A18

M.Tech. (POWER ELECTRONICS)

M.Tech. Amended R18 [A18] CBCS Curriculum

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

An Autonomous, ISO 9001:2015 & QS I-Gauge Diamond Rated Institute, Accredited by NAAC with 'A++' Grade
NBA Accreditation for B.Tech. CE, EEE, ME, ECE, CSE, EIE, IT Programmes
Approved by AICTE, New Delhi, Affiliated to JNTUH, NIRF 135th Rank in Engineering Category
Recognized as "College with Potential for Excellence" by UGC
Vignana Jyothi Nagar, Pragathi Nagar, Nizampet (S.O), Hyderabad – 500 090, TS, India.
Telephone No: 040-2304 2758/59/60, Fax: 040-23042761
E-mail: postbox@vnrvjiet.ac.in, Website: www.vnrvjiet.ac.in

VISION OF THE INSTITUTE

To be a World Class University providing value-based education, conducting interdisciplinary research in cutting edge technologies leading to sustainable development of the nation

MISSION OF THE INSTITUTE

- To produce technically competent and socially responsible engineers, managers and entrepreneurs, who will be future ready.

- To involve students and faculty in innovative research projects linked with industry, academic and research institutions in India and abroad.

- To use modern pedagogy for improving the teaching-learning process.

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF THE DEPARTMENT

To excel in Education, Technology and Research in Electrical and Electronics Engineering leading to sustainable socioeconomic development of the nation.

MISSION OF THE DEPARTMENT

- Excellent teaching-learning environment imbibed with professional ethics and social responsibility in promoting quality education.
- Promoting research through industry collaborations and innovative projects.

M.TECH.
(POWER ELECTRONICS)

M.TECH. (PE)

PROGRAM EDUCATIONAL OBJECTIVES

PEO-I: Proficient in applying sustainable and inclusive technologies to analyse, formulate and provide solutions for real time problems in diversified fields.

PEO-II: Solve complex technological problems using emerging technologies and tools

PEO-III: Work effectively as an individual and team member with good communication skills in project execution.

PEO-IV: Demonstrate interdisciplinary skills and professional ethics in relating engineering issues to broader societal context.

PEO-V: Engage in life long learning for a successful professional career.

M.TECH. (PE)

PROGRAM OUTCOMES

PO-1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO-2: An ability to write and present a substantial technical report/document.

PO-3: An ability to demonstrate a degree of mastery over the area as per the specialization of the program.

PO-4: Design and conduct experiments, as well as analyze the power electronic converters & drives and interpret the data.

PO-5: Function on multidisciplinary technological issues assimilating power electronics advancements.

PO-6: Use the techniques, skills, and modern engineering simulation tools necessary for the design and development of power converter topologies and engage in life long learning.

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. I YEAR COURSE STRUCTURE AND SYLLABUS

(POWER ELECTRONICS)

I SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Core-I	A18PC1PL01	Power Electronic Converters	3	0	0	3
Professional Core-II	A18PC1PL02	Modeling and Analysis of Electrical Machines	3	0	0	3
Professional Core-III	A18PC1PL03	Electric Drives System	3	0	0	3
Professional Elective-I	A18PE1PL01	Advanced Microcontroller-Based Systems	3	0	0	3
	A18PE1PL02	VLSI Design				
	A18PE1PS01	Renewable Energy Systems				
Professional Elective -II	A18PE1PL03	Artificial Intelligence Techniques	3	0	0	3
	A18PE1PS04	SCADA Systems and Applications				
	A18PE1PL04	Digital Signal Processing for Power and Control				
Professional Core Lab-I	A18PC2PL01	Power Electronic Converters Laboratory	0	0	3	1.5
Professional Core Lab-II	A18PC2PL02	Modeling and Simulation of Electrical Drives Laboratory	0	0	3	1.5
Project	A18PW4PE01	Technical Seminar	0	0	4	2
Audit	A18AU5CS01	Research Methodology and IPR	2	0	0	0
Total			**17**	**0**	**10**	**20**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. I YEAR COURSE STRUCTURE AND SYLLABUS

(POWER ELECTRONICS)

II SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Core-IV	A18PC1PL04	Advanced Power Electronic Converters	3	0	0	3
Professional Core-V	A18PC1PL05	Digital Controllers in Power Electronic Applications	3	0	0	3
Professional Core-VI	A18PC1PL06	Advanced Control Systems	3	0	0	3
Professional Elective-III	A18PE1PL05	Electric Hybrid Vehicles	3	0	0	3
	A18PE1PL06	Embedded Systems				
	A18PC1PS05	Power Quality				
Professional Elective -IV	A18PE1PL07	Electro Magnetic Interference and Compatibility	3	0	0	3
	A18PC1PS06	Flexible AC Transmission Systems				
	A18PE1PS08	Smart Grids				
Professional Core Lab-III	A18PC2PL03	Advanced Power Electronic Converters Simulation Laboratory	0	0	3	1.5
Professional Core Lab-IV	A18PC2PL04	Power Electronic Control and Applications Laboratory	0	0	3	1.5
Project	A18PW4PL02	Mini-Project	0	0	4	2
Audit	A18AU5EN01	English for Academic and Research Writing	2	0	0	0
Total			**17**	**0**	**10**	**20**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. II YEAR COURSE STRUCTURE AND SYLLABUS

(POWER ELECTRONICS)

III SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Elective-V	A18PE1LI14	IoT Technologies	3	0	0	3
	A18PE1PL08	Energy Storage Technologies				
	A18PE1PL09	HVDC Transmission				
Open Elective	A18OE1CN01	Business Analytics	3	0	0	3
	A18OE1AM01	Industrial Safety				
	A18OE1AM02	Operations Research				
	A18OE1AM03	Composite Materials				
	A18OE1PS01	Waste to Energy				
Project	A18PW4PL03	Project Part - I	0	0	16	8
Total			**6**	**0**	**16**	**14**

IV SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Project	A18PW4PL04	Project Part - II	0	0	28	14
Total			**0**	**0**	**28**	**14**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PL01) POWER ELECTRONIC CONVERTERS

COURSE PRE-REQUISITES: Power Electronics

COURSE OBJECTIVES:
- To design/develop suitable power converter for efficient control or conversion of power in drive applications
- To design / develop suitable power converter for efficient transmission and utilization of power in power system applications
- To select suitable semiconductor switches for the power converter design

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the operating characteristics of various power electronic devices and the design aspects
CO-2: Analyze operating principles of different converters and find their applications
CO-3: Design the control range/ control methodologies for various power electronic converters

UNIT-I:
Power Semiconductor Switches for Power Control and Conversion: Ideal Switch; operation, static and dynamic characteristics, power dissipation of various semiconductor switches- Diodes - Bipolar Power Transistors - Power MOSFETS - Insulated Gate Bipolar Transistor(IGBT) - Silicon-Controlled Rectifier – DIAC - TRIAC and Gate Turn-off Thyristor (GTO).

UNIT-II:
AC to DC Converters: Principle of Phase controlled converter operation, single phase and three phase bridge rectifiers, single phase and three phase half controlled and fully controlled converters with R, RL& RLE loads, Freewheeling diode, evaluation of performance parameters- input harmonics- power factor and output ripple, control strategies for power factor improvement.

UNIT-III:
DC-DC Converters: Principle of operation of step down and step up converters, Switching mode Regulators- analysis and design of Buck, Boost, Buck-Boost and Cukregulators, limitations of single stage conversion-comparison of regulators.

UNIT-IV:
DC-AC Converters: Single phase bridge inverters - Principle of operation-performance parameters , Three phase inverters - 180 and 120 degree Conduction modes, Voltage control and waveform improvement techniques -Comparison of PWM techniques- harmonic reduction - Current Source Inverters - advantages -applications

UNIT-V:
AC-AC Converters: Principle of phase control, single phase bidirectional controllers with R and RL Loads, Performance Analysis, Three Phase bidirectional controllers-different configurations,AC voltage controllers with PWM control, Principle of operation of single phase and three phase cyclo converters, Reduction of output harmonics, Introduction to Matrix converter- principle of operation.

UNIT-VI:
Design Aspects of Converters: Gate Drive Circuits-MOSFET gate drive & BJT base drive control circuits, Isolation of Gate and Base drives, Thyristor firing circuits, Cooling and heat sinks,

Thermal modeling of power switching devices, Snubber circuit, reverse recovery transients, supply and load side transients, voltage protection and current protection, Electro Magnetic Interference.

TEXT BOOKS:

1. Power Electronics, M. H. Rashid, Prentice Hall of India, 1994
2. Power Electronics- Converters, Application and Design, Ned Mohan, Undeland and Robbins, John Wiley and Sons. Inc, New York
3. Power Electronics–Essentials and Applications, L. Umanand, Wiley India Pvt. Ltd.

REFERENCES:

1. Fundamentals of Power Electronics, Erickson R. W., Chapman and Hall
2. High Power Converters and Drives, Bin Wu, IEEE Press, Wiley

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PL02) MODELLING AND ANALYSIS OF ELECTRICAL MACHINES

COURSE PRE-REQUISITES: Electrical Machines, Control Systems

COURSE OBJECTIVES:
- To comprehend the basic Electro-mechanical Energy conversion in Rotating Machines
- To develop the mathematical models of different electrical machines
- To recognize the different frames for modeling of different AC machines
- To express the voltage and torque equations in State space form
- To understand the operation of Special Electrical Machines

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the electromechanical energy conversion and basic concepts of rotating Machines
CO-2: Write the voltage and torque equations for different machines like DC, induction and Synchronous machines
CO-3: Model different AC machines using Linear transformations with suitable reference frame selection
CO-4: Know the operation and constructional features of special electrical machines

UNIT-I:
Electromagnetic Energy Conversion: Principles of Electromagnetic Energy Conversion,General expressions of stored Magnetic Energy, Co-energy and Force/Torque, examples of Single and Doubly excited systems,Basic Concepts of Rotating Machines, Calculation of Air Gap mmf and machine inductance per phase using physical machine data. Conventions used in Machine Modeling.

UNIT-II:
Modeling of DC Machines: Basic Two-pole DC machine - primitive 2-axis machine - Voltage and Current relationships in matrix form - Torque equation in matrix form , Mathematical model of DC separately excited, Series,, Shunt and Compound motors- state variable forms and Transfer functions, Representation of Compensating Winding in modeling-Numerical problems.

UNIT-III:
Modeling of Induction Machines-I: Linear transformations-Phase transformation (a,b,c to a,β,o)-Power and MMF invariance-Active transformation(a,β,o to d,q,o), Mathematical Modeling of 3 Ph Induction Motor-voltage and current equations without transformations- a,β modeling of Three Phase Induction motor-Transformation to Arbitrary Reference Frame

UNIT-IV:
Modeling of Induction Machines-II: Transformation to Commonly used reference frames-Stator, Rotor, Synchronously rotating reference frames (air gap)- Torque Equations-Equations in state variable form for arbitrary reference frame, Mathematical modeling of two phase asymmetrical and single phase induction machines.

UNIT-V:
Modeling of Synchronous Machines: Basic 3phase Synchronous motor –Assumptions for modeling-Two axis representation of Synchronous Motor, Mathematical model to Rotor reference frame, Electromagnetic Torque, Equivalent dqo circuits, Determination of Synchronous machine dynamic equivalent circuit parameters

UNIT-VI:

Special Machines: Special Machines - Permanent Magnet Synchronous Machine, Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines,Construction and operating principle,Brushless D.C. Motor for space Applications , Analysis of Switched Reluctance Motors, Recent trends in Special Electrical Machines-Axial Flux machines.

TEXT BOOKS:

1. Analysis of Electric Machine, P. C. Krause, 3rd Edition, Wiley IEEE Press
2. Generalized Machine Theory, P. S. Bimbhra, Khanna Publishers, 2002
3. Special Electrical Machines, K. Venkataraman, CRC Press, 2008

REFERENCES:

1. Dynamic Simulations of Electric Machinery: Using MATLAB, Chee-Mun Ong, Prentice-Hall, 1998
2. Electric Machinery, Charles Kingsle Jr., A. E. Fitzgerald, Stephen D. Umans, Tata Mcgraw Hill
3. Electric Motor & Drives: Modeling, Analysis and Control, R. Krishnan, Prentice Hall of India
4. Brushless Permanent Magnet and Reluctance Motor Drives, Miller T. J. E., Clarendon Press
5. Thyristor Control of Electric Drives, Vedam Subramanyam, Tata McGraw-Hill Education, 1988

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PL03) ELECTRIC DRIVES SYSTEM

COURSE PRE-REQUISITES: Power Electronics, Electrical Machines and Control Systems

COURSE OBJECTIVES:
- To understand Basic electrical drives and their analysis
- To analyse speed control of electrical dc and ac drives
- To design power electronic controllers for electric drives

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Model an electric drive system
CO-2: Design modulation strategies of power electronics converters and appropriate controllers for drives application
CO-3: Implement various control schemes for DC and AC drives

UNIT-I:
Dynamics and Control of Electrical Drives: Introduction to Power semiconductor drive and its elements, Dynamics of motor load system, Fundamentals of torque equation, Speed-torque conventions and multi quadrant operation, components of load torques, Nature and classification of load torques, steady state stability, load equalization, modes of operation, speed control and drive classification, closed loop control of drives.

UNIT-II:
Phase Controlled Rectifier fed DC Drives: Principles of DC Motor speed control, single phase and three phase fully controlled converter fed dc separately excited motor – control circuit – control modeling, steady state average Analysis of converter fed DC drive, three phase dual converter fed four quadrant DC motor drive, closed loop operation of two quadrant DC drive, Transfer functions of the subsystems.

UNIT-III:
Chopper fed DC Drives: Principle of operation of the chopper, Four Quadrant chopper drive, Chopper with different power inputs, Model of the chopper, steady state analysis of chopper fed. DC Drive, Closed loop control – Current control loop – PWM controller – Hysteresiscontroller – Modeling – design of current controller.

UNIT-IV:
Scalar Control of Induction Motor Drives: Induction Motor-Principle -torque expression - Equivalent circuit analysis-Stator voltage and frequency control, V/f control, Drive operating regions; Scalar control :Voltage fed inverter control – Open loop volts/Hz control – speed control by slip regulation – speed control with torque and flux control; Current-fed inverter control – Independent current and frequency control – Speed and flux control in Current-Fed inverter drive – Volts/Hz control of Current-fed inverter drive ; Control of Induction Motor by Slip Power Recovery Schemes.

UNIT-V:
Vector Control of Induction Motor Drives: Introduction, DC drive analogy, principle of vector control, Vector control methods- direct method – Flux Vector estimation – indirect vector control; Direct Torque Control, Adaptive control principles – self tuning regulator – model reference adaptive control.

UNIT-VI:

Permanent Magnet Synchronous Motor Drives: Synchronous machines with Permanent magnets, Expression for Torque , model of PMSM, Vector control of PMSM, Control strategies-Constant torque angle control-unity power factor control - constant mutual flux linkages control; Flux weakening operation: direct flux weakening operation –constant torque mode controller, flux weakening controller; indirect flux weakening operation- maximum permissible torque, speed control scheme.

TEXT BOOKS:

1. Fundamentals of electric Drives, G. K. Dubey, 2nd Edition, Narosa Publishing House, 2011
2. Electric Motor Drives Modeling, Analysis and Control, R. Krishanam, PHI India, 2009
3. Modern Power Electronics and AC Drives, B. K. Bose, 1st Edition, Prentice Hall Publication, 2001

REFERENCES:

1. Power Semiconductor Controlled Drives, G. K., Dubey, Prentice Hall International, 1989
2. Analysis of Electric Machinery and Drive Systems, P. C. Krause, 3rd Edition, Wiley-IEEE Press
3. Vector Control of AC Machines, Peter Vas, Oxford University Press, 1990

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL01) ADVANCED MICRO-CONTROLLER BASED SYSTEMS

COURSE PRE-REQUISITES: Microprocessors and Micro-controllers

COURSE OBJECTIVES:
- To understand the architecture of advance microcontrollers
- To understand the applications of these controllers
- To get some introduction to FPGA

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Learn how to program a processor in assembly language and develop an advanced processor-based system
CO-2: Learn the configuration by using different peripherals in a digital system
CO-3: Compile and debug a Program
CO-4: Generate an executable file and use it

UNIT-I:
Structure of Basic Computer: Basic Computer Organization. - Main parts of a computer system –Instruction codes-Computer register-Computer instructions-Timing and control-instruction cycle-Accumulator based processes-Architecture-Memory-Types of memory-two basic memory operations- Organization-I/O Organization

UNIT-II:
Overview and Architecture of 8051: Micro-Controllers-Intel 8051 Architecture-Instruction Sets-Addressing modes- Registers Organization, Memory Organization. - Stack & Subroutine- I/O Ports- Serial Communication. Timers, Interrupts

UNIT-III:
8051- Microcontrollers Instruction Set and Assembly Language Programming in Real Time Control: Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations – Program flow control instructions – Interrupt control flow. Intel 8051 – Basic Assembly language programming
Timer, serial port and Interrupts programming: Programming 8051 timers/counters, 8051 serial port programming, programming timer interrupts, programming External hardware interrupts, programming serial communication interrupts.

UNIT-IV:
Overview and Architecture of PIC 16F877: PIC 16F877- Architecture –Program memory organization –Data memory organization-register files map-special function register-Addressing Modes-Timers–capture /compare/ PWM modules- Programming. Interfacing Memory/ I/O Devices, Serial I/Oand data communication

UNIT-V:
Outline of DSP Processor and FPGA: Digital Signal Processor (DSP) - Architecture – CPU Register-Addressing modes- Assembly language instructions- Timers –serial port- -Programming, Introduction to FPGA- Basic concepts-digital design and FPGA'S- FPGA based system design-Hardware description languages.

UNIT-VI:
Interfacing to 8051: A/D interface and D/A Converter interface, Stepper Motor Interface, DC Motor interface -Key Board Interfacing, -LCD Interfacing

TEXT BOOKS:

1. Microcomputer Architecture and Programming, John F. Wakerly, John Wiley and Sons, 1981
2. The 8051 Microcontroller, Kenneth J. Ayala, Cengage Learning, 2004
3. The PIC Microcontroller: Your Personal Introductory Course, John Morton, Elsevier, 2005

REFERENCES:

1. Microprocessor Architecture, Programming and Applications with the 8085, Ramesh S. Gaonker, Penram International Publishing (India), 1994
2. Advanced PIC Microcontroller Projects in C: from USB to RTOS with the PIC18F Series, Dogan Ibrahim, Elsevier, 2008
3. Microchip Datasheets for PIC16F877
4. TMS320C3x User's Guide
5. FPGA Based System Design, Wayne Wolf

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M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL02) VLSI DESIGN

COURSE PRE-REQUISITES: Electronic Devices and Circuits, Digital IC Concepts

COURSE OBJECTIVES:
- To learn the fabrication process of Integrated Circuit and electrical properties of MOSFET
- To study the concepts of stick diagrams and layouts with the knowledge of MOS layers through design rules
- To learn the design of digital systems using subsystem design approach
- To understand the concepts of PLD's, design capture tools and CMOS testing

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand IC Fabrication process steps required for various MOS circuits
CO-2: Analyze electrical properties and layout flow for circuit level and gate level models
CO-3: Design the digital circuits by using subsystem approach
CO-4: Implement and verify the VLSI systems

UNIT-I:
Introduction: Introduction to MOS Technology – MOS, PMOS, NMOS, CMOS and BiCMOS technologies, fabrication fundamentals: Oxidation, Lithography, Diffusion, Ion implantation, Metallization and Encapsulation.
Basic Electrical Properties: Basic Electrical Properties of MOS, CMOS and BiCMOS Circuits: Ids-Vds relationships, MOS transistor threshold Voltage, gm, gds, figure of merit wo, Pass transistor, NMOS inverter, Various pull-ups, Determination of pull-up to pull-down ratio (Zpu/Zpd), CMOS Inverter analysis and design, BiCMOS inverters, Latch-up in CMOS circuits.

UNIT-II:
VLSI Circuit Design Processes: VLSI Design Flow, MOS Layers, Stick Diagrams, Design Rules and Layouts, Lambda based design rules, Contact cuts , CMOS Lambda based design rules, Layout Diagrams for logic gates, Transistor structures, wires and vias, Scaling of MOS circuits- Scaling models, scaling factors, scaling factors for device parameters, Limitations of Scaling.

UNIT-III:
Basic Circuit Concepts: Sheet Resistance RS and its concept to MOS, Area Capacitance Units, Calculations, the delay unit, Inverter Delays, Driving large Capacitive Loads, Wiring Capacitances, Fan-in and Fan-out, Choice of layers.

UNIT-IV:
Gate Level Design: Architectural issues, Switch logic, Gate logic, Combinational Circuit Design: CMOS logic families including Ratioed Logic, Static, dynamic and Domino Logic,Pass-Transistor Logic and Transmission gate logic.
Sequential Circuit Design: Design of latches and Flip-flops.

UNIT-V:
Subsystem Design: Adders: Carry Ripple adder, Carry Skip adder, Carry lookahead adder, Carry select adder, ALU, Multipliers: Array multiplier, Serial-Parallel multiplier, Parity generator, Comparators, Zero/One Detectors, Up/Down Counter, Memory elements, Shifter.

UNIT-VI:
Semiconductor Integrated Circuit Design: Introduction to ROM, PAL and PLA(PLDs), FPGAs, CPLDs.

CMOS Testing: CMOS Testing, Need for testing, Test Principles, Design Strategies for test, Over view of Chip level Test Techniques and System-level Test Techniques, Layout Design for Improved Testability.

TEXT BOOKS:

1. Essentials of VLSI Circuits and Systems, Kamran Eshraghian, Dougles and A. Pucknell, PHI Edition, 2005
2. Modern VLSI Design, Wayne Wolf, Pearson Education, 3rd Edition, 1997
3. CMOS VLSI Design – A Circuits and Systems Perspective, Neil H.E Weste, David Harris, Ayan Banerjee, Pearson, 2009

REFERENCES:

1. CMOS Logic Circuit Design, John P. Uyemura, Springer, 2007
2. VLSI Design, K. Lal Kishore, VSV Prabhakar, I.K. International, 2009
3. VLSI Design, A. Albert Raj, Latha PHI, 2008
4. Introduction to VLSI Design, Mead and Convey, BS Publications, 2010
5. VLSI Design, M. Michal Vai, CRC Press, 2009

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS01) RENEWABLE ENERGY SYSTEMS

COURSE PRE-REQUISITES: Power Systems, Switchgear Protection, Power Electronics

COURSE OBJECTIVES:
- To learn various renewable energy sources
- To gain understanding of integrated operation of renewable energy sources
- To understand Power Electronics Interface with the Grid

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Gain the Knowledge about renewable energy
CO-2: Understand the working of distributed generation system in autonomous/grid connected modes
CO-3: Know the Impact of Distributed Generation on Power System

UNIT-I:
Distributed Generation: Introduction- Distributed vs Central Station Generation, Reasons for DG, Technical Impacts of DG, DG Technologies, Economic Impact of DG, Barriers to DG Development, Renewable Sources of Energy, Renewable Energy Economics, Interconnection, Recommendations and Guidelines for DG Planning

UNIT-II:
Sustainable Energy Sources: Introduction to Solar Energy, Wind Energy, Hydro Energy, Tidal Energy, Wave Energy, Geothermal Energy, Biomass, Fuel Cells. Combined Heat and Power Status, Options for Space Heating, Properties, Variation in Production with Time, Correlation between CHP and Consumption

UNIT-III:
Grid Integration with Renewable Energy Sources: Direct Machine Coupling with the Grid , Full Power Electronics Coupling with the Grid, Partial Power Electronics Coupling to the Grid, Distributed Power Electronics Interface, Impact of the Type of Interface on the Power System, Local Control of Distributed Generation.

UNIT-IV:
Power Quality Issues in Grid: Impact of Distributed Generation on the Power System, Changes Taking Place, Impact of the Changes, Hosting Capacity Approach, Power Quality Issues: Voltage Quality, Current Quality, Multiple Generator Tripping. Voltage Quality and Design of Distributed Generation: Normal Operation, Variations, Normal Events, Abnormal Events. Hosting Capacity Approach for Events, Increasing the Hosting Capacity

UNIT-V:
Distributed Generators Protection: Over current Protection for Upstream and Downstream Faults, Fuse–Recloser Coordination, Inverse-Time Over current Protection, Calculating the Fault Currents, Calculating the Hosting Capacity, Bus bar Protection, Excessive Fault Current Protection, and Generator Protection.

UNIT-VI:
Economics of Distributed Generation: Introduction-Estimating the cost of distributed versus centralized energy generation, The financial viability of individual DG systems, The social costs and benefits of DG penetration, The overall economic, environmental and social impacts of DG penetration, Case Studies.

TEXT BOOKS:

1. Renewable Energy Sources and Emerging Technologies, Ranjan Rakesh, Kothari D. P., Singal K. C., 2nd Ed., Prentice Hall of India, 2011
2. Integration of Distributed Generation in the Power System, Math H. Bollen, Fainan Hassan, Wiley–IEEE Press, 2011

REFERENCES:

1. Distributed Generation: Induction and Permanent Magnet Generators, Loi Lei Lai, Tze Fun Chan, Wiley-IEEE Press, 2007
2. Photovoltaic System Engineering, Roger A. Messenger, Jerry Ventre, 3rd Ed., 2010
3. Wind Energy Explained: Theory Design and Application, James F. Manwell, Jon G. McGowan, Anthony L. Rogers, 2nd Ed., John Wiley and Sons, 2010
4. The Economics of Distributed Energy Generation: A Literature Review, Grant Allan, Igor Eromenko, Michelle Gilmartin, Ivana Kockar, Peter McGregor, Renewable and Sustainable Energy Reviews, Volume 42, February 2015, Pages 543-556

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M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL03) ARTIFICIAL INTELLIGENCE TECHNIQUES

COURSE PRE-REQUISITES: Control Systems, Power Systems, Electrical Drives

COURSE OBJECTIVES:
- To locate soft commanding methodologies, such as artificial neural networks, Fuzzy logic and genetic Algorithms
- To observe the concepts of feed forward neural networks and about feedback neural networks
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control
- To analyze genetic algorithm, genetic operations and genetic mutations

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Quote the feed forward neural networks and learning and understanding of feedback neural networks
CO-2: Generalize fuzziness involved in various systems and fuzzy set theory
CO-3: Examine genetic algorithm and applications in electrical engineering
CO-4: Understand concept of hybrid AI techniques

UNIT-I:
Artificial Neural Networks: Introduction to AI, biological foundation to intelligent systems. Artificial Neural Network: architecture, learning process, learning rules. Training algorithms: LMS algorithm, Back-propagation algorithm.
Radial basis network-covers theorem, generalized radial basis function networks, estimation of regularization parameter.

UNIT-II:
Fuzzy Logic: Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets –Operations on Fuzzy relations – Min Max operations - Fuzzification, Membership value assignment, development of rule base and decision making system, De-fuzzification to crisp sets, De-fuzzification methods.

UNIT-III:
Genetic Algorithm: Introduction-Encoding –Fitness Function-Reproduction operators-Genetic Modeling –Genetic operators-Crossover-Single – site crossover-Two point crossover –Multi point crossover-Uniform crossover – Matrix crossover-Crossover Rate-Inversion & Deletion – Mutation operator – Mutation –Mutation Rate-Bit-wise operators-Generational cycle- convergence of Genetic - Problems on optimization-Algorithm.

UNIT-IV:
Neuro-Fuzzy Systems: Fuzzy associative memories; Fuzzy rule generation using neural net approaches, Fuzzy neural networks; adaptive neuro-fuzzy inference systems (ANFIS); neuro-fuzzy control.

UNIT-V:
System Identification Using Neural and Fuzzy Systems: System/process identification using neural networks, system identification using fuzzy models: Mamdani Model, Takagi-Sugeno model.

UNIT-VI:

Applications of AI Techniques: Control and Process Monitoring, fault diagnosis and load forecasting, Function Approximation, – Load flow studies – Economic load dispatch – Load frequency control –Single area system and two area system – Position and speed control of DC and AC Motors.

TEXT BOOKS:

1. An Introduction to ANN, J. M. Zurada, Jaico Publishing House
2. Neural Networks, Simon Haykins, Prentice Hall
3. Neural Networks, Fuzzy Logic & Genetic Algorithms, S. Rajasekaran and G.A.V. Pai, PHI, New Delhi, 2003

REFERENCES:

1. Neural Network & Fuzzy System, Bart Kosko, Prentice Hall, 1992
2. Neural Computing Theory & Practice, P.D. Wasserman, Van Nostrand Reinhold, New York,1989
3. Fuzzy Sets, Uncertainty and Information, G. J. Klir and T.A. Folger, PHI, 1994
4. Genetic Algorithms, D.E. Goldberg, Addison Wesley, 1999
5. Neural Networks, Satish Kumar, Tata McGraw-Hill

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS04) SCADA SYSTEMS AND APPLICATIONS

COURSE PRE-REQUISITES: Basic Power Systems

COURSE OBJECTIVES:
- To understand what is meant by SCADA and its functions
- To know SCADA communication
- To get an insight into its application

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications in transmission & distribution sectors and various industries etc.
CO-2: Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system
CO-3: Comprehend about SCADA Protocols. IEC 60870, DNP3, ICCP etc.
CO-4: Learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server

UNIT- I:
Introduction to SCADA:
SCADA: SCADA systems: Components of SCADA Systems & Applications in various industries, SCADA in Power Systems: Advantages, Basic functions& Application functions, Power System field, Types of data& signals in power system, Flow of data from field to SCADA control center, Open System-Need and advantages, Building blocks of SCADA Systems.

UNIT-II:
SCADA RTU & IED Components:
RTU: Block diagram, Sub systems- Communication, Logical, Termination, Power supply, HMI; Advanced RTU Functionalities of the logic subsystem.
IED: Functional block diagram, Hardware and software Architecture, Advanced functionalities, Communication subsystem; Data concentrators and merging units.

UNIT-III:
SCADA MS & HMI Components:
MS: Major functions of basic SCADA software, Hardware components and their main functions, Block diagrams of small, medium, large Master Stations; Global Positioning Systems (GPS), MS performance.
HMI: Components, functionalities, HMI Intelligent alarm filtering and suppression techniques, Classification of SCADA Systems:-Single master- single remote, Single master-multiple RTU, Multiple master- multiple RTUs, Single master- multiple sub master- multiple remote.

UNIT-IV:
SCADA Communication: SCADA communication- Requirements, Topologies, Smart grid communication infrastructure; SCADA Data communication - Techniques, Components, Transmission of Digital Signals and their Modes, Error detection techniques, Media Access Control techniques.

UNIT-V:
SCADA Architecture & Protocols:
SCADA Communication Protocol Architectures: OSI seven layer model, enhanced performance architecture (EPA) model, Transmission Control Protocol (TCP)/ Internet Protocol (IP) model.

SCADA and Smart Grid Protocols: Mod bus, International Electro Technical Commission (IEC 60870), Distributed Network Protocol 3 (DNP3), Inter-Control Center Protocol (ICCP), Ethernet, IEC 61850, IEEE C37.118 Synchrophasor standard, Zig bee & its devices, Wi-Fi, Guided (wired)& Unguided (wireless)media.

UNIT-VI:

SCADA Case Studies & Implementation: Security and challenges for SCADA and smart grid communication, SCADA Case Studies, Laboratory model- Overview of SCADA Hardware Laboratory, Laboratory software relational diagram, Programmable Logic Controller (PLC)-PLC used as RTU, Basic rules of Ladder Logic, Different instructions.

TEXT BOOKS:

1. Power System SCADA and Smart Grids, Mini S. Thomas, John D. McDonald, CRC Press, Taylor and Francis, 2015
2. SCADA- Supervisory Control and Data Acquisition, Stuart A. Boyer, Instrumentation Systems and Automation Society

REFERENCES:

1. Practical SCADA for Industry, David Bailey, Edwin Wright, Newnes, 2003
2. Designing SCADA Application Software: A Practical Approach, Stuart G. McCrady

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M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL04) DIGITAL SIGNAL PROCESSING FOR POWER AND CONTROL

COURSE PRE-REQUISITES: Network Analysis, Advanced Calculus, Linear and Digital IC applications

COURSE OBJECTIVES:
- To understand characteristics of discrete time signals and systems
- To analyze and process signals using various transform techniques
- To understand various factors involved in design of digital filters
- To understand the applications of DSP to Active power filtering

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Analyze and process signals in the discrete domain
CO-2: Design filters to suit specific requirements for specific applications
CO-3: Perform statistical analysis and inferences on various types of signals
CO-4: Apply digital filters to active power filters

UNIT-I:
Introduction: Classification of continuous time Signals & Systems. Linear shift invariant systems, stability and causality, Sampling of Continuous signals- Sampling process-Sampling theorem. Classification of discrete time signals and sequences

UNIT-II:
Fourier Analysis: Introduction to Discrete Fourier series, Discrete Fourier Transform: Properties of Discrete Fourier Transform, linear convolution and circular convolution of sequences using DFT, Computation of DFT, Relation between DFT and Z-Transform.

UNIT-III:
Z-Transform: Introduction to Z-transform, Properties of Z- Transform, Inverse Z- Transform, Application of Z- Transforms for Linear constant coefficient difference equations, Realization of Digital filters, system function – stability criterion.

UNIT-IV:
IIR Filters: Analog filter approximations- Design of Butterworth filter-Design of IIR digital filter from analog filter using- impulse invariant and bilinear transformation techniques, realization of IIR filters-direct, canonic, cascade, and parallel forms. DFT Filter bank-Sliding- Sliding Goertzel - Moving DFT algorithms

UNIT-V:
FIR Filters: Characteristics of FIR Digital Filters, Frequency response, Design of FIR filters using – Rectangular, Hamming, Bartlett- windows, frequency sampling technique, comparison of FIR and IIR filters

UNIT-VI:
Active Power Filters Control Algorithms: Introduction to Active power Filter (APF) - Control circuit of Shunt Active Power Filter, APF control using first harmonic detection-Various control circuits using 4th order Butterworth Filter-5th order Butter worth- Sliding- Sliding Goertzel - Moving DFT Algorithms, P-Q theory control algorithm for shunt APF.

TEXT BOOKS:
1. Digital Signal Processing: Principles, Algorithms and Applications, John G. Proakis, D. G. Manolakis, 3rd Edition, PHI, 2007

2. Discrete Time Signal Processing, A. V. Oppenheim and R. W. Schaffer, PHI, 2009
3. Digital Signal Processing in Power Electronics Control Circuits, Krzysztof Sozan´ski, Springer, 2013

REFERENCES:

1. Digital Signal Processing - Fundamentals and Applications, Li Tan, Elsevier, 2008
2. Fundamentals of Digital Signal Processing using MATLAB, Robert J. Schilling, Sandra L. Harris, Thomson, 2007
3. Digital Signal Processing, S. Salivahanan, A. Vallavaraj, C. Gnanapriya, TMH, 2009
4. Discrete Systems and Digital Signal Processing with MATLAB, Taan S. El Ali, CRC Press,2009
5. Digital Signal Processor; Architecture, Programming & Application, P. Venkata Ramani, M. Bhaskar, Tata McGraw Hill, 2001

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M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PL01) POWER ELECTRONIC CONVERTERS LABORATORY

COURSE PRE-REQUISITES: Power Electronics

COURSE OBJECTIVES:

- To apply the concepts of power electronic converters for efficient conversion/control of power from source to load
- To design the power converter with suitable switches meeting a specific load requirement
- To apply knowledge of Power Electronic Convertor for DC integration to AC

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the operating principles of various power electronic converters
CO-2: Use power electronic simulation packages& hardware to develop the power Converters
CO-3: Analyze and choose the appropriate converters for various applications

LIST OF EXPERIMENTS:

1. Simulation of single-phase half wave controlled rectified with (i) resistive load (ii) inductive load
2. Simulation of single phase (i) fully controlled (ii) half controlled bridge rectifiers with resistive and inductive loads
3. Simulation of three-phase fully / half controlled bridge rectifier with resistive and inductive loads
4. Simulation of the operation of IGBT /MOSFET Based DC-DC Converters. (Buck Converter & Boost Converter)
5. Simulation of single-phase AC voltage regulator with resistive and inductive loads
6. Simulation of single phase and Three phase cyclo-converter
7. Simulation of MOSFET / IGBT based Single phase and Three-phase bridge inverters
8. Experimental study of single phase fully controlled bridge rectifiers with resistiveand inductive loads
9. To study triggering of (i) IGBT (ii) MOSFET
10. Experimental study of MOSFET Based chopper circuit
11. Experimental study of AC Voltage regulator with R and RL loads
12. Experimental study of three phase PWM Inverter

Note: Conduct the experiments from 1 to 7 using suitable simulation tool

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M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PL02) MODELING AND SIMULATION OF ELECTRICAL DRIVES LABORATORY

COURSE PRE-REQUISITES: MATLAB & Electrical Machines

COURSE OBJECTIVES:
- To find torque and assess the DC machines through State space models
- To identify different reference frame for applying transformations
- To study and control different drives using power electronic converters
- To apply different simulation packages for studying different machines

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Assess the performance of dc machines through state space models
CO-2: Study different braking operations of DC machines through simulations
CO-3: Obtain and study the machine equations to different reference frames
CO-4: Study the control of different drives by power electronic converters through simulations

LIST OF EXPERIMENTS:

1. Determination of Torque using the State space model of a DC machine through simulations
2. Simulation of DC motor model and to study its Steady state and Dynamic behavior for a change in Load Torque
3. Study of Regenerative/Dynamic braking operation of DC Motor through simulation
4. Study of changes in mutual inductances of a rotating three phase induction machine
5. Verification of Linear transformations in a Three Induction Motor through simulation studies
6. Simulation of three phase induction motor model referred to different reference frames
7. Modeling and simulation ofThree Phase Induction machine and to study its Steady state and Dynamic behavior for a change in Load Torque
8. Study of Regenerative/Dynamic braking operation of Induction Motor through simulation
9. Performance analysis of Synchronous Motor using its mathematical modeling through simulation studies
10. Study of Thyristor Controlled DC Motor and Chopper Fed DC Motor through simulations
11. Study of V/F Control operation by VSI/CSI Feed Induction Motor Drive through simulations
12. Study of Permanent Magnet Synchronous Motor Drive fed by PWM Inverter using software

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M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	0	**4**	**2**

(A18PW4PL01) TECHNICAL SEMINAR

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify a research topic related to advanced/state-of-the-art technologies
CO-2: Collect the literature and comprehend/analyze critically the technological advancements
CO-3: Engage in effective oral communication through presentation of seminar
CO-4: Engage in effective written communication through report

COURSE OUTLINE:

- A student shall present a seminar on a technical topic during I semester of the M.Tech. programme.
- A student, under the supervision of a faculty member, shall collect literature on a technical topic of his / her choice, critically review the literature and submit it to the Seminar Review Committee (SRC) in a prescribed report form.
- The SRC shall consist of Head of the Department, faculty supervisor and a senior faculty member of the specialization / department.
- Student shall make an oral presentation before the SRC after clearing the plagiarism check.
- Prior to the submission of seminar report to the SRC, its soft copy shall be submitted to the PG Coordinator for PLAGIARISM check.
- The report shall be accepted for submission to the SRC only upon meeting the prescribed similarity index.

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M.Tech. I Semester (PE)	**L**	**T/P**	**C**
	2	**0**	**0**

(A18AU5CS01) RESEARCH METHODOLOGY AND IPR

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To introduce the characteristics of a good research problem
- To choose appropriate approaches of investigation of solutions for research problem
- To familiarize with basic Intellectual Property Rights
- To understand different Patent Rights

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand research problem formulation, analyze research related information and follow research ethics
CO-2: Realize the importance of ideas, concept, and creativity in the present-day context
CO-3: Recognize that when IPR would take such important place in growth of individuals and nation, it is needless to emphasize the need of information about IPR to be promoted among students in general and engineering in particular
CO-4: Appreciate IPR protection which leads to creation of new and better products, and in turn brings about, economic growth and social benefits

UNIT-I:
Introduction: 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:
Literature Survey: Effective literature studies approaches, analysis. Plagiarism, Research ethics.

UNIT-III:
Effective Technical Writing: How to write report, Paper. 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 grants of patents, Patenting under PCT.

UNIT-V:
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT-VI:
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.

TEXT BOOKS:
1. Research Methodology: An Introduction for Science & Engineering Students, Stuart Melville and Wayne Goddard
2. Research Methodology: An Introduction, Wayne Goddard and Stuart Melville

3. Resisting Intellectual Property, Halbert, Taylor & Francis Ltd ,2007

REFERENCES:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, 2nd Edition
2. Research Methodology: Methods and Techniques, C. R. Kothari and Gaurav Garg, New Age International Publishers
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, 2016
4. Intellectual Property Rights Under WTO, T. Ramappa, S. Chand, 2008

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PL04) ADVANCED POWER ELECTRONIC CONVERTERS

COURSE PRE-REQUISITES: Power Electronics, Power Electronic Converters

COURSE OBJECTIVES:
- To describe the operation of multi-level inverters with switching strategies for high power applications
- To comprehend the design of resonant converters and switched mode power supplies
- To understand the design procedure of magnetic and electrostatic components of converters

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Develop and analyze various converter topologies
CO-2: Analyse power supplies and dynamics of DC to DC converters
CO-3: Describe multilevel Inverter topologies for various applications of electrical engineering
CO-4: Design the components for switched mode power supplies

UNIT-I:
Resonant Pulse Inverters: Introduction, 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 inverters – for series loaded inverter – for parallel loaded inverter ; Voltage control of resonant inverters – class E resonant inverter – class E resonant rectifier – evaluation of values of C's and L's for class E inverter and Class E rectifier – numerical problems.

UNIT-II:
Resonant Converters: Zero current switching resonant converters – L type ZCS resonant converter – 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-III:
Multilevel Inverters: Multilevel concept – Classification of multilevel inverters – Diode clamped Multilevel inverter – principle of operation – main features – improved diode Clamped inverter – principle of operation – Flying capacitors multilevel inverter-principle of operation – main features – cascaded multilevel inverter – principle of operation – main features – Multilevel inverter applications – reactive power compensation – back to back intertie system – adjustable drives -Switching device currents – dc link capacitor voltage balancing – features of Multilevel inverters – comparisons of multilevel converters.

UNIT-IV:
Power Supply Applications: Isolated Switch mode dc power supplies – fly back Converter – forward converter – push-pull converter – half bridge converter – Full bridge converter – Resonant d c power supplies – bidirectional power supplies – Applications; power line disturbances – power conditioners – Uninterruptible Power Supplies.

UNIT-V:
DC-DC Converter Dynamics: Pulse Width Modulated Converter-Dynamic and Output Equations of the Converter; Averaged Model of the Converter- Steady State Solution-Small Signal Model of The Converter-Transfer Functions of the converter with examples; Generalized

State Space Model of the Converter –Generalized model –linear small signal model-dynamic functions of the converter-circuit averaged model quantities; some examples.

UNIT-VI:

Design of Power Converter Components: Design of magnetic components-design of transformer - Design of Inductor and current transformer - Selection of filter capacitors - Selection of ratings for devices - input filter design

TEXT BOOKS:

1. Power Electronics, Mohammed H. Rashid, Pearson Education, Third Edition – First Indian Reprint, 2004
2. Power Electronics, Ned Mohan, Tore M. Undeland and William P. Robbins, Second Edition, John Wiley & Sons
3. Course Material on Switched Mode Power Conversion, V. Ramanarayanan, First Edition, 2005

REFERENCES:

1. High Power Convertors and Drives, Bin Wu, IEEE Press – Wiley
2. Fundamentals of Power Electronics, Robert W. Erickson and Dragan Maksimovic, Springer
3. Pulse-width Modulated DC-DC Power Converters, Marian K. Kazimierczuk, John Wiley & Sons
4. Elements of Power Electronics, Philip T. Krein, Oxford University Press
5. Switching Power Supply Design, Abraham I. Pressman, McGraw Hill Publishing Company, 2001

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PL05) DIGITAL CONTROLLERS IN POWER ELECTRONIC APPLICATIONS

COURSE PRE-REQUISITES: Power Electronics

COURSE OBJECTIVES:
- To understand the architecture of Texas Instruments's MSP 430 processor
- To understand PWM generation using MSP 430 Processor
- To understand the architecture of Texas Instruments' LF 2xx processor
- To appreciate digital control of power electronic converters

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Describe the architecture and addressing modes of MSP 430, LF 2xx Processor
CO-2: Formulate programs for PWM generation using MSP 430 Processor
CO-3: Understand the digital control of power electronic converters

UNIT-I:
MSP430 Architecture: Introduction – Where does the MSP430 fit, The outside view, The inside view-Functional block diagram, Memory, Central Processing Unit, Memory Mapped Input and Output, Clock Generator, Exceptions: Interrupts and Resets, MSP430 family.

UNIT-II:
Addressing Modes & Instruction Set: Addressing Modes, Instruction set, Constant Generator and Emulated Instructions, Program Examples.

UNIT-III:
Interrupts and Timers: Clock System, Interrupts and Operating Modes- Clock System, Interrupts, What happens when an interrupted is requested, Interrupt Service Routines, Low Power Modes of Operation, Watchdog Timer, Basic Timer1, Real Time Clock, Timer-A: TimerBlock, Capture/Compare Channels, Interrupts from Timer-A.

UNIT-IV:
Analog I/O and PWM: Analog Input-Output and PWM - Comparator-A, ADC10, ADC12, Sigma-Delta ADC, Internal Operational Amplifiers, DAC, Edge Aligned PWM, Simple PWM, Design of PWM.LCD interfacing.

UNIT-V:
Introduction to DSP Processor: 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 , Code Composer Studio for C2xx DSP.

UNIT-VI:
Design of Controllers in Power Electronics: Typical applications: DSP Implementation of DC-DC buck-boost converter- DSP-based control of permanent magnet brushless DC machines- DSP-based Implementation of clarkes's and park's transformations- DSP-Based implementation of SPWM, SVPWM inverter pulse generation.

TEXT BOOKS:
1. MSP430 Microcontroller Basics, John H. Davies, Elsevier
2. DSP Based Electro Mechanical Motion Control, Hamid. A. Toliyat and Steven G. Campbell, CRC Press, 2004

REFERENCES:

1. Introduction to Embedded Systems Using Microcontrollers and the MSP430, Jiménez, Manuel, Palomera, Rogelio, Couvertier, Isidoro
2. 2833x Digital Signal Controller (DSC) Data Manual
   a. TMS320C28x CPU and Instruction Set Reference Guide - SPRU430
   b. TMS320x28xx, 28xxx Peripheral Reference Guide - SPRU566
   c. TMS320x2833x System Control and Interrupts Reference Guide - SPRUFB0
   d. TMS320x2833x Analog-to-Digital Converter (ADC) Reference Guide - SPRU812
   e. TMS320x28xx, 28xxx Enhanced Pulse Width Modulator (ePWM) & High-Resolution Pulse Width Modulator (HRPWM) Module Reference Guide - SPRU791 & - SPRU924

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PL06) ADVANCED CONTROL SYSTEMS

COURSE PRE-REQUISITES: Control Systems, Linear Control Systems, Digital Control Systems

COURSE OBJECTIVES:
- To cater the knowledge of basic and modern control system for the real time analysis and design of control systems
- To provide adequate knowledge of nonlinear systems
- To analyze the concept of stability of nonlinear systems and categorization
- To provide comprehensive knowledge of optimal control and modern control

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply the knowledge of basic and modern control system for the real time analysis and design of control systems
CO-2: Understand the concepts of state variables analysis
CO-3: Analyze the concept of stability of nonlinear systems and optimal control
CO-4: Analyze the concepts of optimal control and modern control

UNIT-I:
State Space Representation: State Space Representation of physical systems, Transfer function to state space representation, Phase variable form, Canonical Forms – Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form, State space to Transfer function-State diagram Representation.

UNIT-II:
State Transition Matrix, Controllability and Observability: Solution of State Equation, State Transition Matrix; Tests for controllability and observability for continuous time systems – Time varying case, time invariant case, Principle of Duality, Controllability and observability form and other canonical forms.

UNIT-III:
Nonlinear Systems & Phase-Plane Analysis: Introduction to nonlinear systems, Properties of nonlinear systems, Types of nonlinearities, Introduction to phase-plane analysis, Isocline Method, singular points- Stable, Unstable Nodes, Saddle Point.

UNIT-IV:
Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems. Direct method of Lypanov for the Linear and Nonlinear continuous time autonomous systems, Variable gradient method.

UNIT-V:
Modal Control & Calculus of Variations: Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced order observer.
Minimization of functional of single function, Constrained minimization - Minimum principle. Control variable inequality constraints. Control and state variable inequality constraints. Euler Lagrange Equation.

UNIT-VI:
Optimal Control: Formulation of optimal control problem, Minimum time, Minimum energy, minimum fuel problems. State regulator problem. Output regulator problem. Tracking problem, Continuous-Time Linear Regulators.

TEXT BOOKS:

1. Modern Control System Theory, M. Gopal, 2nd Edition, New Age International Publishers, 1996
2. Advanced Control Systems, A. Nagoor Khani, 2nd Edition, RBA Publications 2014

REFERENCES:

1. Modern Control Engineering, K. Ogata, 3rd Edition, Prentice Hall of India, 1998
2. Control Systems Engineering, I. J. Nagarath and M. Gopal, New Age International (P) Ltd.
3. Digital Control and State Variable Methods, M. Gopal, Tata McGraw-Hill Companies, 1997

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL05) ELECTRIC HYBRID VEHICLES

COURSE PRE-REQUISITES: Electrical Machines

COURSE OBJECTIVES:
- To study the different drive train configurations of electric vehicles
- To propose the various propulsion and energy storage systems for EHVs
- To know the sizing of propulsion motors and other systems involved in EH vehicles
- To carry out different design case studies of EHv and BEVs

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Assess the performance, societal and environmental impact of EHVs having known their past history
CO-2: Implement various drive train topologies and control strategies in Electric and Hybrid vehicles
CO-3: Recommend, Design/Size and Control different electric propulsion units and other components of EHVs and BEVs
CO-4: Appropriately select the energy storage system and strategize its management in EHVs

UNIT-I:
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. Conventional Vehicles: Basics of vehicle performance, Forces acting on a vehicle, vehicle power source (plant) characteristics, transmission characteristics: Manual, Hydro-dynamic and Continuously Variable Transmissions, mathematical model of vehicle.

UNIT-II:
Electric Drive-Trains: Advantages of Electric Vehicles (EVs), Basic concept of electric traction, introduction to various electric drive-train topologies (Configurations), Electric Vehicle Performance, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT-III:
Hybrid Electric Drive-Trains: Basic architecture and concept of hybrid traction, patterns of power flow, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

UNIT-IV:
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-V:
Sizing the Drive System: Matching the electric machine and the internal combustion engine (ICE), Sizing of the propulsion motor, Sizing of engine-generator, Sizing the power electronics based on Switch Technology - Switching Frequency and Ripple capacitor design , selecting the energy storage technology, Supporting subsystems

UNIT-VI:
Energy Storage and Energy Management Strategies: Energy Storage Requirements in Hybrid and Electric Vehicles, batteries, Fuel cell and super conductor and Flywheel based Energy storage 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 of design of a Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV).

TEXT BOOKS:

1. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press, 2010
2. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, CRC Press, 2009
3. Electric Vehicle Technology Explained, James Larminie, John Lowry, Wiley, 2003

REFERENCES:

1. Hybrid Vehicle Propulsion, Jefferson C. M., Barnard and R. H., WIT Press, 2002
2. Hybrid, Electric and Fuel Cell Vehicles, Jack Erjavec and Jeff Arias, Cengage Learning, 2012
3. Electric Vehicles - The Benefits and Barriers, Seref Soylu, InTech Publishers, 2011
4. Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles, Jack Erjavec and Jeff Arias, Cengage Learning Pvt. Ltd., 2007
5. Build Your Own Electric Vehicle, Seth Leitman, McGraw Hill, 2013

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL06) EMBEDDED SYSTEMS

COURSE PRE-REQUISITES: C Programming, Micro-processor and Micro-controllers

COURSE OBJECTIVES:
- To understand the basics of real time operating and embedded systems
- To understand the architecture and programming of AVR micro controller
- To interface AVR micro controller with different peripherals
- To understand the practical applications of AVR micro controller

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Program AVR micro controllers for different applications
CO-2: Apply the knowledge of AVR micro controller for real time applications
CO-3: Design an Embedded system using AVR micro controller
CO-4: Interface AVR micro controller with different Peripherals

UNIT-I:
Introduction to Embedded System: An Embedded system, Processor, hardware unit, software embedded into a system, Example of an embedded system, Real time and embedded OS. Structural UNIT-In a Processor, processor selection for embedded systems.

UNIT-II:
Introduction to AVR Micro-controller: AVR system –AVR family processors, Architecture, Addressing modes, Instruction overview, Branch, call, and Time delay loop, AVR I/O Port Programming.

UNIT-III:
Programming with AVR Micro-controller: Assembly level programming, Higher level language programming, AVR programming in C, Timer programming, Interrupt programming.

UNIT-IV:
Interfacing of I/O Device with AVR Micro-controller: AVR LCD and Keyboard interfacing, ADC, DAC, and different sensor interfacing, relay, Opt isolated interface.

UNIT-V:
Motor Control with AVR Micro-controller: Stepper motor interfacing, Servo motor interfacing, PWM Programming, RTC, PC interface, Data Acquisition system.

UNIT-VI:
Real-time Embedded systems using AVR Micro-controller:
Case Studies: DC Motor control, Induction motor control (VSI and CSI fed), UPS Applications, Special machine control(PMBLDC).

TEXT BOOKS:
1. AVR Micro Controller and Embedded Systems: Using Assembly and C, M. A. Mazidi, S. Naimi
2. Embedded System Architecture: Programming and Design, Rajkamal, TMH Edition, 2007
3. Embedded Micro Computer System: Real-Time Interfacing, J. W. Valvano, Cengage-Engineering, First Edition, 2000

REFERENCES:
1. Real-time Systems, Jane W. S. Liu, Prentice Hall, 2000
2. An Embedded Software Primer, David E. Simon, Pearson Education, 1999

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS05) POWER QUALITY

COURSE PRE-REQUISITES: Analysis of Power Electronic Converters, Power Systems

COURSE OBJECTIVES:
- To get the knowledge on Power quality problems and standards
- To get awareness on devices introducing harmonics and mitigation methods
- To describe modeling of components in industrial power systems
- To get the concept of grounding & wiring problems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Acquire knowledge on power quality issues and standards
CO-2: Model and analyze the harmonic introducing devices and effects on system equipment and loads
CO-3: Analyze the control techniques to APFC based on static VAR compensators
CO-4: Analyze the series and shunt active power filtering techniques for harmonics and effects of grounding

UNIT- I:
Introduction to Power Quality: Overview of power quality phenomena-classification of power quality Issues- Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients and Interruptions. Power quality measures and Standards Power acceptability curves- IEEE guidelines, EMC standards and recommended practices.

UNIT II:
Voltage Sags and Pq In Industrial Power Systems: Voltage Sag – Characterization - Single Phase: Voltage sag – definition, causes of voltage sag, voltage sag magnitude, monitoring. Voltage sag calculation in non-radial systems, meshed systems- voltage sag duration. Three Phase: Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags. Modelling of networks and components under non-sinusoidal conditions-transmission and distribution systems- shunt capacitors- transformers-electric machines -loads that cause power quality problems.

UNIT III:
Interruptions and PQ Issues In Drives: Short interruptions – definition, origin of short interruptions and monitoring of short interruptions. Long Interruptions– Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions.
Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of PQ problems in AC Drives, adjustable speed DC drives.

UNIT-IV:
Harmonics: Harmonics, Harmonics indices, Inter harmonics, Notching – Voltage vs Current distortion – Harmonics vs Transients – Sources and effects of harmonic distortion – System response characteristics – total harmonic distortion- RMS value of a harmonic waveform, Principles of controlling harmonics – Standards and limitation – important harmonic introducing devices-SMPS-Three phase power converters-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.
UNIT-V:
Harmonic Mitigation and Grounding: Passive compensation and passive filters, active filtering – shunt, series and hybrid Filters and their control and d-q domain control of three phase shunt active filters. Uninterruptible power supplies- series active power filtering techniques for

harmonic cancellation and isolation. Grounding and wiring-introduction-NEC grounding requirements-reasons for grounding- typical grounding and wiring problems and solutions.

UNIT VI:

PQ Improvement and Custom Power Devices: Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. Voltage source converter, series voltage controller: Dynamic Voltage Restorer, shunt controller: DSTATCOM, combined shunt and series controller: UPQC.

TEXT BOOKS:

1. Understanding Power Quality Problems, Math H. J. Bollen, IEEE Press
2. Electrical Power Systems Quality, Roger C. Durgan, Mark F. McGranaghan and H. Wayne Beaty, 2nd Edition, Tata McGraw-Hill, 2008
3. Power Quality – Problems and Mitigation Techniques, Bhim Singh, Ambarish Chandra, Kamal Al-Haddad, Wiley Publication

REFERENCES:

1. Power Quality in Electrical Systems, Alexander Kusko and Mark M. Thompson, McGraw Hill Publication
2. Power Quality, Sankaran C., CRC Press, 2002
3. Distribution Reliability and Power Quality, T. A. Sort, Taylor & Francis
4. Electric Power Quality, G. T. Heydt, 2nd Edition, Stars in a Circle Publication, 1994
5. Power Quality Enhancement Using Custom Power Devices, A. Ghosh, G. Ledwich, Kluwer Academic, 2002

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL07) ELECTRO MAGNETIC INTERFERENCE AND COMPATIBILITY

COURSE PRE-REQUISITES: 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 should be able to
CO-1: Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems.
CO-2: Assess the insertion loss and design EMI filters to reduce the loss
CO-3: 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 breeds, feed through filters, bifilar wound choke filter, EMI filters at source, EMI filter at output.

UNIT-IV:
EMI Filter Design for Insertion Loss: Worst case insertion loss, design method for mismatched impedance condition and EMI filters with common mode choke-coils, IEC standards on EMI.

UNIT-V:
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-VI:
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.

TEXT BOOKS:
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. Handbook on Switch-Mode Power Supplies, Keith H. Billings, McGraw-Hill Publisher, 1989

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS06) FLEXIBLE ACTRANSMISSION SYSTEMS

COURSE PRE-REQUISITES: Power Electronics, Power Systems, Reactive Power Control

COURSE OBJECTIVES:
- To learn the active and reactive power flow control in power system
- To understand the need for static compensators
- To develop the different control strategies used for compensation
- To understand the need of custom power devices and applications

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Acquire knowledge of reactive power control in power systems
CO-2: Compensation Schemes at Transmission and Distribution level in Power Systems
CO-3: Learn various Static VAR controllers working and applications
CO-4: Understand the modeling and control of Static VAR controllers
CO-5: Understand the working and applications of custom power devices

UNIT-I:
Introduction to FACTS Controllers: Transmission inter connections, power and Reactive power flow control in AC transmission system, loading capability limits, constraints of maximum transmission loading and dynamic stability considerations. Uncompensated and compensated lines, relative importance of controllable parameters. Classification of FACTS controller based on type of connection, relative importance of different types of controllers and benefits of FACTS technology.

UNIT-II:
Objectives of Static Compensation: Objectives of Shunt compensation – midpoint voltage regulation, voltage instability precaution – importance of Transient Stability – Power Oscillation damping. Objectives of series compensation – Improvement of Transient Stability and Voltage Stability – Power Oscillation Damping – Methods of controllable var generation – variable impedance type static var generations, switching converter type var generations and hybrid var generations.

UNIT-III:
SVC and STATCOM: Static versus passive VAR compensator, Static shunt compensators: SVC and STATCOM - Operation and control of TCR, TSC, FC-TCR and TSC-TCR type SVCs and STATCOM - Compensator control. Comparison between SVC and STATCOM.

UNIT-IV:
Static Series Compensators: Variable impendence type FACTS controllers - GCSC, TSSC and TCSC and their control schemes. Switching converter type FACTS controllers: SSSC and its control. Static voltage and phase angle regulators – TCVR and TCPAR Operation and Control –Applications.

UNIT-V:
UPFC and IPFC: Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC.
Basic Principle of P and Q control- Independent real and reactive power flow control- Applications. Introduction to interline power flow controller: basic operation and characteristics.

UNIT-VI:

Modelling and Control of FACTS Controllers: Modeling and analysis of FACTS Controllers – Internal control schemes of STATCOM-indirect output voltage control and direct output voltage control. Transfer function and dynamic response of STATCOM. Implementation of regulation slope for Static Var Generators (SVG's) – Control circuits implementations for Transient stability, power oscillation damping and VAR reserve control for SVG. Approximate models of SVC and STATCOM for power system study.

TEXT BOOKS:

1. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, N. G. Hingorani, L. Gyugyi, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001
2. FACTS Controllers in Power Transmission and Distribution, K. R. Padiyar, New Age International Publishers, 2007

REFERENCES:

1. Flexible AC Transmission Systems-Modeling and Control, X. P. Zhang, C. Rehtanz, B. Pal, Springer Verlag, Berlin, 2006
2. Static Reactive Power Compensation, T. J. E. Miller, John Wiley and Sons, New York, 1982
3. FACTS Controllers & Applications, K. S. Suresh Kumar, S. Ashok, E-book Edition, Nalanda Digital Library, NIT Calicut, 2003

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS08) SMART GRIDS

COURSE PRE-REQUISITES: Electrical Distribution Systems, 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 & it's solution through smart grid

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Appreciate the difference between smart grid & conventional grid
CO-2: Apply smart metering concepts to industrial and commercial installations
CO-3: Formulate solutions in the areas of smart substations, distributed generation and wide Area measurements
CO-4: Come up with smart grid solutions using modern communication technologies

UNIT-I:
Introduction to Smart Grid: Introduction, Evolution of Electric Grid, Smart Grid Concept, Need of Smart Grid, Features-Characteristics- Key Drivers of the Smart Grid, Functions of Smart Grid, Opportunities of Smart Grid, Challenges in Implementation of Smart Grid, Technical Challenges for Development of Smart Grid in India, Smart Grid Benefits, Scope of Smart Grid, Difference between Conventional and Smart Grid, Concept of Resilient, Resilience of Smart Grid Functions, Self-Healing Grid, Smart Grid Implementation, Present Development and International policies in Smart Grid ,

UNIT-II:
Smart Grid Technologies: Introduction, Smart Substation-Technology-Drivers, Classifications of Substations, Elements of Substation, Objectives of Smart Substation, Functions of Smart Substation, Sub-Station Automation: Key Drivers - Benefits – Functions. Feeder Automation, Applications of Feeder Automation, Energy Management System (EMS), System Design, Mechanism of Smart Energy System Outage Management, Plug in Hybrid Electric Vehicles (PHEV). Vehicle to grid.

UNIT-III:
Phasor Measurement Unit: Concept of Phasor Measurement Phasor Measurement Unit (PMU)-Features -Fundamentals, The Global Positioning Satellite (GPS) Systems, Synchrophasor Definition and Measurements, Applications of PMUs in Power Systems, Outlook of PMUs, Main strategy of PMU placement Based on Power Systems Intrinsic Characteristics, The Comparisons between SCADA system and PMUs System, Intelligent Electronic Devices-Functions-Advantages, , Wide Area Monitoring, Wide Area Monitoring Protection and Control (WAMPAC) System

UNIT-IV:
Micro-Grid: Concept of Micro grid, need & applications of Micro grid, Formation of micro grid, Inter connection, protection and 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, Smart Storages, Battery, SMES, Pumped hydro, Compressed air storage.

UNIT-V:

Power Quality in Smart Grid: Introduction, Power Quality, Electromagnetic Compatibility (EMC), Relation Between Voltage Quality and EMC, Field Experiences with Smart Grid Technology, Voltage Quality Planning Levels, Power Quality Standard, Power Quality Issues of Grid Connected Renewable Energy Sources, Causes Of Low Power Quality, Issues ,Challenges and Solutions of RES-Grid Integration, , Power Quality Conditioner (PQC)- Principle – Control Circuit- Series Compensation Control Circuit, Power Quality Monitoring- Considerations, Permanent Power Quality Monitoring Equipment.

UNIT-VI:

Smart Meters and Advanced Metering: Introduction, Smart Meter, The Smart Grid and Smart Meter Systems, Smart Meter-Technologies-Benefits, Advanced Metering Infrastructure (AMI)-Technologies-Protocols- Benefits-Standards-Initiatives- Developments

Local Area Network (LAN)-Objectives-Technologies, Home Area Network (HAN)-Components-Technologies, Wide Area Network (WAN), Types of Connection in WAN, WAN Devices, Broadband Over Power Lines (BPL)-Features-Working, IP based Protocol, Need of Internet Protocol, Goals of IP, IP Based Networks, Cloud Computing, Cyber Security for Smart Grid, Need of Secure Smart Grid, Objectives and Requirements of Cyber Security, Network Security Threats in the Smart Grid

TEXT BOOKS:

1. Smart Grid Fundamentals of Design and Analysis, James Momoh, First Edition
2. Introduction to the Smart Grid Concepts, Technologies and Evolution, S. K. Salman, IET Library, 2017

REFERENCES:

1. Smart Grid Technology, Harsh Tanwar, Bhavishya Mittal, Bhawana Chouhan, Genius Publications
2. Smart-Grid-Handbook: For Regulators & Policy Makers, Indian Smart Grid Forum, 2017

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PL03) ADVANCED POWER ELECTRONIC CONVERTERS SIMULATION LABORATORY

COURSE PRE-REQUISITES: Power Electronic Converters

COURSE OBJECTIVES:
- To implement multilevel converter topologies
- To perform closed loop control of DC-DC converters
- To implement various Isolated and Non-Isolated power electronic converters
- To perform soft switching of power electronic converters
- To compare behaviour of PV systems at different conditions

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Demonstrate multi-level inverter/converter topologies in simulation environment
CO-2: Design the Closed loop controller for DC-DC converters in simulation environment
CO-3: Implement various resonant power electronic converters in simulation environment
CO-4: Identify maximum power point of PV system in simulation environment

LIST OF EXPERIMENTS:

1. Single phase diode clamped Multilevel inverter
2. Single phase flying capacitor Multilevel inverter
3. Single phase cascaded Multilevel inverter
4. Push pull converter
5. Fly back converter
6. Forward converter
7. Series resonant converter
8. Parallel resonant converter
9. Zero voltage switching resonant converters
10. Zero current switching resonant converters
11. Closed loop implementation of buck and boost dc-dc converters. (a) Design of various elements such as inductor, capacitor for continuous current operation. (b) Small signal state space modeling. (c) Dynamic response with change in load
12. Characteristics of solar PV Systems, Maximum Power Point Tracking Charge Controllers

Note: Conduct the above experiments using suitable simulation tool

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PL04) POWER ELECTRONIC CONTROL AND APPLICATIONS LABORATORY

COURSE PRE-REQUISITES: Power Electronics

COURSE OBJECTIVES:
- To perform digital control of DC and AC machines
- To implement PWM generation using digital controllers
- To identify the maximum power point of PV systems at different conditions
- To perform digital control of power electronic converters

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Implement closed loop control of DC machines
CO-2: Execute digital control of AC machines
CO-3: Demonstrate Maximum power point tracking of PV systems at different conditions
CO-4: Demonstrate PWM generation using digital controllers for power electronic converters

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. Thyristorised drive for 1Hp DC motor with closed loop control
4. 3-Phase input IGBT, 4 quadrant chopper drive for DC motor with closed Loop control equipment
5. Characteristics of Solar PV Panel
6. Maximum power point tracker PV systems using a DC DC converter
7. IGBT based 4 quadrant chopper drive for PM DC motor with speed measurement and closed look control
8. PWM signal generation using digital controller
9. Three phase IM speed control
10. Brushless DC Motor Control
11. A DC-DC boost converter control using digital controller
12. A single-phase inverter control using digital controller

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	0	**4**	**2**

(A18PW4PL02) MINI-PROJECT

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the formulated industry / technical / societal problems
CO-2: Analyze and / or develop models for providing solution to industry / technical / societal problems
CO-3: Interpret and arrive at conclusions from the project carried out
CO-4: Demonstrate effective communication skills through oral presentation
CO-5: Engage in effective written communication through project report

COURSE OUTLINE:

- A student shall undergo a mini-project during II semester of the M.Tech. programme.
- A student, under the supervision of a faculty member, shall collect literature on an allotted project topic of his / her choice, critically review the literature, carry out the mini-project, submit it to the department in a prescribed report form.
- Evaluation of the mini-project shall be done by a Project Review Committee (PRC) consisting of the Head of the Department, faculty supervisor and a senior faculty member of the specialization / department.
- Prior to the submission of mini-project report to the PRC, its soft copy shall be submitted to the PG Coordinator for PLAGIARISM check.
- The mini-project report shall be accepted for submission to the PRC only upon meeting the prescribed similarity index.

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M.Tech. II Semester (PE)	**L**	**T/P**	**C**
	2	**0**	**0**

(A18AU5EN01) ENGLISH FOR ACADEMIC AND RESEARCH WRITING

COURSE OBJECTIVES:

- To understand the usage of appropriate vocabulary (Formal, Informal, Gender Insensitive etc.)
- To understand the features and processes of academic writing
- To identify the resources
- To understand standard documentation styles

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

CO-1: Use appropriate vocabulary (Formal, Informal, Slang, Gender Insensitive etc.)

CO-2: Employ processes of academic writing

CO-3: Identify the resources

CO-4: Understand standard documentation styles

UNIT- I:

Introduction to Research:

i. Identifying the topic
ii. Identifying Sources; Finding Sources
iii. Defining the broad area; Defining the specific area; Difference between a broad area and specific area
iv. Choosing a topic
v. Mechanics of Writing – Language, Tone, Style, Ethics

UNIT-II:

Referencing & Library Skills:

i. Literature Survey
ii. Writing Objectives
iii. Hypothesis
iv. Methodology
v. Prospects for Future Research

UNIT-III:

Academic Writing Skills:

i. Paraphrasing
ii. Summarizing
iii. Quoting
iv. Rewriting
v. Expansion

UNIT-IV:

Kinds of Academic Writing:

i. Essays
ii. Reports
iii. Reviews
iv. SOPs
v. Abstracts
vi. Proposals

UNIT-V:

Research Process:

i. Selection of Topic
ii. Formulation of Hypothesis
iii. Collection of Data
iv. Analysis of Data
v. Interpretation of Data
vi. Presentation of Data

UNIT-VI:

i. Title
ii. Abstract
iii. Introduction
iv. Literature Survey
v. Methodology
vi. Discussion
vii. Findings/Results
viii. Conclusion
ix. Documenting Sources

TEXT BOOKS:

1. Writing for Science, Goldbort R., Yale University Press (available on Google Books), 2006
2. Handbook of Writing for the Mathematical Sciences, Highman N., SIAM. Highman's Book, 1998

REFERENCES:

1. How to Write and Publish a Scientific Paper, Day R., Cambridge University Press, 2006
2. English for Writing Research Papers, Adrian Wall Work, Springer New York Dordrecht Heidelberg London, 2011
3. MLA Handbook for Research

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1LI14) IoT TECHNOLOGIES

COURSE OBJECTIVES:

- To understand the new paradigm of objects interacting with people, information systems and with other objects
- To introduce various IoT protocols
- To understand the issues in developing specific real time system on various IoT platforms

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

CO-1: Identify and describe different kinds of internet-connected products developed on IoT platforms

CO-2: Appreciate the challenges involved in establishing user-interaction with connected-objects

CO-3: Develop prototype IoT applications using Arduino

UNIT-I:

Introduction to Internet of Things (IoT): Physical Design, Logical Design, IoT Enabling Technologies, Domain Specific IoT- Home automation, Cities, Environment, Energy and Industry.

UNIT-II:

IoT Protocols-Functionality based IoT Protocol Organization: Connectivity (6LoWPAN, RPL), Identification (EPC, uCode, IPv6, URIs), Communication(WiFi, Bluetooth, LPWAN); Discovery (Physical Web, mDNS, DNS-SD); Data Protocols (MQTT, CoAP, AMQP, Websocket, Node); Device Management (TR-069, OMA-DM); Semantic (JSON-LD, Web Thing Model); Multi-layer Frameworks (Alljoyn, IoTivity, Weave, Homekit)

UNIT-III:

Communication Protocols: IEEE 182.15.4, Zigbee, 6LoWPAN, Wireless HART, Z-wave, ISA100, Bluetooth, NFC, RFID.

UNIT-IV:

Sensor Networks: Wireless Sensor Networks, Basic components of sensor nodes, sensor web, Node behavior in WSN, Detection and connectivity re-establishment. Application of Sensor networks in Mines, Healthcare and Agriculture.

UNIT-V:

Introduction to Arduino Programming: Features, Arduino IDE overview, Sketch, Data types, Function Libraries, Operators, Control statements, Loops, Arrays, Strings, Math Library, Random Numbers, Interrupts. Integration of sensors and actuators with Arduino, Examples.

UNIT-VI:

Software Defined Networks- Overview of current network, limitations. SDN architecture, Basic Concepts, Components/Attributes, Challenges present in SDN, Rule Placement with Open Flow. API's in SDN, Integrating SDN with IoT.

TEXT BOOKS:

1. Internet of Things: Hands-on Approach, A. Bahaga, V. Madisetti, VPT Publisher, 2014
2. Internet of Things, Enabling Technologies, Platforms and Use Cases, Pethu Raj, Anupama C. Raman, CRC Press, Taylor and Francis Group

REFERENCES:

1. Designing the Internet of Things, A. McEwen, H. Cassimally, Wiley, 2013
2. The Internet of Things in the Cloud: A Middleware Perspective, Honbo Zhou, CRC Press, 2012
3. Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Florian Michahelles (Eds.), Springer, 2011
4. The Internet of Things–Key Applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi, Wiley, 2012
5. The Internet of Things: Applications to the Smart Grid and Building Automation, Olivier Hersent, Omar Elloumi and David Boswarthick, Wiley, 2012

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL08) ENERGY STORAGE TECHNOLOGIES

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To Understand nonelectrical storage technologies available
- To Understand Electro chemical secondary batteries characteristics
- To Understand efficiency improvement techniques in storage systems
- To Appreciate various applications of storage systems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Learn Mechanical, Magnetic and Electrostatic storage systems
CO-2: Enumerate merits and demerits of various secondary batteries
CO-3: Study characteristics of Lead acid batteries
CO-4: Improve the efficiency of storage systems
CO-5: Apply knowledge on storage technologies in EV and Power systems

UNIT-I:
Non-electrical Storage Systems: Flywheel, Energy Relations, Flywheel System Components, Benefits of Flywheel over Battery, Superconducting Magnet Energy Storage, Compressed Air Energy storage, Overview Thermal Energy Storage.
Capacitor bank storage, Comparison of storage Technologies.

UNIT-II:
Electro Chemical Storage: History, General battery concepts- Types of Batteries- Primary, seconday- Battery Vs Cell, Nickel-Cadmium -Nickel-Metal Hydride, Nickel hydrogen, Lithium-Ion- Lithium-Polymer, Fuel cells.

UNIT –III:
Specifications and Characteristics: Domains of applications of Energy storage- Starter-Traction-stationary-mobile or nomadic, Review of storage requirements, Definitions of characteristics, Terminology of States, Battery Design, Battery Charging, Charge Regulators, Battery Management, General Equivalent Electrical Circuit, Performance Characteristics.

UNIT-IV:
Sealed-Lead Cells and Batteries: Discharge Characteristics, Charging-Importance-characteristics-charge acceptance-over charging, Types of charging- Constant voltage charging- Constant current charging- Taper charging-special charging- Charging power sources, storage, Testing, safety.

UNIT –V:
Electrical Energy Storage System Efficiency Improvement: Hybrid Electrical Energy storage– Design Considerations- Architecture- Charge management- components Modeling of Power Conversion, Reconfigurable EES Array Architecture, Cycle Efficiency and Capacity Utilization of EES Bank , General Bank Reconfiguration Architecture, Dynamic Reconfiguration Algorithm, Cycle Efficiency and Capacity Utilization Improvement .

UNIT–VI:
Storage Applications: Electric Vehicle application- Regenerative Brake- PV module assistance-Storage bank reconfiguration- Overall cost analysis, Energy storage in Transient regimes of Power system-Problem formulation-modeling- steady tate stability analysis with storage-

storage Parameters to ensure transient stability, Battery rating calculations for standalone system.

TEXT BOOKS:

1. Energy Storage for Power Systems, A. Ter-Gazarian, Peter Peregrinus Ltd., 1994
2. Design and Management of Energy-Efficient Hybrid Electrical Energy Storage Systems, Younghyun Kim, Naehyuck Chang, Springer, 2014
3. Rechargeable Batteries Applications Handbook, EDN Series for Design Engineers, Elsevier

REFERENCES:

1. Lithium Batteries and Other Electrochemical Storage Systems, Christian Glaize, Sylvie Geniès
2. Wind and Solar Power Systems, Second Edition, Mukund R. Patel, CRC Press, 2006

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL09) HVDC TRANSMISSION

COURSE PRE-REQUISITES: Power Electronics, Power Systems

COURSE OBJECTIVES:
- To comprehend the conversion principles of HVDC transmission
- To analyse 3, 6, 12 pulse converters, rectifier and inverter operations of HVDC converters
- To identify the different types of Harmonics and reduction by using filters
- To comprehend Interaction between HVAC and DC systems in various aspects
- To appreciate the reliable MTDC systems and protection of HVDC system

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand HVDC technology
CO-2: Apply the knowledge of modeling and analysis of HVDC system for inter-area power flow regulation
CO-3: Appreciate the reliable Multi terminal HVDC system
CO-4: Apply advanced protective schemes for HVDC systems against transient over voltages and over currents

UNIT-I:
HVDC Technology: Historical development in DC Transmission, Advantages & Disadvantages of DC Transmission over Ac Transmission, DC Transmission Systems: Mono-polar, bi-polar and homo-polar lines, back-to-back HVDC systems, Components of HDVC Transmission System, Main applications of DC Transmission.

UNIT-II:
HVDC Converters: Rectifier and Inverter operation Digital Simulation of converters, Control of HVDC converters and Systems, Individual phase control, Equidistant firing controls, higher level controls. Characteristics and non-characteristics harmonics filter design.

UNIT-III:
HVDC System Control: Constant current control, constant excitation angle control, VDCOL, constant ignition angle control, Individual phase control and equidistant pulse control; Valve blocking and by-passing; Starting, stopping and power flow reversal. Fault development and protection.

UNIT-IV:
MTDC Systems: Introduction-Potential applications of MTDC systems, Types of MTDC systems-Comparison, multi-terminal HVDC systems, control of MTDC systems. MTDC system - Case study - Interaction between AC-DC power systems over voltages on AC/DC side.

UNIT-V:
Power Flow Analysis in HVDC Systems: Introduction, Modeling of DC links, Modeling of HVDC systems - Basic model of the converter, converter equations, per unit system for DC quantities, DC Network equations, DC control equations, Representation for AC-DC power flow solution, representation for stability studies.

UNIT-VI:
Standards for Testing & Measurements in HVDC Systems: Introduction to relevant national and international standards-IEC, IEEE, CIGRE, safe clearances for HV, Study regulations for HV tests, Digital techniques in HV measurements.

TEXT BOOKS:
1. High Voltage Direct Transmission, J. Arrillaga, Peter Peregrinus Ltd. London, 1983
2. HVDC Power Transmission Systems, K. R. Padiyar, Wiley Eastern Ltd., 1990

REFERENCES:
1. Direct Current Transmission, E. W. Kimbark, Vol. I, Wiley Interscience, 1971
2. Power Transmission by Direct Current, Erich Uhlmann, B. S. Publications, 2004
3. EHVAC and HVDC Transmission Engg. Felix A. Farret, M. S. Rao, Practice, Theory, Practice and Solved Problems, Khanna Publishers, 1990

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1CN01) BUSINESS ANALYTICS

COURSE OBJECTIVES:

- To understand the role of business analytics within an organization and to analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making and to become familiar with processes needed to develop, report, and analyze business data
- To use decision-making tools/Operations research techniques and to manage business process using analytical and management tools
- To analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply knowledge of data analytics
CO-2: Think critically in making decisions based on data and deep analytics
CO-3: Use technical skills in predicative and prescriptive modeling to support business decision-making
CO-4: Translate data into clear, actionable insights

UNIT-I:
Business Analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics.
Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT-II:
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data Business Analytics Technology.

UNIT-III:
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.
Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

UNIT-IV:
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.
Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT-V:

Decision Analysis: Formulating Decision Problems, Decision Strategies without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

UNIT-VI:

Recent trends in Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TEXT BOOKS:

1. Business Analytics-Principles, Concepts, and Applications, Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press
2. Business Analytics, James Evans, Pearson Education
3. Business Analytics, Purba Halady Rao, PHI, 2013

REFERENCES:

1. Business Analytics for Managers: Taking Business Intelligence Beyond Reporting, Gert H. N. Laursen, Jesper Thorlund, 2nd Edition, Wiley Publications
2. Business Analytics: Data Analysis & Decision Making, S. Christian Albright, Wayne L. Winston 5th Edition, 2015
3. Business Intelligence Guidebook: From Data Integration to Analytics, Rick Sherman Elsevier, 2014

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1AM01) INDUSTRIAL SAFETY

COURSE PRE-REQUISITES: Elements of Mechanical, Civil, Electrical and Industrial Engineering

COURSE OBJECTIVES:

- To achieve an understanding of principles, various functions and activities of safety management
- To communicate effectively information on Health safety and environment facilitating collaboration with experts across various disciplines so as to create and execute safe methodology in complex engineering activities
- To anticipate, recognize, and evaluate hazardous conditions and practices affecting people, property and the environment, develop and evaluate appropriate strategies designed to mitigate risk
- To develop professional and ethical attitude with awareness of current legal issues by rendering expertise to wide range of industries

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

CO-1: Apply risk management principles to anticipate, identify, evaluate and control physical, chemical, biological and psychosocial hazards

CO-2: Communicate effectively on health and safety matters among the employees and with society at large

CO-3: Demonstrate the use of state-of-the-art occupational health and safety practices in controlling risks of complex engineering activities and understand their limitations

CO-4: Interpret and apply legislative / Legal requirements, industry standards, and best practices in accident prevention programmes in a variety of workplaces

UNIT-I:

Safety Management: Evaluation of modern safety concepts – Safety management functions – safety organization, safety department – safety committee, safety audit - performance measurements and motivation – employee participation in safety and productivity.

UNIT-II:

Operational Safety: Hot metal Operation – Boiler, pressure vessels – heat treatment shop - gas furnace operation-electroplating-hot bending pipes – Safety in welding and cutting. Cold-metal Operation- Safety in Machine shop-Cold bending and chamfering of pipes – metal cutting – shot blasting, grinding, painting – power press and other machines

UNIT-III:

Safety Measures: Layout design and material handling - Use of electricity – Management of toxic gases and chemicals – Industrial fires and prevention – Road safety– Safety of sewage disposal and cleaning – Control of environmental pollution – Managing emergencies in industrial hazards.

UNIT-IV:

Accident Prevention: Human side of safety – personal protective equipment – Causes and cost of accidents. Accident prevention programmes - Specific hazard control strategies - HAZOP – Training and development of employees – First Aid – Firefighting devices – Accident reporting investigation.

UNIT-V:

Safety, Health, Welfare & Laws: Safety and health standards – Industrial hygiene – occupational diseases prevention - Welfare facilities – History of legislations related to safety– pressure vessel act- Indian boiler act- The environmental protection act – Electricity act - Explosive act.

UNIT-VI:

Safe Handling and Storage: Material Handling, Compressed Gas Cylinders, Corrosive Substances, Hydrocarbons, Waste Drums and Containers

TEXT BOOKS:

1. Safety Management, John V. Grimaldi and Rollin H. Simonds, All India Travellers Bookseller, New Delhi, 1989.
2. Safety Management in Industry, Krishnan N. V., Jaico Publishing House, 1996.

REFERENCES:

1. Occupational Safety Manual, BHEL
2. Industrial Safety and The Law, P. M. C. Nair Publisher's, Trivandrum
3. Managing Emergencies in Industries, Loss Prevention of India Ltd., Proceedings, 1999
4. Safety Security and Risk Management, U. K. Singh & J. M. Dewan, A. P. H. Publishing Company, New Delhi, 1996
5. Industrial Safety Management: Hazard Identification and Risk Control, L. M. Deshmukh, McGraw-Hill Education (India) Private Limited, 2005

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1AM02) OPERATIONS RESEARCH

COURSE PRE-REQUISITES: Mathematics, Industrial Engineering

COURSE OBJECTIVES:
- To analyze linear programming models in practical and their practical use
- To apply the transportation, assignment and sequencing models and their solution methodology for solving problems
- To apply the theory of games, replacement, inventory and queuing models and their solution methodology for solving problems
- To evaluate the dynamic programming and simulation models

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply and solve the dynamic programming problems
CO-2: Apply the concept of non-linear programming
CO-3: Carry out sensitivity analysis
CO-4: Model the real world problem and simulate it

UNIT-I:
Introduction to Operations Research-Definitions of OR, Characteristics of OR, Scope of OR, Classification of Optimization Techniques, models in OR, General L.P Formulation, Graphical solution, Simplex Techniques.

UNIT-II:
Revised simplex method - duality theory - dual simplex method – sensitivity or post optimality analysis - parametric programming

UNIT-III:
Nonlinear programming problem - Kuhn-Tucker condition, min cost flow problem - max flow problem - CPM/PERT

UNIT-IV:
Scheduling and sequencing, Inventory models, deterministic inventory, models - Probabilistic inventory control models - Geometric Programming.

UNIT-V:
Waiting line Models, Single and Multi-channel Problems, Dynamic Programming, Game Theory, Simulation.

UNIT-VI:
Introduction to Genetic Algorithms, Operators, applications to engineering optimization, Problems.

TEXT BOOKS:
1. Operations Research, S. D. Sharma, Kedarnath Ramnath, Meerut, New Delhi
2. Engineering Optimization, S. S. Rao, New Age International Publications, 2014
3. Introduction to Genetic Algorithms, S. N. Sivanandam, Springer

REFERENCES:
1. Operations Research-An Introduction, H. A. Taha, PHI, 2008
2. Principles of Operations Research, H. M. Wagner, PHI, Delhi, 1982
3. Introduction to Optimization: Operations Research, J. C. Pant, Jain Brothers, Delhi, 2008

4. Operations Research, Hitler Liebermann McGraw-Hill Pub., 2009
5. Operations Research, Pannerselvam, Prentice Hall of India, 2010

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1AM03) COMPOSITE MATERIALS

COURSE PRE-REQUISITES: Maths, Physics, Chemistry, Engineering Mechanics, Mechanics of Solids

COURSE OBJECTIVES:
- To understand composite materials and their properties, relationship between them and manufacturing methods
- To understand the principles of material science applied to composite materials
- To study the equations to analyze problems by making good assumptions and learn systematic engineering methods to solve practical composite mechanics problems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply fundamental knowledge of mathematics to modeling and analysis of composite materials
CO-2: Understand the manufacturing methods of various composite materials
CO-3: Analyze the failure modes of composites

UNIT-I:
Introduction: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT-II:
Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements.
Mechanical Behavior of Composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT-III:
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications.
Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT-IV:
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications, Introduction to Machining of Composites.

UNIT-V:
Elastic Behavior of Laminate: Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

UNIT-VI:
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight

strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology, Vol. 13–Composites, R. W. Cahn – VCH, West Germany
2. Analysis and Performance of Fiber Composites, Third Edition, B. D. Agarwal, Wiley Publishers

REFERENCES:

1. Mechanics of Composite Materials, Second Edition. Robert M. Jones, Scripta Book Company
2. Materials Science and Engineering-An Introduction, W. D. Callister Jr., Adapted by R. Bala Subramaniam, John Wiley & Sons, NY, Indian Edition, 2007
3. Composite Materials, K. K. Chawla
4. Composite Materials Science and Applications, Deborah D. L. Chung
5. Composite Materials Design and Applications, Danial Gay, Suong V. Hoa and Stephen W. Tasi

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1PS01) WASTE TO ENERGY

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To create awareness in students of energy conservation
- To identify the use of different types of Bio waste energy resources
- To understand different types of bio waste energy conservations
- To detect different waste conversion into different forms of energy

COURSE OUTCOMES: After completion of the course, students should be able to
CO1: Find different types of energy from waste to produce electrical power
CO2: Estimate the use of bio waste to produce electrical energy
CO3: Understand different types of bio waste and its energy conversions
CO4: Analyze the bio waste utilization to avoid the environmental pollution

UNIT-I:
Introduction to Energy from Waste: Classification of waste as fuel, Agro based, Forest residue, Industrial waste, MSW (Municipal solid waste) – Conversion devices – Incinerators, Gasifiers, Digestors

UNIT-II:
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT-III:
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT-IV:
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT-V:
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion.

UNIT-VI:
Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

TEXT BOOKS:
1. Biogas Technology-Transfer and Diffusion, M. M. EL-Halwagi, Elsevier Applied Science Publisher, New York, 1984
2. Introduction to Biomass Energy Conversions, Sergio Capareda

REFERENCES:

1. Non-Conventional Energy, Desai Ashok V., Wiley Eastern Ltd., 1990
2. Biogas Technology - A Practical Handbook, Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw-Hill Publishing Co. Ltd., 1983
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996

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M.Tech. III Semester (PE)	**L**	**T/P**	**C**
	0	**16**	**8**

(A18PW4PL03) PROJECT PART-I

M.Tech. IV Semester (PE)	**L**	**T/P**	**C**
	0	**28**	**14**

(A18PW4PL04) PROJECT PART-II

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify and formulate the problem (Industry/technical/societal)
CO-2: Analyze, design and develop a solution to industry/technical/societal problems
CO-3: Implement and execute the solution
CO-4: Demonstrate effective communication skills through oral presentation
CO-5: Engage in effective written communication through project report

COURSE OUTLINE:

- M.Tech. project work shall be for a minimum duration of 40 weeks spread over two semesters i.e., Project Part-I in III semester and Project Part-II in IV semester.
- A student shall be permitted to register for the major project after satisfying the attendance requirement in all the courses, i.e., theory and practical courses.
- Project reviews namely Project Review I and Project Review II in III semester and Project Review III and Project Pre-submission Seminar in IV semester shall be conducted during the course of Project work.
- A Project Review Committee (PRC) consisting of the Head of the Department as Chairperson and PG Coordinator, Project Supervisor and one senior faculty member of the Department offering the M. Tech. programme as members shall evaluate the progress of project work.
- In Project Review I, a student, in consultation with his Project Supervisor, shall present the title, objective and plan of action of his/her project work to the PRC for approval within four weeks from the commencement of III semester.
- A student can initiate the project work only after obtaining the approval of the PRC.
- The work on the project shall be initiated at the beginning of the III semester.
- Project Review II shall be conducted and evaluated at the end of the III semester.
- Project Review III shall be conducted during IV semester to examine the overall progress of the project work.
- A project pre-submission seminar shall be conducted to decide whether or not the project is eligible for final submission.
- After approval from the PRC, a soft copy of the thesis shall be submitted for PLAGIARISM check to the Examination Branch.
- At the end of IV semester upon fulfilling the above conditions, project viva-voce shall be conducted.
- A student shall submit project progress in prescribed report format during each of the project reviews.