

CMR COLLEGE OF ENGINEERING & TECHNOLOGY
(UGC AUTONOMOUS)
M. TECH- POWER ELECTRONICS
(Applicable for the Batch admitted from the Academic Year 2025-26 onwards)

(R25) COURSE STRUCTURE AND SYLLABUS

I YEAR I SEMESTER

S.No	Course Code	Course Name	Course Category	Hours Per week			Credits
				L	T	P	
1	B543301	Power Converters Analysis	PCC	3	0	0	3
2	B543302	Machine Modelling and Analysis	PCC	3	0	0	3
PROFESSIONAL ELECTIVE-I							
3	B543401	Microcontroller Applications to Power Electronics	PEC-I	3	0	0	3
	B543402	Smart Grid Technologies					
	B543403	Modern Control Theory					
	B543404	Sustainable Energy Solutions					
	B543405	Power Electronic Applications to Power Systems					
PROFESSIONAL ELECTIVE-II							
4	B543406	Power Semiconductor Devices and Modelling	PEC-II	3	0	0	3
	B543407	Reactive Power Compensation and Management					
	B543408	High Frequency Magnetic Design					
	B543409	Electric Vehicle Technologies					
	B543410	Advanced Digital Signal Processing					
5	B520303	Research Methodology & IPR		2	0	0	2
6	B543502	Power Converters and Analysis Lab	PCC	0	0	4	2
7	B543501	Machine Modelling Analysis Lab	PCC	0	0	4	2
8	Audit	Audit Course-I	VAC	2	0	0	0
Total				16	0	8	18
Total Hours Per Week				24			

1 YEAR II SEMESTER

S.No	Course Code	Course Name	Course Category	Hours Per week			Credits
				L	T	P	
1	B543303	Advanced Power Converters Analysis	PCC	3	0	0	3
2	B543304	Electrical Drives	PCC	3	0	0	3
PROFESSIONAL ELECTIVE-III							
3	B543411	Battery Technologies	PEC-III	3	0	0	3
	B543412	Power Quality Improvement Techniques					
	B543413	Integration and Control of Renewable Energy Systems					
	B543414	Industrial load Modelling and Control					
	B543415	SCADA Systems and Applications					
PROFESSIONAL ELECTIVE-IV							
4	B543416	DSP based Drive Control	PEC-IV	3	0	0	3
	B543417	Data Science Applications in Power Engineering					
	B543418	Electric Vehicle Charging Techniques					
	B543419	Electromagnetic interference and compatibility					
	B543420	Distributed Generation					
5	B543801	Mini Project with Seminar	PROJ	0	0	4	2
6	B543503	Advanced Power Converters Lab	PCC	0	0	4	2
7	B543504	Electrical Drives Lab	PCC	0	0	4	2
8	Audit	Audit Course-II	VAC	2	0	0	0
Total				14	0	12	18
Total Hours Per Week				26			

II YEAR I SEMESTER

S.No	Course Code	Course Name	Course Category	Hours Per week			Credits
				L	T	P	
PROFESSIONAL ELECTIVE-V							
1	B543421	Dynamics of Electrical Machines	PEC-V	3	0	0	3
	B543422	Energy Storage Technologies					
	B543423	Smart Metering and Communication Protocols					
	B543424	Wide Band Gap Devices for Power Electronics Applications.					
	B543425	Reliability Engineering					
2	OE	OPEN ELECTIVE	OE	3	0	0	3
3	B543802	Dissertation Work Review – I		0	0	12	6
Total				6	0	12	12
Total Hours Per Week				18			

II YEAR II SEMESTER

S.No	Course Code	Course Name	Course Category	Hours Per week			Credits
				L	T	P	C
1	B543803	Dissertation Work Review - II	PROJ	0	0	12	6
2	B543804	Dissertation Viva-Voce	PROJ	0	0	28	14
Total				0	0	40	20
Total Hours Per Week				40			

***For Dissertation Work Review - I, please refer R25 Academic Regulations.**

Open Elective

S.No	Code	Subject	Course Category	L	T	P	C
1	B555601	Embedded System Design	OE	3	0	0	3
2	B543601	Photovoltaic Systems					
3	B520601	Green Building Technology					
4	B558601	Intrusion Detection System					

Audit Course I & II

S.No	Code	Subject	Course Category	L	T	P	C
1	B500701	English for Research Paper Writing	VAC	2	0	0	0
2	B500702	Disaster Management					
3	B500703	Value Education					
4	B500704	Constitution of India					

M. Tech – I Year I Semester

L	T	P	C
3	0	0	3

(B543301) POWER CONVERTERS ANALYSIS
(Professional Core)

Prerequisite: Power Electronics**Course Objectives:**

- To understand various advanced power electronic devices.
- To comprehend the design of rectifiers and inverters.
- To understand the operation of multi-level inverters with switching strategies for high power applications.

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

- Develop and analyze various converter topologies.
- Use power electronic simulation packages for analyzing and designing power converters.

UNIT-I:**MODERN POWER SEMICONDUCTOR DEVICES**

Modern power semiconductor devices: Symbol, Structure and equivalent circuit of Insulated Gate Bipolar Transistor (IGBT), MOSFET, MOS Turn off Thyristor (MTO), Emitter Turn off Thyristor (ETO), Integrated Gate-Commutated Thyristor (IGCTs), MOS-controlled thyristors (MCTs), Power Integrated Circuits (PICs). Comparison of their features.

UNIT-II:**SINGLE PHASE & THREE PHASE CONVERTERS**

Single phase converters: Half controlled and Fully controlled converters, Evaluation of input power factor and harmonic factor, continuous and Discontinuous load current, Single phase dual converters, Power factor Improvements Techniques, Extinction angle control, Symmetrical angle control, Single phase sinusoidal PWM, Single phase series converters, Overlap analysis, Applications & Problems.

Three phase converters: Half controlled and fully controlled converters, Evaluation of input power factor and harmonic factor, Continuous and Discontinuous load current, three phase dual converters, Power factor Improvements Techniques, Three phase PWM, Twelve pulse converters, Applications & Problems.

UNIT-III:**PULSE WIDTH MODULATED INVERTERS**

Principle of operation, Performance parameters, Single phase bridge inverter, Evaluation of output voltage and current with resistive, inductive and capacitive loads, Voltage control of single phase inverters, Single PWM, Multiple PWM, Sinusoidal PWM, Modified PWM, Phase displacement Control, Advanced modulation techniques for improved performance, Trapezoidal, Staircase, Stepped, Harmonic injection and Delta modulation, Advantages, Applications & Problems.

UNIT-IV**THREE PHASE INVERTERS**

Introduction to Three phase inverter, Analysis of 180 degree conduction for output voltage And current with resistive, inductive loads, Analysis of 120 degree Conduction, Voltage control of three phase inverters, Sinusoidal PWM, Third Harmonic PWM, 60 degree PWM, Space vector modulation, Comparison of PWM techniques, Harmonic reductions, Problems.

UNIT-V**MULTILEVEL INVERTERS**

Multilevel concept, Classification of multilevel inverters, Principle of operation, main features and

comparison of Diode clamped, Improved diode Clamped, Flying capacitors, Cascaded multilevel inverters, Multilevel inverter applications, Reactive power compensation, Back to back intertie system, Adjustable drives, Switching device currents, DC link capacitor voltage balancing.

TEXTBOOKS:

1. Mohammed H. Rashid, "Power Electronics", Pearson Education, 3rd Edition, 1st Indian reprint2004.
2. Ned Mohan Tore M. Undeland and William P. Robbins, "Power Electronics", John Wiley & Sons, 2nd Edition

REFERENCES:

1. Milliman Shepherd and Lizang, "Power converters circuits", Chapter 14 (Matrix converter) PP- 415-444,
2. M.H.Rashid, "Power Electronics hand book".
3. Marian P. Kazmierkowski, Ramu Krishnan, Frede Blabjerg Edition, "Control in Power electronics", Published by Academic Press, 2002.

M. Tech – I Year I Semester

L	T	P	C
3	0	0	3

(B543302) MACHINE MODELLING AND ANALYSIS
(Professional Core)

Prerequisite: Electrical Machines**Course Objectives:**

- To identify the methods and assumptions in modeling machines.
- To recognize the different frames for modeling of AC machines.
- To write voltage and torque equations in state space form for different machines.

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

- Develop the mathematical models of various machines like, induction motor and Synchronous machines, permanent magnet synchronous motor, brushless DC motor using modeling equations.
- Analyze the developed models in various reference frames.

UNIT-I:

Basic Two-pole DC machine, Primitive 2-axis machine, Voltage and Current relationship, Torque equation. Mathematical model of separately excited DC motor and DC Series motor in state variable form, Transfer function of the motor, Numerical problems. Mathematical model of D.C. shunt motor, D.C. Compound motor in state variable form, Transfer function of the motor, Numerical Problems.

UNIT-II:

Linear transformation, Phase transformation (a, b, c to α, β, o), Active transformation (α, β, o to d, q), Circuit model of a 3-phase Induction motor, Linear transformation, Phase Transformation, Transformation to a Reference frame, Two axis models for induction motor, “d-q” model based DOL starting of induction motors.

UNIT-III:

Voltage and current Equations in stator reference frame, Equation in Rotor reference frame, Equations in a synchronously rotating frame, Torque equation, Equations in state – space form.

UNIT-IV:

Circuit model of a 3-phase Synchronous motor, two- axis representation of Synchronous Motor. Voltage and current Equations in state – space variable form, Torque equation, and “dq” model based short circuit fault analysis, Emphasis on voltage, Frequency and recovery time.

UNIT-V:

Modeling of Permanent Magnet Synchronous motor, Modeling of Brushless DC Motor.

TEXTBOOKS:

1. P.S. Bimbhra, "Generalized Machine theory", Khanna Publishers.
2. Paul C. Krause, Oleg wasynezuk, Scott D. Sudhoff, "Analysis of electric machinery and Drives systems".

REFERENCES:

1. Vedam Subranmanyam, "Thyristor control of Electric Drives".
2. Prabha Kundur, "Power System Stability and Control", EPRI.
3. Article in IEEE Transactions on Energy Conversion, "Performance optimization of induction motors during Voltage-controlled soft starting", July, 2004
4. Nithin K.S, Dr.Bos Mathew Jos, Muhammed Rafeek, Dr.Babu Paul, "A Novel Method for Starting of Induction Motor with Improved Transient Torque Pulsations", International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 8, February 2013.

M. Tech – I Year I Semester

L	T	P	C
3	0	0	3

(B543401) MICROCONTROLLER APPLICATIONS TO POWER ELECTRONICS

Professional Elective

Prerequisite: Power Electronics and Microcontrollers**Course Objectives:**

- To study the internal structure and operation of PIC 16F876 microcontroller and 8051 microcontrollers
- To know assembly language program for the generation of firing and control signals employing these microcontrollers.

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

- Understand the architecture of 8051 and 16F876 microcontrollers.
- Develop assembly language programs employing 8051 & 16F876 microcontrollers.
- Analyze the microcontroller programming using MPLAB and develop typical programs for power converter applications.

UNIT-I

8051 microcontrollers: Architecture, Addressing modes, I/O ports, Instruction sets, Simple assembly language programming.

UNIT-II

Use of microcontrollers for pulse generation in power converters, Overview of Zero-Crossing Detectors, Typical firing/gate-drive circuits, Firing/gate pulses for typical single-phase and three-phase power converters.

UNIT III

PIC16F876 Micro-controller: Device overview, Pin diagrams, Memory organization, Special Function Registers, I/O ports, Timers, Capture/ Compare/ PWM modules (CCP).

UNIT-IV

Analog to Digital Converter module, Instruction set, Instruction description, Introduction to PIC microcontroller programming, Oscillator selection, Reset, Interrupts, Watch dog timer.

UNIT-V

Introduction to MPLAB IDE and PICSTART plus, Device Programming using MPLAB and PICSTART plus, Generation of firing / gating pulses for typical power converters.

TEXTBOOKS:

1. S. N. Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", Oxford University Press, 2005.
2. B.H.Khan, "Non-conventional Energy sources", Tata McGraw-hill Publishing Company, New Delhi, 2009.

REFERENCES:

1. Rashid .M. H, "Power electronics Hand book", Academic press, 2001.
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. Rai. G.D, "Non- conventional energy sources", Khanna Publishes, 1993.
4. Gray, L. Johnson, "Wind energy system", Prentice Hall linc, 1995.
5. Andrzej M. Trzynadlowski, "Introduction to Modern Power Electronics", 2ndEdition, Wiley India Pvt. Ltd, 2012.

M. Tech – I Year I Semester

L	T	P	C
3	0	0	3

(B543402) SMART GRID TECHNOLOGIES

Professional Elective

Prerequisite: Power Systems**Course Objectives:**

- To understand concept of smart grid and its advantages over conventional grid
- To know smart metering techniques
- To learn wide area measurement techniques
- To understand the problems associated with integration of distributed generation & its solution through smart grid.

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

- Appreciate the difference between smart grid & conventional grid
- Apply smart metering concepts to industrial and commercial installations
- Formulate solutions in the areas of smart substations, distributed generation and wide area measurements
- Come up with smart grid solutions using modern communication technologies

UNIT-I:

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid Present development & International policies in Smart Grid

UNIT-II:

Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation.

UNIT-III:

Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).

UNIT-IV:

Concept of micro-grid, Need& applications of micro-grid, Formation of micro-grid, Issues of interconnection, Protection & control of micro-grid, Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, Fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources.

UNIT-V:

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Advanced Metering Infrastructure (AMI) and Various Communication means and IP based Protocols.

TEXTBOOKS:

1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE, 2011.
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press, 2009.

REFERENCES:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, "Smart Grid: Technology and Applications", Wiley, 2012.
2. Stuart Borlase, "Smart Grid: Infrastructure, Technology and solutions", CRC Press.
3. A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer.

M. Tech – I Year I Semester**(B543403) MODERN CONTROL THEORY**
Professional Elective

L	T	P	C
3	0	0	3

Prerequisite: Control Systems**Course Objectives:**

- To explain the concepts of basics and modern control system for the real time analysis and design of control systems.
- To explain the concepts of state variables analysis.
- To study and analyze nonlinear systems.
- To analyze the concept of stability for nonlinear systems and their categorization.

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

- Know various terms of basic and modern control system for the real time analysis and design of control systems.
- Perform state variables analysis for any real time system.
- Examine a system for its stability, controllability and observability.
- Implement basic principles and techniques in designing linear control systems.
- Apply knowledge of control theory for practical implementations in engineering and network analysis.

UNIT I:**MATHEMATICAL PRELIMINARIES AND STATE VARIABLE ANALYSIS**

Fields, Vectors and Vector Spaces, Linear combinations and Bases, Linear Transformations and Matrices, Scalar Product and Norms, Eigen values, Eigen Vectors and a Canonical form representation of Linear systems, The concept of state, State space model of Dynamic systems, Time invariance and Linearity, Non uniqueness of state model, State diagrams for Continuous-Time State models, Existence and Uniqueness of Solutions to Continuous-Time State Equations, Solutions of Linear Time Invariant Continuous-Time State Equations, State transition matrix and its properties. Complete solution of state space model due to zero input and due to zero state.

UNIT II:**CONTROLLABILITY AND OBSERVABILITY**

General concept of controllability, Controllability tests, Different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems, General concept of Observability, Observability tests for Continuous-Time Invariant Systems, Observability of different State transformation forms.

UNIT III:**STATE FEEDBACK CONTROLLERS AND OBSERVERS**

State feedback controller design through Pole Assignment, using Ackkermans formula. State observers: Full order and Reduced order observers.

UNIT IV:**NON-LINEAR SYSTEMS**

Introduction to Non-Linear Systems, Types of Non-Linearities, Saturation, Dead-Zone, Backlash, Jump Phenomenon etc., Linearization of nonlinear systems, Singular Points and its types, Describing function, Describing function of different types of nonlinear elements, Stability analysis of Non-Linear systems through describing functions.

Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

UNIT V:

STABILITY ANALYSIS

Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability theorems, Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method, Generation of Lyapunov functions, Variable gradient method, Krasovskii's method.

TEXTBOOKS:

1. M.Gopal, "Modern Control System Theory", New Age International, 1984.
2. Ogata. K, "Modern Control Engineering", Prentice Hall, 1997.

REFERENCES:

1. N K Sinha, "Control Systems", New Age International, 3rd Edition.
2. Donald E.Kirk, "Optimal Control Theory an Introduction", Prentice Hall Network series, 1stEdition.

M. Tech – I Year I Semester

L	T	P	C
3	0	0	3

(B543404) SUSTAINABLE ENERGY SOLUTIONS

Professional Elective

COURSE OBJECTIVES:

- To inculcate sustainable choices in wake of present global scenario
- To raise awareness on the importance and opportunities available in the field of sustainable energy
- To raise entrepreneurs with understanding of technical and economic aspects of sustainable energy solutions

COURSE OUTCOMES: After completion of the course, the student should be able to

- Enrich their understanding of present energy scenario to realize the importance of sustainability
- Understand different ways of generating and utilizing energy in a sustainable manner
- Appreciate the role of EV as a sustainable energy solution
- Understand the various underlying economic aspects

UNIT-I:

Global Energy Scenario: Concept of Sustainability (Social, Economic and Environmental impacts). Sustainable and non-sustainable energy sources. Present global and Indian scenario. Bureau of energy efficiency. Initiatives and incentives for promoting sustainability. UN 2030 goals for clean and affordable energy.

UNIT-II:

Sources of Sustainable Energy: Working principles of: Solar Thermal Power Generation, Solar Photovoltaic Power Generation, Wind Power Generation, Hydro Power Generation, Biomass Power Generation, Hydrogen energy and fuel cells and Wave and Tidal Energy.

UNIT-III:

Sustainable Utilization of Energy: Smart grid technologies - overview, penetration of renewable energy sources. Energy storage technologies. Renewable energy to Hydrogen. Waste to energy: waste to value added materials, capture, storage and utilization of CO₂ from various sources to ensure cyclic carbon economy.

UNIT-IV:

Sustainability Through e-mobility: Electric vehicles. Advantages and environmental impact. Regenerative braking. Hybrid electric vehicles, modes of operation. Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) Technologies-fundamentals.

UNIT-V:

Energy Economics and Management: Cost analysis, interest, accounting rate of return, Payback, Discounted cash flow, Net present value, Internal rate of return, Inflation and life cycle analysis of energy systems.

Energy Management: Definition, objectives, resource conservation, climate protection and cost savings

TEXT BOOKS:

1. Energy, the Environment, and the Sustainability, 1st Edition, Efsthios E. Michaelides, CRC Press, 2018
2. Modern Electric, Hybrid Electric and Fuel cell vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, 3rd Edition, CRC Press, 2018
3. Energy Economics Concepts, Issues, Markets and Governance, 2nd Edition, S. C. Bhattacharyya, Springer, 2019

REFERENCE:

1. Renewable Energy: Power for a Sustainable Future, G. Boyle (Editor), 3rd Edition, Oxford University Press, 2012

M. Tech – I Year I Semester

L	T	P	C
3	0	0	3

(B543405) POWER ELECTRONICS APPLICATION TO POWER SYSTEMS

Professional Elective

Prerequisite: Power System, Power Electronics**Course Objectives:**

1. Understand the basics of formation of bus admittance matrix, modeling of transmission line, and analyze the load flow.
2. Teach the analysis of sensitivity and the basics of power system security.
3. Explain the voltage stability, proximity indicators and participation factors.
4. Familiarize with FACT systems for controlling the power and configuration of various FACT devices.
5. Introduce the thyristor-controlled series capacitor, its analysis, different modes of operation and various models.

UNIT-I:

Power System components models formation of bus admittance matrix, algorithm for formation of bus impedance matrix, Reactive power capability of an alternator, transmission line model and loadability, Reactive power transmission and associated difficulties, regulated shunt compensation, Models of OLTC and Phase shifting transformer, load flow study.

UNIT-II:

Sensitivity analysis: Generation shift distribution factors, line outage distribution factors, Compensated shift factors. Power system security levels, contingency selection and evaluation, security constrained economic dispatch. Precontingency corrective rescheduling.

UNIT-III:

Voltage stability: Proximity indicators e.g., slope of PV-curve, Minimum Eigen value of reduced load flow Jacobian, participation factors based on modal analysis and application.

UNIT-IV:

Flexible ac transmission systems, Reactive power control, Brief description and definition of FACT's controllers, Shunt compensators, Configuration and operating characteristics of TCR, FC-TCR, TSC, Comparison of SVCs.

UNIT-V:

The Thyristor-controlled series capacitor (TCSC), Advantages of the TCSC, Basic principle and different mode of operation, Analysis, Variable-reactance model and transient stability model of TCSC.

TEXTBOOKS:

1. D. P. Kothari and I. J. Nagrath, "Modern Power System Analysis", Tata McGraw Hill 2011.
2. A. J. Wood and B. F. Wollenberg, "Power generation, operation and control", second edition John Wiley and Sons 1996.
3. N. G. Hingorani and L. Gyugyi, "Understanding facts: Concepts and Technology of flexible AC transmission systems", Wiley Press 2000.

REFERENCES:

1. P. Kundur, "Power System Stability and control", McGraw-Hill edition 2008.
2. R. M. Mathur and R. K. Varma, "Thyristor Based FACTS Controllers for electrical Transmission systems", John Wiley and sons 2002.

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

1. Create the bus admittance matrix, describe the reactive power of transmission line, model the transmission line, define the model of OLTC and analyze the load flow of lines.
2. Analyze the sensitivity of different distribution factors, explain the power system security, and select and evaluate the contingency.
3. Determine the voltage stability, proximity indicators and participation factor based on model analysis.
4. Describe the FACT's controllers for power system and configure various Shunt FACT devices.
5. Describe and configure various Series FACT devices.

M. Tech – I Year I Semester

L	T	P	C
3	0	0	3

(B543406) POWER SEMICONDUCTOR DEVICES AND MODELLING

Professional Elective

Prerequisite: Power Electronics**Course Objectives:**

- To improve power semiconductor device structures for adjustable speed motor control applications.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices.
- To understand the static and dynamic characteristics of voltage- controlled power semiconductor devices.
- To enable for the selection of devices for different power electronic applications.
- To understand the control and firing circuit for different devices.

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

- Know the operating characteristics of various basic semiconductor devices and switches
- Understand the advanced power semiconductor devices operation.
- Know the modeling of basic and advanced semiconductor devices and switches through simulation.
- Analyze the applications of various power semiconductor switches.

UNIT-I:**POWER DIODES**

Basic structure and V-I characteristics, Breakdown voltages and control, On-state losses, switching characteristics, Turn-on, Turn off and reverse recovery transient, Schottky diodes, Snubber requirements for diodes, Diode snubber, Modelling and simulation of Power diodes.

POWER BJT'S

Basic structure and V-I characteristics, Breakdown voltages and control, Secondary breakdown and its control, FBSOA and RBSOA curves, On-state losses, switching characteristics, Resistive switching specifications, clamped inductive switching specifications, Turn-on and turn off transient, Storage time, Base drive requirements, switching losses, device protection, Snubber requirements for BJT's and snubber design, Switching aids, Modeling and simulation of power BJT'S.

UNIT-II:**SILICON CONTROLLED RECTIFIERS (THYRISTORS)**

Basic structure, V-I characteristics, Turn-on process, On-state operation, Turn-off process, Switching characteristics, Turn-on transient and di/dt limitations, Turn-off transient, Turnoff time and re-applied dv/dt limitations, Gate drive requirements, Ratings of thyristors, Snubber requirements and snubber design, Modelling and simulation of Thyristor.

TRIACS

Basic structure and operation, V-I characteristics, Ratings, Snubber requirements, Modelling and simulation of triacs.

UNIT-III:**GATE TURNOFF THYRISTOR (GTO)**

Basic structure and operation, GTO switching characteristics, GTO turn-on transient, GTO turn-off transient, Minimum on and off state times, Gate drive requirements, Maximum controllable anode current, Overcurrent protection of GTO'S, Modelling and simulation of GTO'S.

POWER MOSFET's

Basic structure, V-I characteristics, Turn-on process, On state operation, Turnoff process, Switching characteristics, Resistive switching specifications, Clamped inductive switching specifications, Turn-on transient and di/dt limitations, Turn-off transient, Turn off time, Switching losses, Effect of reverse

recovery transients on switching stresses and losses, dv/dt limitations, Gating requirements, Gate charge, Ratings of MOSFET'S, FBSOA and RBSOA curves, Device protection, Snubber requirements, Modeling and simulation of Power MOSFET'S.

UNIT-IV:

INSULATED GATE BIPOLAR TRANSISTOR's (IGBT's)

Basic structure and operation, latch up IGBT, switching characteristics, Resistive switching specifications, clamped inductive switching specification, IGBT turn-on and turn off transient, Current tailing, Gating requirements, Ratings of IGBT'S, FBSOA and RBSOA curves, switching losses, Minimum on and off state times, Switching frequency capability, Overcurrent protection of IGBT'S, Short circuit protection, Snubber requirements and snubber design.

UNIT-V:

ADVANCED POWER SEMICONDUCTOR DEVICES

MOS gated thyristors, MOS controlled thyristors or MOS GTO'S, Base resistance-controlled thyristors, Emitter switched thyristor, Thermal design of power electronic equipment, Modelling and simulation, Heat transfer by conduction, Transient thermal impedance, Heat sinks, Heat transfer by radiation and convection, Heat sink selection for power semiconductor devices.

TEXTBOOKS:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rd Edition, Wiley India Pvt Ltd, 2011.
2. G. Massobrio, P. Antognetti, "Semiconductor Device Modeling with Spice", McGrawHill, 2nd Edition, 2010.

REFERENCES:

1. B. Jayant Baliga, "Power Semiconductor Devices", 1st Edition, International Thompson Computer Press, 1995.
2. V. Benda, J. Gowar, and D. A. Grant, "Discrete and Integrated Power Semiconductor Devices: Theory and Applications", John Wiley & Sons, 1999.

M. Tech – I Year I Semester

L T P C
3 0 0 3

(B543407) REACTIVE POWER COMPENSATION AND MANAGEMENT

Professional Elective

Prerequisite: Power Systems

Course Objectives:

- To identify the necessity of reactive power compensation
- To describe load compensation
- To select various types of reactive power compensation in transmission systems
- To illustrate reactive power coordination system
- To characterize distribution side and utility side reactive power management.

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

- Distinguish the importance of load compensation in symmetrical as well as unsymmetrical loads
- Work out on various compensation methods in transmission lines
- Construct models for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power management

UNIT-I:

LOAD COMPENSATION

Objectives and specifications, Reactive power characteristics, Inductive and capacitive approximate biasing, Load compensator as a voltage regulator, Phase balancing and power factor correction of unsymmetrical loads, Examples.

UNIT-II:

STEADY-STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS

Uncompensated line, Types of compensation, Passive shunt and series and dynamic shunt compensation, Examples.

TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS

Characteristic time periods, Passive shunt compensation, Static compensation, Series capacitor compensation, Compensation using synchronous condenser, Examples.

UNIT-III:

REACTIVE POWER COORDINATION

Objective, Mathematical modeling, Operation planning, Transmission benefits, Basic concepts of quality of power supply, Disturbances, Steady-state variations, Effect of under-voltages, Frequency, Harmonics, Radio frequency and electromagnetic interference.

UNIT-IV:

DEMAND SIDE MANAGEMENT

Load patterns, Basic methods load shaping, Power tariffs, KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.

DISTRIBUTION SIDE REACTIVE POWER MANAGEMENT

System losses, Loss reduction methods, Examples, Reactive power planning, Objectives, Economics Planning capacitor placement, Retrofitting of capacitor banks.

UNIT-V:

USER SIDE REACTIVE POWER MANAGEMENT

KVAR requirements for domestic appliances, Purpose of using capacitors, Selection of capacitors,

Deciding factors, Types of available capacitor, Characteristics and Limitations.

REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEMS AND ARC FURNACES

Typical layout of traction systems, Reactive power control requirements, Distribution transformers, Electric arc furnaces, Basic operation, Furnaces transformer, Filter requirements, Remedial measures, Power factor of an arc furnace.

TEXTBOOKS:

- 1.T.J.E.Miller, "Reactive power control in Electric power systems", John Wiley and sons, 1982.
- 2.D.M. Tagare," Reactive power Management", Tata McGraw Hill, 2004.

REFERENCES:

- 1.Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just, "Reactive Power Compensation: A Practical Guide", Wiley Publication, April2012.

M. Tech – I Year I Semester

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(B543408) HIGH FREQUENCY MAGNETIC DESIGN

Professional Elective

Prerequisite: None

Course Objectives:

- To have a knowledge on magnetic circuits
- To know the skin effect and proximity effect

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

- Design of magnetic components (i.e., inductor and transformer) in a converter.
- Perform steady-state analysis of switched mode power supply.
- Understand core loss in an electromagnetic device, recognize & describe its effect.
- Describe the engineering uses of electromagnetic waves, by frequency band, and the respective hazards associated with them.

UNIT-I:

FUNDAMENTALS OF MAGNETIC DEVICES

Introduction, Magnetic Relationships, Magnetic Circuits, Magnetic Laws, Eddy Currents, Core Saturation, Volt-Second Balance, Inductance, Inductance Factor, Magnetic Energy, Self-Resonant Frequency, Classification of Power Losses in Magnetic Components, Non-inductive Coils.

MAGNETIC CORES

Introduction, Properties of Core Materials, Magnetic Dipoles, Magnetic Domains, Curie Temperature, Magnetization, Magnetic Materials, Hysteresis, Core Permeability, Core Geometries, Iron Alloy Cores, Amorphous Alloy Cores, Nickel-Iron and Cobalt-Iron Cores, Ferrite Cores, Powder Cores, Nano-crystalline Cores, Superconductors, Hysteresis Core Loss, Eddy-Current Core Loss, Total Core Loss, Complex Permeability.

UNIT-II:

SKIN EFFECT & PROXIMITY EFFECT

Introduction, Magnet Wire, Wire Insulation, Skin Depth, Ratio of AC-to-DC Winding Resistance, Skin Effect in Long Single Round Conductor, Current Density in Single Round Conductor, Impedance of Round Conductor, Magnetic Field Intensity for Round Wire, Other Methods of Determining the Round Wire Inductance, Power Density in Round Conductor, Skin Effect on Single Rectangular Plate. Proximity and Skin Effects in Two Parallel Plates, Anti-proximity and Skin Effects in Two Parallel Plates, Proximity Effect in Multiple-Layer Inductor, Appendix: Derivation of Proximity Power Loss.

WINDING RESISTANCE AT HIGH FREQUENCIES

Introduction, Winding Resistance, Square and Round Conductors, Winding Resistance of Rectangular Conductor, Winding Resistance of Square Wire, Winding Resistance of Round Wire, Leakage Inductance, Solution for Round Conductor Winding in Cylindrical Coordinates, Litz Wire, Winding Power Loss for Inductor Current with Harmonics, Effective Winding Resistance for Non-sinusoidal Inductor Current, Thermal Model of Inductors.

UNIT-III:

TRANSFORMERS

Introduction, Neumann's Formula for Mutual Inductance, Mutual Inductance, Energy Stored in Coupled Inductors, Magnetizing Inductance, Leakage Inductance, Measurement of Transformer Inductances, Stray Capacitance, High-Frequency Transformer Model, Non-interleaved Windings,

Interleaved Windings, AC Current Transformers, Winding Power Losses with Harmonics, Thermal Model of Transformers.

DESIGN OF TRANSFORMERS

Introduction, Area Product Method, Optimum Flux Density, Transformer Design for Fly-back Converter in CCM, Transformer Design for Fly-back Converter in DCM.

UNIT-IV:

INTEGRATED INDUCTORS

Introduction, Resistance of Rectangular Trace, Inductance of Straight Rectangular Trace, Construction of Integrated Inductors, Meander Inductors, Inductance of Straight Round Conductor, Inductance of Circular Round Wire Loop, Inductance of Two-Parallel Wire Loop, Inductance of Rectangle of Round Wire, Inductance of Polygon Round Wire Loop, Bond-wire Inductors, Single-Turn Planar Inductor, Inductance of Planar Square Loop, Planar Spiral Inductors, Multi-metal Spiral Inductors, Planar Transformers, MEMS Inductors, Inductance of Coaxial Cable, Inductance of Two-Wire Transmission Line, Eddy Currents in Integrated Inductors, Model of RF Integrated Inductors, PCB Inductors.

DESIGN OF INDUCTORS

Introduction, Restrictions on Inductors, Window Utilization Factor, Temperature Rise of Inductors, Mean Turn Length of Inductors, Area Product Method, AC Inductor Design, Inductor Design for Buck Converter in CCM, Inductor Design for Buck Converter in DCM method.

UNIT-V:

SELF-CAPACITANCE

Introduction, High-Frequency Inductor Model, Self-Capacitance Components, Capacitance of Parallel-Plate Capacitor, Self-Capacitance of Foil Winding Inductors, Capacitance of Two Parallel Round Conductors, Capacitance of Round Conductor and Conducting Plane, Self-Capacitance of Single-Layer Inductors, Self-Capacitance of Multi-layer Inductors, Capacitance of Coaxial Cable.

TEXTBOOKS:

1. Umanand L, Bhat, S.R, "Design of Magnetic Components for Switched Mode Power Converters", ISBN: 978-81-224-0339-8, Wiley Eastern Publication, 1992.
2. Marian K. Kazimierczuk, "High-Frequency Magnetic Components", ISBN: 978-0-470-71453-9, John Wiley & Sons, Inc.

REFERENCES:

1. G.C. Chryssis, "High frequency switching power supplies", McGraw Hill, 1989 (2nd Edition.)
2. Eric Lowdon, "Practical Transformer Design Handbook", Howard W. Sams & Co., Inc., 1980
3. Thompson, "Electrodynamic Magnetic Suspension.pdf"
4. Witulski, "Introduction to modeling of transformers and coupled inductors"
5. Beattie, "Inductance 101.pdf"
6. P. L. Dowell, "Effects of eddy currents in transformer windings.pdf"
7. Dixon, "Eddy current losses in transformer windings.pdf"
8. J J Ding, J S Buckkeridge, "Design Considerations for A Sustainable Hybrid Energy System" IPENZ Transactions, 2000, Vol. 27, No. 1/EMCh.
9. Texas Instruments, "Windings.pdf"
10. Texas Instruments, "Magnetic core characteristics.pdf".
11. Ferroxcube, "3f3 ferrite datasheet.pdf".
12. Ferroxcube, "Ferrite selection guide.pdf", Magnetics, Inc., Ferrite Cores (www.mag-inc.com).

M. Tech – I Year I Semester

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(B543409) ELECTRIC VEHICLE TECHNOLOGIES

Professional Elective

Prerequisite: Power Semiconductor Drives, Electrical Drives and Control, Utilization of Electric Energy

Course Objectives:

- To understand the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
- To know the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used energy storage devices, etc.

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

- Understand the models to describe hybrid vehicles and their performance.
- Understand the different possible ways of energy storage.
- Understand the different strategies related to energy storage systems.

UNIT-I:**INTRODUCTION**

Conventional Vehicles: Basics of vehicle performance, Vehicle power source characterization, Transmission characteristics, Mathematical models to describe vehicle performance.

UNIT-II:**INTRODUCTION TO HYBRID ELECTRIC VEHICLES**

History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies.

Hybrid Electric Drive-Trains: Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis.

UNIT-III:**ELECTRIC TRAINS**

Electric Drive-Trains: Basic concept of electric traction, introduction to various electric drive train topologies, Power flow control in electric drive-train topologies, Fuel efficiency analysis.

Electric Propulsion Unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, Drive system efficiency.

UNIT-IV:**ENERGY STORAGE**

Energy Storage: Introduction to Energy Storage, Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, Sizing the power electronics, selecting the energy storage technology, Communications, Supporting subsystems.

UNIT-V:

ENERGY MANAGEMENT STRATEGIES

Energy Management Strategies: 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.

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

TEXT BOOKS:

1. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.

REFERENCES:

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
2. T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

M. Tech – I Year I Semester

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(B543410) ADVANCED DIGITAL SIGNAL PROCESSING

Professional Elective

M. Tech – II Semester**Prerequisite:** Digital Signal Processing**Course Objectives:**

1. To understand the difference between discrete-time and continuous-time signals
2. To understand and apply Discrete Fourier Transforms (DFT)

UNIT-I:

Discrete time signals, Linear shift invariant systems, Stability and causality, Sampling of continuous time signal, Discrete time Fourier transforms, Discrete Fourier series, Discrete Fourier transform, Z-transforms, Properties of different transforms.

UNIT-II:

Linear convolution using DFT, Computation of DFT Design of IIR digital filters from analog filters, Impulse invariance method, Bi-linear transformation method.

UNIT-III:

FIR filter design using window functions, Comparison of IIR and FIR digital filters, Basic IIR and FIR filter realization structures, Signal flow graph representations, Quantization process and errors, Coefficient quantization effects in IIR and FIR filters.

UNIT-IV:

A/D conversion noise, Arithmetic round-off errors, Dynamic range scaling, Overflow oscillations and zero Input limit cycles in IIR filters, Linear Signal Models. UNIT-V:

All pole, All zero and Pole-zero models, Power spectrum estimation, Spectral analysis of deterministic signals, Estimation of power spectrum of stationary random signals, Optimum linear filters, Optimum signal estimation, Mean square error estimation, Optimum FIR and IIR Filters.

TEXTBOOKS:

1. Sanjit K Mitra, "Digital Signal Processing: A computer-based approach", TMH Edition, 1998.
2. Dimitris G.Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", TMH International Editions, 2000.

1. S Salivahanan. A. Vallavaraj C. Gnanapriya, "Digital Signal Processing", TMH, 2nd reprint 2001.
2. Lourens R Rebinarand Bernold, "Theory and Applications of Digital Signal Processing".
3. Auntoniam, "Digital Filter Analysis and Design", TMH.

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

1. Acquire knowledge about the time domain and frequency domain representations as well analysis of discrete-time signals and systems
2. Study the design techniques for IIR and FIR filters and their realization structures.
3. Acquire knowledge about the finite word length effects in implementation of digital filters.
4. Gain knowledge about the various linear signal models and estimation of power spectrum of stationary Random signals
5. Design of optimum FIR and IIR filters

CO-PO Mapping

M. Tech – I Year I Semester**(B520303)RESEARCH METHODOLOGY & IPR**

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Prerequisite:**Course Objectives:**

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know about the patent rights

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

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products and in turn brings about economic growth and social benefits.

UNIT-I:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, Data collection, Analysis, Interpretation, Necessary instrumentations.

UNIT-II:

Effective literature studies approaches, Analysis, Plagiarism, Research ethics.

UNIT-III:

Effective technical writing, how to write a report, paper in developing a research proposal, Format of research proposal, A presentation and assessment by a review committee.

UNIT-IV:

Nature of Intellectual Property: Patents, Designs, Trade and Copyright.

Process of Patenting and Development: Technological research, Innovation, Patenting, Development. **International Scenario:** International cooperation on Intellectual Property, Procedure for grant of patents, Patenting under PCT.

UNIT-V:

Patent Rights: Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.

New Developments in IPR: Administration of Patent System, New developments in IPR, IPR of Biological Systems, Computer Software etc. Traditional knowledge, Case Studies, IPR and IITs.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, "Research methodology: An Introduction for science & engineering students".
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction".

REFERENCES:

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step-by-Step Guide for beginners".
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Asimov, "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New TechnologicalAge", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

M. Tech – I Year I Semester

(B543502) POWER CONVERTERS AND ANALYSIS LAB

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List of Experiments

Prerequisite: Power Electronic Converters

Course Objectives:

- To simulate various AC-AC, AC-DC, DC-AC converter topologies

List of Experiments

1. Characteristics of IGBT, MTO, ETO, IGCT, MCT
2. Single phase and three-phase fully controlled converter.
3. Single phase and three-phase Half controlled converter.
4. Single phase Extinction angle control.
5. Single phase symmetrical angle control.
6. Single phase PWM controlled full converter.
7. Sinusoidal pulse width modulated single phase inverter.
8. Sinusoidal pulse width modulated three phase inverter.
9. Space vector modulated three phase inverter.
10. Single phase diode clamped Multi-level inverter.
11. Single phase flying capacitor Multi-level inverter.
12. Single phase cascaded Multi-level inverter.

Note: From the above list, minimum of 10 experiments are to be conducted using any simulation tool.

M. Tech – I Year I Semester

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(B543501)MACHINE MODELLING AND ANALYSIS LAB

Prerequisite: Electrical Machines, Machine Modelling Analysis

Course Objectives:

- To identify the methods and assumptions in modeling of machines.
- To recognize the different frames for modeling of AC machines.
- To write voltage and torque equations in state space form for different machines.

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

- Develop the mathematical models of various machines like, induction motor and Synchronous machines, permanent magnet synchronous motor, brushless DC motor using modeling equations.
- Analyze the developed models in various reference frames.

List of Experiments

1. Develop a dynamic model of open loop-controlled dc motor
2. Develop a dynamic model of closed loop-controlled dc motor
3. Convert ABC voltages into stationary frame
4. Convert ABC voltages into synchronous frames
5. Convert ABC voltages into rotor reference frames
6. Develop dynamic model of 3-phase Induction motor and generator
7. Develop a mathematical model for V/f controlled 3-phase Induction motor
8. Develop a mathematical model for 3-phase Synchronous motor
9. Develop a mathematical model for 3-phase Permanent Magnet Synchronous motor
10. Develop a mathematical model for Brushless DC Motor
11. Develop a dynamic model for closed loop control of Induction Motor
12. Develop a dynamic model for closed loop control of Synchronous motor

Note: From the above list, minimum of 10 experiments are to be conducted using any simulation tool.

M. Tech – I Year II Semester

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(B543303) ADVANCED POWER CONVERTERS ANALYSIS

Professional Core

Prerequisite: Power Electronics, Power Electronic Converters**Course Objectives:**

- To comprehend the concepts of different power converters and their applications
- To analyze and design switched mode regulators for various industrial applications.
- To develop resonant power converters with better performance

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

- Select an appropriate power semiconductor device and design a power converter for the required application
- Model existing and modified power converters based on real time applications
- Analyze and design power converters and feedback loops.

UNIT-I:**NON-ISOLATED D.C. TO D.C. CONVERTERS**

Analysis of step-down and step-up dc to dc converters with Resistive and Resistive-Inductive loads, Switched mode regulators, Analysis of Buck Regulators, Boost regulators, Buck and boost regulators, Cuk regulators, Condition for continuous inductor current and capacitor voltage, Comparison of regulators, Multi output boost converters, Advantages, Applications, Problems, State space analysis of regulators.

UNIT-II:**ISOLATED D.C. TO D.C. CONVERTERS**

Classification, switched mode dc power supplies, Fly back Converter, Forward converter, Push-pull converter, Half bridge converter, Full bridge converter, Control circuits, Magnetic design considerations, Applications.

UNIT-III:**RESONANT PULSE INVERTERS**

Resonant pulse inverters, Series resonant inverters, Series resonant inverters with unidirectional switches, Series resonant inverters with bidirectional switches, Analysis of half bridge resonant inverter, Evaluation of currents and voltages of a simple resonant inverter, Analysis of half bridge and full bridge resonant inverter with bidirectional switches, Frequency response of Series resonant, Parallel resonant, Series loaded, Parallel loaded, Series and Parallel loaded inverters, Voltage control of resonant inverters, Class-E resonant inverter, Class-E resonant rectifier, Evaluation of values of 'C' and 'L' for Class-E inverter and Class-E rectifier, Numerical problems.

UNIT-IV:**ZCS & ZVS RESONANT CONVERTERS**

Resonant converters, zero current switching resonant converters, L-type and M-type ZCS resonant converter, zero voltage switching resonant converters, Comparison between ZCS and ZVS resonant converters, Two quadrant ZVS resonant converters, Resonant dc-link inverters, Evaluation of 'L' and 'C' for a zero current switching inverter, Numerical problems.

UNIT-V

POWER CONDITIONERS

Power line disturbances, Power conditioners, Uninterruptible Power supplies, Applications

ADVANCED CONVERTERS

Principle of operation of SEPIC converter, Matrix Converter, Luo Converter, Interleaved Converter.

TEXTBOOKS:

1. Mohammed H. Rashid, "Power Electronics", Pearson Education, 3rd Edition, 1st Indian reprint, 2004.
2. Ned Mohan Tore M. Undeland and William P. Robbins, "Power Electronics", John Wiley & Sons, 2nd Edition.

REFERENCES:

1. Milliman Shepherd and Lizang, "Power converters circuits", Chapter 14 (Matrix converter) pp.415- 444.
2. M.H.Rashid,"Power Electronics Hand Book".
3. Marian P. Kaźmierkowski, Ramu Krishnan, Frede Blabjerg Edition, "Control in Power Electronics",Published by Academic Press, 2002.

M. Tech – I Year II Semester

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(B543304) ELECTRICAL DRIVES

Professional Core

Prerequisite: Power Electronic Converters, Electrical Machines**Course Objectives:**

- To understand principle of operation of scalar control of AC motor and corresponding speed-torque characteristics
- To comprehend the vector control for AC motor drive (IM and SM)
- To explain the static resistance control and Slip power recovery drive
- To explain synchronous motor drive characteristics and its control strategies
- To comprehend the principle of operation of brushless DC motor.

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

- Develop induction motor for variable speed operations using scalar and vector control techniques.
- Identify the difference between the rotor resistance control and static rotor resistance control method and significance of slip power recovery drives.
- Develop controllers for synchronous motor and variable reluctance motor.

UNIT-I:**RECTIFIER CONTROLLED DC MOTOR**

Separately excited DC motors and DC series motors with single phase semi converter and single phase full converter, Three-phase controlled converter, control circuit, control modeling of three phase converter, Steady state analysis of three phase converter control DC motor drive, Two quadrant, Three phase converter controlled DC motor drive, DC motor, load and converter.

CLOSED LOOP CONTROL OF DC DRIVE

Current and speed controllers, Current and speed feedback, Design of controllers, Current and speed controllers, Motor equations, Filter in the speed feedback loop speed controller, Current reference generator, Current controller and flowchart for simulation, Harmonics and associated problems, Sixth harmonics torque.

UNIT-II:**CHOPPER CONTROLLED DC MOTOR DRIVES**

Principle of operation of the chopper, Chopper with other power devices, Model of the chopper, Input to the chopper, Steady state analysis of chopper-controlled DC motor drives.

Closed loop operation: Speed controlled drive system, Current control loop, Pulse width modulated current controller, Hysteresis current controller, Modeling of current controller, Design of current controller.

UNIT-III:**CONTROL OF INDUCTION MOTOR**

Introduction to motor drive, Torque production, Equivalent circuit analysis, Speed – Torque characteristics with Variable voltage, Variable frequency, Constant v/f, Variable stator current operation, Induction motor characteristics in constant torque and field weakening regions.

STATOR SIDE CONTROL

Scalar control, Voltage fed inverter control, Open loop v/f control, Speed control slip regulation, Speed control with torque and flux control, Current controlled voltage fed inverter drive.

ROTOR SIDE CONTROL OF INDUCTION MOTOR DRIVES

Slip power recovery drives, Static Kramer Drive, Phasor diagram, Torque expression, Speed control of Kramer Drive, Static Scheribus Drive, and Modes of operation.

UNIT-IV:

VECTOR CONTROL OF INDUCTION MOTOR DRIVES

Principles of Vector control, Direct and Indirect methods of vector control, Adaptive control principles, Self tuning regulator Model referencing control, Direct torque control of AC motors.

UNIT-V:

CONTROL OF PERMENANT MAGNET SYNCHRONOUS MOTOR DRIVES

Synchronous motor and its characteristic, Control strategies, Constant torque angle control, Unity power factor control, Constant mutual flux linkage control, Closed loop operation.

TEXTBOOKS:

1. R. Krishnan, "Electric Motor Drives Pearson Modeling, Analysis and control", 1st Edition, 2002.
2. B K Bose, "Modern Power Electronics and AC Drives", Pearson Publications, 1st Edition.

REFERENCES:

1. MD Murthy and FG Turn, "Power Electronics and Control of AC Motors", Bull Pergman Press 1stEdition.
2. BK Bose, "Power Electronics and AC Drives", Prentice Hall Eagle wood diffs New Jersey, 1st Edition.
3. M H Rashid, "Power Electronic circuits Deices and Applications", PHI, 1995.
4. G. K. Dubey, "Fundamentals of Electrical Drives", Narosa publications, 1995.

M. Tech – I Year II Semester

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(B543411) BATTERY TECHNOLOGIES

Professional Elective

Prerequisite: None

Course Objective: The Course aims to

- Understand the principles of electrochemical energy storage and different battery chemistries.
- Analyze performance, modeling, and degradation behavior of batteries under various operating conditions.
- Design efficient battery management systems (BMS) for real-time monitoring, safety, and life extension.
- Evaluate battery integration in electric vehicles (EVs), renewable energy systems, and grid storage.
- Explore advanced technologies including solid-state batteries, recycling, second-life use, and simulation tools.

Course Outcomes (COs): After completion of the course, students will be able to:

- Analyze electrochemical principles and evaluate various battery chemistries based on application requirements.
- Develop and validate electrical, thermal, and aging models of batteries using simulations or experimental data.
- Design battery systems and BMS for high-efficiency applications in EVs, grid storage, and renewable systems, with a focus on safety, performance, and sustainability.

UNIT I: Fundamentals of Electrochemical Energy Storage

Electrochemical principles: redox reactions, electrode potential, Nernst equation, charge transport, Energy and power density, Coulombic efficiency, cycle life, Types of batteries: Primary vs Secondary, Thermodynamic and kinetic limitations, Overview of charge/discharge characteristics

UNIT II: Battery Chemistries and Materials

Lead-acid, NiCd, NiMH, Lithium-ion chemistries (LFP, NMC, NCA, LCO), Emerging chemistries: Sodium-ion, Lithium-Sulfur, Zinc-air, Solid-state batteries, Electrode materials: anode, cathode, electrolyte types (liquid, polymer, solid), Separator materials, dendrite formation, Material challenges and future directions

UNIT III: Battery Modeling, Performance & Degradation

Electrical equivalent circuit models (Rint, Thevenin, RC, PNGV), Thermal models and aging models, Parameters: SOC, SOH, DOD, RUL, Calendar aging, cycle aging, and degradation mechanisms, Battery diagnostics and lifetime prediction

UNIT IV: Battery Management Systems (BMS) and Safety

Architecture and components of BMS, SOC estimation techniques (Coulomb counting, EKF, AI-based methods), Cell balancing: passive vs active, Protection strategies: overvoltage, overcurrent, thermal events, Safety standards: IEC, ISO, UL for EVs and stationary systems, Fire hazards and thermal runaway mitigation

UNIT V: Applications and Advanced Topics

EV applications: Battery packs, thermal management, fast charging, Renewable systems: PV + Battery, wind + battery integration, hybrid systems, Grid storage: frequency regulation, peak shaving, time shifting, Second-life batteries: reuse in grid/Renewables, performance metrics, Battery recycling: processes, environmental impact, Case studies: Tesla, CATL, LG, BYD, ISRO

Textbooks:

1. "Linden's Handbook of Batteries" – T. Reddy (McGraw-Hill)
2. "Battery Management Systems, Volume I & II" – Gregory L. Plett
3. "Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors" – Jürgen Garche et al.

References:

1. "Designing Battery Management Systems" – Eric Forgez
2. IIT/NPTEL Lecture Series on Battery Technology – Prof. Laxmidhar Behera / Prof. Ashok Jhunjhunwala
3. IEEE Transactions on Energy Storage & Power Electronics

M. Tech – I Year II Semester

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(B543412) POWER QUALITY IMPROVEMENT TECHNIQUES

Professional Elective

Prerequisite: Power Systems and Power Electronics**Course Objectives:**

- To know different terms of power quality.
- To illustrate power quality issues for short and long interruptions.
- To study of characterization of voltage sag magnitude and three-phase unbalanced voltage sag.
- To know the behavior of power electronics loads, induction motors, synchronous motor etc. by the power quality issues
- To know mitigation of power quality problems by using VSI converters.

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

- Know the severity of power quality problems in distribution system
- Understand the concept of voltage sag transformation from up-stream (higher voltages) to down- stream (lower voltage)
- Compute the power quality improvement by using various mitigating custom power devices.

UNIT-I:**INTRODUCTION AND POWER QUALITY STANDARDS**

Introduction, Classification of Power Quality Problems, Causes, Effects and Mitigation Techniques of Power Quality Problems, Power Quality Terminology, Standards, Definitions, Monitoring and Numerical Problems.

UNIT-II:**CAUSES OF POWER QUALITY PROBLEMS**

Introduction to Non-Linear Loads, Power Quality Problems caused by Non-Linear Loads, Analysis of Non- Linear Loads, Numerical Problems.

UNIT-III:**PASSIVE SHUNT AND SERIES COMPENSATION**

Introduction, Classification and Principle of operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators for Single-Phase System, Three-Phase Three Wire System and Three-Phase Four Wire System.

UNIT-IV:**ACTIVE SHUNT AND SERIES COMPENSATION**

Introduction to Shunt compensators: Classification of DSTATCOM's, Principle of Operation of DSTATCOM.

Different Control Algorithms of DSTATCOM: PI Controller, I-Cos ϕ Control Algorithm, Synchronous Reference Frame Theory, Single-Phase PQ theory and DQ Theory Based Control Algorithms, Analysis and Design of Shunt Compensators, Numerical Problems.

Introduction to Series Compensators: Classification of Series Compensators, Principle of Operation of DVR.

Different Control Algorithms of DVR: Synchronous Reference Frame Theory-Based Control of DVR, Analysis and Design of Active Series Compensators, Numerical Problems.

UNIT-V:

UNIFIED POWER QUALITY COMPENSATORS

Introduction to Unified Power Quality Compensators (UPQC), Classification of UPQCs, Principle of Operation of UPQC.

Control of UPQCs: Synchronous Reference Frame Theory-Based UPQC, Analysis and Design of UPQCs, Numerical Problems.

TEXTBOOKS:

1. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality Problems and Mitigation Techniques", Wiley Publications, 2015.
2. Math H J Bollen, "Understanding Power Quality Problems", IEEE Press, 2000.

REFERENCES:

1. R.C. Dugan, M.F. McGranaghan and H.W. Beaty, "Electric Power Systems Quality", New York, McGraw-Hill, 1996.
2. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007.
3. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000.
4. G.T. Heydt, "Electric Power Quality", 2ndEdition, West Lafayette, IN, Stars in Circle Publications,1994.
5. R. SastryVedamMulukutlaS.Sarma, "Power Quality VAR Compensation in Power Systems", CRC Press.
6. A Ghosh, G. Ledwich," Power Quality Enhancement Using Custom Power Devices", Kluwer Academic, 2002.

M. Tech – I Year II Semester

L	T	P	C
3	0	0	3

(B543413) INTEGRATION AND CONTROL OF RENEWABLE ENERGY SYSTEMS

Professional Elective

Prerequisite: None**Course Objectives:**

- To understand the structure and operational requirements of the electric grid, including supply reliability, power quality, stability, and cost factors.
- To explore the principles and technologies involved in dynamic and static energy conversion, covering both conventional and renewable energy sources.
- To study control strategies and challenges in integrating various energy conversion technologies, including load frequency, voltage control, and modulation techniques.
- To analyze energy storage systems and their role in supporting renewable energy integration and grid stability.
- To examine the integration of renewable energy into the grid, including system sizing, interfacing requirements, protection, standards, and hybrid system operations.

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

- Analyze and evaluate various dynamic and static energy conversion technologies and their operational principles for grid integration.
- Design and apply control strategies for the efficient and stable operation of renewable energy systems, considering both centralized and distributed approaches.
- Demonstrate knowledge of grid integration challenges, energy storage solutions, and compliance with IEEE/IEC standards for reliable renewable energy deployment.

UNIT-I:

Introduction: Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

UNIT-II:

Dynamic Energy Conversion Technologies: Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind-based generation technologies.

UNIT-III:

Static Energy Conversion Technologies: Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies -batteries, fly wheels, super capacitors and ultra-capacitors.

UNIT-IV:

Control Issues and Challenges: Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell-based generators, Dimensioning of filters, Fault-ride through Capabilities.

UNIT-V:

Integration of Energy Conversion Technologies: Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC codes and standards for renewable energy grid integrations.

Text Books:

1. G. Masters, Renewable and Efficient Electric Power Systems, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 2nd Edition.
2. A. Mahaboob Subahani, G. R. Kanagachidambaresan, M. Kathiresh, Integration of Renewable Energy Sources with Smart Grid, Willey 2021.
3. Felix A. Farret, M. Godoy Simoes, Integration of Renewable Sources of Energy, Wiley, 2017, 2nd Edition.

Reference Books:

1. Chetan Singh Solanki, Fundamentals, Technologies & Applications, Solar Photovoltaic, PHI Publishers, 2019, 3rd Edition.
2. Quing-Chang Zhong, Control of Power Inverters in Renewable Energy and Smart Grid Integration, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 1st Edition.
3. Bin Wu, Yongqiang Lang, Navid Zargari, Power Conversion and Control of Wind Energy Systems, IEEE- John Wiley and Sons Ltd. Publishers, 2011, 1st Edition.
4. S. Chowdhury, S. P. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, IET Power Electronics Series, 2012.

Other Suggested Readings:

1. <https://nptel.ac.in/courses/108/102/108102145/>
2. <https://nptel.ac.in/courses/103/103/103103206/>

M. Tech – I Year II Semester

L	T	P	C
3	0	0	3

(B543414) INDUSTRIAL LOAD MODELLING AND CONTROL

Professional Elective

Prerequisite: Power Systems

Course Objectives:

1. To understand the energy demand scenario
2. To understand the modeling of load and its ease to study load demand industrially
3. To know electricity pricing models
4. To study reactive power management in Industries

UNIT-I:

Electric Energy Scenario, Demand Side Management, Industrial Load Management. Load Curve, Load Shaping Objective, Methodologies. Barriers: Classification of Industrial Loads, Continuous and Batch processes, Load Modeling.

UNIT-II:

Direct load control, Interruptible load control. Bottom- u p approach, Scheduling, Formulation of load models, Optimization and control algorithms, Case studies. Reactive power management in industry, Controls, Power quality impacts, Application of filters, Energy saving in industries.

UNIT-III:

Cooling and heating loads, Load profiling, Modeling. Cool storage, Types, Control strategies. Optimal operation, Problem formulation, Case studies.

UNIT-IV:

Captive power units, Operating and control strategies, Power Pooling, Operation models. Energy banking, Industrial Cogeneration.

UNIT-V:

Selection of Schemes, Optimal Operating Strategies. Peak load saving, Constraints, Problem formulation Case study. Integrated Load management for Industries.

TEXTBOOKS:

1. C.O. Bjork, "Industrial Load Management-Theory, Practice and Simulations", Elsevier, the Netherlands, 1989.
2. C.W. Gellings and S.N. Talukdar, "Load management concepts", IEEE Press, New York, 1986, pp. 3-28.

REFERENCES:

1. Y. Manichaikul and F.C. Schweppe, "Physically based Industrial load", IEEE Trans. on PAS, April 1981.
2. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Inter science Publication, USA, 1989.
3. I.J.Nagarath and D.P.Kothari,"Modern Power System Engineering", Tata McGraw Hill Publishers, New Delhi, 1995.
4. IEEE Bronze Book, "Recommended Practice for Energy Conservation and cost- e f f e c t i v e planning in Industrial facilities", IEEE Inc, USA

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

1. Acquire knowledge on energy demand scenario and classify various industrial loads.
2. Acquire knowledge about load control techniques in industries and its application.
3. Understand different types of industrial processes and optimize the process using different tools.
4. Apply load management to reduce demand of electricity during peak time.
5. Apply different energy saving opportunities and Load management in industries.

CO-PO Mapping

M. Tech – I Year II Semester

L	T	P	C
3	0	0	3

(B543415) SCADA SYSTEMS AND APPLICATIONS

Professional Elective

Prerequisite: -**Course Objectives:**

1. To understand what is meant by SCADA and its functions.
2. To know SCADA communication.
3. To get an insight into its application.

UNIT-I:

Introduction to SCADA, Data acquisition systems, Evolution of SCADA, Communication technologies. Monitoring and supervisory functions, SCADA applications in utility Automation, Industries SCADA.

UNIT-II:

Industries SCADA System Components, Schemes, Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.

UNIT-III:

SCADA Architecture, Various SCADA architectures, Advantages and disadvantages of each System, Single unified standard architecture -IEC 61850.

UNIT-IV:

SCADA Communication, Various industrial communication technologies, Wired and wireless methods and fiber optics, Open standard communication protocols.

UNIT-V:

SCADA Applications: Utility applications, Transmission and Distribution sector operations, Monitoring, analysis and improvement. Oil, gas and water industries case studies: Implementation, Simulation exercises.

TEXTBOOKS:

1. Stuart A. Boyer, "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications, USA, 2004.
2. Gordon Clarke, Deon Reynders, "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newnes Publications, Oxford, UK, 2004.

REFERENCES:

1. William T. Shaw, "Cyber Security for SCADA systems", PennWell Books, 2006.
2. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003.
3. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric power", Penn Well, 1999.

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

1. Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical Applications.
2. Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system.
3. Acquire knowledge about single unified standard architecture IEC 61850.
4. Learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.
5. Learn and understand about SCADA applications in transmission and distribution sector, industries etc

M. Tech – I Year II Semester

L	T	P	C
3	0	0	3

(B543416) DSP BASED DRIVE CONTROL

Professional Elective

Prerequisite: Signals and Systems, Digital Signal Processing**Course Objectives:**

- To enrich the learner with digital controller concepts and its application in the field of Power Electronic drives

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

- Understand the architecture of DSP core and its functionalities.
- Acquire knowledge on operation of interrupts and peripherals
- Explore the possibilities of hardware implementation using PLDs and FPGAs.
- Design controllers for power electronic drives.

UNIT-I

Introduction to the C2xx DSP core and code generation, the components of the C2xx DSP core, mapping external devices to the C2xx core, Peripherals and Peripheral Interface, System configuration registers, Memory, Types of Physical Memory, Memory addressing Modes, Assembly Programming using C2xx DSP, Instruction Set, Software Tools.

UNIT II

Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers, Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

UNIT III

ADC Overview, Operation of the ADC in the DSP, Overview of the Event manager (EV), Event Manager Interrupts, General Purpose (GP) Timers, Compare Units, Capture Units and Quadrature Enclosed Pulse (QEP) Circuitry, General Event Manager Information.

UNIT IV

Introduction to Field Programmable Gate Arrays (FPGA), CPLD Vs FPGA, Types of FPGA, Xilinx XC3000 series, Configurable logic Blocks (CLB), Input/output Block (IOB), Programmable Interconnect Point (PIP), Xilinx 4000 series, HDL programming, Overview of Spartan 3E and Virtex II pro FPGAboards case study.

UNIT V

Control of DC motor, Permanent magnet Brushless DC motor, Permanent magnet synchronous motor.

TEXTBOOKS:

1. John.F.Wakerly, "Microcomputer Architecture and Programming", John Wiley and Sons, 1981.
2. Ramesh S.Gaonker, "Microprocessor Architecture, Programming and Applications with the8085", Penram International Publishing (India), 1994.

REFERENCE BOOKS:

2. Hamid.A.Toliyat and Steven G.Campbell, "DSP Based Electro Mechanical Motion Control", CRC Press New York, 2004.
3. XC 3000 series datasheets (version 3.1). Xilinx, Inc., USA, 1998.
4. XC 4000 series datasheets (version 1.6). Xilinx, Inc., USA, 1999.
5. Wayne Wolf, "FPGA based system design, Prentice Hall, 2004.

M. Tech – I Year II Semester**(B543417) DATA SCIENCE APPLICATIONS IN
POWER ENGINEERING**

L	T	P	C
3	0	0	3

Professional Elective

Prerequisite:

None

Course

Objectives:

- To introduce the fundamental concepts of data science and machine learning.
- To understand the process of data preparation and analysis for engineering problems.
- To learn various machine learning algorithms and their applications.
- To apply machine learning techniques to real-world problems in the power generation industry.
- To analyze specific case studies related to power system forecasting and maintenance

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

- Differentiate between data science, machine learning, and AI concepts and their relevance to engineering disciplines.
- Analyze and prepare datasets for use in machine learning models, including handling outliers and performing feature engineering.
- Apply various machine learning algorithms to solve regression and classification problems.
- Understand and articulate the practical applications of machine learning within the power generation industry.
- Develop and evaluate forecasting models for specific power system challenges, such as electrical consumption and wind power failures.

Unit I - Introduction to Data Science

Introduction to data science, introduction to machine learning, overview of the power generation industry, artificial intelligence in the power generation industry, climate change and the power industry, machine learning for industry transition, mitigation of problems using machine learning.

Unit II - Data Science, Statistics, and Time Series

Preparing a clean dataset, measuring and storing data in control systems, data uncertainty, time-series analysis, data correlation, mathematical representation and modeling, data representation and significance, outlier removal, model goodness, feature engineering, dimensionality reduction, practical checklist for dataset preparation.

Unit III - Machine Learning

Introduction to machine learning concepts, supervised and unsupervised learning, regression and classification, bias-variance trade off, model complexity, neural networks (feed-forward and recurrent), support vector machines (SVM), random forest, self-organizing maps (SOM), Bayesian networks, training a model, splitting datasets (training, testing, validation), cross-validation, assessing model performance, role of a domain expert, practical advice for a machine learning project.

Unit IV - Machine Learning in the Power Generation Industry & Electrical Consumption Forecasting

Machine learning studies in power plants and for power users, predictive maintenance, forecasting supply and demand, modeling physical relationships, consumer modeling, practical applications of machine learning in the power industry, case study of electrical consumption forecasting in a medical clinic, integration with Building Management Systems, artificial neural network (ANN) implementation, multilayer perceptron ANN, backpropagation training algorithm, ANN inputs (loads, day type, time, weather), formal procedure for ANN parameter selection.

Unit V - Forecasting Wind Power Plant Failures Topic

Wind power plant damage mechanisms, impact on lifetime cost and power production, vibration spectra analysis for damage detection, predictive maintenance, forecasting failures on turbine blades, rotors, and generators

TEXTBOOKS:

1. Machine Learning and Data Science in the Power Generation Industry: Best Practices, Tools, and Case Studies, edited by Patrick Bangert, Elsevier, ISBN: 9780128197424.
2. Machine Learning for Energy Systems, edited by Denis N. Sidorov, MDPI Books, Publication Date: December 2020, ISBN (Hardback): 978-3-03943-382-7, ISBN (PDF): 978-3-03943-383-4.
3. Data Science for Engineers, by Raghunathan Rengaswamy and Resmi Suresh, CRC Press, Publication Date: December 16, 2022, ISBN (Hardback): 9780367754266, ISBN (eBook): 9781003353584.

REFERENCES:

1. Application of Machine Learning and Deep Learning Methods to Power System Problems, edited by Morteza Nazari- Heris, Somayeh Asadi, Behnam Mohammadi-Ivatloo, Moloud Abdar, Houtan Jebelli, and Milad Sadat-Mohammadi, Springer International Publishing, 2021.
2. Real-World Applications of Artificial Intelligence and Machine Learning in Power Systems: A Code Approach, by T. Mariprasath and V. Kirubakaran, Nova Science Publishers, 2025.

M. Tech – I Year II Semester

L	T	P	C
3	0	0	3

(B543418) ELECTRIC VEHICLE CHARGING TECHNIQUES

Professional Elective

Prerequisite: Electric and Hybrid Vehicles, Power Electronics, Smart Grid Technologies**Course Objectives:**

- To understand the charging infrastructure for EV's
- To explore the working of grid connected with EV's.

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

- Understand the planning and operational issues related to EV's charging.
- Acquire knowledge about EV's charging implementation models.

UNIT-I:**AN OVERVIEW OF EV CHARGING INFRASTRUCTURE:**

Orients the reader to EV charging infrastructure, providing a brief introduction to technical concepts of electric vehicle supply equipment, AC and DC charging, power ratings, and charging standards.

UNIT-II:**LOCATION PLANNING AND LAND ALLOCATION:**

Covers the location and site planning aspects for EV charging, by framing the principles of location planning and demonstrating a methodology for spatial allocation of charging demand, and identifies enabling processes and policies to integrate public charging in urban planning.

UNIT-III:**CONNECTING EVs TO THE ELECTRICITY GRID:**

Focuses on supply of electricity for charging infrastructure, familiarizing readers with the regulations that govern electricity supply for EV charging, the role of DISCOMs in provision of EV charging connections, and the three methods of arranging for power supply for charging infrastructure.

UNIT-IV:**ACHIEVING EFFECTIVE EV-GRID INTEGRATION:**

Zooms out from site-level considerations for supply of electricity to assess grid-level impacts, and then highlights the need for smart charging to minimize adverse impacts of EV charging loads on the grid.

UNIT-V:**MODELS OF EV CHARGING IMPLEMENTATION**

Defines the typical roles within an implementation model for EV charging infrastructure and identifies three models in India – the government-driven model, the consumer-driven model and the charge point operator-driven model – for charging infrastructure implementation.

TEXTBOOKS:

1. Sulabh Sachan, P. Sanjeevikumar, Sanchari Deb, “Smart Charging Solutions for Hybrid and Electric Vehicles”, Wiley Publications, March 2022.
2. Handbook of Electric Vehicle Charging Infrastructure Implementation Version-1

REFERENCES:

1. Vahid Vahidinasab, Behnam Mohammadi-Ivatloo, “Electric Vehicle Integration via Smart Charging, Springer, 2022.
2. Alam, Mohammad Saad, Pillai, Reji Kumar, Murugesan, N, “Developing Charging Infrastructure and Technologies for Electric Vehicles”, IGI Global Publisher, December 2021,

M. Tech – I Year II Semester

L	T	P	C
3	0	0	3

(B543419) ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

Professional Elective

Prerequisite: Power Systems, Power Electronics**Course Objectives:**

- To enumerate sources of Electromagnetic interferences
- To design EMI Filter for insertion loss and for switch mode power supplies
- To understand concept of Faraday screens for EMI Prevention

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

- Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems.
- Assess the insertion loss and design EMI filters to reduce the loss
- Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits

UNIT-I:**INTRODUCTION:**

Sources of conducted and radiated EMI, EMC standardization and description, measuring instruments, conducted EMI references, EMI in power electronic equipment: EMI from power semiconductors circuits.

UNIT-II:**NOISE SUPPRESSION IN RELAY SYSTEMS:**

AC switching relays, shielded transformers, capacitor filters, EMI generation and reduction at source, influence of layout and control of parasites.

UNIT-III:**EMI FILTER ELEMENTS:**

Capacitors, choke coils, resistors, EMI filter circuits. Ferrite beads, feed through filters, bifilar wound choke filter, EMI filters at source, EMI filter at output.

UNIT-IV:**EMI IN SWITCH MODE POWER SUPPLIES:**

EMI propagation modes, power line conducted-mode inference, safety regulations (ground return currents), Power line filters, suppressing EMI at sources, Line impedance stabilization network (LISN), line filter design, common- mode line filter inductors- design& example, series –mode inductors and problems, EMI measurements.

UNIT-V:**FARADAY SCREENS FOR EMI PREVENTION:**

Faraday Screens for EMI prevention in switching devices, transformers, safety screens, faraday screens on output components, reducing radiated EMI on gapped transformer cores, metal screens, electrostatic screens in transformers.

TEXTBOOKS:

1. Electromagnetic Compatibility in Power Electronics, Laszlo Tihanyi, IEEE Press
2. EMI Filter Design, Pullen Timotty. M. Ozenbaugh, N. Richard Lee, CRC Press, Taylor & Francis
3. Practical Design for Electromagnetic Compatibility, R. F. Ficchi Hayden Book Co.

REFERENCES:

1. Stuart Borlase, “Smart Grid: Infrastructure Technology Solutions”, CRC Press.
2. Handbook on Switch-Mode Power Supplies, Keith H. Billings, McGraw-Hill Publisher, 1989
3. <https://www.ee.iitb.ac.in/web/academics/courses/EE785>

M. Tech – I Year II Semester

L	T	P	C
3	0	0	3

(B543420) DISTRIBUTED GENERATION

Professional Elective

Prerequisite: Power Systems, Power Electronics

Course Objectives:

- To understand renewable energy sources.
- To explore the working of off-grid and grid-connected renewable energy generation schemes.

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

- Understand the planning and operational issues related to Distributed Generation.
- Acquire knowledge about Distributed Generation Learn Micro-Grids

UNIT-I: Need for Distributed generation, Renewable sources in distributed generation and current scenario in Distributed Generation.

UNIT-II: Planning of DGs, Siting and sizing of DGs optimal placement of DG sources in distribution systems, Grid integration of DG's, Different types of interfaces, Inverter based DG's and rotating machine- based interfaces, Aggregation of multiple DG units.

UNIT-III: Technical impacts of DG' on Transmission systems and Distribution Systems, De-regulation, Impact of DGs upon protective relaying, Impact of DGs upon transient and dynamic stability of existing distribution systems, Steady-state and Dynamic analysis.

UNIT-IV: Economic and control aspects of DG's Market facts, Issues and challenges, Limitations of DG's, Voltage control techniques, Reactive power control, Harmonics, Power quality issues, Reliability of DG based systems.

UNIT-V: Introduction to micro-grids, Types of micro-grids, Autonomous and non-autonomous grids, Sizing of micro- grids, Modeling & analysis of Micro-grids with multiple DG's, Micro-grids with power electronic interfacing units, Transients in micro-grids, Protection of micro-grids, Case studies, Advanced topics.

TEXTBOOKS:

1. H. Lee Willis, Walter G. Scott, "Distributed Power Generation-Planning and Evaluation", MarcelDecker Press.
2. M.Godoy Simoes, Felix A.Farret, "Renewable Energy Systems-Design and Analysis with Induction Generators", CRC press.

REFERENCES: 1. Stuart Borlase, "Smart Grid: Infrastructure Technology Solutions", CRC Press.

M. Tech – I Year II Semester

L	T	P	C
0	0	4	2

(B543503) ADVANCED POWER CONVERTERS LAB-**Prerequisite:** Power Electronic Converters**Course Objectives:**

- To know gate drive circuit configurations for converter circuits
- To analyze advanced converter topologies

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

- Design the gate driver circuits for converter topologies.
- Design concern topologies based on industrial applications

List of Experiments:

1. Buck Converter
2. Boost Converter
3. Cuk converter
4. Push pull converter
5. Fly back converter
6. Forward converter
7. Series resonant converter
8. Parallel resonant converter
9. ZVS
10. ZCS
11. UPS
12. SEPIC Converter

Note: From the above list, minimum of 10 experiments are to be conducted using any simulation tool**Course Outcomes:** After completion of the course, students will be able to.

1. Design the gate driver circuits for converter topologies.
2. Design concern topologies based on industrial applications
3. Design different resonant converter topologies
4. Design different advanced converter topologies
5. Design different converters for SMPS

M. Tech – I Year II Semester**(B543504) ELECTRICAL DRIVES LAB**

L	T	P	C
0	0	4	2

Prerequisite: Power Electronic Converters**Course Objectives:**

- To simulate various AC-AC, AC-DC, DC-AC converter topologies

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

- Design controlled rectifiers
- Design conventional multi-level inverters for industrial applications.

List of Experiments

1. Speed Measurement and closed loop control using PMDC motor.
2. Thyristorised drive for PMDC Motor with speed measurement and closed Loop control.
3. IGBT used single phase chopper drive for PMDC motor with speed measurement and closed loop control.
4. Thyristorised drive for DC motor with closed loop control.
5. 3-Phase input, thyristorised drive, DC motor with closed loop.
6. 3-Phase input IGBT, chopper drive for DC motor with closed Loop control equipment.
7. Cyclo-converter based AC Induction motor control equipment.
8. Speed control of 3 phase wound rotor Induction motor.
9. Single-phase fully controlled converter with inductive load.
10. Single phase half controlled converter with inductive load.

Course Outcome:

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

1. Demonstrate the control of electrical machines using power electronic converter
2. Illustrate AC to AC converter fed electrical machines
3. Design the control circuit for Induction motors
4. Analyse the performance of half controlled converter fed Inductive load
5. Analyse the performance of chopper fed drive

CO-PO Mapping

M. Tech – II Year I Semester

L	T	P	C
3	0	0	3

(B543421) DYNAMICS OF ELECTRICAL MACHINES

Professional Elective

Prerequisite: Machine Modeling and Analysis

Course Objectives:

- To introduce generalized modeling of electrical machines
- To analyze different electrical machines with dynamic modeling

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

- Understand the basic mathematical analysis of electrical machines and its characteristics.
- Understand behavior of electrical machines under steady state and transient state.
- Understand dynamic modeling of electrical machines.

UNIT-I:

BASIC MACHINE THEORY

Electromechanical Analogy, Magnetic Saturation, Rotating field theory, Operation of Inductor motor, Equivalent circuit, Steady state equation of DC machines, Operation of synchronous motor, Power angle characteristics.

UNIT-II:

ELECTRODYNAMICAL EQUATION & THEIR SOLUTIONS

Spring and Plunger system, Rotational motion, mutually coupled coils, Lagrange's equation, Application of Lagrange's equation, and Solution of Electro dynamical equations.

UNIT-III:

DYNAMICS OF DC MACHINES

Separately excited DC generator and motors, Steady-state and Transient analysis, Interconnection of machines, Ward Leonard system of speed control.

UNIT-IV:

INDUCTION MACHINE DYNAMICS

Induction machine dynamics during starting and braking, Accelerating time, Induction machine dynamic during normal operation, Equation for dynamical response of the induction motor.

UNIT-V:

SYNCHRONOUS MACHINE DYNAMICS

Electromechanical equation, Motor operation, Generator operation, small oscillations, General equations for small oscillations, Representation of the oscillation equations in state variable form.

TEXTBOOKS:

1. Sen Gupta D.P. and J.W, "Electrical Machine Dynamics ", Macmillan Press Ltd., 1980.
2. Bimbhra P.S., "Generalized Theory of Electrical Machines", Khanna Publishers, 2002.

REFERENCES:

1. Vedam Subramanyam, "Thyristor control of Electric Drives".
2. Article in IEEE Transactions on Energy Conversion, "Performance Optimization of Induction motors during Voltage-controlled soft starting", July 2004.

M. Tech – II Year I Semester

L	T	P	C
3	0	0	3

(B543422) ENERGY STORAGE TECHNOLOGIES
Professional Elective

Prerequisite: -

- **Course Objectives**
- To introduce generalized storage techniques
- To analyze the different features of energy storage systems
- To know the management and application of energy storage technologies
- To have an idea about electrical energy storage market potential by different forecasting methods

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

- Understand the role of electrical energy storage technologies in electricity usage
- Know the behavior and features of electrical energy storage systems
- Analyze the applications of energy storage system
- Understand the hierarchy, demand for energy storage and valuation techniques.
- Get knowledge about energy storage forecasting methods

UNIT-I:**ROLE OF ENERGY STORAGE TECHNOLOGIES**

Characteristics of electricity, Electricity and the roles of EES, High generation cost during peak-demand periods, Need for continuous and flexible supply, Long distance between generation and consumption, Congestion in power grids, Transmission by cable, Emerging needs for EES, More renewable energy, Less fossil fuel, Smart Grid uses, The roles of electrical energy storage technologies, The roles from the viewpoint of a utility, The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy.

UNIT-II:**TYPES AND FEATURES**

Classification of EES systems, Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Lead-Acid Batteries, Lithium-Ion Batteries, Flow batteries, Other Batteries in Development, Chemical energy storage, Hydrogen (H₂), Synthetic Natural Gas (SNG), Electrical storage systems, Double- Layer Capacitors (DLC), Superconducting Magnetic Energy Storage (SMES), Thermal storage systems, Standards for EES, Technical comparison of EES technologies.

UNIT-III:**APPLICATIONS**

Present status of applications, Utility use (conventional power generation, grid operation & service), Consumer use (uninterruptable power supply for large consumers), EES installed capacity worldwide, new trends in applications, Renewable energy generation, Smart Grid, Smart Micro grid, Smart House, Electric vehicles.

UNIT-IV:

MANAGEMENT AND CONTROL HIERARCHY

Internal configuration of battery storage systems, External connection of EES systems, Aggregating EES systems and distributed generation (Virtual Power Plant), “Battery SCADA” aggregation of many dispersed batteries. Battery Management Systems (Qualitative Approach).

DEMAND FOR ENERGY STORAGE

Growth in Variable Energy Resources, Relationship between balancing services and variable energy resources, Energy Storage Alternatives, Variable Generator Control, Demand Management, Market Mechanisms, Longer Term Outlook.

VALUATION TECHNIQUES

Overview, Energy Storage Operational Optimization, Market Price Method, Power System Dispatch Model Method, Ancillary Service Representation, Energy Storage Representation, Survey of Valuation Result

UNIT-V:

FORECAST OF EES MARKET POTENTIAL

EES market potential for overall applications, EES market estimation by Sandia National Laboratory (SNL), EES market estimation by the Boston Consulting Group (BCG), EES market estimation for Li-ion batteries by the Panasonic Group, EES market potential estimation for broad introduction of renewable energies, EES market potential estimation for Germany by Fraunhofer, Storage of large amounts of energy in gas grids, EES market potential estimation for Europe by Siemens, EES market potential estimation by the IEA, Vehicle to grid concept, EES market potential in the future.

TEXTBOOKS:

1. Paul Breeze, “Power System Energy Storage Technologies”, 1st Edition, Academic Press.
2. Alfred Rufer, “Energy Storage: Systems and Components”, CRC Press, 2017.

REFERENCES:

1. Huggins and Robert, “Energy Storage Fundamentals, Materials and Applications”, Springer.
2. andreasoberhofer@gmx.de
3. www.ecofys.com/com/publications
4. www.iec.ch.

M. Tech – II Year I Semester

L	T	P	C
3	0	0	3

((B543423) SMART METERING AND COMMUNICATION PROTOCOLS

Professional Elective

Prerequisite: -
Course
Objectives

- Understand smart metering architecture and communication networks fundamental to modern energy systems.
- Analyze and apply various communication standards and protocols used in smart meters and smart grid infrastructures.
- Design secure and efficient communication systems for Advanced Metering Infrastructure (AMI), including HAN, NAN, and WAN.
- Evaluate demand-side integration strategies and data management techniques within smart grids.
- Develop practical simulations or prototypes demonstrating smart meter communication protocols and system resilience.

Course Outcomes (COs): After completion of the course, students will be able to:

- Analyze and evaluate different communication protocols and standards used in smart metering systems.
- Design robust and secure AMI communication architectures across HAN, NAN, and WAN layers.
- Address data integration, demand response, and cybersecurity challenges inherent in smart grid communication systems.

UNIT I: Fundamentals of Smart Metering and AMI

Concepts: Smart grid vs traditional grid, smart metering architecture, key components of smart meters, Advanced Metering Infrastructure (AMI): Drivers, benefits, needs, Hierarchical communication models: Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN), data concentrators, and Meter Data Management Systems (MDMS)

UNIT II: Communication Protocols and Standards

Protocols for smart metering: Modbus, DNP3, IEC 61850, DLMS/COSEM (IEC 62056 series), Open Smart Grid Protocol (OSGP), ANSI C12.22 Power-line communication (PLC) technologies: PRIME, G3-PLC, S-FSK, broadband PLC

UNIT III: Networking Models and Technologies

Computing and communication frameworks in smart grids: ISO/OSI and TCP/IP models, Network media: Wired (Ethernet, fiber), Wireless (Bluetooth, ZigBee, Wi-Fi, Cellular, NB-IoT, LTE-M), M-Bus/Wireless M-Bus Integration of communication legacies: Ethernet, CAN, I²C, LIN, Z-Wave

UNIT IV: Demand-Side Integration & Data Management

Demand Side Integration (DSI): Services, hardware support, system-level implementation, Pricing Strategies: Real-time pricing, time-of-use, peak-load pricing, Data Management: MDMS, data concentrators, forecasting, cloud-based approaches

UNIT V: Security, Syndication & Advanced Applications

Cybersecurity in smart grids: Symmetric and asymmetric encryption, authentication, threats (data injection, load-altering attacks) Integration with SCADA, PMUs, distribution automation equipment: IEDs, RTUs, distribution management systems Emerging topics: IoT protocols (MQTT, CoAP), RESTful APIs, WebHooks for smart metering.

Text Books:

1. Smart Grid Technologies: Communication Technologies and Standards, Güngör et al., IEEE Trans. on Industrial Informatics
2. Smart Grid: Technology and Applications, Janaka Ekanayake et al.
3. Communication Networks for Smart Grids, Budka, Deshpande, Thottan (Springer)

M. Tech – II Year I Semester

L	T	P	C
3	0	0	3

(B543424) WIDE BAND GAP DEVICES FOR POWER ELECTRONICS APPLICATIONS

Professional Elective

Prerequisite: None**Course objectives:**

- To introduce the characteristics and evolution of wide band gap (WBG) devices such as SiC and GaN, and to understand their advantages and challenges in power converter design.
- To analyze the switching behavior and driver circuit requirements of GaN transistors, including loss mechanisms and protection strategies.
- To develop modeling techniques for GaN devices, including electrical, thermal, and reliability aspects.
- To address high-frequency design considerations, including parasitics, EMI, thermal management, and PCB layout for WBG-based systems.
- To explore practical applications of GaN devices in power conversion systems for electric vehicles, renewable energy, and RF amplifiers.

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

- Introduce the basic operation of wide band gap devices and their characteristics
- Ability to do electrical and thermal modeling of wideband devices, as well as EMI filter design for high-frequency power converters
- Familiar with compact single-layer and multilayer PCB designs according to industrial needs
- Utilize wide band gap devices for real-time applications through simulation and experimental studies

UNIT-I:

Wide Band Gap Devices: Introduction to basic power devices, characteristics, and applications – Silicon Power MOSFETs 1976-2010, SiC Planer Power MOSFETs, SiC Trench-Gate Power MOSFETs, Need of GaN device, Basic GaN Transistor structure, GaN Vertical Power HEFTs and Horizontal Power HEFTs, Different types of wide band gap devices, advantages and challenges in designing converters with wide band gap devices.

UNIT-II:

GaN Transistor Characteristics & Driver Circuits: Turn ON and Turn OFF switching characteristics of GaN devices, Hard switching loss analysis, Gate driver design, Impact of gate resistance, dv/dt and di/dt immunity, etc., Protection design for double pulse test set-up.

UNIT-III:

Modeling and Measurement of GaN Transistors: Electrical and thermal modeling of GaN transistors, Thermal management, and Reliability.

UNIT-IV:

High-frequency design complexity: The impact of parasitic inductance and capacitance, EMI filter design for high-frequency power converters, and Heat sink design.

PCB Design: Power circuit design, Driver circuit design, Single layer and Multilayer PCBs, separation of the power circuit and driver circuit, High-frequency power loop optimization.

UNIT-V:

Applications: GaN in AC/DC & DC/AC Power Converters, GaN in Switched Mode Power Amplifiers, Electric Vehicle Applications, and Renewable Applications.

Text Books:

1. A. Lidow, J. Strydom, M. D. Rooij, D. Reusch, GaN Transistors for Efficient Power Conversion, Wiley, 2014.
2. G. Meneghesso, M. Meneghini, E. Zanoni, "Gallium Nitride-enabled High Frequency and High Efficiency Power Conversion," Springer International Publishing, 2018.
3. Maurizio Di Polo Emilio, GaN and SiC Power Devices, Springer, 2024.

Reference Books:

1. B.J. Baliga, "Gallium Nitride and Silicon Carbide Power Devices," World Scientific Publishing Company, 2017.
2. F. Wang, Z. Zhang and E. A. Jones, Characterization of Wide Bandgap Power Semiconductor Devices, IET, 2018.

Other Suggested Readings:

1. <https://nptel.ac.in/courses/108108377>

(B543425) RELIABILITY ENGINEERING
(Program Elective-V.1)

L	T	P	C
3	0	0	3

M. Tech – II Year I Semester

1. To comprehend the concept of Reliability and Unreliability.
2. To derive the expressions for probability of failure, expected value and standard deviation of Binominal distribution, Poisson distribution, Normal distribution and Weibull distributions.
3. To formulate expressions for reliability analysis of series-parallel and non-series parallel systems.
4. To derive expressions for time dependent and limiting state probabilities using Markov models.

UNIT-I:

RELIABILITY AND PROBABILITY

Rules for combining probabilities of events, Definition of Reliability, Significance of the terms appearing in the definition, Probability distribution, Random variables, Probability density and distribution functions, Mathematical expectation, Binominal distribution, Poisson distribution, Normal distribution, Exponential distribution, Weibull distribution.

UNIT-II:

HAZARD RATE

Derivation of the reliability function in terms of the hazard rate, Failures, causes of failures, Types of failures (early failures, chance failures and wear-out failures), Bath tub curve, Preventive and corrective maintenance, Modes of failure, Measures of reliability, Mean time to failure and Mean time between failures.

UNIT-III:

CLASSIFICATION OF ENGINEERING SYSTEMS

Series, Parallel and Series-Parallel systems, Expressions for the reliability of the basic configurations.

Reliability evaluation of non-series-parallel configurations: Decomposition, Path based and cutset based methods, Deduction of the Paths and cut-sets from Event tree.

UNIT-IV:

DISCRETE MARKOV CHAINS

General modeling concepts, stochastic transitional probability matrix, Time dependent probability evaluation and limiting state probability evaluation of one component repairable model, Absorbing states.

Continuous Markov Processes: Modeling concepts, State space diagrams, Stochastic Transitional Probability Matrix, evaluating time dependent and limiting state, Probabilities of one component repairable model. Evaluation of limiting state probabilities of two component repairable model.

UNIT-V:

FREQUENCY AND DURATION TECHNIQUES

Frequency and duration concepts, Application to multi-state problems, Frequency balance approach.

Approximate System Reliability Evaluation: Series system, Parallel system, Network reduction techniques, Cut set approach, Common mode failures, modeling and evaluation techniques, Examples.

TEXTBOOKS:

1. Roy Billinton and Ronald N Allan, “Reliability Evaluation of Engineering Systems”, BS Publications.
2. A. Elsayed, “Reliability Engineering”, Prentice Hall Publications.

REFERENCES:

1. Alessandro Birolini, “Reliability Engineering: Theory and Practice”, Springer Publications.
2. Charles Ebeling, “An Introduction to Reliability and Maintainability Engineering”, TMH Publications.
3. E. Balaguruswamy, “Reliability Engineering”, TMH Publications.

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

1. derive the expressions for probability of failure, expected value and standard deviation of Binominal distribution, Poisson distribution, Normal distribution and Weibull distributions
2. Understand or become aware of various failures, causes of failures and remedies for failures in practical systems.
3. Apply fundamental knowledge of Reliability to modeling and analysis of series-parallel and nonseries parallel systems.
4. Derive expressions for time dependent and limiting state probabilities using Markov models.
5. Solve some practical problems using the concepts.

M. Tech – II Year I Semester

L	T	P	C
3	0	0	3

(B555601) EMBEDDED SYSTEMS
(Open Elective)

M.Tech (PE)**UNIT-I: Embedded Computing & CPU fundamentals**

Embedded Computing: Microprocessors, embedded design process, system description formalisms. Instruction sets- CISC and RISC;

CPU fundamentals: programming I/Os, co-processors, supervisor mode, exceptions, memory management units and address translation, pipelining, super scalar execution, caching, CPU power consumption.

UNIT-II: Embedded computing platform & Program design and analysis

Embedded Computing platform: CPU bus, memory devices, I/O devices, interfacing, designing with microprocessors, debugging techniques.

Program design and analysis: models of program, assembly and linking, compilation techniques, analysis and optimization of execution time, energy, power and size.

UNIT-III: Processes and operating systems

Multiple tasks and multiple processes, context switching, scheduling policies, inter-process communication mechanisms.

UNIT-IV: Hardware accelerators & Networks

Hardware accelerators:
accelerator system design.

CPU's and accelerators,

Networks: Distributed embedded architectures, networks for embedded systems, network-based design and Internet-enabled systems.

UNIT-V: System design techniques

Design methodologies, requirements analysis, system analysis and architecture design, quality assurance.

Text Books:

1. Wolf, W. Computers as components- Principles of embedded computing system design. Academic Press (Indian edition available from Harcourt India Pvt. Ltd., 27M Block market, Greater Kailash II, New Delhi-110 048.)

Reference Books

1. Manuel Jiménez Rogelio, PalomeraIsidoro Couvertier "Introduction to Embedded Systems Using Microcontrollers and the MSP430" Springer Publications, 2014.
2. Frank Vahid, Tony D. Givargis, "Embedded system Design: A Unified Hardware/Software Introduction", John Wily & Sons Inc.2002.
3. Peter Marwedel, "Embedded System Design", Science Publishers, 2007.

Course Outcomes:

After the Completion of the course, the students will be able to

1. Explain the Embedded design process and CPU Fundamentals
2. Understand Embedded computing platform and program design.
3. Explain Scheduling policies and inter process mechanisms in Embedded systems
4. Evaluate the Hardware accelerators & networks for Embedded system.
5. Explain various System design methodologies and quality assurance.

M. Tech – II Year I Semester

L	T	P	C
3	0	0	3

(B543601) PHOTOVOLTAIC SYSTEMS

(Open Elective.6)

Prerequisite: None**Course Objectives:**

- To introduce photovoltaic systems
- To deal with various technologies of solar PV cells
- To understand details about manufacture, sizing and operating techniques
- To have knowledge of design considerations.

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

- Identify photovoltaic system components and system types
- Calculate electrical energy and power
- Correctly size system components, design considerations of solar equipment
- Design a basic grid-tie PV system.

UNIT-I:**SOLAR ENERGY**

Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation, Solar cell, Equivalent circuit, V-I characteristics, Performance improvement.

UNIT-II:**SOLAR CELLS**

Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, Encapsulation systems, Manufacture, Power rating, Hotspot effect, Design qualifications.

UNIT-III:**PROTECTION AND MEASUREMENTS**

Flat plate arrays, Support structures, Module interconnection and cabling, Lightning protection, Performance measurement using natural sun light and simulator, Determination of temperature coefficients, Internal series resistance, Curve correction factor.

UNIT-IV:**PHOTOVOLTAIC SYSTEMS**

Photovoltaic systems, Types, General design considerations, System sizing, Battery sizing, Inverter sizing, Design examples, Balance of PV systems.

UNIT-V:**MAXIMUM POWER POINT TRACKERS**

Maximum power point trackers, Perturb and observe, Incremental conductance method, Hill climbing method, , Hybrid and complex methods, Data based and other approximate methods, Instrument design, Other MPP techniques, Grid interactive PV system.

TEXTBOOKS:

1. F.C.Treble, "Generating electricity from Sun", Pergamon Press.
2. A.K.Mukherjee, Nivedita Thakur,"Photovoltaic systems: Analysis and design", PHI, 2011.

REFERENCES:

1. C.S.Solanki," Solar Photovoltaic's: Fundamentals, Technologies and applications", PHI, 2009.

**(B520601)GREEN BUILDING TECHNOLOGIES
(Open Elective)**

M. Tech – II Year I Semester

L	T	P	C
3	0	0	3

UNIT- I

Introduction

Environmental implications of buildings energy, carbon emissions, water use, waste Disposal. Building materials: sources, methods of production and environmental Implications. Green cover and built environment.

UNIT- II

Implications of Resources

Implication of resources for Building Materials and alternative concepts. Recycling of Industrial and Building Wastes. Biomass Resources for buildings.

UNIT- III

Comforts in Building

Comforts in Building: Thermal Comfort in Buildings-Issues; Heat Transfer Characteristics of Building Materials and Building Techniques. Incidence of Solar Heat on Buildings.

UNIT- IV

Energy Conservation

Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.

UNIT- V

Green Composites for Buildings & Waste Management

Green Composites for buildings. Concepts of Green Composites. Water Utilization in Buildings. Waste Management: Low Energy Approaches to Water Management, Management of Solid Wastes, Management of Sullage water and Sewage.

TEXT BOOKS:

1. K.S. Jagadish, B.U. Venkatarama Reddy and K.S. Nanjundarao. Alternative Building Materials and Technologies. New Age International, 2007.
R22 B.Tech. Civil Engineering JNTUH Hyderabad
Page 85 of 132
2. Michael Bauer, Peter Mosle and Michael Schwarz “Green Building-Guide book for Sustainable Architecture “Springer, 2010.

REFERENCE BOOKS:

1. Osman Attmann Green Architecture Advanced Technologies and Materials. McGraw Hill, 2010.
2. Michael F. Ashby Materials and the Environment, Elsevier, 2009.
3. Jerry Yudelson Green building Through Integrated Design McGraw Hill, 2009.
4. Mili M.Ajumdar (Ed) Energy Efficient Building in India. Teri and Mnes, 2001/2002
5. Low Energy Cooling for Sustainable Buildings John Wiley and Sons Ltd. 2009.
6. Green My Home': 10 Steps to Lowering Energy Costs and Reducing Your Carbon Footprint by Dennis.
7. C. Brewer, ISBN: 97814227798411, Publisher: Kaplan Publishing. Publications Date
8. B. Givoni Man, Climate and Architecture Elsevier, 1969.
9. T. A Markus and E. N. Morris Buildings Climate and Energy. Pitman, London Arvindkishan et al (Ed)

**(B558601)INTRUSION DETECTION SYSTEMS
(OPEN ELECTIVE)**

M. Tech : I Year II Semester

L	T	P	C
3	0	0	3

Course Outcomes:

1. Understand fundamental knowledge of intrusion detection and prevention
2. Understand different types of attacks in network layer and code injection human layer
3. Analyze different anomaly detection algorithms

UNIT - I

The state of threats against computers, and networked systems-Overview of computer security solutions and why they fail-Vulnerability assessment, firewalls, VPN's -Overview of Intrusion Detection and Intrusion Prevention, Network and Host-based IDS

UNIT - II

Classes of attacks - Network layer: scans, denial of service, penetration Application layer: software exploits, code injection-Human layer: identity theft, root access-Classes of attackers-Kids/hackers/sop Hesitated groups-Automated: Drones, Worms, Viruses

UNIT - III

A General IDS model and taxonomy, Signature-based Solutions, Snort, Snort rules, Evaluation of IDS, Cost sensitive IDS

UNIT - IV

Anomaly Detection Systems and Algorithms-Network Behavior Based Anomaly Detectors (rate based)-Host-based Anomaly Detectors-Software Vulnerabilities-State transition, Immunology, Payload Anomaly Detection

UNIT - V

Attack trees and Correlation of alerts- Autopsy of Worms and Botnets-Malware detection - Obfuscation, polymorphism- Document vectors. Email/IM security issues-Viruses/Spam-From signatures to thumbprints to zero day detection-Insider Threat issues-Taxonomy-Masquerade and Impersonation Traitors, Decoys and Deception-Future: Collaborative Security

TEXT BOOKS:

1. Peter Szor, The Art of Computer Virus Research and Defense, Symantec Press ISBN 0-321-30545-3.
2. Markus Jakobsson and Zulfikar Ramzan, Crimeware, Understanding New Attacks and Defenses.

REFERENCE BOOKS:

1. Saiful Hasan, Intrusion Detection System, Kindle Edition.
2. Ankit Fadia, Intrusion Alert: An Ethical Hacking Guide to Intrusion Detection

M. Tech – I& II Semester

L	T	P	C
2	0	0	0

(B5400701) ENGLISH FOR RESEARCH PAPER WRITING

Prerequisite: None

(Audit-I &II .1)

Course objectives:

- To Understand that how to improve your writing skills and level of readability
- To Learn about what to write in each section
- To Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

UNIT-I:

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT-II:

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT-III:

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT-IV:

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

UNIT-V:

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, and skills are needed when writing the Conclusions

UNIT-VI:

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

TEXTBOOKS/ REFERENCES:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

M. Tech – I& II Semester**(B500702) DISASTER MANAGEMENT**
(Audit-I &II .1)

L	T	P	C
2	0	0	0

UNIT-I:

Introduction: Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. Disaster Prone Areas in India: Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics

UNIT-II:

Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

UNIT-III:

Disaster Preparedness and Management: Preparedness: Monitoring of Phenomena Triggering A Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT-IV:

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

UNIT-V:

Disaster Mitigation: Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

TEXT BOOKS/ REFERENCES:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "New Royal book Company.
2. Sahni, Pardeep Et. Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.
3. Goel S. L., Disaster Administration and Management Text and Case Studies", Deep &Deep Publication Pvt. Ltd., New Delhi.

M. Tech – I& II Semester

L	T	P	C
2	0	0	0

(B500703) VALUE EDUCATION

(Audit-I &II)

Prerequisite: None**Course Objectives:**

- To understand value of education and self- development
- To imbibe good values in students
- To know about the importance of character

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

- Get Knowledge of self-development
- Learn the importance of Human values
- Develop the overall personality

UNIT-I:

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

UNIT-II:

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT-III:

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness -Avoid fault Thinking. Free from anger, Dignity of labor- Universal brotherhood and religious tolerance - True friendship - Happiness Vs suffering, love for truth - Aware of Self-destructive habits - Association and Cooperation - Doing best for saving nature

UNIT-IV:

Character and Competence –Holy books vs. Blind faith - Self-management and good health - Science of reincarnation - Equality, Nonviolence, Humility, Role of Women - All religions and same message - Mind your Mind, Self-control - Honesty, Studying effectively

TEXTBOOKS/ REFERENCES:

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

M. Tech – I& II Semester**(B00704) CONSTITUTION OF INDIA**
(Audit-I &II)

L	T	P	C
2	0	0	0

Prerequisite: None**Course Objectives:**

- To understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

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

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

UNIT-I:**History of Making of the Indian Constitution:** History Drafting Committee, (Composition & Working)**UNIT-II:****Philosophy of the Indian Constitution:** Preamble, Salient Features**UNIT-III:****Contours of Constitutional Rights & Duties:** Fundamental Rights Right to Equality, Right to Freedom, right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.**UNIT-IV:****Organs of Governance:** Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualification, Powers and Functions**UNIT-V:****Local Administration:** District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy**UNIT-VI:****Election Commission:** Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

TEXTBOOKS/ REFERENCES:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn. Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

