BMS COLLEGE OF ENGINEERING, BENGALURU-19
(Autonomous Institute Affiliated to VTU)

Scheme & Syllabus of Teaching for 2016-17

M. Tech. Power Electronics

PROGRAM EDUCATIONAL OBJECTIVES

Graduates of the M. Tech Power Electronics Program will,

1. **Excel professionally in Power Electronics and allied domains.**
2. **Undertake research and development that addresses technological requirements of Industry and Institutes of higher learning.**
3. **Adapt to the changing needs of Industry/Society through lifelong learning.**

PROGRAM OUTCOMES

1. **Acquire in-depth knowledge** of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Analyze** complex engineering problems critically, **apply** independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Think laterally and originally**, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. **Extract information** pertinent to unfamiliar problems through literature survey and experiments, **apply appropriate research methodologies**, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Create, select, learn** and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.
6. **Possess knowledge** and understanding of group dynamics, recognize opportunities and contribute positively to **collaborative-multidisciplinary scientific research,** demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. Demonstrate knowledge and **understanding of engineering and management principles** and apply the same to one's own work, as a member and leader in a team, manage projects

efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

8. **Communicate** with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. Recognize the need for, and have the preparation and **ability to engage in life-long learning independently**, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. **Acquire professional and intellectual integrity**, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. **Observe** and **examine critically** the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

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I Semester **CREDIT BASED**

Subject Code	Course Title	Credits				CREDITS
		L	T	P	S	
16EEPE1CMT	Applied Mathematics	3	0	0	0	**3**
16EEPE1CPS	Power Semiconductor Devices	3	0	0	0	**3**
16EEPE1CSP	Solid State Power Controllers	4	0	1	1	**6**
16EEPE1CMS	Modeling & Simulation of Power Electronics Systems	3	0	1	1	**5**
16EEPE1EXX	Elective-1	3	0	0	0	**3**
16EEPE1EXX	Elective - 2	3	0	0	0	**3**
16EEPE1CRM	Research Methodology	2	0	0	0	**2**
Total		**21**	**0**	**2**	**2**	**25**

Note: Two electives to be chosen from the list below:
Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)

Course Elective		**Course Elective**	
16EEPE1EDM	Digital Measurements	16EEPE1EES	Embedded System Design
16EEPE1EMA	Modeling & Analysis of Electrical Machines	16EEPE1ESC	Soft Computing
16EEPE1EPS	Power Electronics in Smart Grid	16EEPE1ECV	CMOS VLSI Design
16EEPE1EAC	Advanced Control System	16EEPE1ERT	Real Time Digital Signal Processing

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II Semester **CREDIT BASED**

Subject Code	Course Title	Credits				CREDITS
		L	T	P	S	
16EEPE2CAD	AC-DC Drives	3	0	1	1	**5**
16EEPE2CSM	Switched Mode Power Conversion	3	1	1	0	**5**
16EEPE2CFC	FACTs Controllers	4	0	0	1	**5**
16EEPE2EXX	Elective - III	3	0	0	0	**3**
16EEPE2EXX	Elective - IV	3	0	0	0	**3**
16EEPE2EXX	Institution Elective	4	0	0	0	**4**
Total		**21**	**0**	**2**	**2**	**25**

Note: Two electives to be chosen from the list below:

Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)

Elective - III		Elective - IV	
16EEPE2EPD	Power Electronics System Design using ICs	16EEPE2EDS	DSP Applications to Drives
16EEPE2EPQ	Power Quality Issues and Mitigation	16EEPE2EPC	Power Quality Enhancement using Custom Power Devices
16EEPE2EPS	Power Supply Systems	16EEPE2EEM	Electro Magnetic Compatibility
16EEPE2EPW	PWM Converters & Applications	16EEPE2EHV	HVDC Power Transmission

Institution Elective	
16EEPE2ERE	Renewable Energy & Photovoltaics
16EEPE2EMS	Micro & Smart Systems

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III Semester **CREDIT BASED**

Subject Code	Course Title	Credits				CREDITS
		L	T	P	S	
16PEPC3CIN	Internship	0	0	21	0	**21**
16PEPC3CIP	Project work (I-phase)	0	0	4	0	**4**
Total		**0**	**0**	**25**	**0**	**25**

NOTE:
III Semester:

- **Internship:** The student shall undergo internship for 16 weeks.

  Preliminary Report submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks

  Final Report submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty. Report Evaluation to be completed within two weeks of submission for 100 marks.

  Viva-Voce on Internship - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HOD as chairman for 100 marks

- **Project Phase: I**

  Problem formulation and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HOD as Chairman.

  Literature survey and progress done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HOD as chairman for 50 marks

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IV Semester **CREDIT BASED**

Subject Code	Course Title	Credits				CREDITS
		L	T	P	S	
16PEPC4CPR	Project work (Final phase)	0	0	23	0	**23**
16PEPC4CTS	Technical Seminar	0	0	02	0	**02**
Total		**0**	**0**	25	**0**	**25**

NOTE:
IV Semester:

- **Project Phase-II** - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HOD as Chairman
- **Project Phase-III** - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation of Project Work and Viva-voce**.
  - ➢ Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4th semester.
  - ➢ The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HOD as chairman will complete the final evaluation of Project.
- Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce** : The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HOD as chairman for 100 Marks

I SEMESTER

Subject	APPLIED MATHEMATICS	Sub-code	16EEPE1CMT
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Recognize the appropriate numerical method to solve algebraic, transcendental, polynomial and system of nonlinear equations.
CO2: Determine the Eigen values of real symmetric matrices.
CO3: Analyze the interpolating polynomial for the given set of experimental observations.
CO4: Apply the concepts of graph theory to engineering oriented problems.
CO5: Demonstrate the concepts of vector space, basis and dimension. Also solve the matrix associated with the linear transformation.

Numerical Methods: Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method, (no derivation) Chebyshev method, general iteration method (first order),acceleration of convergence, system of non-linear equations, and complex roots– Newton-Raphson method.

System of Linear Algebraic Equations and Eigen Value Problems: Iterative methods - Gauss-Seidal method, SOR method, Eigen value problems – Gerschgorian circle, Eigen values and Eigen vectors of real symmetric matrices - Jacobi method, Givens method.

Interpolation: Hermite interpolation, spline interpolation, numerical solution of differential equations – Numerov method, Birge –Vieta method and Bairstow's method.

Graph Theory: Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs-walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, applications of graphs.

Linear Algebra: Vector spaces, linear dependent, independence, basis and dimension, elementary properties, examples. Linear Transformations - Definition, properties, range, null space, rank, nullity and representation of transformations by matrices.

REFERENCE BOOKS:

1. M K Jain, S R K Iyengar and R K Jain, "Numerical Methods for Scientific and Engineering Computations", New Age International, 2004.
2. M K Jain, "Numerical Solution of Differential Equations", 2nd Edition, New Age International, 2008.
3. Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", PHI, 2012.
4. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 2011

Subject	POWER SEMICONDUCTOR DEVICES	Sub-code	16EEPE1CPS
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Apply knowledge of physics of semiconductor and electronic devices to develop and control power electronic systems.

CO2: Describe, analyze characteristics and compare various types of power semiconductor devices for theoretical and practical context.

CO3: Identify and prioritize the use of power devices in various power electronic systems and control applications.

CO4: Apply the concept of thermal design for various power electronic equipments.

CO5: Develop skills and apply the principles to explore the possibility of emerging power semiconductor devices in different areas.

Power Diodes: Basic Structure and I-V Characteristics . Breakdown Voltages and Control . On State Losses, Switching Characteristics . Turn on Transient . Turn off Transient . Reverse Recovery Transient . Schottky Diodes . Snubber Requirements for Diodes and Diode Snubbers.Modelling and simulation of Power Diodes.

Thyristors:
a) Thyristors: - Basic Structure . V-I Characteristics . Turn on Process . On State operation . Turn off process, Switching Characteristics .Turn on Transient and di/dt limitations . Turn off Transient . Turn off time and dv/dt limitations . Ratings of Thyristors . Snubber Requirements and Snubber Design. Modeling and simulation of Thyristors.
b) Gate Turnoff Thyristor (GTO):. Basic Structure and Operation . GTO Switching Characteristics. GTO Turn on Transient. GTO Turn off Transient Minimum ON and OFF State times .Maximum Controllable Anode Current Overcurrent protection of GTOs Modeling and simulation of GTOs.
c) Triacs: Basic Structure and operation . V-I Characteristics .

Transistors:
a) Power BJTs: . Basic Structure and I-V Characteristics .Switching Characteristics.
b) MOSFETs - Basic Structure . V-I Characteristics . Turn on Process . On State operation . Turn off process . Switching Characteristics Resistive Switching Specifications . Clamped Inductive Switching Specifications - Turn on Transient and di/dt limitations . Turn off Transient Turn off time . Switching Losses . Effect of Reverse Recovery Transients on Switching Stresses and Losses - dv/dt limitations . Gating Requirements Gate Charge - Ratings of MOSFETs. FBSOA and RBSOA Curves . Device Protection -Snubber Requirements . Modelling and simulation of Power MOSFETS.
c) Insulated Gate Bipolar Transistors (IGBTs):. Basic Structure and Operation .Latch up IGBT Switching Characteristics . Resistive Switching Specifications . Clamped Inductive Switching Specifications - IGBT Turn on Transient . IGBT Turn off Transient- Current Tailing - Ratings of MOSFETs. FBSOA and RBSOA Curves . Switching Losses - Minimum ON and OFF State times - Switching Frequency Capability - Overcurrent protection of IGBTs . Short Circuit Protection.

Snubber Requirements and Snubber Design.

Thermal design of power electronic equipment:
Heat transfer by conduction, transient thermal impedance - heat sinks .Heat transfer by radiation and convection - Heat Sink Selection for Power Semiconductor Devices

Emerging Devices:
New power semiconductor devices: MOS Gated Thyristors,MOS Controlled Thyristors, emitter turn-off thyristor (ETOs), Integrated Gate Commutated Thyristor (IGCT), Static induction transistor (SIT), Emitter Switched Thyristor.

REFERENCE BOOKS:
1. Ned Mohan, Tore M. Undeland, William P. Robbins, **"Power Electronics Converters, Applications, and Design",** 3rd Edition. Wiley India Pvt Ltd, 2011.
2. M.H. Rashid**, Power Electronics: Circuits, Devices, and Applications,** Published by Prentice Hall, 3rd Edition, 2004.
3. G. Massobrio, P. Antognetti, **"Semiconductor Device Modeling with Spice",** McGraw-Hill, 2nd Edition, 2010.
4. B. Jayant Baliga, "**Power Semiconductor Devices**", PWS Publication, 1st Edition, 1995.
5. V. Benda, J. Gowar, and D. A. Grant, "**Discrete and Integrated Power Semiconductor Devices: Theory and Applications**", John Wiley &Sons, 1999.

Subject	SOLID STATE POWER CONTROLLERS	Sub-code	16EEPE1CSP
Credits	**06**	**L-T-P-S**	**4-0-1-1**

Course outcomes:

CO1: Analyze the performance of single phase and three phase AC- DC converters..
CO2: Conduct experiment and simulation studies on single phase and three phase AC- DC converters.
CO3: Analyze the performance of single phase and three phase inverters.
CO4: Analyze different PWM schemes for voltage control and harmonic reduction in inverters.
CO5: Conduct experiment / simulation studies on single phase and three phase inverters.
CO6: Study the performance of different choppers
CO7: Conduct case study in a team.

Line Commutated Converters: Phase control, single phase semi-converter & fully controlled converter, three phase semi controlled & fully controlled converter, dual converters, power factor improvement methods, effect of source inductance, single phase series converters, twelve pulse converter and design of converter circuits.

Inverters: Principle of operation, performance parameters, single phase bridge inverters and three phase inverters.

Voltage Control of Single Phase Inverters: Single/multiple, pulse/SPWM/ modified SPWM methods, voltage control of three phase inverter, SPWM/third harmonic PWM/Space vector modulation, harmonic reduction, current source inverter, comparison between VSI & CSI.

Multilevel Inverters: Introduction, types, diode clamped multi-level inverters, features & applications.

DC-DC Converters: Principle of operation, analysis of step-down and step-up converters, classification of chopper & chopper circuit design.

Lab experiments:
Experimental and simulation studies on
- Converters
- Inverters and
- Choppers

REFERENCE BOOKS:
1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics Converters, Applications, and Design”, 3rd Edition,Wiley India Pvt Ltd, 2011
2. Rashid M.H, “Power Electronics: Circuits Devices and Applications”, 3rd Edition, Pearson, 2011.
3. B. K. Bose, “Modern Power Electronics & AC Drives”, PHI, 2012.

Subject	**MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS**	**Sub-code**	**16EEPE1CMS**
Credits	**05**	**L-T-P-S**	**3-0-1-1**

Course outcomes:
CO1: Able to apply mathematical skills to represent mathematically a physical system
CO2: Able to apply various modeling methods to develop mathematical modeling
CO3: Able to design and develop digital controllers to control current and voltage of a Power Electronics system.
CO4: Able to apply modern engineering software tools such as MATLAB software to develop model for various Power Electronics circuits.
CO5: Able to extract information through literature survey, apply appropriate design techniques and tools for simulation of Power Electronics based circuits published in conference/ journal papers.
CO6: Able to demonstrate capacity for self-management and teamwork, communicate regarding activities carried out as a part of self study confidently and effectively, to comprehend and write effective reports and design documentation.

Computer Simulation of Power Electronic Converters and Systems: Challenges in computer simulation, simulation process, Types of analysis, mechanics of simulation, circuit-oriented simulators, equation solvers, comparison of circuit oriented simulators and equation solvers.

Modeling of Systems: Input-Output relations, differential equations and linearization, state space representation, transfer function representation, modeling of an armature controlled DC Motor, poles and zeroes circuit averaging method of modelling approach for switched power electronic circuits, space vector modeling, space vectors, representation of space vectors in orthogonal co-ordinates, space vector transformations, modeling of induction motor, state space representation of the d-q model of the induction motor.

Digital Controller Design: Controller design techniques, Bode diagram method, PID controller, design, root locus method, state space method. Tracker, controller design, controlling voltage, controlling current.
Discrete Computation Essentials: Numeric formats, fixed -point numeric format, floating -point numeric format, tracking the base point in the fixed point system, addition of numbers, subtraction of numbers, multiplication of numbers, normalization and scaling, multiplication algorithm, arithmetic algorithm reciprocal, square root, reciprocal of square root, sine and cosine exponential, logarithm, implementation examples, pi controller, sine and cosine, pulse width modulation, space vector pwm, over-modulation.

Lab experiments:
- Modeling using state space representation, transfer function representation of a system.
- Modeling of an armature controlled DC motor
- Modeling of a Buck converter
- Three phase to two phase transformations
- Modeling of three phase Induction motors

- Controllers design techniques – Bode and root locus method
- PID controllers for voltage and current control

REFERENCE BOOKS:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and design", 3rd Edition, John Wiley & Sons, 2009.
2. L.Umanand,"Power Electronics Essentials and Applications", 1st Edition, John Wiley & Sons, 2009.

ELECTIVE-1

Subject	DIGITAL MEASUREMENTS	Sub-code	16EEPE1EDM
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Realize the significance of digital based measurements using Microprocessor/Microcontroller.
CO2: Analyze time and frequency measurement techniques and apply the knowledge for the design of various circuits.
CO3: Realize and design different D/A converters.
CO4: Design A/D converters and apply the concept of voltage measurement technique for various systems.

Philosophy of digital and microprocessor/microcontroller based instruments.

Time measurement techniques: measurement of time interval between events, Order of events, Vernier technique, very low time, period, phase time constant, Capacitance measurements, decibel meter.

Frequency measurement techniques: frequency ratio and product, high and low frequency measurements, deviation meter, tachometer, peak/valley recorder.

DACs: programmable amplifier as DACs, multistage WRDACs, weighted current, weighted reference voltage, weighted charge, DACs, ladder DACs, design of DACs with respect to spread and total resistance, hybrid multiplier and divider Circuits

Voltage measurement techniques: V/f and V/f converters, direct type ADC ramp, tracking, dual slope, successive approximation and flash type multistage flash type ADCs, DVM and its design .

REFERENCE BOOKS:
1. Rathore, T.S., “Digital Measurement Techniques”, Narosa Publishing House, 2003
2. Sonde., B.S., “Monographs on System Design Using Integrated Circuits”, Tata McGraw Hill, 1974
3. Defatta, D.J., Lucas, J.G., Hodgkiss, W.S., “Digital Signal Processing”, John Wiley and Sons, 1988.

Subject	**MODELING AND ANALYSIS OF ELECTRICAL MACHINES**	**Sub-code**	**16EEPE1EMA**
Credits	**03**	**L-T-P-S**	**3-0-0-0**

Course outcomes:
CO1: Apply basic concepts of modeling for DC Machines, three phase induction machine and synchronous machines.
CO2: Model a single phase & three phase transformers, autotransformers and transmission line**.**
CO3: Carry out the dynamic performance analysis of synchronous machines.

Basic Concepts of Modeling: Basic two pole machine representation of commutator machines, 3-phase synchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, current and torque equations.

DC Machine Modeling: Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor, linearization techniques for small perturbations.

Reference Frame Theory: Real time model of a two phase induction machine, transformation to obtain constant matrices, three phase to two phase transformation, power equivalence.

Dynamic Modeling of Three Phase Induction Machine: Generalized model in arbitrary frame, electromagnetic torque, deviation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model, dynamic simulation.

Small Signal Equations of the Induction Machine: Derivation of small signal equations of induction machine, space phasor model, DQ flux linkages model derivation, control principle of the induction motor.

Modeling of Synchronous Machines: Introduction, voltage equations and torque equation in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, torque equations in substitute variables, rotor angle and angle between rotors, per unit system, analysis of steady state operation.

REFERENCE BOOKS:
1. P.S.Bimbra, "Generalized Theory of Electrical Machines", 5th Edition, Khanna Publications, 1995.
2. R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009.
3. P.C.Krause, Oleg Wasynczuk, Scott D. Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2nd Edition, Wiley (India), 2010.
4. Arthur R Bergen and Vijay Vittal, "Power System Analysis", 2nd Edition, Pearson, 2009.
5. PrabhaKundur, "Power System Stability and Control", TMH, 2010.
6. Chee-MunOng, "Dynamic Simulation of Electric Machinery using MATLAB / Simulink", Prentice Hall, 1998.

Subject	**POWER ELCTRONICS IN SMART GRID**	**Sub-code**	**16EEPE1EPS**
Credits	**03**	**L-T-P-S**	**3-0-0-0**

Course outcomes:

CO1: Acquire in-depth knowledge of Smart Grid, distributed generation, Electro Magnetic Compatibility (EMC) Cases in power system and analyze power quality problems in an electricity network.

CO2: Apply the concept of distributed generation and solve the problem of its integration with the existing power system network.

CO3: Select, learn and apply different active power controllers in appropriate places of power system network.

CO4: Acquire in depth knowledge of different energy storage system and solve the problem of energy storage in a smart, complex power system.

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

Power Control and Quality Problems: Introduction, power quality and EMC, power quality issues, monitoring, legal and organizational regulations, mitigation methods, and EMC related phenomena in smart system.

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

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.

REFERRENCE BOOKS:

1. Strzelecki Benysek, “Power Electronics in Smart Electrical Energy Networks”, Springer, 2008.
2. Clark W Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Side Response”, CRC Press, 2009.

Subject	ADVANCED CONTROL SYSTEMS	Sub-code	16EEPE1EAC
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:

CO1: Create state models for continuous and discrete time systems.

CO2: Identify appropriate techniques to analyze both continuous and discrete systems for controllability and observability

CO3: Apply relevant concepts to design continuous and discrete systems with state feedback to meet the specifications.

Digital Control Systems: Review of difference equations and Z - transforms, Z- transfer function (Pulse transfer function), Z - Transforms analysis, sampled data systems, stability analysis (Jury's Stability Test and Bilinear Transformation), pulse transfer functions and different configurations for closed loop discrete-time control systems.

Modern Control Theory: State model for continuous time and discrete time systems, solutions of state equations (for both continuous and discrete systems), concepts of controllability and observability (for both continuous and discrete systems), pole placement by state feedback (for both continuous and discrete systems), full order and reduced order observes (for both continuous and discrete systems), dead beat control by state feedback, optimal control problems using state variable approach, state regulator and output regulator, concepts of model reference control systems, adaptive control systems and design.

Non Linear Control Systems: Common nonlinearities, singular points, stability of nonlinear systems - phase plane analysis and describing function analysis, Lyapunov's stability criterion, Popov's criterion.

REFERENCE BOOKS:

1. Ogata. K. "Modern Control Engineering", 5th Edition, PHI, 2010.
2. Ogata K "Discrete Time Control Systems", 2nd Edition, PHI, 2011.
3. Nagarath and Gopal, "Control Systems Engineering", New Age International Publishers, 2012.
4. M Gopal "Modem Control System Theory", New Age International, 2011.
5. M. Gopal, "Digital Control & State Variable Methods", TMH, 2011.

ELECTIVE-II

Subject	EMBEDDED SYSTEM DESIGN	Sub-code	16EEPE1EES
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Apply the basic concepts and design an embedded system for real time applications.
CO2: Create a platform to try novel ideas to provide different solutions for practical problems.
CO3: Realize a high performance processor to develop a real time system.
CO4: Recognize opportunities and contribute for the multidisciplinary research work.

Introduction to Embedded System: An embedded system, processor, hardware unit, software embedded into a system, example of an embedded system, OS services, real time and embedded OS.

Processor and Memory Organization: Structural unit in a processor, processor selection for an embedded systems, memory devices, memory selection for an embedded system, allocation of memory to program segments and blocks, and direct memory accesses.

Real Time System: Types, real time computing, design issues, ARM system architecture, high performance processors - strong ARM processors, addressing modes, instruction set, and few basic assembly language programs.

Real Time Operating System: Fundamental requirements of RTOS, real time kernel, schedulers, various scheduling modules, latency (interrupt latency, scheduling latency and context switching latency), tasks, state transition diagram, task control block. Inter-task communication and synchronization of tasks, Building real time applications.

REFERENCE BOOKS:
1. Rajkamal "Embedded System Architecture: Programming & Design", TMH, 2010.
2. David E. Simon, "An Embedded Software Primer", Pearson Education, 1999.
3. Philip. A. Laplante, "Real-Time Systems Design and Analysis- An Engineer's Handbook"- 2nd Edition, Pearson.
4. Jane W.S. Liu, "Real-Time Systems", Pearson Education Inc, 2012.
5. K.V.K K Prasad, "Embedded Real Time Systems: Concepts Design and Programming", Dreamtech Press New Delhi, 2003.

Subject	SOFT COMPUTING	Sub-code	16EEPE1ESC
Credits	03	L-T-P-S	3-0-0-0

Learning and Soft Computing: Examples, basic tools of soft computing, basic mathematics of soft computing, learning and statistical approaches to regression and classification.

Single-Layer Networks: Perceptron, Adaptive linear neuron (Adaline), and the LMS algorithm.

Multilayer Perceptrons: Error back propagation algorithm, generalized delta rule, practical aspects of error back propagation algorithm.

Radial Basis Function Networks: Ill-posed problems and the regularization technique, stabilizers and basic functions, generalized radial basis function networks.

Fuzzy Logic Systems: Basics of fuzzy logic theory, mathematical similarities between neural networks and fuzzy logic models, fuzzy additive models.

Support Vector Machines: Risk minimization principles and the concept of uniform convergence, VC dimension, structural risk minimization, support vector machine algorithms.

Case Studies: Neural-network based adaptive control, computer graphics.

REFERENCE BOOKS:

1. Vojislav Kecman, “Learning and Soft Computing”, Pea rson Education (Asia) Pvt. Ltd. 2004.
2. Simon Haykin, "Neural Networks: A Comprehensive Foundation", Pearson Education (Asia) Pvt. Ltd., Prentice Hall of India, 2008.
3. M.T. Hagan, H.B. Demuth and M. Beale, "Neural Network Design", Thomson Learning, 2002.
4. Bart Kosko, "Neural Networks and Fuzzy Systems", Prentice Hall of India, 2010.
5. George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Application", PHI, 2012.

Subject	**CMOS VLSI DESIGN**	**Sub-code**	**16EEPE1ECV**
Credits	**03**	**L-T-P-S**	**3-0-0-0**

Course outcomes:
CO1: Analyze the MOS concepts for various small signal operations.
CO2: Design of various CMOS VLSI Circuits by applying the concept of CMOS miniaturization**.**
CO3: Implementation of structured analog and digital circuits using NMOS & CMOS Functional blocks.
CO4: Apply the various MOS technologies for system design.

Review of MOS circuits: MOS and CMOS static plots, switches, comparison between CMOS and BI - CMOS.

MESFETS: MESFET and MODFET operations, quantitative description of MESFETS.

MIS structures and MOSFETS: MIS systems in equilibrium, under bias, small signal operation of MESFETS and MOSFETS.

Short channel effects and challenges to CMOS: Short channel effects, scaling theory, processing challenges to further CMOS miniaturization.

Beyond CMOS: Evolutionary advances beyond CMOS, Carbon Nano tubes, conventional vs. tactile computing, computing, molecular and biological computing, Mole electronics-molecular Diode and diode- diode logic .Defect tolerant computing,

Super buffers, Bi-CMOS and Steering Logic: Introduction, RC delay lines, super buffers- An NMOS super buffer, tri state super buffer and pad drivers, CMOS super buffers, Dynamic ratio less inverters, large capacitive loads, pass logic, designing of transistor logic, General functional blocks - NMOS and CMOS functional blocks.

Special circuit layouts and technology mapping: Introduction, Talley circuits, NAND-NAND, NOR- NOR, and AOI Logic, NMOS, CMOS Multiplexers, Barrel shifter, Wire routing and module lay out.

System design: CMOS design methods, structured design methods, Strategies encompassing hierarchy, regularity, modularity & locality, CMOS Chip design Options, programmable logic, Programmable inter connect, programmable structure, Gate arrays standard cell approach, Full custom Design.

REFERENCE BOOKS:
1. Kevin F Brrnnan "**Introduction to Semi-Conductor Device**", Cambridge publications, 2005.
2. Eugene D Fabricius "**Introduction to VLSI Design**", MGH, 1990,
3. D.A Pucknell "**Basic VLSI Design**", 3rd Edition, PHI Publication, 1994.
4. Wayne Wolf, "**Modern VLSI Design**" Pearson Education, 2nd Edition, 2002.

Subject	REAL TIME DIGITAL SIGNAL PROCESSING	Sub-code	16EEPE1ERT
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Design filters using appropriate techniques.
CO2: Analyze a signal using FFT
CO3: Implement real time FIR Filter using Motorola DS5630X.

Digital Signal Processing Fundamentals: Review of DSP fundamentals ; FIR filter design by windowing; adaptive filtering techniques, Fourier analysis of signal using FFT, introduction to real time DSP and Motorola DS5630X, architecture, instruction set, addressing modes; simple 5630X program, real time digital FIR filter, real time LMS adaptive filters, real time frequency domain processing.

REFERENCE BOOKS

1. Oppenheim and Schafer, "Digital Signal Processing", Prentice Hall, 2011.
2. Philip L Se Leon, "Real Time Digital Signal Processing using the Motorola DSP S63OXEVM", 2002.
3. J G Proakis, Dimitris G Monolikis, "Digital Signal Processing: Principles, Algorithms and Applications" Pearson Education, 4th Edition, 2012.
4. Samuel Stearns, "Digital Signal Processing with Examples in MATLAB", CRC Press, 2011.

INSTITUTION CORE COURSE

Subject	RESEARCH METHODOLOGY	Sub-code	16EEPE1CRM
Credits	02	L-T-P-S	2-0-0-0

Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan.

Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem - Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources - Reviews, treatise, monographs patents
- web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis.

IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs)- A brief summary of: Patents, Copyrights, Trademarks, Industrial Designs- Integrated Circuits-Geographical Indications-Establishment of WIPO-Application and Procedures.

Aim of this part of the course: is to strengthen students minds towards high quality research through publications, patents and also to learn research ethics.
Publications (8-9 hours)
Research concepts (2 hour) Research importance on economy, Research in India and abroad, Importance of publications, Why, where, when to publish?
Publication ethics (2 hour), Plagiarism (how to use turn it in effectively), International ethics on research, What and what not to publish, Ethical guidelines, Case studies
Quality vs quantity (2 hour) Searching literature with high quality, Impact factor, Citations (google scholar vs web of science), H-index, Case studies.
How to write paper (2 hour), In High quality journals, Conference Articles, Poster preparation, PhD thesis, Inclusion of References.
Journal reviewing process (1 hour), Selection of the good journal, Knowledge bout journal template, Refereeing process, Research topic selection, Research today and tomorrow, Lab scale to Industry, Traditional research to Technology based research.

Interpretation and report writing - Techniques of interpretation - Structure and components of scientific reports - Different steps in the preparation - Layout, structure and language of the report - Illustrations and tables - Types of report - Technical reports and thesis

REFERENCES:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
4. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
5. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
6. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
7. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
8. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
9. Intellectual Property Rights in the Global Economy: Keith Eugene Maskus, Institute for International Economics, Washington, DC, 2000
10. Subbarau NR-Handbook on Intellectual Property Law and Practice-S Viswanathan Printers and Publishing Private Limited.1998

II SEMESTER

Subject	AC AND DC DRIVES	Sub-code	16EEPE2CAD
Credits	05	L-T-P-S	3-0-1-1

Course outcomes:
CO1: Analyze AC-DC Drives circuits critically, in a wider theoretical context.
CO2: Apply appropriate techniques, design and tools, to conduct experiments and projects.
CO3: Develop simulation models for AC-DC drives systems prescribed in the curriculum.
CO4: Design the AC-DC drives circuits, conduct the experiments, compare and analyze the hardware results with that of simulation results.
CO5: Able to choose an appropriate research paper from latest IEEE conference/journal and analyze the work presented in the paper.
CO6: Able to carry out simulation and/or develop prototype model for the selected IEEE conference/journal paper.

Electric Drives: Introduction – block diagram-classification of electrical drives-choice of electrical drives-fundamental torque equation- components of load torque- steady state stability.

DC Drives: Single Quadrant Drive: 1-Phase semi and half wave converter drives, Two quadrant Drive: 1-phase and 3-phase full converter drive.

Two and Four Quadrant drive: 1-phase and three- phase dual converter drive, different braking methods and closed loop control of DC drives.

AC Drives: Voltage and current source inverter - inverter control-six step and PWM operation, Control of Induction motor drive -V/f and field oriented control – direct and indirect vector control, voltage and current source inverter fed induction motor drives, stator and rotor voltage control methods, slip energy recovery drives.

Closed Loop Control of AC Drives: Stator voltage control, V/f control, Slip regulation, speed control of static Kramer's drive, current control, brushless DC motor, stepper motor and variable reluctance motor drives.

Lab experiments:
Experimental/Simulation studies on
- Converter fed separately excited DC drives
- Chopper drives
- Speed control of 3 phase Induction motor

REFERENCE BOOKS:
1. Bose B. K, “Modern Power Electronics & AC Drives” PH I, 2011.
2. Murphy JMD, Turnbull F.G., “Thyristor Control of AC Motors” Pergamon Press Oxford, 1998.
3. R. Krishanan “Electric Motor Drives”, EEE, PHI, 2010.
4. M.H Rashid, “Power Electronics, Circuits, Devices & Applications” Third Edition, PHI, New Delhi 2004.
5. High Performance Control of AC Drives “Haitham Abu - Rub, AtifIqbal, Jaroslaw Guzinski, Wiley, 2012.

BMS COLLEGE OF ENGINEERING, BENGALURU-19

(Autonomous Institute Affiliated to VTU)

Scheme & Syllabus of Teaching for 2016-17

Subject	**SWITCHED MODE POWER CONVERSION**	**Sub-code**	**16EEPE2CSM**
Credits	**05**	**L-T-P-S**	**3-1-1-0**

Course outcomes:

CO1: Analyze the performance of basic converters for CCM and DCM operation
CO2: Conduct experiment/simulation studies on basic converters for CCM /DCM operation
CO3: Carry out the performance analysis of derived converters
CO4: Conduct experiment/simulation studies on derived converters
CO5: Analyse the dynamic response of converter using state space averaging and design controller.
CO6: Analyze the performance of resonant converters.
CO7: Design of magnetic component for converters.

DC – DC Converters (Non isolated Converters): Principle of operation and analysis of buck converter analysis, inductor current ripple and output voltage ripple, capacitor resistance effect, synchronous rectification, design considerations, buck converter for discontinuous current operation, principle of operation and analysis of buck-boost converter analysis, inductors current ripple and output voltage ripple, design considerations, buck-boost converter for discontinuous current operation, principle of operation and analysis of CUK converter , inductor current ripple and output voltage ripple, capacitor resistance effect, design considerations, single ended primary inductance converter (SEPIC).

Isolated Converters: Introduction, transformer models, principle of operation and analysis of fly back converter-continuous and discontinuous current mode of operation, design considerations, principle of operation and analysis of forward converter, design considerations, double ended(Two switch) forward converter, principle of operation and analysis of push-pull converter, design considerations, principle of operation and analysis of full bridge and half-bridge DC-DC converters, design considerations, current fed converters, multiple outputs.

Control of DC-DC Converter: Modeling of DC-DC converters, power supply control, control loop stability, small signal analysis, switch transfer function, filter transfer function, PWM transfer function, Type-2 error amplifier with compensation, design, Type-3 error amplifier with compensation, design.

Resonant Converters: Introduction, resonant switch ZCS converter, principle of operation and analysis, resonant switch ZVS converter, principle of operation and analysis, series resonant inverter, series resonant DC-DC converter, parallel resonant DC-DC converter, series- parallel resonant DC-DC converter, resonant converters comparison, resonant DC link converter.

Introduction on design of Inductors and transformers: Design of inductor for Buck converter and transformer design for Forward converter as case studies.

Lab experiments:
Experimental/Simulation studies on

- Buck converter
- Boost converter
- Buck/Boost converter for CCM & DCM mode

- Flyback and forward converter
- Resonant converter

REFERENCE BOOKS:

1. Daniel W Hart, "Power Electronics", Tata McGraw Hill, 2011.
2. Rashid M.H., "Power Electronics – Circuits, Devices and Applications", 3rd Edition, Pearson, 2011.
3. D M Mitchel, "DC-DC Switching Regulator Analysis" McGraw-Hill Ltd, 1988.
4. Umanand L and Bhatt S R, "Design of Magnetic Components for Switched Mode Power Converters", New Age International, New Delhi, 2001
5. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rd Edition, Wiley India Pvt. Ltd, 2010.

Subject	FACTS CONTROLLERS	Sub-code	16EEPE2CFC
Credits	05	L-T-P-S	4-0-0-1

Course outcomes:
CO1: Justify the need for FACTS controllers in AC transmission lines.
CO2: Model and analyze the steady state characteristics of the AC transmission lines with and without the FACTS controllers.
CO3: Model and analyze various FACTS controllers derived from first principles.
CO4: Apply different FACTS controllers in AC transmission systems.
CO5: Choose a facts controller based IEEE paper, analyze, simulate and/or develop prototype and present the work carried out.

Introduction: Basics of power transmission networks - control of power flow in AC - transmission line- flexible AC transmission system controllers – application of FA CTS controllers in distribution systems.

AC Transmission Line and Reactive Power Compensation: Analysis of uncompensated AC Line - passive reactive power compensation - compensation by a series capacitor connected at the midpoint of the line - shunt compensation connected at the midpoint of the line - comparison between series and shunt capacitor - compensation by STATCOM and SSSC - some representative examples.

Static Var Compensator: Analysis of SVC - Configuration of SVC- SVC Controller – voltage regulator design - some issues - harmonics and filtering - protection aspects – modeling of SVC – applications of SVC.

Thyristor and GTO Controlled Series Capacitor: Introduction - basic concepts of controlled series compensation - operation of TCSC - analysis of TCSC- control of TCSC - modeling of TCSC for stability studies - GTO thyristor controlled series capacitor (GCSC) - mitigation of sub synchronous resonance with TCSC and GCSC - applications of TCSC.

Static Phase Shifting Transformer: General - basic principle of a PST - configurations of SPST improvement of transient stability using SPST - damping of low frequency power oscillations - applications of SPST.

Static Synchronous Compensator (STATCOM): Introduction - principle of operation of STATCOM - a simplified analysis of a three phase six pulse STATCOM - analysis of a six pulse VSC using switching functions - multi-pulse converters control of type 2 converters - control of type I Converters - multilevel voltage source converters - harmonic transfer and resonance in VSC, applications of STATCOM.
UPFC: Unified Power Flow Controller (UPFC) – Principle of operation – modes of operation – applications – modeling of UPFC for power flow studies.

REFERENCE BOOKS:

1. K.R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International, 2007.
2. Narain G Hingorani and L. Gyugyi, "Understanding FA CTS: Concepts and Technology of Flexible AC Transmission Systems", Wiley India, 2011.

3. Y. H. Song and A. T. Johns, “Flexible AC Transmission System”, Institution of Engineering and Technology, 2009.
4. Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.

ELECTIVE – III

Subject	POWER ELECTRONICS SYSTEM DESIGN USING ICs	Sub-code	16EEPE2EFC
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Analyze power electronic systems using ICs and apply the knowledge in a theoretical context.
CO2: Design high performance power electronic circuits using different ICs for various applications.
CO3: Think laterally and originally to solve power electronic circuits, and evaluate problems for switching power supplies.
CO4: Analyze Power Plant control using Programmable Logic Controller.

Introduction: Measurement techniques for voltages, current, power, power factor in power electronic circuits, other recording and analysis of waveforms, sensing of speed.

Switching Regulator Control Circuits: Introduction, isolation techniques of switching regulator systems, PWM systems.

Commercial PWM Control ICs and their Applications: TL 494 PWM Control IC, UC 1840 Programmable off line PWM controller, UC 1524 PWM control IC, UC 1846 current mode control IC, UC 1852 resonant mode power supply controller.

Switching Power Supply Ancillary, Supervisory & Peripheral Circuits and Components: Introduction, Opto-couplers, self-biased techniques used in primary side of reference power supplies, Soft/Start in switching power supplies, current limit circuits, over voltage protection, AC line loss detection, Implementation of different gating circuits.

Programmable Logic Controllers (PLC): Basic configuration of a PLC, Programming and PLC, program modification, power plant control using PLCs.

REFERENCE BOOKS:
1. G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, "Thyristorised Power Controllers",
2. 2nd Edition, New Age International, 2010.
3. Chryssis "High Frequency Switching Power Supplies", 2ndEdition, MGH, 1989.
4. Unitrode application notes: http://www.smps.us/Unitrode.html

Subject	**POWER QUALITY ISSUES AND MITIGATION**	**Sub-code**	**16EEPE2EPQ**
Credits	**03**	**L-T-P-S**	**3-0-0-0**

Introduction: Introduction to power quality, overview of power quality phenomena, power quality and EMC standard.

Long Interruptions and Reliability Evaluation: Introduction, observation of system performance, standards and regulations, overview of reliability evaluation, reliability evaluation techniques, cost of interruptions, comparison of observation and reliability evaluation, examples.

Short Interruptions: Introduction, terminology, origin of short interruptions, monitoring of short interruptions, influence on equipment, single phase tripping, stochastic prediction of short interruptions.

Voltage Sags - Characterization: Introduction, voltage sag magnitude, voltage sag duration, three phase unbalance, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, other characteristic of voltage sags, load influence on voltage sags, sag due starting of induction motors.

Voltage Sags – Equipment Behavior: Introduction, computers and consumer electronics, adjustable speed AC drives, adjustable speed DC drives, other sensitive load.

Voltage Sags – Stochastic Assessment: Compatibility between equipment and supply, voltage sag coordination chart**,** power quality monitoring, method of fault positions, method of critical distances.

Mitigation of Interruptions and Voltage Sags: Overview of mitigation methods, power system design – redundancy through s witching and parallel operation, system equipment interface.

REFERRENCE BOOKS:

1. Math H J Bollen, “Understanding Power Quality Problems; Voltage Sags and Interruptions”, Wiley India, 2011.
2. Roger C Dugan, et.al, “Electrical Power Systems Quality”, 3rd Edition, TMH, 2012.
3. G T Heydt, “Electric Power Quality”, Stars in Circle Publications, 1991.
4. Ewald F Fuchs, et. el, “Power Quality in Power System and Electrical Machines”, Academic Press, Elsevier, 2009.

Subject	POWER SUPPLY SYSTEMS	Sub-code	16EEPE2EPS
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Apply appropriate techniques, resources, and tools, including modeling, for different power supply circuits.
CO2: Demonstrate skills to the development of research in the domain of power supply systems.
CO3: Design and analysis of power supplies for different low and high power circuits.

Review: Linear Regulators, control of inverter and Converter with special modules, Transformer design by calculation and by monographs

Switching type power suppliers: Theory, noise consideration, switching of AC and DC voltages, voltage references and comparators – Switching type regulator

SMPS- Characteristics – Steady state Analysis control.

Methods: Design of feedback compression

UPS: Necessity types, typical layouts of UPS. Standalone High quality Electronics Power Supplies

REFERENCE BOOKS:

1. **Irving M. Gottilieb** "Power supplies, Switching Regulators, Inverters and Converters" BPB Publications - 1985
2. **P.R.K Chetty** "Switched Power Supply Design" BPB Publication- 1987
3. **Ned Mohan** "Power Electronics Converters, Applications and Design" John Wiley & Sons.
4. **Pressman,** "High Frequency Power Supplies" McGraw Hill

UPS Design Guide, International Rectifier

Subject	PWM CONVERTERS AND APPLICATIONS	Sub-code	16EEPE2EPW
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Develop and analyze various PWM Techniques for converters.
CO2: Analyze & estimate the various losses in converters**.**
CO3: Model the PWM Converters and Induction motor drives**.**
CO4: Apply various compensation techniques for the converters.

AC/DC and DC/AC Power Conversion: Overview of applications of voltage source converters.

PWM Techniques: Pulse modulation techniques for I – phase bridges, bus clamping PWM, space vector based PWM, advanced PWM techniques.

Loss Calculations: Practical devices in converters, calculation of switching and conduction losses, compensation for dead time and DC voltage regulation.

Modeling: Dynamic model of PWM converters; constant V/F induction motor drives; estimation of current ripple and torque ripple in inverter fed drives.

Converters with Compensation: Line-side converters with power factor compensation, reactive power compensation, harmonic current compensation.

REFERENCE BOOKS:
1. Mohan, Undeland and Robbins, "Power Electronics: Converter, Applications and Design", Wiley India, 2011.
2. Erickson RW, "Fundamentals of Power Electronics", Chapman Hall, 1997.
3. Joseph Vithyathil, "Power Electronics- Principles and Applications", TMH, 2011.

ELECTIVE-IV

Subject	DSP APPLICATIONS TO DRIVES	Sub-code	16EEPE2EDS
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Identify the functionality of TMS320LF2407 DSP Controller.
CO2: Develop DSP based DC-DC Converters**.**
CO3: Develop DSP based control of various motors.

Introduction: To the TMS320LF2407 DSP Controller, C2xx DSP CPU architecture and instruction set. General Purpose Input/output (GPIO) functionality interrupts on the TMS320LF2407, Analog-to-Digital Converter (ADC), event managers (EVA, EVB).

DSP-Based Applications: Of DC-DC buck-boost converters, DSP based control of stepper motors, DSP-Based control of permanent magnet brushless DC machines, Park and Clarke's transformations. Space Vector Pulse Width Modulation, DSP-based control of permanent magnet synchronous machines.

DSP-based vector control of induction motors.

REFERENCE BOOKS:
1. Hamid Toliyat and Steven Campbell, “DSP-Based Electromechanical Motion Control”, CRC Press, 2011.
2. P.C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, “Analysis of Electrical Machinery and Drive Systems”, 2nd Edition, Wiley India,2010
3. Chee-Mun Ong, “Dynamic Simulation of Electric Machinery using MATLAB / Simulink”, Prentice Hall, 1998.

Subject	POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES	Sub-code	16EEPE2EPC
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:

CO1: Analyze the Power quality issues and concerns of the country.
CO2: Identify the type of Power quality problems with reference to IEEE/IET standards.
CO3: Analyze, evaluate and realize the control techniques for power quality problems.
CO4: Decide on choosing the necessary monitoring equipment and mitigation techniques.

Introduction and Characterization of Electric Power Quality: Electric Power Quality, Power Electronic applications in Power Transmission Systems, Power Electronic applications in Power Distribution Systems. Power Quality terms and Definitions, Power Quality Problems.

Analysis and Conventional Mitigation Methods: Analysis of Power Outages, Analysis of Unbalance , Analysis of Distortion, Analysis of Voltage Sag, Analysis of Voltage Flicker, Reduced Duration and Customer impact of Outages, Classical Load Balancing Problem, Harmonic Reduction, Voltage Sag or Dip Reduction.

Custom Power Devices: Introduction, Utility-Customer Interface, Custom Power Devices, Custom Power Park, Status of Application of CP Devices, Closed-Loop Switching Control, Second and higher order Systems.

Solid State Limiting, Breaking and Transferring Devices: Solid State Current Limiter, Solid State Breaker, Issues in Limiting and Switching operations, Solid State Transfer Switch, Sag/Swell Detection Algorithms.

Generation of Reference Parameter : Generating Reference Currents Using Instantaneous PQ Theory, Generating reference currents using instantaneous Symmetrical Components, General Algorithm for generating reference currents, Generating Reference currents when the Source is Unbalanced.

Active Power Filters: Series Active Filter**,** Shunt Active Filter, UPQC Configurations, Right-Shunt UPQC Characteristics, Left-Shunt UPQC Characteristics, Structure and Control of Right-Shunt UPQC, Structure and Control of Left-Shunt UPQC.

REFERRENCE BOOKS:

1. Arindam Ghosh et.al, Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002.
2. Math H J Bollen, “Understanding Power Quality Problems; Voltage Sags and Interruptions”, Wiley India, 2011.
3. Roger C Dugan, et.al, “Electrical Power Systems Quality”, 3rd Edition, TMH, 2012.
4. G T Heydt, “Electric Power Quality”, Stars in Circle Publications, 1991.
5. Ewald F Fuchs, et. el, “Power Quality in Power System and Electrical Machines”, Academic Press, Elsevier, 2009.
6. C. Shankaran “Power Quality”, CRC Press, 2013.

7. Ewald F Fuchs, et. el, "Power Quality in Power System and Electrical Machines", Academic Press, Elsevier, 2009.
8. C. Shankaran "Power Quality", CRC Press, 2013.

Subject	ELECTRO MAGNETIC COMPATIBILITY	Sub-code	16EEPE2EEM
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Analyse the fundamentals and reasons for noise in Analog electronics, Power electronics and Digital electronics circuit.
CO2: Design and develop filters for Analog electronics, Power electronics and Digital circuits for reduction of noise.
CO3: Design the various types of grounding systems and get familiarised with handling electro static discharge systems, testing standards and Regulations.
CO4: Acquire knowledge about testing standards and regulations.

Review of EMI Theory: Sources of EMI, noise pick up modes and reduction techniques for analog circuits.

Emissions and Reduction Techniques: Use of co-axial cables and shielding of signal lines, conducted and radiated noise emission in power electronic equipment and reduction techniques, EMI induced failure mechanisms for power electronic equipment, EMC in design of digital circuits.

Electrostatic Discharge: ESD and switching interference reduction, susceptibility aspects of power electronic and digital equipment, shielding of electronic equipment.

REFERENCE BOOKS:
1. Otto H. W., "Noise Reduction Techniques in Electronic Systems", 2nd Edition, John Wiley and Sons, 1988.
2. Paul Clayton, "Introduction to Electromagnetic Compatibility", 2nd Edition, Wiley Inter science, 2006.
3. William B. Greason, "Electrostatic Damage in Electronics: Devices and Systems", John Wiley and Sons, 1 986.
4. Joseph Di Giacomo, "Digital Bus Hand Book", McGraw Hill Publishing Company, 1990.
5. White, R. J., "Handbook Series of Electromagnetic Interference and Compatibility", Don White consultants Inc. 1981.

Subject	HVDC POWER TRANSMISSION	Sub-code	16EEPE2EEM
Credits	03	L-T-P-S	3-0-0-0

Course outcomes:
CO1: Justify the application of AC or HVDC transmission systems based on the power transmission scenario such as quantum of power to be transferred, economics, reliability factors, etc.
CO2: Identify and analyze the various working components of the HVDC transmission systems.
CO3: Model and analyze the HVDC transmission systems.
CO4: Design and analyze various controllers and filters for HVDC systems.

DC Power Transmission Technology: Introduction, comparison with AC transmission, application of DC transmission, description of DC transmission system, Planning of HVDC transmission, modern trends in DC transmission, operating problems.

HVDC Converters: Introduction to Line commutated converter, choice of converter configuration for any pulse number, analysis of 6 and 12 pulse Graetz bridge converter without overlap, effect of smoothing reactor. Two and Three level voltage source converters, Pulse Width Modulation. Analysis of converter in two and three, and three and four valve conduction modes, LCC bridge characteristics, twelve pulse converter, detailed analysis of converters. Analysis of voltage source converters.

Control of Converters and HVDC link: DC link control principles, converter control characteristics, firing angle control, current and extinction angle control, Power control, Reactive power control, Control of voltage source converter.
Converter Faults and Protection: Converter faults, protection against over currents, over voltages in converter station, surge arrestor, protection against over voltages. Protection against faults in voltage source converter.
Smoothing Reactor and DC line: Smoothing reactors, Effects of corona loss, DC line insulators, Transient over voltages in DC line, Protection in dc line, Detection and protection of faults, DC breaker

Reactive Power Control: Reactive power control in steady state and transient state, sources of reactive power, SVC and STATCOM.

Harmonics and Filters: Introduction, Generation of harmonics, design of AC and DC filters

Multi Terminal DC Systems: Introduction, applications, types.

REFERENCE BOOKS:

1. K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International, 2012.
2. E.W. Kimbark “Direct Current Transmission”, Vol.1, Wiley Inter-Science, London, 2006.
3. Arrilaga, “High Voltage Direct Current Transmission”, the Institute of Engineering and Technology, 2^{nd}Edition, 2007.
4. S Kamakshaiah and V Kamaraju, “HVDC Transmission”, TMH, 2011.
5. Vijay K Sood, “HVDC and FACTs Controllers; Applications of Static Converters in Power Systems”, BSP Books Pvt. Ltd, First Indian reprint 2013.

INSTITUTION ELECTIVE

Subject	RENEWABLE ENERGY & PHOTOVOLTAICS	Sub-code	16EEPE2ERE
Credits	04	L-T-P-S	4-0-0-0

Course outcomes:
CO1: Understand the physics of photovoltaic system in depth.
CO2: Describe about solar radiation & measurement, cell characterization and solar constant.
CO3: Analyze the concept of charge controllers, MMPT Algorithms, economic aspects of PV systems.
CO4: Design and model PV cells & modules and analyze the issues related to grid integration, interfacing and power quality.

Introduction: Energy sources and their availability, commercial or conventional energy sources, new energy technologies, renewable energy sources, prospects of renewable energy sources.

Physics of Photovoltaic Systems: Introduction, doping, Fermi Level, p-n junction, p-n junction characteristics, photo voltaic effect, photovoltaic material, module, cell temperature.

Photovoltaic energy conversion: Solar radiation and measurements, solar constant, basic sun earth angles-definitions and their representation, solar cells and their characterization.

Solar electric system: Charge controllers, Maximum power point tracking algorithms, solar powered drives, economic analysis of PV systems and applications.

Grid integration of photovoltaics: Photovoltaic power plants, energy conversion, cell types, modelling of PV cells, modeling of PV modules, operation behavior, inverter types, grid interfacing and islanding detection, power quality, future developments.

Standalone photo voltaic Systems

REFERENCE BOOKS:
1. G.D. Rai, “Non-Conventional Energy Sources”, Khanna publishers.
2. Chenming Hu and R.M. White, “Solar Cells from Basics to Advanced Systems, McGraw Hill Book Co.
3. R.Strzelecki and G. Benysek, Editors “Power Electronics in Smart Electrical Energy Networks”, Springer.
4. G.N. Tiwari,”Solar Energy- Fundamentals, Design, Modelling and Applications” Narosa Publishing House.

Subject	**MICRO & SMART SYSTEMS**	**Sub-code**	**16EEPE2EMS**
Credits	**04**	**L-T-P-S**	**4-0-0-0**

Course outcomes:

CO1: Understand the concept of micromachining technologies namely vacuum pump, deposition techniques and lithography.

CO2: Distinguish between the main principle of operation of sensors & actuators.

CO3: Acquire in depth knowledge of characterization techniques like SEM, XRD and TEM.

CO4: Analyze different electronic circuits used to control micro systems.

Introduction: Review of material science, Microsystem versus MEMS, smart materials, structures and systems, integrated microsystems, applications of smart materials and microsystems.

Micromachining Technologies: Silicon as a material for micromachining, vacuum pumps, thin film deposition, ion implantation, lithography, etching, silicon micromachining, specialized materials for micro systems, advanced processes for micro fabrication.

Micro Sensors, Actuators, Systems and Smart Materials: Silicon Capacitive Accelerometer, piezoresistive pressure sensor, conductometric gas sensor, electrostatic comb drive, magnetic microrelay, portable blood analyzer.

Characterization techniques: Introduction, film thickness, scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-Ray diffraction (XRD), X-ray energy dispersive analysis (EDX).

Electronic Circuits and Control for Micro and Smart Systems: Semiconductor devices, electronics amplifiers, practical signal conditioning circuits for microsystems, circuits for conditioning sensed signals, introduction to control theory, implementation of controllers.

Integration of micro and smart systems: Integration of microsystems and microelectronics, microsystems packaging, case studies of integrated microsystems.

Scaling effects in microsystems: Scaling in the mechanical domain, electrostatic domain, magnetic domain, thermal domain, scaling in diffusion, scaling in fluids, scaling effects in the optical domain, scaling in biochemical phenomena.

REFERENCE BOOKS:

1. G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, “Micro and Smart Systems”, Wiley- India.
2. Milton Ohring, “Materials Science of Thin Films” 2nd Edition, ELSEVIER, 2012.
3. MEMS Lecture Series (CDS) by Shanthiram Kal.

III SEMESTER

Subject	INTERNSHIP	Sub-code	16PEPC3CIN
Credits	21	L-T-P-S	0-0-21-0

COURSE OUTCOMES

CO1: Get an insight into the company profile and understand the organizational structure.
CO2: Apply and correlate theory and practice.
CO3: Communicate effectively regarding complex Engineering activities.
CO4: Demonstrate knowledge and understanding of Engineering & Management principles of the company.
CO5: Engage in life-long learning with a commitment to improve knowledge and competence continuously.
CO6 : Acquire professional & intellectual integrity and its impact on the society.
CO7 : Observe and examine critically and make corrections cautiously

Subject	PROJECT WORK (I- PHASE)	Sub-code	16PEPC3CIP
Credits	04	L-T-P-S	0-0-4-0

COURSE OUTCOMES

CO1: Carry out literature survey, and formulate a complex engineering problem.
CO2: Apply the fundamental knowledge of mathematics, engineering and Power Electronics principles in design of solutions or system components
CO3: Identify, Select, and apply a suitable engineering/IT tool in modeling/data interpretation /analytical studies, conduct experiments leading to a logical solution.
CO4: Design a system/system component, simulate and test its functioning as a solution to a complex engineering problem..
CO5: Develop a protoype model for the project work
CO6 : Develop good technical reports and publications in reputed conferences / journals based on project work results.
CO7 : Communicate effectively the work carried out before the expert committee.

IV SEMESTER

Subject	PROJECT WORK (FINAL PHASE)	Sub-code	16PEPC4CPR
Credits	23	L-T-P-S	0-0-23-0

COURSE OUTCOMES

CO1: Carry out literature survey, and formulate a complex engineering problem.
CO2: Apply the fundamental knowledge of mathematics, engineering and Power Electronics principles in design of solutions or system components
CO3: Identify, Select, and apply a suitable engineering/IT tool in modeling/data interpretation /analytical studies, conduct experiments leading to a logical solution.
CO4: Design a system/system component, simulate and test its functioning as a solution to a complex engineering problem..
CO5: Develop a protoype model for the project work
CO6 : Develop good technical reports and publications in reputed conferences / journals based on project work results.
CO7 : Communicate effectively the work carried out before the expert committee.
CO8: Manage project work in the core Power Electronics domain within the stipulated time

Subject	TECHNICAL SEMINAR	Sub-code	16PEPC4CTS
Credits	02	L-T-P-S	0-0-2-0

COURSE OUTCOMES

CO1: Carryout literature survey, and choose a relevant topic reported in recent IEEE conference publications / transactions in the domain of Power Electronics
CO2: Simulate and analyse the results reported in the chosen paper for seminar topic.
CO3: Communicate effectively and develop technical reports.
CO4: Respond to the queries by the evaluation committee and audience

RUBRICS FOR PROJECT WORK EVALUATION OF PG POWER ELECTRONICS PROGRAMME

Parameters for evaluation	**Excellent (>=9)**	**Very good (>=7 and<9)**	**Good (>=6 and <7)**	**Average (>=4 and <6))**
Scholarship of knowledge	Acquired in-depth knowledge through exhaustive literature survey Able to evaluate and carry out analysis independently with wider perspective.	Sufficient literature survey Able to evaluate and carryout analysis reasonably well.	Moderate literature survey Able to evaluate and carryout analysis satisfactorily.	Not very much clear about the project work. Not able to evaluate and analyse independently
Critical Thinking	Apply independent judgment to synthesize information for the project work and to create advances for conducting research.	Apply independent judgment to synthesize information for the project work	Moderately able to synthesize information for the project work.	Partially able to synthesize information for the project work.
Problem Solving	Think laterally and originally, solve problems independently related to project work.	Think originally to solve problems with assistance.	Moderately able to solve problems with assistance.	Partially able to solve problems with assistance.
Research Skill	Apply appropriate techniques, design and implement project work. Publication out of project work results in a reputed journal / IEEE conference	Apply appropriate techniques, design and implement project work. Publication out of project work results in a IEEE conference.	Apply appropriate techniques, design and implement project work. Publication out of project work results in a national conference.	Apply appropriate techniques, design and implement project work.

Usage of modern tools	Usage of software tools for exhaustive simulation and analysis and assess the performance of the system.	Moderate Usage of software tools for simulation and analysis and assess the performance of the system.	Moderate Usage of software tools for simulation and analysis and not able to clearly assess the performance of the system.	Not adequately used software tools for simulation and analysis
Collaborative and Multidisciplinary work	Carried out multidisciplinary project work, ability in decision making	Carried out multidisciplinary project work.	Carried out multidisciplinar y project work integrated with basic Electrical courses.	Project in the domain of Power Electronics.
Project Management and Finance	Able to manage projects efficiently in respective disciplines.	Able to manage projects moderately in respective disciplines.	Able to manage projects partially in respective disciplines.	Not able to manage projects in respective disciplines
Communication	Able to communicate confidently and effectively. Able to answer all the queries by the experts' panel.	Able to communicate confidently and effectively. Able to answer few of the queries by the experts panel	Moderately able to communicate and answer few of the queries by the experts panel	Not able to communicat e confidently and effectively.
Life-long Learning	Commitment to improve knowledge and competence continuously with a high level of enthusiasm.	Commitment to improve knowledge and competence continuously.	Commitment to improve knowledge and competence.	Not enthusiastic in improving the knowledge and competence
Ethical Practices and Social Responsibility	Able to contribute to the community for sustainable development of society.	Able to contribute to the community.	Partially able to contribute to the community.	Not able to contribute to the community.
Independent and Reflective Learning	Able to make corrective measures in the project independently, based on previous mistakes without depending on external feedback.	Able to make corrective measures in the project independently, based on previous mistakes with assistance.	Able to make corrective measures in the project with guidance.	Not able to make corrective measures in the project.

RUBRICS FOR INTERNSHIP EVALUATION OF PG POWER ELECTRONICS PROGRAMME

Parameters for evaluation	**Excellent (>=9)**	**Very good (>=7 and<9)**	**Good (>=6 and <7)**	**Average (>=4 and <6))**
Scholarship of knowledge	Acquired in-depth knowledge about internship	Sufficient knowledge about internship	Moderate knowledge about internship.	Not very much clear about the internship work.
Critical Thinking	Apply independent judgment to synthesize information for the internship.	Apply sufficient judgment to synthesize information for the internship work.	Moderately able to synthesize information for the internship work.	Partially able to synthesize information for the internship work.
Problem Solving	Think laterally and originally, solve problems independently related to internship work.	Think originally to solve problems with assistance.	Moderately able to solve problems with assistance.	Partially able to solve problems with assistance.
Research Skill	Apply appropriate techniques, design and implement internship assignments independently.	Apply appropriate techniques, design and implement internship assignments with assistance.	Apply appropriate techniques, design and implement partially internship assignments	Study of existing system in Industry.
Usage of modern tools	Usage of software tools for exhaustive simulation and analysis and assess the performance of the system.	Moderate Usage of software tools for simulation and analysis and assess the performance of the system.	Moderate Usage of software tools for simulation and analysis and not able to clearly assess the performance of the system.	Not adequately used software tools for simulation and analysis.
Collaborative and Multidisciplinary work	Carried out multidisciplinary internship work, ability in decision making	Carried out multidisciplinary internship work.	Carried out multidisciplinary internship work integrated with basic Electrical courses.	Internship in the domain of Power Electronics.

Project Management and Finance	Able to manage internship assignments efficiently in respective disciplines.	Able to manage internship assignments moderately in respective disciplines.	Able to manage internship assignments partially in respective disciplines.	Not able to manage internship assignments in respective disciplines
Communication	Able to communicate confidently and effectively. Able to answer all the queries by the experts' panel.	Able to communicate confidently and effectively. Able to answer few of the queries by the experts panel	Moderately able to communicate and answer few of the queries by the experts panel	Not able to communicate confidently and effectively.
Life-long Learning	Commitment to improve knowledge and competence continuously with a high level of enthusiasm.	Commitment to improve knowledge and competence continuously.	Commitment to improve knowledge and competence.	Not enthusiastic in improving the knowledge and competence
Ethical Practices and Social Responsibility	Able to contribute to the community for sustainable development of society.	Able to contribute to the community.	Partially able to contribute to the community.	Not able to contribute to the community.
Independent and Reflective Learning	Able to make corrective measures in the internship assignments independently, based on previous mistakes without depending on external feedback.	Able to make corrective measures in the internship assignments independently, based on previous mistakes with assistance.	Able to make corrective measures in the internship assignments with guidance.	Not able to make corrective measures in the internship assignments.