Curriculum of M.Tech Program in Power Control and Drives

Semester wise distribution of the courses

Semester I (M1)

Slot	Course Type	Course Number	Course	Marks		Hours L - T - P	Credits
				CIA	ESE		
A	DCC	22MA060B	Linear Algebra and Optimization Techniques	40	60	3 – 0 - 0	3
B	PCC	22EE161A	Power Converter Circuits	40	60	3 – 0 - 0	3
C	PCC	22EE161B	Modelling of Electrical Machines	40	60	3 – 0 - 0	3
D	PEC	22EE1XXX	Program Elective 1	40	60	3 – 0 - 0	3
E	PEC	22EE1XXX	Program Elective 2	40	60	3 – 0 - 0	3
S	RM	22MC061A	Research Methodology & IPR	40	60	2 – 0 - 0	2
T	LBC	22EE169A	Power Electronics Lab	100	-	0 – 0 - 2	1
Total				**340**	**360**	**19**	**18**

Teaching Assistance: 6 hours

Semester II (M2)

Slot	Course Type	Course Number	Course	Marks		Hours L - T - P	Credits
				CIA	ESE		
A	DCC	22EE160A	Electric Drives	40	60	3 – 0 - 0	3
B	PCC	22EE161C	Design Principles of Power Converters	40	60	3 – 0 - 0	3
C	PEC	22EE1XXX	Program Elective 3	40	60	3 – 0 - 0	3
D	PEC	22EE1XXX	Program Elective 4	40	60	3 – 0 - 0	3
E	IEC	22EE1XXX	Industry/Interdisciplinary Elective	40	60	3 – 0 - 0	3
S	PR	22EE167A	Mini project	100	-	0 – 0 - 4	2
T	LBC	22EE169B	Drives and Simulation Lab	100	-	0 – 0 - 2	1
Total				**400**	**300**	**21**	**18**

Teaching Assistance: 6 hours

Semester III (M3)

Slot	Course Type	Course Number	Course	Marks		Hours L - T - P	Credits
				CIA	ESE		
TRACK 1							
A*	MOOC	----	MOOC	To be successfully completed		-	2
B	AC	22AC071A	Audit Course	40	60	3 – 0 - 0	-
C	PR	22EE178A	Internship	50	50	-	3
D	PR	22EE178B	Dissertation Phase I	100	-	0 – 0 - 17	11
TRACK 2							
A*	MOOC	----	MOOC	To be successfully completed		-	2
B	AC	22AC171A	Audit Course	40	60	3 – 0 - 0	-
C	PR	22EE178A	Internship	50	50	-	3
D	PR	22EE178B	Research project Phase I	100	-	0 – 0 - 17	11
Total				**190**	**110**	**20**	**16**

Teaching Assistance: 6 hours

*MOOC must be successfully completed before the commencement of fourth semester. This course can be carried out at any time from M1 to M3.

Semester IV (M4)

Slot	Course Type	Course Number	Course	Marks		Hours L - T - P	Credits
				CIA	ESE		
TRACK 1							
D	PR	22EE178C	Dissertation Phase II	100	100	0 – 0 - 24	16
TRACK 2							
D	PR	22EE178C	Research project Phase II	100	100	0 – 0 - 24	16
Total				**100**	**100**	**24**	**16**

Teaching Assistance: 5 hours

Syllabus for the theory courses

1) Core courses in M1

#	Course category	Course code	Course Name	Creidts
1	DCC	22MA060B	LINEAR ALGEBRA AND OPTIMIZATION TECHNIQUES	3

Brief syllabus

Vector spaces –subspaces-Basis-null space and column space- linear Transformations - orthogonality – least square solutions - matrix factorizations.

Linear programming problems - Simplex Methods –Two phase method-Duality-Dual Simplex Method-Integer programming.

Non-linear programming (Unconstrained and constrained) Kuhn-Tucker conditions-quadratic programming - Dynamic programming.

#	Course category	Course code	Course Name	Creidts
2	PCC	22EE161A	POWER CONVERTER CIRCUITS	3

Brief syllabus

Power electronic switches-Switching constraints- Characteristics-Losses; Switch model; Uncontrolled Rectifier and Controlled Rectifiers: single phase- Three phase- Semi-converter-Inversion mode of operation.

DC –DC converter-Buck Converter- Boost converter- Buck- Boost converter- Cuk Converter.

Switched Mode Power Converter- Isolation and Protection- Flyback -Forward- Push Pull converters; Half Bridge converter; Full Bridge converter.

Voltage Source Inverters- Single Phase- Three Phase; PWM Techniques; Harmonic Elimination; Current Source Inverter; Multilevel Inverter.

#	Course category	Course code	Course Name	Creidts
3	PCC	22EE161B	MODELLING OF ELECTRICAL MACHINES	3

Brief syllabus

Basic two pole model of rotating machines, Primitive machine - transformer and rotational voltages in the armature voltage and torque matrix.

Transformations - passive linear transformation in machines- Park's transformation- invariance of power.

Application of generalized theory to DC Machine, Synchronous Machines, Three Phase Induction Machines, Single phase induction motor- Steady state and transient analysis. Double cage rotor representation.

2) Core courses in M2

#	Course category	Course code	Course Name	Creidts
1	DCC	22EE160A	ELECTRIC DRIVES	3

Brief syllabus

Introductory concepts of Drives- Multi-quadrant operation of Drives, Stability of drive systems, Closed loop speed control of DC motor drives. DC motor drives and its Operational Strategies- Controlled rectifiers and Chopper based Drive.

Induction Motor Drives: Steady state equivalent circuit of 3-phase Induction motor—Speed control techniques of induction motor, Slip power recovery schemes. Space Vector Model of Induction motor, Basic transformations in reference frame theory- Field Orientation.

Synchronous motor drives – VSI fed synchronous motor drives – V/f control and vector control, CSI fed synchronous motor drives, Vector control of Permanent Magnet Brushless DC Motors.

#	Course category	Course code	Course Name	Creidts
2	PCC	22EE161C	DESIGN PRINCIPLES OF POWER CONVERTERS	3

Brief syllabus

Thermal Design of Power modules. Application of heat sink design in three phase inverters and DC-DC converters.

Magnetics design based on area-product approach-High frequency transformer design and inductor design for DC-DC converter.

Techniques in bus-bar design for medium and high-power converters to minimise DC-bus loop inductance; Ground loops.

Gate drive circuit design; Popular gate drive circuits for MOSFETs, SCRs, BJTs and IGBTs.

Thermal protection de-saturation schemes; Basics of EMI/EMC issues.

3) Elective courses

a) Program Elective courses

List of Program Elective courses

#	Course code	Course Name
1.	22EE162A	Advanced Signal Processing
2.	22EE162B	Renewable Sources of Energy
3.	22EE162C	Flexible AC Transmission Systems
4.	22EE162D	Microcontroller Applications in Power Electronics
5.	22EE162E	Soft Computing Techniques
6.	22EE162F	PWM Schemes for Power Converters
7.	22EE162G	Dynamics of Linear Systems
8.	22EE162H	Application of Power Electronics in Power Systems
9.	22EE162I	Power System Protection
10.	22EE162J	Switch Mode Power Converters
11.	22EE162K	Power Electronics for Renewable Energy Systems
12.	22EE162L	Modern Power Converters
13.	22EE162M	Advanced Instrumentation
14.	22EE162N	Finite Element Methods for Electrical Machines
15.	22EE162O	EHVAC and DC Transmission
16.	22EE162P	Power Quality in Electrical Systems
17.	22EE162Q	Hybrid Electric Vehicles
18.	22EE162R	SCADA Systems and Applications
19.	22EE162S	Special Electrical Machines and Drives
20.	22EE162T	Analysis, Design and Grid Integration of Photovoltaic Systems

Syllabus of Program Elective courses

#	Course code	Course Name
1	22EE162A	ADVANCED SIGNAL PROCESSING

Brief syllabus

Discrete time signals and Systems: LTI systems, linear convolution, Discrete Fourier Transform and Fast Fourier Transform: Discrete time sequences, linear convolution using DFT, Fast Fourier Transform.

Filter Design Techniques: Bilinear transformation technique, Impulse invariance method. FIR filter design, Comparison of IIR and FIR Digital Filters.

Finite Word Length Effects and Time frequency analysis, Quantization in Sampling, Discrete Fourier Transform Computations, Time frequency distribution, Wavelet transform.

Multi rate signal processing: Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D, Application.

#	Course code	Course Name
2	22EE162A	RENEWABLE SOURCES OF ENERGY

Brief syllabus

Direct solar energy-Solar radiation data - Solar Energy Applications. Energy from oceans-Wave energy generation-Wave energy conversion devices; Tidal energy - basic principles, tidal power generation systems, Ocean thermal energy conversion.

Wind energy- Wind energy conversion systems- design of windmills, Types of wind machines, Small hydro power stations- Turbines and generators for SHP; Biomass and biofuels – Biogas generation: types of biogas plants- Applications of biogas; Energy from waste;

Geothermal energy-classification of geothermal resources- schematic of geothermal power plants. Power from satellite stations; Hydrogen energy; Nuclear Fusion energy.

b) Industry Elective courses

#	Course code	Course Name
3	22EE162C	FLEXIBLE AC TRANSMISSION SYSTEMS

Brief syllabus

Power flow control – Voltage regulation and Reactive power flow control. Benefits of FACTS -Transmission line compensation - Phase angle control. Reactive power compensation – shunt and series compensation principles. Converters for static compensation.

Static shunt Compensator - TCR, TSR, TSC, FC-TCR - Static Series compensator - Variable impedance type series compensators – GCSC, TCSC, TSSC. Static Voltage and Phase Angle Regulators - TCVR &TCPAR.

Shunt Compensators -SVC and STATCOM –Series Compensators – SSSC. Combined series-shunt compensator –UPFC Basic principle of P and Q control - IPFC. Simulation of FACTS controllers.

#	Course code	Course Name
4	22EE162D	MICROCONTROLLER APPLICATIONS IN POWER ELECTRONICS

Brief syllabus

Evolution of microcontrollers: 8051 architecture, Interrupts & Timers/Counters. Serial data input/output, Internal RAM & ROM, interfacing with external memory, ADC & DAC interfacing with the controller, PWM signal generation using timer/counter.

Microprocessor based applications and control: Measurement of non-electrical quantities like Strain, Temperature, Speed and Torque. Per-unit representation of variables in digital domain- Implementation of P, PI and PID controllers using microprocessors

Applications of MCS-51 Microcontrollers, Microcontroller Based Firing Scheme generation for Converters and motor control.

#	Course code	Course Name
5	22EE162E	SOFT COMPUTING TECHNIQUES

Brief syllabus

Introduction – Difference between soft computing and hard computing, artificial intelligence.

Artificial Neural Networks –ANN models, architecture, Learning, Supervised and unsupervised learning, Back propagation network, Adaptive Resonance Theory, Case studies.

Fuzzy logic – Fuzzy set properties and operations; membership functions, Fuzzy logic systems, Applications. Genetic Algorithm – basic concepts, operators, steps.

Hybrid Systems – Adaptive Neuro-fuzzy Inference System, Genetic algorithm based back propagation networks, fuzzy back propagation networks.

#	Course code	Course Name

6	22EE162F	PWM SCHEMES FOR POWER CONVERTERS

Brief syllabus

Single-Pole-Double-Throw and Single-Pole-Multi-Throw representation of power converters- Topologies of Inverters.

Fourier Analysis of single phase and three phase Inverters-Basic modulation techniques - implementation of unipolar and bipolar modulation.

Three phase Voltage Source Inverters -Sine-Triangle PWM -Space Vector PWM-Comparison. Harmonic distortion and losses in PWM-Over modulation-Current controlled PWM. Multilevel Converters-Topologies-Principle of operation-Modulation Strategy.

#	Course code	Course Name
7	22EE162G	DYNAMICS OF LINEAR SYSTEMS

Brief syllabus

Design of feedback control systems- Review of compensator design using Root locus and Bode plots- PID controllers

State Space Analysis Design- Linear state variable feedback for SISO systems- Transfer function approach-controllable and uncontrollable modes - regulator problems,

Observers - Asymptotic observers for state measurement-implementation of the observer-full order and reduced order observers combined observer–controller

MIMO systems - Introduction-controllability-observability- different companion forms for MIMO systems.

#	Course code	Course Name
8	22EE162H	APPLICATIONS OF POWER ELECTRONICS IN POWER SYSTEMS

Brief syllabus

Flexible AC Transmission- Series and Shunt Compensation - Types of FACTS controllers. Operation and control of SVC, STATCOM, TCSC, SSSC

Power Quality problems in distribution systems-harmonics-Passive and active Filters - IEEE standards for power quality.

Need for HVDC, AC vs. DC: Comparative advantages. Converters and their characteristics. Control of the converters.

Distributed generation-Grid Interconnection - Modelling of converters in DG-Protection and control of grid converters.

#	Course code	Course Name
9	22EE162I	POWER SYSTEM PROTECTION

Brief syllabus

Computer relaying - Review of relaying practices; Review of mathematical basis for protective relaying algorithms.

Transmission line relaying algorithms; Protection of transformers, Machines and buses; Power transformer algorithms; digital protection of generators and motors.

Hardware organization; System relaying and control; Development in new relaying principles; recent developments in relaying.

#	Course code	Course Name
10	22EE162J	SWITCH MODE POWER CONVERTERS

Brief syllabus

Linear Regulators and Switching Regulators- Analysis of buck converter, boost converter and buck-boost converter. Analysis of fly back converter, Forward converter- Double ended forward converter-AC power supplies- power line disturbances- UPS.

Voltage mode control of SMPS- Current mode control of SMPS- Small signal approximation- Equivalent Circuit Modelling.

AC modelling -Perturbation and Linearization-Modelling the pulse width modulator; State Space averaging–Modelling of Flyback converter. Resonant converters, Resonant switch converters; High frequency link integral half cyclo converter.

#	Course code	Course Name
11	22EE162K	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Brief syllabus

Environmental aspects of electric energy conversion, Qualitative study of various renewable energy systems.

Solar PV Systems -boost and buck-boost converters-Charge controllers- Batteries.

Design of a Standalone PV System -Selection of inverter, Battery sizing, Array sizing;

Wind Energy Conversion Systems -AC Voltage controllers -Grid interactive inverters-matrix converters.

Analysis of SCIG, DFIG and PMSG- Operation of Standalone and Grid integrated WECS.

Grid Integrated solar system - Hybrid Renewable Energy systems, MPPT algorithms of PV and WECS.

#	Course code	Course Name
12	22EE162L	MODERN POWER CONVERTERS

Brief syllabus

Switched mode power converters: Buck, Boost, Buck - Boost converter, Cuk. DC-DC converter with isolation: Flyback, Forward , Push – Pull , Half Bridge and Full Bridge converter.

Series and parallel resonant inverters; Zero current and Zero voltage switching resonant converters;

Control of switched mode DC power supplies: Single Phase: Monolithic PWM control circuit, Electromagnetic and radio frequency interference.

AC power supplies, classification: Resonant AC power supplies, Introduction power line disturbances.

#	Course code	Course Name
13	22EE162M	ADVANCED INSTRUMENTATION

Brief syllabus

Generalized performance characteristics of instruments. Dynamic response and frequency response studies, Response of a general form of instrument.

Plant level automation- process and instrumentation diagrams Performance modelling, Telemetry, Pneumatic Instrumentation; Reliability in Instrumentation and Control.

Petrinet models, Smart Sensors, Wireless sensors and Wireless Sensor network protocol.

Virtual instrumentation – Definition, flexibility – Block diagram and architecture of virtual instruments– Virtual instruments versus traditional instruments Review of software in virtual instrumentation - VI programming techniques.

#	Course code	Course Name
14	22EE162N	FINITE ELEMENT METHODS FOR ELECTRICAL MACHINES

Brief syllabus

Need for Field Analysis based design- Recent Trends Mathematical Formulation of Field Problems- Development of Torque/Force

Electromagnetic Field Equations, Philosophy of FEM - Differential/Integral Equations - Finite Difference Method - Finite Element Method- boundary conditions.

Rayleigh Ritz and Galerkin Approach to finite Elements- Normal gradient boundary conditions- Forced and natural boundary conditions.

Elements of CAD Systems - Preprocessing - Modeling - meshing - Material Properties - Boundary Conditions - Setting up Solutions- The electric field-finite element analysis.

#	Course code	Course Name
15	22EE162O	EHVAC AND DC TRANSMISSION

Brief syllabus

EHV AC transmission- interconnected AC networks-HVDC transmission system- Power flow in AC and HVDC lines-steady state U_d/I_d characteristics.

Converter circuits- analysis of converters- control characteristics; Harmonics and filters. Reactive power requirements in HVDC substations- planning of HVDC; DC line oscillations and line dampers-over voltage protection; Earth electrode.

EHV AC Transmission; Corona; Insulation requirements of EHV AC and DC transmission lines; insulation coordination; switching over voltage.

#	Course code	Course Name
16	22EE162P	POWER QUALITY IN ELECTRICAL SYSTEMS

Brief syllabus

Power quality issues in distribution systems, Need for power quality monitoring, IEEE guides, standards and recommended practices

Modeling of networks and components under non- sinusoidal conditions, Harmonic Analysis, Effects of Power System harmonics on Power System equipment and loads.

Harmonic elimination, Dynamic voltage restorers and UPQC control strategies.

#	Course code	Course Name
17	22EE162Q	HYBRID ELECTRIC VEHICLES

Brief syllabus

Hybrid Electric Vehicles, Basics of vehicle performance: Dynamics of electric and hybrid vehicles. Hybrid Electric Drivetrains.

Electric Propulsion unit, Configuration and control of DC Motor, Induction Motor drives, Permanent Magnet Motor drives, Switched reluctance motor.

Energy Storage Requirements, Hybridization of different energy storage devices. Sizing the drive system, Matching the electric machine and the internal combustion engine.

Design of a Hybrid Electric Vehicle and Battery Electric Vehicle. In vehicle networks, Energy Management Strategies.

#	Course code	Course Name
18	22EE162R	SCADA SYSTEMS AND APPLICATIONS

Brief syllabus

Introduction to SCADA systems, Fundamental Principle and components, Monitoring and supervisory functions, Application area of SCADA system.

SCADA Architecture: Various SCADA architectures, SCADA Communication: Various industrial communication, Open standard communication protocols, Operation and control of interconnected power system, Automatic substation control.

SCADA configuration, Energy management system, System operating states, System security, state estimation, SCADA Applications.

#	Course code	Course Name
19	22EE162S	SPECIAL ELECTRICAL MACHINES AND DRIVES

Brief syllabus

Stepper motor- single phase stepping motors, torque production, Static and Dynamic characteristics, Drive systems for open loop and, Closed loop control.

Switched reluctance motor- Torque equation, Power controllers, Characteristics and control.

Permanent Magnet Brushless DC motor- Commutation in DC motors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives.

Permanent Magnet Synchronous motor- Phasor diagram, Torque speed characteristics, Self control, Vector control, Current control schemes. Sensor less control.

#	Course code	Course Name
20	22EE162T	ANALYSIS, DESIGN AND GRID INTEGRATION OF PHOTOVOLTAIC SYSTEMS

Brief syllabus

Solar Cell- Design of Solar Cells, Mismatch in cell/module. PV module equivalent parameters, Effect of Variation of Solar Insolation and Temperature –Batteries for PV systems, MPPT Algorithms, Mechanical Tracking.

Design of DC-DC converter, single phase and three-phase inverter with PV as a source.

Grid Synchronization: Grid support features of utility, Micro-grids, and frequency/voltage control in islanded mode of operation, distributed storage and smart grid concepts.

Stand-alone PV system, Grid Interactive PV System, Hybrid solar PV system. Over current protection of solar PV power system.

c) Interdisciplinary courses/Indusry

List of Interdisciplinary courses/Indusry

#	Course code	Course Name	Offering Department
1.	22EE165A	Solar and Wind Energy Conversion Systems	**EED**
2.	22EE165B	Electric Vehicle Technology	**EED**
3.	22EE165C	Process Control and Industrial Automation	**EED**
4.	22EE165D	Embedded Systems and Real Time Applications	**EED**
5.	22EE165E	Smart Grid and Energy Storage Systems	**EED**
6.	22EE165F	Electrical System Design and Building Services	**EED**

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