Department of Electrical Engineering

Teaching Scheme of B. Tech.-I (Semester I & II)
(Electrical Engineering)

SEMESTER – I (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-I	MA 101 S1	3-1-0	04
2	Physics-I	PH 102 S1	3-0-2	04
3	Branch Specific Course -I (Basic Electrical Engineering)	EE 103 S1	3-0-2	04
4	Chemistry	CY 104 S1/S2	3-0-2	04
5	Engineering Drawing	CIME 105 S1/S2	2-0-4	04
6	Energy and Environmental Engineering	CIME 106 S1/S2	3-0-2	04
7	Holistic Empowerment and Human Values*	HU 107 S1/S2	3-0-0	00
		Total	**20-1-12=33**	**24**

* Audit Course (attendance would be compulsory as per institute norms)

SEMESTER – II (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-II	MA 112 S2	3-1-0	04
2	Physics-II	PH 113 S2	4-0-0	04
3	Branch Specific Course -II (Electronics Devices & Circuits)	EC 114 S2	3-0-2	04
4	Engineering Mechanics	AM 108 S2/S1	3-0-2	04
5	Fundamentals of Computers & Programming	CO 109 S2/S1	3-0-2	04
6	English & Professional Communications	HU 110 S2/S1	3-0-0	03
7	Workshop Practice	ME 111 S2/S1	0-0-4	02
		Total	**19-1-10=30**	**25**

S1 = Semester-1, S2 = Semester-2
AM = Applied Mechanics, CH = Chemical, CI = Civil, CO = Computer,
ME = Mechanical, EE = Electrical, EC = Electronics,
PH = Physics, CY = Chemistry, MA = Mathematics, HU = Humanities, MG = Management

Department of Electrical Engineering

Teaching Scheme of B. Tech.-I (Semester I & II)
(Electrical Engineering)
SEMESTER – I (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-I	MA 101 S1	3-1-0	04
2	Physics-I	PH 102 S1	3-0-2	04
3	Branch Specific Course -II (Electronics Devices & Circuits)	EC 114 S1	3-0-2	04
4	Engineering Mechanics	AM 108 S2/S1	3-0-2	04
5	Fundamentals of Computers & Programming	CO 109 S2/S1	3-0-2	04
6	English & Professional Communications	HU 110 S2/S1	3-0-0	03
7	Workshop Practice	ME 111 S2/S1	0-0-4	02
		Total	**18-1-12=31**	**25**

Semester – II (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-II	MA 112 S2	3-1-0	04
2	Physics-II	PH 113 S2	4-0-0	04
3	Branch Specific Course -I (Basic Electrical Engineering)	EE 103 S2	3-0-2	04
4	Chemistry	CY 104 S1/S2	3-0-2	04
5	Engineering Drawing	CIME 105 S1/S2	2-0-4	04
6	Energy and Environmental Engineering	CIME 106 S1/S2	3-0-2	04
7	Holistic Empowerment and Human Values*	HU 107 S1/S2	3-0-0	00
		Total	**21-1-10=32**	**24**

* Audit Course (attendance would be compulsory as per institute norms

S1 = Semester-1, S2 = Semester-2

AM = Applied Mechanics, CH = Chemical, CI = Civil, CO = Computer,
ME = Mechanical, EE = Electrical, EC = Electronics,
PH = Physics, CY = Chemistry, MA = Mathematics, HU = Humanities, MG = Management

Department of Electrical Engineering

SEMESTER – III (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-III	MA217	3-1-0	04
2	Electric Circuits	EE201	4-1-0	05
3	Electrical Machines I	EE203	3-1-2	05
4	Digital Circuits	EC211	3-1-2	05
5	Introduction to Data Structure	CS207	3-0-2	04
		Total	**16-4-6=26**	**23**

SEMESTER – IV (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Applications of Numerical Methods in Electrical Engineering (to be taught by the concerned Department)#	EE202	3-1-2	05
2	Electrical Machines II	EE204	3-1-2	05
3	Elements of Power Systems	EE206	3-1-2	05
4	Electromagnetic Field Theory	EE208	3-1-0	04
5	Signals & Systems	EE212	3-1-0	04
		Total	**15-5-6=26**	**23**

Resolution 4 of 56th IAAC meeting held on 19/05/2022

Department of Electrical Engineering

SEMESTER –V (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Professional Ethics, Economics & Management	HU301	3-1-0	04
2	Power System Analysis	EE301	3-1-2	05
3	Control Systems	EE303	3-1-2	05
4	Power Electronic Converters	EE305	3-1-2	05
5	EIS-I	--	3-0-0	03
6	Electrical and Electronic Measurements	EE307	3-1-2	05
7	Seminar	EE309	0-0-2	01
		Total	**18-5-10=33**	**28**

SEMESTER –VI (Effective from 2022-2023)

Sr. No.	Subject	Code	Scheme	Credit
1	Power Electronics System and Electric Drives	EE304	3-1-2	05
2	Microprocessor & Microcontrollers	EE306	3-1-2	05
3	Instrumentation	EE308	3-1-2	05
4	EIS-II	--	3-0-0	03
5	ES-I	EE3AA	3-0-0	03
6	ES-II	EE3BB	3-0-0	03
7	ES-III	EE3CC	3-0-0	03
		Total	**21-3-6=30**	**27**

Department of Electrical Engineering

<u>SEMESTER –VII</u> (Effective from 2023-2024)

Sr. No.	Subject	Code	Scheme	Credit
1	Microcontroller and Embedded 'C' Programming	EE401	3-0-2	04
2	Electrical Machine Design	EE403	3-1-0	04
3	Switch Gear and Protection	EE405	3-0-2	04
4	ES-IV	EE4AA	3-0-0	03
5	ES-V	EE4BB	3-0-0	03
6	ES-VI	EE4CC	3-0-0	03
7	Project	EE407	0-0-6	03
		Total	**18-1-10=29**	**24**

<u>SEMESTER –VIII</u> (Effective from 2023-2024)

Sr. No.	Subject	Code	Scheme	Credit
1	Internship Training in Industry/Academic Institute/Research Organization	EE402	0-0-20	10
		Total	**0-0-20=20**	**10**

Total credits= 184

ELECTIVE INTERDISCIPLINARY SUBJECTS- EIS-I (EE3XX) (INSTITUTE LEVEL)	
Course Code	Subject Name
EE361	Renewable Energy Sources
EE363	Optimization Methods
EE365	Forecasting and Planning Methods
EE367	Fundamental of Electrical Power Systems (Non-Electrical Students)
EE369	Modern Electrical Drives (Non-Electrical Students)
EE371	Introduction to Power Electronics Converters (Non-Electrical Students)

ELECTIVE INTERDISCIPLINARY SUBJECTS- EIS-II (EE3YY) (INSTITUTE LEVEL)	
Course Code	Subject Name
EE362	Industrial Automation and Process Control
EE364	State Variable Analysis
EE366	Energy Audit and Management
EE368	Advanced Materials for Energy Applications
EE372	Distributed Power Generation and Micro-grids
EE374	Electromagnetic Field Theory (Non-Electrical Students)

CORE ELECTIVE SUBJECTS- ES-I (EE3AA) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE322	Power Plant Engineering
EE324	Adaptive Control and Soft Computing
EE326	Utilization of Electrical Energy
EE328	Modelling and Simulation of Electrical Machines
EE332	Random Processes
EE334	Artificial Intelligent Techniques

CORE ELECTIVE SUBJECTS- ES-II (EE3BB) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE338	Power Quality Disturbances and Mitigations
EE342	High Voltage Engineering
EE344	FACTS Devices
EE346	Discrete-Time control Systems
EE348	Restructuring and Deregulation of Power Systems
EE352	Special Electrical Machines

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CORE ELECTIVE SUBJECTS- ES-III (EE3CC) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE354	Advanced Electrical Drives
EE356	Electronic Instrumentation and Control
EE358	Power System Transients
EE376	Advanced Industrial Automation
EE378	Reliability Evaluation of Electrical Systems
HU322	**Innovation, Incubation and Entrepreneurship (To be taught by DoAMH)**

CORE ELECTIVE SUBJECTS- ES-IV (EE4AA) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE421	Electrical Traction and Linear Machines
EE423	EHV AC Transmission
EE425	Advanced Power Electronics
EE427	Nonlinear and Optimal Control
EE429	Advanced Microcontroller (Digital Signal Controller)
EE431	Industrial Instrumentation
EE433	Power System Operation and Control
EE435	Wind and Solar Energy Conversion Systems

CORE ELECTIVE SUBJECTS- ES-V (EE4BB) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE437	Power Filter Technology
EE439	Smart Grid Technology
EE441	HVDC Transmission
EE443	Electric Vehicles
EE445	Digital Signal Processing
EE447	Modern Materials for Electrical Engineering
EE449	Special Electrical Machines and Drives

CORE ELECTIVE SUBJECTS- ES-VI (EE4CC) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE451	Switch Mode Power Supply
EE453	Computer Methods for Power Systems
EE455	Robotics
EE457	Communication Engineering
EE459	VLSI Technology
EE461	Antenna and Wave Propagation
EE463	Cryptography and Cyber Security for Smart Grid

APPENDIX: 2.1

Teaching Scheme of B. Tech.-I (Semester I & II)
DIVISION – A, B, C, D & E

SEMESTER – I

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-I	MA 101 S1	3-1-0	04
2	Physics-I	PH 102 S1	3-0-2	04
3	Branch Specific Course-I	XXXX 103 S1	3-1-0/3-0-2	04
4	Applied Chemistry	CY 104 S1/S2	3-0-2	04
5	Engineering Drawing	CEME 105 S1/S2	2-0-4	04
6	Energy and Environmental Engineering	CEME 106 S1/S2	3-0-2	04
7	Holistic Empowerment and Human Values*	HU 107 S1/S2	3-0-0	00
		Total	**20-2-10=32/ 20-1-12=33**	**24**

* Audit Course (attendance would be compulsory as per institute norms

SEMESTER – II

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-II	MA 112 S2	3-1-0	04
2	Physics-II	PH 113 S2	4-0-0	04
3	Branch Specific Course-II	XXXX 114 S2	3-1-0/3-0-2	04
4	Engineering Mechanics	AM 108 S2/S1	3-0-2	04
5	Fundamentals of Computer & Programming	CS 109 S2/S1	3-0-2	04
6	English & Professional Communication	HU 110 S2/S1	3-0-0	03
7	Workshop Practice	ME 111 S2/S1	0-0-4	02
		Total	**19-2-8=29/ 19-1-10=30**	**25**

S1 = Semester-1, S2 = Semester-2
AM = Applied Mechanics, CH = Chemical, CE = Civil, CS = Computer,
ME = Mechanical, EE = Electrical, EC = Electronics,
PH = Physics, CY = Chemistry, MA = Mathematics, HU = Humanities

Branch Specific Course: First two letters indicate branch for which the course is offered and the last two letters indicate the department which is offering the course

Teaching Scheme of B. Tech.-I (Semester I & II)
DIVISION – F, G, H, I & J

SEMESTER – I

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-I	MA 101 S1	3-1-0	04
2	Physics-I	PH 102 S1	3-0-2	04
3	Branch Specific Course-I	XXXX 103 S1	3-1-0/3-0-2	04
4	Engineering Mechanics	AM 108 S2/S1	3-0-2	04
5	Fundamentals of Computer & Programming	CS 109 S2/S1	3-0-2	04
6	English & Professional Communication	HU 110 S2/S1	3-0-0	03
7	Workshop Practice	ME 111 S2/S1	0-0-4	02
		Total	**18-2-10=30/ 18-1-12=31**	**25**

SEMESTER – II

Sr. No.	Subject	Code	Scheme	Credit
1	Mathematics-II	MA 112 S2	3-1-0	04
2	Physics-II	PH 113 S2	4-0-0	04
3	Branch Specific Course-II	XXXX 114 S2	3-1-0/3-0-2	04
4	Applied Chemistry	CY 104 S1/S2	3-0-2	04
5	Engineering Drawing	CEME 105 S1/S2	2-0-4	04
6	Energy and Environmental Engineering	CEME 106 S1/S2	3-0-2	04
7	Holistic Empowerment and Human Values*	HU 107 S1/S2	3-0-0	00
		Total	**21-2-8=31/ 21-1-10=32**	**24**

* Audit Course (attendance would be compulsory as per institute norms

S1 = Semester-1, S2 = Semester-2
AM = Applied Mechanics, CH = Chemical, CE = Civil, CS = Computer,
ME = Mechanical, EE = Electrical, EC = Electronics,
PH = Physics, CY = Chemistry, MA = Mathematics, HU = Humanities

Branch Specific Course: First two letters indicate branch for which the course is offered and the last two letters indicate the department which is offering the course

Branch Specific Courses for Electrical and Electronics Engineering Department

Basic Electrical Engineering

EEEE 103 S1
ECEE 103 S1

	L	T	P	Credit
Scheme	3	0	2	04

MAGNETIC CIRCUIT AND ELECTROMAGNETIC INDUCTION **(08 Hours)**
Amperes circuital law, analogy between electric & magnetic circuits, fringing, leakage, series, parallel, series-parallel circuits, Faradays law, Lenz law, self-inductance, mutual inductance, coefficient of mutual inductance, coefficient of coupling, inductance in series, parallel, series-parallel, Analysis of coupled coils, dot rule, conductively coupled equivalent circuit.

SERIES AND PARALLEL AC CIRCUITS **(06 Hours)**
Complex algebra and its application to circuit analysis, R-L, R-C, R-L-C series and parallel circuits, series and parallel resonance.

ELECTRICAL NETWORKS ANALYSIS **(10 Hours)**
Kirchhoff's Voltage Law, Kirchhoff's Current Law, independent and dependent sources, Mesh current and Nodal Voltage analysis, Super position theorem, Thevenin's theorem, Norton's theorem, Reciprocity theorem, Maximum power transfer theorem

POLYPHASE CIRCUITS **(06 Hours)**
Balanced three phase systems, star and mesh connections, calculations for balanced and unbalanced three phase networks, polyphase vector diagram, and measurement of power in three phase circuits.

SINGLE PHASE TRANSFORMERS **(04 Hours)**
Principle of transformer, construction - shell type, core type, transformer on no-load, with load, phasor diagram for transformer under no-load and loaded condition (with unity, lagging power factor load) equivalent circuit, open circuit and short circuit test, losses in the transformer, efficiency, voltage regulation.

THREE-PHASE INDUCTION MOTORS **(04 Hours)**
Rotating magnetic field, types of induction motor, Principle of operation, slip, different power stages, efficiency of the induction motor.

ELECTRIC WIRING AND ILLUMINATION **(04 Hours)**
Circuits in domestic wiring, simple control circuit in domestic installation, Types of lamps, fixtures & reflectors, illumination schemes for domestic, industrial & commercial premises, Lumen requirements for different categories, working principle of tube light (fluorescent tube) , LED.

Total Lecture Hours: 42

List of Practical

1. Power measurement in single phase R-L series circuit.
2. Power measurement in single phase R-C series circuit.
3. To study the working principle of tube light and fan.
4. Hysteresis loop on CRO.
5. Study the different types of wiring in electrical engineering.
6. Determination of single phase transformer equivalent circuit parameters using open-circuit and short circuit test.
7. Load test on single phase transformer.
8. Three phase power measurement using two wattmeter method.
9. Star- delta connection of three phase circuit.

BOOKS RECOMMENDED:

1. V. N. Mittle and Arvind Mittal, "Basic Electrical Engineering", 2nd edition, Tata McGraw-Hill Education 2005.
2. Edminister Joseph A., "Electrical circuits", Schaum's outline series, McGraw hill, 2nd edition, 1983
3. B. L. Theraja and A. K. Theraja, "A text book of Electrical Technology: Volume I: Basic Electrical Engineering", S. Chand, 2013.
4. Kothari Nagrath, " Basic Electrical Engineering", 2nd edition, Tata McGraw-Hill Education 2007.
5. A. chakrabarti, M. L. Soni, P.V. Gupta, U. S. Bhatnagar, "Power System Engineering", Dhanpatrai & Co., Second edition, 2013.
6. A.Chakrabarti, " Circuit Theory", Dhanpat Rai & Co. , Sixth edition, 2012

Branch Specific Courses for Computer Engineering Department

Electrical Networks

CSEE 103 S1

Scheme	L	T	P	Credit
	3	0	2	04

- **AC FUNDAMENTALS AND CIRCUITS** **(07 Hours)**
  Alternating voltages and currents through purely resistive inductive and capacitive circuits, R-L, R-C, R-L-C series circuits, impedance and admittance, circuits in parallel, series and parallel resonance, Complex algebra and its application to circuit analysis, Circuit Transient, Initial and Final Value Theorem, DC and Induction Machines, Electrical Measurements, Power System

- **POLYPHASE CIRCUITS AND TRANSFORMES** **(04 Hours)**
  Balanced three phase systems, Star and Mesh connections, Relation between Line and Phase quantities, Measurement of power, Principle of transformer, construction, transformer on no-load, with load, phasor diagram for transformer under no-load and loaded condition (with unity, lagging power factor load) equivalent circuit, open circuit and short circuit test, efficiency, voltage regulation.

- **NETWORK CONCEPTS** **(04 Hours)**
  Network element symbols and conventions, Active element conventions, current and voltage conventions, loops and meshes, Nodes, coupled circuits and Dot conventions.

- **MESH CURRENT AND NODE VOLTAGE NETWORK ANALYSIS** **(07 Hours)**
  Kirchhoff's Voltage Law, Kirchhoff's Current Law, Definitions of mesh current and nodal voltage, Choice of mesh currents or nodal voltages for network analysis, Self and mutual inductances, Mesh Equation in the Impedance Matrix Form by inspection, Solution of Linear Mesh Equations, Nodal Voltage Analysis Nodal Equations in the Form of Admittance Matrices by inspection, Solution of Linear Nodal Equations.

- **NETWORK THEOREMS AND GRAPH** **(07 Hours)**
  Linearity and Superposition, Independent and Dependent Source and their Transformations, Thevenin, Norton, Reciprocity and Maximum Power Transfer Theorems, Use of these theorems in Circuit Analysis, Duality and Dual of a Planner Network, Fundamental Concepts, Definition of Graph and Various Related Terms, Paths and Circuits Connections, Tree Of a Graph, Cut Sets and Tie Sets, Non-separable Planner and Dual Graphs, Matrices of Oriented Graphs, Properties and Inter-Relationship of Incidence, Tie Set and Cut Set Matrices, Complete Analysis Using Tie Set and Cut Set Matrices.

- **WAVE FORM ANALYSIS BY FOURIER SERIES** **(06 Hours)**
  Trigonometric and complex exponential forms, the frequency spectra of periodic wave forms, the Fourier Integral and continuous frequency spectra, Fourier transform and their relationship with Laplace transform.

- **NETWORK FUNCTIONS AND TWO PORT PARAMETERS** **(07 Hours)**
  Poles and zeros of a function, physical and analytical concepts, Terminal and terminal pairs, Driving point immitances, Transfer functions, Definitions, calculations and interrelationship of impedance, admittance, hybrid and transmission line parameters for four terminal networks. Image impedance and its calculations for symmetrical and unsymmetrical π, T and Ladder Networks.

(Total Lecture Hours: 42)

PRACTICALS

1. To study Ammeter and Voltmeter for current and voltage measurement in circuit
2. To study Energy meter
3. To study Power measurement method for three phase circuits using watt meter method
4. Verification of superposition theorem for electric circuit
5. Verification of Thevenin's theorem of electric circuit
6. Calculation and verification Norton's theorem
7. Open circuit and short circuit test for the transformers for efficiency calculation
8. Verification of Kirchhoff's current law and Kirchhoff's voltage law for electric circuit
9. Capacitance measurement of parallel plates
10. Calculation of efficiency of auto transformer

BOOKS RECOMMENDED

1. "Engineering Circuit Analysis", W.H.Hyat, J.E.Kemmerly, S.M.Durbin, 6thEdition, TMH, 2006.
2. "Network Analysis", Van Valkenburg M E, 3rd Edition, PHI, 2002.
3. "Network Theory, Analysis & Synthesis", Samarjit Ghosh, PHI, 2005.
4. "Network Analysis & Synthesis", C.L.Wadhwa, Revised 3rdEdition, New Age International Publishers, 2007.
5. "Basic Electrical Engineering", Kothari and Nagrath, 2nd edition, 2007, Tata McGraw-Hill Education.
6. "Basic Electrical Engineering", V. N. Mittle & Arvind Mittal, 2nd edition, 2005, Tata McGraw-Hill Education.

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
DEPARTMENT OF ELECTRICAL ENGINEERING

B. Tech. Programme

B. Tech. II

Semester III

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	MA217	Mathematics-III	3	1	0	04	100	25	-	-	125
2.	EE201	Electric Circuits	4	1	0	05	100	25	-	-	125
3.	EE203	Electrical Machines I	3	1	2	05	100	25	25	25	175
4.	EC211	Digital Circuits	3	1	2	05	100	25	25	25	175
5.	CS207	Introduction to Data Structure	3	0	2	04	100	00	25	25	150
		Total(L-T-P)	**16**	**04**	**06**	**23**	**500**	**100**	**75**	**75**	**750**
		Total		**26**		**23**					

Semester IV

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE202	Applications of Numerical Methods in Electrical Engineering	3	1	2	05	100	25	25	25	175
2.	EE204	Electrical Machines II	3	1	2	05	100	25	25	25	175
3.	EE206	Elements of Power Systems	3	1	2	05	100	25	25	25	175
4.	EE208	Electromagnetic Field Theory	3	1	0	04	100	25	-	-	125
5.	EE212	Signals & Systems	3	1	0	04	100	25	-	-	125
		Total(L-T-P)	**15**	**05**	**06**	**23**	**500**	**125**	**75**	**75**	**775**
		Total		**26**		**23**					

B. Tech. II year, Semester III

L	T	P	Credit
3	1	0	04

Mathematics-III

MA 217 Scheme

1. Course Outcomes (Cos):

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

CO1	explain the concept of convergence and divergence of infinite series
CO2	express the periodic functions in the form of Fourier series along with different cases.
CO3	compute Fourier Integral from Fourier series
CO4	explain the concept of Fourier transform with their applications
CO5	apply basic concept of the Linear Algebra to Electrical Engineering Problems

2. Syllabus

- **INFINITE SERIES** **(07 Hours)**
  Introduction, Positive term series, Comparison test, Cauchy's root test, D'Alembert's test, Raabe's test, Logarithmic test, Integral test, Gauss's test, Series with arbitrary terms, Rearrangement of terms.
- **FOURIER SERIES** **(07 Hours)**
  Definition, Fourier series with arbitrary period, in particular periodic function with period 2π. Fourier series of even and odd function, Half range Fourier series.
- **FOURIER INTEGRAL AND FOURIER TRANSFORMS** **(07 Hours)**
  Fourier Integral theorem, Fourier sine and cosine integral complex form of integral, Inversion formula for Fourier transforms, Fourier transforms of the derivative of a function.
- **MATRICES** **(07 Hours)**
  Properties of matrices, Non-singular Matrices, Reduced Row-Echelon form, Systems of linear equations, Solution of system of linear equations, LU Decomposition Method
- **EIGENVALUES AND EIGENVECTORS** **(07 Hours)**
  Eigenvalues and eigenvectors, Characteristic polynomials, Minimal polynomials, Diagonalizability, Triangularization, Rational canonical form, Jordon canonical form, Positive Define Matrices, Singular Value Decomposition.
- **VECTOR SPACE AND SUBSPACES** **(07 Hours)**
  Fields, Vector spaces over a field, subspaces, Linear independence and dependence, coordinates, Bases and dimension, Gram-Schmidt ortho-normalization, Orthonormal basis, Orthogonal projection.

  Tutorials will be based on the coverage of the above topics separately **(14 Hours)**

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. Books Recommended:

1. E. Kreyszig, Advanced Engineering Mathematics, 10^{th} Edition, John Wiley, 2015.
2. C. R. Wiely, Advanced Engineering Mathematics, 6^{th} Edition, McGraw-Hill, 1995.
3. O'Neil Peter, Advanced Engineering mathematics, 8^{th} Edition, Thompson, 2017.
4. D. Greenbar Michael, Advanced Engineering Mathematics, Pearson Singapore Indian Edition, 2007.
5. Sheldon Axler, Linear Algebra Done Right, 3^{rd} Edition, Springer. 2015.

B. Tech. II year, Semester III

Electrical Circuits

L	T	P	Credit
4	1	0	05

EE 201 **Scheme**

1. Course Outcomes (Cos):

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

CO1	apply concept of graph theory for solution of AC and DC circuits.
CO2	develop a mathematical model (differential equations) of a given electric circuit and solve it using technique of domain transformation.
CO3	construct a given waveform by using set of standard functions.
CO4	calculate various parameters of two port network and inter relationship between them.
CO5	design filter circuits for given specifications.

2. Syllabus

- **GRAPH THEORY AND ITS APPLICATIONS** **(10 Hours)**
  Fundamental concepts, definitions of a graph and various related terms, cut sets and tie sets, matrices of oriented graphs, properties and inter relationships of incidence, tie set and cut set matrices, complete circuit analysis using tie set and cut set techniques
- **LAPLACE TRANSFORMATION** **(09 Hours)**
  Laplace transform properties and theorems, Laplace transform of standard functions, Laplace transforms for periodic functions, initial and final value theorems, Inverse Laplace transform using partial fraction expansion and convolution integral methods. Waveform synthesis.
- **NETWORK FUNCTIONS AND TWO PORT PARAMETERS** **(16Hours)**
  Poles and zeros of a function, physical and analytical concepts, terminals and terminal pairs, driving point immittances, transfer functions, restrictions on locations of poles and zeros in S-plane. time domain behavior from pole zero locations in the S plane, procedure for finding network functions for general two terminal pair network, transfer immittances, two port and N-port networks, Ladder, Lattice, Pie, and Tee networks. Definitions, calculations and interrelationships of impedance, admittance, hybrid, and transmission line parameters for two port networks and their interrelations
- **ONE TERMINAL PAIR NETWORKS** **(05 Hours)**
  Reactive networks and their properties, external and internal critical frequencies, separation property for reactive functions and its proof
- **TWO TERMINAL PAIR REACTIVE NETWORKS (FILTERS)** **(08Hours)**
  Ladder network and its decomposition into tee, pie, and L sections, image impedance, image transfer function and applications to LC networks, attenuation and phase shift in symmetrical Tee and Pie networks, constant K-filters, m-derived filters, composite filters, lattice filters, Bartlett’s bisection theorem. Introduction to the active filters
- **AC AND DC TRANSIENTS** **(08 Hours)**
  Initial and final conditions of networks and their S-domain equivalent circuits , R-L, R-C and R-L-C DC transients, two mesh transients, R-L, R-C and R-L-C sinusoidal transient analysis using Laplace transform methods, two mesh AC transients, complete response of RL, RC and RLC circuits to step, sinusoidal, exponential, ramp, impulse and the combinations of these excitations.

Total Hours: 56

Tutorials will be conducted separately for 14 hours

3. **Books Recommended**:

1. W. H. Hayt, J. E. Kemmerly, and Durbin S. M., Engineering Circuit Analysis, Tata McGraw Hill, 6^{th} Edition, 2006.
2. M.E. Van Valkenburg, Network Analysis, Prentice Hall, India, 3^{rd} Edition, 2002.
3. A. Chakrabarti, Circuit Theory, Dhanpat Rai & Co., 6^{th} Edition, 2012.
4. A. Edminister Joseph, Electrical circuits, Schaum's outline series, McGraw hill, 2^{nd} Edition, 1983.
5. Charles K. Alaxander and Matthew N.O. Sadiku, Fundamentals of electric circuits, Tata McGraw Hill, 5^{th} Edition, 2013.

B. Tech. II year, Semester III

L	T	P	Credit
3	1	2	05

Electrical Machines – I

EE203 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the construction and principle of operation of the transformers and induction motors.
CO2	perform tests on the transformers and induction motors
CO3	analyze the performance of the transformers and induction motors
CO4	compare the performance of different types of transformers and induction motors
CO5	select the machines for different real world applications
CO6	communicate effectively through laboratory report writing, presentation and perform task as an efficient team member

2. Syllabus

- **TRANSFORMERS** **(06 Hours)**
  Review of equivalent circuits and vector diagram, circuit parameter determination, per unit impedance, regulation, losses, efficiency, magnetic inrush and effect of saturation, parallel operation.
- **POLYPHASE TRANSFORMERS** **(09 Hours)**
  Standard connections phase angle difference, harmonic analysis, open delta connection, Scott connections, three-phase to six-phase conversion, three winding transforms and parallel operation.
- **AUTO TRANSFORMERS** **(02 Hours)**
  Construction, voltage and current ratios, phasor diagram and equivalent circuit.
- **TESTS ON TRANSFORMERS** **(04 Hours)**
  OC- SC tests, Polarity test, Back to back Sumpner's test.
- **THREE-PHASE INDUCTION MOTORS** **(07 Hours)**
  Review of equivalent circuit and vector diagram, performance analysis, torque-speed characteristics, no load and blocked rotor tests, circle diagram.
- **STARTING, BRAKING AND SPEED CONTROL** **(07 Hours)**
  Double cage motors, starting problems, methods of starting, speed control methods, cascade connections, cogging and crawling, regenerative braking, plugging, ac and dc dynamic (rheostatic) braking.
- **INDUCTION GENERATORS AND REGULATOR** **(03 Hours)**
  Principle of operation, performance analysis, application.
- **SINGLE PHASE INDUCTION MOTORS** **(04 Hours)**
  Principle of operation, revolving field theory, cross field theory, equivalent circuit and performance analysis, determination of circuit parameters by no- load and blocked rotor test, starting methods, unbalanced operation of three phase induction motor.

Total Hours:42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. Determination of efficiency & regulation of single- phase transformer from Open circuit and short circuit test.
2. Determination of efficiency & regulation of single- phase transformer from Sumpner's test.
3. Scott connection of 1-phase transformers.
4. Open delta connection of three single-phase transformers.
5. Standard connections for three-phase transformer.
6. Load test on three-phase Induction Motor.
7. Load test on three-phase Induction Generator.
8. Determination of the equivalent circuit parameters from No-Load and Blocked rotor tests of three-phase Induction Motor.
9. Determination of the equivalent circuit parameters from No-Load and Blocked rotor tests of 1-phase Induction Motor.
10. Determination of the performance parameters of three-phase induction motor from circle diagram.
11. Induction regulator.
12. Unbalanced operation of three-phase Induction Motor.

4. Books Recommended:

1. I. J. Nagrath and D. P. Kothari, Electric Machines, Tata McGraw Hill, New Delhi, 2005.
2. M. G. Say, The performance and design of alternating current machines, CBS Publishers and Distributors, Delhi, 1983.
3. Fitzgerald, Kingsley and Umans, Electric Machinery, Tata McGraw Hill, New Delhi, 2003
4. S. K. Sen, Electrical Machinery, Khanna Pub., Delhi, 2012.
5. Mukherjee and Chakravorty, Electrical Machines, Dhanpat Rai Pub., New Delhi, 2005.

B. Tech. II year, Semester III

L	T	P	Credit
3	1	2	05

Digital Circuits

EC211 **Scheme**

1. Course Outcomes (Cos):

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

CO1	apply Boolean algebra to understand binary logic and logic circuits.
CO2	formulate combinational logic problems and solve using truth table. Optimize using K-map and other equivalent techniques
CO3	investigate and realize various options for implementing sequential synchronous logic
CO4	explain operation of synchronous sequential circuit, counters, registers and memory
CO5	formulate RTL (register transfer language) statements to describe complex digital hardware and derive or infer logic circuit from RTL Description
CO6	design and analyze circuits for ALU and Shifter. Design and investigate various Control unit architecture (Hardwired, Micro-program, PLA etc.) to control and sequence hardware operations

2. Syllabus:

- **BOOLEAN ALGEBRA AND SIMPLIFICATION** **(08 Hours)**
  Basic Logic Operation and Logic Gates, Truth Table, Basic Postulates and Fundamental Theorems of Boolean Algebra, Standard Representations of Logic Functions- SOP and POS Forms, Simplification of Switching Functions-K-Map and Quine-McCluskey Tabular Methods, Synthesis of Combinational Logic Circuits
- **COMBINATIONAL LOGIC CIRCUITS** **(08 Hours)**
  Binary Parallel Adder, BCD Adder, Encoder Priority Encoder, Decoder, Multiplexer and De-multiplexer Circuits, Implementation of Boolean Functions using Decoder and Multiplexer, Arithmetic and Logic Units, BCD-To-Segment Decoder, Common Anode and Common Cathode, 7-Segment Displays, Random Access Memory, Read Only Memory and Erasable Programmable ROMs, Programmable Logic Arrays(PLA) and Programmable Array Logic(PAL)
- **LATCHES AND FLIP-FLOPS** **(06 Hours)**
  Cross Coupled SR Flip-Flop Using NAND or NOR Gates, Clocked Flip-flops, D-Types and Toggle Flip-flops, Truth Tables and Excitation Tables for Flip-flop. Master Slave Configuration, Edge Triggered and Level Triggered Flip-flop, Flip-flop with Preset and Clear
- **SEQUENTIAL LOGIC CIRCUIT** **(06 Hours)**
  Introduction to State Machine, Mealy and Moore Model, State Machine Notation, State Diagram, State Table, Transition Table, Table Excitation, Table and Equation, Basic Concepts of Counters and Register, Shift Left and Right Register, Registers with Parallel Load, Serial-in-Parallel-Out(SIPO) and Parallel-In-Serial-Out(PISO), Register Using Different Types of Flip-flop, Binary Counters, BCD Counters, Up Down Counter, Johnson Counter, Module-N Counter, Design of Counter using State Diagrams and Tables, Sequence Generators
- **REGISTER TRANSFER LOGIC** **(04 Hours)**
  Arithmetic Logic and Shift Micro-Operation, Conditional Control Statements, Fixed-Point and Floating-Point Data, Arithmetic Shifts, Instruction code and Design of Simple Computer
- **PROCESSOR DATA PATH AND CONTROL UNIT** **(06 Hours)**
  Processor Organization, Design of Arithmetic Logic Unit (ALU), Design of Accumulator, Control Organization, Hard-Wired Control, Micro Program Control, Control of Processor Unit, PLA Control

- **INTRODUCTION TO VHDL** **(04 Hours)**
  Introduction, Gate-Level Modeling, Data Type, Operators, Operands, Process and Behavioral Modeling, Timing Controls, Structural modeling, Registers, Flip-flop, Counter, Multiplexer, Adder/Subtractors, Tri-State Buffers
- **TUTORIALS** **(14 Hours)**

Total Hours:42

Tutorials will be conducted separately for 14 hours

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3. List of Experiments:

(Following experiments are to be performed using discrete components)

1. Introduction to variety of logic gates and digital ICs
2. Flip-flops using NAND/ NOR Gate.
3. Half-Adder/ Half-subtarctor Circuits using a serial Input.
4. Full-Adder/ Full-subtarctor Circuits using a serial Input.
5. Parity checker and parity generator circuit
6. 4-Bit Gray to Binary, Binary to Gray Code convertor using Select input.

(Following experiments are to be performed on CPLD kit using VHDL)

7. Logic expression with the Help of MUX IC 74153.
8. (a) Modulo-7 Ripple Counter with synchronous reset.
   (b) 4-bit up/down ripper counter with asynchronous reset
9. 4-Bit Shift Left/Right Register.
10. Sequence Generator using LFSR method.
11. Excess-3 BCD Adder/ Subtractor with Select Input.

4. Books Recommended:

1. Mano Morris, Digital Logic and Computer Design, Pearson Education, 4th Edition, 2006.
2. Anand Kumar, Fundamentals of Digital Circuits, PHI, 4th Edition, 2016.
3. R. P. Jain and M. H. S. Anand, Digital Electronics Practices using Integrated Circuits, Tata McGraw Hill, 1st Edition, 2004.
4. Lee Samual, Digital Circuits and Logic Design, PHI, 1st Edition, 1998.
5. Floyed Thomas L. and R. P. Jain, Digital Fundamentals, Pearson Education, 8th Edition, 2006.
   Brown S. and Zvonko Vranesic, Fundamental of Logic with Verilog Design, Tata McGraw Hill, 1st Edition, 2003.

B. Tech. II year, Semester III

Introduction to Data Structures

L	T	P	Credit
3	0	2	04

CS207 **Scheme**

1. Course Outcomes (Cos):

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

CO1	recognize the need of different data structures and understand its characteristics.
CO2	apply different data structures for given problems.
CO3	design and analyze different data structures, sorting and searching techniques.
CO4	evaluate data structure operations theoretically and experimentally.
CO5	solve for complex engineering problems.

2. Syllabus

- **BASICS OF DATA STRUCTURES** **(02 Hours)**
  Review of Concepts: Information and Meaning, Abstract Data Types, Internal Representation of Primitive Data Structures, Arrays, Strings, Structures, Pointers.

- **LINEAR LISTS** **(06 Hours)**
  Sequential and Linked Representations of Linear Lists, Comparison of Insertion, Deletion and Search Operations for Sequential and Linked Lists, Doubly Linked Lists, Circular Lists, Lists in Standard Template Library (STL), Applications Of Lists.

- **STACKS** **(06 Hours)**
  Sequential and Linked Implementations, Representative Applications such as Recursion, Expression Evaluation Viz., Infix, Prefix and Postfix, Parenthesis Matching, Towers of Hanoi, Wire Routing in a Circuit, Finding Path in a Maze.

- **QUEUES** **(06 Hours)**
  Operations of Queues, Circular Queue, Priority Queue, Dequeue, Applications of Queues, Simulation of Time Sharing Operating Systems, Continuous Network Monitoring System Etc.

- **SORTING AND SEARCHING** **(04 Hours)**
  Sorting Methods, Bubble Sort, Selection Sort, Quick Sort, Radix Sort, Bucket Sort, Dictionaries, Hashing, Analysis of Collision Resolution Techniques, Searching Methods, Linear Search, Binary Search, Character Strings and Different String Operations.

- **TREES** **(08 Hours)**
  Binary Trees and Their Properties, Terminology, Sequential and Linked Implementations, Tree Traversal Methods and Algorithms, Complete Binary Trees, General Trees, AVL Trees, Threaded Trees, Arithmetic Expression Evaluation, Infix-Prefix-Postfix Notation Conversion, Heaps as Priority Queues, Heap Implementation, Insertion and Deletion Operations, Heapsort, Heaps in Huffman Coding, Tournament Trees, Bin Packing.

- **MULTIWAY TREES** **(04 Hours)**
  Issues in Large Dictionaries, M-Way Search Trees, B Trees, Search, Insert and Delete Operations, Height of B-Tree, 2-3 Trees, Sets and Multisets in STL.

- **GRAPHS** **(06 Hours)**
  Definition, Terminology, Directed and Undirected Graphs, Properties, Connectivity in Graphs, Applications, Adjacency Matrix and Linked Adjacency Chains, Graph Traversal, Breadth First and

Depth First Traversal, Spanning Trees, Shortest Path and Transitive Closure, Activity Networks, Topological Sort and Critical Paths.

Total Hours: 42

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3. List of Experiments:

(Problem statements will be changed every year and will be notified on website.):

1 Implementation of Array and its applications
2 Implementation of Stack and its applications
3 Implementation of Queue and its applications
4 Implementation of Link List and its applications
5 Implementation of Trees and its applications
6 Implementation of Graph and its applications
7 Implementation of Hashing functions and collision resolution techniques
8 Mini Project (Implementation using above Data Structure)

4. Books Recommended:

1. Trembley and Sorenson, An Introduction to Data Structures with Applications, 2^{nd} Edition, Tata McGraw Hill, 1991.
2. Tanenbaum and Augenstein, Data Structures using C and C++, 2^{nd} Edition, Pearson, 2007.
3. Horowitz and Sahani, Fundamentals of Data Structures in C, 2^{nd} Edition, Silicon Press, 2007.
4. T. H. Cormen, C. E. Leiserson, and R. L. Rivest, Introduction to Algorithms, 3^{rd} Edition, MIT Press, 2009.
5. Robert L. Kruse, C. L. Tondo and Brence Leung, Data Structures and Program Design in C, 2^{nd} Edition, Pearson Education, 2001.

B. Tech. II year, Semester IV

Applications of Numerical Methods in Electrical Engineering

L	T	P	Credit
3	1	2	05

EE202 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Explain various numerical methods.
CO2	Compare their convergence rate, errors and propagation of error.
CO3	Implement the algorithms through software like on C/C++/MATLAB.
CO4	Apply the numerical methods for solving problems related to electrical engineering.
CO5	Modeling various systems and perform regression analysis.

2. Syllabus:

- **ERRORS IN NUMERICAL COMPUTATION AND THEIR ESTIMATION (04 Hours)**
  Introduction, Taylor Theorem Revisit, Measuring Errors, Sources of Error, Binary Representation, Floating Point Representation, Propagation of Errors.
  Application: errors in electrical measurements and instrumentations

- **SOLUTION OF TRANSCENDENTAL AND POLYNOMIAL EQUATIONS (07 Hours)**
  Bisection method, Secant Method, False position method, Newton Raphson method for Polynomial and transcendental equations, system of nonlinear equations, rate of convergence, conditions for convergence

- **SOLUTION TO SYSTEM OF LINEAR ALGEBRAIC EQUATIONS (08 Hours)**
  Gauss elimination method, Gauss Jordon Method, LU decomposition, Jacobi and Gauss Seidel Iteration methods, conditions for convergence
  Applications: solution to mesh and nodal analysis of electrical networks, solution to power load flow, operation of different electrical applications

- **INTERPOLATION AND REGRESSION (11 Hours)**
  Direct method of interpolation, Linear interpolation and higher order interpolation using Lagrange's and Newton's forward, backward and divided difference formulae, linear, quadratic, exponential and logarithmic regression, adequacy of regression models.
  Applications: prediction of the performance of electrical motors and generators from their practical data, application to load forecasting and generation scheduling, prediction of solar intensity and wind velocity.

- **NUMERICAL INTEGRATION (03 Hours)**
  Trapezoidal rule, Simpson's 1/3 and 3/8 rules and Errors
  Applications: average, RMS quantity determination of electrical measuring quantities, load demand calculations.

- **SOLUTION TO ORDINARY DIFFERENTIAL EQUATIONS (09 Hours)**
  Taylor series, Euler's method, Euler's predictor corrector method, Runge-Kutta method of Second and Fourth Order, higher order/coupled ordinary differential equation
  Applications: DC and AC transients of electrical networks, solution for generators oscillations

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

The programmes are to be executed in C++/MATLAB

1. To find the roots of the polynomial using bisection, false position, Newton-Raphson, secant methods
2. To find the solution of set of nonlinear equations using Newton-Raphson method
3. To find the numerical integration suing trapezoidal, Simpson's 1/3 and Simpson's 3/8 method
4. To find the interpolating polynomial using Linear, Lagrangian, Newton's forward, backward and divided difference methods
5. To find the solution to set of linear simultaneous equations using Gauss elimination, Gauss-Jordan, Jacobi and Gauss-Seidel methods
6. To find the solution to ordinary differential equations using Euler's, modified Euler's, Runge-Kutta 2^{nd} order and 4^{th} order methods
7. To regress a given set of data using polynomial, exponential and logarithmic regression formulae

4. Books Recommended:

1. S. S. Shastri, Introductory Methods of Numerical Analysis, Prentice Hall Ltd., 4^{th} Edition, 2005.
2. M. K. Jain, M. K. Iyengar and S.R.K., Jain, Numerical Methods for Scientific and Engineering Computation, 4^{th} Edition, 2003, New Age international Publishers, Pvt. Ltd.
3. S. A. Teukolsky W. T. Vetterling, W. H. Press and B. P. Flannery, Numerical recipes in 'C', 2^{nd} Edition, Foundation Books Pvt. Ltd., 2001.
4. R. S. Salaria, Numerical methods: A computer oriented approach, BPB Publications, 1996.
5. S. D. Conte and Carl de Boor, Elementary Numerical Analysis- An Algorithmic Approach, 3^{rd} Edition, McGraw-Hill, 1980.

B. Tech. II year, Semester IV

Electrical Machines – II

L	T	P	Credit
3	1	2	05

EE204 Scheme

1. COURSE OUTCOMES (COs):

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

CO1	explain the construction and principle of operation of the DC machines and synchronous machines
CO2	perform tests on the DC machines and synchronous machines
CO3	analyze the performance of the DC machines and synchronous machines
CO4	compare the performance of different types of DC machines and synchronous machines
CO5	select the machines for different real world applications
CO6	communicate effectively through laboratory report writing, presentation and perform task as an efficient team member

2. SYLLABUS

- **DIRECT CURRENT MACHINES** **(09 Hours)**
  Construction, armature windings, simple lap and wave windings, armature reaction, demagnetizing and cross magnetizing ampere-turns, compensating winding, commutation, commutation time and type, reactance voltage, inter-poles, ampere-turns for inter-poles, self and separate excitations, shunt, series and compound motors and generators, magnetization characteristics, performance characteristics of DC generators and motors.

- **STARTING, SPEED CONTROL AND BRAKING OF DC MACHINES** **(06 Hours)**
  Starting problems, methods of starting, starters, methods of speed control, methods of braking.

- **TESTING OF DC MACHINES** **(05 Hours)**
  Swinburne's test, Hopkinson's test, separation of core losses, retardation test, series field test.

- **BRUSHLESS D.C. MACHINES** **(03 Hours)**
  Construction, equivalent circuit, performance analysis.

- **SYNCHRONOUS MACHINES**
  Construction, cylindrical and salient pole type, basic principles, armature windings, distributed winding, full pitched windings, chording, EMF equation, distribution and pitch factors, excitation system, **(04Hours)**
  armature reaction, synchronous machine impedance, SCR, equivalent circuit, phasor diagram, voltage regulations, synchronous impedance method, MMF method, ZPF method, operating characteristics **(05Hours)**
  'V' and inverted 'V' curves, power angle characteristics, power flow equation for salient and non-salient pole type synchronous machines, salient pole synchronous machine - two reaction model, phasor diagram, **(05 Hours)**
  power angle characteristic, hunting, damper winding, parallel operation of alternators, starting methods of synchronous motors, synchronous condenser, synduction machines **(05Hours)**

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. LIST OF EXPERIMENTS:

1. Speed control of dc shunt motor.
2. Swinburne’s test
3. Speed torque characteristic of a D. C. Shunt motor.
4. D. C. Series motor, Speed -torque characteristic.
5. External & Internal characteristics of D. C. separately excited and Shunt generator.
6. Regulation of an alternator by synchronous impedance method
7. 'V' and 'inverted V' curves of a synchronous motor.
8. Regulation of an alternator by zero power factor method
9. Regulation of an alternator by MMF method.
10. Synchronization of an alternator with infinite bus bar.
11. Power factor improvement using synchronous motor.
12. Hopkinson’s Test on DC machines.
13. Retardation Test on DC Shunt motor.
14. Separation of core losses of DC machines.

4. BOOKS RECOMMENDED:

1. Nagrath and Kothari, “Electric Machines”, TMH, New Delhi, 2005.
2. M. G. Say, The performance and design of alternating current machines, CBS Publishers and Distributors, Delhi, 1983.
3. A. E. Clayton and N. M. Hancock, The Performance and Design of Direct Current Machines, CBS Publishers, 2004.
4. P. K. Mukherjee and S. Chakravorty, Electrical Machines, Dhanpat Rai Pub., New Delhi, 2005.
5. Fitzgerald, Kingsley and Umans, Electric Machinery, Tata McGraw Hill, New Delhi, 2003.

B. Tech. II year, Semester IV

L	T	P	Credit
3	1	2	05

Elements of Power Systems

EE206 Scheme

1. Course Outcomes (Cos):

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

CO1	classify and analyze the electrical power transmission and distribution.
CO2	compute the cost of power generation and the cost of electricity.
CO3	design the transmission line and analyze the performance of transmission lines.
CO4	analyze the performance of the underground cable.
CO5	Simulate/model the power system components in MATLAB/ETAP platforms and analyze the numerical results.

2. SYLLABUS:

- **SUPPLY SYSTEMS** **(04 Hours)**
  AC and DC power supply systems, comparison of ac and dc transmission, advantages of high transmission voltage, various systems of power supply, comparison of conductor materials in overhead system and underground cable system, economic choice of conductor size and economic choice of voltage.

- **D.C. AND A. C. DISTRIBUTION** **(06 Hours)**
  Types of dc distributors, dc distribution calculations, ac distributor, fed at one and fed at both the ends with concentrated loads and uniformly distributed loads, ring distributors with inter connectors, current distribution in three wire and four wire ac systems, overview of distribution automation.

- **ECONOMIC ASPECTS OF POWER SYSTEM** **(06 Hours)**
  Power factor improvement, Tariff structure, ABT, Economic aspects of power generation.

- **UNDERGROUND CABLES** **(05 Hours)**
  Underground cables, construction of cables, classification of cables, cables for three phase services, insulation resistance of a single core cable, capacitance of a single core cable, dielectric stresses in a single core cable, most economical conductor size in a cable, grading of cables, capacitance grading and inter-sheath grading, capacitance of three core cable and measurements of capacitances, dielectric loss and tan(δ) measurement.

- **CALCULATION OF LINE PARAMETERS** **(09 Hours)**
  Conductors, types of conductors in use, bundled conductor, spacing of conductors, symmetrical and unsymmetrical spacing, equivalent spacing, transposition, transmission line constants, calculation of resistance, inductance and capacitance for simple arrangements and multi-circuit lines, symmetrical and unsymmetrical spacing, concept of self GMD, mutual GMD and their uses in calculations of parameters of overhead lines, skin and proximity effects.

- **CHARACTERISTICS AND PERFORMANCE OF POWER TRANSMISSION LINES** **(12 Hours)**
  Short and medium transmission lines, Line performance, effect of capacitance, charging currents, short and medium lines, calculation by nominal-T, nominal-π and end-condenser method, regulation and efficiency, Concept of ABCD constants, the long transmission line- rigorous solution, evaluation of ABCD constants, interpretation of long line equation, surge impedance and surge impedance loading,

the equivalent circuit of a long transmission line, power flow through a transmission line, circle diagrams, Ferranti effect. Reactive power compensation, transmission line transients, concept of travelling waves, reflection and refraction coefficients.

Total hours: 42

Tutorials will be conducted separately for 14 hours

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3. List of Experiments:

The experiments are based on the MATLAB/ETAP simulations of power system components and hardware experiments and a substation/power plant visit.

1. Demonstration visit of 66 kV/22 kV SVNIT sub-station.
2. Study of single line diagram of Power System.
3. Power factor improvement of load.
4. Performance calculation of short and medium transmission lines.
5. Performance calculation of long transmission lines.
6. String efficiency calculation of suspension type insulator.

4. Books Recommended:

1. W. D. Stevenson, Element of Power System Analysis, McGraw Hill, 4th Edition 1982.
2. I. J. Nagrath and D. P. Kothari, Power System Engineering, 4th edition, Tata McGraw Hill publishing Company Ltd, 2014.
3. A. Chakrabarti, M. L. Soni, P. V. Gupta and U. S. Bhatnagar, A Text Book on Power System Engineering, Dhanpat Rai & Co., 2nd Edition 2001.
4. Hadi Saadat, Power System Analysis. 5th reprint, TMH publishing Company Ltd, 2004.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis, Prentice-Hall, Inc., 2nd Edition 2000.

B. Tech. II year, Semester IV

Electromagnetic Field Theory

L	T	P	Credit
3	1	0	04

EE208 Scheme

Course Outcomes (Cos):

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

CO1	describe various theorems related to vector analysis
CO2	differentiate different types of coordinate systems and use them for solving the problems of electromagnetic field theory
CO3	explain concepts, theories and laws of electrostatics, magnetics, electromagnetics, electromagnetic wave propagation and transmission lines
CO4	analyze problems of electrostatics, magnetics, electromagnetics and electromagnetic wave propagation
CO5	apply theories and laws of electrostatics, magnetics and electromagnetics to solve electrical engineering problems
CO6	deduce the electromagnetic wave propagation from Maxwell's equations

1. Syllabus:

- **VECTOR ANALYSIS:** **(08 Hours)**
  General Treatment on Cartesian, cylindrical, spherical and general curvilinear co-ordinate systems with reference to vectors, operation of gradient, divergence, curl, Laplacian., Gauss's Divergence theorem, Stoke's theorem.

- **ELECTROSTATICS:** **(09 Hours)**
  Review of electric field quantities and their definitions. Gauss's flux theorem, Poisson's Equation and Laplace Equation, uniqueness theorem, Green's theorem, Coulomb's law, dipole moment. Electrostatic Field in Dielectric: Polarization, electric flux density, boundary conditions, capacitor and capacitance, electrostatic shielding, energy stored in electric fields.

- **MAGNETIC FIELDS AND ELECTROMAGNETIC INDUCTION:** **(10 Hours)**
  Magnetic flux and flux density, static currents in conducting media, Ampere's law, Biot-Savart law, boundary between magnetic media, forces between currents, magnetic potentials, magnetic torque and moment, Dipole, Energy stored in magnetic field. Faraday's law of induction (transformer and motion), Inductor and Inductances (self and mutual).

- **MAXWELL'S EQUATIONS & ELECTROMAGNETIC WAVES:** **(09 Hours)**
  Maxwell's equations - Equation of continuity - Displacement current - Maxwell's equation in point and integral forms ,Time-varying potentials, wave equations, plane waves in Losses Dielectrics, Free space & Good conductors, Poynting vector and Theorem.

- **TRANSMISSION LINES:** **(06 Hours)**
  Line equations, input impedance, SWR and power, smith chart, some applications of Transmission lines.

Total hours: 42

Tutorials will be conducted separately for 14 hours

2. **Books Recommended:**

1. W. H. Hayt, J. A. Buck, and M. Jaleel Akhtar, "Engineering Electromagnetics", 8th Edition, McGraw Hill Publication
2. David J. Griffiths, Introduction to Electrodynamics, 4th Edition, PHI, 2013.
3. S. P. Seth, Elements of Electromagnetic Fields, Dhanpat Rai & Co., 4th Edition, 2012.
4. C. L. Wadhwa, Engineering Electromagnetics, New Age International Publishers, 3rd Edition, 2012.
5. Fawwaz T. Ulaby, Electromagnetics for engineers, Pearson education, first Indian reprint,2005.

B. Tech. II year, Semester IV

L	T	P	Credit
3	1	0	04

Signal and Systems

EE212 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify various signals and their mathematical representation
CO2	develop insights into discrete-time systems and their realization
CO3	analyze the characteristics of LTI systems with the help of impulse response and convolution
CO4	design the system properties in frequency domain
CO5	analyze random signals and justify their usefulness in engineering systems

2. Syllabus:

- **SIGNALS AND THEIR PROPERTIES** **(08 Hours)**
  Classification of Signals, continuous-time and discrete-time signals, deterministic and random signals, periodic signals, even and odd signals, exponential and sinusoidal signals, unit step and unit impulse signals, systems with and without memory, time-varying, time-invariant, stationarity, causality, homogeneity, linearity, stability of systems
- **LINEAR TIME INVARIANT SYSTEMS** **(08 Hours)**
  Properties of linear time-variant systems, continuous-time LTI systems, relationship between linear differential equations with constant coefficients, transfer function, state space models, convolution integrals from transfer function and state space models, discrete-time LTI systems, relationship between linear difference equations with constant coefficients, pulse transfer function, discrete-time state space models, convolution sum from transfer function and state space models, connections between time-invariance, causality, stationarity.
- **FOURIER SERIES REPRESENTATION AND FOURIER TRANSFORM** **(05 Hours)**
  Fourier series representation of continuous-time periodic signals, Parseval formula for continuous-time periodic signals, continuous time Fourier transform, discrete-time Fourier transforms, connection between the Fourier transform and Laplace transform, connection between the z-transform and discrete-time Fourier transform.
- **THE LAPLACE TRANSFORMATION TECHNIQUE** **(06 Hours)**
  Definition of the Laplace transformation, the need of the Laplace transformation, region of the convergence of the Laplace transform of signals, properties of the Laplace transform, the Laplace transforms of test signals and practically useful signals, unilateral Laplace transform and bilateral Laplace transforms.
- **THE Z-TRANSFORMATION TECHNIQUE** **(06 Hours)**
  Definition of the z- transformation, the need of the z- transformation, region of the convergence of the z- transform of signals, pulse transfer function, stability of systems using the z-transform. The z-transforms of test signals and practically useful signals, unilateral z transform and bilateral z transforms
- **FEEDBACK CONCEPTS** **(09 Hours)**
  Physical representation of network, general restrictions on physical network characteristics Feedback, mathematical definition of feedback, stability and feedback realizability, contour integration and Nyquist criterion for stability, physical representation of network, general restrictions on physical network characteristics

Total Lectures: 42

Tutorials will be conducted separately for 14 hours

3. Books Recommended:

1. A. V. Oppenheim, A. S. Wilsky and S. H. Nawab, Signals and Systems, Pearson India Education Services Private limited India, 2nd Edition, 2016.
2. R. A. Gabel and R. A. Robert, Signals and Linear Systems, John Wiley and Sons, 3rd Edition, 1987.
3. B. P. Lathi, Principles of Linear Systems and Signals, Oxford University Press, 2nd Edition, 2009.
4. C. T. Chen, Systems and Signal Analysis - A Fresh Look, Oxford University Press India, 3rd Edition, 2004.
5. S. T. Alan, Introduction to Signals and Systems, Thomson India Edition, 1st Edition, 2007.

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT

DEPARTMENT OF ELECTRICAL ENGINEERING

B. Tech. Programme

B. Tech. III

Semester V

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	HU301	Professional Ethics, Economics & management	3	1	0	04	100	25	-	-	125
2.	EE301	Power System Analysis	3	1	2	05	100	25	25	25	175
3.	EE303	Control Systems	3	1	2	05	100	25	25	25	175
4.	EE305	Power Electronic Converters	3	1	2	05	100	25	25	25	175
5.	--	EIS-I	3	0	0	03	100	-	-	-	100
6.	EE307	Electrical and Electronic Measurements	3	1	2	05	100	25	25	25	175
7.	EE309	Seminar	0	0	2	01	-	-	20	30	50
		Total (L-T-P)	**18**	**05**	**10**	**28**	**600**	**125**	**120**	**130**	**975**
		Total		**33**		**28**					

ELECTIVE INTERDISCIPLINARY SUBJECTS- EIS-I (EE3XX) (INSTITUTE LEVEL)	
Course Code	Subject Name
EE361	Renewable Energy Sources
EE363	Optimization Methods
EE365	Forecasting and Planning Methods
EE367	Fundamental of Electrical Power Systems (Non-Electrical Students)
EE369	Modern Electrical Drives (Non-Electrical Students)
EE371	Introduction to Power Electronics Converters (Non-Electrical Students)

Semester VI

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE304	Power Electronics System and Electric Drives	3	1	2	05	100	25	25	25	175
2.	EE306	Microprocessor and Microcontrollers	3	1	2	05	100	25	25	25	175
3.	EE308	Instrumentation	3	1	2	05	100	25	25	25	175
4.	--	EIS-II	3	0	0	03	100	-	-	-	100
5.	EE3AA	ES-I	3	0	0	03	100	-	-	-	100
6.	EE3BB	ES-II	3	0	0	03	100	-	-	-	100
7.	EE3CC	ES-III	3	0	0	03	100	-	-	-	100
		Total (L-T-P)	**21**	**03**	**06**	**27**	**700**	**75**	**75**	**75**	**925**
		Total		**30**		**27**					

ELECTIVE INTERDISCIPLINARY SUBJECTS- EIS-II (EE3YY) (INSTITUTE LEVEL)	
Course Code	Subject Name
EE362	Industrial Automation and Process Control
EE364	State Variable Analysis
EE366	Energy Audit and Management
EE368	Advanced Materials for Energy Applications
EE372	Distributed Power Generation and Micro-grids
EE374	Electromagnetic Field Theory (Non-Electrical Students)

CORE ELECTIVE SUBJECTS- ES-I (EE3AA) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE322	Power Plant Engineering
EE324	Adaptive Control and Soft Computing
EE326	Utilization of Electrical Energy
EE328	Modelling and Simulation of Electrical Machines
EE332	Random Processes
EE334	Artificial Intelligent Techniques

CORE ELECTIVE SUBJECTS- ES-II (EE3BB) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE338	Power Quality Disturbances and Mitigations
EE342	High Voltage Engineering
EE344	FACTS Devices
EE346	Discrete-Time Control Systems
EE348	Restructuring and Deregulation of Power Systems
EE352	Special Electrical Machines

CORE ELECTIVE SUBJECTS- ES-III (EE3CC) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE354	Advanced Electrical Drives
EE356	Electronic Instrumentation and Control
EE358	Power System Transients
EE376	Advanced Industrial Automation
EE378	Reliability Evaluation of Electrical Systems
HU322	Innovation, Incubation and Entrepreneurship (To be taught by DoAMH)

B. Tech. III year, Semester V

L	T	P	Credit
3	1	0	04

Professional Ethics, Economics and Business Management

HU301 **Scheme**

1. Course Outcomes (Cos):

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

CO1	identify application of ethics in society and development of understanding regarding professional ethical issues related to Electrical engineering
CO2	develop managerial skills to become future engineering managers
CO3	develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	develop experiential learning through Management games, Case study discussion, Group discussion etc.
CO6	apply knowledge of Economics and Business management aspects in Electrical engineering

2. Syllabus:

- **PROFESSIONAL ETHICS** **(06 Hours)**
  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics

- **ECONOMICS** **(08 Hours)**
  Introduction To Economics, Micro & Macro Economics, Applications & Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(14 Hours)**
  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Individual & Group Behavior, Perception, Value, Attitude, Leadership

- **FUNCTIONAL MANAGEMENT** **(12 Hours)**
  Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing; Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance

- **MODERN MANAGEMENT ASPECTS** **(02 Hours)**
  Introduction To ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

Total Hours: 56

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3. Books Recommended:

1. Balachandran V. and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, PHI, 2nd Edition, 2011
2. Prasad L.M., Principles & Practice Of Management, Sultan Chand & Sons, 8th Edition,2015
3. Banga T. R. & Shrama S.C., Industrial Organisation & Engineering Economics, Khanna Publishers, 25th Edition, 2015
4. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, Prentice Hall of India, 5th edition, 2012
5. Kotler P., Keller K. L, Koshi A.& Jha M., Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014
6. Tripathi P.C., Personnel Management & Industrial Relations, Sultan Chand & sons, 21st Edition, 2013
7. Chandra P., Financial Management, Tata McGraw Hill, 9th Edition, 2015

4. Additional Reading:

1. Crane A. & Matten D., Business Ethics: Managing Corporate Citizenship and Sustainability in the Age of Globalization, Oxford University, 2010
2. Fritsch D. J., Business Ethics: a Global and Managerial Perspectives, McGraw Hill Irwin, Singapore, 2004
3. Mandal S. K., Ethics in Business and Corporate Governance, Tata McGraw Hill, 2011

B. Tech. III year, Semester V

Power System Analysis

L	T	P	Credit
3	1	2	05

EE301 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the concept of per unit system and its application in power
CO2	analyze symmetrical and unsymmetrical fault conditions in electrical power systems.
CO3	discuss, analyze and compare different methods of power flow analysis in power system and estimate economic load dispatch.
CO4	classify power system stability, and its importance in power system operation
CO5	illustrate using software tools (MATLAB, ETAP etc.) to examine system performance with reference to fault, load flow and stability and analyze the results

2. Syllabus:

- **REPRESENTATION OF POWER SYSTEM COMPONENTS** **(04 Hours)**
  Introduction, single phase solution of balanced three phase networks, the one line diagram and the impedance or reactance diagram, per-unit (pu) system, complex power, synchronous machine, representation of loads.

- **LOAD FLOW STUDIES** **(08 Hours)**
  Network model formulation, formation of Y bus, power flow problem, different types of buses, approximate power flow, Gauss Seidel method, Newton-Raphson method, Decoupled Power flow studies, Fast Decoupled power flow studies, comparison of power flow methods.

- **ECONOMIC LOAD DISPATCH** **(04 Hours)**
  Economic dispatch of thermal units and methods of solution, Transmission losses, B matrix loss formula, Composite generation production cost function-solution by gradient search techniques, Nonlinear function optimization

- **SYMMETRICAL FAULT ANALYSIS** **(08 Hours)**
  Introduction, transient on a transmission line, short circuit of a synchronous machine on no load, short circuit of a loaded synchronous machine, balanced three phase fault, short circuit capacity, fault analysis using bus impedance matrix, selection of protective equipment.

- **UNSYMMETRICAL FAULT ANALYSIS** **(08 Hours)**
  Symmetrical component analysis of unsymmetrical faults, single line to ground (LG) fault, line to line (LL) fault, double line to ground (LLG) fault, open conductor faults, bus impedance matrix method for analysis of unsymmetrical faults.

- **POWER SYSTEM STABILITY** **(10 Hours)**
  Importance of stability analysis in power system planning and operation - classification of power system stability - angle and voltage stability – simple treatment of angle stability into small-signal and large-signal (transient) stability Single Machine Infinite Bus (SMIB) system: Development of swing equation - equal area criterion - determination of critical clearing angle and time by using modified Euler method and Runge-Kutta second order method. Algorithm and flow chart.

Total Hours:42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

Simulations based on different types of faults, stability and transients using MATLAB and ETAP.

1. To study mathematical modeling of R-L, R-L-C and complex electrical circuit using MATLAB.
2. To study mathematical modeling of 3rd order differential equation.
3. To solve differential equations using Euler's and trapezoidal rule.
4. To observe variable of rotor angle and to find critical clearing time when fault occurs at:
   - (i) Sending end of the line
   - (ii) Mid-point of the line
   - (iii) When the fault at mid-point is cleared by removing the faulty line of SMIB system.
5. To study short circuit analysis of overhead transmission line using MATLAB.
6. To study and obtain sub-transient current for symmetrical fault using ETAP software.
7. To perform load flow analysis using ETAP software.
8. To study and determine fault current for short circuit analysis using ETAP software.

4. Books Recommended:

1. J. J. Grainger and W. D. Stevenson, Power System Analysis, McGraw Hill, New Delhi, 1st Edition, 1994.
2. Hadi Saadat, Power System Analysis, 5th reprint, Tata McGraw Hill publishing Company Ltd, New Delhi, 2004.
3. I. J. Nagrath and D. P. Kothari, Power System Engineering, Tata McGraw Hill publishing Company Ltd., New Delhi, 3rd Edition, 2014.
4. J. Duncan Glover, S. Mulkutla Sarma and Thomas Overby, Power System Analysis and Design, 5th Edition Cengage Learning 2012.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis, Prentice Hall of India, Inc., 2nd Edition, 2000.

B. Tech. III year, Semester V

Control Systems

L	T	P	Credit
3	1	2	05

EE303 Scheme

1. Course Outcomes (Cos):

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

CO1	classify various types of control systems and to develop mathematical modeling of physical systems
CO2	analyze the response of various control systems in the time domain
CO3	analyze the stability of control systems using a variety of methods
CO4	evaluate the response and stability of control systems using frequency domain techniques
CO5	design various control schemes for linear systems

2. Syllabus:

- **INTRODUCTION TO CONTROL SYSTEMS: (02 Hours)**
  Open loop control and close loop control; Illustrative examples of control systems.

- **MATHEMATICAL MODELS OF PHYSICAL SYSTEMS: (10 Hours)**
  Linear and non-linear systems; equations and transfer functions for linear mechanical translational systems and linear electrical network; Force-Voltage and Force-Current analogy; Block diagram representation of control systems; Block diagram reduction; Transfer functions of armature-controlled and field-controlled DC servomotors and 2-phase AC servomotors; Signal flow graph and Mason's gain formula.

- **TIME DOMAIN ANALYSIS OF CONTROL SYSTEMS: (06 Hours)**
  Typical test signals; Response of first-order systems; Transient response of a second order system due to step input; Time domain specifications of a second order system; Impulse and ramp response of second order system; Steady-state errors; Static error coefficients; Error series and dynamic error coefficients.

- **CONCEPTS OF STABILITY: (08 Hours)**
  Introduction to stability, definition through impulse response function, asymptotic stability and relative stability, Routh-Hurwitz stability criterion. Basic Properties of Root Loci, Construction of Root Loci, Effects of Adding Poles and Zeros.

- **FREQUENCY DOMAIN ANALYSIS OF CONTROL SYSTEMS: (08 Hours)**
  Steady state response of a system due to sinusoidal input; Frequency response; Logarithmic plots or Bode diagrams; Log-magnitude versus phase plots; Resonant peak and resonant frequency of a second order system; Polar plots; conformal mapping, principal of argument, Nyquist stability criterion, Stability analysis; Relative stability; Gain margin and phase margin; Closed loop frequency response.

- **DESIGN OF CONTROL SYSTEMS: (08 Hours)**
  Introduction to phase lag, phase lead and phase lag-lead networks and their applications. P, PI, PID Controllers.

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. To obtain open loop and close loop transfer function for an oven.
2. To control the speed of two-phase AC Servo motor using auto tunable PI controller.
3. To understand the practical Air blower control system and to control the speed Of Blower using Programmable Logic Controller (PLC) and VFD from SCADA.
4. a) To obtain no load speed Vs control voltage curve for the two phase servo motor
   b) To obtain speed –torque curves for the various control voltages of servo motor.
5. To obtain Close Loop Response of an OVEN.
6. To understand the about the transient behavior on practical Air blower control system.
7. To understand the PID controller tuning using MATLAB.
8. To obtain the frequency response of phase lead network
9. a) To obtain step response and to find transient time domain specification for Second order system using MATLAB.
   b) To obtain Bode plot and Root locus using MATLAB.

4. Books Recommended:

1. I. J. Nagrath and M. Gopal, Control system engineering, New Age International Publishers, 3rd Edition, 2001.
2. K. Ogata, Modern control system engineering, Pearson Education Asia, 4th Edition, 2002.
3. B. C. Kuo, Automatic control system, Prentice Hall of India, 7th Edition, 1995.
4. Richard C. Dorf and Robert H Bishop, Modern control system, Pearson Education Asia. 8th Edition, 2004.
5. N. S. Nise, Control System Engineering, John Wiley & sons, 4th Edition, 2004.

B. Tech. III (Electrical), Semester – V	**L**	**T**	**P**	**C**
EE-305 Power Electronic Converters	**3**	**1**	**2**	**5**

1. COURSE OUTCOMES (COs):

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

CO1	understand the basic principle of operation of semiconductor devices and list their applications.
CO2	analyze and compare the performance of various line commutated converters.
CO3	analyze and design various DC-DC converters.
CO4	design single-phase and three-phase inverters for various applications.
CO5	develop laboratory prototype of power electronic systems.

2. SYLLABUS:

- **POWER SEMICONDUCTOR DEVICES** **(8 Hours)**
  Review of Power semiconductor devices and their static characteristics: Diode, DIAC, Thyristor, TRIAC, Power BJT, MOSFET, IGBT etc., Thyristor: Characteristics, Two transistor analogy, Gate Characteristics, and Methods of triggering, Gate and Base drive circuits - Preliminary design considerations, Ratings and protection of devices, Temperature control of power devices and heat sink design.

- **LINE COMMUTATED CONVERTERS** **(14 Hours)**
  Principle of phase control, half wave controlled rectifiers, half wave controlled rectifiers with R, R-L, R-L-E load, single phase full wave controlled converters, 2-pulse mid-point converters, 2-pulse half and fully controlled bridge converters with R, R-L, R-L-E load, Three phase converter system with diodes, 3 phase half and fully controlled bridge converters, Effect of source impedance on the performance of the converters, Dual converters. Principle of operation and analysis of AC voltage controllers with R and R-L load.

- **DC-DC CONVERTERS** **(10 Hours)**
  Basic principle of operation, Control strategies – Duty ratio control and frequency control, Types of chopper circuits, Steady state time domain analysis of different types of choppers, Principle of operation and analysis of non-isolated DC-DC converters: Buck, Boost, and Buck-Boost converters.

- **INVERTERS** **(10 Hours)**
  Single phase voltage source inverters, half bridge inverters, full bridge inverters, Steady state analysis, Voltage control in single phase inverters, 3-phase bridge inverters, Pulse width modulated inverters, Reduction of harmonics in inverters.

Total Hours: 42

Tutorials will be conducted separately for 14 hours

3. LIST OF EXPERIMENTS:

1. Study of IGBT, MOSFET, SCR, TRIAC, DIAC Characteristics.
2. Study of Different SCR Triggering Circuit Trainer – DC, R, R-C, UJT.
3. Study of Single Phase Half Controlled Bridge Converter with R, R-L Load.
4. Study of Single Phase Fully Controlled Bridge Converter with R, R-L Load.
5. Study of Single Phase SCR Full Bridge Inverter Circuit.
6. Study of High Voltage Thyristorised Chopper.
7. Study of Single Phase AC Voltage Controller Using SCR.
8. Study of Single Phase AC Voltage Controller Using Triac.

9. Study of Single Phase Dual Converter Circuit.
10. Study of SCR DC Circuit Breaker Circuit.
11. Study of Three Phase SCR Triggering Circuit Using Tca785 IC.
12. Study of AC Solid State Relay Using IC 555, Opto Coupler & Triac.
13. Simulation of Power EC circuits in PSIM and SIMULINK.

4. BOOKS RECOMMENDED:

1. Bimbhra P. S., “Power electronics”, Khanna Publishers, New Delhi, 5th Edition, 2014.
2. Rashid M. H., “Power Electronics Circuits, Devices, and Applications”, Prentice-Hall of India Pvt. Ltd., New Delhi, 3rd Edition, 2004.
3. Singh M. D., Khanchandani, K. B., “Power electronics”, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2nd Edition, 2006.
4. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and Design”, John Willey & Sons, Inc., 2nd Edition, 1995.
5. Agrawal J. P., “Power electronic systems: Theory and design”, Addison Wesley Longman (Singapore) Pte. Ltd. New Delhi, 2nd Edition, 2001.

B. Tech. III year, Semester V

L	T	P	Credit
3	1	2	05

Electrical and Electronic Measurements

EE307 Scheme

1. Course Outcomes (Cos):

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

CO1	identify different standards and explain measurement techniques of resistance, inductance and capacitance.
CO2	explain magnetic measurement techniques, discuss and analyze utilization of CT and PT.
CO3	classify different indicating instrument.
CO4	Operate electronic meters and oscilloscope
CO5	Illustrate calibration and traceability of test equipment

2. Syllabus:

- **STANDARDS (03 Hours)**
  Standards and their classification. Electrical Standards: EMF, current, resistance and capacitance standards
- **MEASUREMENT of RESISTANCE, INDUCTANCE AND CAPACITANCE (07 Hours)**
  Concept of four arm bridge network, Kelvin's double bridge, Anderson bridge, Schering bridge, Wagner earthling device, Localization of cable fault using loop methods
- **MAGNETIC MEASUREMENTS (05 Hours)**
  Measurement of flux: ballistic galvanometer, Grassot flux meter, Hall effect devices for measurement of flux, measurement of iron loss by wattmeter method, Hibbert magnetic standard.
- **INSTRUMENT TRANSFORMERS (06 Hours)**
  Theory of current and voltage transformer, ratio error and phase angle, burden, turns compensation performance characteristics, testing of CT and PT and applications of CT and PT in measurement of power.
- **INDICATING INSTRUMENTS (07 Hours)**
  Classification, operating principles, general construction details of indicating instruments, balancing, control and damping method, theory and construction of PMMC, moving iron and electrostatic instruments, electrodynamics wattmeter.
- **ELECTRONIC METERS AND OSCILLOSCOPE (08 Hours)**
  DC amplifier voltmeter, AC voltmeter using rectifiers, true RMS responding voltmeter, Oscilloscope block diagram, CRT and its circuits, vertical deflection systems, delay line, multiple trace, horizontal deflection system, oscilloscope probes, Function generator.
- **CALIBRATION AND MEASUREMENT (06 Hours)**
  calibration and traceability of instruments, Calibration of indicating instruments using DC potentiometer, High voltage oil testing equipment, H.V. breakdown tester, Insulation resistance measurement techniques, calibration of energy meter

Total hours:42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. To measure unknown resistance using Kelvin's Double Bridge.
2. To measure unknown inductance using Anderson Bridge
3. To calibrate voltmeter using Potentiometer.
4. To measure unknown capacitance using Schering Bridge
5. Calibration of single phase energy meter.
6. Testing of Current Transformer using Biffi's method.
7. To find out iron loss and flux density in a given sample of laminated steel core. (Lloyd fisher square)
8. To perform the operation of HV oil testing.
9. To study operation of oscilloscope and function generator.

4. Books Recommended:

1. Golding and Widdis, Electrical measurements and Measuring instruments, Wheeler books, 5th Edition.
2. A. K. Sawhney, Electrical and electronic Measurements and Instrumentation, Dhanpat Rai & Co., 17th Edition.
3. A. D. Helfrick and W. D. Cooper, Modern electronic Instrumentation and Measurement techniques, PHI, 2nd Edition, 2009.
4. D. A. Bell, Electronic Instrumentation and Measurement, Oxford Uni. Press, 3rd Edition, 2013.
5. P. Purkait, B. Biswas, S. Das and C. Koley Electrical and Electronics Measurement and Instrumentation, McGraw Hill Education, 1st Edition, 2013.

B. Tech. III year, Semester V

Renewable Energy Sources (EIS-I)

L	T	P	Credit
3	0	0	03

EE361 **Scheme**

1. Course Outcomes (Cos):

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

CO1	recognize the limits of the conventional energy sources and discuss the potential of present scenario of renewable energy conversion.
CO2	explain solar thermal energy conversion and list their associated applications.
CO3	explain working of wind and solar energy conversions, associated performance characteristics and their applications.
CO4	describe the basic operation of the other renewable energy sources.
CO5	predict the impacts of the renewable energy sources on the environment and from the aspect of economy

2. Syllabus:

- **INTRODUCTION TO RENEWABLE ENERGY** **(03 Hours)**
  Man and energy, world's production and reserves of commercial energy sources, India's production and reserves, energy alternatives, fossil fuels and climate change.
- **SOLAR THERMAL ENERGY** **(06 Hours)**
  Introduction, the rooftop solar water heating system, the nature and availability of solar radiation, low-temperature solar energy applications, active and passive solar heating, day lighting, solar thermal engines and electricity generation, solar energy storage system, sensible and latent heat storage, solar pond, economics-potential and environmental impact.
- **SOLAR PHOTOVOLTAICS** **(12 Hours)**
  Introduction, brief on semi-conductor physics, basic principle, electrical characteristic of PV cell and module, crystalline silicon and thin film PV technologies, other innovative PV technologies, PV for remote power and grid-connected PV systems, cost of energy from PV, environmental impacts and safety, PV integration, resources and further process.
- **WIND ENERGY** **(10 Hours)**
  Introduction, classifications and descriptions of wind turbines, wind data in form of wind speed, speed-frequency distribution curve, speed-duration curve, power density-duration curve, performance calculations, and environmental impacts.
- **BIO-ENERGY** **(03 Hours)**
  Introduction, biomass as a fuel, bio-energy from crops and wastes, combustion of solid biomass, production of gaseous fuels and liquid fuels from biomass, environmental impacts, economics and future prospects.
- **HYDRO ELECTRICITY** **(04 Hours)**
  Introduction, the resources, stored energy and available potential, different turbines for hydro power, types of hydro-electric plants, small scale hydroelectricity, system integration and environmental considerations and economics.
- **OTHER SOURCES OF ENERGY AND THEIR UTILIZATIONS** **(04 Hours)**
  Wave energy, tidal power, ocean thermal energy (OTEC), geothermal energy, fuel cells.

Total hours:42

3. <u>Books Recommended:</u>

1. Godfred Boyle, Renewable energy: Power for a sustainable future, 2^{nd} Edition, Oxford University Press Inc., New York, 2012.
2. S. P. Sukhatme and J. K. Nayak, Solar energy: Principles of thermal collection and storage, 3^{rd} Edition, Tata McGraw Hill, New Delhi, 2010.
3. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, technologies and applications, 2^{nd} Edition, PHI Learning Private Limited, New Delhi, 2011.
4. John Twidell and Tony Weir, Renewable energy resources, 2^{nd} Edition, Taylor & Francis, London, 2006.
5. J. W. Tester, E. M. Drake, M. J. Driscoll, M. W. Golay and W. A. Peters, Sustainable energy: Choosing among options, PHI Learning Private Limited, New Delhi, 2009.

B. Tech. III year, Semester V

Optimization Methods (EIS-I)

L	T	P	Credit
3	0	0	03

EE363 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain basic concepts and theoretical principles in optimization.
CO2	convert the a real-world problem, described in words, into a mathematical formulation and solve them.
CO3	apply efficient computational procedures to solve optimization problems.
CO4	compare different optimization methods to solve single variable Optimization problems to find maxima/minima.
CO5	analyze and apply various optimization methods for getting optimum solution of multi variable optimization problems with different constraints.

2. Syllabus:

- **MATHEMATICAL PRELIMINARIES** **(04 Hours)**
  convex sets, intersection of convex sets, vertices or extreme points of a convex set, convex polyhedron, hyper-planes, closed and open half space, convex functions, Local & Global Maxima and Minima. Saddle point, Unconstrained optimization- First and second order necessary and sufficient conditions.

- **LINEAR PROGRAMMING** **(10 Hours)**
  Standard form, Geometry of LP problems, Definitions and theorems, formulation of LP problems, graphical representation and solution of LP in two-dimensional space. Feasible, Basic Feasible and Optimal solutions, pivotal reduction of a set of linear equations, slack and surplus variables, Simplex method and algorithm, two phase method, degeneracy, Big M method. Duality in linear programming, duality theorems. Integer Linear programming graphical representation, Gomory's cutting plane method for all Integers programming problem.

- **TRANSPORTATION AND ASSIGNMENT PROBLEM** **(05 Hours)**
  Description, finding initial basic feasible solution, test for optimality, new Basic solution. Assignment Problem and its solution.

- **SINGLE VARIABLE OPTIMIZATION ALGORITHMS** **(05 Hours)**
  Optimality Criteria- Uni-modal function-Bracketing Methods-Region-Elimination Methods-Fibonacci & Golden section search –Gradient Based Methods:-Newton-Raphson method, Bisection Method, Secant Method.

- **MULTIVARIABLE OPTIMIZATION ALGORITHMS:** **(07 Hours)**
  Optimality Criteria-Unidirectional Search- Direct Search Methods- Hooke-Jeeves pattern method-Powell's conjugate direction method.
  Gradient Based Methods: Steepest Descent Method-Newton's Method-Conjugate Gradient Method-Quasi-Newton method.

- **CONSTRAINED OPTIMIZATION ALGORITHMS:** **(07 Hours)**
  Direct Substitution-Lagrange Multiplier Method-Kuhn-Tucker Conditions- Frank and Wolfe method. Cutting plane method.

- **ADVANCED OPTIMIZATION TECHNIQUES:** **(04 Hours)**
  Introduction to Multi objective Optimization, Genetic Algorithm, Swarm base Optimization techniques and other Nontraditional Optimization Algorithms

Total Hours: 42

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3. Books Recommended:

1. S. S. Rao, Engineering Optimization, 3rd Edition, New Age International (P) Ltd, New Delhi, 2004.
2. David G. Luenberger, Linear and Non Linear Programming, 2nd Edition, Addison-Wesley Pub. Co., Massachusetts, 1973.
3. W. L. Winston, Operation Research-Applications & Algorithms, Thomson publications, 2003.
4. W. F. Stoecker, Design of Thermal Systems, 3rd Edition, McGraw Hill, 1989.
5. G. B. Dantzig, Linear Programming and Extensions, Princeton University Press, 1998.

B. Tech. III year, Semester V

L	T	P	Credit
3	0	0	03

Forecasting and Planning Methods (EIS-I)

EE365 **Scheme**

1. Course Outcomes (Cos):

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

CO 1	explain the basics of forecasting and planning for engineering.
CO 2	apply methods of time series decomposition and its smoothing for better forecasting and planning.
CO 3	learn various simple and multiple regression models for forecasting.
CO 4	learn the BOX-Jenkins and ARIMA for forecasting.
CO 5	Discuss the basics of planning for engineering applications
CO 6	classify various methods of planning and their applications.

2. Syllabus:

- **FUNDAMENTALS OF FORECASTING (04 Hours)**
  The forecasting perspective and Time Series Forecasting, overview of forecasting techniques and tools, time series, and cross-sectional data, and plots, univariate and bivariate statistics, autocorrelation, measuring forecast accuracy, ACF of forecast error, prediction intervals, least square estimates, transformation and adjustments.

- **TIME-SERIES DECOMPOSITION AND EXPONENTIAL SMOOTHING METHODS (06 Hours)**
  Principle of decomposition, seasonal adjustment, moving averages, local regression smoothing, classical decomposition, additive and multiplicative decomposition, extensions to X-12 ARIMA, STL decomposition, inner loop, outer loop, choosing the STL parameters, Exponential smoothing methods: Exponential smoothing methods, single exponential smoothing and its adaptive approach, Holt’s linear and Holt-Winter’s method: Pegel’s classification.

- **SIMPLE AND MULTIPLE REGRESSION (08 Hours)**
  Least squares estimation, the correlation coefficient, residuals, The F-test for overall significance, confidence intervals for individual coefficients, t-tests for individual coefficients, forecasting using the simple regression model, non-linear relationship, non-linearity in the parameters, using logarithms to form linear models, local regression.

- **BOX-JENKINS METHODOLOGY FOR ARIMA MODELS (06 Hours)**
  Examining correlation in time series data, the autocorrelation function, white noise model autocorrelation coefficient, Random walk model, tests for stationarity, ARIMA models of time series, autoregressive, moving average model, Mixtures ARIMA models, identification and estimation of parameters.

- **FORECASTING AND PLANNING (10 Hours)**
  The role of forecasting in planning, Comparison and selection of forecasting methods, Introduction to Planning, multidisciplinary nature, role of a planner, definitions and Basics of Planning, Goals and objectives of planning; Components of planning; Benefits of planning; Arguments for and against planning. Planning Process, Levels of Planning in India.

- **PLANNING METHODS** **(08 Hours)**
  Definition of development plan; Types of development plans, Comprehensive planning, requirements for planning; sources of primary and secondary data; questionnaire design, measurement scale and their application, sampling techniques, types of socio-economic surveys; self-surveys, interviews, questionnaires and observer participation, Data requirement for various types of regional plans; Techniques for conducting surveys.

Total Hours: 42

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3. Books Recommended:

1. Makridakis, Spyros, Forecasting methods and application, John Wiley, 3rd Edition, 1993.
2. X. Wang & J. R. Mc Donald, Modern Power system planning, McGraw. Hill, 2nd Edition, 2003.
3. A. S. Pabla, Electrical Power system planning, Mac Millan, Delhi, 4th Edition, 1998.
4. Sullivan, Power system planning, McGraw. Hill, 1977.
5. E. Lakervi and E. J. Holmes, Electricity distribution network design, IEE, 2nd Edition, 2003.

B. Tech. III year, Semester V

Fundamentals of Electrical Power Systems (Non-electrical students) (EIS-I)

L	T	P	Credit
3	0	0	03

EE367 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify and compare the electrical power transmission and distribution.
CO2	estimate the cost of power generation and the cost of electricity.
CO3	discuss various protective devices and compare them.
CO4	analyze the performance of the underground cable.
CO5	illustrate and the concept of lighting system and various components associated.

2. Syllabus:

- **SUPPLY SYSTEMS** **(04 Hours)**
  AC and DC power supply systems, comparison of ac and dc transmission, advantages of high transmission voltage, various systems of power supply, comparison of conductor materials in overhead system and underground cable system.

- **UNDERGROUND CABLES** **(05 Hours)**
  Underground cables, construction of cables, classification of cables, cables for three phase services, insulation resistance of a single core cable, capacitance of a single core cable, dielectric stresses in a single core cable, most economical conductor size in a cable, grading of cables, capacitance grading and inter-sheath grading, capacitance of three core cable and measurements of capacitances.

- **CHARACTERISTICS AND PERFORMANCE OF POWER TRANSMISSION LINES** **(08 Hours)**
  Conductors, types of conductors in use, bundled conductor, spacing of conductors, symmetrical and unsymmetrical spacing, equivalent spacing, transposition, types of transmission line towers and insulator string Short and medium transmission lines, Line performance, effect of capacitance, charging currents, short and medium lines, calculation by nominal-T, nominal-π and end-condenser method, regulation and efficiency, Concept of ABCD constants, evaluation of ABCD constants for short and medium line.

- **ECONOMIC ASPECTS OF POWER SYSTEM** **(07 Hours)**
  Cost of Generation and Tariff, Power factor and its effect on system economy, Power factor improvement.

- **PROTECTION OF POWER SYSTEM** **(10 Hours)**
  Rewirable fuses, HRC fuses, isolators and earthing switches, selection of fuses. Effectively grounded and ungrounded systems, resonant grounding Methods of neutral grounding, Bulk oil circuit breaker, arc controlled devices, MOCB, ACB, ABCB, SF_6 circuit breaker, vacuum circuit breaker and DC circuit breakers, circuit breaker ratings, auto-recloser, Fundamental characteristics of relays, standard definition of relay terminologies, relay classifications, operating principles of single and double actuating quantity type electromechanical relays, directional relay, differential relay, numerical relay.

- **ILLUMINATION AND LIGHTING SYSTEM** **(08 Hours)**

  Nature of light, visibility spectrum curve of relative sensitivity of human eye and wave length of light. Definition: Luminous flux, solid angle, luminous intensity, illumination, luminous efficiency, depreciation factor, coefficient of utilization, space to height ratio, reflection factor, glare, shadow, lux. Laws of illumination. Different type of lamps, construction and working of incandescent and discharge lamps – their characteristics, fittings required for filament lamp, mercury vapour lamp, fluorescent lamp, metal halide lamp, neon lamp. Calculation of number of light points for interior illumination, calculation of illumination at different points, considerations involved in simple design problems. Illumination schemes; indoor and outdoor. Illumination levels. Main requirements of proper lighting; absence of glare, contrast and shadow. General ideas about street lighting, flood lighting, monument lighting and decorative lighting, LED lighting

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Total Hours: 42

3. Books Recommended:

1. I. J. Nagrath and D. P. Kothari, Modern Power System analysis, Tata McGraw Hill Publishing Company Ltd, New Delhi, 4th Edition, 2011.
2. W. D. Stevenson, Element of Power System Analysis, McGraw Hill, 4th Edition, 1982.
3. A. Chakrabarti, M. L. Soni, P. V. Gupta, and U. S. Bhatnagar, A Text Book on Power System Engineering, Dhanpat Rai & Co., 2012.
4. C. L. Wadhwa, Electric Power System, New Age International Ltd, 3rd Edition, 2010.
5. V. K. Mehta, Rohit Mehta, Principles of Power System, S. Chand & Co. 2003.

B. Tech. III year, Semester V

Modern Electrical Drives
(Non-electrical students) (EIS-I)

L	T	P	Credit
3	0	0	03

EE369 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the basic concept of electric drives, their components and principle of operation
CO2	distinguish the characteristics of open loop and closed loop control of drives
CO3	apply various power electronic converters to electric drives
CO4	apply various control strategies to modern AC DRIVES
CO5	analyze qualitatively the multi-quadrant operations drives

2. Syllabus:

- **FUNDAMENTALS OF ELECTRIC DRIVES** **(07 Hours)**
  Electric drives, advantages of electrical drives, parts of electrical drives, choice of electrical drives, status of ac and dc drives, types of load, fundamental of torque equation, speed-torque convention and multi quadrant operation, selection of power rating.

- **ELECTRICAL MOTORS** **(11 Hours)**

  DC Motors – permanent magnet, filed would, series, shunt compound - constructional features, principle of operation, torque equation, speed torque characteristics
  AC Motors – Induction Motor, Synchronous Motor, Brushless DC Motor, Permanent Magnet Synchronous Motor, Switched Reluctance Motor, Stepper Motor, Universal Motor, Hysteresis Motor, Servo Motor - constructional features, principle of operation, torque equation, speed torque characteristics.

- **POWER ELECTRONICS CONTROL OF ELECTRICAL MOTORS** **(14 Hours)**
  Power electronics control - scope and applications, Types of power electronics circuits and their applications in drives, Speed and current sensors, open-loop and closed-loop control, position control, practical applications.

- **VARIOUS CONTROL TECHNIQUES FOR AC DRIVES** **(10 Hours)**
  Scalar control, Concept of Space vector, field oriented control and direct torque control, soft computing techniques and adaptive controllers.

Total Hours: 42

3. Books Recommended:

1. B. K. Bose, Modern Power Electronics & AC Drives, 1st Edition, Pearson.
2. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2nd Edition, 2001.
3. R. Krishnan, Switched Reluctance Motor Drives, Modelling, Simulation, Analysis, Design and applications, CRC press, 2006.
4. T. J. E. Miller, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford, 1989.
5. M. H. Rashid, Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.

B. Tech. III year, Semester V

Introduction to Power Electronic Converters (Non-electrical students) (EIS-I)

L	T	P	Credit
3	0	0	03

EE371 **Scheme**

1. Course Outcomes (Cos):

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

CO1:	explain the basic principle of operation of semiconductors devices
CO2:	explain the various triggering schemes different converters
CO3:	classify and explain the functions of phase controlled rectifiers, DC-DC converters, Inverters and AC voltage regulators
CO4:	analyze the steady state performance of converters
CO5:	compare the performance of the converters based on topologies, control techniques and types of load

2. Syllabus:

- **POWER SEMICONDUCTOR DEVICES (10 Hours)**
  Introduction to Power Electronics Scope and Applications, Interdisciplinary Nature of Power Electronics, power electronic devices like Power SCR, BJT, MOSFET, IGBT, triggering scheme.

- **PHASE CONTROLLED RECTIFIERS (12 Hours)**
  Principle of phase control, half wave controlled rectifiers, half wave controlled rectifiers with R, R-L, single phase full wave controlled converters, 2-pulse mid-point converters, 2-pulse half and fully controlled bridge converters with R, R-L, Three phase converter system with diodes, 3 phase half and fully controlled bridge converters, Effect of source impedance on the performance or the converters, Dual converters.

- **DC-DC CONVERTERS (10 Hours)**
  Introduction, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Converter, Control Principles, Applications of DC-DC Converters.

- **INVERTERS (06 Hours)**
  Single phase voltage source inverters, Half bridge inverters, full bridge inverters, Voltage control in single phase inverters, 3-phase bridge inverters, Pulse width modulated inverters, Reduction of harmonics in Inverter.

- **AC VOLTAGE CONTROLLERS (04 Hours)**
  Principle of AC Voltage Controllers – Integral Cycle Control and Phase Control, Types of AC voltage controllers, Analysis of 1-phase Integral Cycle Control AC controllers with R load, Analysis of 1-phase Phase Control AC controllers with R and R-L load, Thyristor controlled reactors (TCR).

Total Hours: 42

3. Books Recommended:

1. P. S. Bimbhra, Power electronics, Khanna Publishers, New Delhi, 5th Edition, 2012.
2. M. H. Rashid, Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.
3. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
4. M. D. Singh and K. B. Khanchandani, Power electronics, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2nd Edition, 2017.
5. J. P. Agrawal, Power electronic systems: Theory and design, Addison Wesley Longman (Singapore) Pte. Ltd. New Delhi, 2nd Edition, 1995.

B. Tech. III (Electrical), Semester – VI	L	T	P	C
EE-304 Power Electronics Systems and Electric Drives	3	1	2	5

2. COURSE OUTCOMES (COs):

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

CO1	explain the basic concept of PESs
CO2	apply various power electronic converters to DC and AC drives
CO3	devise different control techniques for DC and AC drives
CO4	compare the performance of various methods of drive control
CO5	decide the suitability of PESs for applications in emerging areas.

3. SYLLABUS:

- **INTRODUCTION TO DRIVES AND DC DRIVES** **(10 Hours)**
  Introduction to drives, Fundamental torque equation, speed-torque convention and multi quadrant operation, dynamics of motor load combination, nature and classification of load torque, calculation of acceleration time in transient operation, acceleration time for specific nature of motor and load torque, stability of electrical drives, Selection of Motor Power Rating.
  DC Drives: Phase controlled DC-Drives: Operation with continuous and discontinuous modes, Supply Harmonics, Power Factor and Ripple in motor current; Chopper Controlled DC Drives, Sources current harmonics in chopper, Converter Ratings and closed loop control scheme.

- **AC DRIVES** **(12Hours)**
  Induction Motor Drives: Speed control techniques: Stator voltage control, Variable frequency control, Open loop V/f control, Static rotor resistance control and Slip power recovery control schemes, Slip compensation technique.
  Synchronous Motor Drives: Self-controlled schemes, Variable frequency control of multiple synchronous motor, Permanent magnet AC motor drives, Control of Brushless DC Motor Drives and its applications,

- **ADVANCED POWER ELECTRONICS CONVERTERS** **(10 Hours)**
  Isolated DC-DC Converters: Fly-back, forward, Push-pull converter, half and full bridge converter, topologies, control and design; Active Front End Converter and its control for unity power factor operation; Multilevel Inverters; Modulation techniques: SPWM and SVM, Design of Inductor and Transformer.

- **APPLICATIONS OF POWER CONVERTERS** **(10 Hours)**
  Applications of DC-DC converters for MPPT techniques, Electronic ballasts, Electric Vehicles (EVs) and Power Supply Design; Uninterruptible Power Supply; Application of PESs in Distribution system for Power Conditioning, PESs applications in Distributed Energy System such as Solar, Diesel Engine, Wind based isolated and grid connected system.

Total Hours: 42

Tutorials will be conducted separately for 14 hours

4. LIST OF EXPERIMENTS:

1. Study of Speed Control of DC Shunt Motor Using Single Phase Fully Controlled Converter.
2. Controlling of DC Motor with Single Phase Dual Converter.
3. Study of Speed Control of Three Phase AC Induction Motor (V/F Control).
4. Experimental investigation of a 5 HP Induction Motor Drive.
5. Study of DSP Controlled Induction Motor Drive.
6. Study of DSP Controlled BLDC Motor Drive.
7. Simulation of V/F control of 3 phase induction motor using MATLAB.

8. Simulation of speed control of three phase induction motor using stator voltage control (AC Voltage controller) in MATLAB.

5. BOOKS RECOMMENDED:

1. B. K. Bose, "Modern Power Electronics & AC Drives", Pearson, 1st Edition.
2. Dubey G.K, "Fundamentals of Electrical Drives", Narosa Publishing House, 2nd Edition, 2001.
3. R. Krishnan "Electric motor drives Modeling, Analysis and Control" PHI-India, 1st Edition, 2015.
4. Rashid M. H., "Power Electronics Circuits, Devices, and Applications", Prentice-Hall of India Pvt. Ltd., New Delhi, 3rd Edition, 2004.
5. Ned Mohan et al, "Power Electronics: Converters, Applications, and Design", John Wiley & Sons. Inc., 3rd Edition, 2010.
6. Bin Wu, High-Power Converters and AC Drives, A John Wiley and Sons, Inc., Publication, 2006.

B. Tech. III year, Semester VI

Microprocessor and Microcontrollers

L	T	P	Credit
3	1	2	05

EE306 **Scheme**

1. Course Outcomes (Cos):

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

CO 1	Illustrate with examples basic concepts of digital circuits.
CO 2	explain architecture of 8–bit Microprocessor (8085A), concept of memory and input-output interfacing with timing diagrams.
CO 3	Describe architecture of 8 bit microcontroller (8051) with special function registers (SFR), basic on chip peripherals like Timer0, Timer 1, UART, and External Interrupts and program execution timings (MIPS).
CO 4	Demonstrate interfacing of external peripheral like ADC, DAC, Key board, LCD and seven segment LED display with 8051 Microcontroller.
CO 5	develop assembly language and embedded 'C' programs with the exposure of Kiel µvision IDE.
CO 6	Design and develop using microcontroller, power electronics based electrical systems and provide solution to other real world problems.

2. Syllabus:

- **REVIEW OF DIGITAL LOGIC CONCEPTS** **(02 Hours)**
  Number systems, gates & De-Morgan's equivalents, 3-state logic gates, flip-flops, buffers, decoders, Encoders, multiplexers, de-multiplexers.

- **MICROPROCESSOR SYSTEM ARCHITECTURE** **(03 Hours)**

  Introduction, Registers, concept of address and data buses, system control signals, basic bus timing, memory (RAM, ROM), input output devices, Microcomputer systems

- **INTRODUCTION TO 8085A MICROPROCESSOR ARCHITECTURE** **(03 Hours**)
  Introduction to 8085A, pin diagram and pin description, bus timing and instruction timing, de-multiplexing of buses, generation of control signals, concept of interrupts.

- **MEMORY INTERFACING WITH 8085A** **(04 Hours**)
  Different types of memory, memory map, address decoding scheme for different memory, memory timings.

- **INPUT OUTPUT DEVICES INTERFACING WITH 8085A** **(04 Hours)**
  Basic interfacing concepts, peripheral I/O interfacing and memory mapped I/O interfacing

- **8051 MICROCONTROLLER ARCHITECTURE** **(06 Hours)**
  Introduction, 8051 family microcontrollers, hardware architecture, input/output pins, I/O ports and circuits, on chip ram ,general purpose registers ,special function registers, timers-counters, concepts of interrupts.

- **ASSEMBLY LANGUAGE PROGRAMMING OF 8051** **(10 Hours)**
  Concept of IDE (assembler, compiler, linker, de-bugger), addressing modes, data move instructions, arithmetic and logical instructions, jump, loop and call instructions, concepts of subroutines, interrupt service routine.

- **PERIPHERALS OF 8051 – HARDWARE CONCEPTS AND ‘C’ PROGRAMMING** **(10 Hours)**

  GPIO port architecture, timers, interfacing with push button keys, interfacing with seven segment LED display, interfacing with ADC

Total hours: 42

Tutorials will be conducted separately for 14 hours

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3. List of Experiments:

(to write and execute assembly language programme for)

1. Arithmetic operations of Signed and Unsigned Numbers
2. Memory Block Movements (Forward, reverse, overlapping)
3. Ascending and descending arrangement of data string.
4. Code conversion. (Hexadecimal, BCD, Binary, ASCII etc.)

   (Embedded ‘C’ programming)
5. Toggling of port pin with time delay
6. Sensing of push button keys
7. Two digit second clock based on seven segment display
8. Interrupt driven clock
9. Programming of ADC and DAC

4. Books Recommended:

1. R. S. Gaonker, Microprocessor Architecture, programming and application, Wiley Eastern Limited, 6th Edition, 2013.
2. Kenneth J. Ayala, The 8051 Microcontroller, Penram International 3rd Edition, 1999.
3. M. Mazidi and others, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 2nd Edition, 2007.
4. Michael Slater, Microprocessor based Design, Prentice Hall of India, 3rd Edition, 2016.
5. Badri Ram, Fundamentals of microprocessors and microcomputers, Dhanpat Rai & Sons, 4th Edition, 1993.

B. Tech. III year, Semester VI

L	T	P	Credit
3	1	2	05

Instrumentation

EE308 Scheme

1. Course Outcomes (Cos):

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

CO1	analyze performance characteristics of measurement systems.
CO2	demonstrate different types of transducers.
CO3	explain different types of recorders and data transmission techniques.
CO4	discuss operational amplifier and its applications.
CO5	Classify various digital displays and digital measuring instruments.

2. Syllabus:

- **PERFORMANCE CHARACTERISTICS OF MEASUREMENT SYSTEMS (06 Hours)**
  Input-output configuration of instruments and measurement systems, methods of correction for interfering and modifying inputs, static performance characteristics of instruments, noise, signal to noise ratio, errors in measurement
- **TRANSDUCERS (09 Hours)**
  Classification of transducers, passive transducers: resistive, inductive and capacitive transducers, active transducers: thermocouple, piezoelectric transducer, taco-generator, pH cell, basic signal conditioning circuits for transducers.
- **DATA TRANSMISSION ,RECORDERS and DATA LOGGERS (05 Hours)**
  Introduction to industrial data transmission techniques, Distinction between recorder and data loggers, strip chart recorder, X-Y recorders, data logger
- **OPERATIONAL AMPLIFIER FUNDAMENTALS (04 Hours)**
  Operational Amplifier, Basic Op-Amp Configuration, an Op-Amp with Negative Feedback, Voltage Series and Voltage Shunt Configurations, Difference Amplifiers,
  Specification of An Op-Amp, Offset Voltages and Currents, CMRR, Slew Rate
- **LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIERS (06 Hours)**
  Summing, Scaling and Averaging Amplifiers, Voltage to Current Converter with Floating and Grounded Load, Current to Voltage Converter, Integra tor and Differentiator, Instrumentation Amplifier, Isolation amplifier
- **NON-LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIERS (06 Hours)**
  Schmitt Trigger, Voltage Comparator, Voltage Limiters And Window Detector, Clippers And Clampers, Peak Detector, Precision Rectifiers, Analog Switches
- **BASICS of DIGITAL INSTRUMENTS (06 Hours)**
  Digital meter displays: LED and LCD, Quantization and digitization process, Quantization error, Specifications of digital instruments like digits, resolution and accuracy, Ramp type Digital voltmeter, Dual slope DVM, Digital multi-meter, LCRQ meter, Digital storage oscilloscope

Total hours: 42

Tutorials will be conducted separately for 14 hours

3. List of Experiments:

1. To study input and output characteristics of LVDT.
2. To study strain measurement using Strain Gauge and cantilever assembly.
3. Measurement of liquid level capacitive transducer.
4. To determine the breakdown voltage of transformer oil.
5. To determine the breakdown voltage of different types of paper.
6. To study the characteristics of RTD.
7. To study and perform Inverting & Non-Inverting Configuration Op-amp.
8. To study and perform Summing, Scaling & Averaging Circuits using Op-amp.
9. To study and perform Integrator & Differentiator using Op-amp.
10. To study Peak detector.

4. Books Recommended:

1. A. K. Sawhney, Electrical and electronic Measurements and Instrumentation, Dhanpat Rai & co., 17^{th} Edition.
2. Gayakwad Ramakant, Op-Amps and Linear Integrated Circuits, PHI, 3^{rd} Edition, 1993.
3. A. D. Helfrick and Cooper W. D., Modern electronic Instrumentation and Measurement techniques, Prentice Hall of India, 1997.
4. E. O. Doebelin, Measurement Systems - Application and Design, 4^{th} Edition, McGraw-Hill, New York, 1992.
5. D. A. Bell, Electronic Instrumentation and Measurement, Oxford University press, 3^{rd} Edition, 2013.

B. Tech. III year, Semester VI

Industrial Automation and Process Control (EIS-II)

L	T	P	Credit
3	0	0	03

EE362 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify various types of Industrial process
CO2	explain working principle of various type of sensors and actuators
CO3	discuss various type of controller and various control system configurations
CO4	develop ladder logic program for PLC for various industrial applications
CO5	discuss case study of Industrial automation.

2. Syllabus:

- **INTRODUCTION OF INDUSTRIAL PROCESSES** **(04 Hours)**
  Process with analog variables, discrete state sequential process, hybrid process, overview of automation.
- **SENSORS** **(06 Hours)**
  Mechanical sensors: strain; motion; pressure; flow: Thermal sensors: RTD; thermistors; thermocouple Optical sensors; photo detectors; pyrometers; optical sources.
- **ACTUATORS** **(05 Hours)**
  Final control operation: signal conversions; actuators; control elements, signal conversions: analog electrical signals; digital signals; pneumatic signals, actuators: electrical; pneumatic; hydraulic, fluid valves : control valve principle; types; sizing
- **CONTROL SYSTEM CONFIGURATIONS** **(05 Hours)**
  Feedback control, Feed Forward Control, Ratio Control, cascade Control, over-ride control, optimizing control system
- **CONTROLLER PRINCIPLES** **(06 Hours)**
  Controller modes, electronic controller, pneumatic controller, digital controllers, controller software.
- **PROGRAMMABLE LOGIC CONTROLLERS** **(12 Hours)**
  Advantages & disadvantages of PLC with respect to relay logic, PLC architecture, Input Output modules, PLC interfacing with plant, ladder diagram
- **CASE STUDY OF INDUSTRIAL AUTOMATION** **(04 Hours)**
  Boiler, conveyor belt system, Heat Exchanger

Total Hours:42

3. Books Recommended:

1. John Webb, Programmable Logic Controllers Principles & applications, Prentice Hall of India, 1st Edition, 2003.
2. C. D. Johnson, Process Control Instrumentation Technology 4th Edition, PHI.
3. Andrews, Applied Instrumentation in Process Industries (Volume-IV).
4. D. Patranabis, Principles of Process Control, Tata Mc-Grow Hill Publishing Company Ltd., New Delhi, 3rd Edition.
5. T. A. Hughes, Programmable Controllers, 4th Edition, 2004, ISA.

B. Tech. III year, Semester VI

L	T	P	Credit
3	0	0	03

State Variable Analysis (EIS-II)

EE364 Scheme

1. Course Outcomes (Cos):

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

CO1	construct state-space models for the systems from the ubiquitous domains (electrical/mechanical).
CO2	correlate differential equations, transfer function model with the state space models.
CO3	recast linear, nonlinear, multi input multi output, continuous and discrete systems in state space form.
CO4	design control systems using the state space techniques and analyze the properties of state space models which are essential for developing controllers and observers.
CO5	adopt state space technique for the models of real world problems.

2. Syllabus:

- **MATHEMATICAL BACKGROUND-MATRICES: (03 Hours)**
  Definition of Matrices; Matrix Algebra; Matrix Multiplication and Inversion; Rank of a Matrix; Differentiation and Integration of Matrix.

- **STATE SPACE ANALYSIS METHODS AND TECHNIQUES: (16 Hours)**
  State Variables; State-Space Representation of Electrical and Mechanical and Electromechanical Systems; State Space Representation of Nth Order, Linear Differential Equation; Transformation to Phase Variable Canonical Form; Relationship Between Transfer Functions and State Equations; Characteristic Equation; Eigen Values and Eigen Vectors; Transformation to Diagonal Canonical Form; Jordan Canonical Form.

- **SOLUTION OF THE TIME-INVARIANT SYSTEMS: (06 Hours)**
  Solution of the Time-Invariant State Equation; State Transition Matrix and its Properties; Transfer Matrix; Transfer Matrix of Closed Loop Systems, Methods of calculations of the matrix exponentials using algebraic and algorithmic methods.

- **CONTROLLABILTY AND OBSERVABILITY: (08 Hours)**
  Concept of Controllability and Observability; Kalman’s Theorems on Controllability; and Observability, Alternative Tests (Gilbert’s Method) of Controllability and Observability; Principle of Duality; Relationship among Controllability, Observability and Transfer Function, Decomposition of Transfer Function-Direct, Cascade and Parallel Decomposition; State Diagram.

- **LYAPUNOV STABILITY ANALYSIS: (09 HOURS)**
  Stability of Equilibrium State in the Sense of Lyapunov; Graphical Representation of Stability; Asymptotic Stability and Instability; Sign-Definiteness of Scalar Function; Second Method of Lyapunov; Stability Analysis of Linear Systems; Krasovskii’s Theorem; Lyapunov Function Based on Variable Gradient Method.

Total Hours: 42

3. Books Recommended:

1. I. J. Nagrath and M. Gopal, Control System Engineering, New Age International Publishers, 3rd Edition, 2001.
2. K. Ogata, Modern Control System Engineering, Pearson Education Asia, 4th Edition, 2002.
3. B. C. Kuo, Automatic Control Systems, Prentice Hall of India, 7th Edition, 1995.
4. N. S. Nise, Control System Engineering, John Wiley & sons, 4th Edition, 2004.
5. P. F. Blackman, Introduction to State Variable Analysis, the McMillan Press, 1st Edition, 1977.

B. Tech. III year, Semester VI

Energy Audit and Management (EIS-II)

L	T	P	Credit
3	0	0	03

EE366 **Scheme**

1. Course Outcomes (Cos):

After completion of the course, the students will be able to:

CO1	recognize the significance of energy management and its role in industries
CO2	analysis of Energy conservation and needs of energy audit and management.
CO3	evaluate the energy economics.
CO4	plan and design energy efficient systems
CO5	estimate the economy and judge the environmental concerns.

2. Syllabus:

- **ENERGY MANAGEMENT** **(12 Hours)**
  Energy Scenario – Energy Demand and Ecological Balance –Resource availability and management, Strategies, Tools available, Energy Monitoring and Targeting, Energy Norms, Energy Policy, Demand Side Management–Role of Energy Managers in Industries - maximizing system efficiencies, Optimizing input energy requirements - Principles and Imperatives of Energy Conservation - Energy Consumption pattern, Energy Conservation acts, Energy Conservation Implementation Programme (ECIP), Energy Audit concepts, needs, energy management (audit) approach, energy audit instruments, Energy action planning and Project management.

- **ELECTRICAL ENERGY AUDITING** **(10 Hours)**
  Potential areas of Electrical Energy Conservation in various industries–Energy Management opportunities in Cable selection, Electricity Act, Electric Heating and Lighting systems –Six basic rules of Energy, Efficient Lighting, Energy losses in electric motors and drives, Energy Efficient Motors and Drives, Soft starters with energy saver, Power factor improvement, Energy conservation in domestic gadgets and transport, DG system- factors affecting selection & performance.

- **ENERGY ECONOMICS** **(10 Hours)**
  Economic analysis of investments, Present value criterion, Discount rate, simple payback period, return on investment, net present value(NPV), internal rate of return, life cycle costing, energy performance contracts and role of ESCOs, Energy Management Information Systems.

- **ECONOMICS OF POWER GENERATION** **(10 Hours)**
  Factors affecting the cost of generation – Load factor, Diversity factor, Plant capacity factor, Plant use factor, Load curves, Load duration curves, Reduction of costs by Interconnection of Stations, Choice of size & number of generator units, Tariffs : types and significance.

Total Hours:42

3. **Books Recommended:**

1. Albert Thumann, Handbook of Energy Engineering, The Fairmont Press Inc., 6^{th} Edition, 2003.
2. Wayne C. Turner, Energy management Handbook, John Wiley and sons, 9^{th} Edition, 2019.
3. Prasanna Chandra, Financial management, Tata McGraw Hill, 10^{th} Edition, 2019.
4. S. Choudhury, Projects: Planning, Analysis, Selection, Implementation and Review, Tata McGraw Hill Publishing Company, New Delhi, 1995.
5. Cleaner Production, Energy Efficiency Manual for GERIAP, UNEP, prepared by National Productivity Council, Bangkock.

B. Tech. III year, Semester VI

Advanced Materials for Energy Applications (EIS- II)

L	T	P	Credit
3	0	0	03

EE368 **Scheme**

1. Course Outcomes (Cos):

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

CO1	recognize the need for materials and its future for energy needs.
CO2	describe the physics and chemistry of the materials behind the energy conversion.
CO3	categorize the materials for different energy applications.
CO4	discuss the energy conversion process with different materials.
CO5	design a basic device structure using the materials for different energy applications.

2. Syllabus:

- **ENERGY IN TRANSITION** **(02 Hours)**
  Introduction, Materials for Energy, How Far Ahead Is the Future?
- **MATERIALS FOR PHOTOVOLTAIC SOLAR CELLS** **(08 Hours)**
  The Physics of Solar Cells, Types of Solar Cell, Transparent Conductive Materials, Toward Low Cost, Fast and Scalable Processing, Low-Cost Electricity Production from Sunlight: Third-Generation Photovoltaics and the Dye-Sensitized Solar Cell, Basics of Organic Photovoltaics, Dye-Sensitized Solar Cell Principle
- **THERMOELECTRICS** **(03 Hours)**
  Introduction, Definition, Applications of Thermoelectricity, Semi-classical Theory of Thermoelectricity in Solids, Thermoelectric Materials, Conclusion
- **PIEZOELECTRIC CONVERSION** **(03 Hours)**
  Introduction, Principles of Piezoelectric Transduction, Energy Conditioning Circuitry, Applications of Piezoelectric Energy Harvesting, Current Research Thrusts, Summary and Future Visions
- **FUEL CELLS** **(05 Hours)**
  Introduction, History, Types of Fuel Cells, Thermodynamics, Fuel Cell Efficiency, Applications.
- **BATTERIES: FUNDAMENTALS AND MATERIALS ASPECTS** **(06 Hours)**
  Introduction, Rechargeable Battery Systems, Beyond Li-Ion: From Single to Multivalent Ion Chemistriesm, Redox Flow Batteries
- **ENVIRONMENTALLY FRIENDLY SUPERCAPACITORS** **(04 Hours)**
  Introduction, Energy Storage Devices, Super-capacitors Background, Charge Storage Mechanisms, Classification, Designing High-Performance Environmentally Friendly Super-capacitors, Characterization, Future Perspectives
- **HYDROGEN STORAGE** **(03 Hours)**
  Conventional Hydrogen Storages, Hydrogen Physisorption, Metal Hydrides, Complex Hydrides, Amides and Imides, Ammonia-Borane, Conclusions
- **SUPERCONDUCTORS** **(05 Hours)**
  Introduction, Fundamental Phenomenology of Superconductivity, Superconducting Materials for Application, Coated Conductor Fabrication, Superconductors for Energy Applications, Superconductors for Transportation Applications, Paradigm-Shifting Energy Technologies, Other Applications of Superconductors, Cooling, Cost, Summary

- **SOLID-STATE LIGHTING: AN APPROACH TO ENERGY-EFFICIENT ILLUMINATION** **(03 Hours)**
  Properties of Light, Light Sources, LED Physics, Light Emitting Diodes Based on III-V Junctions, Organic Light Emitting Diodes, White Light with LEDs, New Approaches, LED Packaging, LED Drivers, Lighting Control Systems and Applications

Total Hours: 42

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3. Books Recommended:

1. Xevier Moya and David Monoz-Rojas, Materials for Sustainable Energy Applications-Conversion, Storage, Transmission and Consumption, Pan Stanford Publishing, Singapore, 2016.
2. O. S. Burheim, Engineering Energy Storage. Academic Press, 1st Edition 2017.
3. S. O. Kasap, Principles of Electrical Engineering Materials and Devices, Irwin Professional Publishing, 1997.
4. S. M. Sze, Physics of Semiconductor Devices, 2nd Edition, Wiley Eastern Publication, New Delhi, 1993.
5. Donald A. Neamen, Semiconductor Physics and Devices, 3rd Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2007.

B. Tech. III year, Semester VI

Distributed Power Generation and Micro-Grids (EIS-II)

L	T	P	Credit
3	0	0	03

EE372 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the concept of conventional grid and micro-grids
CO2	appraise the need of distributed renewable energy resources
CO3	describe the extraction and conversion of solar and wind energy.
CO4	evaluate the response and protection of micro-grids.
CO5	recognize the need of smart meters, electricity tariff and other smart devices.

2. Syllabus:

- **INTRODUCTION** **(07 Hours)**
  The basic concepts of power grid, the electric grid vs micro-grids: technical and historic perspective, concept of micro-grid, typical configuration of micro-grid, AC and DC micro-grids, interconnection of micro-grids, technical and economic advantages of micro-grid, challenges and disadvantages of micro-grids, Islanding, need and benefits, different methods of islanding detection, modelling a micro-grid system

- **DISTRIBUTED ENERGY RESOURCES:** **(07 Hours)**
  Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries , ultra-capacitors, flywheels, Advantages and disadvantages of DG.

- **MICRO-GRID SOLAR ENERGY SYSTEM:** **(07 Hours)**
  the solar energy conversion process, photovoltaic power conversion, photovoltaic material, photovoltaic characteristic, photovoltaic efficiency, design of photovoltaic system, MPPT, storage system based on a single cell battery, the energy yield of a photovoltaic module and the angle of incident, Application of power electronics in solar system

- **MICRO-GRID WIND ENERGY SYSTEM:** **(08 Hours)**
  Wind power, wind turbine generators, power flow analysis of an induction machine, the operation of an induction generator, Permanent magnet synchronous generators, reluctance generators and Application of power electronics in wind farms.

- **PROTECTION ISSUES FOR MICROGRIDS:** **(06 Hours)**
  Introduction, Islanding, Different islanding scenarios, Major protection issues of standalone Micro-grid - Impact of DG integration on electricity market, environment, distribution system, communication.

- **INTRODUCTION TO SMART METERS, ELECTRICITY TARIFF:** **(07 Hours)**
  One Part Tariff, Two Part Tariff and Maximum Demand Tariff, Dynamic Pricing - Time of-use (TOU) pricing, critical-peak pricing (CPP) and Real Time, Pricing- Automatic Meter Reading (AMR).

Total Hours: 42

3. Books Recommended:

1. Ali Keyhani, Mohammad Marwali and Min Dai, Integration and Control of Renewable Energy in Electric Power System John Wiley publishing company, 2009.
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, Micro-grids and Active Distribution Networks, IET Power Electronics Series, 2012.
3. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley, 2nd Edition, 2016.
4. James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley, 1st Edition, 2012.
5. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, Electrical Power System Quality, McGraw-Hill, 3rd Edition, 2017.

B. Tech. III year, Semester VI

Electromagnetic Field Theory (Non-Electrical Students)

L	T	P	Credit
3	0	0	03

EE374 **Scheme**

Course Outcomes (Cos):

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

CO1	describe various theorems related to vector analysis
CO2	differentiate different types of coordinate systems and use them for solving the problems of electromagnetic field theory
CO3	explain concepts, theories and laws of electrostatics, magnetics, electromagnetics, electromagnetic wave propagation and transmission lines
CO4	analyze problems of electrostatics, magnetics, electromagnetics and electromagnetic wave propagation
CO5	apply theories and laws of electrostatics, magnetics and electromagnetics to solve electrical engineering problems
CO6	deduce the electromagnetic wave propagation from Maxwell's equations

1. Syllabus:

- **VECTOR ANALYSIS:** **(08 Hours)**
  General Treatment on Cartesian, cylindrical, spherical and general curvilinear co-ordinate systems with reference to vectors, operation of gradient, divergence, curl, Laplacian., Gauss's Divergence theorem, Stoke's theorem.

- **ELECTROSTATICS:** **(09 Hours)**
  Review of electric field quantities and their definitions. Gauss's flux theorem, Poisson's Equation and Laplace Equation, uniqueness theorem, Green's theorem, Coulomb's law, dipole moment. Electrostatic Field in Dielectric: Polarization, electric flux density, boundary conditions, capacitor and capacitance, electrostatic shielding, energy stored in electric fields.

- **MAGNETIC FIELDS AND ELECTROMAGNETIC INDUCTION:** **(10 Hours)**
  Magnetic flux and flux density, static currents in conducting media, Ampere's law, Biot-Savart law, boundary between magnetic media, forces between currents, magnetic potentials, magnetic torque and moment, Dipole, Energy stored in magnetic field. Faraday's law of induction (transformer and motion), Inductor and Inductances (self and mutual).

- **MAXWELL'S EQUATIONS & ELECTROMAGNETIC WAVES:** **(09 Hours)**
  Maxwell's equations - Equation of continuity - Displacement current - Maxwell's equation in point and integral forms ,Time-varying potentials, wave equations, plane waves in Losses Dielectrics, Free space & Good conductors, Poynting vector and Theorem.

- **TRANSMISSION LINES:** **(06 Hours)**
  Line equations, input impedance, SWR and power, smith chart, some applications of Transmission lines.

Total hours: 42

2. <u>**Books Recommended**</u>:

1. W. H. Hayt, J. A. Buck, and M. Jaleel Akhtar, “Engineering Electromagnetics”, 8th Edition, McGraw Hill Publication
2. David J. Griffiths, Introduction to Electrodynamics, 4th Edition, PHI, 2013.
3. S. P. Seth, Elements of Electromagnetic Fields, Dhanpat Rai & Co., 4th Edition, 2012.
4. C. L. Wadhwa, Engineering Electromagnetics, New Age International Publishers, 3rd Edition, 2012.
5. Fawwaz T. Ulaby, Electromagnetics for engineers, Pearson education, first Indian reprint,2005.

B. Tech. III year, Semester VI

Power Plant Engineering (ES – I)

L	T	P	Credit
3	0	0	03

EE322 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the basics of various components of the power station
CO2	describe the working of steam and hydro power stations
CO3	describe the working of nuclear and diesel and gas power stations.
CO4	explain the working of the power stations based on non-conventional resources.
CO5	design the controllers for various power stations.

2. Syllabus:

- **STEAM POWER STATION** **(04 Hours)**
  Main flow circuits of thermal power station, thermodynamic cycles of steam flow, general layout of power stations, power station auxiliaries, cooling system of alternators, flue-gas flow arrangement, circulating water system, cooling tower.
- **HYDROELECTRIC POWER PLANT** **(06 Hours)**
  Selection of site, water power equations, types of dams, arrangement and layouts of hydro-electric station, classification of plants, water turbines, properties of water wheels, specific speed on the basis of discharge, combined steam and hydro-plants, pumped storage hydro station.
- **NUCLEAR POWER STATION** **(07 Hours)**
  Atomic structure, isotopes, energy release by fission, chain reaction, atomic reactor, fuels, moderators and coolants, types of reactors, fast breeder reactor, radio activity and hazards.
- **DIESEL AND GASTURBINE STATION** **(06 Hours)**
  Field of use, general layout and principle of operation.
- **NON CONVENTIONAL METHOD OF POWER GENERATION** **(06 Hours)**
  MHD generation, wind power, tidal power, solar power, solar cell and fuel cell.
- **COMBINATIONS OFDIFFERENT TYPESOF POWER PLANTS** **(10 Hours)**
  Types of power station, advantages of combined working of different types of power station, need for coordination of different types of power station, run-off river plant in combination with steam plant, hydro- electric plants with ample storage in combination with steam plants, pumped storage plant in combination with ordinary hydro-electric plant, co-ordination of hydro-electric and gas turbine plant, co-ordination of hydro-electric and nuclear power station, co-ordination of different types of power plants in power station.
- **POWER STATION CONTROL** **(03 Hours)**
  Excitation systems, excitation control, field protection, commissioning of alternators, power supply for station auxiliaries, power station control.

Total Hours:42

3. Books Recommended:

1. Arogya swamy, Power Station Practice, Oxford & IBM Publication Co., New Delhi, 1976.
2. Baptidanov L., Power Station & Substation, Moscow Peace Publication.
3. Leznov S. & Taits, Power Station & Substation Maintenance, Moscow Mir Publication, 1983.
4. Leznov S. & Taits, Power Station Electrification, Moscow Mir Publication, 1983.
5. Bruce, John, London, Power Station Efficiency Control, Sir Issac Pitman & Sons Ltd., 1926.

B. Tech. III year, Semester VI

Adaptive Control and Soft Computing (ES – I)

L	T	P	Credit
3	0	0	03

EE324 Scheme

1. Course Outcomes (Cos):

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

CO1	explain various concepts related to adaptive control and soft computing techniques.
CO2	compare various soft computing techniques like ANN and fuzzy.
CO3	apply ANN, Fuzzy logic for implementing adaptive control strategies
CO4	choose a particular soft computing technique for solving a specific problem
CO5	design fuzzy, ANN based controllers for various applications.

2. Syllabus:

- **ADAPTIVE CONTROL** **(15 Hours)**
  Need for adaptive control, MIT rule, Model reference and self-tuning adaptive control techniques, Auto tuning, Gain scheduling, Design of Gain-Scheduling Controllers, Adaptive Feedback Linearization, Adaptive Back Stepping, Stability, convergence issues in adaptive control. Practical aspects, implementation and applications of adaptive control.

- **ARTIFICIAL NEURAL NETWORK BASED CONTROL:** **(15 Hours)**
  Introduction to ANN, different activation functions, different architectures, different learning methods; Back Propagation and Radial Basis Function networks: Representation and identification, modelling the plant, control structures – supervised control, Model reference control, Indirect and direct adaptive controller design using neural network.

- **FUZZY LOGIC BASED CONTROL:** **(12 Hours)**
  Fuzzy Controllers: Preliminaries: Mamdani and Sugeno inference methods, Fuzzy sets in commercial products: basic construction of fuzzy controller –Indirect and direct adaptive fuzzy control: case studies.

Total Hours: 42

3. Books Recommended:

1. I. D. Landau, Adaptive Control: Algorithms, Analysis and Applications, Springer, 2nd Edition, 2011.
2. V. V. Chalam, Adaptive Control Systems: Techniques and Applications, Marcel Dekker, New York, 1st Edition, 1987.
3. K. J. Astromand B. Wittenmark, Adaptive Control, Addison Wesley, 1995.
4. Simon O. Haykin, Neural Network and Learning Machines, 3rd Edition, PHI, 2008.
5. Kwang H. Lee, First course on Fuzzy Theory and Applications, Springer, 2005.

B. Tech. III year, Semester VI

Utilization of Electrical Energy (ES – I)

L	T	P	Credit
3	0	0	03

EE326 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain basic principles of illumination, electric heating and welding and refrigeration system
CO2	estimate the lighting requirements for household Lighting and industrial lighting needs and its design
CO3	calculate the heat developed in different electrical furnaces and ovens
CO4	evaluate the performance of various electric welding techniques.
CO5	evaluate the rating of electrical equipment used in refrigeration and air conditioning system.

2. Syllabus:

- **ILLUMINATION** **(10 Hours)**
  Nature of light, visibility spectrum curve of relative sensitivity of human eye and wave length of light. Various definitions related to illumination, Laws of illumination, construction and working of Different type of lamps, characteristics, fittings required for various lamps, Calculation of number of light points for interior illumination, calculation of illumination at different points, considerations involved in simple design problems. Illumination schemes: indoor and outdoor, Illumination levels. Main requirements of proper lighting; absence of glare, contrast and shadow. General ideas about different lighting schemes.
- **HEATING** **(10 Hours)**
  Advantages of electrical heating. Heating methods: Resistance heating – direct and indirect resistance heating, electric ovens, their temperature range, properties of resistance heating elements, domestic water heaters and other heating appliances and thermostat control circuit. Induction heating; principle of core type and coreless induction furnace. Electric arc heating; direct and indirect arc heating, construction, working and applications of arc furnace. Dielectric heating, applications in various industrial fields. Infra-red heating and its applications. Microwave heating, Power electronics application in heating system.
- **WELDING** **(10 Hours)**
  Advantages of electric welding. Principles of resistance welding, types – spot, projection seam and butt welding and welding equipment used. Principle of arc production, electric arc welding, characteristics of arc, carbon arc, metal arc, hydrogen arc welding method of and their applications. Power supply required. Advantages of using coated electrodes, comparison between AC and DC arc welding, welding control circuits, welding of aluminum and copper. Introduction to TIG, MIG Welding, Power electronics application in welding system.
- **REFRIGERATION AND AIR CONDITIONING** **(12 Hours)**
  Introduction, Refrigeration systems, domestic refrigerator, Types of air conditioning systems, central air conditioning system, heating of buildings, calculation of rating of electrical equipment, Modern and efficient refrigeration and air conditioning system.

Total Hours:42

3. Books Recommended:

1. Gupta, J. B., Utilization of Electrical Energy and Electric Traction, S. K. Kataria and sons, 10^{th} Edition, 1990.
2. R. K. Rajput, Utilization of Electrical Power, Laxmi publications, 1^{st} Edition, 2007.
3. C. L. Wadhwa, Generation Distribution and Utilization of Electrical Energy, New Age International publishers, 4^{th} Edition, 2011.
4. E. O. Taylor, Utilization of Electric Energy, Orient Blackswan, 1971.
5. H. Partab, Art and Science of Utilization of Electrical Energy, Dhanpat Rai & Co, 2017.

B. Tech. III year, Semester VI

Modeling and Simulation of Electrical Machines (ES – I)

L	T	P	Credit
3	0	0	03

EE328 Scheme

1. Course Outcomes (Cos):

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

CO1	explain the basic principle of electrical machines based on principle of electromagnetic energy conversion
CO2	develop the mathematical model of DC machine
CO3	explain various reference frame theories for modeling electric machines
CO4	deduce the mathematical model of induction, synchronous and permanent magnet synchronous machines based on reference frame theory
CO5	analyze the performance of electric machines based on the derived mathematical machines
CO6	simulate various electric machines based on mathematical models

2. Syllabus:

- **BASIC PRINCIPLE OF ELECTRIC MACHINE** **(03 hours)**
  Review of Magnetic circuit and electromagnetics (Faraday's law, Ampere's law, Bio Savart's law, Kirchhoff law and Maxwell's equation (integral form and point form)), Principle of transformer action, Principle of Electromagnetic Energy Conversion, Elementary electric machine
- **DC MACHINE MODELLING** **(06 hours)**
  Modeling of D.C. Machine (Separately Excited, shunt and series type), Linearization of machine equations, State-Space Modeling of the machine.
- **INDUCTION MACHINE MODELING** **(12 hours)**
  Distributed Winding in AC Machinery, winding function, air gap mmf, rotating mmf, Flux linkage and Inductance, Stator and rotor voltage equation and torque equation in stator reference frame, Reference frame theory: Space phasor description, Derivation of induction motor modelling in rotor flux and stator flux reference frame, Derivation of steady state model.
- **PERMANENT MAGNET MACHINE MODELING** **(11hours)**
  Voltage and torque equation of surface mount permanent magnet machine in stator reference frame, Voltage and torque equation of surface mount permanent magnet machine in rotor reference frame, Derivation of steady state model.
- **SYNCHRONOUS MACHINE MODELING** **(10 hours)**
  Voltage and torque equation of salient pole synchronous machine including damper winding in stator reference frame, Voltage and torque equation of salient pole synchronous machine including damper winding in rotor reference frame.

Total Hours: 42

3. Books Recommended:

1. P. C. Krause, Oreg Wasynczuk, Scott D. Sudhoff, Analysis of Electric Machinery and drive systems, Wiley Interscience, 2nd Edition, 2010.
2. P. S. Bimbhra, Generalized theory of Electrical M/C, Khanna Publication, 2000.
3. S. K. Sen, Electrical Machinery, Khanna Pub., Delhi, 2012.
4. Mrittunjay Bhattacharya, Electrical Machines: Modelling and Analysis, PHI, 2016.
5. R. Ramanujam, Modelling and Analysis of Electrical Machines, Wiley, 2019.

B. Tech. III year, Semester VI

L	T	P	Credit
3	0	0	03

Random Processes (ES - I)

EE332 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Illustrate with examples the concepts of random variables and probability densities
CO2	infer the statistical properties of various random variables and their properties
CO3	develop stochastic models for various real-life problems
CO4	appreciate the importance of Gaussian random variables and Gaussian density in real-life problems
CO5	apply concepts of state estimation for linear and nonlinear systems

2. Syllabus:

- **CONCEPTS OF PROBABILITY** **(06 Hours)**
  Introduction, set theory, probability space, Total and Conditional Probability, Bayes' Theorem, Examples.
- **RANDOM VARIABLES** **(12 Hours)**
  Concept of random variable, Equivalent Events, Classification of Random variables: Continuous and Discrete, Concepts of probability density function (pdf) and probability mass function (pmf), Cumulative distribution function (cdf), Generation of random variables, Vector random variables, Independent random variables, Co-relatedness and Independence.
- **STATISTICAL PROPERTIES OF SCALAR AND VECTOR RANDOM VARIABLES** **(12 Hours)**
  Frequently used random variables: Uniform and Gaussian random variables, Concepts of Expectation and moments, second central moment, variance, covariance, autocorrelation matrix, Cross correlation matrix, Correlation coefficient, cross covariance, Marginal probability density, Conditional probability density, Joint probability density, Properties of Gaussian random variables.
- **STOCHASTIC PROCESSES** **(12 Hours)**
  Difference between stochastic and deterministic system, Concept of random process, stationarity and ergodicity, auto correlation function, cross correlation function and their properties, Gaussian process, Markov process, central limit theorem, white noise-properties. Concepts of modelling: Brownian motion, random walk problem, Linear perturbation models, Models for computer control: Linear and nonlinear discrete dynamic models. Least squares estimate, Kalman and extended Kalman filter.

Total Hours: 42

3. Books Recommended:

1. A. Papoulis & S. U. Pillai, Probability, Random Variables and Stochastic Process, 4^{th} Edition, McGraw Hill, 2002.
2. X. Rong Li, Probability Random Signal and Statistics, CRC Press, 1999.
3. A. H. Jazwinski, Stochastic Processes and Filtering Theory, Dover publication, 2005.
4. V. K., Rohatgi and Md. Ehsanes Saleh, An introduction to probability and statistics, 2^{nd} Edition, Wiley India, 2009
5. P. S. Maybeck, Stochastic Models, Estimation and Control, Vol. 1, Academic Press, 1979.

B. Tech. III year, Semester VI

L	T	P	Credit
3	0	0	03

Artificial Intelligence Techniques (ES - I)

EE334 **Scheme**

1. Course Outcomes (Cos):

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

CO1	recognize the need of artificial intelligence
CO3	classify various artificial neural network based on its topology and processing methods
CO4	design the ANN for various applications
CO5	explain the basics of fuzzy logic
CO6	design the fuzzy logic controller for various applications.

2. Syllabus:

- **INTRODUCTION TO ARTIFICIAL INTELLIGENCE** **(04 Hours)**
  Foundations of AI, History of AI, Agents and environments, The nature of the Environment, Problem solving Agents, Problem Formulation, Search Strategies

- **KNOWLEDGE AND REASONING FOR AI** **(06 Hours)**
  Knowledge-based Agents, Representation, Reasoning and Logic, Prepositional logic, First-order logic, Using First-order logic, Inference in First-order logic, forward and Backward Chaining

- **ARTIFICIAL NEURAL NETWORKS** **(08 Hours)**
  History of Neural Networks, Structure and Functions Of Biological And Artificial Neuron, Neural Network Architectures, Characteristics Of ANN, Basic Learning Laws and Methods. Neural Networks Components and Terminology, Neural Networks Topology, Neural Network Adaption, Comparing Neural Networks and Other information Processing Methods, Preprocessing and Post Processing.

- **ARTIFICIAL NEURAL NETWORKS APPLICATIONS** **(08 Hours)**
  Single Layer Neural Network and architecture, McCulloch-Pitts Neuron Model, Learning Rules, Perceptron Model, Perceptron Convergence Theorem, Delta learning rule, Outstar Learning, Kohenen Self Organization Networks, Learning Vector Quantization

- **FUZZY SYSTEMS CONCEPTS AND PARADIGMS** **(06 Hours)**
  Fuzzy sets and Fuzzy Logic, Theory of Fuzzy sets, Approximate Reasoning, Fuzzy Systems Implementations and Fuzzy Rule System Implementation.

- **FUZZY APPLICATIONS** **(10 Hours)**
  Automated Methods for Fuzzy System: Definitions, Batch Least Squares Algorithm, Recursive Least Squares Algorithm, Gradient Method, Clustering Method, Learning From Examples, Modified Learning From Examples, Decision Making with Fuzzy Information: Fuzzy Synthetic Evaluation, Fuzzy Ordering, Non transitive Ranking, Preference and Consensus, Multi objective Decision Making, Fuzzy Bayesian Decision Method, Decision Making Under Fuzzy States and Fuzzy Actions.

Total Hours: 42

3. Books Recommended:

1. Simon Hakins, Neural Networks, Pearson Education, 3rd Edition 2016.
2. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, Willey, 2010
3. Yang Xiao, Security and Privacy in Smart Grids, CRC Press Taylor & Francis Group, 2014.
4. Stuart Russell, Peter Norvig: Artificial Intelligence: A Modern Approach, 2nd Edition, Pearson Education, 2007.
5. Eberhart & Shi, Computational Intelligence - Concepts to Implementations, Morgan Kaufmann, 1st Edition, 2007.

B. Tech. III (Electrical), Semester – VI

L	T	P	Credit
3	0	0	03

Power Quality Disturbances and Mitigations (ES – II)

EE338 **Scheme**

1. Course Outcomes (Cos):

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

CO1	identify the power quality events and problems
CO2	analyze of stationary/Non-stationary signals
CO3	assess the power quality events.
CO4	design and analyze of power filters
CO5	design the controllers for power filters

2. Syllabus:

- **POWER QUALITY** **(08 Hours)**
  Signal processing and power quality, Origin of power quality variation and events, power quality indices, causes and effects of power quality disturbances, Power quality standards, Power quality measuring instruments, Analysis of Power outages, unbalance, distortions, voltage sag, flickers and load balancing.
- **PROCESSING OF STATIONARY & NON-STATIONARY SIGNALS** **(09 Hours)**
  Stationary signals: Overview of analysis methods, frequency domain analysis and signal transformation, estimation of harmonics and inter-harmonics.
  Non –stationary signals: Power quality data analysis methods, discrete STFT for analyzing time –evolving signal components, discrete wavelet transform for time scale analysis disturbances, block–based modeling.
- **CHARACTERIZATION OF POWER QUALITY EVENTS** **(09 Hours)**
  Voltage magnitude, phase angle and three characteristics versus time, event indices, transient.
- **EVENT CLASSIFICATION** **(08 Hours)**
  Overview of event classification method, step used for event classification, learning and classification using artificial neural network.
- **POWER FACTOR CORRECTION & MITIGATION OF POWER QUALITY PROBLEMS** **(08 Hours)**
  Power factor improvement techniques, Passive Compensation, Passive filter: Design and operation, Active filter: Design of shunt and series active filter and Control algorithms.

Total Hours:42

3. Books Recommended:

1. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, Wiley Interscience, New Jersey, 2007.
2. Bollen Math, H. J. GU and Y. H. Irene, Signal Processing of Power Quality Disturbances, Wiley Interscience Publication (IEEE Press), 2006.
3. J. Wakileh George, Power System Harmonics: Fundamentals, analysis and filter Design, Springer, (first Indian reprint) 2007.
4. E. F. Fuchs, A. S. Masoum Mohammad, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 2008.
5. A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer International Edition, Delhi, 2009.

B. Tech. III (Electrical), Semester – VI

High Voltage Engineering (ES – II)

L	T	P	Credit
3	0	0	03

EE342 **Scheme**

1. Course Outcomes (Cos):

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

CO1	illustrate different methods of generating various high voltages and currents
CO2	explain various methods of measuring various high voltages and currents
CO3	analyze various breakdown phenomena occurring in gaseous, liquid and solid dielectrics
CO4	apply appropriate testing method(s) for various high voltage apparatus
CO5	estimate the testing source requirement for any high voltage testing
CO6	plan the high voltage laboratory

2. Syllabus:

- **GENERATION OF VARIOUS TYPES OF HIGH VOLTAGES** **(12 Hours)**
  Generation of High DC Voltages: Half Wave and full wave circuits –Ripple voltages in HW and FW rectifiers. Voltage doubler circuits – Simple voltage doubler, cascade voltage doubler. Voltage multiplier circuits – Crockroft Walton voltage multiplier circuits. Ripple and regulation. Electrostatic machines – principles – Van de Graff generator.

  Generation of high AC voltages: Cascade transformers, resonant transformers – parallel and series resonant test systems. Generation of high frequency high voltages – Tesla coil.

  Generation of impulse voltages – Standard impulse wave shape Basic circuits for producing impulse waves – Analysis of commercial impulse generator circuits – Wave shape control, multi-stage impulse generators – Marx circuit – modified Marx impulse generator circuit – Components of multi stage impulse generator. Generation of Switching surges. Generation of impulse current. Definition of impulse current waveform – Circuit for producing impulse current waves.

- **MEASUREMENTS OF HIGH VOLTAGES & CURRENTS** **(06 Hours)**
  Measurement of high voltages and currents-DC,AC and impulse voltages and currents-DSO, electrostatic and peak voltmeters, sphere gaps-factors affecting measurements, potential dividers(capacitive and resistive)-series impedance ammeters, Rogowski coils, hall effect generators.

- **ELECTRICAL BREAKDOWN IN GASES, LIQUIDS & SOLID DIELECTRICS** **(10 Hours)**
  Introduction to Insulation materials. Breakdown in gas and gas mixtures-breakdown in uniform and non-uniform fields, Paschen's law, Townsends criterion, streamer mechanism, corona discharge, breakdown in electro negative gases, Breakdown in liquid dielectrics-suspended particle mechanism, Breakdown in solid dielectrics-intrinsic, streamer, thermal breakdown.

- **DESIGN, PLANNING AND LAYOUT OF HV LABORATORY** **(04 Hours)**
  Test Facilities, Activities & Studies in HV lab, Classification of HV lab, Size & rating of HV lab, grounding of impulse testing laboratories.

- **HV TESTING OF ELECTRICAL APPRATUS** **(10Hours)**
  Non-destructive testing of dielectric materials – measurement dielectric constant and loss factor. Testing of Insulators, Bushings, Isolators, Circuit breakers, Cables, Transformers, Surge diverters, RI Measurement.

Total Hours:42

3. Books Recommended:

1. E. Kuffel, W. S. Zaengl and J. Kuffel, High voltage Engineering Fundamentals, Newnes, 2nd Edition, 2002.
2. M. S. Naidu, V. Kamaraju, High Voltage Engineering, Tata Mcgraw Hill, 2nd Edition, 2001.
3. L. L. Alston, High voltage Technology, BS Publications, 2008.
4. Nils Hylten-Cacallius, High voltage Laboratory Planning, High voltage test system, Asea Haefely.
5. Standard Techniques for High Voltage Testing, IEEE Publication, 1978.
6. Relevant IS standards and IEC standards.

B. Tech. III (Electrical), Semester – VI

FACTS Devices (ES – II)

L	T	P	Credit
3	0	0	03

EE344 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the basic principle of power transmission and reactive power control.
CO2	analyze shunt compensation and its requirement.
CO3	evaluate series compensation and its requirement
CO4	analyze of shunt-series compensation and its requirement.
CO5	design of controllers for FACTS devices.

2. Syllabus:

- **LOAD COMPENSATION** **(07 Hours)**
  Requirement and objectives of load compensations, Practical considerations, power factor and voltage regulations, balancing of unsymmetrical loads, Active filters: : Principle of operation, Analysis, Configurations, Control system, Applications.
- **REACTIVE POWER COMPENSATION** **(08 Hours)**
  Analysis of uncompensated AC line, Passive reactive power compensation, Compensation by a series capacitor connected at the mid-point of the line, Effect on Power Transfer capacity, Compensation by STATCOM and SSSC
- **STATIC SHUNT COMPENSATORS** **(10 Hours)**
  Static Var Compensators (TCR, FC-TCR, TSC-TCR): Principle of operation, Analysis, Configurations, Control system, Applications, protection aspect. STATCOM: Principle of operation, Analysis of six pulse and multi-pulse converters, Control systems, Applications.
- **STATIC SERIES COMPENSATORS** **(10 Hours)**
  Concept of controlled series compensation, (TCSC, GCSC): Principle of operation, Analysis, Configurations, Control system, Applications. SSSC: Principle of operation, Analysis, Configurations, Control system, Applications.
- **COMBINED COMPENSATORS** **(07Hours)**
  (UPFC,IPFC) Principle of operation, Analysis, Configurations, Control system, Applications.

Total Hours: 42

3. Books Recommended:

1. K. R. Padiyar, FACTS Controller in Power Transmission and Distribution, New Age international, 1st Edition, 2007.
2. N.G. Hingorani, Understanding FACTS, IEEE Press, Standard Publishers Distributor, 2001.
3. T. J. E. Miller, Reactive Power Control in Electric Systems, John Wiley, 2010.
4. R. Mathur, N. Mohan and R. K. Varma, Thyristor–based FACTS Controllers for Electrical Transmission System, Wiley Inter-Science, 2011.
5. Acha E., Agelidis V. G., Anaya-Lara O., T.J.E. Miller, Power Electronics Control in Electrical System, Newnes Power Engineering Series, 2002.

B. Tech. III (Electrical), Semester – VI

Discrete-time Control Systems (ES – II)

L	T	P	Credit
3	0	0	03

EE346 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify various Discrete-Time control systems
CO2	analyze the Discrete-Time control systems with Z transformation
CO3	design Discrete-Time control systems and to assess the stability of DTCS
CO4	obtain and analyze State-space representations of discrete-time systems
CO5	design various discrete-time systems control schemes

2. Syllabus:

- **INTRODUCTION TO DISCRETE-TIME CONTROL SYSTEMS** **(03 Hours)**
  Introduction, digital control systems, quantizing and quantization error, data acquisition, conversion, and distribution systems.
- **THE Z TRANSFORMATION** **(08 Hours)**
  The z transform, transforms of elementary functions, important properties and theorems of the z transform, the inverse z transform, z transform method for solving difference equations.
- **Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEMS** **(08 Hours)**
  Impulse sampling and data hold, obtaining the z transform by the convolution integral method, reconstructing original signals from sampled signals, the pulse transfer function, realization of digital controllers and digital filters.
- **DESIGN OF DISCRETE-TIME CONTROL SYSTEMS** **(10 Hours)**
  Introduction, mapping between the S plane and the z plane, stability analysis of closed-loop systems in the z plane, transient and steady-state response analysis, design based on the root-locus method, design based on the frequency-response method, analytical design method.
- **STATE-SPACE ANALYSIS** **(08 Hours)**
  State-space representations of discrete-time systems, solving discrete-time state-space equations, pulse-transfer-function matrix, discretization of continuous-time state-space equations, Lyapunov stability analysis.
- **POLE PLACEMENT AND OBSERVER DESIGN** **(05 Hours)**
  Controllability, observability, useful transformations in state-space analysis and design, via pole placement, state observers, servo systems.

Total Hours:42

3. Books Recommended:

1. K. Ogata, Discrete Time Control System, Pearson Education, Inc., 2nd Edition, 2015.
2. B. C. Kuo, Discrete Data Control System, Prentice-Hall, 2nd Edition, 1992.
3. I. J. Nagrath and M. Gopal, Control System Engineering" New Age International Publishers, 3rd Edition, 2001.
4. M. Gopal, Digital control System, McGraw-Hill Education, 4th Edition, 2017.
5. B. C. Kuo, Automatic Control System, Prentice Hall of India, 7th Edition, 1995.

B. Tech. III (Electrical), Semester – VI

L	T	P	Credit
3	0	0	03

Restructuring and Deregulation of Power Systems (ES – II)

EE348 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the basics and benefits of restructuring and deregulations
CO2	evaluate the market scenario and completion in deregulated environment
CO3	judge the pricing and agreements associated with deregulation policies.
CO4	explore the contingency and ancillary service management restructured and deregulated system.
CO5	explore the impact of availability and unavailability in terms of reliability indices

2. Syllabus:

- **DEREGULATION OF THE ELECTRICITY SUPPLY INDUSTRY** **(06 Hours)**
  Deregulation, Reconfiguring Power systems, unbundling of electric utilities, Background to deregulation and the current situation around the world, benefits from a competitive electricity market, after-effects of deregulation.
- **POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT** **(10 Hours)**
  Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: Genco in Pool and Bilateral markets, market participation issues, competitive bidding.
- **TRANSMISSION OPEN ACCESS AND PRICING ISSUES** **(08 Hours)**
  Power wheeling, Transmission open access, pricing of power transactions, security management in deregulated environment, congestion management in deregulation.
- **ANCILLARY SERVICES MANAGEMENT** **(08 Hours)**
  General description of some ancillary services, ancillary services management in various countries, reactive power management in deregulated electricity markets
- **RELIABILITY AND DEREGULATION** **(10 Hours)**
  Reliability analysis: interruption criterion, stochastic components, component models, calculation methods, Network model: stochastic networks, series and parallel connections, minimum cut sets, reliability costs, Generation, transmission and distribution reliability, Reliability and deregulation: conflict, reliability analysis, effects on the actual reliability, regulation of the market.

Total Hours: 42

3. Books Recommended:

1. K. Bhattacharya, MHT Bollen and J.C Doolder, Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 2001.
2. Lei Lee Lai, Power System Restructuring and Deregulation, John Wiley and Sons, UK. 1st Edition, 2001.
3. Fred I Denny and David E. Dismukes, Power System Operations and Electricity Markets, CRC Press, LLC, 1st Edition, 2002.
4. Mohammad Shaidehpur, Muwaffaq Alomoush, _Restrctured electrical Power Systems, Operation, Trading and Volatility,_ Marcel Dekker Publications.
5. Xiao Ping Zhang, Restructured electrical Power Systems with equilibrium Models, John Wiley & Sons, 1st Edition, 2010.

B. Tech. III (Electrical), Semester VI

Special Electrical Machines (ES-II)

L	T	P	Credit
3	0	0	03

EE352 **Scheme**

1. Course Outcomes (Cos):

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

CO1	list different types of special electrical machines
CO2	describe the basic principles of special Electrical machines
CO3	compare the performance of various special electric machines
CO4	analyze the steady state performance of special Electrical machines
CO5	identify the special constructional and operating features of special electrical machines
CO6	select appropriate special electric machine for given application

2. Syllabus:

- **SERVO MOTORS** **(05 Hours)**
  Symmetrical components applied to two - phase servo motors - equivalent circuit and performance based on symmetrical components - servo motor torque - speed curves.
- **VARIABLE RELUCTANCE MOTORS** **(08 Hours)**
  Construction of VRM, Concepts of co-energy and expression of torque, inductance, current and torque calculation and waveforms, Drive circuit for VRM.
- **STEPPER MOTORS** **(07 Hours)**
  Construction features, half stepping and the required switching sequence, stepper motor ratings, static and dynamic characteristics, application and selection of stepper motor.
- **RELUCTANCE MOTORS** **(02 Hours)**
  Construction – poly-phase and split phase reluctance motors - capacitor type reluctance motors.
- **HYSTERISIS MOTORS** **(02 Hours)**
  Construction – poly-phase: capacitor type and shaded pole hysteresis motors.
- **UNIVERSAL MOTORS** **(03 Hours)**
  Essential parts of universal motor, performance characteristics and application.
- **LINEAR MACHINES** **(08 Hours)**
  Basic difference between LEMS and rotating - machine - classification of LEMS, linear motors and levitation machines - linear induction motors - linear synchronous motors - DC linear motors - linear levitation machines.
- **PMDC MOTORS** **(01 Hour)**
  Construction, principle of operation, performance analysis.
- **BRUSHLESS DC MOTORS** **(06Hours)**
  Construction, principle of operation, phasor diagram, characteristics, performance analysis.

Total Hours: 42

3. Books Recommended:

1. V. D. Toro, Electric machines and power systems, Prentice Hall of India, 1985.
2. Veinott, Fractional horse power electric motors, McGraw Hill, 4th Edition, 1987.
3. S. A. Nasar, Boldeal, Linear Motion Electric machine, John Wiley,1976.
4. V. V. Athani, Stepper Motors, New Age International Pvt. Ltd., 1997.
5. I. J. Nagrath and D. P. Kothari, Electric Machines, Tata McGraw Hill Publishing Company, New Delhi, 4th Edition, 2010.

B. Tech. III (Electrical), Semester – VI

L	T	P	Credit
3	0	0	03

Advanced Electrical Drives (ES – III)

EE354 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the basic principle of operation of conventional and modern electric drives
CO2	apply the concept of reference frame theory and space vector concept for AC drives.
CO3	develop various control strategies for modern electric drives
CO4	apply the soft computing techniques for electric drives.
CO5	compare various soft computing techniques in terms of dynamic and steady state response.

2. Syllabus:

- **REVIEW OF FUNDAMENTALS OF AC DRIVE** **(06 Hours)**

  Reference frame theory, concept of space vector, state space model.

- **INDUCTION MOTOR DRIVES** **(12 Hours)**
  Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage, PWM and SVPWM method, rotating field, dynamic d-q model, Stator voltage control, V/f controlled induction motors, DC drive analogy, field oriented control, sensor less control, doubly fed induction machine, direct torque and flux control, CSI fed induction motor drives, Applications.

- **SYNCHRONOUS MOTOR DRIVES** **(12 Hours)**
  Introduction, Sinusoidal SPM machine drives, synchronous reluctance machine drives, Trapezoidal SPM machine drive, wound field synchronous motor drive, Load-commutated Synchronous Motor Drives, Model of PMSM, Vector controlled PMSM drive, UPF control, torque angle control, optimum torque per ampere control.

- **SOFT COMPUTING FOR ELECTRICAL DRIVES** **(12 Hours)**
  PI tuning methods, speed control using fuzzy logic controllers and adaptive controllers, Application of neural network for control of electrical drives, identification and parameter estimation.

Total Hours:42

3. Books Recommended:

1. B.K. Bose, Modern Power Electronics & AC Drives, Pearson, 1st Edition, 2005.
2. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall, 1st Edition, 2015.
3. Peter Vas, Vector Control of Electric Drives, Oxford Publishers, 1998.
4. S. Dewan, B. Slemon, A. G. R. Straughen, Power Semiconductor drives, John Wiley and Sons, NewYork 2009.
5. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2nd Edition, 2001.

B. Tech. III (Electrical), Semester – VI

L	T	P	Credit
3	0	0	03

Electronic Instrumentation and Control (ES – III)

EE356 Scheme

1. Course Outcomes (Cos):

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

CO1	classify various Digital measurement techniques and to explain working principle of various type of digital Frequency and time measuring Instruments
CO2	explain working principle of various type of Instrumentation amplifiers, multiplexers, de-multiplexers, convertors and data acquisition systems
CO3	discuss various types of Industrial automation
CO4	explain working principle of various type of sensors and transmitters
CO5	develop ladder logic program for PLC for various industrial applications including SCADA

2. Syllabus:

- **DIGITAL MEASUREMENT** **(09 Hours)**
  Digital measurement techniques for voltage, current, power, energy, resistance, capacitance and loss angle (TAN ∂), impedance and quality factor.
- **DIGITAL FREQUENCY AND TIME MEASURING INSTRUMENTS** **(05 Hours)**
  Frequency counter, period duration meter, pulse width meter, frequency ratio meter, Errors in digital instruments.
- **SIGNAL CONDITIONING, DATA ACQUISITION AND CONVERSION** **(06 Hours)**
  Review of Instrumentation amplifiers and isolation techniques, sample and hold circuits, multiplexers and de-multiplexers, digital to analog converters, data acquisition systems, encoders, grounding and shielding techniques.
- **INTRODUCTION TO INDUSTRIAL AUTOMATION** **(03 Hours)**
  Introduction, advantages and disadvantages, topologies and components of Industrial Automation.
- **INTRODUCTION TO SENSORS AND TRANSMITTER** **(05 Hours)**
  Overview of sensors to sense position, speed, temperature, pressure, flow, level etc., Transmitter, Architecture of current loop.
- **AN OVERVIEW OF PLC** **(05 Hours)**
  Introduction, definitions and history of PLC, manufacturing and assembly processes, PLC advantages and disadvantages, overall PLC system, CPU, PLC, input and output modules, program recording devices.
- **PROGRAMMING PLC** **(07 Hours)**
  Ladder diagrams, programming ON/OFF inputs to produce ON/OFF outputs, digital gate logic and contact coil logic, creating ladder diagrams from process control descriptions, timer function, counter function, arithmetic functions, comparison functions.
- **INTRODUCTION TO SCADA** **(02 Hours)**
  Introduction, need, features of SCADA.

Total Hours:42

3. Books Recommended:

1. A. D. Helfrick, W. D. Cooper, Modern electronic Instrumentation and Measurement Techniques, Prentice Hall India, 1997.
2. E. O. Doebelin, Measurement Systems - Application and Design, 4th Edition, McGraw-Hill, New York, 1992.
3. T.S. Rathore, Digital Measurement Technique, Narosa publishing house, 2nd Edition.
4. Curtis Johnson, Process Control Instrumentation Technology, Prentice Hall of India, 6th Edition.
5. John. W. Webb, Ronald A Reis, Programmable Logic Controllers - Principles and Applications, 4th Edition, Prentice Hall Inc., New Jersey, 1998.

B. Tech. III (Electrical), Semester – VI

Power System Transients (ES – III)

L	T	P	Credit
3	0	0	03

EE358 **Scheme**

1. Course Outcomes (Cos):

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

CO1	recall the fundamentals of transient analysis of RLC circuit and circuit breaker operation
CO2	identify the source and characteristics of lightning, switching, and temporary over voltages
CO3	interpret the concept of travelling wave propagation on transmission lines
CO4	analyze switching transients in electric equipment like transformer, generator and motor
CO5	evaluate different protection schemes for power system equipment against travelling wave

2. Syllabus:

- **OVERVOLTAGES IN POWER SYSTEMS** **(12 Hours)**
  Transient over voltages due to lightning, Theory of ground wires, Direct stroke to a tower, Effect of reflection up and down the tower, Tower grounding and counterpoises, Switching transients, Single and double frequency transients, Abnormal switching transients, Capacitance switching, Kilometric fault, Line dropping and load ejection, Closing and reclosing of lines, High charging currents, Over voltages induced by faults, Ferro-resonance, Switching transients in integrated systems, Peaking switching over voltages in EHV lines and cables.
- **TRAVELLING WAVES IN TRANSMISSION LINES** **(12 Hours)**
  Origin and nature of power system transients, Traveling waves on transmission lines, General wave equation, Attenuation and distortion of waves, Reflection and refraction of traveling waves at different line terminations, Bewley Lattice Diagram, Traveling waves in multi-conductor systems, Transition points on multi-conductor circuits.
- **PROTECTION AGAINST TRAVELLING WAVES** **(06 Hours)**
  Rod gap, Arcing Horn, Lightning Arresters, Surge Absorber, Insulation Coordination.
- **TRANSIENT IN TRANSFORMERS AND ROTATING ELECTRICAL MACHINES** **(12 Hours)**
  High frequency transients and voltage distribution in windings of transformer and rotating electrical machines, Surge impedance.

Total Hours: 42

3. Books Recommended:

1. I.V. Begley, Traveling waves in Transmission Systems, John Wiley (1933, 51), Dover.
2. R. Rudenberg., Electric Stroke waves in Power System, Harvard Unive rsity Press and Cambridge, Massachusetts.
3. Allan Greenwood, Electric Transients in Power Systems, Wiley Inter science 2nd Edition, 2010.
4. C.S. Indulkar and D.P. Kothari, Power System Transients, A Statistical Approach, Prentice Hall of India Pvt. Ltd., New Delhi. 110001, 2nd Edition, 2010.
5. V.A. Venikov, Transient phenomena in Electrical Power Systems, Pergamon Press, London, 2014.

B. Tech. III (Electrical), Semester – VI

L	T	P	Credit
3	0	0	03

Advanced Industrial Automation (ES – III)

EE376 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify various types of Automation
CO2	explain working principle of various component of Industrial automation
CO3	discuss various type of controller for Industrial automation
CO4	develop ladder logic program for PLC for various industrial applications including SCADA and HMI
CO5	discuss case study of Industrial automation

2. Syllabus:

- **INTRODUCTION TO INDUSTRIAL AUTOMATION** **(02 Hours)**
  Need of Industrial Automation, Advantages and disadvantages of automation, automation pyramid.
- **COMPONENTS OF INDUSTRIAL AUTOMATION** **(12 Hours)**
  Advanced sensors and measurement systems, Signal Conditioning and Processing, standard Instrumentation signal, transmitters, actuators.
- **CONTROLLERS FOR INDUSTRIAL AUTOMATION** **(12 Hours)**
  PLC, High end PLC programming, timer function, counter function, arithmetic functions, comparison functions analog input and output, subroutine, interrupt. PID Tuning, close loop speed control, closed loop temperature control.
- **HMI and SCADA** **(08 Hours)**
  Introduction to HHI and SCADA, Communication of SCADA and HMI with PLC and PC. Communication of SCADA with VFD.
- **CASE STUDY** **(08 Hours)**
  Industrial automation in various industries, like chemical, textile, oil and Gas, food and beverages etc.

Total Hours:42

3. Books Recommended:

1. John Webb, Programmable Logic Controllers Principles & Applications, Prentice Hall of India, 1st Edition, 2013.
2. Andrews, Applied Instrumentation in Process Industries, Gulf Professional Publishing; 2nd Edition, 1979.
3. D. Patranabis, Principles of Process Control, Tata Mcgraw Hill, 3rd Edition, 2017.
4. S. K. Singh, Computer Aided Process Control, Prentice Hall of India, 2004.
5. Kevin Collins, PLC Programming for Industrial Automation, Exposure Publishing, 2006.

B. Tech. III (Electrical), Semester – VI

Reliability Evaluation of Electrical Systems (ES – III)

L	T	P	Credit
3	0	0	03

EE378 **Scheme**

1. Course Outcomes (Cos):

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

CO 1	explain the basic of reliability and its importance for electrical network.
CO 2	implement and model for reliability evaluation of generating systems for LOLE and reliability indices.
CO 3	calculate the duration and frequency of outages and availability from reliability.
CO 4	evaluate the impact of interconnections on reliability.
CO 5	apply the concept of reliability for electrical distribution network for its secure and safe operation with relays, circuit breakers, switches etc.
CO 6	implement the Monte Carlo simulation concept for electrical networks for verification and execution of reliability indices.

2. Syllabus:

- **INTRODUCTION TO RELIABILITY** **(06 Hours)**
  Background, quantitative and qualitative assessment, reliability indices and criteria, reliability evaluation techniques, reliability concepts, basic probability concepts, binomial distribution for reliability and probability, engineering applications of binomial distribution, electrical power generation capacity outage probability and reliability, loss of load expectation (LOLE) and calculation of expected energy not supplied (EENS).
- **NETWORK MODELING AND RELIABILITY** **(08 Hours)**
  Simple network modeling, series, parallel system, redundant systems, perfect switching and imperfect switching, reliability of complex system, conditional probability approach, cut-set and tie-set approach, event-tree, fault-tree, multi-failure modes, Poisson’s distribution, normal distribution, exponential distribution, Weibull distribution, data analysis, goodness-of-fit tests, reliability evaluation of series/parallel/stand-by systems using probability distribution. Application to electrical network for reliability estimation.
- **DISCRETE AND CONTINUOUS MARKOV PROCESS** **(08 Hours)**
  General modeling concept of discrete Markov chain, stochastic transitional probability matrix, limiting states, absorbing states, continuous Markov process, state-space diagrams, limiting and absorbing states of continuous Markov process, time dependent state probabilities, differential equation method, matrix multiplication method, repairable systems reliability, mean time to failure (MTTF), Markov process of electrical systems.
- **FREQUENCY AND DURATION TECHNIQUES** **(10 Hours)**
  Concepts of frequency and duration, multi-state problems, mean duration of individual states, frequency balance approach, two stage repair and installation process, electrical power generation model and system risk evaluation, capacity expansion, composite generation and transmission system, state selection, system and load point indices, System risk indices, Individual state load model, Cumulative state load model.
- **MONTE CARLO SIMULATION AND ITS APPLICATIONS** **(10 Hours)**
  Concepts of simulation, random variates, conversion of uniform random numbers, application of Monte Carlo Simulation, tossing a coin, throwing a die, repetitive tossing, time dependent reliability, two component non-repairable system, three component non-repairable system, repairable and standby

system evaluation, stopping rules, variance reduction techniques, Application to generation capacity reliability evaluation, Reliability/LOLE assessment with chronological /nonchronological load, Application to composite generation and transmission.

Total Hours: 42

3. Books Recommended:

1. Roy Billinton andRonald N. Allan, Reliability Evaluation of Engineering Systems Concepts and Techniques, 2nd Edition, Springer Science, 1992.
2. Roy Billinton and Ronald N. Allan, Reliability Evaluation of Power Systems, 2nd Edition, Springer Science & Business Media, 1992.
3. T. A. Short, Taylor & Francis group, Distribution Reliability and Power Quality, 1st Edition, 2018.
4. Roy Billinton, Ajit Kumar Verma, Rajesh Karki, Reliable and sustainable Electric Power and Energy Systems Management, Springer, 2014.
5. Chetan Singh., Panida Jirutitijaroen. and Joydeeep Mitra, Electric Power Grid Reliability Evolution: Models and Methods, John Wiley & Sons, 2018.

B. Tech. III (Electrical), Semester - VI

Innovation, Incubation and Entrepreneurship (ES-III)

HU 322 **Scheme: 3-0-0**

1. Course Outcomes (COs):

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

CO1	Explain the concepts of Entrepreneurship
CO2	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	Develop skills related to Project Planning and Business Plan development
CO4	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	Build knowledge about Sources of Information and Support for Entrepreneurship

2. Syllabus:

- **CONCEPTS OF ENTREPRENEURSHIP** **(08 Hours)**

  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Entrepreneurial Traits, Characteristics and Skills, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers, Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc.

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(14 Hours)**

  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan

  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan

  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan

  Financial Management: Basics of Financial Management, Ratio Analysis, Investment Decisions, Capital Budgeting and Risk Analysis, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(8 Hours)**

  Search for Business Idea, Product Innovations, New Product Development – Stages in Product Development; Sequential stages of Project Formulation; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(2 Hours)**

  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(6 Hours)**

Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(4 Hours)**

  State level Institutions, Central Level institutions and other agencies

(Total Lecture Hours: 42)

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3. Books Recommended:

1. Desai Vasant, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, India, 6th Revised Edition, 2020
2. Charantimath P. M., Entrepreneurial Development and Small Business Enterprises, Pearson Education, 3rd Edition, 2018
3. Holt David H., Entrepreneurship: New Venture Creation, Pearson Education, 2016
4. Chandra P., Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill, 9th Edition, 2019
5. Banga T. R. & Shrama S .C., Industrial Organization & Engineering Economics, Khanna Publishers, 25th Edition, 2015

4. Further Reading:

1. Prasad L.M., Principles & Practice of Management, Sultan Chand & Sons, 8th Edition, 2015
2. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, Prentice Hall of India, 5th edition, 2012
3. Kotler P., Keller K. L, Koshi A.& Jha M., Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014
4. Tripathi P.C., Personnel Management & Industrial Relations, Sultan Chand & sons, 21st Edition, 2013
5. Chandra P., Financial Management, Tata McGraw Hill, 9th Edition, 2015

SARDARVALLABHBHAI NATIONALINSTITUTE OF TECHNOLOGY, SURAT

DEPARTMENT OF ELECTRICAL ENGINEERING

B. Tech. Programme

B. Tech. IV

Semester VII

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE401	Microcontroller and Embedded 'C' Programming	3	0	2	04	100	-	25	25	150
2.	EE403	Electrical Machine Design	3	1	0	04	100	25	-	-	125
3.	EE405	Switch Gear and Protection	3	0	2	04	100	-	25	25	150
4.	EE4AA	ES-IV	3	0	0	03	100	-	-	-	100
5.	EE4BB	ES-V	3	0	0	03	100	-	-	-	100
6.	EE4CC	ES-VI	3	0	0	03	100	-	-	-	100
7.	EE407	Project	0	0	6	03	-	-	40	60	100
		Total (L-T-P)	18	01	10	24	600	25	90	110	825
		Total		**29**		**24**					

CORE ELECTIVE SUBJECTS- ES-IV (EE4AA) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE421	Electrical Traction and Linear Machines
EE423	EHV AC Transmission
EE425	Advanced Power Electronics
EE427	Nonlinear and Optimal Control
EE429	Advanced Microcontroller (Digital Signal Controller)
EE431	Industrial Instrumentation
EE433	Power System Operation and Control
EE435	Wind and Solar Energy Conversion Systems

CORE ELECTIVE SUBJECTS- ES-V (EE4BB) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE437	Power Filter Technology
EE439	Smart Grid Technology
EE441	HVDC Transmission
EE443	Electric Vehicles
EE445	Digital Signal Processing
EE447	Modern Materials for Electrical Engineering
EE449	Special Electrical Machines and Drives

CORE ELECTIVE SUBJECTS- ES-VI (EE4CC) (DEPARTMENT LEVEL)	
Course Code	Subject Name
EE451	Switch Mode Power Supply
EE453	Computer Methods for Power Systems
EE455	Robotics
EE457	Communication Engineering
EE459	VLSI Technology
EE461	Antenna and Wave Propagation
EE463	Cryptography and Cyber Security for Smart Grid

Semester VIII

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1.	EE402	Internship in Industry/Academic Institute/ Research Organization	0	0	20	10	-	-	120	180	300
Total (L-T-P)			**0**	**0**	**20**	**10**	**0**	**0**	**120**	**180**	**300**
Total			**20**			**10**					

B. Tech. IV (Electrical), Semester – VII

Microcontroller and Embedded C Programming

L	T	P	Credit
3	0	2	04

EE401 **Scheme**

1. Course Outcomes (Cos):

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

CO 1	revise basic concepts of 8051 microcontroller and embedded 'C' programming.
CO 2	explain architecture of CIP 51 8 bit microcontroller with the advanced features of the controller.
CO 3	describe the functionality of Programmable internal and external peripherals of CIP 51.
CO 4	write embedded 'C' code for CIP51 with the exposure of SI Lab IDE.
CO 5	develop microcontroller based prototype for automation, power electronics based electrical systems and other real world problems.

2. Syllabus:

- **INTRODUCTION TO CIP-51 CONTROLLER ARCHITECTURE** **(04 Hours)**

  Memory Map, Instruction Pipeline, PLL & Clock System, On Chip Peripherals, concept of Cross-bar and Pin assignment

- **INTRODUCTION TO EMBEDDED 'C' PROGRAMMING** **(04 Hours)**

  Variables and constants, storage classes, enumerations and definitions, I/O operations, control statements, functions, pointers and arrays, structure and unions, interrupt service routines.

- **HARDWARE CONCEPT AND PROGRAMMING OF CIP-51 PERIPHERALS** **(14 Hours)**

  Timer/Counters, GPIO, ADC, DAC, UART, Interfacing of seven-segment LED and LCD display, interfacing of pushbutton keys, interfacing of Matrix key board

  ADVANCED PERIPHERAL OF CIP-51 **(12 Hours)**

  Comparator, SPI & I2C serial Communication interface, MAC unit on CIP-51, On-chip PLL and Its programming

- **CIP-51 BASED DESIGN OF EMBEDDED SYSTEMS** **(08 Hours)**

  Design and implementation of ZCD circuits, Thyristor and triac firing circuit, Non isolated buck and boost converters

Total Hours: 42

3. List of Experiments:

(to write and execute using 'C' programming to)

1. generate square wave of different frequency using timer T0
2. generate square wave of different frequency using timer T0
3. generate different duty cycle and different switching frequency waveform with timer T0 and T2.
4. interface LCD with cip-51
5. display digital clock on LCD
6. turn on and turn off led with key debounce
7. generate PWM signal using timer T2 and PCA timer

8. generate high frequency square wave using PCA Timer
9. generate sine wave and triangular wave using DAC
10. measure voltage and current using ADC
11. measure frequency of unknown signal using timer T2 and PCA timer
12. transmit following character data string at 9600 baud rate using uart0. Use timer 2 to generate required baud rate data string- ‗hello svnit"

4. Books Recommended:

1. Barnett, O'cull, Cox, Embedded C Programming and the Microchip PIC, Cengage Learning publication.
2. M. Mazidi, J. G. Mazidi and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 3rd edition, 2007.
3. Mark Siegesmund, Embedded C Programming: Techniques and Applications of C and PIC MCUS, Elsevier Science, 1st Edition 2014.
4. Datasheet of SILABS C8051F12X. (www.silabs.com)
5. Application notes from SILAB C8051F12X.

B. Tech. IV (Electrical), Semester – VII

Electrical Machine Design

L	T	P	Credit
3	1	0	04

EE403 **Scheme**

1. Course Outcomes (Cos):

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

CO1	demonstrate the basic steps involved in design of electrical machines
CO2	describe the basic equations related to the electric machine design
CO3	calculate the performance indices of electrical machines
CO4	estimate the design parameters as per performance requirements
CO5	analyze the effect of design parameters on the performance of electric machines
CO6	develop the design of transformers, induction machines, dc machines and synchronous machines

2. SYLLABUS:

- **GENERAL ASPECTS OF ELECTRICAL MACHINE DESIGN** **(04 Hours)**
  Electrical engineering materials, magnetic circuit design, thermal design
- **TRANSFORMERS** **(09 Hours)**
  Output equation - single phase and three phase power transformers - main dimensions - choice of specific electric and magnetic loadings- design of core, LV winding, HV winding, tank and cooling tubes - prediction of no load current, forces on winding during short circuit, leakage reactance and equivalent circuit based on design data – computer aided design examples.
- **GENERAL CONCEPTS AND CONSTRAINTS IN DESIGN OF ROTATING MACHINES** **(03 Hours)**
  Specific loadings and output equations of AC and DC machines.
- **DC MACHINES** **(08 Hours)**
  Main dimensions - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system, commutator, interpoles, compensating winding and brushes – Carter's coefficient - real and apparent flux density – Computer aided design examples.
- **ALTERNATORS** **(08 Hours)**
  Salient pole and turbo alternators - main dimensions - choice of speed and number of poles - design of armature conductors, slots and winding - design of air-gap, field system and damper winding - prediction of open circuit characteristics and regulation of the alternator based on design data – computer aided design examples.
- **INDUCTION MACHINES** **(10 Hours)**
  Main dimensions - design of stator and rotor windings, stator and rotor slots and air-gap of slip ring and squirrel cage motors – calculation of rotor bar and end ring currents in cage rotor - calculation of equivalent circuit parameters and prediction of magnetizing current based on design data – computer aided design examples.

Total Hours:42

Tutorials will be conducted separately for 14 hours

3. Books Recommended:

1. A. K. Sawhney, Chakrabarti, A Course in Electrical Machine Design, Dhanpat Rai & Co., 2016.
2. Clayton & Hancock, Performance & Design of DC Machines, CBS, 3rd Edition, 2001.
3. M. G. Say, Performance & Design of AC Machines, Pitman, ELBS.3rd Edition, 1983.
4. S.K.Sen, Principles of Electrical Machine Design, Oxford & IBH Pub., 2nd Edition, 2006
5. R. K. Agarwal, Principles of Electrical Machine Design, S. K. Kataria & Co., 2nd Edition, 2012.

B. Tech. VI year, Semester VII

L	T	P	Credit
3	0	2	04

Switchgear and Protection

EE405 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the basic concept of protection of electrical power system
CO2	demonstrate the function of various Circuit Breakers, fuse and related switches with respect to their construction, theory and applications.
CO3	explain use of current transformer and potential transformer in protection.
CO4	identify appropriate relaying schemes to protect Generator, Motor, Transformer and Bus bar based on fault
CO5	distinguish the various protection methods for the protection of Transmission line

2. Syllabus:

- **FUSES, SWITHCHES AND NEUTRAL GROUNDING** **(03 Hours)**
  Rewirable fuses, HRC fuses, isolators and earthing switches, selection of fuses. Effectively grounded and ungrounded systems, resonant grounding Methods of neutral grounding.
- **BASIC PRINCIPLES AND RATINGS OF CIRCUIT BREAKERS** **(04 Hours)**
  Arc phenomenon, arc Interruption theories, arc control devices, recovery and restriking voltages, current chopping, Interruption of capacitive current, resistance switching, circuit breaker operating mechanism and control systems, making current, breaking current symmetrical and unsymmetrical, continuous current rating, MVA capacity.
- **CIRCUIT BREAKERS** **(09 Hours)**
  Bulk oil circuit breaker, arc controlled devices, MOCB, ACB, ABCB, SF_6 circuit breaker, vacuum circuit breaker and DC circuit breakers, circuit breaker ratings, auto recloser. Testing of circuit Breaker.
- **CURRENT TRANSFORMER AND POTENTIAL TRANSFORMER** **(02 Hours)**
  Construction, Operation, Vector Diagram of CTs , PTs and CVTs.
- **FUNCTIONS OF PROTECTIVE RELAYING** **(02 Hours)**
  Fundamental characteristics of relays, standard definition of relay terminologies, relay classifications, operating principles of single and double actuating quantity type electromechanical relays, directional relay, reverse power relay.
- **GENERATOR & MOTOR PROTECTION** **(06 Hours)**
  Modern methods of protecting generators against faults in stator, rotor and prime movers and other abnormal conditions. Abnormal operating conditions, under voltage, phase and earth fault, overload and unbalanced voltage protections for motors.
- **TRANSFORMER PROTECTION** **(03 Hours)**
  Protection of transformers, basic differential over current relays, restricted earth fault protection, gas relays, overall generator-transformer differential protection, magnetizing inrush protection.
- **BUSBAR PROTECTION** **(03 Hours)**
  Protection of outdoor and indoor bus-bar by current differential, voltage differential and directional comparison principles, linear coupler, high impedance schemes.
- **TRANSMISSION LINE PROTECTION** **(05 Hours)**

Operating characteristics of impedance, reactance relays on R-X diagram, overreach and memory action, ohm and mho types relays and their characteristics, relay response under power swings and effect of fault resistance, setting of distance relays. Carrier Current Protection- Phase comparison and directional comparison principles.

- **BASICS OF NUMERICAL RELAYS** **(05 Hours)**
  Numerical relaying fundamentals, sampling theorem, anti-aliasing filters, least square method for estimation of phasors, Fourier algorithms, Fourier analysis and discrete Fourier transform, estimation of phasors from discrete Fourier transform, Applications for implantation of various numerical relays.

Total Hours:42

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3. Books Recommended:

1. B. Oza, N. C. Nair, R. P. Mehta, V. H. Makwana, Power System Protection and Switchgear, Tata McGraw Hill Ltd. 1st Edition, 2011.
2. Y. G. Paithankar, S. R. Bhide, Fundamentals of power system protection, Prentice Hall of India, 2nd Edition, 2010.
3. B. Ravindranath, M. Chander, Power system Protection and Switchgear, New Age International Publisher, 2nd Edition, 2018.
4. J. Lewis Blackburn, Protective Relaying: Principles and Applications, Marcel Dekker Incorporation, 3rd Edition, 2006.
5. Badri Ram, D. N. Vishwakarma, Power System Protection and Switchgear, Tata McGraw Hill Publishing Company, New Delhi, 2nd Edition, 2017.

L	T	P	Credit
3	0	0	03

Electric Traction and Linear Machines (ES – IV)

EE421 **Scheme**

1. Course Outcomes (Cos):

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

CO1	describe the constructional details and classify the linear machines.
CO2	apply knowledge to find present scenario in traction system
CO3	obtain speed time curves in traction system
CO4	compute energy consumption in various traction motor system
CO5	compare various topologies and control for linear machines

2. Syllabus:

- **TRACTION SYSTEMS** **(06 Hours)**

  Introduction, systems of electric traction systems of track electrification, comparison between DC and AC systems of railway electrification from the point of view of main line and suburban line railway services, Modern traction system.

- **TRAIN MOVEMENT AND ENERGY CONSUMPTION** **(08 Hours)**

  Speed-time curves, mechanics of train movement, energy output from driving axles, factors affecting specific energy consumption of an electric train operating on a given schedule speed.

- **ELECTRIC TRACTION MOTORS AND CONTROL** **(10 Hours)**

  Features, characteristics, types, rating and ventilation, Starting and speed control of DC traction motors, starting methods, transition methods, method of speed control, thyristor control of traction motors, speed control and starting of single phase and three phase induction motors, braking; mechanical considerations and control equipment.

- **LINEAR ELECTRIC MACHINES** **(18 Hours)**

  Classifications and Applications of LEMs, Linear Induction Motors: Topologies, Circuit Theories, Transients, and Control, DC-Excited Linear Synchronous Motors, Superconducting Magnet Linear Synchronous Motors, Flat Linear Permanent Magnet Synchronous Motors: topology and control, Linear DC PM Brushless Motors, Application of linear machines in transportation system.

Total hours: 42

3. Books Recommended:

1. Ion Boldea, Linear Electric Machines, Drives, and MAGLEVs Handbook, CRC press, 2013.
2. Jacek F. Gieras, Zbigniew J. Piech, Bronislaw Z. Tomczuk, Linear Synchronous Motors, Transportation and Automation Systems, 2nd Edition, CRC press.
3. Gupta, J.B., Utilization of Electrical Energy and Electric Traction, S.K.Kataria and sons, 10th Edition, 1990.
4. Rajput R. K.,Utilization of Electrical Power, Laxmi publications, 1st Edition, 2007.
5. H. Partab, Modern Electric Traction, Dhanpat Rai & Co., 3rd Edition, 2012.

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L	T	P	Credit
3	0	0	03

EHV AC Transmission (ES – IV)

EE423 **Scheme**

1. Course Outcomes (Cos):

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

CO1	enumerate the requirements of EHVAC transmission systems
CO2	calculate the line and ground parameters as well as voltage gradients of EHVAC transmission
CO3	analyze the corona effects for audible noise, power loss and radio interference
CO4	interpret the effect of electrostatic field
CO5	estimate the reactive power requirement and compensation of EHVAC transmission
CO6	design EHV transmission lines for a given specifications

2. Syllabus:

- **INTRODUCTION TO EHV AC TRANSMISSION** **(04 Hours)**
  Role of EHV AC transmission, standard transmission voltages, Average values of line parameters, power handling capacity and Line loss, surge impedance loading.
- **CALCULATION OF LINE AND GROUND PARAMETERS** **(06 Hours)**
  Resistance of conductors, Properties of bundle conductors, Inductance of EHV line configuration, Line capacitance calculation, Sequence inductance and capacitance, line parameters for Modes of propagation.
- **VOLTAGE GRADIENTS OF CONDUCTORS** **(06 Hours)**
  Field of sphere gap & line charges and their properties, charge potential relations for multi conductor lines, surface voltage gradient on conductors, gradient factors and their use, distribution of voltage gradient on sub conductors of bundle.
- **CORONA AND ITS EFFECTS** **(06 Hours)**
  Coronal loss formulas, charge- voltage diagram and corona loss, Audible noise, limits for audible noise, AN measurement and meters, formula for audible noise and use in design, radio interference, limits of radio interference fields, CIGRE formula, measurement of RI, RIV and excitation function.
- **ELECTROSTATIC FIELD OF EHV LINES** **(05 Hours)**
  Calculation of Electrostatic filed of AC Lines, Effect of High Electrostatic filed on Humans, Animals and plants, Measurement of Electrostatic filed.
- **POWER FREQUENCY VOLTAGE CONTROL AND OVER VOLTAGES** **(10 Hours)**
  Problems at Power frequency, Generalized constants, No-load voltage conditions and charging current, The power circle diagram and it use, Voltage control using synchronous condensers, Cascade connection of components- Shunt and Series Compensation, Sub synchronous resonance in series capacitor compensated line.
- **DESIGN OF EHV LINES** **(05 Hours)**
  Design factors under steady state, Line insulation design based upon transient over voltages.

Total Hours: 42

3. Books Recommended:

1. Begamudre, EHV AC Transmission Engineering, Wiley Easter Ltd. 4^{th} Edition, 2011.
2. EPRI, Palo Alto, Transmission line Reference Book 345 KV & above".
3. W. D. Stevenson, Element of Power System Analysis, Mc Graw Hill, 4^{th} Edition, 2017.
4. Nagrath& Kothari, Power System Engineering, 4th Edition, Tata Mcgraw Hill publishing Company Ltd, 2014.
5. A. Chakrabarti, M. L. Soni, P. V. Gupta, & U. S. Bhatnagar, A Text Book on Power System Engineering, Dhanpat Rai & Co., 2016.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Advanced Power Electronics (ES-IV)

EE425 **Scheme**

1. Course Outcomes (Cos):

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

CO1	distinguish the power devices and their driver circuits
CO2	analyze the CCM and DCM operation switched-mode dc-dc converters
CO3	estimate the power quality indices and improve it using power electronics
CO4	apply power electronics for field applications
CO5	use simulation tools like PSIM and MATLAB

2. Syllabus:

- **MODERN SEMICONDUCTOR DEVICES** **(04 Hours)**
  Power Diodes, Power BJT, Power MOSFETs, Thyristor, GTOs, IGBT, MCT – Basic characteristics and controlling, Emerging devices and circuits, Power Integrated Circuits.
- **PRACTICAL DESIGN CONSIDERATION** **(06 Hours)**
  Gate and Base drive circuits – Design Consideration for different Devices, DC-Coupled Circuits, Isolated Drive Circuits, and Protection in Drive Circuits. Snubber circuits Designing, Temperature control and Heat sink design consideration, Design of Magnetic Components.
- **DC-DC SWITCHED MODE CONVERTERS** **(08 Hours)**
  Introduction, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Cuk Converter, Control Principles, Applications of DC-DC Converters.
- **SWITCHING DC POWER SUPPLIES** **(08 Hours)**
  Introduction, Linear Power Supplies, Switching Power Supplies, DC-DC Converter with isolation – Fly-back converters, Half Bridge Converters, Full Bridge converters, Forward Converter, Push-pull converter, Protection, Isolation and Design criteria for SMPS.
- **STATIC POWER ELECTRONICS APPLICATIONS** **(06 Hours)**
  Electronic Ballasts, UPSs, Power Electronics in Capacitor Charging Applications, Power Electronics for Renewable Energy Sources HVDC Transmission, Automotive Applications of Power Electronics.
- **POWER ELECTRONICS IN POWER QUALITY** **(05 Hours)**
  Power Quality, Reactive Power and Harmonic Compensation, IEEE Standards, Static VAR Compensator, Thyristor Controlled Reactor (TCR), Thyristor Switched Capacitors (TSC), Principle of Active Filters, Types of Active Power Filters, Shunt Active Power Filters, Series Active Power Filters.
- **SIMULATION OF POWER ELECTRONIC CONVERTERS AND VARIOUS CONTROL STRATEGIES USING PSIM SOFTWARE** **(05 Hours)**
  Introduction, Use of Simulation Tools for Design and Analysis, Simulation of Power Electronics Circuits with , PSIM, State-Space Averaged Models and their simulation using PSIM software.

Total Hours:42

3. Books Recommended:

1. Rashid, M. H., Power Electronics Handbook, Elsevier Academic Press, 2nd revised Edition, 2006.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics Converters, Applications, and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Agrawal, J. P., Power electronic systems: Theory and design, Addison Wesley Longman (Singapore) Pte. Ltd. New Delhi, 2001.
4. Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, Springer international Edition.
5. L. Umanand, Power Electronics – Essentials & Applications, Wiley India Pvt. Ltd, 2009.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Nonlinear and Optimal Control (ES – IV)

EE427 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify nonlinearity in control systems design point of view
CO2	analyze nonlinear systems based on describing functions
CO3	evaluate the stability of nonlinear systems by analyzing limit cycles
CO4	visualize and understand the response of second order nonlinear control systems using various phase-plane methods
CO5	impart the basic idea of optimal control strategies and their implementation

2. Syllabus:

- **INTRODUCTION TO NONLINEARITY: (06 Hours)**
  Introduction to nonlinear components and systems, inherent and intentional nonlinearity, specific example of nonlinear spring for introducing non linearity like jump resonance and variation of resonant frequency with amplitude of input, linearization of non-linear state equations, non-linear measurement systems, input-output Volterra models, variational equation approach for solving non-linear systems.
- **DESCRIBING FUNCTION ANALYSIS OF NONLINEAR CONTROL SYSTEM: (08 Hours)**
  Introduction to Nonlinear Systems Describing Functions for Common Types of Nonlinearities Describing Function Analysis, Stability and Limit Cycles.
- **PHASE-PLANE ANALYSIS: (12 Hours)**
  Introduction, Analytical Methods for constructing Trajectories, Graphical Methods for constructing Trajectories, Isocline Method, Delta Method, Pell's Method, Lienard's Method, Classification of Singular Points, Limit Cycles, Phase-Plane Analysis of Linear control systems, Phase-Plane Analysis of' Non-linear control systems, Minimum Time Trajectory, Optimum Switching Curve.
- **OPTIMAL CONTROL SYSTEM: (16 Hours)**
  Introduction, Calculus of Variation Fixed-End-Point Problem, Free-End-Point Problem and constrained variation problem, Optimal Control Problems, The Hamiltonian Formulation, A Linear Regulator Problem, Pontryagin's Minimum Principle, Minimum Time problems, Fuel optimal problem.

Total Hours: 42

3. Books Recommended:

1. H. K. Khalil, Nonlinear Systems, Pearson 3rd Edition, 2001.
2. J.E. Slotine and W. Li, Applied Nonlinear Control, Prentice Hall, New Jersey, 1991.
3. D.E. Kirk, Optimal Control Theory: An Introduction, Dover Publications, Inc., 1st Edition, 2004.
4. B.D.O. Anderson & J. B. Moore, Optimal Control: Linear Quadratic Methods, Dover Publication, 2007.
5. R. C. Dorf & R. H. Bishop, Modern control system, Pearson Education Asia. 8th Edition, 2004.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Advanced Microcontroller (Digital Signal Controller) (ES – IV)

EE429 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the basics of 32-bit ARM cortex M-series (RISC) architecture and STM32F4xx MCU architecture
CO2	explore advanced concepts of Embedded C Programming.
CO3	illustrate STM32 peripherals with practice of code examples.
CO4	discuss and analyze interfacing circuits with STM32
CO5	design and develop hardware and embedded software for real life systems.

2. Syllabus:

- **INTRODUCTION TO ARM CORTEX-M ARCHITECTURE** **(04 Hours)**
  Von Neumann and Harvard CPU architecture, Overview of cortex M0and M4 cores, Thum-2 ISA, Registers, Operating Modes, Core buses, MPU, NVIC, System Tick Timer, Memory Map.
- **INTRODUCTION TO STM32F4XX MCU ARCHITECTURE** **(04 hours)**
  Memory and Bus Architecture, Power controller, Reset and Clock control.
- **INTRODUCTION TO PROGRAMMING OF STM32 CONTROLLER** **(04 hours)**
  Thumb-2 Instruction Set, Pointers, structure, Union, Pointer to Structure, Points to Function, enumeration, Introduction to IDE Debugging Techniques, Programming methods and addressing mechanism for Memory Mapped peripheral registers.
- **HARDWARE CONCEPT AND PROGRAMMING OF STM32 PERIPHERALS** **(18 hours)**
  GPIO, General purpose timers, Advanced control timers, ADC, DAC, USART, SPI, I2C.
- **INTERFACING AND PROGRAMMING OF STM32 WITH INPUT/OUTPUT SYTEMS** **(08 hours)**
  Pushbutton keys, Matrix keyboard, LCD display, External interrupt, Relay, ZCD circuit, Thyrisor and TRIAC Firing, encoder interface, PWM generation for buck and boost converter.
- **INTRODUCTION TO STM32 H7 MCU** **(04 hours)**
  6 stage pipeline with dual instruction issue, instruction cache, data cache, 64 bit AXI bus interface, instruction TCM and data TCM.

Total Hours: 42

3. Books Recommended:

1. Georey Brown, Discovering the STM32 Microcontroller, Creative Common Attribution.
2. Donald Norris, The Insider's Guide to STM32 Microcontrollers, Hitex (UK) Ltd., 1st Edition, 2018.
3. Joseph Yiu, The Definite Guide to Cortex –M3, Elsevier Publication, 2007.
4. Andrew & Sloss, ARM System Development Guide, Elsevier publication, 2007.
5. Data Sheets and User Reference Manuals of STM32f4xx, STM32h7xx.

B. Tech. IV (Electrical), Semester – VII

Industrial Instrumentation (ES – IV)

L	T	P	Credit
3	0	0	03

EE431 **Scheme**

1. Course Outcomes (Cos):

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

CO1	use transducers for industrial parameter measurements.
CO2	use transducers for process parameter measurements.
CO3	classify various analytical instruments and use them for measuring electrical and non-electrical quantities
CO4	explain industrial communication and signal transmission.
CO5	design instrumentation systems

2. Syllabus:

- **TRANSDUCER FOR INDUSTRIAL MEASUREMENTS** **(07 Hours)**
  Working principles and characteristics of transducers used for measuring weight, density, vibration, distance, thickness, torque and shaft power.
- **TRANSDUCERS FOR PROCESS MEASUREMENTS** **(07 Hours)**
  Working principle and characteristic of transducer used for measuring pressure, level, temperature, flow, moisture, humidity and pH value.
- **INSTRUMENTS FOR ANALYSIS** **(07 Hours)**
  Classification of analytic instruments, sampling for online analysis, pH measurements, electrical conductivity measurement, gas analyzer, liquid analyzer, oxygen determination.
- **CONTROL ELEMENTS** **(04 Hours)**
  Final control operations, signal conversions, actuators, control elements.
- **INDUSTRIAL COMMUNICATION SYSTEMS** **(06 Hours)**
  Role of data communication systems in industrial automation, the OSI (open system interconnection) model, RS 485 specifications, multi-drop system, automatic address recognition, biasing and termination requirements of RS 485 network, RS 485 transceiver IC, modbus protocol.
- **SIGNAL TRANSMISSION** **(05 Hours)**
  Architecture of current loop, HART protocol for sensor calibration, data transmission systems, field BUS and industrial Ethernet technology.
- **INSTRUMENTATION SYSTEM DESIGN** **(06Hours)**
  Data acquisition systems and its input and output interfacing with microcontroller and microprocessors, PC based data acquisition systems, Electromagnetic interference (EMI) and Electromagnetic Compatibility (EMC) in instrumentation system.

Total Hours: 42

3. Books Recommended:

1. Rangan Sarma, Mani, Instrumentation devices and systems, Tata Mcgraw Hill, 2nd Edition.
2. E. O. Doebelin, Measurement Systems - Application and Design, 4th Edition, McGraw-Hill, New York, 1992.
3. D. Patranabis, Principles of Industrial Instrumentation, 2nd Edition, Tata McGraw Hill, New Delhi, 1997.
4. M. M. S. Anand, Electronic instruments and instrumentation Technology, Prentice-Hall of India, 2004.
5. C. D. Johnson, Process Control Instrumentation Technology" 4th Edition, Prentice Hall of India.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Power System Operation and Control (ES – IV)

EE433 **Scheme**

1. Course Outcomes (Cos):

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

CO1	analyze various methods of voltage control.
CO2	analyze various methods of load forecasting.
CO3	model multi-area system for frequency control.
CO4	analyze various methods of contingency analysis.
CO5	apply state estimation methods for power system state estimation.

2. Syllabus:

- **AUTOMATIC GENERATION CONTROL** **(05 Hours)**
  Single area load frequency control, speed governing system and characteristics, Multiarea load frequency control; flat frequency, flat tie-line load and tie-line load bias control, Economic Dispatch and AGC, EMS, SCADA.
- **METHODS OF VOLTAGE CONTROL** **(06 Hours)**
  Reactive power and its relation to voltage control, location of voltage control equipment, methods of voltage control, excitation control, voltage regulators, tap changing transformers, booster transformers, induction regulators, reactive power injection and voltage control by synchronous condenser.
- **UNIT COMMITMENT** **(05 Hours)**
  Constraints in Unit commitment, Spinning reserve, Thermal and hydro constraints, Unit commitment solution methods- Priority list methods, Dynamic programming solution.
- **HYDRO THERMAL SCHEDULING** **(06 Hours)**
  Short and long range hydro-thermal scheduling, hydroelectric plant models, scheduling problems, Short range hydro-thermal scheduling: Gradient approach, Pumped storage hydro plant, Dynamic programming solution to the hydrothermal scheduling problems.
- **POWER SYSTEM SECURITY** **(07 Hours)**
  Factors affecting power system security, Contingency analysis: Detection of network problems, Correcting the generation approach: Sensitivity methods, compensated factors, correcting the generation dispatch using linear programming.
- **STATE ESTIMATION IN POWER SYSTEMS** **(08 Hours)**
  Power system state estimation, least square estimation, state estimation of an AC network, Tracking state estimation of power systems, External system equivalence, Detection and identification of bad measurements, Network observability and Pseudo-measurements, Application of power system state estimation.
- **LOAD FORECASTING TECHNIQUES** **(05 Hours)**
  Forecasting methodology, Estimation of periodic components, Estimation: Time series approach, Estimation of stochastic component: Kalman filtering approach, Long term load predictions using econometric models, Reactive load forecast.

Total Hours:42

3. Books Recommended:

1. J. J. Grainger and W. D. Stevenson, Power System Analysis, McGraw Hill, New Delhi 1st Edition, 2017.
2. A. J. Wood and B.F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons, 2nd Edition.
3. O. I. Elgerd, Electric Energy Systems Theory, McGraw Hill, 2nd Edition, 1982.
4. Arthur R. Bergen, Vijay Vittal, Power system Analysis, Pearson Education (Singapore) Pte, Ltd., 2nd Edition, 2004.
5. I. J. Nagrath & D.P. Kothari, Modern Power System Analysis, Tata McGraw Hill, 4th Edition, 2011.

B. Tech. IV (Electrical), Semester – VII

Wind and Solar Energy Conversion Systems (ES – VI)

L	T	P	Credit
3	0	0	03

EE435 **Scheme**

1. Course Outcomes (Cos):

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

CO1	recognize the limits of the conventional energy sources and examine present scenario of wind and solar energy conversion.
CO2	explain the working principle of wind energy conversion and identify the suitable turbine and power electronic interfaces.
CO3	explain the working principle of solar energy conversion, maximum power tracking algorithms and power electronics interface.
CO4	design the wind and solar energy systems at preliminary level.
CO5	select the suitable hybrid energy system for a given application.

2. Syllabus:

- **PLACEMENTS OF WIND AND SOLAR ENERGY IN WORLD AND INDIA** **(04 Hours)**
  Conventional energy sources and their limitations, current status of renewable energy sources.
- **WIND ENERGY CONVERSION** **(15 Hours)**
  Introduction, types of wind turbines and their characteristics, wind data and energy estimation, basic components of wind electric conversion system, types of electrical machines suitable for wind energy conversion, maximum power extraction, power electronics interface for wind turbine, different configuration for wind farms.
- **SOLAR PHOTOVOLTAIC POWER CONVERSION** **(15 Hours)**
  Basics of p-n junction, p-n junction exposure to light, photovoltaic cell/module characteristics and effects of light intensity and temperature variations, maximum power point tracking algorithms, power electronics interface for solar Photovoltaics, design of PV applications (domestic loads, battery storage, and irrigation), grid connected PV systems.
- **HYBRID ENERGY SYSTEMS** **(08 Hours)**
  Why hybrid systems?, types of hybrid systems (PV-diesel-battery, wind-PV, fuel cell-PV), limitations of hybrid systems.

Total hours: 42

3. Books Recommended:

1. J. K. Nayak and S. P. Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Tata Mcgraw Hill, 4th Edition, 2017.
2. Chetan Singh Solanki, Solar Photovoltaics: Fundamental, Technologies and Applications, 2nd Edition, PHI Learning Pvt. Limited, New Delhi, 2011.
3. Gary L. Johnson, "Wind Energy Systems", Prentice Hall Inc., 1985.
4. Klouse Jägar, et al., Solar Energy: Fundamental, Technology and Systems, Delft University of Technology, Netherlands, 2014.
5. A few IEEE review papers and industrial application notes.

B. Tech. IV (Electrical), Semester – VII

Power Filter Technology (ES – V)

L	T	P	Credit
3	0	0	03

EE437 **Scheme**

1. Course Outcomes (Cos):

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

CO1	describe the linear, nonlinear loads and identify the sources of power quality disturbances in the distribution system
CO2	classify and explain the functions of passive, active and hybrid power filters
CO3	develop different control techniques to mitigate the power quality disturbances
CO4	analyze and compare the merits and demerits of several power quality control techniques
CO5	design the controller for integration of the renewable energy sources to the grid through power filter technology

2. Syllabus:

- **ELECTRICAL POWER QUALITY** **(06 Hours)**
  Definitions, power quality standards, Classification of power system disturbances, power quality problems, formulations and measures used for power quality, effect of poor power quality on power system devices, non-ideal supply source, power factor correction and voltage regulation mode.
- **POWER QUALITY PROBLEM CREATING LOADS AND PASSIVE COMPENSATION** **(06 Hours)**
  Definition of linear and nonlinear loads, power electronics and electrical machine based nonlinear loads, current fed and voltage fed type nonlinear loads, mixed loads, grounding and banding, passive shunt and series compensator: operation and design methods.
- **PASSIVE POWER FILTER** **(06 Hours)**
  Classification of passive filters, application potentials and limitation of passive filter, basic principle, hybrid passive filters, design methods.
- **ACTIVE POWER FILTER** **(10 Hours)**
  Classification of active filters, application potential and advantages, basic principle, design of power circuit components, time domain control techniques: IRPT, PQ theory and SRF theory, real time implementation issues, voltage sensor and current sensors used in active filters, various topologies of active filters in three wire and four systems. Custom power devices: introduction, load compensation using DSTATCOM, DVR: structure and control, UPQC: configuration, structure and control techniques.
- **HYBRID POWER FILTER** **(08 Hours)**
  Classification of hybrid filters, applications potentials and limitation of hybrid filter, basic principle, hybrid filters, advantages, design and control techniques.
- **CUSTOM POWER DEVICES IN DISTRIBUTED GENERATION** **(06 Hours)**
  Distributed energy source: wind, hydro and solar based system, application of custom power devices for reactive power compensation, harmonic suppression and load balancing, Design problems.

Total Hours:42

3. Books Recommended:

1. E. F. Fuchs, Masoum, A. S. Mohammad, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 1st Edition, 2008.
2. A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer International Edition, Delhi, reprint 1st Edition, 2012.
3. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, Willey Interscience, New Jersey, 2nd Edition, 2017.
4. Antonio Moreno Munoz, Power Quality:Mitigation Technologies in a Distributed Environment, Springer-Verlag, London, reprint 1st Edition, 2010.
5. C. Sankaran, Power Quality, CRC Press, New York, 2001.

B. Tech. IV (Electrical), Semester – VII

Smart Grid Technology (ES – V)

L	T	P	Credit
3	0	0	03

EE439 **Scheme**

1. Course Outcomes (Cos):

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

CO1	identify the background for smart Grid and have knowledge of smart grid in the context of Indian grid.
CO2	classify smart grid architectures and understand the role of automation in transmission and distribution.
CO3	apply PMUs, PDCs, WAMs. Technology for smart grid
CO4	identify and apply a suitable evolutionary algorithm for the given smart grid application.
CO5	use performance analysis tools for smart grid
CO6	analyze and perform basic design of smart grid electric power systems, with emphasis on micro-grids.

2. Syllabus:

- **SMART GRID ARCHITECTURAL DESIGNS** **(07 Hours)**
  Today's Grid versus the Smart, General View of the Smart Grid Market Drivers, Stakeholder Roles and Function, Utilities, Working Definition of the Smart Grid Based on Performance, Measures, Functions of Smart Grid Components, Smart Devices Interface Component, Storage Component, Monitoring and Control Technology Component, Demand Side Management Component.

- **DISTRIBUTED ENERGY RESOURCES** **(07 Hours)**
  Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Penetration and Variability Issues Associated with Sustainable Energy Technology, Demand Response Issues, Electric Vehicles and Plug-in Hybrids.

- **SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY** **(07 Hours)**
  Monitoring, PMU, Smart Meters, and Measurements Technologies, Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU), Smart Meters, Smart Appliances, Advanced Metering Infrastructure (AMI), Multi-agent Systems (MAS) Technology, Multi-agent Systems for Smart Grid Implementation.

- **PERFORMANCE ANALYSIS TOOLS FOR SMART GRID DESIGN** **(08 Hours)**
  Introduction to Load Flow Studies, Challenges to Load Flow in Smart Grid and Weaknesses of the present Load Flow Methods, Load Flow State of the Art: Classical, Extended Formulations, and Algorithms, Distribution Load Flow Methods, Congestion Management Effect, Load Flow for Smart Grid Design, the Development of Stochastic Dynamic.
  Optimal Power Flow (DSOPF), DSOPF Application to the Smart Grid, Static Security Assessment (SSA) and Contingencies, Contingency Studies for the Smart Grid.

- **STABILITY ANALYSIS TOOLS FOR SMART GRID** **(06 Hours)**
  Introduction to Stability, Voltage Stability Assessment, Voltage Stability and Voltage Collapse, Classification of Voltage Stability, Static Stability (Type I Instability), Dynamic Stability (Type II Instability), Angle Stability Assessment, Transient Stability, State Estimation.

- **POWER QUALITY MANAGEMENT IN SMART GRID** **(07 Hours)**
  EMC in smart grid, equipment required for grid connected systems, grid connection requirements from power provider, addressing safety and power quality for grid connection, metering and rate arrangement for grid connected systems, web based power quality monitoring.

Total hours: 42

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3. Books Recommended:

1. James Momoh, Smart Grid Fundamentals of Design and Analysis, A. John Wiley & Sons, 1st Edition, 2012.
2. Bharat Modi, Anu Prakash, Yogesh Kumar, Fundamentals of smart grid technology, S. K. Kataria & Sons, 2015
3. A. Keyhani, Smart Power Grid Renewable Energy Systems, Wiley 2nd Edition, 2016.
4. I.S. Jha, Subirata Sen, Rajesh Kumar and D.P. Kothari, Smart grid: Fundamental & applications, New Age international, New Delhi, 2019.
5. Gilbert N Sorebo and Michael C. Echols, Smart grid Security, CRC press, 1st Edition, 2012.

B. Tech. IV (Electrical), Semester – VII

HVDC Transmission (ES – V)

L	T	P	Credit
3	0	0	03

EE441 **Scheme**

1. Course Outcomes (Cos):

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

CO1	describe the basic concepts of HVDC transmission system
CO2	analyze the convertor for HVDC transmission applications
CO3	choose between AC and DC transmission systems for an application
CO4	explain the various control methods for HVDC power flow
CO5	select the suitable protection method for various converter faults
CO6	decide the converter configuration for harmonic mitigation on both AC and DC sides

2. Syllabus:

- **INTRODUCTION** **(06 Hours)**
  Introduction to AC and DC Transmission - application of DC Transmission - description of DC transmission - DC system components and their functions - modern trends in DC Transmission.
- **CONVERTER** **(10 Hours)**
  Pulse Number - Converter configuration - analysis of Graetz circuit - converter bridge characteristics - characteristics of 12 Pulse converters.
- **HVDC CONTROLLERS** **(10 Hours)**
  General principle of DC link control - converter control characteristics - system control hierarchy - firing angle control - current and extinction angle control - Dc link power control - high level controllers.
- **FILTERS** **(08 Hours)**
  Introduction to harmonics - generation of harmonics - design of AC filters - DC filters - carrier frequency and RI noise.
- **PROTECTION** **(08 Hours)**
  Basics of protection - DC reactors - voltage and current oscillations - circuit breakers - over voltage protection - switching surges - lightning surges - lightning arresters for DC systems.

Total hours: 42

3. Books Recommended:

1. Kimbark, Direct Current Transmission - Vol. 1, John Wiley and Sons Inc., New York, 1st Edition, 1971.
2. K. R. Padiyar, HVDC Power Transmission Systems, Wiley Eastern Limited, New Delhi, 2nd Edition, 2017.
3. J. Arrillaga, High Voltage Direct Current Transmission, Peter Peregrines, London, 2nd Edition, 1998.
4. Vijay K. Sood, HVDC and FACTS Controllers: Applications of Static Converters in Power Systems, Springer; 1st Edition, 2004.
5. Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim, and Seok-Jin Lee, HVDC Transmission, Wiley-Blackwell, 2009.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Electric Vehicles (ES – V)

EE443 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain various terminologies related to electric vehicle.
CO2	explain the concepts and drivetrain configurations of electric vehicles
CO3	develop different electric motors drive systems and energy storage system for EV.
CO4	construct different battery charger topologies for electric vehicles
CO5	design the complete electric propulsion system for EV/HEV.

2. Syllabus:

- **DESIGN OF ELECTRIC VEHICLE: (10 Hours)**
  Basics of vehicle dynamics, Traction Effort, Modeling of vehicle acceleration and range, Concept and role of different drive cycle for vehicle performance analysis. Sizing of propulsion motor, internal combustion engine (ICE) and power electronics; sizing of the energy storage system, Electronic Control Units, In-vehicle Communications between Electronic Control and Supporting subsystems.
- **ENERGY STORAGE SYSTEM: (06 Hours)**
  Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Terminologies related to Energy storage system, Battery, Fuel Cell, Ultra Capacitor and Flywheel based energy storage and its analysis, Hybridization of different energy storage devices, design of power source for different types of vehicle, Energy Management system - Charge Balancing circuits for the Energy storage system.
- **ELECTRIC PROPULSION DRIVE AND CONTROLLER: (10 Hours)**
  Selection of Motor drive based on vehicle torque and speed characteristics, Electric Motors in EV, Configuration and control of BLDC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, and Switch Reluctance Motor drives, controllers, drive system efficiency.
- **ENERGY MANAGEMENT STRATEGIES FOR EV: (04 Hours)**
  Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.
- **ENERGY MANAGEMENT STRATEGIES FOR EV: (04 Hours)**
  Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Total Hours:42

3. Books Recommended:

1. Iqbal Hussain, Electric & Hybrid Vehicles – Design Fundamentals, 2nd Edition, CRC Press, 2011.
2. James Larminie, Electric Vehicle Technology Explained, John Wiley & Sons, 2nd Edition, 2012.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2nd Edition, 2009.
4. Chris Mi, Dearborn, M. Abul Masrur, David Wenzhong Gao, Hybrid electric Vehicles Principles and applications with practical perspectives, A John Wiley & Sons, Ltd., 2011.
5. Iqbal Hussain, Electric & Hybrid Vehicles – Design Fundamentals, 2nd Edition, CRC Press, 2011.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Digital Signal Processing (ES – V)

EE445 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify the discrete time signals, systems
CO2	design optimum structures for realizing IIR and FIR systems
CO3	apply signal processing techniques to real situation problems
CO4	design and implement different types of FIR/IIR filters
CO5	develop various DSP FFT algorithms through software like MATLAB

2. Syllabus:

- **INTRODUCTION** **(03 Hours)**
  Review of continuous-time signals and systems, convolution of continuous-time signals, Laplace transform, the Fourier series and Fourier transform.
- **DISCRETE-TIME SIGNALS AND SYSTEMS** **(05 Hours)**
  Sequences, discrete-time systems, linear time-invariant systems, convolution representation of linear time-invariant discrete-time systems, convolution of discrete-time signals, linear difference equations with constant coefficients, realizations, frequency-domain representation of discrete-time signals and systems.
- **SAMPLING OF CONTINUOUS-TIME SIGNALS** **(08 Hours)**
  Periodic sampling, frequency-domain representation of sampling, reconstruction of a band-limited signal, discrete-time processing of continuous-time signals, continuous-time processing of discrete-time signals, changing the sampling rate using discrete-time processing.
- **THE Z-TRANSFORM** **(09Hours)**
  The Z-transform, properties of the Z-transform, transfer function representation, Inverse Z-transform, Z-transform applied to difference equations, the complex convolution theorem, stability of discrete-time systems, frequency response of discrete-time systems.
- **THE DISCRETE FOURIER TRANSFORM** **(09 Hours)**
  Discrete-time Fourier transform (DTFT), the discrete Fourier series, the Fourier transform of periodic signals, discrete Fourier transform (DFT), properties of the DFT, system analysis via the DTFT and DFT, circular convolution, linear convolution using the DFT. The Fast Fourier Transform (FFT) Algorithms: Decimation in time FFT, introduction to radix-2 FFTs, some properties of radix-2 decimation in time FFT, decimation in frequency algorithm, computing the inverse DFT by doing a direct DFT.
- **INTRODUCTION TO DIGITAL FILTERS** **(08 Hours)**
  Recursive digital filters-infinite impulse response (IIR) Filters: Analog approximations, impulse invariant method, bilinear transformation method, matched Z-transform method, realizations, non-recursive digital filters – finite impulse response (FIR).

Total Hours: 42

3. Books Recommended:

1. Proakis and Manolakis, Digital Signal Processing, Prentice Hall of India, 4th Edition, 2007.
2. S. K. Mitra, Digital Signal Processing" McGraw Hill Education, 4th Edition, 2016.
3. Ashok Ambardar, Analog and Digital Signal Processing, Brooks and Cole Publication, 1st Edition, 2007.
4. Oppenhein-Schafer, Discrete Time Signal Processing, Prentice Hall of India, 3rd Edition, 2014.
5. Rabiner-Gold, Theory and Application of Digital Signal Processing, Prentice Hall of India, 1st Edition, 2015.

B. Tech. IV (Electrical), Semester – VII

Modern Materials for Electrical Engineering (ES – V)

L	T	P	Credit
3	0	0	03

EE447 **Scheme**

1. Course Outcomes (Cos):

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

CO1	understand the properties of liquid, gaseous and solid insulating materials.
CO2	classify various materials based on their magnetic properties
CO3	explain semiconductor material technology.
CO4	apply their knowledge on materials for electrical engineering and applications
CO5	evaluate insulating, conducting and magnetic materials used in electrical machines.
CO6	identity and use special purpose materials.

2. Syllabus:

- **DIELECTRIC MATERIALS** **(09 Hours)**
  Dielectric as Electric Field Medium, leakage currents, dielectric loss, dielectric strength, breakdown voltage, breakdown in solid dielectrics, liquid dielectric, Electric conductivity in solid, liquid and gaseous dielectrics, Properties of ferroelectric materials in static fields, Spontaneous polarization, Curie point, Anti-ferromagnetic materials, Piezoelectric and Pyroelectric materials.

- **MAGNETIC MATERIALS** **(09 Hours)**
  Classification of magnetic materials, spontaneous magnetization in ferromagnetic materials, magnet anisotropy, magnetostriction, diamagnetism, magnetically soft and hard materials, special purpo materials, feebly magnetic materials, Ferrites, cast and cermet permanent magnets, ageing of magnet factors effecting permeability and hysteresis.

- **SEMICONDUCTOR MATERIALS** **(8 Hours)**
  Method of semiconductor material preparation, Purification and Doping, Introduction to process of Manufacturing Semiconductor Devices, Transistors, Integrated Circuits. Monolithic Diodes, Integrated Resistors and Integrated Capacitor.

- **MATERIALS FOR ELECTRICAL APPLICATIONS** **(8 Hours)**
  Materials used for resistors, rheostats, heaters, transmission line structures, stranded conductors, bimetals fuses, soft and hard solders, electric contact materials, electric carbon materials, thermocouple materials. Solid, liquid and gaseous insulating materials. Effect of moisture on insulation.

- **SPECIAL PURPOSE MATERIALS** **(8 Hours)**
  Refractory Materials, Structural Materials, Radioactive Materials, Galvanization and Impregnation materials, Processing of electronic materials, Insulating varnishes and coolants, Properties ar applications of mineral oils, Testing of Transformer oil as per ISI.

Total Hours: 42

3. Books Recommended:

1. A. J. Dekkar, Electrical Engineering Materials, Prentice Hall Publications Co., Reprint Edition, 2009.
2. S. O. Kasap, Principle of Electronic Materials and Devices, 2^{nd} Edition, Tata McGraw- Hill.
3. C. Indulkar, Introduction to Electrical Engineering Materials, S. Chand & Company Ltd-New Delhi, 4^{th} Edition, 2004.
4. S.P. Seth and P.V. Gupta, A course in Electrical Engineering Materials, Dhanpat Rai & Sons, 3^{rd} Edition, 2011.
5. T. K. Basak, A course in Electrical Engineering Materials, New Age Science Publications, 2009.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Special Electrical Machines and Drives (ES-V)

EE449 **Scheme**

1. Course Outcomes (Cos):

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

CO1	describe the basic principles of special Electrical machines
CO2	analyze the steady state performance of special Electrical machines
CO3	compare the performance of various special electric machines
CO4	identify the special constructional and operating features of special electrical machines
CO5	analyze the controlling method of special electric machines
CO6	select appropriate special electric machine for given application

2. Syllabus:

- **PERMANENT MAGNET BRUSHLESS D.C. MOTORS** **(07 Hours)**
  Fundamental equations – EMF and Torque equations – Torque speed characteristics – Rotor position sensing – Sensor less motors – Motion control

- **PERMANENT MAGNET SYNCHRONOUS MOTORS** **(07 Hours)**
  Construction - Principle of operation – EMF and torque equations – Starting – Rotor configurations – Dynamic model –control strategy

- **SYNCHRONOUS RELUCTANCE MOTORS** **(07 Hours)**
  Construction – axial and radial flux motors – operating principle – characteristics-drive circuit

- **SWITCHED RELUCTANCE MOTORS** **(07 Hours)**
  Construction-principle of operation-torque production-characteristics-power controller

- **STEPPING MOTORS** **(07 Hours)**
  Features – fundamental equations – PM stepping motors – Reluctance stepping motors – Hybrid stepping motors – Torque and voltage equations – characteristics-microprocessor based control

- **LINEAR MACHINES** **(07 Hours)**
  Classification of LEMS, linear motors and levitation machines - linear induction motors - linear synchronous motors - DC linear motors - linear levitation machines-performance characteristics and control of LEMS

Total Hours: 42

3. Books Recommended:

1. T. J. E. Miller, Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989.
2. T. Kenjo and A. Sugawara, Stepping Motors and their Microprocessor Controls, Oxford Science Publications, 2nd Edition, 2017.
3. K. Venkataratnam, Special Electrical Machines, CRC Press, 1st Edition, 2008.
4. S. A. Nasar and Boldeal, Linear Motion Electric Machine, John Wiley, 1976.
5. V. V. Athani, Stepper Motors, New Age International Pub., 1997.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Switched Mode Power Supply (ES – VI)

EE451 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the principle of switched-mode dc-dc power conversion.
CO2	design of reactive components for SMPS
CO3	analyze CCM and DDM operations of switched-mode power conversion.
CO4	modellingof switch mode power converters
CO5	design the controller for closed loop operation of the SMPS system

2. Syllabus:

- **THE PRINCIPLES OF SWITCHING POWER CONVERSION** **(07 Hours)**
  Introduction, evolution of switching topologies, switching devices - ideal and real characteristics, control, drive and protection.
- **REACTIVE COMPONENT DESIGNING** **(10 Hours)**
  Inductor, Transformer, Capacitor, Issues related to switches, Energy storage, their selection and design.
- **SWITCHING POWER CONVERTERS** **(15 Hours)**
  Switching power converters - circuit topology, operation, steady-state model, dynamic model.
  Analysis, modeling and performance functions of switching power converters.
  Non-isolated converters, Isolated converters, CCM and DCM operation of converters, Modeling of converters.
- **CONTROLLER DESIGNING** **(10 Hours)**
  Review of linear control theory, Closed-loop control of switching power converters, Sample designs and construction projects.

Total Hours: 42

3. Books Recommended:

1. Fang Lin Luo and Hong Ye. _Power Electronics: Advanced Conversion Technologies,_CRC Press, Taylor & Francis Group, Boca Raton London New York, 2nd Edition, 2018.
2. Middlebrook, Robert David and Slobodan Cuk, Advances in Switched-Mode Power Conversion, Volumes 1 and 2, 2nd Edition, TESLA co., 1983.
3. Erickson, W. Robert, Fundamentals of Power Electronics,_Chapman & Hall, 2nd Edition, 1997.
4. A. Pressman, Switching Power Supply Design,_McGraw-Hill, 3rd Edition, 2009.
5. V. Ramanarayanan, Course Material on Switched Mode Power Conversion,_Department of Electrical Engineering, IISc, Bangalore 560012. http://minchu.ee.iisc.ernet.in/new/people/faculty/vr/book.pdf

Computer Methods for Power Systems (ES – VI)

L	T	P	Credit
3	0	0	03

EE453 **Scheme**

1. Course Outcomes (Cos):

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

CO1	illustrate various methods of solving linear system
CO2	apply various methods of solving non- linear system to power system problems.
CO3	apply various methods of solving sparse matrices to power system problems.
CO4	use various methods of numerical integration to solve differential equation pertaining to power system.
CO5	use modal analysis for small signal stability study of power systems.
CO6	Estimate states of the system using optimization techniques

2. Syllabus:

- **SOLUTION OF LINEAR SYSTEMS** **(06 Hours)**
  Gaussian elimination, LU factorization with partial and complete pivoting, condition numbers and error propagation, relaxation methods, conjugate gradient methods.
- **SOLUTION OF NONLINEAR SYSTEMS** **(07 Hours)**
  Method to solve nonlinear system: Newton's method, Broyden's method, Finite difference method, Power system applications: Power flow, regulating transformers, Decoupled power flow, Fast Decoupled power flow, PV curves and continuation power flow, Three phase power flow.
- **SPARSE MATRIX SOLUTION TECHNIQUES** **(06 Hours)**
  Storage methods, sparse matrix representation, Ordering schemes: Scheme O, Scheme I, Scheme II, Other scheme, Power system applications.
- **NUMERICAL INTEGRATION** **(07 Hours)**
  explicit methods, implicit methods, One step methods, Multistep methods, fixed step methods, variable step methods, Stability and accuracy-analysis of numerical methods, stiff systems, step size selection, differential algebraic systems, Power system application: Transient stability analysis.
- **EIGENVALUE PROBLEMS** **(08 Hours)**
  Eigen value computations methods: QR algorithm, Power method, Arnoldi methods, Prony method. Power system applications: Modal analysis, participation factors, SSR analysis.
- **OPTIMIZATION** **(08 Hours)**
  Least squares optimization, Weighted Least square optimization, Steepest Descent algorithm, Newton's method. Power system applications: Optimal power flow, Linear and Nonlinear least square state estimation.

Total Hours:42

3. Books Recommended:

1. Mariesa Crow, Computational Methods for Electric Power Systems, 2nd edition, Electric power engineering series, CRC Press, 2009.

2. S. A. Soman, S. A. Khaparde, and Shubha Pandit, Computational Methods for Large Sparse Power System Analysis, Kluwer Academic Publishers, 2012.

3. Stagg and El-Abiad, Computer Methods in Power System Analysis, McGraw Hill Series, International student Edition, 1968.

4. Reijer Idema and Domenico J. P. Lahaye, Computational Methods in Power System Analysis, Volume 1, Atlantis Press, Atlantis Studies in Scientific Computing in Electromagnetics. 2014.

5. J. Arrillaga and C. P. Arnold, Computer Analysis of Power Systems, John Wiley & Sons Ltd, 1990

Robotics (ES – VI)

L	T	P	Credit
3	0	0	03

EE455 **Scheme**

1. Course Outcomes (Cos):

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

CO1	classify and characterize the robots based on the configuration and work volume.
CO2	analyze the manipulator design, including actuator, drive and sensor issues.
CO3	design the robots that addresses the human limitations and meets societal requirements.
CO4	apply the forward kinematics, inverse kinematics and Jacobean for serial and parallel robots.
CO5	explain and solve the problems related to robot design and control.

2. Syllabus:

- **INTRODUCTION AND ROBOT KINEMATICS** **(09 Hours)**
  Basic concepts of Robots and automation, classification, specifications, Application, Notation – Direct Kinematics, Co-ordinate frames, rotations, Homogeneous coordinates, the Arm equation – Kinematic analysis of a typical Robot.

- **DYNAMIC OF ROBOTS** **(08 Hours)**
  Continuous path motion-interpolated motion – Straight line motion – Tool configuration Jacobian matrix and manipulator Jacobian – Manipulator Dynamics – Kinetic of potential energy –Energized forces – Lagrange’s Equation – Euler Dynamic model.

- **ROBOT DRIVES AND CONTROL** **(09 Hours)**
  Design of drive systems, Hydraulic and Pneumatic drives, Linear and rotary actuators and control valves, Electro hydraulic servo valves, electric drives, Motors, designing of end effectors, Vacuum, magnetic and air operated grippers. The control problem – state equation – Single axis PID control – PD gravity control –Computed torque control – Variable Structure control – Impedance control.

- **ROBOT VISION AND CELL DESIGN APPLICATION** **(08 Hours)**
  Fundamentals of Robot applications – Robot vision – Image representation – Template – matching – Robot cell design – Safety in Robotics, Robot cell layouts, Multiple Robots and machine interference.

- **ROBOT PROGRAMMING AND APPLICATIONS** **(08 Hours)**
  Methods of Robot Programming, Characteristics of task level languages lead through programming methods. Types of applications – material handling applications – Machine loading and unloading – spot welding – arc welding – spray painting, workspace analysis and trajectory planning – work envelope of different robots, the pick and place operation.

Total Hours: 42

3. Books Recommended:

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2015.
2. S. B. Niku, Introduction to Robotics, Analysis, Systems, Applications, Prentice Hall, 2nd Edition, 2011.
3. Richard D. Klafter, Thomas A Chmielewski, Michael Negin, Robotics Engineering – An Integrated Approach, Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
4. Saha S. K., Introduction to Robotics, Tata McGraw Hill Education Pvt. Ltd, 2nd Edition, 2017.
5. K. S. Fu, R. C. Gonzalez and C. S. G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 2017.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Communication Engineering (ES – VI)

EE457 **Scheme**

1. Course Outcomes (Cos):

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

CO1	visualize the fundamental blocks of communication systems
CO2	analyze the signal modulation and demodulation in communication
CO3	compare the advantage of frequency modulation technique over analog modulation
CO4	evaluate the effect of noise in various modulation schemes
CO5	analyze different use modulation techniques

2. Syllabus:

- **COMMUNICATION FUNDAMENTALS** **(10 Hours)**
  Basic blocks of Communication System. Amplitude (Linear) Modulation – AM, DSB-SC, SSB-SC and VSB-SC. Methods of generation and detection. FDM. Super Heterodyne Receivers.
- **FREQUENCY AND PHASE MODULATION** **(11 Hours)**
  Angle (Non-Linear) Modulation - Frequency and Phase modulation. Transmission Bandwidth of FM signals, Methods of generation and detection. FM Stereo Multiplexing.
- **NOISE ANALYSIS** **(11 Hours)**
  Noise - Internal and External Noise, Noise Calculation, Noise Figure. Noise in linear and nonlinear AM receivers, Threshold effect. Noise in FM receivers, Threshold effect, Capture effect, FM Threshold reduction, Pre-emphasis and De-emphasis.
- **PULSE MODULATION TECHNIQUES** **(10 Hours)**
  Pulse Modulation techniques – Sampling Process, PAM, PWM and PPM concepts, Methods of generation and detection. TDM. Noise performance.

Total Hour: 42

3. Books Recommended:

1. S. Haykins, Communication Systems, Wiley, 4th Edition, 2009.
2. D. Kennedy, Electronic Communication Systems, McGraw Hill, 4th Edition, 2008.
3. B. Carlson, Introduction to Communication Systems, McGraw Hill, 4th Edition, 2009.
4. J. Smith, Modern Communication Circuits, McGraw Hill, 2nd Edition, 1997.
5. J. Beasley, J. Miller, Modern Electronic Communication, 9th Edition, Prentice Hall, 2008.

B. Tech. IV (Electrical), Semester – VII

VLSI Technology (ES – VI)

L	T	P	Credit
3	0	0	03

EE459 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the different VLSI design methodologies and design styles.
CO2	state the insights into the MOS devices and their characteristics
CO3	design the CMOS combinational logic and sequential circuits.
CO4	describe transistor level circuit design issues.
CO5	develop digital modeling and simulation with hardware description language (VHDL).

2. Syllabus:

- **INTRODUCTION TO VLSI DESIGN:** **(08 Hours)**
  Historical Perspective, Design Hierarchy, Concepts of Regularity, Modularity and Locality, VLSI Design Styles, VLSI Design Flow, Semi-Custom- Full Custom IC Design Flow, Data Path, Control Path Programmable Logic Array, CMOS And Bipolar Transistor Gate Arrays And Their Limitations, Standard Cells, FPGA/CPLD Architecture, Computer-Aided Design Technology.
- **CMOS FABRICATION:** **(06 Hours)**
  N-well, P-well, Twin-tub processes, Fabrication steps, Crystal growth, Photolithography, Oxidation, Diffusion, Ion implantation, Etching, Metallization.
- **CMOS COMBINATIONAL AND SEQUENTIAL LOGIC CIRCUITS:** **(08 Hours)**
  CMOS Logic Circuits, Complex Logic Circuits, CMOS Transmission Gate, Behavior of MOS Logic Elements, SR Latch Circuit, Clocked Latch and Flip-Flop Circuits, CMOS D-Latch and Edge-Triggered Flip-Flop, Dynamic logic circuit- Basic of Pass Transistor Circuits, Synchronous Dynamic Circuit Techniques.
- **CIRCUIT CHARACTERIZATION AND PERFORMANCE ESTIMATION:** **(08 Hours)**
  MOSFET Scaling and Small Geometry Effects, Delay Estimation, Logical Efforts And Transistor Sizing, Power Dissipation, Interconnect, Design Margin, Reliability.
- **DIGITAL MODELING AND SIMULATION WITH VHDL:** **(12 Hours)**
  Introduction to VHDL, Basic Language Elements, Behavioral Modeling, Dataflow Modeling, Structural Modeling, Generics, Configurations, Packages, Design of basic Arithmetic blocks- Adder, Multiplexer, Flip-Flop.

Total hours: 42

3. Books Recommended:

1. H. E. Weste Neil, D. Harris and A. Banerjee, CMOS VLSI Design: A Circuits and Systems Perspective, Pearson Education, 3rd Edition, 2002.
2. Debaprasad Das, VLSI Design, Oxford University Press, 2nd Edition, 2015.
3. Ken Martin, Digital Integrated Circuits, Oxford University Press, 2014.
4. Peter Van, Microchip Fabrication, Mc-Graw Hill Professional, 6th Edition, 2014.
5. J.P. Uyemura, Introduction to VLSI Circuits and Systems, John Wiley & Sons (Asia), 2006.

B. Tech. IV (Electrical), Semester – VII

Antenna and Wave Propagations (ES – VI)

L	T	P	Credit
3	0	0	03

EE461 **Scheme**

1. Course Outcomes (Cos):

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

CO1	review the fundamentals of electromagnetic theory and its application to antenna
CO2	distinguish transmitting and receiving antenna, and to analyze their characteristics
CO3	recognize the need of antenna arrays and their mathematical formulations
CO4	apply the concepts of optics and acoustics principle to differentiate and evaluate the characteristics of primary and secondary antennas
CO5	classify the various factors involved during the propagation of radio waves using practical antennas

2. SYLLABUS:

- **RADIATION FUNDAMENTALS** **(06 Hours)**
  Radiation fundamentals, Potential theory, Helmholtz integrals, Radiation from a current element, Basic antenna parameters, Radiation field of an arbitrary current distribution, Small loop antennas.
- **ANTENNAS** **(12 Hours)**
  Receiving antenna, Reciprocity relations, Receiving cross section and its relation to gain, Reception of completely polarized waves, Linear antennas, Current distribution, Radiation field of a thin dipole, Folded dipole, Feeding methods, Baluns.
- **ANTENNA CONSTRUCTION** **(12 Hours)**
  Antenna arrays, Array factorization, Array parameters, Broad side and end fire arrays, Yagi-Uda arrays Log-periodic arrays, Aperture antennas, Fields as sources of radiation, Horn antennas, Babinet's principle, Parabolic reflector antenna, Micro strip antennas.
- **WAVE PROPAGATION** **(12 Hours)**
  Propagation in free space, Propagation around the earth, surface wave propagation, structure of the ionosphere, propagation of plane waves in ionized medium, Determination of critical frequency, MUF, Fading, tropospheric propagation, Super refraction.

Total hours: 42

3. Books Recommended:

1. R. Collin, Antennas and Radio Wave Propagation, McGraw Hill, 1st Edition, 2013.
2. W. Stutzman, G. Thiele, Antenna Theory and Design, Wiley, 2012.
3. K. Lee, Principles of Antenna Theory, Wiley, 1984.
4. B. Carlson, Introduction to Communication Systems, McGraw Hill, 4th Edition, 2009.
5. F. Terman, Electronic Radio Engineering, 4th Edition, McGraw Hill, 1955.

B. Tech. IV (Electrical), Semester – VII

L	T	P	Credit
3	0	0	03

Cryptography and Cyber Security for Smart Grids (ES – VI)

EE463 **Scheme**

1. Course Outcomes (Cos):

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

CO1	explain the concept of encryption and privacy issues and its significance in cyber security
CO2	explain cryptography and risk analysis using various terms and methods such as attack classification, ciphers, keys etc.
CO3	evaluate the impact of bad data injection and identification for cyber security using encryption.
CO4	employ cloud network for information storage for smart grids and its security. The Indian perspective will also be explored.
CO5	explore the privacy prevention and its methods for smart grids and its management and legal concerns and rules/protocols for cyber security.

2. Syllabus:

- **INTRODUCTION AND OVERVIEW OF THE SECURITY AND PRIVACY ISSUES IN ELECTRICAL NETWORK** **(04 Hours)**
  Security issues in smart grids, Physical network security, Information network security, Privacy issues in smart grids, Reliability in smart grid- preliminaries on reliability quantification, System adequacy quantification, Congestion prevention: An economic dispatch algorithm.
- **CRYPTOGRAPHY FOR CYBER SECURITY** **(10 Hours)**
  Introduction and Overview of Cryptography and security, Historical perspective, Threats, risks, consequences, Physical and Information network security, Preventive and remedial measures, Basics of cryptography: Confusion vs. diffusion, Stream ciphers vs. block ciphers, Symmetric vs asymmetric key cryptography, Merkle Damgard construction, MD family, SHA family, Digital signatures , RSA algorithm, Encryption using non-cryptographic tools, Authentication principles and methods, Passwords, two-factor authentication.
- **BAD DATA DETECTION** **(06 Hours)**
  Preliminaries on falsification detection algorithms, Autocorrelation function (ACF), Time series modeling of load power: Outline of the proposed methodology, Seasonality, Fitting the AR and MA models, Case study: Stabilizing the variance, Fitting the stationary signal, Model fine-tuning and evaluation
- **CLOUD NETWORK DATA SECURITY IN SMART GRID** **(10 Hours)**
  Introduction, Service-level agreements, Live migration of a VM image in cloud computing: Data Migration, Network migration, Architecture and Solutions for: Application Manager, Site Broker, Hybrid cloud broker, Smart Meters and Smart Loads: The Advance Metering Infrastructure (AMI), Internet-Protocol-Based Mesh AMI, Standardization of AMI: ANSI C12.22, IEC 62056, AMI and Distribution Management System Integration (DMI), Software Architecture and Evaluation.
- **PRIVACY PRESERVATION IN SMART GRID** **(08 Hours)**
  End- User Privacy: Introduction and Preliminaries to privacy preservation methods, K- Anonymity cloaking, Location obfuscation, Privacy Preservation using location obfuscation methods, Preliminaries on Mobile nodes trajectory privacy, Location based services, Privacy preservation

quantification: Probabilistic model, A Vernoi-based location obfuscation method, Computing the instantaneous privacy level, concealing the movement path.

- **MANAGEMENT ASPECTS IN CYBER SECURITY** **(04 Hours)**
  System Administration policies, Security audit, Penetration testing and ethical hacking, Mandatory Access control, Discretionary Access Control, Monitoring and logging tools, Legal aspects.

Total Hours: 42

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3. Books Recommended:

1. William Stallings, Cryptography and network security, Pearson Education.
2. Atul Kahate, Cryptography and Network Security, 2nd Edition Tata McGraw Hill Publication, New Delhi-2006.
3. G. Kianoosh, Boroojeni, M.Hadi Amini and S.S. Iyengar, Smart Grids: Security and Privacy Issues, Springer, 2017.
4. Wade Trapple, Lawrence C. Washington, Introduction to Cryptography with coding Theory, 2nd Edition pearson Education.
5. E.D Knapp, Raj Samani, Applied Cyber Security and the Smart Grid, Elsevier-SYNGRESS.