DEPARTMENT OF ELECTRICAL ENGINEERING

Course Book for

M.Tech. in Power Electronics & Drives

Visvesvaraya National Institute of Technology

2014

Brief about M.Tech programs:

The main objectives of 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, where in 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.

Departmental core (DC)		**Departmental Electives (DE)**	
Category	Credit	Category	Credit
Departmental core (DC)	72	Departmental Electives (DE)	32
Grand Total (DC+DE)			104

The number of credits attached to a subject depends on number of classes in a week. For example, a subject with 3-2-0 (L-T-P) means it has 3 Lecture, 2 Tutorial and 0 Practical hours in a week. This subject will have eight credits (3x2 + 2x1 + 0x1 = 8). 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:

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

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

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 & H.O.D	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.	Associate Professor	Ph. D.	Power System Protection, Artificial Intelligence Technique
Bhorgate 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.	On deputation
Kulkarni P.S.	Associate Professor	Ph. D.	Power Systems Operation & Control, Renewable Energy Systems
Patne N.R.	Assistant Professor	Ph. D.	Power Systems, Power Quality
Patnaik S.P.	Associate Professor	Ph. D.	Power Electronics Converters
Ramteke M.R.	Associate Professor	Ph. D.	Power Electronics
Satputaley R.J.	Assistant Professor	M.Tech.	Power Systems, Power Quality
Suryawamshi 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

SCHEME OF EXAMINATION/INSTRUCTION-M TECH (PED)

I Semester			
Code	**Course**	**L-T-P**	**Credits**
Core			
EEL422	Power Conversion and Control	3-0-0	6
EEL508	Electrical Machines Analysis and Control	3-0-0	6
EEL423	Electrical Drives-I	3-0-0	6
EEL410	Advanced Control Theory	3-0-0	6
EEP408	Power Electronics Lab	0-0-2	2
EEP426	Electrical Drives Lab	0-0-2	2
Elective (Any one)			
EEL421	Power Quality	3-0-0	6
EEP421	Power Quality lab	0-0-2	2
EEL505	AI Based System	3-0-0	6
	Total Credits	34/36	

II Semester			
Code	**Course**	**L-T-P**	**Credits**
Core			
EEL509	PE Circuit Design & Analysis	3-0-0	6
EEL510	Electrical Drives-II	3-0-0	6
EEL411	FACTS	3-0-0	6
EEP411	FACTS lab	0-0-2	2
Elective (Any two)			
EEL512	Distributed Generation	3-0-0	6
EEP512	*Distributed Generation lab	0-0-2	2
EEL511	Special Topics in PE	3-0-0	6
MAL405	Applied Linear Algebra	3-0-0	6
EEP424	Simulation/ Implementation of PE circuits	0-0-2	2
	Total credits	32/34	
*Compulsory with EEL512			

III Semester			
Code	**Course**	**L-T-P**	**Credits**
Core			
EED503	Project Phase-I	---	6
Elective (Any Two)			
EEP425	Processor Application in EE	3-0-0	6
EEL430	Adv DSP	3-0-0	6
EEL421	Power Quality	3-0-0	6
EEP421	*Power Quality lab	0-0-2	2
EEL505	AI based Systems	3-0-0	6
EEP425	*Proc App in EE	0-0-2	2
	Total Credits	22/20	
*Lab is compulsory with theory			

IV Semester			
Code	**Course**	**L-T-P**	**Credits**
Core			
EED504	#Project Phase II (# prerequisite: Project Phase-I)	---	18

FIRST SEMESTER

EEL422: POWER CONVERSION, CONTROL AND APPLICATIONS (3-0-0- Credits-6)

Objectives:

- The main objective of this subject is to get detail knowledge of semiconductor device, characteristics and converter applications

Syllabus:

Review of power semiconductor Devices, VI-characteristics (ideal and practical), gate driver circuits.

DC-DC converters: Various types, analysis, control of converter, duty ratio control, current &voltage control.

Voltage Source Inverters (VSI): Principle and steady state analysis of VSI, Methods for controlling inverter, equivalent circuit.

AC to DC converters: Line commutated & PWM converter, multi-quadrant operation, regeneration, input current and reactive power requirements.

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. IEE & IEEE papers.

EEL508: ELECTRICAL MACHINES ANALYSIS AND CONTROL (3-0-0- Credits-6)

Objectives:

- To get acquainted with mathematical modeling of synchronous and induction machine
- To learn various methods 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 P.C.Krause, Oreg Wasynczuk, Scott D. Sudhoff, "Analysis of Electric Machinery and drive systems" , IEEE Press, 2002.
2. P. S. Bhimbra, "Generalised 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.

EEL423: ELECTRIC DRIVES-I (3-0-0- Credits-6)

Objectives:

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

Syllabus:

Dynamics of Electric Drives: load-torque characteristics, stability criteria. Control of converters for DC drives, Chopper controlled DC motor drives.

Power supplies for variable speed drives: Voltage source inverters, Current source inverters, Space Vector pulse width modulated inverters and their control methodology.

Phase controlled induction motor drives, frequency control induction motor drives.
Induction motor drives in scalar control mode and their applications.

Text Books:

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

Reference Books:

1. M.H. Rashid, "Power electronics Handbook" Elsevier Academic Press,2009.
2. W. Leonhard, "Control of electrical drives", Narosa Publishing House, New Delhi, 1984.

EEL410: ADVANCED CONTROL THEORY (3-0-0- Credits-6)

Objectives:

- To teach determination of linear and non-linear systems' relative stability
- Study of analog and digital control techniques

Syllabus:

Review of State variable analysis, Controllability and observability.

Digital Control Systems, Models of Digital control Devices, State description of Digital processors and sampled continuous time plants, Discretisation of Digital continuous time state equations, Solution of state difference equation.

Controllability and observability tests for digital control systems, Stability of discrete time systems, Pulse transfer function and its realization, Stability improvement by state feedback, Pole-placement design and state observers

Text Books:

1. M.Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill, New Delhi, 1997.

Reference Books:

1. D.E. Kirk, "Optimal Control Theory", Prentice Hall, 1970.
2. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.

EEP408: POWER ELECTRONICS LAB (0-0-2- Credits-2)

List of experiments:

1. To study the V_T, I_T characteristics of SCR
2. To study DC circuit breaker using SCR
3. To study phase control AC to DC converter using SCR
4. To study the relaxation oscillator using UJT
5. Simulation of
   (i) Single-Phase Half wave controlled Rectifier
   (ii) Single-Phase Full wave fully controlled Rectifier
   [R, R-L, R & high L].
6. To study four modes of operation of Traic
7. To study AC voltage regulator using SCR
8. To study Single-Phase Inverter using self controlled devices as IGBT/MOSFET (Single PWM, Multiple PWM, Sinusoidal PWM)
9. To study the Three-Phase Inverter
10. To Study DC-DC Converter
    a. Buck converter
    b. Boost converter
11. Simulation of following Experiments Using PSIM

Boost Converter

(i) AC voltage regulator using SCR
(ii) Single-Phase Inverter using self controlled devices as IGBT/MOSFET (Single PWM, Multiple PWM, Sinusoidal PWM)
(iii) Three-Phase Inverter
(iv) DC-DC Converter
(a) Buck Converter

EEP426: ELECTRICAL DRIVES LAB (0-0-2-Credits -2)

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.

EEL421: POWER QUALITY (3-0-0- Credits-6)

Objectives:

- To study literature of power quality
- Effect of power quality in distribution system, mitigation of power quality problem by power electronic devices are studied

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Syllabus:

Introduction to power quality, PQ standards, terms, definitions.

Voltage sag and interruptions, its sources, types, characteristics, behavior of different electric equipments, concept of area of vulnerability

Voltage swell and transient overvoltages, sources of overvoltages like capacitor switching, load switching, lightening etc. problems due to over voltages, computer tools for transient analysis

Harmonics distortions, voltage and current harmonics, THD , sources of other harmonics, its ill effects, interharmonics, harmonic filters, other PQ problems like EMI, noise, notching , flicker , DC offset.

Typical wiring and grounding problem causing poor power quality, solutions to wiring and grounding problem.

Need of measuring and monitoring of PQ problems, location of monitoring equipments and frequency.

Text Books:

1. Roger C. Dugan, "Electrical power system quality", McGraw Hill.
2. Alexander Kusko, "Power quality in electrical systems", McGraw Hill.

Reference Books:

1. Ewald Fusch, "Power quality in power system and electrical machines", Academic press.
2. H.J.Math ,"Understanding power quality problems: voltage sags and interruptions", by IEEE press.

EEP421: POWER QUALITY (0-0-2- Credits-2)

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.

EEL505: ARTIFICIAL INTELLIGENCE BASED SYSTEM (3-0-0- Credits-6)

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

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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. Kevin Warwick, Arthur Ekwue and Raj Aggarwal ,"Artificial Intelligence Techniques in Power Systems, The Institution of Electrical Engineers" , London, 1989.
2. Bart Kosko , "Neural networks and Fuzzy Systems", Prentice Hall of India, 1990.

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.

SECOND SEMESTER

EEL509: POWER ELECTRONIC CIRCUIT DESIGN AND ANALYSIS (3-0-0- Credits-6)

Objectives:

- This gives details of various converter design aspects including modeling of converters

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 fitter, 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.

EEL510 ELECTRICAL DRIVES-II (3-0-0-Credits- 6)

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, Sensorless 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.

EEL411: FACTS (3-0-0- Credits-6)

Objectives

- ***To impart the knowledge, to tackle the problem of regulatory constraints on the expansion of power transmission network by introduction of high power electronic controllers for regulation of power flow and voltages in the AC transmission network.***

Syllabus:

Introduction of Semiconductor Devices, Steady State and Dynamic Problems in AC Systems, Power Flow.

Flexible AC Transmission Systems (FACTS): Basic Realities & Roles, Types of Facts Controller, Principles of Series and Shunt Compensation.

Description of Static VAR Compensators (SVC), Thyristor Controlled Series Compensators (TCSC), Static Phase Shifters (SPS), Static Condenser (STATCON), Static Synchronous Series, Compensator (SSSC) and Unified Power Flow Controller (UPFC).

Modeling and Analysis of FACTS Controllers, Control Strategies to Improve System Stability, Power Quality Problems in Distribution Systems.

Harmonics, Harmonics Creating Loads, Modeling, Series and Parallel Resonances, Harmonic Power Flow, Mitigation of Harmonics, Filters, Passive Filters, Active Filters, Shunt, Series, Hybrid Filters.

Text Books:

1. N.G. Hingorani, "Understanding of FACTs", IEE press.
2. T.E.Acha, "Power Electronics Control in Electrical Systems" , New NES (Elsevier) Publication, 2006.

Reference Books:

1. G.T. Heydt, "Power Quality, Stars in a Circle Publications", Indiana, 1991.
2. T.J.E. Miller, "Static Reactive Power Compensation", John Wiley & Sons, New York, 1982.
3. Yong Hua Song, "Flexible AC transmission system (FACTS)".
4. Recent publications on IEEE Journals.

EEP411: FACTS LAB (0-0-2-Credits-2)

List of experiments for FACTS lab:

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. Modeling of Thyristor Converters.
6. Modeling of Thyristor Controlled Reactors (TCR).
7. Modeling of Thyristor Controlled Series Capacitors (TCSC) .
8. Modeling of Static Shunt compensator (STATCOM).
9. Modeling of Static Synchronous Series compensator (SSSC).

EEL512: DISTRIBUTED GENERATION (3-0-0- Credits-6)

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, Geo Thermal Energy, Bio Mass 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.

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, John Wiley and Sons, 2nd Ed,2010.

EEP512: DISTRIBUTED GENERATION LAB (0-0-2- Credits-2)

List of experiments:

1 Single PV module I-V and P-V characteristics with radiation and temperature changing effect.

2 I-V and P-V characteristics with series and parallel combination of modules.

3 Effect of shading and Effect of tilt angle on I-V and P-V characteristics of solar module.

4 Study of Stand-alone system using Combine AC and DC load system with battery.

5 Finding MPP by varying the resistive load by varying the duty cycle of DC-DC converter.

6 Finding P_{max} with different values of perturbation (delta D).

7 Perform the experiment with battery in the circuit.

8 Observe the output voltage waveform of inverter in auto mode.

9 Observe the RMS value and waveform of output voltage with both 180 and 120 degree control.

10 Field Visit to Solar Street Lighting System.

11 Study of Solar PV Grid-Tied system.

12 Study of Wind Energy System.

EEL511: SPECIAL TOPICS IN POWER ELECTRONICS (3-0-0- Credits-6)

Objectives:

- Gives an idea about the use of power electronics in various fields and applications

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.

Text/ Reference Books:

1. Recent IET/IEEE publications.

MAL405: APPLIED LINEAR ALGEBRA (3-0-0- Credits-6)

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.

EEP424: SIMULATION/IMPLEMENTATION OF PE CIRCUITS (0-0-2- Credits-2)

List of Experiments based on following points:

2. Generation of PWM wave forms in SPWM, SVPWM.
3. Simulation of PWM waveforms and their analysis (FFT, Crest Factor, P.F, DPF).
4. Passive component design optimization under various switching frequencies (DC-DC converters).
5. Power quality issues in line commutated converters.
6. Design of different switching circuits using OP-Amps.

THIRD SEMESTER

EED503: PROJECT PHASE 1 (0-0-3- Credits-6)

EEL425: PROCESSOR APPLICATIONS IN ELECTRICAL ENGINEERING (3-0-0- Credits-6)

Objectives:

- To learn DSP and microprocessor based applications for PE and drives
- Introduction to microcontrollers

Syllabus:

Introduction to Digital Signal Processor (DSP) and its applications in Power Electronics converters and drives, FPGA based controller for PE and Drives.

Microprocessor Vs Microcontroller, Architecture and programming of 8051 microcontroller: Special Function Registers, Internal RAM and ROM, Interfacing with external memory, programmable built in ports, on chip counters / timers, Serial Data Input/Output, Interrupts, assembly language Programming and applications.

Microprocessor based applications: Measurement of various electrical and non-electrical parameters, Speed monitoring and control of various motors, Control of firing circuits of power electronics systems, Numerical Protective relays etc.

Text Books:

1. Muhammad Ali Mazidi. , "The 8051 Microcontroller And Embedded Systems Using Assembly And C, 2/E", Pearson Education India, 01-Sep-2007.
2. Ayala, J. Kenneth, "The 8051 Microprocessor Architecture, Programming and Applications", Penram International, 1996.

Reference Books:

1. Trevor Martin, "The Insider's Guide To The Philips ARM7-Based Microcontrollers", Published by Hitex (UK) Ltd, April 2005.
2. Joseph Yiu, "The Definite Guide to cortex –M3", Elsevier publication, 2007.
3. Andrew & Sloss, "Arm System Development Guide", Elsevier Publication, 2007.
4. Datasheet and user manual of TI, Microchip range of digital signal controllers.

EEL430: ADVANCED DIGITAL SIGNAL PROCESSING (3-0-0- Credits-6)

Objectives:

- In depth study of DSP techniques

Syllabus:

Signal flow graph representation, DF1, DF2, parallel and cascade form,. Finite word length effects in Digital Filters. Discrete Fourier transform (DFT), fast Fourier transform algorithms. Design of FIR digital filters: window method, Park-McClellan's method. Design IIR digital filters: Butterworth, Chebyscheve approximation. Low pass, Band pass, Band stop, and High pass filters. Bilinear, Impulse processing algorithm.

Text Books:

1. Sanjit k. Mitra, "Digital Signal processing, a computer based approach", Tata McGraw Hill.
2. A. V. Oppenheim and Schefer, "Discrete time signal processing", PH 1989.

Reference Books:

1. John G. Proakis and D. G. Manolakis, " Digital signal Processing: principles, algorithms and applications," PH 1992.
2. Thomas J. Cavicchi, " Digital signal Processing", Wiley 2002.

EEL421: POWER QUALITY (3-0-0- Credits-6)

Objectives:

- ***To study the aspects of power quality problems.***
- ***Effect of power quality in distribution system is studied.***

Syllabus:

Introduction to Power Quality, PQ Standards, Terms, Definitions.

Voltage Sag and Interruptions, Its Sources, Types, Characteristics, Behavior of Different Electric Equipments, Concept of Area of Vulnerability.

Voltage Swell And Transient Over voltages, Sources Of Over voltages Like Capacitor Switching, Load Switching, Lightening Etc. Problems Due To Over Voltages, Computer Tools For Transient Analysis.

Harmonics Distortions, Voltage And Current Harmonics, THD , Sources Of Other Harmonics, Its Ill Effects, Inter-harmonics, Harmonic Filters, Other PQ Problems Like EMI, Noise, Notching , Flicker , DC Offset.

Typical Wiring and Grounding Problem Causing Poor Power Quality, Solutions to Wiring and Grounding Problem.

Need of Measuring and Monitoring Of PQ Problems, Location of Monitoring Equipments and Frequency.

Text Books:

1.Roger C. Dugan, "Electrical power system quality", McGraw Hill.
2.Alexander Kusko, "Power quality in electrical systems", McGraw Hill.

Reference Books:

1. Ewald Fusch, "Power quality in power system and electrical machines", Academic press.
2. M.J.Math, "Understanding power quality problems: voltage sags and interruptions" by IEEE press.

EEP421: POWER QUALITY (0-0-2- Credits-2)

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.

EEL505: AI BASED SYSTEMS (3-0-0- Credits-6)

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 fiels 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.

EEP425: PROCESSOR APPLICATIONS IN E.E (0-0-2-Credits-2)

List of experiments:

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 one is to be completed including software and hardware using D-Space 1104 & Other 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.

FOURTH SEMESTER

EED504 PROJECT PHASE II (0-0-9-Credits-18)
