DEPARTMENT OF ELECTRICAL ENGINEERING

Revised Scheme

(To be implemented from July 2015)

and

Course Book

for

M.Tech. (Power Electronics and Drives)

Visvesvaraya National Institute of Technology

July 2015

Brief about M.Tech (Power Electronics and Drives) program:

The main objectives of Power Electronics and Drives (PED) PG program are

1. To develop specified manpower for electrical power and energy industry.
2. To enhance analytical skills so as to enable to solve complex industrial problems.
3. To augment the student's capacity in pursuing research in emerging areas of power electronics and drives.
4. To improve student's perspective towards environmental issues by sensitizing and building the awareness of green technologies.
5. To inculcate the culture of research oriented projects with state of art facility laboratories in power electronics and drives.

Department of Electrical Engineering offers M.Tech program in Integrated Power Systems & M.Tech program in Power Electronics & Drives. These are four semester programs, wherein students has to complete certain number of credits as indicated in Table 1. Each subject (or course) has certain number of credits. There are two types subjects: Core and Elective. Core courses are compulsory and some courses from electives are to be taken to complete the required credits.

Table – I

Credit requirements for M Tech (Power Electronics and Drives) program

Departmental core (DC)		**Departmental Electives (DE)**	
Category	Credit	Category	Credit
Program core (PC)	39	Program Electives (PE)	13
Grand Total (PC + PE)			52

The number of credits attached to a subject depends on number of classes in a week. For example, a subject with 3-0-2 (L-T-P) means it has 3 Lectures, 0 Tutorials and 2 Practical hours in a week. This subject will have 4 credits (3x1 + 0x1 + 2x0.5 = 4). If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:-

Grades	AA	AB	BB	BC	CC	CD	DD	FF
Grade Points	10	09	08	07	06	05	04	Fail

The performance of a student will be evaluated in terms of two indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. SGPA & CGPA are:

$$\textbf{SGPA} = \frac{\sum_{\text{semester}} (\text{Course credits X Grade points}) \text{for all courses except audit}}{\sum_{\text{semester}} (\text{Course credits }) \text{for all courses except audit}}$$

$$\textbf{CGPA} = \frac{\sum_{\text{All semester}} (\text{Course credits X Grade points}) \text{for all courses with pass grade except audit}}{\sum_{\text{All semester}} (\text{Course credits }) \text{for all courses except audit}}$$

Students can Audit a few subjects. i.e., they can attend the classes and do home work and give exam also, but they will not get any credit for that subject. Audit subjects are for self enhancement of students.

The Cumulative Grade Point Average (CGPA) earned by the student on a scale of 10 is an indication of his/her academic standing and in the class. Where, for purpose of placement of students and/or their eligibility for competitive exams etc., a conversion of CGPA to percentage is required, a CGPA of 10 may be deemed to be 100% and accordingly the following table is used for conversion. Further, the institute does not issue certificate towards position/rank at the class or institute level.

CGPA	4.00	5.0	6.0	7.0	8.0	9.0	10.0
Percentage	40	50	60	70	80	90	100

Details about faculty members of Electrical Engineering Department

Name of Faculty Member	Designation	Qualification	Areas of Specialization
Aware M.V.	Professor	Ph. D.	Electrical Drives, Power Electronics, High Voltage Engineering
Ballal M.S.	Associate Professor	Ph. D.	Condition Monitoring, Incipient Fault Detection, Power Quality
Bhat S.S.	Associate Professor	Ph. D.	Power System Analysis
Bhide S.R.	**Professor & HoD**	Ph. D.	Power System Protection, Artificial Intelligence Technique
Borghate V.B.	Associate Professor	Ph. D.	Power Electronics, Electrical Machine Design
Chaudhari M.A.	Associate Professor	Ph. D.	Power Quality, Power Electronics
Dhabale A.	Assistant Professor	M.Tech.	Control Systems, Electrical Drives
Junghare A.S.	Associate Professor	Ph. D.	Power Systems, Control Systems
Kale V.S.	Associate Professor	Ph. D.	Power System Protection, A.I Applications in Power Systems
Khedkar M.K.	Professor	Ph. D.	Power Systems
Kulkarni P.S.	Associate Professor	Ph. D.	Power Systems Operation & Control, Renewable Energy Systems
Keshri Ritesh *	Assistant Professor	Ph D	Power Electronics and Drives
Lokhande M. M.	Assistant Professor	Ph. D.	Power Electronics, Electrical machines, Electric Vehicles, photovoltaic
Patne N.R.	Assistant Professor	Ph. D.	Power Systems, Power Quality
Ramteke M.R.	Associate Professor	Ph. D.	Power Electronics
Satputaley R.J.	Assistant Professor	M.Tech.	Power Systems, Power Quality
Suryawanshi H.M.	Professor	Ph. D.	Power Electronics, Electrical Drives
Tambay S.R.	Assistant Professor	M.Tech.	Power System Protection, Power System Analysis
Umre B.S.	Associate Professor	Ph. D.	Power Systems, Electrical Machines

- Will be joining on 14^{th} Aug., 2015

CREDIT REQUIREMENTS FOR M.TECH (POWER ELECTRONICS AND DRIVES)

Program Core (PC)		**Program Elective (PE)**	
Category	Credit	Category	Credit
Program Core (DC)	39	Program Electives (DE)	13
Grand Total (PC + PE)			52

Details of credits:

I Semester				**II Semester**			
CORE				**CORE**			
Code	**Course**	**L-T-P**	**Cr**	**Code**	**Course**	**L-T-P**	**Cr**
EEL518	Electrical Drives-I	3-0-0	3	EEL510	Electrical Drives-II	3-0-0	3
EEL522	Power Electronics Converters	3-0-0	3	EEL523	Analysis & Design of PE Converters	3-0-0	3
EEL525	Processor Application in PE	3-0-0	3	EEL526	Analysis of FACTS devices	3-0-0	3
EEP519	Electrical Drives Lab	0-0-2	1	EEP524	Simulation/ Implementation of PE circuits	0-0-2	1
EEP520	Power Electronics Lab	0-0-2	1	EEP526	Analysis of FACTS devices lab	0-0-2	1
EEP525	Processor Application in PE Lab	0-0-2	1				
ELECTIVE (Any Two)				**ELECTIVE (Any One Theory)**			
EEL514	Pulse width modulation Techniques for Power Converters	3-0-0	3	EEL431	Smart Grid	3-0-0	3
EEL516	Advanced Control Theory	3-0-0	3	EEL511	Special Topics in PE	3-0-0	3
EEL532	Analysis of Electrical Machines	3-0-0	3	EEL512	Distributed Generation	3-0-0	3
				MAL505	Applied Linear Algebra	3-0-0	3
	Total No of Credits	**18**			**Total No of Credits**	**14**	

III Semester				IV Semester			
CORE				CORE			
Code	**Course**	**L-T-P**	**Cr**	**Code**	**Course**	**L-T-P**	**Cr**
EEL515	Digital Control System	3-0-0	3	EED504	#Project Phase II (# prerequisite: Project Phase-I)	-	9
EEP515	Digital Control System Lab	0-0-1	1				
EED503	Project Phase-I	---	3				
Elective (Any one (theory + lab) combination)							
EEL505	AI based Systems	3-0-0	3				
EEL521	Advanced Power Quality	3-0-0	3				
EEP505	*AI based Systems Lab	0-0-2	1				
EEP521	* Advanced Power Quality lab	0-0-2	1				
	Total No of Credits	**11**			**Total No of Credits**	**9**	

*Compulsory with theory course

FIRST SEMESTER M. TECH (PED)

EEL518: ELECTRIC DRIVES-I (3-0-0- Credits-3)

Objectives:

- ***Basic electrical drives and their analysis.***
- ***Design of controller for drives.***
- ***Scalar control of electrical drives.***

Syllabus:

Dynamics of Electric Drives: Fundamentals of torque equations, speed torque convention and multi-quadrant operation, components of load torques, classification of load torques, steady state stability, load equation. Speed control and drive classification, close loop control of drives.

DC motor drives- Modeling of DC machines, steady state characteristics with armature and speed control, phase controlled dc motor drives, chopper controlled DC motor drives.

Poly-phase induction machines- Dynamic modeling of induction machines, small signal equations, control characteristics of induction machines. Phase-controlled induction machines, stator voltage control, slip energy recovery scheme, frequency controlled induction motor drives.

Industrial drives- Traction motors, stepper motor, servo motor.

Text Books:

1. G.K, Dubey, "Power semiconductor controlled Drives", Prentice Hall international, New Jersey, 1989.
2. R.Krishanam, “Electric motor drives modeling, analysis and control”, PHI-India-2009.

Reference Books:

1. G. K. Dubey – Fundamentals of electric Drives, Narosa Publishing House, 2nd edition, 2011.
2. W. Leonhard – Control of Electrical drives, Springer, 3rd edition, 2001.
3. P.C. Krause – Analysis of Electric Machine, Wiley-IEEE press 3rdedition.
4. B. K. Bose – Modern Power Electronics and AC Drives, Prentice Hall publication, 1st edition, 2001.

Course outcomes:

Students are able to

- ***Select and implement the drives for industrial processes.***
- ***Design scalar control drive for industrial application.***
- ***Implement various variable speed drives in electrical energy conversion systems.***

EEL522: POWER ELECTRONICS CONVERTERS (3-0-0- Credits-3)

Objectives:

- **To get insight into power semiconductor switching devices and switching characteristics**
- **To analyze performance of different converters**
- **To study applications of converters**

Syllabus:

1. Review of power semiconductor devices, VI-Characteristics (ideal and practical), gate driver circuits.
2. DC-DC Converters: various types, analysis, control of converter, duty ratio control, current & voltage control.
3. Voltage Source Inverters (VSI): principle and steady state analysis of VSI, methods for controlling inverter, equivalent circuit.
4. AC To DC Converters: line commutated & PWM converter, multi-quadrant operation, regeneration, input current and reactive power requirements.
5. Converter applications

Text Books:

1. N. Mohan, T. Undeland, and W. Robbins, "Power Electronics Converters, Applications, and Design," Third edition, 2003, John Wiley and Sons Inc.

2. M.H. Rashid. "Power Electronics, circuit, Devices and applications," Prentice Hall of India.

Reference Books:

1. Robert W Erickson , "Fundamentals of Power Electronics" , Springer. Second edition-2000,
2. Marian K. Kazimierczuk ,"Pulse-Width Modulated DC_DC power converter ", John Wiley & sons Ltd. ,2008
3. M P. Kaźmierkowski, R Krishnan , F Blaabjerg "Control in Power Electronics" , Elsevier Science (USA), 2002,

Course outcomes:

Students are able to
1. Use semiconductor devices in different applications.
2. Design magnetic circuits.
3. Design different PWM techniques.
4. Implement converter topologies

EEL525: PROCESSOR APPLICATIONS IN POWER ELECTRONICS (3-0-0- Credits-3)

Objectives:

- ***To study microcontroller and its applications in electrical engineering***
- ***To learn DSP and microprocessor based applications for PE and drives***

Syllabus:

Micro controller 8051, Special Function Registers, Interfacing with external memory, programmable built in ports, on chip counters / timers, Serial Data Input/Output, Interrupts, assembly language Programming and applications.

Need of Digital Signal Processor (DSP), Examples of TI DSP family. Comparison of different DSPs of TI, Architecture of DSP TMS 320 F2812, pin diagram, main features, Block diagram, peripherals as CPU timers, Event managers, ADC, Enhanced controller area network (eCAN), Serial communication interface modules, Digital i/o and shared pin functions, serial peripheral interface module, PIE block.

Register Functional Overview, Register Bits I/O Mapping, PLL based Modes of Operation, PLL Control Register (PLLCR) field Description, Peripheral Clock Control, High-Speed Peripheral Clock Prescaler (HISPCP) Register, Watchdog Block, EALLOW Protected Registers, All GP registers, GP Timers, Compare units, Timer operating modes, DBTCON register, PWM waveform generation and programming.

Applications of Digital Signal Processor in Power Electronics converters and drives, FPGA based controller for PE and Drives.

Text Books:

1. eZdspTM F2812 technical reference
2. TMS320x281x DSP Data manual.
3. Muhammad Ali Mazidi , “The 8051 Microcontroller And Embedded Systems Using Assembly And C, 2/E”, Pearson Education India, 01-Sep-2007.

Reference Books:

1. Ayala, J. Kenneth, “The 8051 Microprocessor Architecture, Programming and Applications”, Penram International, 1996.
2. TMS320x281x DSP Event Manager (EV) Reference Guide
3. Trevor Martin, "The Insider's Guide To The Philips ARM7-Based Microcontrollers", Published by Hitex (UK) Ltd, April 2005.

Course Outcomes:

Students are able to

- ***develop program in microcontroller to control converter***
- ***configure different registers in DSP TMS 320 F2812***
- ***implement different PWM technique using DSP***
- ***design and implement DSP based systems.***

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EEP519: ELECTRICAL DRIVES LAB (0-0-2-Credits -1)

List of experiments:

1) Time response of the separately excited dc motor.
2) Three phase fully controlled converter driven DC Sep. Exc. Motor.
3) DC-DC Buck converter for DC motor speed control.
4) DC-DC boost converter for DC motor speed control.
5) 1-phase AC Voltage controller for IM.
6) 1-phase inverter operation and performance analysis.
7) PID controller-Design and implementation for close loop operation of electrical drives.
8) ABC to DQ transformation of machine variables.
9) *v/f* control of induction motor drive.

EEP520: POWER ELECTRONICS LAB (0-0-2- Credits-1)

List of experiments:

1. To Study DC-DC BUCK Converter
2. To Study DC-DC BOOST Converter
3. To Study DC-DC BUCK-BOOST Converter
4. To Study DC-DC Cuck Converter
5. To Study DC-DC Forward Converter
6. To Study DC-DC Flyback Converter
7. To Study AC-DC fully controlled Inverter
8. To Study different PWM techniques. (FFT, Crest Factor, P.F, DPF).

EEP525: PROCESSOR APPLICATIONS IN P.E. Lab (0-0-2-Credits-1)

List of experiments:

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1. Microcontroller 8051 based
   - (i) AC voltage controller.
   - (ii) 1-phase control rectifier.
   - (iii) DC-DC Buck / Boost /Buck-Boost converter.
   - (iv) Light dimmer.
   - (v) Integral cycle controller.
   - (vi) ON –OFF AC Voltage controller.

   Any one from above, including software and hardware.

2 &3. Any two experiments from the following list first is to be completed including software and hardware using D-Space 1104 & second using DSP-2812
   - (i) Single pulse PWM for 1- phase inverter.
   - (ii) Multiple pulse PWM for 1- phase inverter.
   - (iii) 3- Phase Inverter operating in square wave mode (180^0 operation).
   - (iv) 3- Phase Inverter with 120^0 mode of operation.
   - (v) Sinusoidal PWM technique in 1-phase Inverter.
   - (vi) Sinusoidal PWM technique in 3-phase Inverter.

EEL514: PULSE WIDTH MODULATION TECHIQUES FOR POWER CONVERTERS (3-0-0- credits-3)

Objectives:

- ***Necessity and importance of PWM techniques.***
- ***Implementation of PWM controllers.***

Syllabus:

Introduction to PE converters-Modulation of one inverter phase leg-Modulation of single phase VSI and 3 phase VSI, Zero space vector placement modulation strategies, Losses-Discontinuous modulation, Modulation of CSI, Over modulation of converters, programme modulation strategies, pulse width modulation for multilevel inverters, Implementation of modulation controller, Continuing developments in modulation as random PWM, PWM for voltage unbalance, Effect of minimum pulse width and dead time

Text Books:

1. D. Grahame Holmes, Thomas A. Lipo, "Pulse width modulation of Power Converter: Principles and Practice", John Wiley & Sons, 03-Oct-2003

2. Bin Vew, "High Power Converter", Wiley Publication

Reference Books:

1. Marian K. Kazimicrczuk, "Pulse width modulated dc-dc power converter", Wiley Publication
2. IEEE papers

Related Links:

1. nptel.ac.in

Course Outcomes:

Students are able to

- ***Appreciate importance of PWM techniques***
- ***Implement PWM using different strategies***
- ***Control CSI and VSI using PWM***
- ***Compare performance of converter for different PWM technique***

EEL516: ADVANCED CONTROL THEORY (3-0-0- Credits-3)

Objectives:

- ***The course provides glimpses into the advanced methods of modeling and analysis of the dynamical systems***
- ***The course is a strong step in inculcating the research aptitude in the students***

Syllabus:

Math Modeling of Dynamical Systems: Newtonian and Lagrangian approaches, concept of dynamical state of a system, concept of equilibrium point, linearisation of non-linear model.
Review of Linear Algebra concepts: Field, Vector space, linear combination, linear independence, bases of a vector space, representation of any vector on different basis, matrix representation of a linear operator, change of basis, rank, nullity, range space and null space of a matrix, Eigen value and Eigen vector of a matrix, similarity transform, diagonalisation.
Modern Control Analysis: Concept and computation of systems modes, controllability theorem and its proof, observability theorem and its proof, controllable and observable subspaces.
Stability Analysis: Stability of linear systems, stability types and their definitions for any general system, stability of an equilibrium point, Lyapunov stability theory for LTI systems, quadratic forms and Lyapunov functions.
Modern Control Design: Converting the math model to controllable canonical form and its use for pole placement, concept of linear observer and its design, design of reduced order observer, compensator design using separation principle, poles of compensator, open-loop and close-loop systems.
Optimal Control Theory: Introduction to the philosophy of optimal control, formulation of optimal control problem, different performance criterion, linear quadratic regulator (LQR) and optimum gain matrix, Riccati equations, conceptual models and statistical models for random processes, Kalman filter.

Text Books:

1. Control System Design: An Introduction to State-Space Methods, Bernard Friedland, Dover Publications, Inc. Mineola, New York.
2. Linear Systems, Thomas Kailath, Prentice-Hall Inc., New Jersey.

Reference Books:

1. Modern Control System Theory,M. Gopal, New Age International (P) Limited, New Delhi.
2. Linear System Theory and Design, Chi-Tsong Chen, Oxford University Press Inc., New York.

Course Outcomes:

Students are able to

- ***Obtain mathematical model of dynamical systems.***
- ***Appreciate concept of linear algebra***
- ***Analyze the system dynamics and Lyapunov stability theory***
- ***Design linear quadratic controller***

EEL532: ANALYSIS of ELECTRICAL MACHINES (3-0-0- Credits-3)

Objectives:

- ***To get acquainted with mathematical modeling of synchronous and induction machine***
- ***To learn dynamics of speed control of AC machines***

Syllabus:

Elements of generalized theory Basic two pole machine, Transformer and speed voltages in the armature, Kron's primitive machine, Analysis of Electric Machines.
Linear transformation in machines-Invariance of power, transformation from a displayed brush axis, Reference theory Transformation from 3 phases–to-2 phase, (α-β and d-q transformation), Physical concept of Park's transformation.Transformation between reference frames.

Polyphase Induction Machines- Mathematical Modeling of Induction Machines. Voltage and torque equations in machine variables, Linearised equations of induction and synchronous machines, Small displacement stability-eigen values, Reduced order equations of induction and synchronous machines.

Analysis of steady state and dynamic operation of Induction Motor. Control theories of motor-Scalar and vector control of induction and synchronous machine, Direct torque control of induction and synchronous machine.
Operation and Control of special machines-Basic operation and control of BLDC, PMBLDC and SRM motors.

Text Books:

1. P. C. Krause, Oreg Wasynczuk, Scott D. Sudhoff, "Analysis of Electric Machinery and drive systems" , IEEE Press, 2002.
2. P. S. Bhimbra, "Generalized Theory of Electrical Machines", Khanna Publications.

Reference Books:

1. Werner Leonhard, "Control of Electrical Drives", Springer; 3rd edition, 2001.
2. D. P. Sen Gupta and J. W. Lynn, "Electrical Machine Dynamics, The Macmillan Press, 1980.
3. T.J.E Miller, "Brushless permanent Magnet & Reluctance Motor Drives" clarendom press, Oxford 1989.
4. Kenjo T and Nagamoris "Permant Magnet & brushless Dc motor" Clarendon press, Oxford, 1989.

Course outcomes:

Students are able to

- design the induction machine for starting, accelerating and breaking time w.r.to rotor resistance
- analyse of different types of control theories of Induction and Synchronous machines
- model and simulate AC machines for advanced studies.
- utilize BLDC and SRM motors.

SECOND SEMESTER M. TECH (PED)

EEL510: ELECTRICAL DRIVES-II (3-0-0-Credits- 3)

Objectives:

- ***To learn design of controllers for drives***
- ***To study DSP based control approach for drives***

Syllabus:

1. Design of speed and torque controllers for dc drives, converter selection & its characteristics, harmonics & associated operational problems.
2. Vector controlled of induction motor drives, A qualitative examination, Mathematical description of vector control, Detuning effects in induction motor vector control.
3. Direct torque control of induction motor, Sensor less operation of the induction motor drives.
4. Permanent Magnet Synchronous & Brushless dc motor drives control, Switch Reluctance Motor control.
5. DSP applications in drives control. Basic control scheme implementation with DSP.

Text Books:

1. R. Krishnan, “Electric Motor Drives, Modeling, Analysis & control”, Prentice Hall of India.
2. B. K. Bose, “Modern Power Electronics and AC drives”, Prentice Hall of India.

Reference Books:

1. Boldea & S.A.Nasar, “Electric Drives”, Taylor & Francies.
2. Vedan Subrahmanay, “Electric drives, concepts & Applications”.
3. A. Hamid Toliyat and Steven Campbell, “DSP based Electromechanical Motion Control”, By, CRC Press, 2004.

Course Outcomes:

Students are able to

- ***select type of drive for AC and dc motor***
- ***design dc drive***
- ***derive dynamic model of ac motor, compare scalar and vector control of induction motor***
- ***develop DSP program for implementation of control of drive.***

EEL523: ANALYSIS AND DESIGN of POWER ELECTRONIC CONVERTERS (3-0-0- Credits-3)

Objectives:

- ***Modeling of converters***
- ***Design aspects of converters***
- ***Selection of reactive components***

Syllabus:

1. Switched mode converters: Topologies steady state & dynamic analysis, modeling and control, EMI issues.
2. Soft switching converters: Resonant converters, topologies, steady state and dynamic analysis, modeling and control.
3. Multilevel converters: principles, topologies, control and applications.
4. Other Advanced converters: Multi pulse converters, high power factor converter, matrix converter.
5. Closed loop control: Feedback and stability, stability criteria, frequency response.
6. Design and selection of Magnetic components Inductor, HF transformer, line and EMI filter, heat sink calculations.

Text Books:

1. N. Mohan, T. Undeland, and W. Robbins, “Power Electronics Converters, Applications, and Design,” Third edition, 2003, John Wiley and Sons Inc.
2. Rashid M.H. “Power Electronics, circuit, Devices and applications”, Prentice Hall of India.

Reference Books:

1. IEE & IEEE papers.

Course outcome:

Students are able to
1. Design DC-DC converter independently.
2. Use components of converter such as heat sinks, selection of devices, ratings etc.
3. Apply knowledge to design and develop new converters.
4. Design new control techniques for converters.

EEL526: ANALYSIS OF FACTS DEVICES (3-0-0-Credits- 3)

Objectives:

- ***To appreciate the role of FACTs devices in power system***
- ***To study modeling and analysis of FACTs devices***
- ***To design FACTs devices***

Syllabus:

I. **Introduction**-brief discussions on Transmission line theory, use of Voltage source inverter (VSI) for reactive power support Flexible AC transmission systems (FACTS): Basic realities & roles, Types of FACTs controller. Comparison between Series and Shunt Capacitor.

II. **Thyristor controlled shunt Compensation** SVC (TSC, TCR, FCTCR): Controller Configuration, Analysis, Modeling of SVC, Voltage Regulator Design, application, Numerical.

III. **Thyristor controlled Series Compensation, (TCSC, GCSC)** Operation, Analysis, control, Modeling application, Numerical.

IV. **Static Synchronous Compensator (STATCOM) Introduction,** Principle of operation, Six Pulse VSC, multipulse VSC, Multilevel VSC, Modeling and Active and reactive power control, Numerical

V. **Static Synchronous Series Compensator (SSSC)** Introduction, Principle of operation, Modeling and Control of SSSC, SSSC with an Energy Source, Numerical

VI. **Unified Power Flow Controller**: Introduction, analysis, Principle of operation, power flow control

Text Books:

1. E. Acha., T J E Miller, V.G Agelidis, O Anaya-Lara, " Power Electronic control in Electrical Systems.", Elsevier
2. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS

Reference Books:

1. Yong Hua Song, "Flexible AC transmission system (FACTS)".
2. IEE and IEEE papers.

Course outcomes:

Students will be able to

1. ***Design thyristorised shunt and series compensation.***
2. ***Model and analyze VSC based shunt compensator.***
3. ***Model and analyze VSC based series compensator.***
4. ***Appreciate importance of unified power flow controller.***

EEP524: SIMULATION/IMPLEMENTATION OF PE CIRCUITS (0-0-2- Credits-1)

List of experiments:

1. To design DC-DC BUCK Converter
2. To design DC-DC BOOST Converter
3. To design DC-DC BUCK-BOOST Converter
4. To design DC-DC Chuck Converter
5. To design DC-DC Forward Converter
6. To design DC-DC Flyback Converter
7. To design AC-DC fully controlled Inverter
8. To design different PWM techniques.
9. Design of different switching circuits using OP-Amps

EEP526: ANALYSIS OF FACTS DEVICES LAB: (0-0-2- Credits-1)

List of experiments:

1. Familiarization with PSCAD/EMTDC, power world simulator software.
2. Understanding of Reactive Power and Power Factor Correction in AC Circuits
3. To study the effect of real and reactive powers on bus voltages
4. To study the influence of including a tap-changer and a phase-shifter on power flow and bus voltage
5. Modelling of Thyristor Converters.
6. Modelling of Thyristor Controlled Reactors (TCR).
7. Modelling of Thyristor Controlled Series Capacitors (TCSC) .
8. Modelling of Static Shunt compensator (STATCOM).
9. Modelling of Static Synchronous Series compensator (SSSC).

EEL431 : SMART GRID (3-0-0-Credits -3)

Objectives:
The students will be able to :

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

Syllabus:

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self Healing Grid, Present development & International policies in Smart Grid. Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation Smart Substations, Substation Automation, Feeder Automation. 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), Phasor Measurement Unit(PMU). **Microgrids and Distributed Energy Resources**: Concept of microgrid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources. **Power Quality Management in Smart Grid:** 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. **Information and Communication Technology for Smart Grid**: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

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
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, "Smart Grid: Technology and Applications", Wiley 2012
4. Jean Claude Sabonnadière, Nouredine Hadjsaïd, "Smart Grids", Wiley ISTE 2012

Reference Books

1. James Momoh, "Smart Grid Fundamentals of Design and Analysis," Wiley, 2012
2. A. Keyhani, "Smart Power Grid Renewable Energy Systems," Wiley 2011

Course Outcomes:

Student should be able to

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

EEL511: SPECIAL TOPICS IN POWER ELECTRONICS (3-0-0- Credits-3)

Objectives:

- ***Study of different lighting system***
- ***Application of power electronics in power system***
- ***To give knowledge about recent trends of power electronics***

Syllabus:

1. Power Line Conditioners.
2. Inter line and Inter phase power Flow.
3. Uninterruptible power supplies.
4. Battery Charger.
5. Electronic Ballast.
6. Energy storage devices.
7. Advanced active power filters.

and selected relevant current topics related to PE.

Text/ Reference Books:

1. Recent IET/IEEE publications.

Course outcomes:

Students will be able to

- ***Analyze and design the UPS, Battery charger and electronic ballast circuits.***
- ***Find the application of energy storage devices like Ultra-capacitors and SMES with the use of power electronic circuits.***
- ***Use the power electronic circuits as solution for the power system problems.***
- ***Learn the recent advancement in the relevant power electronic area.***

EEL512: DISTRIBUTED GENERATION (3-0-0- Credits-3)

Objectives:

- ***To learn the principles of generating Heat Energy and Electrical energy from Non-conventional / Renewable Energy Sources.***
- ***To gain understanding of the working of Off-grid and Grid-connected Renewable Energy Generation Schemes.***

Syllabus:

Introduction, Distributed vs Central Station Generation, Sources of Energy such as Micro-turbines, Internal Combustion Engines, Solar Energy, Wind Energy, Combined Heat and Power, Hydro Energy, Tidal Energy, Wave Energy, Geothermal Energy, Biomass and Fuel Cells, Power Electronic Interface with the Grid, Impact of Distributed Generation on the Power System, Power Quality Disturbances, Transmission System Operation, Protection of Distributed Generators, Economics of Distributed Generation, Case Studies.

Text Books:

1. Ranjan Rakesh, Kothari D.P, Singal K.C, ‘Renewable Energy Sources and Emerging Technologies’, 2nd Ed. Prentice Hall of India, 2011

Reference Books:

1. Math H.Bollen, Fainan Hassan, “Integration of Distributed Generation in the Power System”, July 2011, Wiley –IEEE Press.
2. Loi Lei Lai, Tze Fun Chan, “Distributed Generation: Induction and Permanent Magnet Generators”, October 2007, Wiley-IEEE Press.
3. Roger A.Messenger, Jerry Ventre, “Photovoltaic System Engineering”, 3rd Ed, 2010.
4. James F.Manwell, Jon G.Mc Gowan, Anthony L.Rogers, “Wind Energy Explained – Theory, Design and Application”, John Wiley and Sons, 2nd Ed,2009.

Course Outcomes

Students are able to:-

i. ***Understand the working of distributed generation system in autonomous/grid connected modes.***
ii. ***Know the Impact of Distributed Generation on Power System.***
iii. ***Know the protection and economics of Distributed Generators.***

MAL505: APPLIED LINEAR ALGEBRA (3-0-0- Credits-3)

Objectives:

- ***Learning matrices, vector algebra***
- ***Study of state space solutions***

Syllabus:

Systems of linear equations: Matrices and elementary row operations, uniqueness of echelon forms, Moore- Penrose generalized inverse.

Vector spaces, sub spaces, bases and dimension, coordinates, linear transformations and its algebra and representation by matrices, algebra of polynomials, determinant functions, permutation and uniqueness of determinants, additional properties, elementary canonical forms, characteristic values and vectors, Caley-Hamilton theorem, Annihilating polynomial, invariant subspaces.

Simultaneous triangularization, simultaneous diagonalization, Jordan form, inner product spaces, unitary and normal operators, bilinear forms
Methods to solve state space solution in discrete and continuous time, Numerical tests for controllability and observability

Text Books:

1. B. N. Datta, "Numerical Methods for Linear Control Systems", Elsevier publications.
2. Kenneth Hoffmann and Ray Kunze**, "**Linear Algebra**",** PHI India limited, 1971.

Reference Books:

1. V. Krishnamoorthy, "An introduction to linear algebra", Affiliated East West Press, New Delhi.
2. P. G. Bhattachrya, S. K. Jain, S. R. Nagpaul, "First course in Linear algebra", Wiley Eastern Ltd.
3. K. B. Datta, "Matrix and Linear algebra", Prentice Hall of India.

Course Outcomes:

- ***Apply matrices and vector algebra***
- ***Apply state space solutions to analyze electrical engineering problems.***
- ***Apply properties and theorems about linear spaces to specific mathematical structures that satisfy the linear space axioms.***
- ***Develop specific skills, competencies, and thought processes to support further study in his/her field of power electronics and drives***

THIRD SEMESTER M. TECH (PED)

EEL515: DIGITAL CONTROL SYSTEMS (3-0-0- Credits-3)

Objectives:

- ***The basics of sampling and data processing are covered.***
- ***Data in sampled form is used for controlling purpose.***

Syllabus:

Sampling and Data Reconstruction Processes: Sampled – Data Control Systems, Ideal Sampler, Sampling Theorem, Sample and Hold Operations, Frequency Domain Considerations

Z-Transforms; Properties, Inverse, Applications to Solution of Difference Equations, Convolution Sums.

Stability of Discrete Systems: Location of Poles, Jury's Stability Criterion, Stability Analysis through Bilinear Transforms.

Design of Digital Control Systems: PID Controllers and Frequency Domain Compensation Design.

State Variable Methods and the Discrete Linear Regulator Problem.

Text Books:

1. M. Gopal, "Digital Control Engineering and State Variable Methods", Fourth Edition, 2012, Tata McGraw-Hill.

2. Katsuhiko K Ogata, "Discrete time Control Systems", Second Edition, 2005, Prentice Hall Publish.

3. B.Kuo, " Digital Control Systems" , Oxford University Press

Reference Books:

1. K.J. Astrom and B. Wittenmark, "Computer Controlled Systems", Prentice-Hall India 1994.
2. R. Isermann, "Digital Control Vol.1", Narosa Publications, 1993.

Course outcomes:

Student will be able to:

1) Model digital filters and systems
2) Analyze digital systems in time domain and frequency domain.
3) Model and analyze digital systems in state space representation.
4) Design controllers for digital systems in state space representation

EEP515: DIGITAL CONTROL SYSTEMS Lab (0-0-2- Credits-1)

List of experiments:

1) Voice signal and image signal – sampling and reconstructing, effect of sampling frequency on retrieval of signal.
2) Representation of system in 'z' domain transfer function. Study of 'z' and 'inverse z' transform
3) Study of Zero Order Hold and First Order Hold circuit
4) Study of design of filters using Series, parallel and Ladder programming.
5) Study of mapping between 's' plane and 'z' plane.
6) Study of transient response of digital system.
7) Study of digital PID controllers.
8) Study of Root Locus of a system in 'z' domain. Effect of addition of pole and zero.
9) Study of frequency response of a system in 'z' domain
10) Design problem on pole placement

EED503: PROJECT PHASE 1 (Credits-3)

Objectives:

- **To develop the ability to study a topic in depth and understand and simulate work done till now by other researchers in a given topic**
- **To inculcate culture of handling all aspects of solution of a practical problem**
- **To understand, formulate and analyze the problem resulting into a novel solution**

Syllabus:

Become familiar with the problems in areas of power electronics and drives as suggested by faculty members by working in depth on the given topic and understand tools for analysis of given topic and present seminars based on the work done

EEL505: AI BASED SYSTEMS (3-0-0- Credits-3)

Objectives:

- ***To learn various theoretical aspects of four major approaches to artificial intelligence namely, Artificial Neural Network, Fuzzy Logic, Genetic Algorithm and Expert System***
- ***To study methodologies for applying AI techniques to the problems in the fields of electrical engineering.***

Syllabus:

Introduction:-Brief history of artificial intelligence, comparison with deterministic methods Aims objectives of artificial intelligence and current state of the art.

Fuzzy logic: Introduction to concepts, fuzzy reasoning, defuzzification, adaptive fuzzy systems.

Expert systems: Introduction to knowledge based systems Structure and definitions Knowledge acquisition Inference engine, forward and backward chaining.
Artificial Neural networks: Basic concepts, back-propagation, multi-layer networks, introduction to various paradigms, learning in neural networks.

Evolutionary Computing (Genetic algorithms): Basic concepts.
Applications of AI to power systems like alarm processing, condition monitoring, protective relaying etc.

Text Books:

1. M.T. Hagan, H.B.Demuth, M. Beale, "Neural Network Design", Cengage Learning.
2. S. Rajasekaran, G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", Prentice Hall of India.
3. Kevin Warwick, "Arthur Ekwue and Raj Aggarwal.; "Artificial Intelligence Techniques in Power Systems", The Institution of Electrical Engineers , London, 1989.

Reference Books:

1. T.S. Dillon and M.A Laughtonm; "Expert system applications in power systems", Prentice Hall International, 1992.
2. Jacek M. Zurada, "Introduction to artificial neural Systems," Jaico Pub. House, 2003.
3. DanW. Patterson, "Introduction to artificial intelligence & Expert System", Prentice Hall of India, 2004.
4. Bart Kosko, "Neural networks and Fuzzy Systems", Prentice Hall of India, 1990.

Course Outcomes:

Students are

1. able to understand the theory behind Neural Network, Fuzzy Logic, Genetic Algorithm and Expert System.
2. able to understand the use of appropriate soft computing technique to solve problems in power system.
3. able to design and build simple fuzzy inference systems and neural network based systems.
4. able to solve optimization problems using Genetic algorithm.

EEL521: ADVANCED POWER QUALITY (3-0-0-CREDITS- 3)

Objective:

- ***Various issues related to power quality in power distribution systems.***
- ***Fundamental load compensation techniques for unbalanced linear loads.***
- ***Control theories of load compensation and mitigation***

Syllabus:

Definitions of various powers, power factor and other figures of merit under balanced, unbalanced and non-sinusoidal conditions applied to single phase as well as three phase circuit.

Fundamental of load compensation, voltage regulation, phase balancing and power factor correction of unbalanced load. Generalized approach for load compensation using symmetrical components.

Introduction to custom power devices and their applications in power system. There operating principles.

Detailed modeling, analysis and design aspects, DVR. Modeling analysis and design aspects of DSTATCOM

Compensators to mitigate power quality related problems. Realization of DVR and DSTATCOM by using VSC

Text book:

1. Power quality enhancement using custom power devices, A. Ghosh and G. Ledwich, Kluwer Academic Publication, 2002.
2. Power quality, C. Shankran, CRC Press, 2001.
3. Electrical power systems quality Roger C. Dugan et al., Tata McGraw-Hill, 2002.

Reference Books:

1. Handbook of power quality, editor: Angelo Baggini, John Wiley & Sons, 2008.
2. Instantaneous power theory and application to power conditioning, H. Akagi et al., IEEE Press, 2007.

Related Links:

1. nptel.ac.in
2. Power Standards Lab - Tutorials & Standards
   Website: www.powerstandards.com/tutor.htm

***Course outcomes*:**

Students will be able to

- ***analyse of three phase circuits under different conditions***
- ***do correct load compensation in presence of harmonics and unbalance.***
- ***design compensators at distribution level to mitigate power quality issues.***

EEP505: AI BASED SYSTEMS Lab (0-0-2- Credits-1)

List of Programs

1. Write a program to simulate a perceptron network for pattern classification and function approximation.
2. Write a program to solve a XOR function using feed-forward neural network trained using back-propagation algorithm.
3. Write a program to implement adaptive noise cancellation using ADALINE neural network.
4. Given the region to be de-fuzzified, write programs to discuss the various methods that might be chosen.
5. Implementation of simple Over Current Relay using fuzzy logic.
6. Simulation and comparison of fuzzy PID controller with conventional PID controller for a given plant.
7. Solve optimal relay coordination as a Linear programming Problem using Genetic Algorithm.
8. Solve optimal relay coordination as a Non-Linear programming Problem using Genetic Algorithm.
9. Solve Economic Load Dispatch problem using Genetic Algorithm.
10. Assignment based on research papers.

Note: The above experiments may be implemented using Scilab / Matlab programming language, Simulink and toolboxes.

EEP521: ADVANCED POWER QUALITY LAB (0-0-2- Credits-1)

List of experiments:

1. To study the effect of non linear loads on power quality.
2. To demonstrate the voltage and current distortions experimentally.
3. To reduce the current harmonics with filters.
4. To study the voltage sag due to starting of large induction motor.
5. To study the capacitor switching transients.
6. To study the effect of balanced non linear load in a three phase circuit on neutral current.
7. To study the effect of ground loop.
8. To study the effect of voltage flicker on power quality.
9. To calculate the distortion power factor.
10. Study the effect of harmonics on meter reading.
11. To study effect of voltage sag on electrical equipments.
12. To obtain the current harmonics drawn by power electronics interface using PSCAD software.

FOURTH SEMESTER MTECH (PED)

EED504 PROJECT PHASE II (Credits-9)

Objectives :

- **To develop the ability to propose a new solution to an existing problem**
- **To develop ability to refine the proposed solution by comparing results with similar solutions suggested by other researchers**
- **To develop ability to test the proposed solution on new systems/ configurations and establish the proposed solution as a better solution in terms of computing time/ simplicity/ storage/ hardware requirements**

Syllabus:

Find solution to the problems in areas of power electronics and drives as proposed by faculty members in earlier phase and present seminars and submission of project report based on the work done.