Describing functions- Analysis using Describing functions	2
4.6	Jump resonance	1
5.0	**Stability**	
5.1	Introduction – Equilibrium Points	1
5.2	Stability in the sense of Lyapunov – BIBO Stability – Stability of LTI Systems	1
5.3	Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems	1
5.4	The Direct Method of Lyapunov and the Linear Continuous Time tonomous Systems	1
5.5	Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems	2
5.6	Krasovskii and Variable-Gradient Method	2
	Total	**36**

Course Designers:

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3	Dr.S.Latha Professor EEE	sleee@tce.edu

22EEZQ0	DIGITAL CONTROL SYSTEM

Category	L	T	P	Credit
PSE	3	0	0	3

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

Prerequisite

NIL

Course Outcomes

On the successful completion of the course, students will be able to

No	Course Outcome	TCE Proficiency Scale	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Explain the process of sampling performance of digital control system	TPS2	70%	70%
CO2	Calculate the response of a given pulse transfer function in time domain and frequency domain	TPS3	70%	70%
CO3	Analyze the effect of controllers/compensators in the closed loop performance of a given Linear Time Invariant sampled data system	TPS4	70%	70%
CO4	Design pole placement controller for a given transfer function	TPS3	70%	70%
CO5	Analyze the effect of state feedback with observers for a given Linear Time Invariant sampled data system	TPS4	70%	70%
CO6	Design LQR and LQG controller for a given LTI sampled data system	TPS3	70%	70%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	**M**	**L**									**M**		
CO2	**S**	**M**	**L**	**L**							**M**		
CO3	**S**	**S**	**M**	**M**							**M**		
CO4	**S**	**M**	**L**	**L**							**M**		
CO5	**S**	**S**	**M**	**M**							**M**		
CO6	**S**	**M**	**L**	**L**							**M**		

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT 1			CAT 2			ASSIGNMENT 1				ASSIGNMENT 2				TERMINAL			
TPS	1	2	3	1	2	3	3	4	5	6	3	4	5	6	1	2	3	4

SCALE																		
CO1	05	10													02	10		
CO2	05	10	25				50									05	10	
CO3	05	10	30					50							02	05	15	
CO4				05	05	20									02	05	10	
CO5					10	25						100			02	05	10	
CO6				05	10	20									02	05	10	

Syllabus

Introduction to digital control systems and Z- Transform Techniques

Basic elements, data conversion and quantization, sample and Hold devices, mathematical modelling of the sampling process, data reconstruction and filtering of sampled signals, pulse transfer function

Analysis using Z- Transform Techniques

Time responses of discrete data systems, steady state error analysis, stability, root loci and frequency domain analysis of discrete time systems.

Controller design using transfer function models:

Root locus and bode plot based design of compensators, Dead-Beat and Dahlin Control, Pole Placement Controller with Performance Specifications, Implementation of Unstable Controllers, Internal Model Principle for Robustness, Redefining Good and Bad Polynomials, PID Tuning Through Pole Placement Control

Controller Design using state space models:

State equations of discrete-data systems with sample and hold devices, Free and forced response, Relation between transfer function and state space models, Controllability and observability, stability, Pole placement design by state feedback and output feedback, Full order and reduced order observer design, LQR, Kalman Filter, LQG

Text Book:

1. Ogata, Discrete-time Control Systems, Prentice hall, Second edition, 2005.

Reference Books

1. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publication Limited, 2008
1. KannanMoudgalya, “Digital Control”, Wiley India Ltd, Wiley India, 2007
2. Benjamin C. Kuo, Digital control systems, Second edition (Indian),2007, Oxford University Press.
3. Franklin, Powell, Workman, Digital Control of Dynamic Systems, Pearson Education Third edition, 2006.

Course Contents and Lecture Schedule

Module No.	Topic	No of Lecture Hours
1	**Introduction to digital control systems and Z- Transform Techniques**	
1.1	Basic elements, data conversion and quantization, sample and Hold devices	2
1.2	Pulse transfer function	2
2	**Analysis using Z- Transform Techniques**	
2.1	Time responses of discrete data systems	2
2.2	Steady state error analysis of digital control systems	2
2.3	Stability	2
2.6	Root loci for digital control systems	2
2.7	Frequency domain analysis of discrete time systems	2
3.0	**Controller design using transfer function models**	
3.1	Root locus and bode plot based design of compensators	2

3.2	Dead-Beat and Dahlin Control, Pole Placement Controller with Performance Specifications, Implementation of Unstable Controllers,	1
3.4	Internal Model Principle for Robustness,	1
3.5	Redefining Good and Bad Polynomials,	1
3.6	PID Tuning Through Pole Placement Control	1
4	**Controller Design using state space models**	
4.1	State equations of discrete-data systems with sample and hold devices,	2
4.2	Free and forced response, Relation between state space and transfer functions, Controllability and observability of discrete data systems	2
4.4	Controllability and observability, stability.	2
4.5	Pole placement design by state feedback: single input and multiple input	2
4.6	Full order and reduced order observer design	2
4.9	LQR	2
4.10	Kalman Filter	2
4.11	LQG	2
	Total	**36**

Course Designers:

1. Dr.S.Baskar Professor EEE sbeee@tce.edu
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3. Dr.S.Latha Professor EEE sleee@tce.edu

22EEZR0	AN INTRODUCTION TO ARTIFICIAL INTELLIGENCE	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

The objectives of this course are to provide in-depth understanding of the underlying concepts of Artificial Intelligence and its types. Also the course provides knowledge on Problem solving Methods, knowledge representation and software agents. Eventually the course extends the students knowledge upto the level of designing artificial intelligence system for real world scenario.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %

CO1	Describe the characteristics of Artificial Intelligence	TPS2	75%	75%
CO2	Explain the different types of Problem solving Methods	TPS2	75%	75%
CO3	Describe the knowledge representation in Artificial Intelligence	TPS2	75%	75%
CO4	Describe the architecture for Intelligent Agents and multi agent system	TPS2	75%	75%
CO5	Demonstrate the AI applications of Language Models	TPS3	75%	75%
CO6	Demonstrate the AI applications of Robot	TPS3	80%	80%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	M	L						M		M	
CO2.	S	M	L	L				M		M	
CO3.	S	M	L	L				M		M	
CO4.	M	L						M		M	
CO5.	S	M	L	L				M		M	
CO6.	M	L						M		M	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1								Theory Assessment-2						Theory Terminal Examination			
	Assignment-1				CAT-1				Assignment-2			CAT-2						
TPS / COs	1	2	3		1	2	3	4	1	2	3	1	2	3	1	2	3	
CO1			40		10	10	20								4	15		
CO2			40		5	10	20								4	15		
CO3			20		5	10	10								4	5		
CO4												10			4	5		
CO5											50	5	20	20	2	5	15	
CO6											50	5	20	20	2	5	15	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Introduction: Definition - Future of Artificial Intelligence – Characteristics of Intelligent Agents– Typical Intelligent Agents – Problem Solving Approach to Typical AI problems - Features of ChatGPT.

Problem solving Methods: Search Strategies- Uninformed - Informed - Heuristics - Local Search Algorithms and Optimization Problems - Searching with Partial Observations - Constraint Satisfaction Problems – Constraint Propagation - Backtracking Search - Game Playing - Optimal Decisions in Games – Alpha - Beta Pruning - Stochastic Games

Knowledge Representation: First Order Predicate Logic – Prolog Programming – Unification – Forward Chaining-Backward Chaining – Resolution – Knowledge Representation - Ontological Engineering-Categories and Objects – Events - Mental Events and Mental Objects - Reasoning Systems for Categories - Reasoning with Default Information

Software Agents: Architecture for Intelligent Agents – Agent communication – Negotiation and Bargaining – Argumentation among Agents – Trust and Reputation in Multi-agent systems.

AI applications: Language Models – Information Retrieval- Information Extraction – Natural Language Processing - Machine Translation – Speech Recognition – Robot – Hardware – Perception – Planning – Moving.

Reference Books

1. S. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach‖, Prentice Hall, Third Edition, 2009.
2. I. Bratko, ―Prolog: Programming for Artificial Intelligence‖, Fourth edition, Addison-Wesley Educational Publishers Inc., 2011.
3. M. Tim Jones, ―Artificial Intelligence: A Systems Approach(Computer Science)‖, Jones and Bartlett Publishers, Inc.; First Edition, 2008.
4. Nils J. Nilsson, ―The Quest for Artificial Intelligence‖, Cambridge University Press, 2009.
5. William F. Clocksin and Christopher S. Mellish,‖ Programming in Prolog: Using the ISO Standard‖, Fifth Edition, Springer, 2003.

Course Contents and Lecture Schedule

Module No.	Topic	No. of.Lecture Hours
1.0	**Introduction**	
1.1	Definition, Future of Artificial Intelligence	1
1.2	Characteristics of Intelligent Agents, Typical Intelligent Agents	2
1.3	Problem Solving Approach to Typical AI problems	2
1.4	Features of ChatGPT	1
2.0	**Problem solving Methods**	
2.1	Search Strategies, Uninformed – Informed, Heuristics	1
2.2	Local Search Algorithms and Optimization Problems	1
2.3	Searching with Partial Observations	1
2.4	Constraint Satisfaction Problems, Constraint Propagation	1
2.5	Backtracking Search, Game Playing, Optimal Decisions in Games	1
2.6	Alpha - Beta Pruning, Stochastic Games	1
3.0	**Knowledge Representation**	
3.1	First Order Predicate Logic, Prolog Programming, Unification	1
3.2	Forward Chaining-Backward Chaining	1
3.3	Resolution, Knowledge Representation	1
3.4	Ontological Engineering-Categories and Objects	1
3.5	Events, Mental Events and Mental Objects	1
3.6	Reasoning Systems for Categories, Reasoning with Default Information	1
4.0	**Software Agents**	
4.1	Architecture for Intelligent Agents	2
4.2	Agent communication	1
4.3	Negotiation and Bargaining	1
4.4	Argumentation among Agents	1
4.5	Trust and Reputation in Multi-agent systems.	1
5.0	**AI applications**	
5.1	Language Models	2
5.2	Information Retrieval, Information Extraction	2
5.3	Natural Language Processing	2
5.4	Machine Translation	2
5.5	Speech Recognition	2
5.6	Robot: Hardware, Perception, Planning, Moving.	2
	Total	36

Course Designer(s):

1. Dr.P.S.Manoharan Professor EEE	psmeee@tce.edu

22EEZS0	FUZZY LOGIC AND NEURAL NETWORKS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

The objective of this course is to present sufficient background in both fuzzy and neural network so that students in future can pursue advanced soft computing methodologies. This course combines knowledge, techniques, and methodologies from various sources, using techniques from neural networks and fuzzy set theory, As an extension, the course uses the Neuro Fuzzy models for the complex engineering problems.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Describe the fundamentals of fuzzy logic	TPS2	75%	75%
CO2	Demonstrate fuzzy logic algorithm to solve engineering problems.	TPS3	75%	75%
CO3	Describe the architecture of artificial neural network	TPS2	75%	75%
CO4	Describe the different neural network techniques	TPS2	75%	75%
CO5	Explain the various associative memories of neural network	TPS2	75%	75%
CO6	Demonstrate artificial neural network models to solve engineering problems.	TPS3	75%	75%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	M	L						M		M	
CO2.	S	M	L	L				M		M	
CO3.	S	M	L	L				M		M	
CO4.	M	L						M		M	
CO5.	S	M	L	L				M		M	
CO6.	M	L						M		M	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory Assessment-1								Theory Assessment-2						Theory Terminal Examination			
	Assignment-1				CAT-1				Assignment-2			CAT-2						
TPS / COs	1	2	3		1	2	3	4	1	2	3	1	2	3	1	2	3	
CO1					10	10	10								4	10		
CO2			50		5	10	30								4		25	
CO3			50		5	10	10								4	5		
CO4												10	10	10	4	5		
CO5											50	5	10	10	2	10		

CO6											50	5	10	30	2		25	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Fundamentals of Fuzzy Logic: Fuzzy logic - fuzzy set theory- basic concept of crisp sets and fuzzy sets- complements- union intersection-combination of operation- general aggregation operations-fuzzy relations-compatibility relations-orderings- morphisms- fuzzy relational equations-fuzzy set and systems-

Fuzzy Logic Applications: Design steps in fuzzy logic controller - Fuzzy logic toolbox - Application of fuzzy logic controller in real time problems

Architecture of Neural Networks: Motivation for the development of natural networks-artificial neural networks-biological neural networks - typical Architecture-setting weights-common activations functions-Basic learning rules- Mcculloch-Pitts neuron- Architecture, algorithm, applications-single layer net for pattern classification- Biases and thresholds, linear separability - Hebb'srule- algorithm - perceptron -Convergence theorem-Delta rule

Neural Network Techniques: Back propagation neural net: standard back propagation-architecture algorithm- derivation of learning rules, number of hidden layers--associative and other neural networks- hetro associative memory neural net, auto associative net- Bidirectional associative memory-applications-Hopfield nets-Boltzman machine- Kohonenself organizing maps and applications – Perceptron neural network

Neural network Applications: Neural network toolbox to modelling – Application of neural network to forecasting and 56odelling – ANFIS

Reference Books

1. Kliryvan, Fuzzy System & Fuzzy logic Prentice Hall of India, First Edition
2. Lawrence Fussett, Fundamental of Neural network Prentice Hall, First Edition.
3. George J.Klir, Bo Yuan, Fuzzy sets and Fuzzy Logic, Second Edition, PHI,2006
4. Bart Kosko, Neural network and Fuzzy System, Prentice Hall, 1994.
5. J.Klin and T.A.Folger, Fuzzy sets - University and information- Prentice Hall, 1996.
6. J.M.Zurada, Introduction to artificial neural systems‖, Jaico Publication house, 1994.
7. S.N.Sivanandam, and S.N.Deepa, Principles of Soft computing, Second Edition, WileyIndia Pvt. Ltd,2013

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1.0	Fundamentals of Fuzzy Logic	
1.1	Fuzzy logic, fuzzy set theory	1
1.2	Basic concept of crisp sets and fuzzy sets, complements	1
1.3	Union intersection, combination of operation, general aggregation operations	2
1.4	Fuzzy relations, compatibility relations, orderings, morphisms, fuzzy relational equations	2
1.5	Fuzzy set and systems	1
2.0	Fuzzy Logic Applications	
	Design steps in fuzzy logic controller	2
	Fuzzy logic toolbox	2
	Application of fuzzy logic controller in real time problems	2
2.0	Architecture of Neural Networks	
2.1	Motivation for the development of natural networks	1
2.2	Artificial neural networks, biological neural networks	1
2.3	Typical Architecture, setting weights, common activations functions	1
2.4	Basic learning rules, Mcculloch-Pitts neuron, Architecture, algorithm,	2

	applications	
2.5	Single layer net for pattern classification, Biases and thresholds, linear separability	2
2.6	Hebb'srule- algorithm, perceptron, Convergence theorem, Delta rule	2
3.0	Neural Network Techniques	
3.1	Back propagation neural net: standard back propagation, architecture algorithm	2
3.2	derivation of learning rules, number of hidden layers	2
3.3	associative and other neural networks, hetro associative memory neural net, auto associative net	2
3.4	Bidirectional associative memory, applications, Hopfield nets	1
3.5	Boltzman machine, Kohonenself organizing maps and applications	1
3.6	Perceptron neural network	1
4.0	Neural network Applications	
4.1	Neural network toolbox to modelling	2
4.2	Application of neural network to forecasting and modeling	2
4.3	ANFIS	1
	Total	36

Course Designer(s):

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22EEZT0	EVOLUTIONARY COMPUTATION TECHNIQUES	Category	L	T	P	Credit
		PSE	3	0	0	3

Preamble

Evolutionary computation is a sub-field of artificial intelligence (AI) and is used extensively in complex optimization problems and for continuous optimization. Evolutionary computation is used to solve problems that have too many variables for traditional algorithms. Computers performing evolutionary computing run such evolutionary algorithms as genetic algorithms, evolutionary programming, Particle Swarm Optimization, genetic programming, etc. The objective of this course is introducing single objective and multi objective evolutionary algorithms and explains their real time applications.

Prerequisite

- Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %

CO1	Explain the parameters and algorithmic implementation of Genetic Algorithms (GA)	TPS2	75%	75%
CO2	Explain the parameters and algorithmic implementation of Particle Swarm Optimization (PSO)	TPS2	75%	75%
CO3	Explain the parameters and algorithmic implementation of Evolutionary Programming (EP) and Differential Evolution (DE)	TPS2	75%	75%
CO4	Explain the parameters of Multiobjective Evolutionary Optimisation	TPS2	75%	75%
CO5	Demonstrate real time application of single objective evolutionary algorithms	TPS3	75%	75%
CO6	Demonstrate real time application of multi objective evolutionary algorithms	TPS3	80%	80%

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	M	L						M		M	
CO2.	S	M	L	L				M		M	
CO3.	S	M	L	L				M		M	
CO4.	M	L						M		M	
CO5.	S	M	L	L				M		M	
CO6.	M	L						M		M	

S- Strong; M-Medium; L-Low

Assessment Pattern

	Theory								Theory						Theory			
	Assessment-1								Assessment-2						Terminal Examination			
	Assignment-1				CAT-1				Assignment-2			CAT-2						
TPS / COs	1	2	3		1	2	3	4	1	2	3	1	2	3	1	2	3	
CO1		40			20	20									4	15		
CO2		40			10	20									4	15		
CO3		20			10	20									4	5		
CO4												10			4	5		
CO5											50	5	20	20	2	5	15	
CO6											50	5	20	20	2	5	15	

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Introduction to Evolutionary Computation – Single objective and multi objective problems - Evolutionary Algorithms: Genetic Algorithms, Particle Swarm Optimization - Evolutionary Programming, Differential Evolution – Different Components of Evolutionary Algorithms.

Genetic Algorithms (GA): Genetic algorithm steps-Selection schemes, Crossover and Mutation - Algorithmic Implementation of GA

Particle Swarm Optimization (PSO): Introduction to swarm optimization, Velocity and position update equations– Algorithmic Implementation of PSO

Evolutionary Programming (EP): Initialization – Offspring Creation - Competition & Selection - Stopping criteria - Hybrid evolutionary algorithms

Differential Evolution (DE): Parameter Selection -Variants - Algorithmic Implementation of Differential Evolution

Multiobjective Evolutionary Optimisation: Pareto optimality - Multiobjective evolutionary algorithms - Non-domination sorting - Diversity operator- NSGA - NSGA-II.

Applications: Genetic algorithm Applications - PSO Applications - Application of Hybrid evolutionary algorithms – Applications of Multiobjective evolutionary algorithms

Reference Books

1. T. Baeck, D. B. Fogel, and Z. Michalewicz, Handbook on Evolutionary Computation, IOP Press, 1997.
2. Z Michalewicz, Genetic Algorithms + Data Structures = Evolution Programs (3rd edition), Springer-Verlag, Berlin, 1996
3. D E Goldberg, Genetic Algorithms in Search, Optimisation & Machine Learning, Addison-Wesley, 1989.
4. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lecture Hours
1.0	**Introduction to Evolutionary Computation**	
1.1	Single objective and multi objective problems	1
1.2	Genetic Algorithms, Particle Swarm Optimization	2
1.3	Evolutionary Programming, Differential Evolution	2
1.4	Different Components of Evolutionary Algorithms.	1
2.0	**Genetic Algorithms (GA)**	
2.1	Genetic algorithm steps-Selection schemes, Crossover and Mutation	2
2.2	Algorithmic Implementation of GA	2
3.0	**Particle Swarm Optimization (PSO)**	
3.1	Introduction to swarm optimization, Velocity and position update equations	2
3.2	Algorithmic Implementation of PSO	2
4.0	**Evolutionary Programming (EP)**	
4.1	Initialization, Offspring Creation, Competition & Selection, Stopping criteria	2
4.2	Hybrid evolutionary algorithms	2
5.0	**Differential Evolution (DE)**	
5.1	Parameter Selection -Variants	2
5.2	Algorithmic Implementation of Differential Evolution	2
6.0	**Multiobjective Evolutionary Optimisation**	
6.1	Pareto optimality, Multiobjective evolutionary algorithms	2
6.2	Non-domination sorting, Diversity operator	1
6.3	NSGA - NSGA-II.	2
7.0	**Applications**	
7.1	Genetic algorithm Applications, PSO Applications	3
7.2	Application of Hybrid evolutionary algorithms	3
7.3	Applications of Multiobjective evolutionary algorithms	3
	Total	36

Course Designer(s):

1. Dr.S.Baskar Professor EEE sbeee@tce.edu
2. Dr.P.S.Manoharan Professor EEE psmeee@tce.edu

22EEQA0	CIRCUITS AND NETWORKS

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

Electric circuit and networks is the fundamental theory upon which all branches of electrical engineering are built. Many areas of electrical engineering, such as power, electric machines, control, electronics, communications, and instrumentation, are based on electric circuit theory. Therefore, the basic electric circuit theory course is the most important course for an electrical engineering student, and always an excellent starting point for a beginner in electrical engineering education. Circuit theory is also valuable to students specializing in other branches of the engineering because circuits are a good model for the study of energy systems in general, and because of the applied mathematics, physics, and topology involved.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the fundamental components of Electric circuits	TPS2	80	75
CO2	Apply mesh analysis, nodal analysis and network theorems to interpret the behaviour of the given electrical circuit	TPS3	80	75
CO3	Demonstrate the resonance in series and parallel circuits.	TPS3	80	75
CO4	Explain the network topology of circuits	TPS2	80	75
CO5	Explain the behaviour of magnetically coupled circuits and mutual inductance of a coupled circuit	TPS2	80	75
CO6	Calculate three-phase quantities of the given three phase circuit.	TPS3	80	75

Assessment Pattern: Cognitive Domain

Bloom's Scale CO	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I (%)			CAT – II (%)			Assg. II (%)					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CO1	20	-	-	-	-	25	-	-	-	-	-	-	**10**	10	
CO2	-	20	30	-	-	25	-	-	-	-	-	-	-	10	20
CO3	-	20	10	-	-	50	-	-	-	-	-	-	-	-	10
CO4	-	-	-	-	-	-	10	20	-	-	-	50	-	10	
CO5	-	-	-	-	-	-	10	20	-	-	-	20	-	10	
CO6	-	-	-	-	-	-		10	30	-	-	30	-	10	10
Total	**20**	**40**	**40**	-	-	**100**	**20**	**50**	**30**	-	-	**100**	**10**	**50**	**60**

Syllabus

Electric Circuits: Circuit laws, Sources, Resistance, inductance, capacitance Reactance, Impedance, series, parallel, star - Delta connections & conversions, AC fundamentals.

Circuit analysis: Mesh and Nodal analysis, Source transformation, Thevenin's Theorem, Norton's Theorem, Superposition theorem, and maximum power transfer theorem

Resonance: Resonance in a series and parallel circuit, Q factor, bandwidth and application of resonance.
Network Topology: General network analysis - Elementary concepts of network topology – Graph - Tree – Co Tree - Tree branch and link - Tie set schedule and cut set schedule
Coupled Circuits: Mutual Inductance, Dot rules, Energy in coupled circuits, Duality
Three Phase Circuits: Balanced, unbalanced star – delta connections. Power measurement.

Learning Resources

1. W.H. Hayt & J.K. Kemmerly and Steven M. Durbin, "Engineering circuit analysis", Tata McGraw Hill, 7th edition, New Delhi, 2007
2. Charles K. Alexander, Matthew N.O. Sadiku, "Fundamentals of Electric Circuits", Tata McGraw Hill, 5th edition, 2013
3. Mahmood Nahvi, Joseph A Edminister, "Electric Circuits", Tata McGraw - Hill Education, 5th Edition, 2010.
4. Sudhakar A and Shyam Mohan SP, "Electric Circuit Analysis", Tata McGraw Hill, New Delhi, 2008
5. NPTEL E-Learning Courses: Basic Electrical Circuits https://onlinecourses.nptel.ac.in/noc17_ee13
6. https://www.electrical4u.com

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours
1.0	**Electric Circuits**	
1.1	Circuit laws, Sources, Resistance, inductance, capacitance Reactance, Impedance, series, parallel,	3
1.2	Star - Delta connections & conversions, AC fundamentals.	3
2.0	**Circuit Analysis**	
2.1	Mesh and Nodal analysis,.	3
2.2	Thevenin's Theorem, Norton's Theorem, Superposition theorem	3
2.2	Source transformation theorem and maximum power transfer theorem	3
3.0	**Resonance**	
3.1	Resonance in a series and parallel circuit,	3
3.2	Q factor, bandwidth and application of resonance.	2
4.0	**Network Topology:**	
4.1	General network analysis - Elementary concepts of network topology	3
4.2	Graph - Tree – Co Tree - Tree branch and link	2
4.3	Tie set schedule and cut set schedule	2
5.0	**Coupled Circuits:**	
5.1	Mutual Inductance, Dot rules, Energy in coupled circuits	
5.2	Duality	2
6.0	**Three Phase Circuits**	
6.1	Balanced, unbalanced star – delta connections.	2
6.2	Power measurement	2
6.3	Mutual Inductance, Dot rule in coupled circuit	3
	TOTAL	36

Course Designers:

1. Dr.C.K. Babulal Professor EEE ckbeee@tce.edu
2. Dr.R. Rajan Prakash Associate Professor EEE r_rajanprakash@tce.edu

22EEQB0	ELECTRICAL MACHINES PERFORMANCE AND APPLICATION

Category	L	T	P	Credit
PSE	2	1	0	3

Preamble

The energy conversion between electrical and mechanical power is performed by the electrical machine in both directions. Electrical machines can be used for different ranges of speed. It can be used as motor particularly in traction, electrical vehicles, etc. or as generators in power station, wind turbines, etc.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course, students will be able to

CO	Course Outcome (CO)	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Study transformer construction, operation, various tests, efficiency and voltage regulation.	TPS 3	80%	70%
CO2	Study about DC machines, operation, performance, applications, recent advancements.	TPS 2	80%	70%
CO3	Study of synchronous machine Characteristics, Performance and its applications.	TPS 2	80%	70%
CO4	Study induction motor operation, Characteristics, Performance, speed regulation and its application.	TPS 3	80%	70%
CO5	Study Special purpose motor operation, Characteristics and its application.	TPS 2	80%	70%
CO6	Select a suitable motor for a load based on its starting and Running characteristics	TPS 3	80%	70%

Mapping with Programme Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	S	M	L	L				M		M			S	
CO2	M	L						M		M			M	
CO3	S	M						M		M			S	
CO4	S	M	L	L				M		M			S	
CO5	S	M	L	L				M		M			S	
CO6	S	M	L	L				M		M			S	

S- Strong; M-Medium; L-Low

Assessment Pattern

CO	CAT1			Assignment 1			CAT2			Assignment 2			Terminal					
TPS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	4	5	6

Scale																	
CO1	4	10	10			100							4	10	10			
CO2	4	10											4	10				
CO3	2	10											2	10				
CO4							4	10				50	4		10			
CO5							2	10					2	10				
CO6							4	10	10			50	4	10	10			

* Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Transformer

Principle, Role of Transformer, Types of Transformer based on Construction, Transformer Rating, Voltage Regulation of Transformer, Losses and Efficiency, Power Transformer, Distribution Transformer, Auto Transformer, Instrument Transformer, Impedance Matching, Isolation, Application

DC Machine

Operating Principle, Generator & Motor action, types of excitation, EMF and Torque equations, Commutation and Armature Reaction, Characteristics and Application of DC Generator & Motor, Starting and Speed Control of DC Motors, Electric Braking

Synchronous Machine

Construction, types & operating principle of synchronous generator, A.C armature windings, voltage regulation, parallel operation, synchronization, effect of field excitation change.
Synchronous Motor, principle, starting, hunting, damper windings.

Induction Machine

Three-phase induction motors. Principle of operation, construction, types. Rotating magnetic field, EMF equation of an AC Machine, torque developed in an induction motor, torque-speed characteristics, starting & speed control. Single phase induction motors, starting, application, Induction Generator.

Special Purpose Motor

Stepper Motor, Universal Motor, shaded-pole Motor, BLDC Motor

Selection of Motors for an Application

Rating and Starting & Running Characteristics of Different types of Load – Pumps, Blowers, Mixers, Crane /Elevator, Continuous Duty and Intermittent Duty,

Reference Books & web resources

1. P.S.Bhimbra, " Electrical Machinery", Khanna Publications, 7th Edition, 1977.
2. R.K.Rajput, " A Text Book of Electrical Machines", Laxmi Publications, 5th Edition, 2016.
3. Partab.H, "Art and science of utilization of Electrical Energy", 2015, Dhanpat Rai & Co. (P) Ltd., Delhi, 2016.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Transformer**	
1.1	Principle, Role of Transformer, Types of Transformer based on Construction	2
1.2	Transformer Rating, Voltage Regulation of Transformer, Losses and Efficiency,	2
1.3	Power Transformer, Distribution Transformer, Auto Transformer, Instrument Transformer,	2

Module No.	Topic	No. of Periods
1.4	Impedance Matching, Isolation, Application	1
2	**DC Machine**	
2.1	Operating Principle, Generator & Motor action, types of excitation	2
2.2	EMF and Torque equations, Commutation and Armature Reaction,	2
2.3	Characteristics and Application of DC Generator & Motor,	2
2.4	Starting and Speed Control of DC Motors, Electric Braking	1
3	**Synchronous Machine**	
3.1	Construction, types & operating principle of synchronous generator, Types of A.C armature windings	2
3.2	voltage regulation, parallel operation, synchronization, effect of field excitation change.	2
3.3	Synchronous Motor, principle, starting, hunting, damper windings.	2
4	**Induction Machine**	
4.1	Three-phase induction motors. Principle of operation, construction, types	2
4.2	Rotating magnetic field, EMF equation of an AC Machine, torque developed in an induction motor,	2
4.3	Torque-speed characteristics, starting & speed control.	2
4.4	Single phase induction motors, starting, application,	1
4.5	Induction Generator	1
5	**Special Purpose Motor**	
5.1	Stepper Motor, Universal Motor	1
5.2	Shaded-pole Motor, BLDC Motor	2
6	**Selection of Motors for an Application**	
6.1	Rating - Continuous Duty and Intermittent Duty,	1
6.2	Starting Characteristics of Different types of Load – Pumps, Blowers, Mixers, Crane /Elevator	2
6.3	Running Characteristics of Different types of Load – Pumps, Blowers, Mixers, Crane /Elevator	2
	Total	36

Course Designers

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B.E. EEE DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2022-23 ONWARDS

(Revised Courses of Study and Scheme of Evaluation)

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

COURSES OF STUDY

(For the candidates admitted from 2022-23 onwards)

SECOND SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE210	Matrices and Transforms	BSC	3	1	-	4
22EE220	Materials Science for Electrical Engineering	ESC	3	-	-	3
22EE230	Electric Circuit Analysis	PCC	3	-	-	3
22EE240	Electromagnetic Fields	PCC	2	1	-	3
22EE250	Digital Systems	PCC	3	-	-	3
22EE260	Electronic devices and circuits	PCC	3	-	-	3
22CHAA0	Environmental Science (Audit Course)					
PRACTICAL						
22EE270	Electrical Workshop	ESC	-	-	2	1
22EE280	Electronic Devices and Circuits	PCC Lab	-	-	2	1
Total			**17**	**2**	**4**	**21**

BSC : Basic Science Courses
HSMC : Humanities and Social Science including Management courses
ESC : Engineering Science Courses
L : Lecture , T : Tutorial ,P: Practical

Note :

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

THIRD SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE310	Numerical methods and Complex variables	BSC	3	1	-	4
22EE320	DC Machines and Transformers	PCC	2	1	-	3
22EE330	Linear Integrated Circuits	PCC	3	-	-	3
22EE340	Signals and Systems	PCC	3	-	-	3
22EE350	Problem Solving using computers	ESC	3	-	-	3
22ES390	Design Thinking	ESC	3	-	-	3
PRACTICAL						
22EE370	DC Machines and Transformers Lab	PCC Lab	-	-	2	1
22EE380	Integrated Circuits Lab	PCC Lab	-	-	2	1
Total			**17**	**2**	**4**	**21**

THIAGARJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

FOURTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE410	Probability Distribution and Random Process	BSC	3	1	-	4
22EE420	AC Machines	PCC	2	1	-	3
22EE430	Measurements and Instrumentation	PCC	3	-	-	3

22EE440	Control Systems	PCC	2	1	-	3
22EE450	Power Electronics	PCC	3	-	-	3
22EE490	Project Management	HSMC	3	-	-	3
THEORY CUM PRACTICAL						
22EE460	Data Structures Elective	ESC	2		2	3
PRACTICAL						
22EE470	Electrical Problem solving using computers	PCC Lab	-	-	2	1
22EE480	AC Machines Lab	PCC Lab	-	-	2	1
Total			**18**	**4**	**4**	**24**

THIAGARAAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

FIFTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE510	Generation, Transmission and Distribution	PCC	2	1	-	3
22EE520	Micro Controllers	PCC	2	1	-	3
22EE530	Electric drives	PCC	3	-	-	3
22EE540	Power System Analysis	PCC	3	-	-	3
	Interdisciplinary Elective	IE	3	-	-	3
22EE550	Object Oriented Programming	ESC	3	-	-	3
PRACTICAL						
22EE570	Measurement and Control Lab	PCC Lab	-	-	2	1
22EE580	Microcontrollers lab	PCC Lab	-	-	2	1

22EE590	Project -I	PW	-	-	6	3
Total			**16**	**2**	**10**	**23**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

SIXTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EE610	Accounting and Finance	HSMC	3	-	-	3
22EEPXX	PEC-1 (3)	PEC-1 (3)	3	-	-	3
22EEPXX	PEC-2 (3)	PEC--2 (3)	3	-	-	3
22EEPXX	PEC-3 (3)	PEC--3(3)	3	-	-	3
	Basic Science Elective	OE	3	-	-	3
22EG660	Professional Communication	HSMC		1	2	2
PRACTICAL						
22EE670	Power Electronics and Drives Lab	PCC Lab	-	-	2	1
22EE680	Electric Power Systems lab	PCC Lab	-	-	2	1
22EE690	Project -II	PW	-	-	6	3
Total			15	1	12	22

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

SEVENTH SEMESTER

Course Code	**Name of the Course**	**Category**	**No. of Hours / Week**			**credits**
			L	**T**	**P**	
THEORY						

22EEPXX	PEC-4 (3)	PEC-4 (3)	3	-	-	3
22EEPXX	PEC-5 (3)	PEC-5 (3)	3	-	-	3
22EEPXX	PEC-6 (3)	PEC-6 (3)	3	-	-	3
22EEPXX	PEC-7 (3)	PEC--7 (3)	3	-	-	3
22EEPXX	PEC-8 (3)	PEC-8 (3)	3	-	-	3
THEORY CUM PRACTICAL						
PRACTICAL						
22EE770	Energy Management System Lab	PCC Lab	-	-	2	1
22EE790	Project -III	PW	-	-	6	3
Total			**12**	**-**	**8**	**19**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 B.E. / B.Tech. Degree Programmes

EIGHTH SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEPXX	PEC-9 (3)	PEC-9 (3)	3	-	-	3
22EEPXX	PEC-10(3)	PEC-10(3)	3	-	-	3
THEORY CUM PRACTICAL						
PRACTICAL						
22EE890	Project -IV	PW		-	6	3
Total			**3**	**-**	**6**	**9**

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B.E. / B.Tech. Degree Programme

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2022-2023 onwards)

SECOND SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE210	Matrices and Transforms	3	40	60	100	27	50
2	22EE220	Materials Science for Electrical Engineering	3	40	60	100	27	50
3	22EE230	Electric Circuit Analysis	3	40	60	100	27	50
4	22EE240	Electromagnetic Fields	3	40	60	100	27	50
5	22EE250	Digital Systems	3	40	60	100	27	50
6	22EE260	Electronic devices and circuits	3	40	60	100	27	50
PRACTICAL								
7	22EE270	Electrical Workshop	3	60	40	100	18	50
8	22EE280	Electronic Devices and Circuits	3	60	40	100	18	50

THIRD SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total

THEORY									
1	22EE310	Numerical methods and Complex variables	3	40	60	100	27	50
2	22EE320	DC Machines and Transformers	3	40	60	100	27	50
3	22EE330	Linear Integrated Circuits	3	40	60	100	27	50
4	22EE340	Signals and Systems	3	40	60	100	27	50
5	22EE350	Problem Solving using computers	3	40	60	100	27	50
6	22ES390	Design Thinking						
PRACTICAL								
7	22EE370	DC Machines and Transformers Lab	3	60	40	100	18	50
8	22EE380	Integrated Circuits Lab	3	60	40	100	18	50

FOURTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE410	Probability Distribution and Random Process	3	40	60	100	27	50
2	22EE420	AC Machines	3	40	60	100	27	50

3	22EE430	Measurements and Instrumentation	3	40	60	100	27	50
4	22EE440	Control Systems	3	40	60	100	27	50
5	22EE450	Power Electronics	3	40	60	100	27	50
6	22EE490	Project Management	3	40	60	100	27	50
THEORY CUM PRACTICAL								
7	22EE460	Data Structures Elective	3	50	50	100	25	50
PRACTICAL								
8	22EE470	Electrical Problem solving using computers	3	60	40	100	18	50
9	22EE480	AC Machines Lab	3	60	40	100	18	50

FIFTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE510	Generation, Transmission and Distribution	3	40	60	100	27	50
2	22EE520	Micro Controllers	3	40	60	100	27	50
3	22EE530	Electric drives	3	40	60	100	27	50

4	22EE540	Power System Analysis	3	40	60	100	27	50
5		Interdisciplinary Elective	3	40	60	100	27	50
6	22EE550	Object Oriented Programming	3	40	60	100	27	50
PRACTICAL								
7	22EE570	Measurement and Control Lab	3	60	40	100	18	50
8	22EE580	Microcontrollers lab	3	60	40	100	18	50
9	22EE590	Project -I	3	40	60	100	27	50

SIXTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EE610	Accounting and Finance	3	40	60	100	27	50
2	22EEPXX	PEC-1 (3)	3	40	60	100	27	50
3	22EEPXX	PEC-2 (3)	3	40	60	100	27	50
4	22EEPXX	PEC-3 (3)	3	40	60	100	27	50
5		Basic Science Elective	3	40	60	100	27	50
6	22EG660	Professional Communication	3	40	60	100	27	50
PRACTICAL								

7	22EE670	Power Electronics and Drives Lab	3	60	40	100	18	50
8	22EE680	Electric Power Systems lab	3	60	40	100	18	50
9	22EE690	Project -**II**	3	40	60	100	27	50

SEVENTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEPXX	PEC-4 (3)	3	40	60	100	27	50
2	22EEPXX	PEC-5 (3)	3	40	60	100	27	50
3	22EEPXX	PEC-6 (3)	3	40	60	100	27	50
4	22EEPXX	PEC-7 (3)	3	40	60	100	27	50
5	22EEPXX	PEC-8 (3)	3	40	60	100	27	50
PRACTICAL								
6	22EE770	Energy Management System Lab	3	60	40	100	18	50
7	22EE790	Project -**III**	3	40	60	100	27	50

EIGHTH SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEPXX	PEC-9 (3)	3	40	60	100	27	50
2	22EEPXX	PEC-10(3)	3	40	60	100	27	50
THEORY CUM PRACTICAL								
PRACTICAL								
3	22EE890	Project -IV (P-3)	3	40	60	100	27	50

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1.	22EEPA0	Power System Operation and Control	3	40	60	100	27	50
2.	22EEPB0	Electrical Machine Design	3	40	60	100	27	50
3.	22EEPC0	Switchgear and Protection	3	40	60	100	27	50
4.	22EEPD0	Wind and Solar Technology	3	40	60	100	27	50
5.	22EEPF0	Operation and Maintenance of Electrical equipment	3	40	60	100	27	50
6.	22EEPG0	Energy Audit and Management in Electric Utilities	3	40	60	100	27	50
7.	22EEPH0	Power System Stability	3	40	60	100	27	50
8.	22EEPJ0	VLSI Design	3	40	60	100	27	50
9.	22EEPK0	Computer Organization	3	40	60	100	27	50
10.	22EEPR0	Control System Design	3	40	60	100	27	50
11.	22EEPS0	Industrial Instrumentation	3	40	60	100	27	50

12.	22EEPU0	Flexible AC Transmission Systems	3	40	60	100	27	50
13.	22EEPV0	Power Quality	3	40	60	100	27	50
14.	22EEPW0	Power Electronics for Renewable Energy Systems	3	40	60	100	27	50
15.	22EERM0	Electric Vehicles	3	40	60	100	27	50
16.	22EEPY0	Design of Electrical Installations	3	40	60	100	27	50
17.	22EEPZ0	Smart Grid	3	40	60	100	27	50
18.	22EERA0	Thermal power plant instrumentatio n & control	3	40	60	100	27	50
19.	22EERB0	High Voltage Engineering	3	40	60	100	27	50
20.	22EERD0	Biomedical Instrumentatio n	3	40	60	100	27	50
21.	22EERG0	ASIC Design	3	40	60	100	27	50
22.	22EERJ0	Operation Research	3	40	60	100	27	50
23.	22EERK0	HVDC Transmission	3	40	60	100	27	50
THEORY CUM PRACTICAL								
24.	22EEPL0	Internet of Things	3	50	50	100	25	50
25.	22EEPM0	FPGA based System Design	3	50	50	100	25	50

26.	22EEPN0	Digital Signal Processing	3	50	50	100	25	50
27.	22EEPQ0	Embedded Systems Design	3	50	50	100	25	50
28.	22EEPT0	Soft Computing	3	50	50	100	25	50
29.	22EERF0	Real Time Operating System	3	50	50	100	25	50
30.	22EERH0	Machine Learning	3	50	50	100	25	50
31.	22EERL0	Simulation of Power Electronic Systems	3	50	50	100	25	50

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015

(A Govt. Aided Autonomous Institution affiliated to Anna University)

CHOICE BASED CREDIT SYSTEM

Categorization of Courses

Degree: B.E. **Programme: EEE** **Batch: 2022-23 onwards**

A. **FOUNDATION COURSES: Total Credits to be earned: (53-58)**

a. Humanities and Social Sciences including Management Courses (HSMC) **(09-12)**

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					
1.	22EG140	Technical English	2	-	-	2	Nil
2.	22EE610	Accounting and Finance	3	-	-	3	Nil
3.	22EE490	Project Management	3	-	-	3	Nil
		THEORY CUM PRACTICAL					
1.	22EG660	Professional Communication	-	1	2	2	Nil
		PRACTICALS					
1.	22EG170	English Laboratory	-	-	2	1	Nil

b. Basic Science Courses (BSC)**(24-27)**

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					

1.	22MA110	Calculus for Engineers	3	1	-	4	Nil
2.	22PH120	Physics	3	-	-	3	Nil
3.	22CH130	Chemistry	3	-	-	3	Nil
4.	22EE210	Matrices and Transforms	3	1	-	4	Nil
5.	22EE310	Numerical methods and Complex variables	3	1	-	4	Nil
6.	22EE410	Probability Distribution and Random process	3	1	-	4	Nil
		PRACTICALS					
1.	22PH180	Physics Laboratory	-	-	2	1	Nil
2.	22CH190	Chemistry Laboratory	-	-	2	1	Nil

C. Engineering Science Courses (ESC)**(21-27)**

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					
1.	22EE150	Engineering Exploration	2	-	-	2	Nil
2.	22EE220	Materials Science for Electrical Engineering	3	-	-	3	Nil
3.	22EE350	Problem Solving using computers	3	-	-	-	Nil
4.	22ES390	Design Thinking	3	-	-	3	Nil
5.	22EE460	Data Structures	2	-	2	3	22EE350
5.	22EE550	Object Oriented Programming	3	-	-	3	Nil
		THEORY CUM PRACTICAL					
1.	22ME160	Engineering Graphics	3	-	2	4	Nil
2.							
		PRACTICALS					
1.	22EE270	Electrical Workshop	-	-	2	1	Nil

B. PROFESSIONAL CORE COURSES(PCC) Credits to be earned: (55)

Course Code		Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		THEORY					
1.	22EE230	Electric Circuit Analysis	3	-	-	3	Nil
2.	22EE240	Electromagnetic Fields	2	1	-	3	22PH120 22MA110
3.	22EE250	Digital Systems	3	-	-	3	Nil
4.	22EE260	Electronic devices and circuits	3	-	-	3	Nil
5.	22EE320	DC Machines and Transformers	2	1	-	3	22EE230
6.	22EE330	Linear Integrated Circuits	3	-	-	3	22EE260 22EE280
7.	22EE340	Signals and Systems	3	-	-	3	Nil
8.	22EE420	AC Machines	2	1	-	3	22EE230 22EE240
9.	22EE430	Measurements and Instrumentation	3	-	-	3	Nil
10.	22EE440	Control Systems	2	1	-	3	22EE230 22EE340

							22EE210
11.	22EE510	Generation, Transmission and Distribution	2	1	-	3	22EE230 22EE240
12.	22EE520	Microcontrollers	2	1	-	3	22EE250
13.	22EE450	Power Electronics	3	-	-	3	Nil
14.	22EE530	Electric drives	3	-	-	3	Nil
15.	22EE540	Power System Analysis	3	-	-	3	Nil
		PRACTICALS					
16.	22EE280	Electronic Devices and Circuits Lab	-	-	2	1	Nil
17.	22EE370	DC Machines and Transformers Lab	-	-	2	1	Nil
18.	22EE380	Integrated Circuits Lab	-	-	2	1	22EE260, 22EE280
19.	22EE470	Electrical Problem solving using computers	-	-	2	1	Nil
20.	22EE480	AC Machines Lab	-	-	2	1	22EE320
21.	22EE570	Measurement and Control Lab	-	-	2	1	22EE440
22.	22EE580	Microcontrollers Lab	-	-	2	1	22EE250
23.	22EE670	Power Electronics and Drives Lab	-	-	2	1	22EE320 22EE420 22EE450
24.	22EE680	Electric Power Systems Lab	-	-	2	1	Nil
25.	22EE770	Energy Management System Lab	-	-	2	1	Nil

C. ELECTIVE COURSES: Credits to be earned: (24-39)

a. Programme Specific Electives (PSE) Credits to be earned:15-24

S.No.	Course code	Name of the Course	Number of Hours / Week			Credit	Prerequisites (Updated)
			L	T	P		
		ELECTRICAL ENERGY SYSTEMS					
	THEORY						
6.	22EEPA0	Power System Operation and Control	3	-	-	3	Nil
7.	22EEPB0	Electrical Machine Design	2	1	-	3	Nil
8.	22EEPC0	Switchgear and Protection	3	-	-	3	Nil
9.	22EEPD0	Wind and Solar Technology	3	-	-	3	Nil
10.	22EEPF0	Operation and Maintenance of Electrical equipment	3	-	-	3	22EE320 22EE420 22EE510
11.	22EEPG0	Energy Audit and Management in Electric Utilities	2	1	-	3	NIL
12.	22EEPH0	Power System Stability	3	-	-	3	22EE230 22EE320 22EE420
13.	22EEPY0	Design of Electrical Installations	2	1	-	3	Nil
14.	22EEPZ0	Smart Grid	3	-	-	3	Nil
		ANALOG AND DIGITAL ELECTRONIC SYSTEMS					
	THEORY						
5.	22EEPJ0	VLSI Design	2	1	-	3	22EE250

6.	22EEPK0	Computer Organization	3	-	-	3	22EE250
	THEORY CUM PRACTICAL						
1.	22EEPL0	Internet of Things	2	-	2	3	22EE520
2.	22EEPM0	FPGA based System Design	2	-	2	3	22EE250
3.	22EEPN0	Digital Signal Processing	2	-	2	3	22EE340
4.	22EEPQ0	Embedded Systems Design	2	-	2	3	22EE520 22EE580
		CONTROL AND AUTOMATION					
	THEORY						
4.	22EEPR0	Control System Design	2	1	-	3	22EE440
5.	22EEPS0	Industrial Instrumentation	3	-	-	3	Nil
	THEORY CUM PRACTICAL						
1.	22EEPT0	Soft Computing	2	-	2	3	Nil
		POWER ELECTRONICS AND DRIVES					
3.	22EEPU0	Flexible AC Transmission Systems	2	1	-	3	2EE450
4.	22EEPV0	Power Quality	3	-	-	3	Nil
5.	22EEPW0	Power Electronics for Renewable Energy Systems	3	-	-	3	22EE450
6.							

b. Programme Specific Elective for Expanded Scope (PEES) Credits to be earned: 09-15

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit	
			L	T	P		
ELECTRICAL ENERGY SYSTEMS							
	THEORY						
1.	22EERA0	Thermal power plant instrumentation & control	3	-	-	3	Nil
2.	22EERB0	High Voltage Engineering	3	-	-	3	Nil
3.	22EERC0	Energy Storage Systems	2	-	-	2	
		ANALOG AND DIGITAL ELECTRONIC SYSTEMS					
	THEORY						
1.	22EERD0	Bio-medical Instrumentation	3	-	-	3	Nil
2.	22EERG0	ASIC Design	3	-	-	3	22EE250
		THEORY CUM PRACTICAL					
1.	22EERF0	Real Time Operating System	2	-	2	3	22EE520
2.	22EERH0	Machine Learning	2	-	2	3	Nil
		CONTROL AND AUTOMATION					
	THEORY						
1.	22EERJ0	Operation Research	3	-	-	3	Nil
		POWER ELECTRONICS AND DRIVES					
		THEORY					
1.	22EERK0	HVDC Transmission	3	-	-	3	Nil
2.	22EE1A0	Battery Technology	1	-	-	1	Nil
3.	22EERM0	Electric Vehicles	3	-	-	3	Nil
		THEORY CUM PRACTICAL					
1.	22EERL0	Simulation of Power Electronic Systems	2	-	2	3	22EE450

c. General Elective Credits to be earned: 03-06
d. Electives from foundation courses- HSMC, BSC, ESC Credits to be earned: 03-06

D. Project Credits to be earned: 12

S.No	Course code	Course Name	Credits
1.	22EE590	Project -I	3
2.	22EE690	Project -II	3
3.	22EE790	Project -III	3
4.	22EE890	Project- IV	3

E. Mandatory Courses (Not included for CGPA)

Audit Course 1 , Audit Course 2 (as per UGC guideline)

Minimum credits to be earned for the award of the degree =160 (From A to D) for Regular students and 120 (From A to D) for Lateral entry students.

B.E. EEE DEGREE PROGRAMME

FOR THE STUDENTS ADMITTED IN

THE ACADEMIC YEAR 2023-24 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided 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 03.05.2023 Approved in 65th Academic Council Meeting in 27.05.23

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
22EEL10	Numerical Methods, Probability and Complex variables	BSC	3	1	-	4
Total			**3**	**1**	**-**	**4**

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	22EEL10	Numerical Methods, Probability and Complex variables	3	40	60	100	27	50

LATERAL ENTRY (IV SEMESTER)

22EEL10	**NUMERICAL METHODS, PROBABILITY AND COMPLEX VARIABLES**

Category	L	T	P	Credit
BS	3	1	0	4

Preamble

An Electrical engineering student needs to know sufficient numerical tools and techniques for solving engineering problems arises in their field. This course aims at developing the ability to formulate an engineering problem in a mathematical form appropriate for subsequent computational treatment and to choose an appropriate numerical approach. Analytic functions and Contour integration are extremely important while creating engineering models in control systems, communication systems and searching algorithms.

An electrical engineering student needs to have some basic statistical tools and techniques to apply in diverse applications in digital signal processing (voice, image, video, etc.), communications systems and networks, radar systems and power systems that require an understanding of Probability distributions and Testing of Hypotheses. Also Curve Fitting is very much essential to find the statistical averages that occur in the above areas. The course is designed to impart the knowledge and understanding of the above concepts to Electrical Engineers and apply them in their areas of specialization.

Prerequisite

- NIL

Course Outcomes

On the successful completion of the course, students will be able to

COs	Course Outcomes	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Apply various concepts to solve linear equations and system of linear equations.	TPS3	75	70
CO2	Apply numerical differentiation, numerical integration	TPS3	75	70
CO3	Build expected values using standard distributions for discrete and continuous random variables	TPS3	70	65
CO4	Apply the concept of testing of hypotheses for small and large samples using various tests.	TPS3	70	65
CO5	Construct complex analytic function.	TPS3	70	65
CO6	Organize the value of integrals of functions of complex variable .	TPS3	70	65

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	S		S	-	-	-	-	L	-	-	L	S	S
CO2	S	S		S	-	-	-	-	L	-	-	L	S	S
CO3	S	M			-	-	-	-	L	-	-	L	S	S
CO4	S	S	S		-	-	-	-	L	-	-	L	S	S
CO5	S	S	S		M	-	-	-	L	-	-	L	S	S
CO6	S	S	S		M	-	-	-	L	-	-	L	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I		Assessment - II		Terminal Exam
	CAT – I	Assg. I	CAT – II	Assg. II	

Bloom's Scale CO	(%)			(%)			(%)			(%)			(%)		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	-	25	-	-	25	-	-	-	-	-	-	-	3	10
CO2	3	10	12	-	-	25	-	-	-	-	-	-	-	3	9
CO3	7	10	33	-	-	50	-	-	-	-	-	-	-	9	16
CO4	-	-	-	-	-	-	7	10	33	-	-	50	-	9	16
CO5	-	-	-	-	-	-	-	-	20	-	-	20	-	3	7
CO6	-	-	-	-	-	-	3	10	17	-	-	30	-	3	12
Total	**10**	**20**	**70**	-	-	**100**	**10**	**20**	**70**	-	-	**100**	-	**30**	**70**

*Terminal examination should cover all Course Outcomes in the appropriate TPS Scale level.

Syllabus

Numerical Methods: Introduction to Numerical solution – Regula-Falsi method - Newton Raphson method – Gauss elimination method – Gauss-Jordan method – Gauss Seidel methods. Numerical differentiation using Newton's forward and backward interpolation formula – Introduction to Numerical integration -Trapezoidal rule –Simpson's rules. **(12 Hours)**

Probability Distribution: Random variables – Probability distributions for discrete and continuous random variables –Probability mass function, Probability density functions – Cumulative distribution functions and expected values – Binomial Distribution - Normal Distribution. **(12 Hours)**

Testing of Hypothesis: Tests of Hypotheses and Tests of significance – Errors in Testing of Hypotheses – Tests of significance for large samples (Mean and Proportion)- Tests of significance for small samples (t-test) **(12 Hours)**

Complex Differentiation and Integration: Introduction to functions of complex variables - Analytic functions – C-R equations –– Taylor series – Laurent's series - Singularities – Residues – Cauchy's residue theorem. **(12 Hours)**

Reference Books

1. B.S.Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2018.
2. P.Kandasamy,K.Thilagavathy,K.Gunavathi, Numerical methods, S.Chand & Company Ltd, New Delhi,8th Edition, 2013.
3. T.Veerarajan, Probability Statistics And Random Processes, Tata Mc graw hill,2018.

Course Contents and Lecture Schedule

Module No.	Topic	No. Of Hours
1.	**Numerical Methods**	
1.1	Introduction to numerical solution and Regula-Falsi method	1
1.2	Newton Raphson method	1
1.3	Gauss elimination and Gauss Jordan Methods	2
	Tutorial	1
1.4	Gauss Seidel methods	1
1.5	Numerical differentiation using Newton's forward interpolation formula	2
1.6	Numerical differentiation using Newton's backward interpolation formula	1
	Tutorial	1
1.7	Trapezoidal rule and Simpson's rules for Numerical integration	2
2	**Probability Distribution**	
2.1	Random variables	1
2.2	Probability distributions for Discrete and Continuous random variables	2
	Tutorial	1
2.3	Probability density functions – Cumulative Distribution functions	2
2.4	Expected values	1
	Tutorial	1
2.5	Binomial Distribution	2
2.6	Normal Distribution	1
	Tutorial	1
3	**Testing of Hypothesis**	
3.1	Tests of Hypotheses and Tests of significance - Errors in Testing of Hypotheses	2
3.2	Tests of significance for large samples (Mean)	2
	Tutorial	1
3.3	Tests of significance for large samples (Proportion)	2
	Tutorial	1
3.4	Tests of significance for small samples (t-test)	3
	Tutorial	1
4	**Complex Differentiation and Integration**	
4.1	Introduction to functions of complex variables and complex differentiation	2
4.2	Analytic functions	2
	Tutorial	1
4.3	Taylors' and Laurent's series	2
4.4	Classification of singularities	1

	Tutorial	1
4.5	Evaluation of integrals using Cauchy's Residue theorem	2
	Tutorial	1
	Total No. of Hours	**48**

Course Designer(s):

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