M.Tech.: Power Electronics and Drives

ELECTRICAL ENGINEERING DEPARTMENT

M.Tech. Programme

in

POWER ELECTRONICS AND DRIVES

SYLLABUS
FOR
CREDIT BASED CURRICULUM

DEPARTMENT OF ELECTRICAL ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY

JAIPUR-302017

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF ELECTRICAL ENGINEERING
M. Tech- Power Electronics & Drives (Full Time)

Semester I

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EET501	Electric Drives and their Control	Program Core	Theory	3	2	1	0
2	21EET502	Intelligent Control Techniques	Program Core	Theory	3	2	1	0
3	21EET503	Power Conversion Techniques	Program Core	Theory	3	2	1	0
4	PE (Odd)		Program Elective	Theory	3	2	1	0
5	PE (Odd)		Program Elective	Theory	3	2	1	0
6	21EEP504	Power Electronics & Drives Lab	Program Core	Lab	3	0	0	6

Semester II

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EET505	Industrial Control Electronics	Program Core	Theory	3	2	1	0
2	21EET506	Switched Mode Power Conversion	Program Core	Theory	3	2	1	0
3	PE (Even)		Program Elective	Theory	3	2	1	0
4	PE (Even)		Program Elective	Theory	3	2	1	0
5	PE (Even)		Program Elective	Theory	3	2	1	0
6	OE		Open Elective	Theory	3	2	1	0

Semester III

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EES602	Seminar	Program Core	Seminar	3			
2	21EED601	Dissertation	Program Core	Dissertation	7			

Semester IV

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EED603	Dissertation	Program Core	Dissertation	14			

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF ELECTRICAL ENGINEERING
M. Tech- Power Electronics & Drives (Part Time)

Semester I

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EET501	Electric Drives and their Control	Program Core	Theory	3	2	1	0
2	21EET502	Intelligent Control Techniques	Program Core	Theory	3	2	1	0
3	21EET503	Power Conversion Techniques	Program Core	Theory	3	2	1	0

Semester II

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EET505	Industrial Control Electronics	Program Core	Theory	3	2	1	0
2	21EET506	Switched Mode Power Conversion	Program Core	Theory	3	2	1	0
3	PE (Even)		Program Elective	Theory	3	2	1	0

Semester III

S. No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	PE(Odd)		Program Elective	Theory	3	2	1	0
2	PE(Odd)		Program Elective	Theory	3	2	1	0
3	21EEP504	Power Electronics & Drives Lab	Program Core	Lab	3	0	0	6
4	21EES602	Seminar	Program Core	Seminar	3			

Semester IV

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	PE(Even)		Program Elective	Theory	3	2	1	0
2	PE(Even)		Program Elective	Theory	3	2	1	0
3	OE		Open Elective	Theory	3	2	1	0

Semester V

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EED601	Dissertation	Program Core	Dissertation	7			

Semester VI

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	21EED603	Dissertation	Program Core	Dissertation	14			

Program Core

Course Code	Course Title	PRS	PRM	PRE	CWS	MTE	ETE
21EET501	Electric Drives and their Control	-	-	-	20-30	20-40	30-50
21EET502	Intelligent Control Techniques	-	-	-	20-30	20-40	30-50
21EET503	Power Conversion Techniques	-	-	-	20-30	20-40	30-50
21EET505	Industrial Control Electronics	-	-	-	20-30	20-40	30-50
21EET506	Switched Mode Power Conversion	-	-	-	20-30	20-40	30-50
21EEP504	Power Electronics & Drives Lab	40-60	20-30	20-30	-	-	-
21EES602	Seminar	70	30	-	-	-	-
21EED601	Dissertation	-	-	-	-	30	70
21EED603	Dissertation	-	-	-	-	30	70

Program Elective

	Course Code	Course Title	PRS	PRE	CWS	MTE	ETE
PE (Odd)	21EET805	Digital Signal Processing &Applications			20-30	20-40	30-50
	21EET821	HVDC Transmission	-	-	20-30	20-40	30-50
	21EET825	EHV AC/DC Transmission System	-	-	20-30	20-40	30-50
	21EET827	Modeling & Simulation of Power Electronic Systems	-	-	20-30	20-40	30-50
	EET-641	Digital Controller Application in Power Converters	-	-	20-30	20-40	30-50
	EET-643	Embedded System Design	-	-	20-30	20-40	30-50
	EET-649	Application of Power Electronics in Smart Grid	-	-	20-30	20-40	30-50
	EET-651	Optimization Algorithms	-	-	20-30	20-40	30-50
	EET-653	Computer Networks	-	-	20-30	20-40	30-50
PE (Even)	21EET819	PWM Converters and Applications	-	-	20-30	20-40	30-50
	21EET828	Flexible AC Transmission Systems	-	-	20-30	20-40	30-50
	21EET830	Integrated Energy Systems	-	-	20-30	20-40	30-50
	21EET835	Modern Control Theory	-	-	20-30	20-40	30-50
	21EET836	Excitation of Synchronous Machines and their Control	-	-	20-30	20-40	30-50
	21EET849	Power System Quality	-	-	20-30	20-40	30-50
	EET-622	Advances in Power Transmission & Distribution	-	-	20-30	20-40	30-50
	EET-644	Advanced Electrical Drives	-	-	20-30	20-40	30-50
	EET-648	Renewable Power Generation and Control	-	-	20-30	20-40	30-50
	EET-650	Applications of Power Electronics in Power Systems	-	-	20-30	20-40	30-50
	EET-654	Advanced Theory and Analysis of AC Machines	-	-	20-30	20-40	30-50

Open Elective (OE): To be offered by other department/center/program

Code	Course Code	PRS	PRE	CWS	MTE	ETE
		-	-	20-30	20-40	30-50

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department : **Department of Electrical Engineering**

Course Code : **21EET501**

Course Name : **Electric Drives and their Control**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Core*

Prerequisites : none;

Course Contents

Characteristics of Electric Motors: Characteristics of DC motors, 3-phase Induction motors and Synchronous motors. Starting and Breaking of Electric motors. Status of DC and AC Drives.
Dynamics of Electric Drives: Parts of electric drives electric motors, power modulators, sources, control unit, and mechanical system. Fundamental torque equations. Multi-quadrant operation. Equivalent values of drive parameters-loads with rotational motion and translational motion, components of load torque, nature and classification of load torques. Dynamic conditions of a drive system. Energy loss in transient operations, load equalization.
Motor Power Rating: Power losses of motors, heating and cooling of electric motors. Thermal model of motor for heating and cooling, classes of motor duty, Determination of motor rating, continuous duty, short time duty and intermittent periodic duty. Equivalent current, torque and power for fluctuating and intermittent loads.
Control of electric Drives: Modes of operation. Closed-loop control of drives. Current-limit control. Closed-loop torque, and speed control. Closed-loop control of multi motor drives. Speed and current sensing. Phase-locked-loop control.
DC Motor Drives: Starting, Braking, and speed control Transient Analysis of separately excited motor with armature and field control, energy losses during transient operation. Phase controlled converter DC drives, dual-converter control of DC drive, power factor, supply harmonics and ripple in motor current. Chopper control DC drives. Source Current harmonics.
3-Phase Induction Motor Drives: Starting, Breaking and Transient Analysis. Calculation of energy losses. Speed Control, Staler Voltage control. Variable Frequency control from voltage and current sources, Slip power recovery-Static Scherbius and Cramer Drives.
Synchronous Motor Drives: Starting, Pull in and Braking of Synchronous motor. Speed control-variable frequency control, Cycloconverter control.
Brushless DC Motor, Linear Induction Motor, Stepper Motor and Switched Reluctance Motor Drives: Important Features and applications.
Energy Conservation in Electrical Drives: Losses in electrical drive system. Measures for energy conservation in electric drives, Use of efficient motor, Energy efficient operation of drives, Improvement of power factor and quality of supply.

References:

[1] G K Dubey, Fundamentals of Electric Drives, Narosa, 2010.
[2] B K Bose, Modern Power Electronics and Electric Drives, PH Publishers, John Wiley, 2004.

Department : **Department of Electrical Engineering**

Course Code : **21EET502**

Course Name : **Intelligent Control Techniques**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Core*

Prerequisites : none;

Course Contents

Introduction: Approaches to intelligent control; Architecture for intelligent control; Symbolic reasoning system; rule-based systems; AI approach; Knowledge representation; Expert systems.

Fuzzy Logic Control System: Motivation and basic definitions; Fuzzy arithmetic and Fuzzy relations; Fuzzy logic modeling and control; Fuzzy knowledge and rule bases; Fuzzy modeling and control schemes for nonlinear systems; Self-organizing fuzzy logic control; Fuzzy logic control for nonlinear time-delay system; Stabilization using fuzzy models; Fuzzy estimators; Adaptive fuzzy control.

ANN based Controllers and Estimators: Concept of Artificial Neural Networks and its basic mathematical model; McCulloch-Pitts neuron model; simple perceptron; Adaline and Madaline; Feed-forward Multilayer Perceptron; Learning and Training the neural network; Data Processing: Scaling; Fourier transformation; principal-component analysis and wavelet transformations; Hopfield network; Self-organizing network and Recurrent network; Neural Network based controllers and estimators.

Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps; Adjustment of free parameters; Solution of typical control problems using genetic algorithm; Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems; Evolutionary Fuzzy logic controllers.

Case Studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox; Stability analysis of Neural-Network interconnection systems; Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox; Stability analysis of fuzzy control systems.

References:

[1] Padhy.N.P.; “Artificial Intelligence and Intelligent System”; Oxford UniversityPress.

[2] KOSKO;B. "Neural Networks and Fuzzy Systems"; Prentice-Hall of India Pvt. Ltd.

[3] Jacek.M.Zurada; "Introduction to Artificial Neural Systems";Jaico PublishingHouse.

[4] KLIR G.J. & FOLGER T.A. "Fuzzy sets; uncertainty and Information"; Prentice-Hall of India Pvt. Ltd.

Department : **Department of Electrical Engineering**

Course Code : **21EET503**

Course Name : **Power Conversion Techniques**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Core*

Prerequisites : none;

Course Contents

Analysis of switched circuits- thyristor controlled half wave rectifier – R, L, RL, RC load circuits, classification and analysis of commutation

Single-Phase and Three-Phase AC to DC converters- half controlled configurations- operating domains of three phase full converters and semi-converters – Reactive power considerations.

Analysis and design of DC to DC converters- Control of DC-DC converters, Buck converters, Boost converters, Buck-Boost converters, Cuk converters

Single phase and Three phase inverters, Voltage source and Current source inverters, Voltage control and harmonic minimization in inverters.

AC to AC power conversion using voltage regulators, choppers and cyclo-converters, consideration of harmonics.

References:

[1] Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design", John Wiley and sons.Inc, Newyork, 1995.

[2] Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, New Delhi, 1995.

[3] P.C Sen., "Modern Power Electronics", Wheeler publishing Co, First Edition, New Delhi, 1998.

Department : **Department of Electrical Engineering**

Course Code : **21EET505**

Course Name : **Industrial Control Electronics**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Core*

Prerequisites : none;

Course Contents

Review of switching regulators and switch mode power supplies-Uninterrupted power supplies-OFF-LINE AND ON-LINETOPOLOGIES-Analysis of UPS topologies-solid state circuit breakers-solid-state tap-changing of transformer.
Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, derivative overrun, integral windup-cascaded control-Feedforward control-Digital control schemes- control algorithms-programmable logic controllers.
Signal conditioners-Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters; Isolation circuits – cabling; magnetic and electro static shielding and grounding.

Opto-Electronic devices and control, electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation, interrupter modules and photo sensors – Fiber optics – Bar code equipment, application of barcode in industry.

Stepper motors – types, operation, control and applications; servo motors- types, operation, control and applications – servo motor controllers – servo amplifiers – linear motor applications-selection of servo motor.

References:

[1] Michael Jacob, "Industrial Control Electronics – Applications and Design", Prentice Hall, 1988.
[2] Thomas, E. Kissel, "Industrial Electronics" PHI, 2003.
[3] James Maas, "Industrial Electronics", Prentice Hall, 1995.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **21EET506**

Course Name : **Switched Mode Power Conversion**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Core*

Prerequisites : none;

<u>Course Contents</u>

Reactive Elements in Power Electronic Systems, Design of inductor, Design of transformer, Capacitors for power electronic applications.
Basic concepts of Switched Mode power converters, DC-DC converters Characteristics, constituent elements, operating principles.
Steady state analysis, stress and sizing of elements, control methods, duty ratio, current programmed, frequency programmed and sliding mode control, Dynamic analysis and frequency domain models.
Classification of resonant converters, Basic resonant circuit concepts, Load resonant converters, Resonant switch converters, Zero voltage switching.
Design of feedback compensators, unity power factor rectifiers, resistor emulation principle and applications to rectifiers.

References:

[1] Switched Mode Power Conversion, Course Notes, CCE, IISc, 2004.
[2] Issa Batarseh, "Power Electronic Circuits", John Wiley, 2004.
[3] Philip T Krein, "Elements of Power Electronics",Oxford Press.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **21EEP504**

Course Name : **Power Electronics & Drives Lab**

Credits : **3 L - 0 T - 0 P - 6**

Course Type : *Program Core*

Prerequisites : none;

<u>Course Contents</u>

Experiments and computer simulations on:
Single phase, three phase Semi converters and Full converters,
DC-DC Choppers using SCRs and Self communicating Devices.
Single phase and three phase inverters using IGBTs,
AC-AC voltage regulators.
DC and AC drives

Department : **Department of Electrical Engineering**

Course Code : **21EET821**

Course Name : **HVDC Transmission**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Rectification: The 3-phase Bridge rectifier or Graetz circuit, Inversion, Kinds of D.C links, Paralleled and Series connection of thyristors, Power flow in HVDC transmission system.
Converter Station: Major components of a converter station-converter unit, filters, reactive power source. Ground return and ground electrode.
Basic principles of DC link control: Converter control characteristics, firing angle control and extinction angle control. Parallel operation of D.C. link with A.C. transmission line.
Introduction to Multiterminal HVDC Systems and HVDC Circuit Breakers, Comparison between AC and DC transmissions, break even distance for overhead transmission lines and underground cables.Application of HVDC transmission.

Text books

[1] K.R. Padiyar, HVDC Power Transmission System, Wiley Estern Limited.
[2] E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **21EET828**

Course Name : **Flexible AC Transmission Systems**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Conventional reactive power compensation, Theory of Power Transmission Control, Basic principle of FACTS (Flexible AC Transmission System), Principle of Static Var compensation (SVC).Basic Principle of Thyristor Controlled Series Compensation (TCSC) Basic series and shunt FACTS devices. Advance new generation FACTS devices, Control and coordination of FACTS devices, Locations of FACTS Devices.

Text books

[1] N G Hingorani, Understanding Facts: Concepts and Technology of Flexible AC Transmission Systems, Wiley, 2011.

Department : **Department of Electrical Engineering**

Course Code : **21EET830**

Course Name : **Integrated Energy Systems**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Pattern of fuel consumption: Agricultural, domestic, industrial and community needs. Projection of Energy Demands, substitution of conventional sources by alternative sources and more efficient modern technologies. Potential of Solar, Wind, Biogas, Natural Gas, Forest produce, Tidal, Geothermal, Minihydro and other modern applications. Hybrid and Integrated Energy Systems. Total Energy concept and Waste heat utilization.

Text books

[1] G D Rai, Non Conventional Energy Sources, Khanna Publishers, 1988.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **21EET825**

Course Name : **EHV AC/DC Transmission System**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Bulk power transmission over long distance, need for EHV transmission problems of EHV transmission, Power Handling capacity and surge impedance loading. Current carrying capacity of conductor. Choice of economic voltage, standard transmission voltages.
Bundled Conductors: Properties of bundled conductors, geometric mean radius of bundle, inductance and capacitance, Voltage gradients of conductors, maximum surface voltage gradients of bundled conductors, maximum surface electric fields for bundled and single conductor lines. Electrostatic fields of EHV lines. Effect of E.S. field on Humans, Animals and Plants.
Series and Shunt compensation: Effect of series capacitors, location of series capacitors. Sub-synchronous resonance in series-capacitor compensated lines and counter measures. Shunt compensation - Variation of no load receiving end voltage, Static VAR Systems: TCR-FC, TCR, TSC-TCR and MSC-TCR Schemes.

Text books

[1] K R Padiyar, Facts Controllers In Power Transmission And Distribution, New Age Int. Publishers, 2016.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **EET-622**

Course Name : **Advances in Power Transmission & Distribution**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Basic theory of line compensation. FACTS devices, The FACTS optimisation problem. Transient and dynamic stability enhancement using FACTS components. Concepts of modern grid. Introduction to distribution automation, Layout of substations and feeders, Optimum siting and sizing of substations Distribution system load flow, configuration of distribution system, optimum capacitor placement. Optimum feeder switching for loss minimization and load control. Distribution system restoration. Distribution system monitoring and control: SCADA, Concept of modern distribution systems.

Text books

[1] Rakesh Das Begmudre, Extra High Voltage AC Transmission Engineering, Wiley Estern Limited.

[2] K.R. Padiyar, HVDC Power Transmission System, Wiley Estern Limited.

[3] E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.

[4] Math H. J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, Wiley-IEEE Press.

[5] Flexible Ac Transmission Systems, Yong-Hua Song, Allan T. Johns, IEE publication

[6] Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Narain G. Hingorani, Laszlo Gyugyi

Department : **Department of Electrical Engineering**

Course Code : **EET-641**

Course Name : **Digital Controller Application in Power Converters**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Introduction to the C2xx DSP core and code generation, The components of the C2xx DSP core, Mapping external devices to the C2xx core , peripherals and Peripheral Interface, System configuration registers , Memory , Types of Physical Memory , memory Addressing Modes , Assembly Programming using C2xx DSP, Instruction Set, Software Tools. Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

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

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

Controlled Rectifier, Switched Mode Power Converters, PWM Inverters, DC motor control, Induction Motor Control

References

[1] Hamid.A.Toliyat and Steven G.Campbell " DSP Based Electro Mechanical Motion

[2] Control " CRC Press New York , 2004

[3] XC 3000 series datasheets (version 3.1). Xilinx,Inc.,USA, 1998

[4] XC 4000 series datasheets (version 1.6). Xilinx,Inc.,USA, 1999

[5] Wayne Wolf," FPGA based system design ", Prentice hall, 2004

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **21EET835**

Course Name : **Modern Control Theory**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

[**i**] **Discrete Time Systems**: Z-Transform Method, Sampled Data Control Systems, Digital Controller, Sample and Hold Operation, Frequency consideration in Sampling and Reconstruction, Z-transformation, Solution of Differential & State Equations by 'Z' Transform Method, The Inverse Z-Transform, Pulse Transfer Function and Stability in Z-plane.

[ii] State-space model specifications: Transform Design of Digital Controls & State Space Concepts: Design Specifications, Design on the 'W'-plane, 'W plane & 'Z' plane. The Cayley Hamilton Theorem, Concepts of Controllability and Observability**.**

[iii] Stability: Generalized Stability Criterion (d-partition technique), Pole Assignment method, Lyapunov's method, Lure's transformation, Popov's criterion, introduction to stochastic process

[iv] Microprocessor Based Control Systems: Digital Quantization, Positional Control System, Temperature Control System, Stepper Motor Drive circuits and Control of a Manipulator Arm.

[v] Optimization: Time Optimal System (without proof of control law), Calculation of switching trajectories for second order systems. Optimal control System based on quadratic performance indices (proof through Lyapunov's function), basic concepts of Model Reference Control System and Adaptive System. Pontryagin's maximum principle, constrained and unconstrained input, Dynamic Programming, optimality principle, Discrete and Continuous Dynamic Programming.

BOOKS:

[a] Text Books

[1] Thomas Kailath, Linear Systems, the University of Michigan, Prentice-Hall.

[2] M. Gopal, Digital control and state variable methods: conventional and intelligent control systems, Tata McGraw hill education private limited, New Delhi.

[3] K. Ogata, Modern Control Engineering, Automatic control, Prentice Hall.

[4] R. C. Dorf, R.H. Bishop, Modern control systems, Pearson Education, Pearson prentice hall.

[5] D. Subbaram Naidu, Optimal control systems, CRC press.

[b] REFERENCE BOOKS:

[1] Linear Algebra and Its Applications. Gilbert Strang,

[2] P. N. Paraskevopoulos, Modern Control Engineering, Marcel Dekker, New York, USA.

[3] R. L. Williams II, D. A. Lawrence, Linear state-space control systems, John Willey & Sons, INC, Canada.

[4] F. Lin, Robust Control Design: An Optimal Control Approach, John Willey & Sons ltd, USA.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **EET-643**

Course Name : **Embedded System Design**

Credits : **3 L - 2 T - <u>1</u> P - <u>0</u>**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Embedded System -Types of Embedded System - Requirements of Embedded System - Issues in Embedded software development - Applications.
Processor & Memory Organization: Structural units in processor - Processor selection - Memory devices - Memory selection - Memory Allocation & Map –Interfacing
Devices - Device Drives & Buses For Device Networks: I/O devices - Timers & Counter devices - Serial Communication - Communication between devices using different buses. Device drives - Parallel and serial port device drives in a system - Interrupt servicing mechanism - context and periods for context switching - Deadline and Interrupt Latency.
Programming & Program Modeling Concepts : Program elements - Modeling Processes for Software Analysis - Programming Models - Modeling of Multiprocessor Systems - Software algorithm Concepts -Design -Implementation -Testing -Validating -Debugging - Management and maintenance - Necessity of RTOS.
Hardware and Software Co-Design: Embedded system design and co- design issues in software development -Design cycle in development phase for Embedded System - Use of ICE & Software tools for development of ES - Issues in embedded system design.

References

[1] Brown S, and Vranesic Z, Fundamentals of Digital logic with Verilog design, McGraw Hill Education 2017.

[2] Mazidi, Mckinlay and Causey, PIC Micro-controllers and Embedded Systems, Pearson education India: First Edition 2008.

[3] Franklin G F, Powell J D and Naeini, Feedback Control of Dynamic Systems, Pearson 2008.

[4] Sedra A. S and Smith K, Microelectronic Circuits: theory and Applications, Oxford University Press, 2017

[5] Proakis J G and Manolakis D K, Digital Signal Processing, Pearson 2007.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **EET-644**

Course Name : **Advanced Electrical Drives**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Vector Control of Induction Motor: Principles of vector control, direct vector control, derivation of indirect vector control, implementation-block diagram; estimation of flux, flux weakening operation.
Control of Synchronous Motor Drives: Synchronous motor and its characteristics- Control strategies-Constant torque angle control- power factor control, constant flux control, flux weakening operation, Load commutated inverter fed synchronous motor drive, motoring and regeneration, phasor diagrams.
Control of Switched Reluctance Motor Drives: SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.
Control of BLDC Motor Drives: Principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor -current controlled Brushless dc motor Servo drive.

Books:

[1] De Doncker, Rik W., Pulle, Duco W.J., Veltman, Andre, “Advanced Electrical Drives”, Springer, 2020.
[2] Ned Mohan, “Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB/Simulink®”, John Wiley & Sons, Inc, 2014.

Department : **Department of Electrical Engineering**

Course Code : **21EET805**

Course Name : **Digital Signal Processing & Applications**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Review of Discrete – Time Signal & System representation in Z – Transform domain – Inverse Z – Transform – Properties – System characterization in Z – domain -- Equivalence between Fourier Transform and the Z-Transform of a Discrete signal.
Sampling in Fourier domain - Discrete Fourier Transform and its properties – Linear filtering using DFT – Resolution of DFT - FFT Algorithm – Radix-2 FFT Algorithm - DIT & DIF Structures - Higher Radix schemes.
Classification of filter design - Design of IIR filters – Bilinear transformation technique –Impulse invariance method – Step invariance method. FIR filter design – Fourier series method - Window function technique - Finite Word Length Effects.
Introduction to Multirate Signal Processing - Decimation - Interpolation - Case Studies on Speech Coding, Transform Coding – DSP based measurement system.

Books:

[1] Ludemann L. C., "Fundamentals of Digital Signal Processing", Harper and Row publications, 1986.
[2] Antoniou A., "Digital Filters – Analysis and Design", Tata Mc-Graw Hill, 1980.
[3] Oppenheim and Schaffer, 'Discrete time Signal processing', PHI, 1989.
[4] P.P. Vaidhyanathan, " Multirate systems and filter banks", PHI, 1993.

Department : **Department of Electrical Engineering**

Course Code : **21EET819**

Course Name : **PWM Converters and Applications**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

AC/DC and DC/AC power conversion, overview of applications of voltage source converters, pulse modulation techniques for bridge converters.
Bus clamping PWM, space vector based PWM, advanced PWM techniques, practical devices in converter; calculation of switching and conduction losses.
Compensation for dead time and DC voltage regulation; dynamic model of a PWM converter, multilevel converters; constant V/F induction motor drives.
Estimation of current ripple and torque ripple in inverter fed drives; line – side converters with power factor compensation.
Active power filtering, reactive power compensation; harmonic current compensation.

References

[1] Mohan, Undeland and Robbins,' Power Electronics; Converters, Applications and Design', John Wiley and Sons, 1989.
[2] Erickson R W,' Fundamentals of Power Electronics', Chapman and Hall, 1997.
[3] Vithyathil J,'Power Electronics: Principles and Applications ', McGraw Hill, 1995

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **21EET827**

Course Name : **Modeling & Simulation of Power Electronic Systems**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Modelling of Power Electronic Converters: Modelling of semiconductor devices, Switch realization– single quadrant and two quadrant switches, switching losses
Review of DC-DC converters: Steady-state analysis of converter in continuous and discontinuous modes (CCM & DCM), and estimation of converter efficiency, Development of circuit model for simulating dynamic operating conditions in CCM & DCM, Feedback control for converters
Controller design Dynamic Modelling of Electrical Machines: Modelling of DC machines, Modelling of three phase Induction machine, Reference frame theory – ARF, RRF, SYRF, SRF, equations of transformation, voltage equations, torque equations, analysis of steady-state operation, acceleration characteristics, effect of loading and operation with non-sinusoidal voltages
Choice of simulators: Power Electronic Circuit simulation using PSPICE, Analysis of Dynamic behaviour of Electrical Machines using MATLAB/SIMULINK.

Reference:

[1] R.W. Erickson, DraganMaksimovic, “Fundamentals of Power Electronics”, Springer, 2005.

[2] P.C. Krause, O. Wasynczuk, S.D. Sudhoff, “Analysis of Electrical Machinery & Derive Systems” , Wiley Student Edition, 2002.

Department : **Department of Electrical Engineering**

Course Code : **EET-648**

Course Name : **Renewable Power Generation and Control**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Introduction to Renewable Energy Systems: Wind power, Hydropower, Solar energy-Biomass, Bio-fuel, Geothermal Heat energy, Solar-thermal plants, Applications.
Introduction to PV-Cells, Array, Solar power extraction using PV-Cells, I-V Characteristics, PV-Inverters without D.C. to D.C. converters, Grid interfacing-with isolation, without isolation, Maximum power point tracking-Methods, PV-Inverters with D.C. to D.C. converters-on low frequency side and high frequency side with isolation, without isolation.
Wind Energy Sources and potentials, Evaluation of Wind Intensity, Topography, General Classification of Wind Turbines-Rotor Turbines, Multiple-Blade Turbines, Drag Turbines, Lifting Turbines, System TARP–WARP, Generators and speed control used in wind power energy, Wind Power Control: Fixed speed with capacitor bank, Rotor resistance control, DFIG, Synchronous Generator-external magnetized, Synchronous Generator-permanent magnets.

Fuel Cells: Fuel cells, Commercial Technologies for Generation of Electricity, Constructional Features of Solid Oxide Fuel Cells, Constructional Features of Proton Exchange Membrane Fuel Cells, Load Curve Peak Sharing with Fuel Cells, Advantages and Disadvantages of Fuel Cells, voltage step-up using D.C.-D.C. converter- with and without battery storage, Voltage controller for Fuel cell using D.C. – D.C. converter, Inverter interaction with fuel cell for A.C. loads, A.C. Voltage build-up and controller for fuel cells- using power converters and transformers (isolation).

REFERENCE

[1] Mukhtar Ahmad, "Operation and Control of Renewable Energy Systems", Wiley, 2017.
[2] J Aabakken, "Power Technologies Energy Data Book: Fourth Edition", NREL, 2006.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **EET-649**

Course Name : **Application of Power Electronics in Smart Grid**

Credits : **3 L - 2 T - <u>1</u> P - <u>0</u>**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Introduction: Introduction to smart grid, electricity network, local energy networks, electric transportation, low carbon central generation, fundamental problems of electrical power systems, power flow control, distributed generation and energy storage, attributes of the smart grid, alternate views of smart grid.

Power Control and Quality Problems: Introduction, general problems and solutions of power control, power quality and EMC, power quality issues, monitoring, legal and organizational regulations, mitigation methods and EMC related phenomena in smart system, ECM cases in distributed power system.

High Frequency AC Power Distribution Platform: Introduction, high frequency in space applications, telecommunications, computer and commercial electronics system, automotive and motor drives, micro grids.

Integration of Distributed Generation with Power System: Distributed generation past and future, interconnection with a hosting grid, integration and interconnection concerns, power injection principle, injection using static compensators and advanced static devices, distributed generation contribution to power quality problems and current challenges.

Active Power Controllers: Dynamic static synchronous controllers, D-STATCOM, Dynamic static synchronous series controllers, dynamic voltage restorer, AC/AC voltage regulators.

Energy Storage Systems: Introduction, structure of power storage devices, pumped-storage hydroelectricity, compressed air energy storage system, flywheels, battery storage, hydrogen storage, super conducting magnet energy storage, super capacitors, applications of energy storage devices.

REFERENCE

[1] Strzelecki Benysek, "Power Electronics in Smart Electrical Energy Networks", Springer, 2008.

[2] Clark W Gellings, "The Smart Grid: Enabling Energy Efficient and Demand Side Response", CRC Press, 2009.

Department : **Department of Electrical Engineering**

Course Code : **EET-650**

Course Name : **Applications of Power Electronics in Power Systems**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Steady state and dynamic problems in AC systems: Flexible AC transmission systems (FACTS), Principles of series and shunt compensation, Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC),
Modelling and Analysis of FACTS controllers: Control strategies to improve system stability, Power Quality problems in distribution systems
Harmonics: Harmonics creating loads, modelling, harmonic propagation, Series and parallel resonances, harmonic power flow, Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker, Mitigation of power quality problems using power electronic conditioners, IEEE standards, HVDC Converters and their characteristics, Control of the converters (CC and CEA), Parallel and series operation of converters.

Text / References

[1] N.G. Hingorani & Laszlo Gyugyi ,Understanding FACTS , IEEE Press, 2000.

[2] E. F. Fuchs & Mohammad A.S. Masoum, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press 2008.

[3] K.R. Padiyar, FACTS controllers in power transmission and distribution, New Age International publishers, New Delhi, 2007.

[4] K.R. Padiyar, HVDC Power Transmission Systems, New Age International publishers, New Delhi, 1999.

Department : **Department of Electrical Engineering**

Course Code : **EET-651**

Course Name : **Optimization Algorithms**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Optimization Fundamentals – Definition, Classification of problems, Unconstrained and constrained optimization, Optimality conditions.
Linear Programming – Simplex Method, Duality, Sensitivity methods.
Nonlinear Programming – Powel's method, Steepest descent method, conjugate gradient method, Newton's method, GRG method, Sequential quadratic programming, Penalty function method, Augmented Lagrange multiplier method.
Dynamic Programming and Integer Programming – Interior point methods, Karmakar's algorithm, Dual affine, Primal Affine, Barrie algorithm
Meta- Heuristic Optimization – Simulated annealing, Evolutionary Programming, Genetic Algorithm, Swarm optimization and other nature inspired algorithms.

References:

[1] Rao S. S., "Engineering Optimization", New Age International Pvt Ltd.
[2] Gill Murray and Wright, "Practical Optimization", Academic Press.
[3] Laurence A. Wolsey, "Integer Programming", John wiley and Sons.
[4] Fred Glover, G. A. Kochenberger, "Handbook of Metaheuristics", Kluwer Academic Publishers.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **21EET849**

Course Name : **Power System Quality**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Power quality: concepts and definition, Power quality and voltage quality, Power quality standards, General classes of power quality problems, CBEMA and ITI Curves, Power quality terms, Power frequency variations

Long-duration voltage variations, Short-duration voltage variations , Voltage imbalance, Waveform distortion, Voltage sags and interruptions, sources of sags and interruptions Estimating voltage sag performance, Sensitivity of Equipment to voltage sag.

Transients: origin and classifications, capacitor switching transient, lightning-load switching, impact on users, protection, mitigation.

Power system harmonics: harmonics, inter-harmonics, sub-harmonics, Difference between harmonics and transients, voltage and current distortion, harmonic indexes, sources of harmonic distortion , effects of harmonic distortion, mitigation and control techniques, harmonic filters.

Power quality conditioners: shunt and series compensators, DSTATCOM-Dynamic voltage restorer, unified power quality conditioners-case studies

Text /Reference

[1] Surya Santoso, H. Wayne Beaty, Roger C. Dugan, Mark F. McGranaghan, "Electrical Power Systems Quality", McGraw-Hill, 2002.

[2] Bollen, M.H.J, "Understanding Power Quality Problems: Voltage sags and interruptions", IEEE Press, New York, 2000.

[3] C.Sankaran, "Power Quality" CRC Press

[4] ArindamGhosh, Gerard Ledwich, "Power quality enhancement using custom power devices", Springer, 2002.

[5] Angelo B. Baggini, "Handbook of power quality" , Wiley, 2008

[6] Arrillaga, J, Watson, N.R., Chen, S.,"Power System Quality Assessment", Wiley, NewYork, 2000

Department : **Department of Electrical Engineering**

Course Code : **EET-653**

Course Name : **Computer Networks**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

Course Contents

Computer Network – Hardware and Software, OSI and TCP reference Model, Transmission media, Wireless transmission, public switched telephone network - Structure, multiplexing and switching.
Data link layer - design issues, Data link protocols. Medium access sub layer - channel allocations, Multiple Access protocols, IEEE protocols.
Network layer - Design issues, routing algorithms, congestion control algorithms, QoS , Transport layer- Design issues, Connection management .
Application layer – DNs, Electronic mail, World Wide Web, multimedia, Cryptography, Internet transport protocols - TCP and UDP

References

[1] James F. Kurose and Keith W. Ross, ‘Computer Networking’, 2nd Edition, Pearson Education, 2003.
[2] Tanenbaum, A.S., 'Computer Networks', 4th Edition, Prentice Hall of India, 2003.
[3] Stallings, W., 'Data and Computer Communication',PHI,5th edition, 2000.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **EET-654**

Course Name : **Advanced Theory and Analysis of AC Machines**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Physical model, Different reference frame, Transformations, Primitive Machine, Dynamic variable, Formulation of dynamic equations of a generalized machine, Maxwell equations; Electric field of Transformers, Shaft voltages and fluxes, bearing currents, induction motor modelling, oscillations In Induction machines, Asymmetries in stator and rotor windings, Asynchronous-synchronous Operation of synchronous machine; Modelling, Operational Impedances, Time constants, Stability, Power angle characteristics, Symmetrical and Asymmetrical short circuit analysis, Measurement of Reactance, Power Systems.

References

[1] P C Krause, Analysis of Electric Machinery and Drive Systems, Wiley, 2010

[2] P S Bhimbra, Generalized Theory Of Electrical Machines, Khanna Publishers, 2006.

Department : **<u>Department of Electrical Engineering</u>**

Course Code : **EET-656**

Course Name : **Excitation of Synchronous Machines and their Control**

Credits : **3 L - 2 T - 1 P - 0**

Course Type : *Program Elective*

Prerequisites : none;

<u>Course Contents</u>

Excitation Systems: Principal Controls of a generating unit. Arrangement of excitation components, voltage response-ratio. Excitation specifications. Ceiling voltage, time constant and response of excitation systems. Requirements of excitation systems: Classification of excitation systems.

D.C. Excitation Systems: configuration of DC excitation system with main and pilot exciters. Amplidyne and magnetic amplifier. Automatic voltage regulator with magnetic amplifier and Amplidyne. Limitation and problems of DC excitation systems. Improvement in DC excitation system.

AC Shunt Excitation Systems (Static Rectifier Excitation Systems): Static thyristor rectifier schemes. Transient Response during fault condition. Use of booster transformer. Application for shunt excitation systems.

AC Separately Excitation Systems. (Alternator- Rectifier Excitation System): Scheme of alternator-rectifier excitation system with (i) diode rectifier and (ii) thyristor rectifier.

Comparison and Application of these schemes. Harmful effects of static excitation systems or system machine components, means of prevention.

Brushless Excitation Systems: Brush-slip ring problem. Scheme of Brushless excitation system with rotating diode. Control, protection and monitoring of Brushless excitation system. Introduction to brushless excitation system with rotating thyristors.

Introduction to Superconducting Exciter.

Automatic Voltage Regulator (AVR): Solid state automatic voltage regulator scheme. Auto and manual follow-up. Thyristor converter and AVR protection. Introduction to Digital AVR.

Excitation Control: Introduction to power stabilizing signal-speed, frequency and power signals. Rotor current limiter, MVAR limiter. Effect of excitation on generator power limits, Dynamic and Transient stabilities.

References

[1] Agamalov Oleg, 'Control Systems Structures of Synchronous Machines Excitation', LAP Lambert Academic Publishing, 2013.

[2] Jean Paul Louis,'Control of Synchronous Motors', Wiley, 2011