COURSE STRUTURE
AND
SYLLABUS

POWER ELECTRONICS AND ELECTRICAL DRIVES

R 21

For

M. TECH. TWO YEAR DEGREE COURSE

(Applicable for the batches admitted from 2021-2022)

VIGNANA BHARATHI INSTITUTE OF TECHNOLOGY

(An Autonomous Institution)

Aushapur (V), Ghatkesar (M), Hyderabad, Medchal Dist.-501301

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
PEED M. TECH - COURSE STRUCTURE (R21)

M.TECH - I YEAR I – SEMESTER **R21**

S No	Course Type	Course Code	Name of the Course	L	T	P	Credits
1	Professional Core -I	21PE6111	Machine Modeling and Analysis	3	0	0	3
2	Professional Core -II	21PE6112	Power Electronic Devices and Converters	3	0	0	3
3	Professional Elective -I	21PE6171 21PS6171 21EC6171	1. Renewable Energy Systems 2. Smart Grid Technologies 3. Advanced Digital Signal Processing	3	0	0	3
4	Professional Elective -II	21PE6172 21PE6173 21PE6174	1. FACTS and Custom Power Devices 2. Electric Traction System 3. Modern Control Theory	3	0	0	3
5	Professional Core Lab-I	21PE6151	Machine Modeling Simulation Lab	0	0	4	2
6	Professional Core Lab-II	21PE6152	Power Converters Lab	0	0	4	2
7	Mandatory Course	21MC6111	Research Methodology & IPR	2	0	0	2
8	Audit	21AU6101	Stress Management by Yoga	2	0	0	0
						Total	18

M.TECH - I YEAR II – SEMESTER **R21**

S No	Category	Course Code	Course Title	L	T	P	Credits
1	Professional Core -III	21PE6211	Advanced Power Electronics	3	0	0	3
2	Professional Core -IV	21PE6212	Electric Drives	3	0	0	3
3	Professional Elective -III	21PS6271 21PE6271 21PE6272	1.Reactive Power Compensation and Management 2. Power Electronics for Renewable Energy Systems 3. High-power converters & topologies	3	0	0	3
4	Professional Elective -IV	21PE6273 21EC6271 21PS6275	1.AI Techniques in Electrical Engineering 2. Advanced Micro Controller based Systems 3. Power Quality	3	0	0	3
5	Professional Core Lab-III	21PE6251	Advanced Power Electronics Simulation Lab	0	0	4	2
6	Professional Core Lab-IV	21PE6252	Electric Drives Lab	0	0	4	2
7	Project Work	21PE6291	Mini project with Seminar	0	0	4	2
8	Audit	21MC6201	English for Research Paper Writing	2	0	0	0
						Total	18

M.TECH - II YEAR I – SEMESTER R21

S.No.	Category	Course Code	Course Title	L	T	P/D	Credits
1	Professional Elective -V	21PE7171 21PE7172 21PE7173	Energy Storage Technologies Electric and Hybrid Vehicles Digital Control Systems	3	0	0	3
2	Open Elective			3	0	0	3
3	Project Work	21PE7181	Dissertation Work Review - I	0	0	12	6
						Total	12

M.TECH - I IYEAR I I– SEMESTER R21

S.No.	Category	Course Code	Course Title	L	T	P	Credits
1	Project Work	2PE7281	Dissertation Work Review — II	0	0	12	6
2	Project Work	21PE7282	Dissertation Viva-Voce	0	0	24	14
						Total	20

MACHINE MODELING AND ANALYSIS

M. Tech. (PEED) I Year I Semester	**L**	**T**	**P**	**C**
Course Code: 21PE6111	**3**	**0**	**0**	**3**

Prerequisite*:* Electrical Machines

Course Objectives:

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

Course Outcomes: At the end of the course, the student is able to:

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

UNIT-I

DC machine modelling: Magnetically coupled circuits, review of basic concepts, magnetizing inductance, electromechanical energy conversion. Basic Two-pole DC machine - primitive 2-axis machine –Voltage and Current relationship –Torque equation. Mathematical model of separately excited DC motor and DC Series motor in state variable form – Transfer function of the motor - Numerical problems. Mathematical model of D.C. shunt motor D.C. Compound motor in state variable form–Transfer function of the motor - Numerical Problems.

UNIT-II

Transformations: Linear transformation–Phase transformation (a, b, c to α, β, o) – Active transformation (α, β, 0 to d, q). Circuit model of a 3-phase Induction motor – Linear transformation – Phase Transformation–Transformation to a Reference frame – Two axis models for induction motor-d-q model based DOL starting of Induction Motors

UNIT-III

State space representation: Voltage and current equations in stator reference frame–equation in rotor reference frame– equations in asynchronously rotating frame–torque equation-Equations in state–space form.

UNIT-IV

Modelling of synchronous motor: Circuits model of a 3-phase synchronous motor–Two axis representation of synchronous motor. Voltage and current equations in state–space variable form–torque equation-dq model based short circuit fault analysis-emphasis on voltage, frequency and recovery time.

UNIT-V

Modelling of special machines: Modelling of Permanent Magnet Synchronous motor – Modelling of Brushless DC Motor.

TEXT BOOKS:

1. Generalized Machine theory - P. S. Bimbhra, Khanna Publishers.

2. Analysis of Electric Machinery and Drives Systems - Oleg Wasynczuk, Paul C. Krause, Scott D. Sudhoff, Steven D.Pekarek.

REFERENCES:

1. Thyristor control of Electric Drives - Vedam Subranmanyam.
2. NPTEL Course on “Modelling and Analysis of Electrical Machines”, https://www.youtube.com/playlist?list=PLbMVogVj5nJQBG9363J1uq5Fnq4m1yGXL

POWER ELECTRONIC DEVICES AND CONVERTERS

M.Tech. (PEED) I Year I Semester	**L**	**T**	**P**	**C**
Course Code: 21PE6112	**3**	**0**	**0**	**3**

Prerequisite: Power Electronics

Course Objectives:

- To understand the characteristics and principle of operation of modern power semiconductor devices.
- Tocomprehendtheconceptsofdifferentpowerconvertersandtheirapplications.
- To analyze and design switched mode regulators for various industrial applications.

Course Outcomes: At the end of the course, the student is able to:

- Choose appropriate device for a particular converter topology.
- Usepowerelectronicsimulationpackagesforanalyzingand designingpowerconverters.

UNIT-I

MODERN POWER SEMICONDUCTOR DEVICES: Review of SCR, Modern Power Semiconductor Devices- MOS Turn off thyristor (MTO)-Emitter turnoff thyristor, integrated gate commutated thyristor (IGCTs), MOS-Controlled thyristors (MCTs), and Insulated gate bipolar thyristors (IGBT), introduction to GaN & SiC devices.

UNIT-II

CONTROLLED RECTIFIERS

SINGLE-PHASE CONVERTERS: Single-phase converters – Half controlled and Fully controlled converters–Evaluation of input power factor and harmonic factor–continuous and Discontinuous load current – single-phase dual converters – power factor improvements techniques–Extinction angle control–symmetrical angle control, single-phase sinusoidal PWM, Applications &Problems.

THREE-PHASE CONVERTERS – Half controlled and fully controlled converters–Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current–three phase dual converters – power factor improvements techniques –Applications – Problems.

UNIT-III

D.C to D.C CONVERTERS:

Analysis of step-down and step-up dc to dc converters with Resistive and Resistive – inductive loads – Switched mode regulators – Analysis of Buck Regulators – Boost regulators – buck-boost regulators – Cuk regulators – Condition for continuous inductor current and capacitor voltage – comparison of regulators –advantages –Applications.

UNIT-IV

INVERTERS

Introduction, two-level inverters, Sinusoidal PWM technique - Modulation Scheme, Harmonic Content, over modulation, Third Harmonic Injection PWM, Introduction to Multilevel Inverters: Cascaded H-Bridge Multilevel Inverters, Diode-Clamped Multilevel Inverters, three-level neutral point clamped (NPC).

UNIT-V
IMPEDANCE-SOURCE INVERTERS

Introduction: Z-source inverter, Quasi Z-source inverters; both continuous and discontinuous types, modulation methods- simple boost control and maximum boost techniques.

TEXT BOOKS:

1. Mohammed H. Rashid “Power Electronics” Pearson Education Third Edition –First Indian reprint2004.
2. Ned Mohan, Tore M. Undeland and William P.Robbins, “Power Electronics” John Wiley & Sons – Second Edition.

REFERENCE BOOKS:

1. Milliman Shepherd and Lizang – “Power converters circuits”– Chapter14 (Matrix converter) PP-415-444,
2. Bin Wu, “high-power converters and AC drives”, IEEE press A John Wiley & Sons, Inc., Publication, 2006.
3. Yushan Liu, Baoming Ge, Frede Blaabjerg, Omar Ellabban, Poh Chiang Loh, impedance source power electronic converters 2016.
4. Advance power electronics and control – NPTEL Course https://www.youtube.com/playlist?list=PLLy_2iUCG87DzWK9cLYKxjH1LRACxdEKi
5. Hongpeng Liu, Yuhao Li, Jiabao Jiang, Zichao Zhou, Impedance Source Inverters, 2020.

RENEWABLE ENERGY SYSTEMS

M.Tech (PEED/EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PE6171	**3**	**0**	**0**	**3**

Course Objectives:

- To recognize the awareness of energy conservation in students
- To identify the use of renewable energy sources for electrical power generation
- To collect different energy storage methods
- To detect about environmental effects of energy conversion

Course Outcomes: Upon the completion of this course, the student will be able to

- find different renewable energy sources to produce electrical power
- estimate the use of conventional energy sources to produce electrical energy
- role-play the fact that the conventional energy resources are depleted
- arrange Store energy and to avoid the environmental pollution

UNIT-I

Solar PV systems: Photo voltaic power generation ,spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photo voltaic systems, test specifications for PV systems, applications of super conducting materials in electrical equipment systems.

UNIT-II

Wind energy systems: Wind Energy conversion: Power from wind, properties of air and wind, types of wind Turbines, operating characteristics.

UNIT-III

Ocean energy conversion:

Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation.

Wave energy conversion: properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Application of OTEC systems examples.

Principles of MHD power generation, ideal MHD generator performance, practical MHD generator, MHD technology.

UNIT-IV

Miscellaneous energy conversion systems:

coal gasification and liquefaction, biomass conversion, geothermal energy, thermo electric energy conversion, principles of EMF generation, description of fuel cells, Co-generation and energy storage, combined cycle co- generation, energy storage.

UNIT-V

Batteries & Fuel cells:

Types of fuel cells, H2-O2 Fuel cells, Application of fuel cells – Batteries, Description of batteries, Battery application for large power. Environmental effects of energy conversion systems, pollution from coal and preventive measures steam stations and pollution, pollution free energy systems.

TEXT BOOKS:

1. "Energy conversion systems" by Rakosh das Begamudre, New age International publishers, New Delhi -2000.
2. "Renewable Energy Resources" by John Twidell and Tony Weir, 2nd Edition, Fspon& Co.

REFERENCEBOOKS:

1. "Understanding Renewable Energy Systems", by Volker Quaschning, 2005, UK.
2. "Renewable Energy Systems Advanced energy conversion Technologies & Applications" by Faner Lin LuoHoner Ye, CRC press, Taylor & Francisgroup

SMART GRID TECHNOLOGIES

	L	T	P	C
M.Tech (PEED/EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PS6171	**3**	**0**	**0**	**3**

Prerequisite: *Power Systems*

Course Objectives: to prepare the students to

- Understand concept of smart grid and its advantages over conventional grid
- Know smart metering techniques
- Learn wide area measurement techniques
- Understand the problems associated with integration of distributed generation & its solution through smart grid.

Course Outcomes: Students will be able to

- Distinguish between conventional grid and smart grid
- Apply smart metering concepts to industrial and commercial installations
- Formulate solutions in the areas of smart substations, distributed generation and wide
- area measurements
- Develop smart grid solutions using modern communication technologies

UNIT-I INTRODUCTION TO SMART GRID & SMART METERS

Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid, Indian Smart Grid – Key Challenges for Smart. Introduction to Smart Meters, Real Time Prizing, Automatic Meter Reading (AMR), Outage Management System (OMS), Transmission Automation, Distribution Automation.

UNIT-II INFORMATION AND STORAGE SYSTEMS

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

UNIT-III MICROGRID

Concept of micro-grid, need & applications of micro-grid, formation of micro-grid, Issues of interconnection, protection & control of micro-grid, Plastic & Organic solar cells, thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources. Plug in Hybrid Electric Vehicles (PHEV), Vehicle to grid.

UNIT-IV POWER QUALITY

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT-V COMMUNICATION TECHNIQUES IN SMART GRID

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area, Network (NAN), Wide Area Network (WAN), Bluetooth, Zig Bee, GPS, Wi-Fi, Wi-Max based communication.

TEXT BOOKS:

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

REFERENCE BOOKS:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, “Smart Grid: Technology and Applications”, Wiley2012
2. Stuart Borlase, “Smart Grid: Infrastructure, Technology and solutions “ CRC Press
3. A.G.Phadke, “Synchronized Phasor Measurement and their Applications”, Springer.

ADVANCED DIGITAL SIGNAL PROCESSING

M.Tech (PEED) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21EC6171	**3**	**0**	**0**	**3**

Prerequisite: Digital Signal Processing

Course Objectives:
- To understand the difference between discrete-time and continuous-time signals
- To understand and apply Discrete Fourier Transforms(DFT)

Course Outcomes: After taking this course, student will be able to:
- Knowledge about the time domain and frequency domain representations as well analysis of discrete time signals and systems
- Study the design techniques for IIR and FIR filters and their realization structures.
- Acquire knowledge about the finite word length effects in implementation of digital filters.
- Knowledge about the various linear signal models and estimation of power spectrum of stationary Random signals
- Design of optimum FIR and IIR filters

UNIT-I

Introduction to digital signal processing: Fundamental concept of signals, classification of signals, classification of systems, Discrete time signals, Linear shift invariant systems-Stability and causality, Sampling of continuous time signals-Discrete time Fourier transform-Discrete Fourier series- Discrete Fourier transform, Z transform-Properties of different transforms

UNIT-II

Design of filters – 1: Linear convolution using DFT, Computation of DFT Design of IIR digital filters from analog Filters, Impulse invariance method, bilinear transformation method.

UNIT-III

Design of filters – 2: FIR filter design using window functions, Comparison of IIR and FIR digital filters, Basic IIR and FIR filter realization structures, Signal flow graph representations Quantization process and errors, Coefficient quantisation effects in IIR and FIR filters

UNIT-IV

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

UNIT-V

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

TEXT BOOKS:

1. Sanjit K Mitra, "Digital Signal Processing: A computer-based approach ",TataMc Grow-Hill Edition 1998.
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Mc Grow Hill international editions.-2000.

REFERENCE BOOKS:

1. S Salivahanan. A. Vallavaraj C. Gnanapriya, Digital Signal Processing – TMH – 2nd reprint2001.
2. Lourens R Rebinarand Bernold, Theory and Applications of Digital Signal Processing.
3. Auntoniam, Digital Filter Analysis and Design, TMH. Dept.

FACTS AND CUSTOM POWER DEVICES

M.Tech (PEED/EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PE6172	**3**	**0**	**0**	**3**

Prerequisite: Power Systems and Power Electronics

Course Objectives: Students will be able to:

- 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

Course Outcomes: Upon the completion of the course the student will be able to

- Understand the concepts of FACTS
- Apply the knowledge of static var and UPFC concepts
- Analyze the concept of voltage sag and swell

UNIT I: REACTIVE POWER FLOW CONTROL

Reactive power flow control in Power Systems – Control of dynamic power unbalances in Power System, Power flow control -Constraints of maximum transmission line loading – Benefits of FACTS Transmission line compensation. Uncompensated line -Shunt compensation – Series compensation –Phase angle control. Reactive power compensation, Shunt and Series compensation principles – Reactive compensation at transmission and distribution level.

UNIT II: SHUNT & SERIES COMPENSATION

Static versus passive VAR compensator, Static shunt compensators: SVC, and STATCOM - Operation and control of TSC, TCR and STATCOM -Compensator control, Comparison between SVC and STATCOM, Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators – TCVR and TCPAR Operation and Control –Applications, Static series compensation – GCSC, TCSC and Static synchronous series compensators and their Control.

UNIT III UPFC & IPFC

SSR and its damping Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPF, Basic Principle of P and Q control- Independent real and reactive power, flow control- Applications, interline power flow controller

UNIT IV MITIGATION OF HARMONICS

Introduction to Power quality, problems in distribution systems, harmonics. Loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filtering, – shunt, series and hybrid and their control.

UNIT V POWER QUALITY ISSUSES

Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners- IEEE standards on power quality.

TEXT BOOKS

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2007.

2. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and

Control", Springer Verlag, Berlin, 2006.
3. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.
4. K.S.Sureshkumar, S.Ashok, "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT Calicut, 2003.
5. G. T.Heydt, "Power Quality", McGraw-Hill Professional, 2007.
6. T. J. E. Miller, "Static Reactive Power Compensation", John Wiley and Sons, Newyork, 1982.

ELECTRIC TRACTION SYSTEMS

M. Tech. (PEED) I Year I Semester
Course Code: 21PE6173

L	T	P	C
3	0	0	3

Prerequisite: Electric Drives, Power Systems

Course Objectives:

- To understand various systems of track electrification, power supply system and mechanics of electric train.
- To identify a suitable drive for electric traction.

Course Outcomes: Upon the completion of the course the student will be able to

- Understand Traction systems and its mechanics.
- Identify the power supply equipment for traction systems.
- Analyze various types of motors used in traction and differentiate AC and DC traction drives.

UNIT – I

Traction Systems: Electric drives - Advantages & disadvantages - System of track electrification - d.c., 1-Phase low frequency, 3-Phase low frequency and composite systems, Problems of 1-phase traction system - Current unbalance, Voltage unbalance, Production of harmonics, Induction effects, Booster transformer - Rail connected booster transformer comparison between AC and DC system.

UNIT – II

Traction mechanics: Types of services, Speed - time curves - Construction of quadrilateral and trapezoidal speed time curves, Average & schedule speeds. Tractive effort - Speed characteristic, Power of traction motor, specific energy consumption - Factors affecting specific energy consumption, Coefficient of adhesion, slip - Factors affecting slip, magnetically suspended trains.

UNIT – III

Power supply arrangements: High voltage supply, Constituents of supply system - Substations, Feeding post, Feeding & sectioning arrangements, Remote control center, Design considerations of substations, Over Head Equipment (OHE)- principle of design of OHE, Polygonal OHE - Different types of constructions, Basic sag & tension calculations, Dropper design, Current collection gear for OHE.

UN IT – IV

Traction motors: Desirable characteristics, D.C. series motors, A.C. series motors, 3-Phase induction motors, linear induction motors, D.C. motor series & parallel control - Shunt bridge transition – Drum controller, Contact type bridge transition control, Energy saving, Types of braking in a.c. and d.c. drives, Conditions for regenerative braking, Stability of motors under regenerative braking.

UNIT –V

Semi conductor converter controlled drives: Advantages of A.C. Traction - Control of d.c. motors - single and two-stage converters, Control of ac. motors - CSl fed squirrel cage induction motor, PWM VSl induction motor drive, D.C. traction — Chopper controlled d.c. motors, composite braking, Diesel electric traction — D.C. generator fed d.c. series motor, Alternator fed d.c. series motor, Alternator fed squirrel-cage induction motor, Locomotive and axlecodes

TEXT BOOKS:

1. Partab.H - Modern Electric Traction, Dhanpat Rai & Sons –2017.
2. Dubey. G.K. - Fundamentals of Electrical Drives, Narosa Publishing House - 2001.
3. C. L. Wadhwa — Generation, Distribution and Utilization of Electrical Energy, NewAge International - 2015.
4. J.B. Gupta - Utilization of Electrical Power and Electric Traction, S. K. Kataria& Sonspublications, 2013.

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MODERN CONTROL THEORY

M.Tech (PEED) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21PE6174	**3**	**0**	**0**	**3**

Prerequisites: Linear control systems

Course Objectives:

- To explain the concepts of basic and modern control system for the real time analysis and design of control systems.
- To explain and apply concepts of state variables analysis.
- To study and analyze non linear systems.
- To analyze the concept of stability of nonlinear systems and categorization.
- To apply the comprehensive knowledge of optimal theory for Control Systems.

Course Outcomes: Upon the completion of the course the student will be able to

- Understand the concepts of state variable analysis.
- Understand the concepts of canonical forms
- Apply the knowledge of basic and modern control system for the real time analysis and design of control systems.
- Perform the stability analysis nonlinear systems by Lyapunov method develop design skills in optimal control problems
- Analyze the concept of stability of nonlinear systems and optimal control

UNIT–I

Mathematical Preliminaries: Fields, Vectors and Vector Spaces – Linear combinations and Bases Linear Transformations and Matrices – Scalar Product and Norms – Eigen-values, Eigen Vectors and a Canonical form representation of Linear operators – The concept of state – State Equations for Dynamic systems – Time invariance and Linearity – Non-uniqueness of state model – State diagrams for Continuous-Time State models.

UNIT-II

State Variable Analysis: Linear Continuous time models for Physical systems– Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and its properties. General concept of controllability – General concept of Observability – Controllability tests for Continuous-Time Invariant Systems – Observability tests for Continuous-Time Invariant Systems – Controllability and Observability of State Model in Jordan Canonical form – Controllability and Observability Canonical forms of State model.

UNIT-III

Non Linear Systems: Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc;– Singular Points – Introduction to Linearization of nonlinear systems, Properties of Non-Linear systems – Describing function–describing function analysis of nonlinear systems – Stability analysis of Non-Linear systems through describing functions .Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

UNIT-IV

Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability, and Lypanov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method. Generation of Lyapunov functions – Variable gradient method – Krasooviski's method. State feedback controller design through Pole Assignment – State observers: Full order and Reduced order.

UNIT-V

Optimal Control: Introduction to optimal control - Formulation of optimal control problems – calculus of variations – fundamental concepts, functional, variation of functional – fundamental theorem of theorem of Calculus of variations – boundary conditions – constrained minimization – formulation using Hamiltonian method – Linear Quadratic regulator.

TEXT BOOKS:

1. Modern Control System Theory by M.Gopal – New Age International-1984
2. Control System Engineering, Nagrath and Gopal - New Age International – Fourth Edition.

REFERENCE BOOKS:

1. Optimal control by Kirck , Dover Publications
2. Advanced Control Theory A. NagoorKani, RBA Publications,1999
3. Modern Control Engineering by Ogata. K – Prentice Hall –1997

MACHINE MODELLING SIMULATION LAB

M.Tech. (PEED) I Year I Semester	**L**	**T**	**P**	**C**
Course Code: 21PE6151	**0**	**0**	**4**	**2**

Prerequisite: Electrical Machines, Machine Modelling Analysis

Course Objectives:

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

Course Outcomes: At the end of the course, the student is able to:

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

List of experiments

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

Note: Conduct **any 10** experiments from the above list of experiments

POWER CONVERTERS LAB

M.Tech. (PEED) I Year I Semester	**L**	**T**	**P**	**C**
Course Code: 21PE6152	**0**	**0**	**4**	**2**

Prerequisite: Power Electronic Converters

Course Objectives:

- To study Characteristics of AC-AC Converters.
- To study Characteristics of AC-DC Converters.
- To study Characteristics of DC-DC Converters.
- To study Characteristics of DC-AC Converters.
- To Analyze various converters

Course Outcomes: At the end of the course, the student will be able to:

- Analyze the operation of AC-AC Converters.
- Analyze the operation of AC-DC Converters.
- Analyze the operation of DC-DC Converters.
- Analyze the operation of DC-AC Converters.
- Analyze the operation of various converter topologies developed.

List of experiments

1. Single-phase full converter using RL loads.
2. Single-phase semi converter using RL loads.
3. Cyclo-converter based ac induction motor control equipment.
4. Three-phase semi converter using RL loads.
5. Single-phase AC Voltage controller using RL load.
6. Single-phase Cyclo-converter using RL load.
7. Single-phase inverter with PWM controller.
8. Single-phase series inverter.
9. Single-phase parallel inverter.
10. Single-phase bridge inverter.
11. Single-phase dual converter.

Note: Conduct any **10** experiments from the above.

RESEARCH METHODOLOGY AND IPR

M. Tech (PEED/EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21MC6111	**2**	**0**	**0**	**2**

Prerequisite: Research theory

Course Objectives:

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

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

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

UNIT-I

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

UNIT-II

Report writing: 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-III

Intellectual Property Rights: 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-IV

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and data bases. Geographical Indications.

UNIT-V

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

REFERENCE BOOKS:

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

STRESS MANGEMENT BY YOGA

	L	T	P	C
M.Tech (PEED/EPS) I Year I semester	**L**	**T**	**P**	**C**
Course code: 21MC6101	**2**	**0**	**0**	**0**

***Prerequisite:* -** Yoga and its Benefits

Course Objectives:

To achieve overall health of body and mind.
To overcome stress.

Course Outcomes: Students will be able to

Develop healthy mind in a healthy body thus improving social health also
Improve efficiency

UNIT-I

Definitions of Eight parts of yoga. (Ashtanga)

UNIT-II

Yam and Niyam.

UNIT-III

Do`s and Don't's in life.
i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay,ishwarpranidhan

UNIT-IV

Asan and Pranayam

UNIT-V

i) Various yoga poses and their benefits for mind &body
ii)Regularization of breathing techniques and its effects-Typesofpranayam

TEXT BOOKS:

1. YogicAsanas for Group Training-Part-I" : Janardan Swami YogabhyasiMandal,Nagpur.
2."Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama Publication Department),Kolkata

REFERENCE BOOKS:

1. Stress and Its Management by Yoga" : by K.N.Udupa and R.C Prasad

ADVANCED POWER ELECTRONICS

M.Tech (EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PE6211	**3**	**0**	**0**	**3**

Pre-requisites: Analysis of Power Converters, Power Electronics

Course Outcomes:

- Modeling of power converters under steady state and small signal condition.
- Develop power converters with better performance for challenging applications
- Analyze and design power converters & feedback loops, selection of power circuit components
- Analyze power quality problems and suggest solutions

UNIT- I

ISOLATED CONVERTERS

Introduction, Forward Converter, Flyback Converter, Push-Pull Isolated Buck Converter, Full-Bridge and Half-Bridge Isolated Buck Converters, Boost-Derived Isolated Converters, Isolated Versions of the SEPIC and the CUK Converters.

UNIT- II

RESONANT CONVERTERS – 1

Introduction - Basic resonant circuit concepts, switch-mode inductive current switching, zero-voltage and zero-current switching's, Classification, basic resonant circuit concepts – series resonant circuits, parallel-resonant circuits, Load resonant converters – series and parallel. Zero voltage switching clamped voltage converters, Phase modulated resonant converters, Hybrid-resonant converter.

UNIT- III

RESONANT CONVERTERS – 2

Current-source parallel-resonant inverters, class E converters, resonant-switch converters, ZCS resonant-switch converters, ZVS resonant-switch converters, comparison, zero-voltage-switching, clamped-voltage topologies, resonant dc-link inverters with zero-voltage switching's, high-frequency -link integral-half –cycle converters.

UNIT- IV

STEADY STATE CONVERTER ANALYSIS AND MODELING

Introduction, Inductor Volt-Second Balance, Capacitor Charge Balance, and the Small-Ripple Approximation, Boost Converter Example, Cuk Converter Example, DC Transformer Model, Inclusion of Inductor Copper Loss, Construction of Equivalent Circuit Model, Example: Boost Converter Model Semiconductor Conduction Losses.

UNIT- V

THE BASIC AC MODELING APPROACH

Averaging the Inductor Waveforms, Discussion of the Averaging Approximation, Averaging the Capacitor Waveforms, Average Input Current, Perturbation and Linearization, Construction of the Small-Signal Equivalent Circuit Model, Discussion of the Perturbation and Linearization Step, Results for Several Basic Converters, Example: A Non-ideal Flyback Converter

STATE-SPACE AVERAGING

The State Equations of a Network, Basic State-Space Averaged Model, Discussion of the State-Space Averaging Result, Example: State-Space Averaging of a Non-ideal Buck–Boost Converter

TEXT BOOKS:

1. Erickson RW, "Fundamentals of Power Electronics", Chapman and Hall.
2. Power Electronics: Converters, Applications & Design: N Mohan, T.M.Undeland, W. P.Robbins, J. Wiley&Sons.

REFERENCE BOOKS:

1. Power Electronics-circuits, Devices & Applications: M.H.Rashid, PHI.
2. Switched mode power conversion – NPTEL Course
https://www.youtube.com/playlist?list=PLbMVogVj5nJRY--U9E7dvmqgB9RhGuymk
3. Advance power electronics and control – NPTEL Course
https://www.youtube.com/playlist?list=PLLy_2iUCG87DzWK9cLYKxjH1LRACxdEKi

ELECTRIC DRIVES

M.Tech. (PEED) I Year II Semester	L	T	P	C
Course Code: 21PE6212	3	0	0	3

Prerequisite: Power Electronic Converters, Electrical Machines

Course Objectives:

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

Course Outcomes: After taking this course, student will be able to:

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

UNIT–I

RECTIFIER CONTROLLED DC MOTOR:

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

CLOSED LOOP CONTROL OF DC DRIVE:

Current and speed controllers - Current and speed feedback – Design of controllers – Current and speed controllers – Motor equations – filter in the speed feedback loop speed controller – current reference generator – current controller and flow chart for simulation – Harmonics and associated problems – sixth harmonics torque.

UNIT–II

CHOPPER CONTROLLED DC MOTOR DRIVES:

Principle of operation of the chopper – Chopper with other power devices – model of the chopper – input to the chopper – steady state analysis of chopper controlled DC motor drives – Closed loop operation: Speed controlled drive system – current control loop – pulse width modulated current controller – hysteresis current controller – modeling of current controller – design of current controller.

UNIT–III

CONTROL OF INDUCTION MOTOR:

Introduction to motor drives – Torque production – Equivalent circuit analysis – Speed–TorqueCharacteristicswithvariablevoltageoperationVariablefrequency operation constant v/t operation – Variable stator current operation – Induction motor characteristics in constant torque and field weakening regions.

STATOR SIDE CONTROL:

Scalar control – Voltage fed inverter control – Open loop volts/Hz control – speed control slip regulation – speed control with torque and flux control – current controlled voltage fed inverter drive –

ROTOR SIDE CONTROL OF INDUCTION MOTOR DRIVES:

Slip power recovery drives – Static Kramer Drive – Phasor diagram – Torque expression – speed control of Kramer Drive – Static Scheribus Drive – modes of operation.

UNIT–IV

VECTOR CONTROL OF INDUCTION MOTOR DRIVES:

Principles of Vector control – Vector control methods – Direct methods of vector control – Indirect methods of vector control – Adaptive control principles – Self tuning regulator Model referencing control – Direct torque control of ACmotors.

UNIT–V

CONTROL OF SYNCHRONOUS MOTOR DRIVES:

Synchronous motor and its characteristics – Control strategies – Constant torque angle control – Unity power factor control – Constant mutual flux linkage control – closed loop operation.

TEXT BOOKS:

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

REFERENCE BOOKS:

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

REACTIVE POWER COMPENSATION AND MANAGEMENT

M.Tech (PEED/EPS) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PS6271	**3**	**0**	**0**	**3**

Prerequisite: Power Systems

Course Objectives:

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

Course Outcomes:

- Upon the completion of this course, the student will be ableto
- Distinguish the importance of load compensation in symmetrical as well as un symmetrical loads
- Observe various compensation methods in transmission lines
- Construct model for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power management

UNIT-I

Load compensation:

Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT-II

Steady–state reactive power compensation in transmission system:

Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples.

transient state reactive power compensation in transmission systems:

Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples.

UNIT-III

Reactive power coordination:

Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences.

UNIT-IV

Demand side management:

Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels

Distribution side reactive power management:

System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

UNIT-V

User side reactive power management:

KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

Reactive power management in electric traction systems and arc furnaces:

Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

TEXT BOOKS:

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

REFERENCE BOOKS:

2. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just “Reactive Power
3. Compensation: A Practical Guide, April, 2012, Wiley publication

POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

M. Tech. (PEED) I Year I Semester	**L**	**T**	**P**	**C**
Course Code: 21PE6271	**3**	**0**	**0**	**3**

Prerequisite: Power Electronics, Renewable Energy Systems
Course Objectives: to prepare students to

- Provide knowledge about the stand alone and grid connected renewable energy systems.
- Equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- Analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
- Design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems. To develop maximum power point tracking algorithms.

Course Outcomes: At the end of the course, the student is able to:

- Ability to understand and analyze power system operation, stability, control and protection.
- Ability to handle the engineering aspects of electrical energy generation and utilization.

UNIT-I:
INTRODUCTION
Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar,wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

UNIT-II:
ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION
Reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT-III:
HIGH POWER CONVERTERS: KEY TECHNOLOGY FOR WIND TURBINES
Development of Wind Power Generation, Wind Power Conversion, Basic Control Variables for Wind Turbines, Wind Turbine Concepts, Power Converters for Wind Turbines - Two-Level, Multilevel, Multi-cell Converter, Power Semiconductors for Wind Power Converter, Controls and Grid Requirements for Modern Wind Turbines - Active Power Control, Reactive Power Control, Total Harmonic Distortion, Fault Ride-Through Capability.

UNIT-IV: PHOTOVOLTAIC ENERGY CONVERSION SYSTEMS
Introduction, Power Curves and Maximum Power Point of PV Systems, Grid-Connected PV System Configurations – Centralized, String, Multi-string, Control of Grid-Connected PV Systems, Recent Developments in Multilevel Inverter-Based PV Systems

UNIT-V: HYBRID RENEWABLE ENERGY SYSTEMS
Introduction, Diesel generator and photovoltaic systems – Diesel engine – PV power generation, wind – diesel hybrid system – system with no storage, system with battery, wind – PV systems.

TEXT BOOKS:
1. Abu-Rub, H., Malinowski, M., & Al-Haddad, K. (Eds.) Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications,John Wiley & Sons, Ltd,2014.
2. B.H.Khan Non-conventional Energy sources Tata McGraw-hill Publishing Company, New Delhi, 2009.
3. S. N. Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", Oxford University Press, 2005.

HIGH-POWER CONVERTERS & TOPOLOGIES

M.Tech (PEED/EPS) I Year II semester **L T P C**
Course code: 21PE6272 **3 0 0 3**

Prerequisite: Power Electronics

Course Objectives: Students will be able to

- Understand high-power semiconductor devices
- Understand the concepts of multipulse rectifiers
- Understand the concepts of multi-level inverters

Course Outcomes: Students will be able to

- Identify the of high-power converter devices.
- Identify the need of high-power converter topologies.
- Describes various multipulse rectifier concepts.
- Describes different multi-level inverter concepts.

UNIT-I

Introduction: Overview of High-Power Drives, Technical Requirements and Challenges, Converter Configurations.

High-Power Semiconductor Devices: Introduction, High-Power Switching Devices, Operation of Series Connected Devices.

UNIT-II

Front-end Multipulse converters: Introduction, Six-Pulse Diode Rectifier, Series-Type multi-pulse Diode Rectifiers, Separate-Type Multipulse Diode Rectifiers, Six-Pulse SCR Rectifier, 12-Pulse SCR Rectifier, 18- and 24-Pulse SCR Rectifiers.

UNIT-III

Cascaded H-Bridge Multilevel Inverters: Introduction, H-Bridge Inverter, Multilevel Inverter Topologies, Carrier-Based PWM Schemes, Staircase Modulation

UNIT-IV

Diode-Clamped Multilevel Inverters: Introduction, Three-Level Inverter, Space Vector Modulation, Neutral-Point Voltage Control, Carrier-Based PWM Scheme and Neutral-Point Voltage Control, Other Space Vector Modulation Algorithms, High-Level Diode-Clamped Inverters, NPC/H-Bridge Inverter.

UNIT-V

Other Multilevel Voltage Source Inverters: Introduction, Multilevel Flying-Capacitor Inverter, Active Neutral-Point Clamped Inverter, Neutral-Point Piloted Inverter, Nested Neutral-Point Clamped Inverter, Modular Multilevel Converter.

TEXT BOOKS:

1. Bin Wu, “high-power converters and AC drives”, IEEE press A John Wiley & Sons, Inc., Publication, 2nd edition, 2017.
2. Power Electronics: Converters, Applications & Design: N Mohan, T.M.Undeland, W. P.Robbins, J. Wiley&Sons.
3. https://www.youtube.com/playlist?list=PLp6ek2hDcoNAZzkG0zfABMmFNtGUl9QMB

AI TECHNIQUES IN ELECTRICAL ENGINEERING

M.Tech (PEED) I Year II semester	**L**	**T**	**P**	**C**
Course code: 21PE6273	**3**	**0**	**0**	**3**

Prerequisites: Power Electronics, Power systems.

Course Objectives:

- To understand soft commanding methodologies, such as artificial neural networks and Learning methods.
- To observe the concepts of ANN models.
- 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.
- To Apply the AI techniques in load forecasting, DC&AC Motors.

Course Outcomes: Upon the completion of this course, the student will be able to

- Understand the artificial neural networks, feed forward neural networks and Learning methods.
- Understand the concepts of BPA, SOM and FLN models.
- Develop fuzzy logic control for applications in electrical engineering
- Develop genetic algorithm for applications in electrical engineering.
- Apply the AI knowledge for load forecasting and DC/AC drives.

UNIT-I: ARTIFICIAL NEURAL NETWORKS

Introduction, Organization of the Brain, Biological Neuron, Artificial Neuron Models, Neural networks Architecture– Single layer and multi-layer feed-forward and feedback networks, learning process-supervised learning-unsupervised learning–Hebbian learning.

UNIT-II: ANN PARADIGMS

Back propagation Algorithm (BPA), Self –Organizing Map (SOM), Radial Basis Function Network-Functional Link Network (FLN), Hopfield Network.

UNIT-III: FUZZY LOGIC

Introduction –Fuzzy versus crisp, Fuzzy sets-Membership function –Basic Fuzzy set operations, Properties of Fuzzy sets –Fuzzy Cartesian Product, Operations on Fuzzy relations –Fuzzy logic–Fuzzy Quantifiers, Defuzzification methods.

UNIT-IV: GENETIC ALGORITHMS

Basic principle, Evolution of genetic algorithm –Basic concepts-Encoding –Fitness Function-Reproduction operators, Genetic Modeling -Cross over-Single site cross over, Two point cross over –Multi point cross over Uniform cross over, Matrix cross over -Mutation operator.

UNIT-V: APPLICATIONS OF AI TECHNIQUES

Short term and long term load forecasting, fault diagnosis, Economic load dispatch, DC/AC four quadrant drive control-Speed control of DC and AC Motors.

TEXT BOOKS

1. S.Rajasekaran and G.A.V.Pai Neural Networks, Fuzzy Logic & Genetic Algorithms, PHI, New Delhi, 2003.
2. Rober J. Schalkoff, Artificial Neural Networks, Tata McGraw Hill Edition, 2011.

REFERENCES:

1. P.D.Wasserman; Neural Computing Theory & Practice, Van Nostrand Reinhold, New York, 1989.
2. Bart Kosko; Neural Network & Fuzzy System, Prentice Hall,1992
3. D.E.Goldberg, Genetic Algorithms, Addison-Wesley 1999.
4. Kevin warwick, arthurekwue, raj agrawal: Artificial intelligence techniques in power systems, Institution of Engineering and Technology (1 March 1997).

ADVANCED MICROCONTROLLER BASED SYSTEMS

M. Tech. (PEED) I Year II Semester	**L**	**T**	**P**	**C**
Course Code: 21EC6271	**3**	**0**	**0**	**3**

Prerequisite: Microprocessors and Microcontrollers

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 taking this course, student will be able to:

- To learn how to program a processor in assembly language and develop an advanced processor based system.
- To learn configuring and using different peripherals in a digital system.
- To compile and debug a Program.
- To generate an executable file and use it.

UNIT-I

Computer Organization: Basic Computer Organization, Accumulator based processes-Architecture-Memory Organization- I/O Organization

UNIT-II

Micro-Controllers: Intel 8051, Intel 8056- Registers, Memories, I/O Ports, Serial Communication. Timers, Interrupts, Programming. Intel 8051 – Assembly language programming-Addressing-Operations-Stack & Subroutines, Interrupts-DMA.

UNIT-III

Communication: PIC 16F877- Architecture Programming, Interfacing Memory/ I/O Devices, Serial I/O and data communication

UNIT-IV

DSP & FPGA Controllers: Digital Signal Processor (DSP) - Architecture – Programming, Introduction to FPGA

UNIT-V

Applications: Microcontroller development for motor control applications, Stepper motor control using microcontroller.

TEXTBOOKS:

1. John.F.Wakerly: "Microcomputer Architecture and Programming", John Wiley and Sons 1981.
2. Ramesh S.Gaonker: "Microprocessor Architecture, Programming and Applications with the 8085", Penram International Publishing (India),1994.

REFERENCE BOOKS:

1. Raj Kamal: “The Concepts and Features of Microcontrollers”, Wheeler Publishing, 2005.
2. Kenneth J. Ayala, “The 8051 microcontroller”, Cengage Learning,2004.
3. John Morton,” The PIC microcontroller: your personal introductory course”, Elsevier, 2005.
4. Dogan Ibrahim,” Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series”, Elsevier,2008.
5. Microchip datasheets for PIC16F877.

POWER QUALITY

M. Tech. (PEED) I Year II Semester **L T P C**
Course Code: 21PS6275 **3 0 0 3**

Prerequisite: Power Systems

Course Objectives:

- To Study the basics of power quality, power quality problems and power quality standards,
- To Study about the characteristics of non-linear loads
- To Study Voltage, Current, Power and Energy measurements and analysis methods of Laplace's, Fourier and Hartley and Wavelet Transforms
- To Study the analysis and conventional mitigation methods
- To Study about various devices used to enhance power quality.

Course Outcomes: After taking this course, the student will be able to:

- Know the different characteristics of electric power quality in power systems,
- Learn about the applications of non-linear loads,
- Know the applications of Hartley and Wavelet Transforms,
- Learn how to mitigate the power quality problems
- Learn about the application of FACTS device on DG side.
-

UNIT-I:
INTRODUCTION
Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.
POWER QUALITY AND EMC STANDARDS:
Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

UNIT-II:
LONG & SHORT INTERRUPTIONS
Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.
SHORT INTERRUPTIONS: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

UNIT-III:
SINGLE AND THREE-PHASE VOLTAGE Sag CHARACTERIZATION
Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults, phase angle jumps,

magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT- IV:

POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS

Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT-V:

MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

TEXT BOOKS:

1. “Understanding Power Quality Problems” by Math H J Bollen. IEEE Press.
2. “Power Quality VAR Compensation in Power Systems”, R. Sastry Vedam Mulukutla S. Sarma,CRC Press.

REFERENCES:

1. Power Quality, C. Sankaran, CRC Presss.
2. Electrical Power Systems Quality, Roger C. Dugan, Mark F. Mc Granaghan, Surya Santoso, H. Wayne Beaty, Tata McGraw Hill Education Private Ltd.

ADVANCED POWER ELECTRONICS SIMULATION LAB

M. Tech. (PEED) I Year II Semester	**L**	**T**	**P**	**C**
Course Code: 21PE6251	**0**	**0**	**4**	**2**

Prerequisite: Power Electronics, Power Converters

Course Objectives:

- Gate drive circuit configurations for converter circuits
- Advanced converter topologies
- Open loop and closed loop speed control analysis of AC and DC drives.
- Soft switching techniques.

Course Outcomes: After taking this course, student will be able to:

- Perform the open loop and closed loop speed control analysis of AC and DC drives.
- Design the gate driver circuits for converter topologies.
- Know the complete study of advanced converter technologies.
- Know the complete study Sine-PWM techniques for inverter topologies.

List of Experiments

1. Closed loop implementation of buck and boost dc-dc converters.
2. Sine-PWM techniques for single-phase half-bridge inverters.
3. Sine-PWM techniques for single-phase full-bridge inverters.
4. Sine-PWM techniques for three-phase two-level inverters.
5. Series resonant converter.
6. Parallel resonant converter.
7. Zero Current Switching (ZCS) converter.
8. Push pull converter.
9. Fly back converter.
10. Forward converter.
11. Three-phase impedance (Z) source inverter.

Note: Conduct **any 10** experiments from the above list of experiments

ELECTRIC DRIVES LAB

M. Tech. (PEED) I Year II Semester	**L**	**T**	**P**	**C**
Course Code: 21PE6252	**0**	**0**	**4**	**2**

Prerequisite: Power Electronic Devices and Circuits and Electrical Machines

Course Objectives:

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

Course Outcomes: After taking this course, student will be able to:

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

List of Experiments:

1. Thyristerised drive for 1 HP separately exited DC motor with closed loop control.
2. Speed control of 3-phase wound rotor Induction Motor Drive.
3. 3 Phase input thyristerised drive 3HP DC motor with closed loop.
4. 3 Phase input IGBT 4 quadrant chopper for DC motor with closed loop control equipment.
5. Speed Measurement and closed loop control using PMDC Motor Drive.
6. Speed measurement and closed loop control of PMDC Motor Drive with thyrister circuit.
7. IGBT used single 4 quadrant chopper drive for PMDC Motor with speed measurement and closed loop control.
8. Isolated Gate Drive circuits for MOSFET / IGBT based circuits.
9. Characteristics of solar PV systems.
10. Maximum power point tracking charge controllers.
11. Inverter control for solar PV based systems.

Note: Conduct **any 10** experiments from the above list of experiments

ENGLISH FOR RESEARCH PAPER WRITING

M.Tech (PEED/EPS) I Year II semester	**L T P C**
Course code: 21MC6201	**2 0 0 0**

Prerequisite: English grammar

Course objectives:

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

UNIT- I

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

UNIT- II

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

UNIT-III

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

UNIT-IV

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

UNIT-V

skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions, useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

TEXT BOOKS:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

REFERENCE BOOKS:

1. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman’s book.
2. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

ENERGY STORAGE TECHNOLOGIES
(Professional Elective - V)

M.Tech (PEED/EPS) II Year I semester	**L**	**T**	**P**	**C**
Course code: 21PE7171	**3**	**0**	**0**	**3**

Course Objectives: to prepare the students to

- introduce generalized storage techniques
- analyze the different features of energy storage systems
- know the management and applications of energy storage technologies
- know about electrical energy storage market potential by different forecasting methods

Course Outcomes: the student will be able to:

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

UNIT-I:

THE ROLES OF ELECTRICAL ENERGY STORAGE TECHNOLOGIES IN ELECTRICITY USE: Characteristics of electricity, Electricity and the roles of EES, High generation cost during peak-demand periods, Need for continuous and flexible supply, Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses, The roles of electrical energy storage technologies, The roles from the viewpoint of a utility, The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy.

UNIT-II:

TYPES AND FEATURES OF ENERGY STORAGE SYSTEMS: Classification of EES systems, Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Lead-Acid Batteries, Lithium-Ion Batteries, Flow batteries, Other Batteries in Development, Chemical energy storage, Hydrogen (H2), Double-layer capacitors (DLC), Superconducting magnetic energy storage (SMES), Standards for EES, Technical comparison of EES technologies.

UNIT-III:

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

UNIT-IV:

MANAGEMENT AND CONTROL HIERARCHY OF EES: Internal configuration of battery storage systems, External connection of EES systems, Aggregating EES systems and distributed generation (Virtual Power Plant), “Battery SCADA” – aggregation of many dispersed batteries.

DEMAND FOR ENERGY STORAGE: Growth in Variable Energy Resources, Relationship between balancing services and variable energy resources, Energy Storage Alternatives, Demand Management, Market Mechanisms, and Longer Term Outlook.

UNIT-V:

FORECAST OF EES MARKET POTENTIAL BY 2030: EES market potential for overall applications, EES market estimation by Sandia National Laboratory (SNL), EES market estimation by the Boston Consulting Group (BCG), EES market estimation for Li-ion batteries by the Panasonic Group, EES market potential estimation for broad introduction of renewable energies, EES market potential estimation for Germany by Fraunhofer, EES market potential estimation for Europe by Siemens, EES market potential in the future

TEXT BOOKS:

1. Power System Energy Storage Technologies, 1st Edition by Paul Breeze, Academic Press

2. Energy Storage: Systems and Components, by Alfred Rufer, CRC Press, 2017

REFERENCES:

1. Energy Storage Fundamentals, Materials and Applications, by Huggins and Robert, Springer.

2. www.ecofys.com/com/publications

ELECTRIC AND HYBRID VECHILES

M.Tech (PEED) II Year I semester **L T P C**
Course code: 21PE7172 **3 0 0 3**

Prerequisite: Power Semiconductor Drives, Electrical Machines

Course Objectives:

- To understand the fundamental concepts of conventional vehicles
- To understand the fundamental concepts, principles, analysis and design of hybrid and electric vehicles.
- To understand the performance of electrical propulsion units with different motor drives.
- To understand electrical energy storage using batteries, fuel cells and super capacitors.
- To understand various energy management strategies in electric vehicles.

Course Outcomes: At the end of this course, students shall be

- Able to analyze mechanical design of conventional vehicles
- Able to describe hybrid vehicles and their performance.
- Able to analyze various motor drives used in electrical vehicles
- Able to understand different possible ways of energy storage.
- Able to Understand the different strategies related to energy storage systems.

UNIT-I: INTRODUCTION

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

UNIT-II: INTRODUCTIONTOHYBRIDELECTRICVEHICLES

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

HYBRID ELECTRICDRIVE TRAINS: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.

UNIT III ELECTRIC TRAINS

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive train topologies, power flow control in electric drive-train topologies.

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.

UNIT-IV: ENERGYSTORAGE

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, battery management system, Fuel Cell based energy storage, Super Capacitor based energy storage, Fly wheel-based energy storage, Hybridization of different energy storage devices.

UNIT-V: ENERGYMANAGEMENTSTRATEGIES

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies. Review of various Energy management strategies.

TEXT BOOKS:

1. C.Mi,M.A.MasrurandD.W.Gao,“Hybrid Electric Vehicles: Principles and ApplicationswithPracticalPerspectives”,JohnWiley&Sons,2011.
2. S.Onori,L.SerraoandG.Rizzoni,“HybridElectricVehicles:EnergyManagementStrategies”, Springer,2015.

REFERENCES:

1. M.Ehsani,Y.Gao,S.E.GayandA.Emadi,“ModernElectric,HybridElectric,andFuelCellVehicles:Fundamentals,Theory,andDesign”,CRCPress,2004.
2. T. Denton,“ElectricandHybridVehicles”,Routledge,2016.
3. AishwaryaPanday, Hari Om Bansal, "A Review of Optimal Energy Management Strategies for Hybrid Electric Vehicle", International Journal of Vehicular Technology, vol. 2014, Article ID 160510, 19 pages, 2014. https://doi.org/10.1155/2014/160510

DIGITAL CONTROL SYSTEMS

M.Tech (PEED) II Year I semester	**L**	**T**	**P**	**C**
Course code: 21PE7173	**3**	**0**	**0**	**3**

Prerequisites: Linear control systems, Z-Transforms

Course Objectives:

- To explain basic and digital control system for the real time analysis and design of control systems.
- To apply the knowledge state variable analysis in the design of discrete systems.
- To explain the concept of stability analysis and design of discrete time systems.

Course Outcomes: Upon the completion of the course the student will be able to

- Understand the concepts of Digital control systems.
- Analyze and design discrete systems in state variable analysis.
- Relate the concepts of stability analysis and design discrete time systems.

UNIT – I: Introduction: Advantages of sampling in control systems – examples of discrete data and digital systems – data conversion and quantization – sample and hold devices – D/A and A/D conversion – sampling theorem – reconstruction of sampled signals –ZOH. Z-transform: Definition and evaluation of Z-transforms – mapping between s-plane and z-plane – inverse z-plane transform – theorems of the Z-transforms –limitations of z-transforms –pulse transfer function –pulse transfer function of ZOH –relation between G(s) and G(z) – signal flow graph method applied to digital systems.

UNIT- II: State Space Analysis: State space modeling of digital systems with sample and hold – state transition equation of digital time in variant systems – solution of time in variant discrete state equations by the Z-Transformation –Transformation to phase to variable canonical form-The state diagram – decomposition of digital system – Response of sample data system between sampling instants using state approach. Stability: Definition of stability – stability tests – The second method of Liapunov.

UNIT- III: Time Domain Analysis: Comparison of time response of continuous data and digital control systems-correlation between time response and root locus j the s-plane and z-plane – effect of polezero configuration in the z-plane upon the maximum overshoot and peak time of transient response – Root loci for digital control systems – steady state error analysis of digital control systems – Nyquits plot – Bode plot-G.M and P.M.

UNIT- IV: Design: The digital control design with digital controller with bilinear transformation – Digital PID controller-Design with deadbeat response-Pole placement through state feedback-Design of full order state observer-Discrete Euler Lagrance Equation – Discrete maximum principle.

UNIT-V: Digital State Observer: Design of - Full order and reduced order observers. Design by max. Principle: Discrete Euler language equation-discrete maximum principle.

TEXT BOOKS:

1. K. Ogata,Discrete-Time Control systems - Pearson Education/PHI, 2nd EditionJanuary 2015.
2. M. Gopal, Digital Control and State Variable Methods TMH. July 2017

REFERENCE BOOKS:

1. KuoDigital Control Systems, Oxford University Press, 2nd Edition, 2003.
2. M. GopalDigital Control Engineering New Age India Private Limited second edition Jan 2014.