# KERALA TECHNOLOGICAL UNIVERSITY


## (THRISSUR CLUSTER - 07)

## SCHEME AND SYLLABI

## of

## M. TECH.

## in

# POWER ELECTRONICS

**OFFERING DEPARTMENT**

## ELECTRICAL & ELECTRONICS ENGINEERING

## CLUSTER LEVEL GRADUATE PROGRAM COMMITTEE

| | | |
|---|---|---|
| 1. | Dr Devdas Menon, Professor, IIT Madras, Chennai | Chairman |
| 2 | Principal, Government Engineering College Trichur, Thrissur | Convener |
| 3 | Principal, AXIS College of Engineering & Technology, East Kodaly, Murikkingal, Thrissur | Member |
| 4 | Principal, IES College of Engineering, Chittilappilly, Thrissur | Member |
| 5 | Principal, MET'S School of Engineering, Mala, Thrissur | Member |
| 6 | Principal, Royal College of Engineering & Technology, Akkikkavu, Thrissur | Member |
| 7 | Principal, Vidya Academy of Science & Technology, Thalakkottukara, Thrissur | Member |
| 8 | Principal, Thejus Engineering College, Vellarakkad, Erumappetty, Thrissur | Member |
| 9 | Principal, Universal Engineering College, Vallivattom, Konathakunnu, Thrissur | Member |
| 10 | Principal, Sahrdaya College of Engineering & Technology, Kodakara, Thrissur | Member |

**CERTIFICATE**

This is to certify that

1. The scheme and syllabi are prepared in accordance with the regulation and guidelines issued by the KTU from time to time and also as per the decisions made in the CGPC meetings.
2. The suggestions/modifications suggested while presenting the scheme and syllabi before CGPC on 25.6.2015 have been incorporated.
3. There is no discrepancy among the soft copy in MS word format, PDF and hard copy of the syllabi submitted to the CGPC.
4. The document has been verified by all the constituent colleges.

Coordinator in charge of syllabus revision of the programme

Dr T N Padmanabhan Nambiar
Sr Professor
Vidya Academy of Science & Technology, Thalakkotkara

Principal of the lead college

Dr. Sudha Balagopal
Principal
Vidya Academy of Science & Technology, Thalakkotkara

Principals of the colleges in which the programme is offered

| No | Name of the college | Principal's Name | Signature |
|---|---|---|---|
| 1 | Govt. Engineering College, Thrissur | Dr. Indira Devi | |
| 2 | Principal, Vidya Academy of Science & Technology, Thalakkotkara | Dr. Sudha Balagopal | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

Date: July, 2015
Place: Thrissur

Dr. Devdas Menon,
Professor, IIT Madras
Chairman

# VISION and MISSION of the Programme

## VISION

Progress through Quality education in Electrical & Electronics Engineering and to emerge as a Centre of excellence in education and research for grooming the engineers as leaders of the society.

## MISSION

- Provide our students strong theoretical knowledge, practical engineering skills and attitudes that will allow them to succeed as engineers and leaders.
- Create and maintain state-of-the art research environment, which provides its students and faculty with opportunities to create, interpret, apply and disseminate knowledge of electrical engineering.
- Prepare socially responsible graduates for life-long learning to meet intellectual, ethical and career challenges.

# PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

There is a growing concern about the efficient use of depleting energy resources. Power Electronics encompasses many areas within Electrical Engineering. It plays an important role in processing and controlling the flow of electric energy efficiently and intelligently, by supplying voltage and current in forms that are optimally suited for user loads from a few watts to several megawatts. The application areas include heating and lighting control, ac and dc power supplies, motor control, HVDC power transmission, FACTS controllers, renewable energy integration, Power Quality improvement, Energy conservation, processes control and factory automation. The objective of the programme is to make the students aware of these issues and learn the theoretical aspects of power control, design fabricate and test power electronics systems for applications mentioned above. The objectives are met by offering a number of core courses supplemented by electives which the students can choose and culminating in project work. In addition program also has courses for generating research aptitude and improving communication skill.

# PROGRAMME OUTCOMES
# (POs)

A. Ability to apply knowledge of mathematics, science and engineering to conceptualize experiments, analyze data and utilize the same effectively in engineering practice.
B. Acquire skills to use modern simulation tools and digital hardware technology for modelling and prototyping of complex power electronic systems.
C. Enhance research capabilities and demonstrate problem identification, analysis and synthesis skills.
D. Ability to demonstrate and design different types of converters and inverters.
E. Study the application of power electronics systems to improve the performance of power system.
F. Analyse, design and integrate various renewable sources to the power grid, to meet the energy demand.
G. Demonstrate knowledge of project management principles as an individual or as a team to execute project/ develop prototype successfully with due consideration of economical and financial factors.
H. Ability to comprehend and write report and documentation to make effective presentation both oral and written.
I. Acquire professional ethical practices/ethics of research, integrity, professional code of conduct.
J. Ability to engage in self-study and life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

# Scheme of M. Tech Programme in POWER ELECTRONICS

## SEMESTER 1

| Exam Slot | Course Code | Course Title | Hours/week | | | ICA | ESE | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | | | |
| A | 07MA 6019 | Applied Mathematics | 3 | 1 | 0 | 40 | 60 | 100 | 4 |
| B | 07EE 6201 | System Dynamics | 3 | 1 | 0 | 40 | 60 | 100 | 4 |
| C | 07EE 6103 | Analysis of Power Electronic Circuits I | 3 | 1 | 0 | 40 | 60 | 100 | 4 |
| D | 07EE 6105 | Electric Drives | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| E | 07EE 6xxx | Elective I | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | 07GN 6001 | Research Methodology | 0 | 2 | 0 | 100 | 0 | 100 | 2 |
| | 07EE 6009 | Power Electronics Lab | 0 | 0 | 2 | 100 | 0 | 100 | 1 |
| | 07EE 6111 | Introduction to Seminar | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | | | 15 | 6 | 2 | 400 | 300 | 700 | 21 |

L-Lecture T-Tutorial P-Practical ICA-Internal Continuous Assessment

ESE-End Semester Examination

**ELECTIVE I**

07EE 6207 Optimization Techniques
07EE 6117 Power Semiconductor Devices & Modelling
07EE 6127 High Voltage AC and DC Transmission
07EE 6137 Dynamics of Electric Machines

**Note:** 8 hours/week is meant for departmental assistance by students.

# SEMESTER 2

| Exam Slot | Course Code | Course Title | Hours/week | | | ICA | ESE | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | | | |
| A | 07EE 6102 | Analysis of Power Electronic Circuits II | 3 | 1 | 0 | 40 | 60 | 100 | 4 |
| B | 07EE 6104 | Switched Mode Power Converters | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| C | 07EE 6106 | Advanced Electric Drives | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| D | 07EE 6xxx | Elective II | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| E | 07EE 61xx | Elective III | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | 07EE 6114 | Mini Project | 0 | 0 | 2 | 100 | - | 100 | 2 |
| | 07EE 6116 | Advanced Power Electronics Lab | 0 | 0 | 2 | 100 | - | 100 | 1 |
| | 07EE 6124 | Seminar I | 0 | 0 | 2 | 100 | - | 100 | 2 |
| TOTAL | | | 15 | 1 | 6 | 500 | 300 | 800 | 21 |

L-Lecture T-Tutorial P-Practical ICA-Internal Continuous Assessment ESE- End Semester Examination

**ELECTIVE II**

07EE 6208 Flexible AC Transmission Systems
07EE 6118 Design of Power Electronic System
07EE 6128 Nonlinear Control Systems
07EE 6138 Computer Aided Design of Electrical Machines

**ELECTIVE III**

07EE 6112 Industrial Control Electronics
07EE 6122 Renewable Energy Technologies
07EE 6132 Optimal and Adaptive Control Systems
07EE 6142 Robotics and Automation

**Note**: 8 hours / week is meant for departmental assistance by students.

**Industrial Training Optional (**During inter semester holydays of 2nd & 3rd Semesters)

# SEMESTER 3

| Exam Slot | Course Code | Course Title | Hours/week | | | ICA | ESE | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | | | |
| A | 07EE 7xxx | Elective IV | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| B | 07EE 7xxx | Elective V | 3 | 0 | 0 | 40 | 60 | 100 | 3 |
| | 07EE 7105 | Seminar II | 0 | 0 | 2 | 100 | 0 | 100 | 2 |
| | 07EE 7107 | Project (Phase 1) | 0 | 0 | 12 | 50 | 0 | 50 | 6 |
| TOTAL | | | 6 | 0 | 14 | 230 | 120 | 350 | 14 |

L-Lecture T-Tutorial P-Practical ICA-Internal Continuous Assessment
ESE- End Semester Examination

**ELECTIVE IV**

07EE 7101 Digital Control Systems
07EE 7211 Power Quality
07EE 7121 Industrial Instrumentation
07EE 7131 Digital Signal Processors

**ELECTIVE V**

07EE 7103 Special Electrical Machines and Drives
07EE 7213 Soft Computing Techniques
07EE 7123 Electromagnetic Compatibility
07EE 7133 Electric Systems for Wind and Solar Energy

## SEMESTER 4

| Sl. No. | Course code | Subject | Hours/week | | | ICA | ESE | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | | | |
| 1 | 07EE 7102 | Project (Phase 2) | 0 | 0 | 21 | 70 | 30 | 100 | 12 |

L-Lecture T-Tutorial P-Practical ICA-Internal Continuous Assessment ESE- End Semester Examination.

**Total credits for all semesters: 68**

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# SEMESTER 1

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| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07MA 6019** | **APPLIED MATHEMATICS** | **3-1-0-4** | **2015** |

**Prerequisite:** UG level Mathematics

**Course Objectives :** *To familiarize the students with the ideas and notions of Eigen value problems, principle of least squares, geometry of Fourier series, wavelets, development of probability distributions and probability theory, aspects of inferential statistics, reliability modelling, stationary stochastic processes, discrete time Markov chains and its stationary distributions etc.*

**Syllabus :** Solution of system of linear equations, Eigen value problems in engineering, method of least squares, geometry of Fourier series, discrete wavelet transform, probability distributions, conditional probability, CLT, linear regression and correlation, statistical inference, reliability, stationary processes and Markov chains.

**Course Outcome:** These concepts will help the students to appreciate (i) matrix methods in engineering, structure of vector spaces applied to wavelets which is a tool in signal and image processing and (ii) probabilistic and statistical methods to understand and analyze uncertainty.

**References**


1. Datta, B N (2010), *Numerical Linear Algebra and Applications*, 2nd Edition, PHI Learning Pvt. Ltd., Delhi. (for Module 1).
2. Gubner J A (2006), *Probability and Random Processes for Electrical and Computer Engineers*, Cambridge University Press, Cambridge, New York. (for Modules 3 & 4).
3. Johnson, R A (2008), Miller & Freud's *Probability and statistics in Engineering*, 7th Edition, Pearson, Delhi. (for Modules 3, 4 & 5).
4. Medhi, J (2009), *Stochastic Processes*, 3rd Edn., New Age International (P) Ltd., New Delhi. (for Module 6).
5. Soman K P, Ramachandran, K I and Resmi N G (2013), *Insight into Wavelets, from Theory to Practice*, 3rd Edn., PHI Learning, Delhi. (for Module 2).
6. Kreyszig, E (1999/ 2007), *Advanced Engineering Mathematics*, 8th Edn, Wiley India Pvt. Ltd., Delhi. (for Module 1).

| COURSE PLAN<br>COURSE NO: 07MA 6019 COURSE TITLE: APPLIED MATHEMATICS<br>(L-T-P: 3-1-0) CREDITS: 4 | | | |
|---|---|---|---|
| **Module** | **Contents** | **Contact Hours** | **Sem.Exam Marks:%** |
| I | Matrices and Least squares: Solution of system of linear equations using LU factorization - Gauss-Siedel methods - Eigen value problems in engineering - Method of least squares - Fitting a straight line and a second degree curve | 8 | 15 |
| II | Discrete wavelet transform: Fourier series and geometry - Discrete wavelet transform - Haar scaling function and wavelet function and their orthogonality - Haar bases | 8 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Probability distributions: Binomial and Poisson - Uniform, exponential, gamma and Weibull - Normal distributions | 8 | 15 |
| IV | Probability: Conditional probability, Bayes' theorem, independence - Lindeberg-Levy central limit theorem - Sampling distributions ($t$, $\chi 2$ and $F$) - Linear regression and correlation | 8 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Statistics and Reliability: Unbiased estimators of mean and variance - Tests for mean and variance - Interval estimation of mean and variance - Reliability of series and parallel systems, failure time distributions, - Exponential and Weibull models in reliability and life testing. | 10 | 20 |
| VI | Stochastic processes: Specification/ classification of processes - Strict and wide sense stationary processes - Discrete time Markov chains, higher transition probabilities - Communication classes, irreducible chains - Classification of states, regular chains - Stationary (invariant) distributions | 7 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6201 | SYSTEM DYNAMICS | 3-1-0-4 | 2015 |

**Prerequisite:** Fundamental Knowledge of Control System

**Course Objectives**

*To study the analysis of systems using state space model*
*To understand the concept of stability*
*To familiarize the optimal control problem*

**Syllabus**

State variable representation of system – Stability - Solution of state equation - State space representation of discrete time systems - Discretization of continuous time state equation-case studies - Lyapunov stability - definition of stability - stability analysis of non-linear system - Concepts of controllability and observability - effect of state feedback on controllability and observability - Design of full order and reduced order observer for continuous time and discrete time systems – case studies - Optimal control - optimal control based on quadratic performance measure – optimal control system design - solution of reduced Riccatti equation. Robust control systems – introduction - sensitivity analysis of robustness - design of robust PID controlled systems – Case Studies related to power system control, FACTs control.

**Course Outcome**

At the end of course, the student will be able to:

- Write state space equations for the Linear System
- Design feedback controller and examine stability of the system

**References**


1. Thomas Kailath, *"Linear systems"*, Prentice Hall Inc
2. K.Ogata, *"Modern Control Engineering"* (Second Edition), Prentice Hall Inc, 1990
3. K.Ogata, *"Discrete-time Control Systems"*, PHI
4. M.Gopal, *"Digital Control and State Variable Methods"*, TMH, 1997
5. M.Gopal, *"Modern Control System Theory"*, New Age International, 1993
6. P.Kundur, *"Power System Stability and Control"*, McGraw-Hill Publishing Company, 1994
6. C.T.Chen, *"Linear System Theory and Design"*, Holt Rinechart and Winston, 1984
7. Richard.C.Dorf and R.T Bishop, *"Modern Control System"*, PHI


**COURSE PLAN**

**COURSE NO: 07EE 6201 COURSE TITLE: SYSTEM DYNAMICS**
**(L-T-P: 3-1-0) CREDITS: 4**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | State variable representations of systems- transfer function and transfer function matrix from state variable form - solutions of state equations – state transition matrix - Eigen values of state matrix – modal decompositions | 8 | 15 |

| | | | |
|---|---|---|---|
| II | Observability and controllability - minimal realizations of MIMO systems - analysis of linear time varying systems-<br><br>**Case Study**: 1. Power flow modal analysis and computing participation factors of an IEEE 14 bus power system<br>2. Weakest bus identification based on modal analysis<br>3. FACTS controller design based on modal analysis for damping dominant mode of oscillation<br>4. Minimal realization of some controllers | 8 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | The concepts of stability- absolute stability and BIBO Stability- equilibrium states - Lyapunov stability theorems - stability analysis using Lyapunov's first method and second method - Lyapunov function and its properties. | 8 | 15 |
| IV | State variable feedback – controller design - Ackerman's Formula - stabilisation by state and output - feedback – observers for state measurement – observer design- combined observer-controller-reduced order observer - observability under feedback and invariant zeros<br>Case Study:<br>1. Design of an observer for a power system application<br>2. Design of an observer for a power electronics application.<br>3. Design of a power system stabilizer based on state variable feedback | 8 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Compensators -Design of stable systems using Lyapunov method - MATLAB Exercises.<br>Case Study:<br>1. Design of compensators for a real power system<br>2. Design of compensators for a standalone power system based on renewable technologies.<br>3. Design of a compensator for parametric variations that affect drives | 8 | 20 |
| VI | Difference equation model for LTIV systems - impulse response model - transfer function model - discrete state space representation - solution of state equations - controllability and observabilty - stability analysis using Lyapunov method - state feedback of linear discrete time systems- Design of Observers- MATLAB Exercises. | 8 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6103 | ANALYSIS OF POWER ELECTRONIC CIRCUITS - I | 3-1-0-4 | 2015 |

**Prerequisite:** Transient analysis of linear electric circuits and switching behaviour of power electronics devices

**Course Objectives**

*To provide fundamental concepts of various power electronic converters and its detailed analysis*

**Syllabus**

Review of Power Devices –gate drive circuit - di/dt and dv/dt protection- gate trigger circuits – Controlled rectifiers – analysis with RL & RLE loads - inversion mode - effect of source inductance - DC-DC converters – analysis with RL & RLE load – time ratio control – current limit control – two-quadrant & four-quadrant chopper –Inverters – 1-phase half bridge and full bridge – 3-phase inverter - PWM techniques –linear & over modulation - bipolar & unipolar voltage switching – dc side current – filter - current source inverter – load commutated CSI - 1-phase & 3-phase – IGBT based CSI –AC voltage controllers – ON-OFF control – phase angle control – input PF – integral cycle control - two stage sequence control with R load – 3-phase full-wave controller with R load – waveforms. Cycloconverter – single-phase to single-phase cycloconverter with R & RL load – 3-phase to 3-phase cycloconverter – control scheme.

**Course Outcome**

After successful completion of this course the student will be able to analyse AC-DC control rectifier, DC-DC converter, DC-AC Inverter, AC voltage controller and AC-AC conversion.

**References**


1. Ned Mohan, Undeland, Robbins, *"Power Electronics Converters, Applications and Design"*, John Wiley 2006
2. M.H. Rashid, *"Power Electronics Circuits, Design and Applications"*, Pearson Education
3. Cyril W Lander, *Power Electronics*, McGraw Hill
4. M.D. Singh, K.B. Khanchandani, *"Power Electronics"*, Tata McGraw-Hill
5. Daniel W Hart, *"Introduction to Power Electronics"*, Prentice-Hall
6. Joseph Vithayathil , *"Principles of Power Electronics"*, Mc-Graw Hill
7. William Shepherd, Li Zhang, *"Power Converter Circuits"*, Marcell Dekker Inc


**COURSE PLAN**

**COURSE NO: 07EE 6103 COURSE TITLE: ANALYSIS OF POWER ELECTRONIC CIRCUITS - I**
**(L-T-P: 3-1-0) CREDITS: 4**

| Module | Contents | Contact Hours | Sem.Exam Marks |
|---|---|---|---|
| I | Review of Power Devices – characteristics of Ideal and practical switches – Power diodes – reverse recovery characteristics - power transistors – power MOSFET – IGBT – Thyristor – GTO – switching characteristics – inductive load – switching losses – gate drive circuit - di/dt and dv/dt protection | 8 | 15 |

| | | | |
|---|---|---|---|
| II | Gate drive circuit - di/dt and dv/dt protection- gate trigger circuits – pulse triggering using pulse transformers and optocouplers – power dissipation and selection of heat sink. Controlled rectifiers – single-phase half-wave converter full converter – semi converter - analysis with RL & RLE loads – continuous & discontinuous conduction - input PF with continous and ripple free load current - inversion mode. | 8 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Effect of source inductance - 3-phase - half-wave , full converter & semi converter – analysis with RLE loads – continuous conduction only – inversion mode - effect of source inductance –line notching and distortion - single-phase dual converters – circulating & non circulating current operation. DC-DC converters – Step-down chopper – step- up chopper - analysis with RL & RLE load – time ratio control – current limit control – two-quadrant & four-quadrant chopper – voltage commutated chopper – current commutated chopper. | | 15 |
| IV | Inverters – 1-phase half bridge and full bridge – Analysis with RL load - THD– 3-phase inverter – 180° mode – analysis with RL load – common mode voltage - voltage control of inverters - PWM techniques – single pulse, sinusoidal pulse width modulation – linear & over modulation - bipolar & unipolar voltage switching - DC side current – effect of blanking time on voltage in PWM inverter. | 8 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Filter - current source inverter – load commutated CSI – auto-sequential current fed inverter - 1-phase & 3-phase – IGBT based CSI – control of current magnitude.AC voltage controllers – ON-OFF control – phase angle control – 1-phase full wave – analysis with R, L, RL load – input PF - Integral cycle control - two stage sequence control with R load | 8 | 20 |
| VI | 3-phase full-wave controller with R load – waveforms. Cycloconverter – single-phase to single-phase cycloconverter with R & RL load - 3-phase 3-pulse cycloconverter – circulating current mode operation – circulating current-free mode operation - 3-phase to 3-phase cycloconverter – control scheme | 8 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

| | |
|---|---|
| First Internal Test | – 15 Marks |
| Second Internal Test | – 15 Marks |
| Assignments/Term Paper/Seminar | – 10 Marks |

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 6105** | **ELECTRIC DRIVES** | **3-0-0-3** | **2015** |

**Prerequisite:** Fundamental Knowledge of various types of AC & DC motors

**Course Objectives**

T*o provide a strong background on various methods of speed control of different electrical machines*

**Syllabus**

Electric Drives – advantages - equivalent values of drive parameters - steady state stability - load equalization –determination of motor rating. DC motor drives – Transient analysis of separately excited motor – speed control – controlled rectifier fed DC drives - three-phase fully controlled & half controlled rectifier control separately excited DC motor - dual converter– rectifier control of series motor –chopper control of separately excited DC motor and series motor –closed loop speed control. Induction motor drives – 3-phase induction motor - analysis with unbalanced source voltages and single-phasing –braking – speed control – VSI and CSI induction motor drives – cycloconverter control – slip power recovery - subsynchronous and super synchronous motoring and regeneration - single phase induction motor – speed control. Synchronous motor drives– torque equation – power factor control – operation with non-sinusoidal supply - speed control of synchronous motors – rotor position encoder – closed loop speed control.

**Course Outcome**

After successful completion of this course the students will know the method of control of DC Motor and Induction motor by using power electronic based converters and selection of motors for specific applications, study about starting, running &breaking.

**References**


1. K Dubey, '*Power Semi-conductor Controlled Drives"*, Prentice Hall
2. R. Krishnan, "*Electical Motor Drives"*, Prentice Hall of India
3. GK Dubey, "*Fundamentals of Electrical Drives"*, Narosa
4. Bimal K Bose, "*Modern Power Electronics & AC Drives"*, Prentice Hall of India
5. Vedam Subarhmanian, "*Electric Drives"*, Tata McGraw Hill

| COURSE PLAN<br>COURSE NO: 07EE 6105 COURSE TITLE: ELECTRIC DRIVES<br>(L-T-P: 3-0-0) CREDITS: 3 | | | |
|---|---|---|---|
| **Module** | **Contents** | **Contact Hours** | **Sem.Exam Marks** |
| I | Electric Drives – advantages – parts of electric drives - dynamics of electric drive - torque equation – four quadrant operation - equivalent values of drive parameters- classification of load torques - steady state stability - load equalization - Classes of motor duty- determination of motor rating. | 4 | 15 |
| II | DC motor drives – starting – regenerative braking, dynamic braking, plugging – Transient analysis of separately excited motor – speed control – controlled rectifier fed DC drives – single phase fully controlled & half controlled rectifier control of separately excited DC motor – discontinuous and continuous conduction - three-phase fully controlled & half controlled rectifier control separately excited DC motor | 9 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Dual converter for multi-quadrant operation of separately excited DC motor – rectifier control of series motor – supply harmonics, power factor and ripple in motor current –chopper control of separately excited DC motor and series motor –closed loop speed control below and above base speed. | 5 | 15 |
| IV | Induction motor drives – 3-phase induction motor - torque equation – analysis with unbalanced source voltages and single-phasing – analysis of induction motor fed from non-sinusoidal voltage supply – regenerative braking, pugging, dynamic braking – speed control – pole changing – stator voltage control – static rotor resistance control - stator frequency control below and above base speed | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | VSI and CSI induction motor drives – cycloconverter control – closed loop slip controlled VSI and CSI drive – slip power recovery – static Kramer drive – static Scherbius drives – subsynchronous and super synchronous motoring and regeneration - single phase induction motor – equivalent circuit – speed control. | 6 | 20 |
| VI | Synchronous motor drives – cylindrical rotor and salient pole types – torque equation – power factor control – operation with non-sinusoidal supply - speed control of synchronous motors – true synchronous mode and self controlled mode – rotor position encoder – load commutated synchronous motor drive – closed loop speed control – line commutated cycloconverter fed synchronous motor drive. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

| | |
|---|---|
| First Internal Test | – 15 Marks |
| Second Internal Test | – 15 Marks |
| Assignments/Term Paper/Seminar | – 10 Marks |

**End Semester Examination: 60 marks**

## ELECTIVE I

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 6207** | **OPTIMIZATION TECHNIQUES** | **3-0-0-3** | **2015** |

**Prerequisite:** Nil

**Course Objectives**

*This course deals with optimization techniques of linier systems both constrain and non-constrained.*

**Syllabus**

Linear programming: overview of optimization techniques -Definitions and theorems-Simplex method-Revised simplex method-Duality and Dual simplex method-Sensitivity analysis. Unconstrained dimensional optimization techniques: Necessary and sufficient conditions-search methods (unrestricted Fibonacci and golden)-Direct search methods-Descent methods-Steepest descent - Constrained optimization techniques & dynamic programming: Equality and inequality constraints-Kuhn-Tacker conditions-Gradient projection method-cutting plane method-.Principle of optimality-recurrence relation-Computation procedure-continuous dynamic programming. Recent developments in optimization techniques.

**Course Outcome**

After successful completion of this course the students should be able to apply linear programming methods to engineering problems, distinguish between constrain and non-constrain optimisation and know the principle of dynamic programming

**References**


1. Rao S.S, '*Optimisation:Theory and Application"*, Wiley Eastern Press
2. Pierre, D.A., "*Optimisation, Theory with Applications"*, John Wiley & Sons
3. Fox, R.L., "*Optimisation method for Engineering Design"*, Addition Wesley
4. Hadely,G., "*Linear Programming"*, Addition Wesley
5. Bazaara & Shetty, "*Non-linear Programming*"
6. D.E. Goldberg, "*Genetic Algorithm in Search, Optimization, and Machine Learning"*, Addison-Wesly, 1989.
7. Marco Dorigo, Vittorio Miniezza and Alberto Colorni, "*Ant System:Optimization by a colony of Cooperation Agent"*, IEEE transaction on system man and Cybernetics-Part B:cybernetics, Volume 26, No 1, pp. 29-41,1996.
8. Shi, Y. Eberhart, R.C., "*A Modified Particle Swarm Optimizer"*, Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998

Recent literature should also be referred

**COURSE PLAN**
**COURSE NO: 07EE 6207 COURSE TITLE: OPTIMIZATION TECHNIQUES**
**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Linear programming: Statement and classification of optimization problems overview of optimization techniques standard form of linear programming problems-Definitions and theorems-Simplex method | 6 | 15 |
| II | Revised simplex method-Duality and Dual simplex method-Sensitivity analysis. Unconstrained dimensional optimization techniques: Necessary and sufficient conditions-search methods (unrestricted Fibonacci and golden)-Interpolation methods (Quadratic, Cubic and direct root method). | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Direct search methods-Random search-pattern search and Rosen Brock's hill climbing method-Descent methods-Steepest descent, conjugate gradient, Quasi Newton and DFE method. | 6 | 15 |
| IV | Constrained optimization techniques & dynamic programming: Necessary and sufficient conditions-Equality and inequality constraints-Kuhn-Tacker conditions-Gradient projection method-cutting plane method-Penalty function method (Interior and exterior). | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Principle of optimality-recurrence relation-Computation procedure-continuous dynamic programming-case studies | 6 | 20 |
| VI | Recent developments in optimization techniques: Rosenbrocks Rotating Coordinate Method-Tabu search-Simulated Annealing-Genetic Algorithm-Particle Swarm Optimization –Ant colony Optimization-Bees Algorithm-case studies. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6117 | POWER SEMICONDUTOR DEVICES & MODELING | 3-0-0-3 | 2015 |

**Prerequisite:** Fundamental Knowledge about the physics of Semiconductor devices

**Course Objectives**

*The purpose is to make students aware of the device physics and operation of common power semiconductor devices and also those which are in the development stage*

**Syllabus**

Power switching devices overview - Power handling capability - Device selection strategy – switching losses – EMI due to switching - Power diodes –Current Controlled Devices - BJT's –Power Darlington - Thyristors –Gate and switching characteristics - series and parallel operation - comparison of BJT and Thyristor – steady state and dynamic models. - Power MOSFETs and IGBTs – Principle of construction, Switching Characteristics- Steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT. Firing and Protection Circuits- Over voltage, over current and gate protections - Design of snubbers. Thermal Protection - Heat transfer - Cooling - Guidance for hear sink selection – Mounting types.

**Course Outcome**

After successful completion of this course the students know the physics of semiconductor devices, control characterise and protection methods of voltage control & current control devise and method of cooling

**References**


1. Kassakian J G et al, "*Principles of Power Electronics*", Addison Wesley
2. B W Williams, "*Principles and Elements of Power Electronics*", University of Strathclyde,Glasgow
3. Mohan, Undeland, Robins, "*Power Electronics – Concepts, Applications and Design*", JohnWiley and Sons, Singapore
4. M D Singh, K B Khanchandani, "*Power Electronics*", Tata McGraw Hill


**COURSE PLAN**

**COURSE NO: 07EE 6117 COURSE TITLE: POWER SEMICONDUTOR DEVICES & MODELING**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks:% |
|---|---|---|---|
| I | Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols - Power handling capability – SOA - Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes – Types - forward and reverse characteristics - switching characteristics – rating - Schottky Diode | 6 | 15 |
| II | Current Controlled Devices - BJT's – Construction, Device Physics, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power Darlington | 6 | 15 |

| FIRST INTERNAL EXAM | | | |
|---|---|---|---|
| III | Thyristors – Physical and electrical principle underlying operation - Gate and switching characteristics - converter grade and inverter grade and other types - series and parallel operation - comparison of BJT and Thyristor – steady state and dynamic models of BJT & Thyristor. | 6 | 15 |
| IV | Voltage Controlled Devices - Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, Device physics, Static and Switching Characteristics- Steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Firing and Protection Circuits - Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT - Over voltage, over current and gate protections - Design of snubbers. | 6 | 20 |
| VI | Thermal Protection - Heat transfer – conduction, convection and radiation - Cooling – liquid cooling, vapour – phase cooling - Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6127 | HIGH VOLTAGE DC AND AC TRANSMISSION | 3-0-0-3 | 2015 |

**Prerequisite:** Fundamental Knowledge about the power flow in transmission line.

**Course Objectives**

*To understand the concept, planning of DC power transmission and comparison with AC Power transmission*
*To analyze HVDC converters*
*To study about compounding and regulation*
*To analyze harmonics and design of filters*
*To learn about HVDC cables and simulation tools*

**Syllabus**

INTRODUCTION - Introduction of DC Power transmission technology –Description of DC transmission system – Planning for HVDC transmission –Analysis of HVDC Converters– Choice of converter configuration –Converter bridge characteristics – Detailed analysis of converters. Compounding and Regulations - General –Inverter compounding –Transmission characteristics with the rectifier and inverter compounding – Communication link – Transformer tap changing. Harmonics and filters and Simulation – Generation of harmonics – Design of AC filters and DC filters –Introduction to system simulation – Modeling of HVDC systems for digital dynamic simulation.

**Course Outcome**

After successful completion of this course the students able to understand principals and technology of DC transmission, know about HVDC converter and control of power flow, model HVDC lines and converters & the effects of harmonic in DC lines

**References**


1. Padiyar, K. R., "*HVDC Power Transmission System*", Wiley Eastern Limited, New Delhi 1990, First edition.
2. Edward Wilson Kimbark, "*Direct Current Transmission*", Vol. I, Wiley Interscience, New York, London, Sydney, 1971.
3. Colin Adamson and Hingorani N G, "*High Voltage Direct Current Power Transmission*",Garraway Limited, London, 1960.
4. Arrillaga, J., "*High Voltage Direct Current Transmission*", Peter Pregrinus, London, 1983.
5. Rakosh Das Begamudre, "*Extra High Voltage AC Transmission Engineering*", New AgeInterantional (P) Ltd., New Delhi, 1990.


**COURSE PLAN**

**COURSE NO: 07EE 6127 COURSE TITLE: HIGH VOLTAGE DC AND AC TRANSMISSION (L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks:% |
|---|---|---|---|
| I | INTRODUCTION - Introduction of DC Power transmission technology – Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system | 6 | 15 |
| II | Planning for HVDC transmission – Modern trends in DC transmission. ANALYSIS OF HVDC CONVERTERS - Pulse number – Choice of converter configuration | 6 | 15 |

| | | | |
|---|---|---|---|
| **FIRST INTERNAL EXAM** | | | |
| III | Simplified analysis of Graetz circuit – Converter bridge characteristics – Characteristics of a twelve pulse converter – Detailed analysis of converters. | 6 | 15 |
| IV | COMPOUNDING AND REGULATIONS - General – Required regulation – Inverter compounding – Uncompounded inverter – Rectifier compounding – Transmission characteristics with the rectifier and inverter compounding – | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Communication link – Current regulation from the inverter side – Transformer tap changing. HARMONICS AND FILTERS and SIMULATION - Introduction – Generation of harmonics – Design of AC filters and DC filters | 6 | 20 |
| VI | Interference with neighbouring communication lines. Introduction to system simulation – Philosophy and tools – HVDC system simulation – Modeling of HVDC systems for digital dynamic simulation. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6137 | DYNAMICS OF ELECTRIC MACHINES | 3-0-0-3 | 2015 |

**Prerequisite:** Fundamental Knowledge on steady state operation of synchronous machines, induction machines and DC machines.

**Course Objectives**

*This course deals with generalized modeling and analysis of different electrical machines used for industrial drive applications.*

**Syllabus**

Introduction – Unified approach to the analysis of electrical machine – voltage, power and torque equation –linear transformation – power invariance – park's transformation. DC machines – application of generalized theory to separately excited, shunt, series and compound machines –Polyphase synchronous machines – generalized machine equations – steady state analysis – transient analysis –Induction machines –generalized model –steady state analysis – equivalent circuit– effect of voltage and frequency variations – electric transients in induction machines – speed control of induction motor – introduction to vector control –single phase induction motor – generalized model – steady state analysis.

**Course Outcome**

After successful completion of this course the students will know the working principles of electric machine (DC machine, synchronous Machine and induction machine, Control techniques of electric motors, also the steady state and transient analysis.

**References**


1. Krauss, Wasyncsuk and Sudholf, "*Analysis of Electrical Machines and Drive Systems"*, John Wiley
2. PS. Bhimbra, "*Generalized Theory of Electrical Machines"*, Khanna Publishers
3. A E Fitzgerald, Kingsley, Umans, "*Electric Machinery"*, McGraw Hill
4. Adkins and Harey, "*General Theory of AC Machines"*
5. Bimal K Bose, "*Modern Power Electronics & AC Drives"*, Pearson Education


**COURSE PLAN**

**COURSE NO: 07EE 6137 COURSE TITLE: DYNAMICS OF ELECTRIC MACHINES**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Introduction – Unified approach to the analysis of electrical machine – basic two-pole machine – Kron's primitive machine – voltage, power and torque equation – linear transformation from 3-phase to 2-phase - transformation from rotating axes to stationary axes – power invariance. | 6 | 15 |
| II | Park's transformation for 3-phase synchronous and induction machines. DC machines – application of generalized theory to separately excited, shunt, series and compound machines | 6 | 15 |

| | | | |
|---|---|---|---|
| **FIRST INTERNAL EXAM** | | | |
| III | Sudden short circuit of separately excited generator - separately excited dc motor - steady state and transient analysis – transfer functions of separately excited dc generator & motor. | 6 | 15 |
| IV | Polyphase synchronous machines – generalized machine equations – steady state analysis of salient pole and non-salient pole machines – phasor diagrams – power angle characteristics – reactive power – short circuit ratio – transient analysis – sudden 3-phase short circuit at generator terminals – reactance – time constants – transient power angle characteristics. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Induction machines – 3-phase induction machine-generalized model – voltage equation – steady state analysis – equivalent circuit – torque-slip characteristics – effect of voltage and frequency variations – electric transients in induction machines | 6 | 20 |
| VI | Speed control of induction motor – introduction to vector control – applications in speed control of induction machine – single phase induction motor – generalized model – voltage and torque equations – steady state analysis. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07GN 6001 | RESEARCH METHODOLOGY | 0-2-0-2 | 2015 |

**Prerequisite:** Basic knowledge of engineering technology.

## Course Objectives

The main objective of the course is to provide a familiarization with research methodology and to induct the student into the overall research process and methodologies. This course addresses:

- The scientific research process and the various steps involved
- Formulation of research problem and research design
- Thesis preparation and presentation.
- Research proposals, publications and ethics
- Important research methods in engineering

As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self-study and group discussions. The faculty mainly performs a facilitator's role.

## Syllabus

Overview of research methodology - Research process, scientific method, research design process. Research Problem and Design - Formulation of research task, literature reviewand web as a source, problem solving approaches, experimental research, and ex post facto research. Thesis writing, reporting and presentation -Interpretation and report writing, principles of thesis writing- format of reporting, oral presentation. Research proposals, publications and ethics - Research proposals, research paper writing, considerations in publishing, citation, plagiarism and intellectual property rights. Research methods – Modelling and Simulation, mathematical modeling, graphs, heuristic optimization, simulation modeling, measurement design, validity, reliability, scaling, sample design, data collection methods and data analysis

## Course Outcome

At the end of course, the student will be able to:

- Discuss research methodology concepts, research problems, research designs, thesis preparations, publications and research methods.
- Analyse and evaluate research works and to formulate a research problem to pursue research
- Prepare a thesis or a technical paper, and present or publish them
- Apply the various research methods followed in engineering research for formulation and design of own research problems and to utilize them in their research project.

## References


- C. R. Kothari, Research Methodology, Methods and Techniques, New Age International Publishers
- K. N. Krishnaswamy, Appa Iyer Sivakumar, M. Mathirajan, Management Research Methodology, Integration of principles, Methods and Techniques, Pearson Education
- R. Panneerselvam, Research Methodology, PHI Learning
- Deepak Chawla, Meena Sondhi, Research Methodology–concepts & cases, Vikas Publg House
- J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
- Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
- Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.

- Fred M Kerlinger , Research Methodology
- Ranjit Kumar, Research Methodology – A step by step guide for beginners, Pearson Education
- John W Best, James V Kahan – Research in Education , PHI Learning
- Donald R. Cooper, Pamela S. Schindler, Business Research Methods, 8/e, Tata McGraw-Hill Co Ltd
- Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes
- Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
- Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
- Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
- Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
- Donald H.McBurney, Research Methods, 5th Edition, Thomson Learning, ISBN:81-315-0047- 0,2006
- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers..
- Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing
- Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
- Additional suitable web resources
- Guidelines related to conference and journal publications


**COURSE PLAN**

**COURSE NO: 07GN 6001 COURSE TITLE: RESEARCH METHODOLOGY**

**(L-T-P: 0-2-0) CREDITS: 2**

| Module | Contents | Contact Hours | Sem.Exam Marks |
|---|---|---|---|
| I | Overview of Research Methodology**:** Research concepts – meaning – objectives – motivation - types of research – research process – criteria for good research – problems encountered by Indian researchers - scientific method - research design process – decisional | 5 | 15 |
| II | Research Problem and Design: Formulation of research task – literature review – methods – primary and secondary sources – web as a source – browsing tools - formulation of research problems – exploration - hypothesis generation - problem solving approaches- introduction to TRIZ(TIPS)- experimental research – principles -Laboratory experiment - experimental designs - ex post facto research - qualitative research | 5 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Thesis writing, reporting and presentation: Interpretation and report writing – techniques of interpretation – precautions in interpretation – significance of report writing – principles of thesis writing- format of reporting - | 4 | 15 |

| | | | |
|---|---|---|---|
| | different steps in report writing – layout and mechanics of research report - references – tables – figures – conclusions. oral presentation – preparation - making presentation – use of visual aids - effective communication | | |
| IV | Research proposals, publications, ethics and IPR: Research proposals - development and evaluation – research paper writing – layout of a research paper - journals in engineering – considerations in publishing –scientometry- impact factor- other indexing like h-index – citations - open access publication -ethical issues - plagiarism –software for plagiarism checking- intellectual property right- patenting case studies . | 5 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Research methods – Modelling and Simulation: Modelling and Simulation – concepts of modelling – mathematical modelling - composite modelling – modelling with – ordinary differential equations – partial differential equations – graphs heuristics and heuristic optimization - simulation modelling | 5 | 20 |
| VI | Research Methods – Measurement, sampling and Data acquisition: Measurement design – errors -validity and reliability in measurement - scaling and scale construction - sample design - sample size determination - sampling errors - data collection procedures - sources of data - data collection methods - data preparation and data analysis | 4 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6009 | POWER ELECTRONICS LAB | 0-0-2-1 | 2015 |

**Prerequisite:** Knowledge about power electronic devices and ability to use different laboratory measurement equipments.

**Course Objectives**

*To provide practical knowledge through hardware implementation & simulation of power electronic circuits*

**List of Exercises / Experiments**

1. Different types of Gate drives and protection circuits for MOSFETS, IGBTs and Thyristors
2. Single Phase Semi-converter with R-L load for continuous & discontinuous conduction modes
3. Single Phase Full-converter with R-L load for continuous & discontinuous conduction modes
4. SCR firing circuit and grid synchronization using digital and analog ICs
5. Controlled and Uncontrolled rectifier with different types of filters - continuous & discontinuous modes of operation
6. Speed control of chopper fed DC motor drives
7. Transformer, Inductor and low pass filter design
8. Current & Voltage commutated thyristorized chopper
9. Regulated linear power supply with over current protection using OP-amp and power transistors and PCB design
10. Half bridge square wave inverter feeding RL load
11. Single-phase Sine triangle PWM inverter feeding RL load
12. Single Phase AC Voltage Controller using TRIAC
13. Control of dc-dc converters (Buck, Boost and Buck-Boost converter) using discrete ICs like TL494/SG3525/UC3842, Power loss computation, Selection of heatsinks and PCB design.
14. Study of harmonic pollution by power electronics loads using power quality analyser

(Out of the above, a minimum of SIX hardware experiments and SIX simulation studies are to be conducted. Simulation can be done using any of the software packages like MATLAB/SIMULINK, ORCAD, PSCAD etc.)

**Internal Continuous Assessment: 100 marks**

i) Practical Records /outputs 40%

ii) Regular Class Viva-Voce 20%

iii) Final Test (Objective) 40%

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6111 | INTRODUCTION TO SEMINAR | 0-1-0-0 | 2015 |

**Course Objectives**

*The basic objective of this course is to improve the oral communication skill of the students.*

**Syllabus**

Individual students are required to choose a topic (need not be engineering) of their interest in consultation with faculty and present for about 30 minutes. They will be guided about sound modulation, sequence of presentation, eye contact and writing on the black board.

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# SEMESTER 2

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| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6102 | ANALYSIS OF POWER ELECTRONIC CIRCUITS – II | 3-1-0-4 | 2015 |

**Prerequisite:** Attended course on Analysis of Power Electronic Circuits – I [07EE 6103]

**Course Objectives**

*To provide a strong foundation on advanced converter techniques and their control in modern Power Electronic Systems*

**Syllabus**

PWM Strategies for Inverters - Space Vector Modulation –Power factor improvement of rectifier circuits – PWM control – semi converters & full converters – Twelve-pulse converter. Z-source inverter –modified carrier based PWM inverter - Multilevel inverters – Diode-clamped multilevel inverter - Flying-capacitors multilevel inverter – cascaded multilevel inverter – PWM for multilevel inverters – comparison. Current Regulated PWM Voltage Source Inverters -Variable Band Hysteresis Control, Fixed Switching Frequency Current Control Methods. - Matrix converter - 3-phase matrix converter – switching control strategy.

**Course Outcome**

At the end of course, the student will be able to:

- Various types of inverters and their working principles
- Power factor improvement in rectifiers circuits
- Method of current control in inverters

**References**


1. Fang Lin Luo & Hong Ye, "*Power Electronics, Advanced Conversion Technologies"*, CRC Press
2. Branko L Dokic & Branko Blanusa, "*Power Electronics, Converters and Regulators"* , Springer
3. Barry Williams, "*Principles and Elements of Power Electronics"*, University of Strathclyde
4. Muhammad H. Rashid, "*Power Electronics Circuits, Design and Applications"*, Pearson Education
5. Muhammad H Rashid (Ed), "*Power Electronics Handbook"*, Academic Press
6. William Shepherd & Li Zhang, "*Power Converter Circuits*", Marcel Dekker Inc
7. A.M. Trzynadlowski, "*Introduction to Modern Power Electronics*", Wiley, 2010


**COURSE PLAN**

**COURSE NO: 07EE 6102 COURSE TITLE: ANALYSIS OF POWER ELECTRONIC CIRCUITS – II**

**(L-T-P: 3-1-0) CREDITS: 4**

| Module | Contents | Contact Hours | Sem.Exam Marks |
|---|---|---|---|

| | | | |
|---|---|---|---|
| I | PWM Strategies for Inverters - Review of Sinusoidal PWM – Trapezoidal modulation, staircase modulation, stepped modulation, harmonic injected modulation | 8 | 15 |
| II | Delta modulation – Third harmonic PWM - Space Vector Modulation – concept of space vector - space vector switching - over modulation. | 8 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Power factor improvement of rectifier circuits – Extinction angle control, symmetric angle control, PWM control - 1-phase sinusoidal PWM, 3-phase PWM rectifier - 1-phase series converters – semi converters & full converters – Twelve-pulse converter. | 8 | 15 |
| IV | Z-source inverter – equivalent circuit & operation – shoot-through zero state – modified carrier based PWM inverter with shoot-through zero state – modulation index and boost factor. | 8 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Multilevel inverters – Diode-clamped multilevel inverter – improved diode-clamped inverter - Flying-capacitors multilevel inverter – cascaded multilevel inverter – PWM for multilevel inverters – comparison. Current Regulated PWM Voltage Source Inverters - Methods of Current Control, hysteresis Control- hysteresis current controller used in specific application- Variable Band Hysteresis Control, Fixed Switching Frequency Current Control Methods | 8 | 20 |
| VI | Matrix converter – principle – matrix converter switches - 3-phase matrix converter – switching control strategy - Venturini control method – principle – switching duty cycles –modulation matrix – realization of input filter - commutation and protection issues in matrix converter | 8 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6104 | SWITCHED MODE POWER CONVERTERS | 3-0-0-3 | 2015 |

**Prerequisite:** Attended course on Analysis of Power Electronic Circuits – I [07EE 6103]

**Course Objectives**

*The students to acquaint with working, analysis and modelling of different types of converters.*

**Syllabus**

Converters in steady state - Converters without electrical isolation- buck, boost and buck-boost converters-linear and switched mode power supplies. Converters with electrical isolation-flux imbalance problems and solutions-switch stress and utilization. Converter Dynamics and control - ac modeling approach-state space averaged modeling-converter transfer functions. Direct duty ratio control-comparison between direct duty ratio control and current mode control. Resonant converters -basic resonant circuit concepts-load resonant converters-resonant switch converters-ZVS clamped voltage dc-dc converters-resonant dc link inverters with zero coltage switching-Utility interface issues and magnetic circuits design - Generation of current harmonics-current harmonics and power factor-harmonic standards and recommended practices -improved single phase utility interface-active shaping of input line current-improved 3-phase utility interface-electromagnetic interference.

**Course Outcome**

At the end of course, the student will be able to:

- Learn different types of inverter and control under static & dynamic states
- Mathematical modelling of converters
- Control output to meet utility standards

**References**


1. Robert W. Erickson and Dragan Maksimovic, 'Fundamentals of Power Electronics', Springer, 2nd Edition
2. Ned Mohan et.al, Power Electronics., John Wiley and Sons
3. L.Umanand, "*Power Electronics: Essentials & Applications*", Wiley India Pvt Ltd
4. S. S. Ang, A. Oliva, "*Power Switching Converters"*, Marcel Dekker, 2nd ed.,
5. Keith H Billings "*Handbook of Switched Mode Power Supplies*", McGraw Hill Publishing Company
6. Marian K. Kazimierczuk, "*Pulse-width Modulated DC-DC Power Converters*", John Wiley& Sons Ltd., 1st Edition.
7. Abraham I Pressman,"*Switching Power Supply Design*". McGraw Hill Publishing Company.
8. Otmar Kilgenstein,"*Switched Mode Power Supplies in Practice*",John Wiley and Sons.
9. H. W. Whittington, B. W. Flynn, D. E. Macpherson, "*Switched Mode Power Supplies"*, John Wiley & Sons Inc., 2nd Edition.


**COURSE PLAN**

**COURSE NO: 07EE 6104 COURSE TITLE: SWITCHED MODE POWER CONVERTERS**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Converters in steady state - Converters without electrical isolation- buck, boost and buck-boost converters-different modes of operation- converters with non idealities -linear and switched mode power supplies. | 6 | 15 |

| | | | |
|---|---|---|---|
| II | Converters with electrical isolation-forward converter-fly back converter-half bridge converter-full bridge converter-push pull converter-flux imbalance problems and solutions-switch stress and utilization. | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Converter Dynamics and control - Basic ac modeling approach-state space averaged modeling-circuit averaging and averaged switch modeling-converter transfer functions. Direct duty ratio control-error amplifiers-current mode control-slope compensation-comparison between direct duty ratio control and current mode control. | 6 | 15 |
| IV | Resonant converters - Classification of resonant converters-basic resonant circuit concepts-load resonant converters-resonant switch converters-ZVS clamped voltage dc-dc converters | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Resonant dc link inverters with zero voltage switching-high frequency link integral half cycle converter. | 6 | 20 |
| VI | Utility interface issues and magnetic circuits design - Generation of current harmonics-current harmonics and power factor-harmonic standards and recommended practices-need for improved utility interface-improved single phase utility interface-active shaping of input line current-improved 3-phase utility interface-electromagnetic interference. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6106 | ADVANCED ELECTRIC DRIVES | 3-0-0-3 | 2015 |

**Prerequisite:** Attended course on Electric Drives [07EE 6105]

**Course Objectives**

*To provide fundamental concepts in modeling of induction motors and synchronous machines and the advanced drive control schemes used in these machines*

**Syllabus**

Basic principles for Electric Machine Analysis- Electro mechanical Energy conversion- Air gap MMF- Dynamic modeling of induction machines – 3-phase to 2-phase transformation – electromagnetic torque – derivation of stator reference frame model, rotor reference frame model, synchronously rotating reference frame model – dynamic model of synchronous machines-Vector controlled induction motor drive – Principle of vector or field oriented control –Indirect rotor flux oriented vector control scheme- Parameter sensitivity - Stator flux oriented vector control-implementation with voltage source inverters- decoupling- Typical applications of vector controlled drives- Speed controller design-Flux weakening operation of vector controlled induction motor - Sensor less vector control schemes - Direct torque control of induction motor – control strategy - comparison of DTC and FOC –Permanent magnet synchronous machine drives – operating point and air gap line- radial and parallel magnetization - Modelling of PMSM – Vector control of PM synchronous machine – control strategies

**Course Outcome**

At the end of course, the student will be able to:

- Fundamental knowledge about electro mechanical energy conversion
- Dynamic analysis of different electrical machine
- Different methods of speed control of machines for good dynamic response

**References**


1. R Krishnan, "*Electric Motor Drives*", PHI, 2007
2. B K Bose, "*Modern Power Electronics and AC Drives"*, PHI, 2006
3. P. C. Krause, Wasynczuk and Sudhoff, "*Analysis of Electric Machinery and Drive Systems*", Wiley, 2004
4. R Krishnan, "*Permanent Magnet Synchronous and Brushless dc drives*", CRC Press, 2010
5. D W Novotny and T A Lipo, "*Vector Control and Dynamics of AC Drives*", Oxford,1997
6. Ned Mohan, "*Advanced Electric Drives*", John Wiley, 2014
7. Joseph Vithayathil, "*Power Electronics- Principles and Applications*", TMH, 2010
8. W Leonhard, "*Control of Electric Drives*", Springer, 2001
9. C.M. Ong, "*Dynamic simulation of Electric Machinery*", Prentice Hall, 1998
10. A.M. Trzynadlowski, "*Field orientation Principle in the control of Induction Motors*, Kluwer


**COURSE PLAN**

**COURSE NO: 07EE 6106 COURSE TITLE: ADVANCED ELECTRIC DRIVES**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks:% |
|---|---|---|---|

| | | | |
|---|---|---|---|
| I | Basic principles for Electric Machine Analysis- Magnetically coupled circuits- Electro mechanical Energy conversion- energy, co-energy and electromagnetic torque- Air gap MMF due to sinusoidal winding distribution- Dynamic modeling of induction machines – 3-phase to 2-phase transformation –power equivalence | 6 | 15 |
| II | generalized model in arbitrary reference frame – electromagnetic torque – derivation of stator reference frame model, rotor reference frame model, synchronously rotating reference frame model – dynamic model of synchronous machines-Vector controlled induction motor drive – Principle of vector or field oriented control – Comparison with separately excited dc motor- direct rotor flux oriented vector control – estimation of rotor flux and torque–Indirect rotor flux oriented vector control scheme | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Parameter sensitivity - Stator flux oriented vector control- decoupling requirements- implementation of vector control schemes with current source and current regulated inverters- implementation with voltage source inverters- decoupling- Typical applications of vector controlled drives- Speed controller design | 6 | 15 |
| IV | Flux weakening operation of vector controlled induction motor - flux weakening for stator and rotor flux orientation- comparison with dc motor torque capability curves- Sensor less vector control schemes- Speed estimation using slip calculation- Direct torque control of induction motor – control strategy - comparison of DTC and FOC | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Permanent magnet synchronous machine drives – types of permanent magnet and magnet characteristics– operating point and air gap line- radial and parallel magnetization- Halbach arrays- SPM and IPM machines- Modelling of PMSM | 6 | 20 |
| VI | Vector control of PM synchronous machine – control strategies – constant torque-angle control, unity power factor control, constant mutual flux-linkages control, optimum torque per ampere control, flux weakening operation, speed controller design | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

# ELECTIVE II

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6208 | FLEXIBLE AC TRANSMISSION SYSTEMS | 3-0-0-3 | 2015 |

**Prerequisite:** Knowledge about power flow in inter connected systems

**Course Objectives**

*Operation, control and application of different FACTS devices*
*Power-electronic controllers for active and reactive power control in transmission lines*

**Syllabus**

FACTS and preliminaries: FACTS concept and general system considerations - power flow in AC system - Static Shunt Compensators - SVC and STATCOM - Compensator Control - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement, case studies. Static Series Compensation - GCSC, TSSC, TCSC and SSSC - operation and control - external system control for series compensators - SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control, case studies. UPFC and IPFC: The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance - Special Purpose FACTS Controllers - Interline Power Flow Controller - operation and control.

**Course Outcome**

At the end of course, the student will be able to:

- Know different type of FACTS devices
- The application of in power flow control voltage control and stability improvement

**References**


1. N.G. Hingorani & L. Gyugyi, "*Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems"*, IEEE Press
2. K. R. Padiyar, "*FACTS Controllers in Power Transmission and Distribution"*, New Age International
3. T.J.E Miller, "*Reactive Power Control in Electric Systems"*, John Wiley & Sons.
4. Ned Mohan et.al, "*Power Electronics"*, John Wiley and Sons.
5 Dr Ashok S & K S Suresh Kumar "*FACTS Controllers and applications*" course book for STTP, 2003.
6 Published Literatures.


**COURSE PLAN**

**COURSE NO: 07EE 6208 COURSE TITLE: FLEXIBLE AC TRANSMISSION SYSTEMS**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | FACTS and preliminaries: FACTS concept and general system considerations - power flow in AC system - definitions on FACTS - basic types of FACTS controllers –dynamic brake | 6 | 15 |

| | | | |
|---|---|---|---|
| II | Static Shunt Compensators - SVC and STATCOM - operation and control of TSC, TCR, STATCOM - Compensator Control - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement, case studies | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Static Series Compensators: Static Series Compensation - GCSC, TSSC, TCSC and SSSC - operation and control - external system control for series compensators | 6 | 15 |
| IV | SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control, case studies | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | UPFC and IPFC: The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance | 6 | 20 |
| VI | Special Purpose FACTS Controllers - Interline Power Flow Controller - operation and control – case studies | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6118 | DESIGN OF POWER ELECTRONICS SYSTEM | 3-0-0-3 | 2015 |

**Prerequisite:** Attended course on Analysis of Power Electronic Circuits I – [07EE 6103]

**Course Objectives**

*Design gating drive circuits for switching devices with isolation.*
*Design snubber circuits and heat sinks for switching devices.*
*Design inductor and transformer operating at high frequency.*

**Syllabus**

Design of Gate and Base Drive Circuits: Transistor base drive circuits - Thyristor drive circuits - layout considerations. Snubber circuits –diode, thyristor and Transistor snubber circuits, turn off and turn-on snubber, overvoltage snubber, snubber for bridge circuit configurations, GTO snubber considerations. Cooling and Design of heat sinks: Control of device temperature, heat transfer by conduction, heat sinks, heat transfer by radiation and convection- Design of Magnetic components: Magnetic materials and core, copper windings, thermal considerations, inductor design analysis and procedure, transformer design, leakage inductance, comparison of sizes of transformer and inductor - Demonstration design of converter circuits, 3 phase rectifier. Buck converter, boost converter.

**Course Outcome**

At the end of course, the student will be able to:

- Select power electronic devices and drive circuits for a system
- Select appropriate snubber circuit
- Design transformer and inductor used in power circuit
- Select cooling methods & heat sink for power devices
- Design a power circuit for AC-DC and DC-DC power converter

**References**


1. Ned Mohan, Tore M. Undeland and William P.Riobbins, “Power Electronics—Converters, Applications and Design” Third Edition, John Wiley and Sons. Inc2014
2. Muhammad H. Rashid, “Power Electronics, Circuits, Devices and Application”’ Third Edition, Prentice Hall of India Private Limited, 2004
3. Joseph Vithayathil, “Power Electronics-Principle and Applications’’, Tata McGraw Hill Education Pvt Ltd, 2010.
4. Barry W. Williams, “Principles of Elecments of Power Electronics Deviceses, Drivers, Applications and Passive Components”, Barry W. Williams, 2006.
5. Daniel W. Hart, “Power Electronics”, Tata McGraw Hill, 2011.


**COURSE PLAN**

**COURSE NO: 07EE 6118 COURSE TITLE: DESIGN OF POWER ELECTRONICS SYSTEM**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|

| | | | |
|---|---|---|---|
| I | Design of Gate and Base Drive Circuits: Design consideration, dc – coupled drive circuits isolated drive circuits, cascade-connected drive circuits Thyristor drive circuits power device protection in drive circuits layout considerations. | 6 | 15 |
| II | Snubber circuits: Function and type of Snubber circuits, diode snubbers thyristor snubber circuits, Transistor snubber circuits | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Turn off and turn-on snubber, overvoltage snubber, snubber for bridge circuit configurations, GTO snubber considerations. | 6 | 15 |
| IV | Cooling and Design of heat sinks: Control of device temperature, heat transfer by conduction, heat sinks, heat transfer by radiation and convection. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Design of Magnetic components: Magnetic materials and core, copper windings, thermal considerations, inductor design analysis and procedure, transformer design, eddy currents, leakage inductance, transformer design, comparison of sizes of transformer and inductor | 6 | 20 |
| VI | Demonstration design of converter circuits, 3 phase rectifier. Buck converter, boost converter. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 6128** | **NONLINEAR CONTROL SYSTEMS** | **3-0-0-3** | **2015** |

**Prerequisite:** Attended course on System Dynamics – [07EE 6201]

**Course Objectives**

*To study the characteristics and analysis of nonlinear systems using phase plane and describing function method*
*To understand the concept of Lyapunov stability and linearization procedures*
*To familiarize the advanced control techniques: sliding mode, back stepping*

**Syllabus**

Introduction and classical techniques: Characteristics of nonlinear systems - phase plane analysis - describing function - Single input Describing Function (SIDF). Lyapunov Stability and Design: Stability of Nonlinear Systems- Lyapunov stability - local stability - Direct method of Lyapunov – Centre manifold theorem - Invariance theorems - Input output stability - Lyapunov based design. Feedback Control and Feedback Stabilization : Circle Criterion - Popov Criterion - simultaneous Lyapunov functions - Feedback linearization - stabilization - regulation via integral control - gain scheduling - input state linearization - input output linearization - state feedback control - Nonlinear Design Tools: Sliding Mode Control- Concept of variable - implementation of switching control laws. Reduction of chattering in sliding mode, Lyapunov Redesign: Stabilization-Nonlinear Damping.

**Course Outcome**

At the end of course, the student will be able to:

- Analysis non-linear control system
- Learn feedback control methods
- Examine stability of the system

**References**


1. Hassan K Khalil, "*Nonlinear Systems*", Prentice - Hall International (UK) 1996
2. Slotine & W.LI, "*Applied Nonlinear Control*", Prentice Hall, Engloe wood NewJersey 1991
3. A Isidori, "*Nonlinear Control Systems*", Springer verlag New York 1995
4. C Edwards, S Spurgeon, "*Sliding Mode Control*", Theory and Applications, CRC Press, 1998.
5. V. Utkin, J Guldner,J Shi, "*Sliding Mode Control in Electro Mechanical Systems*", CRC Press, 2009.


**COURSE PLAN**

**COURSE NO: 07EE 6128 COURSE TITLE: NONLINEAR CONTROL SYSTEMS**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks |
|---|---|---|---|
| I | Introduction and classical techniques : Characteristics of nonlinear systems - classification of equilibrium points - limit cycles - analysis of systems with piecewise constant inputs using phase plane analysis - describing function of standard nonlinearities- study of limit cycles (amplitude and frequency) using Single input Describing Function(SIDF). | 6 | 15 |
| II | Lyapunov Stability and Design : Stability of Nonlinear Systems- Lyapunov stability - local stability - local linearization and stability in the small - Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems – | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | variable gradient method - Centre manifold theorem - region of attraction - Invariance theorems - Input output stability - L stability - L stability of state models - L2 stability- Lyapunov based design | 6 | 15 |
| IV | Feedback Control and Feedback Stabilization : Analysis of feedback systems-Circle Criterion - Popov Criterion - simultaneous Lyapunov functions - Feedback linearization - stabilization - regulation via integral control | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | gain scheduling - input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control | 6 | 20 |
| VI | Nonlinear Design Tools: Sliding Mode Control- Concept of variable - structure controller and sliding control, reaching condition and reaching mode, existence condition-implementation of switching control laws. Reduction of chattering in sliding mode, Lyapunov Redesign: Stabilization-Nonlinear Damping, Back stepping Control. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 6138** | **COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES** | **3-0-0-3** | **2015** |

**Prerequisite:** Knowledge about design of electrical machines

**Course Objectives**

*To introduce the technique of Finite Element Methods in the area of electrical machines*

**Syllabus**

Computer aided design of electrical machines - Analysis and synthesis methods - - Mathematical Formulation of Field Problems-Development of torque/force - E - Electrical Vector/Scalar potential - Stored energy in field problems – Inductances - Laplace and Poisson's Equations - Energy functional - Principle of energy conversion. Philosophy of FEM- Finite Difference method - Finite Element Method - Energy minimization - Variational method - 2D Field problems - Solution techniques. CAD Packages - Setting up solution - Postprocessing. Design Applications-Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines.

**Course Outcome**

At the end of course, the student will be able to:

- Basic concept of electric machine
- Apply FEM methods for field plotting
- Design electromagnetic machines

**References**


1. S J Salon, "*Finite Element Analysis of Electrical Machines"*, Kluwer Academic Publishers, London, 1995.
2. Vlado Ostovic, "*Computer Aided Analysis of Electric Machines"*, PHI (UK) Ltd, 1994.
3. Silvester and Ferrari, "*Finite Elements for Electrical Engineer"*, Cambridge University Press, 1983.
4. S R H Hoole, "*Computer-Aided, Analysis and Design of Electromagnetic Devices"*, Elsevier1989.
5. D A Lowther, P P Silvester, "*Computer Aided Design in Magnetics"*, Springer Verlag, New York.
6. M Ramamoorthy, "Computer Aided Design of Electrical Equipments", Affiliated East West Press.
7. C W Trowbridge, "*An Introduction to Computer Aided Electromagnetic Analysis"*, Vector Field Ltd.
8. Chee-Mun Ong, "*Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK"*, Prentice Hall, 1998.
9. *User Manuals of Software Packages like MAGNET, ANSOFT& ANSYS.*
10. *Chee-Mun Ong, "Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK", Prentice Hall, 1998.*

| COURSE PLAN<br>COURSE NO: 07EE 6138 COURSE TITLE: COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES (L-T-P: 3-0-0) CREDITS: 3 | | | |
|---|---|---|---|
| **Module** | **Contents** | **Contact Hours** | **Sem.Exam Marks: %** |
| I | Computer aided design of electrical machines - Conventional design procedures - Analysis and synthesis methods - Limitations - Need for field analysis based design.- Mathematical Formulation of Field Problems- Development of torque/force - Electromagnetic Field Equations - Magnetic Vector/Scalar- potential | 6 | 15 |
| II | Electrical Vector/Scalar potential - Stored energy in field problems – Inductances - Laplace and Poisson's Equations - Energy functional - Principle of energy conversion. | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Philosophy of FEM- Mathematical Models - Differential/Integral equations - Finite Difference method - Finite Element Method | 6 | 15 |
| IV | Energy minimization - Variational method - 2D Field problems - Discretisation- Shape functions - Stiffness matrix - Solution techniques. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | CAD Packages-Elements of a CAD System - Preprocessing - Modeling - Meshing -Material properties - Boundary Conditions - Setting up solution - Postprocessing. | 6 | 20 |
| VI | Design Applications-Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines-case studies. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

# ELECTIVES III

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6112 | INDUSTRIAL CONTROL ELECTRONICS | 3-0-0-3 | 2015 |

**Prerequisite:** Knowledge in Analog and Digital Electronics

**Course Objectives**

*To gives a comprehensive coverage of various control electronics used in the industries. This combines the analog and digital concepts together with Power Electronics for the design of the controllers. Microcontrollers and Digital Signal processors for control applications*

**Syllabus**

Analog Controllers - Proportional controllers, Digital control schemes, control algorithms, programmable logic controllers. Signal conditioners- Isolation circuits –Opto-Electronic devices and control - interrupter modules and photo sensors; Fiber-optics; Bar code equipment, application of barcode in industry. Introduction to microprocessors, microcontrollers, Digital Signal Processors. Basic building blocks, architecture ofTMS320LF 28xx DSP, instruction set, programming, application development, PI controller, Clarks and Park transformation, PWM generation, PLL and unit sine wave generation.

**Course Outcome**

At the end of course, the student will be able to:

- Design of PE based system
- Select suitable power devices and feedback circuit elements
- Use of DSP for control applications
- Provide electric isolation of power & drive circuits

**References**


1. Michael Jacob, "*Industrial Control Electronics – Applications and Design*", Prentice Hall, 1995.
2. Thomas E. Kissell, "*Industrial Electronics*", Prentice Hall India, 2003
3. James Maas, "*Industrial Electronics"*, Prentice Hall, 1995.
4. Toliyat, Hamid A. and SlevenCampell, "*DSP Based Electomechanical Motion Control*", CRC Press 2003.
5. TMS 320 F 240 Technical Reference Mannual.
6. Application notes on DSP based Motor Control.
7. www.ti.co


**COURSE PLAN**

**COURSE NO: 07EE 6112 COURSE TITLE: INDUSTRIAL CONTROL ELECTRONICS**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks:% |
|---|---|---|---|

| | | | |
|---|---|---|---|
| I | Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID Controllers, derivative overrun, integral windup, cascaded control, Feed forward control | 6 | 15 |
| II | Digital control schemes, control algorithms, programmable logic controllers. Signal conditioners- Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Isolation circuits – cabling; magnetic and electro static shielding and grounding. | 6 | 15 |
| IV | Opto-Electronic devices and control, electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Interrupter modules and photo sensors; Fiber-optics; Bar code equipment, application of barcode in industry. | 6 | 20 |
| VI | Introduction to microprocessors, microcontrollers, Digital Signal Processors. Basic building blocks, architecture ofTMS320LF 28xx DSP, instruction set, programming, application development, PI controller, Clarks and Park transformation, PWM generation, PLL and unit sine wave generation. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6122 | RENEWABLE ENERGY TECHNOLOGIES | 3-0-0-3 | 2015 |

**Prerequisite:** Nil

**Course Objectives**

*To study the various renewable energy sources and related power conversion technologies*

**Syllabus**

Renewable energy Sources: classification of RE technologies – stand alone, hybrid and grid – connected; Recent developments in renewable energy sector- global and national energy policies - Wind energy- Global and local winds, resource assessment –Weibull parameters; WEG technologies for grid connection. Solar energy –PV cell-principle, types and construction; modeling of PV cell, Maximum power tracking; SPV systems – stand alone and grid-connected. Other renewable energy technologies; Biomass – gasifiers; small hydro-resource assessment, selection of turbines, Electronic load controller; Wave, Tidal, Ocean thermal and Geothermal energy systems – principles and technologies; Energy storage systems.

**Course Outcome**

At the end of course, the student will be able to:

- Know different types of renewable energy source
- Economic aspects of utilization by converting to electric energy

**References**


1. Thomas B Johansson , "*Renewable Energy: Sources for Fuels and Electricity*", Island Press, Washington, 1993
2. John W Twidell and A D Weir , "*Renewable Energy Sources*",ELBS,1986
3. N K Bansal, M Kleeman and M Mellis , "*Renewable Energy Resources and Conversion Technology"*, Tata McGraw Hill , 1990
4. S N Bhadra , D Kastha and S Banarji , "*Wind Electrical Systems*", Oxford University Press , 2005


**COURSE PLAN**

**COURSE NO: 07EE 6122 COURSE TITLE: RENEWABLE ENERGY TECHNOLOGIES**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks |
|---|---|---|---|
| I | Renewable energy Sources: Renewable energy utilization in ancient times, classification of RE technologies – stand alone, hybrid and grid –connected; Recent developments in renewable energy sector- global and national energy policies | 6 | 15 |

| | | | |
|---|---|---|---|
| II | Wind energy- Global and local winds, resource assessment, wind regime modeling –Weibull parameters; WEG technologies for grid connection. | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Solar energy – Solar radiation and measurements; PV cell-principle, types and construction; modeling of PV cell, Maximum power tracking | 6 | 15 |
| IV | SPV systems – stand alone and grid-connected. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Other renewable energy technologies; Biomass – gasifiers; | 6 | 20 |
| VI | Small hydro-resource assessment, selection of turbines, Electronic load controller; Wave, Tidal, Ocean thermal and Geothermal energy systems – principles and technologies; Energy storage systems. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6132 | OPTIMAL AND ADAPTIVE CONTROL SYSTEMS | 3-0-0-3 | 2015 |

**Prerequisite:** Knowledge about in Control system engineering

**Course Objectives**

*The course aims to give an overview of the optimal control problem, adaptive control problem and different solution methods.*

**Syllabus**

Optimal control problem: open loop and closed loop form of optimal control- fundamental concepts and theorems of calculus of variations – function and functional - Lagrange equation and solution- extremal of functionals of several independent functions – various boundary condition equations - The variational approach to solve optimal control problems - Different boundary condition equations for solving the optimal control problem – closed loop control for linear regulator problem – Pontryagin's minimum principle - state inequality constraints - Dynamic programming: principle of optimality – application to optimal control problem – need for interpolation - curse of dimensionality - discrete linear regulator problem - Model Reference Adaptive systems (MRAS): mathematical description of MRAS - design hypothesis - equivalent representation of MRAS

**Course Outcome**

At the end of course, the student will be able to:

- Know about optimal control problem
- Application of adaptive control
- Solution methods in optimal control problem

**References**


1. Donald E. Kirk, "*Optimal Control Theory, An introduction*", Prentice Hall Inc., 2004
2. A.P. Sage, "*Optimum Systems Control*", Prentice Hall, 1977
3. HSU and Meyer , "*Modern Control, Principles and Applications*", McGraw Hill, 1968
4. Yoan D. Landu, "*Adaptive Control"* (Model Reference Approach), Marcel Dekker. 1981
5. K.K.D.Young, "*Design of Variable Structure Model Following Control Systems*", IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.
6. A.S.I. Zinobar, O.M.E. EI-Ghezawi and S.A. Billings, "*Multivariable variable structure adaptive model following control systems*". Proc. IEE., Vol. 129, Pt.D., No.1, pp 6-12, 1982


**COURSE PLAN**

**COURSE NO: 07EE 6132 COURSE TITLE: OPTIMAL AND ADAPTIVE CONTROL SYSTEMS (L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|

| | | | |
|---|---|---|---|
| I | Optimal control problem: open loop and closed loop form of optimal control- performance measures for optimal control problems – general form of performance measure - fundamental concepts and theorems of calculus of variations – function and functional | 6 | 15 |
| II | Extremal of functionals of a single function - Euler - Lagrange equation and solution- extremal of functionals of several independent functions – various boundary condition equations - piecewise-smooth extremals - extremal of functionals with dependent functions. | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | The variational approach to solve optimal control problems: necessary conditions for optimal control using Hamiltonian – Different boundary condition equations for solving the optimal control problem – closed loop control for linear regulator problem - linear tracking problem – Pontryagin's minimum principle - state inequality constraints - minimum time problems – minimum control effort problems. | 6 | 15 |
| IV | Dynamic programming: principle of optimality - application to multi stage decision making – application to optimal control problem – need for interpolation - recurrence relation of dynamic programming - curse of dimensionality | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Discrete linear regulator problem - Hamilton-Jacobi-Bellman equation - continuous linear regulator problem. | 6 | 20 |
| VI | Model Reference Adaptive systems (MRAS): the need for MRAS - an over view of adaptive control systems - mathematical description of MRAS - design hypothesis - equivalent representation of MRAS - introduction to design method based on the use of Lyapunov function – case studies | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6142 | ROBOTICS AND AUTOMATION | 3-0-0-3 | 2015 |

**Prerequisite:** Fundamental concepts of control engineering and programming language

**Course Objectives**

*To study the various technologies in the field of robotics and automation*

**Syllabus**

Geometric configuration of robots - Control systems – Robot programming languages and applications – Introduction to robotic vision. Robot Arm Kinematics- Composite rotation matrices – Homogenous transformation – Denavit Hattenberg representation and various arm configurations. Robot Arm Dynamics- joint velocities – Kinetic energy – Potential energy and motion- Planning of Manipulator Trajectories- General consideration on trajectory planning joint interpolation & Cartesian path trajectories- Control of Robot Manipulators- PID control computed, torque technique

**Course Outcome**

At the end of course, the student will be able to:

- Understand robot kinematics
- Mathematical description of arm control
- Plan Trajectories of robots

**References**


1. Fu K S, Gonazlez R C and Lee C S G, "*Robotics (Control, Sensing, Vision and Intelligence)*", McGraw-Hill, 1987.
2. Wesley, E Sryda, "*Industrial Robots: Computer Interfacing and Control*" PHI, 1985.
3. Asada and Slotine, "*Robot Analysis and Control*", John Wiley and Sons, 1986.
4. Philippe Coiffet, "*Robot Technology, Vol. II (Modeling and Control)*", Prentice Hall INC, 1981.
5. Saeed B Niku, "*Introduction to Robotics, Analysis, Systems and Applications*", Pearson Education, 2002.
6. Groover M P, Mitchell Wesis, "*Industrial Robotics Technology Programming and Applications*", Tata McGraw-Hill, 1986.
7. Sciavicco L, B Siciliano, "*Modeling & Control of Robot Manipulators*", *2nd Edition*, Springer Verlag, 2000.
8. Gray J O, D G Caldwell (Ed), "*Advanced Robotics & Intelligent Machines*", The Institution of Electrical Engineers, UK, 1996.
9. Craig John J, "*Introduction to Robotics: Mechanics and Control*", Pearson, 1989.


**COURSE PLAN**

**COURSE NO: 07EE 6142 COURSE TITLE: ROBOTICS AND AUTOMATION**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors – End effectors – Control systems – Robot programming languages and applications | 6 | 15 |
| II | Introduction to robotic vision. Robot Arm Kinematics- Direct and inverse kinematics – Rotation matrices – Composite rotation matrices – Euler angle- representation | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Homogenous transformation – Denavit Hattenberg representation and various arm configurations. | 6 | 15 |
| IV | Robot Arm Dynamics- Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion-equations – Generalized D'Alembert equations of motion. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Planning of Manipulator Trajectories- General consideration on trajectory planning joint interpolation & Cartesian path trajectories- Control of Robot Manipulators- PID control computed, torque technique | 6 | 20 |
| VI | Near minimum time control – Variable structure-control – Non-linear decoupled feedback control – Resolved motion control and adaptive control. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 6114** | **MINI PROJECT** | **0-0-2-2** | **2015** |

**Course Objectives**

*To estimate the ability of the student in transforming the theoretical knowledge studied so far into a working model of a power electronic system.*
*For enabling the students to gain experience in organisation and implementation of a mini project and thus acquire the necessary confidence to carry out hardware implementation of main project.*

**Syllabus**

This is a hardware based mini project and each student is expected to fabricate a power electronic based system having practical applications. This should be a working model. Student has to design, fabricate, assemble and test power electronics based system, mount on an enclosure with appropriate terminals and controls. The PCB layout should be done by using any standard PCB design software. Proper heat sinking, EMI and protection features are also to be incorporated. Use of SMD devices is encouraged. The basic concepts of product design may be taken into consideration while designing the project.

**Internal continuous assessment: 100 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 6116 | ADVANCED POWER ELECTRONICS LAB | 0-0-2-1 | 2015 |

**Prerequisite:** Attended courses on Analysis of Power Electronic Circuits I – [07EE 6103] and Electric Drives – [07EE 6105]

**Course Objectives**

*To provide practical knowledge through hardware implementation & simulation of power electronic circuits*

**List of Exercises / Experiments**

1. Speed control of converter fed DC motor drives using PWM generation block in microcontroller/DSP/FPGA
2. Open loop and closed loop speed control of chopper fed DC motor drives using Microcontroller/DSP/FPGA
3. Single phase sine-triangle PWM and SVPWM generation using Microcontroller/DSP/FPGA
4. Dead time generation to avoid shoot-through fault using Microcontroller/DSP/FPGA
5. Single phase VSI feeding RL load using sine-triangle PWM with proper isolation and fault protection
6. Single phase Hysteresis current control of VSI feeding an inductive load
7. VSI fed three phase induction motor drive using open loop V/f control controlled by Microcontroller/DSP/FPGA
8. Fly back converter design and implementation
9. Forward converter design and implementation
10. Closed loop voltage control of switching regulators controlled by Microcontroller/DSP/FPGA
11. Simulation of free acceleration characteristics of 3-phase induction motor
12. Simulation of Vector control of 3-phase induction motor
13. Simulation of Direct Torque Control of 3-phase induction motor
14. Simulation of vector control of PMSM
15. Simulation of STATCOM & DSTATCOM
16. Simulation of Active Power Filter, DVR
17. Simulation of TCSC, UPQC
18. Simulation of PWM rectifier
19. Simulation of a separately excited DC motor drive with PI control design using symmetrical optimum method
20. Simulation Study on the switching and conduction power losses in generic power electronic converters

(Out of the above, a minimum of SIX hardware experiments are to be conducted and at least and FOUR simulation assignments are to be given. Simulations of the hardware experiments are also recommended and comparison of hardware results with the simulation result is encouraged. Simulation can be done using any of the software packages like MATLAB/SIMULINK, ORCAD, PSCAD etc.)

**Internal Continuous Assessment: 100 marks**

i) Practical Records /outputs 40%

ii) Regular Class Viva-Voce 20%

iii) Final Test (Objective) 40%

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 6124** | **SEMINAR I** | **0-0-2-2** | **2015** |

**Course Objectives**

*To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self-esteem and courage that are essential for an engineer.*

**Syllabus**

Individual students are required to choose a topic of their interest from power electronic related topics preferably from outside the M.Tech syllabus. And give a seminar on that topic about 45 minutes. By the end of the semester student will demonstrate the simulation of system/circuit presented A committee consisting of at least three faculty members (preferably specialized in power electronics) shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of his seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation and Simulations.

**Internal Continuous Assessment: 100 marks**

i) Marks for the report: 30%

ii) Presentation: 40%

iii) Ability to answer questions on the topic: 30%

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# SEMESTER 3

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## ELECTIVES IV

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7101 | DIGITAL CONTROL SYSTEMS | 3-0-0-3 | 2015 |

**Prerequisite:** Attended course on System Dynamics –[ 07EE 6201]

**Course Objectives**

*To familiarise digital controllers.*
*To understand the analysis and design of digital control system.*

**Syllabus**

Introduction to discrete time control system- Sampling process- hold circuits-Zero and first order hold- Review of z- transforms and inverse z- transforms- solution of difference equations- pulse transfer function- Realization of pulse transfer functions (Digital Controllers)- Review of stability analysis in z- plane- Transient and Steady state response analysis - frequency response specifications- Nyquist stability criterion in the z- plane- Digital Controllers- Lag, lead, and lag-lead compensators- State Space analysis of digital control systems- - Transfer function from state model- Solution of linear time invariant discrete time state equations-Concept of controllability and observability for a linear time invariant discrete time control system

**Course Outcome**

At the end of course, the student will be able to:

- Familiarize with digital controller
- Capable of designing digital control system satisfying output specifications
- Familiar with physical digital control systems

**References**


1. K. Ogata, "*Discrete- time Control Systems*", PHI
2. M. Gopal, "*Digital Control and State Variable Methods*", Tata McGraw Hill
3. B. C. Kuo, "*Digital Control Systems*", Prentice Hall
4. Charles L. Philip and Troy Nagle, "*Digital Control Systems*", Prentice Hall

| COURSE PLAN<br>COURSE NO: 07EE 7101 COURSE TITLE: DIGITAL CONTROL SYSTEMS<br>(L-T-P: 3-0-0) CREDITS: 3 | | | |
|---|---|---|---|
| **Module** | **Contents** | **Contact Hours** | **Sem.Exam Marks: %** |
| I | Introduction to discrete time control system- Block diagram of a digital control system-Typical examples- Sampling process- Data reconstruction and hold circuits- Zero and first order hold- Review of z- transforms and inverse z- transforms- solution of difference equations- pulse transfer function- pulse transfer function with dead time- system time response | 6 | 15 |
| II | Realization of pulse transfer functions (Digital Controllers) - Direct Programming- Standard Programming- Series programming- parallel programming- ladder programming. Review of stability analysis in z- plane- Jury's stability test and extension of Routh's stability criterion to discrete systems- | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Transient and Steady state response analysis- transient response specifications- steady state error analysis- Construction of root loci- effect of sampling period on transient response specifications- frequency response specifications- Nyquist stability criterion in the z- plane- Digital Controllers- PI, PD & PID Controllers | 6 | 15 |
| IV | Lag, lead, and lag-lead compensators- Design of lag compensator and lead compensator based on root locus and Bode plot approaches.State Space analysis of digital control systems- state space representation of discrete time systems | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Transfer function from state model- Diagonal/ Jordan Canonical forms from transfer function- Solution of linear time invariant discrete time state equations- discretization of continuous time space equation- representing state models in CCF, OCF, DCF/ JCF using transformation matrix. | 6 | 20 |
| VI | Concept of controllability and observability for a linear time invariant discrete time control system- condition for controllability and observability- state feedback- condition for arbitrary pole placement- design vi<br><br>a pole placement- state observers- design of full order state observer- case studies | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

| | |
|---|---|
| First Internal Test | – 15 Marks |
| Second Internal Test | – 15 Marks |
| Assignments/Term Paper/Seminar | – 10 Marks |

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 7211** | **POWER QUALITY** | **3-0-0-3** | **2015** |

**Prerequisite:** Knowledge in signal processing and power system engineering

**Course Objectives**

*To familiarize with power quality problems and measurements.*
*To study the impact of and on the device and different mitigation techniques, application of custom power devices*

**Syllabus**

Overview of power quality phenomena-classification of power quality issues-power quality measures and standards- Harmonics -IEEE guides, standards and recommended practices. Power factor reduction due to harmonics- Loads that cause power quality problems-Power Quality Measurement and Analysis - event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Wavelet Transform.Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters –Custom Power devices: Network reconfiguring Devices, Load compensation, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: - series active power filtering techniques for harmonic cancellation and isolation – case studies

**Course Outcome**

At the end of course, the student will be able to:

- Know about power quality issues
- Cause of poor power quality
- Understand mitigation techniques

**References**


1. Arindam Ghosh "*Power Quality Enhancement Using Custom Power Devices*", Kluwer, Academic Publishers
2. Heydt, G.T., "*Electric Power Quality*", Stars in a Circle Publications, Indiana

3. R Sastry Vedam, "*Power Quality VAR compensation in Power Systems*", CRC press,NewYork,2009
4. R.C. Duggan, "*Power Quality*"
5. A.J. Arrillga, "*Power System Harmonics*"
6. Derek A. Paice, "*Power electronic converter harmonics*"
7. Ewald F Fuchs, Mohammad A.S., "*Power Quality in Power Systems and Electrical Machines"*, Elsevier, Academic Press
8. Bollen, M.H.J., "*Understanding Power Quality Problems: Voltage sags and interruptions"*, IEEE Press, New York
9. Arrillaga. J, Watson, N.R., Chen, S., "*Power System Quality Assessment"*, Wiley, New York, 2000.

**COURSE PLAN**
**COURSE NO: 07EE 7211 COURSE TITLE: POWER QUALITY**
**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Overview of power quality phenomena-classification of power quality issues-power quality measures and standards-flicker-transient phenomena- THD-TIF-DIN-C message weights-flicker factor. Harmonics -sources of harmonics-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices. IEEE Standard 1459: Definitions for the Measurement of Electric Power Quantities Under Sinusoidal, Nonsinusoidal, Balanced, or Unbalanced Conditions. Awareness of IEEE Standard 519 and IEEE 1159 | 6 | 15 |
| II | Power factor reduction due to harmonics-Distortion power-distortion power factor and displacement power factor. Loads that cause power quality problems-power quality problems created by drives and its impact on drives - case studies | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Single phase AC/DC converters, SMPS, three phase AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives. | 6 | 15 |
| IV | Power Quality Measurement and Analysis -Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods Harmonics extraction techniques- Selective Harmonics Extraction and its need- shunt active power filtering techniques | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |

| | | | |
|---|---|---|---|
| V | Frequency domain methods: Laplace's, Fourier and Wavelet Transform. Utility-Customer interface – Harmonic filters: passive, Active and hybrid filters | 6 | 20 |
| VI | Custom Power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P-Q theory, Synchronous detection method - series active power filtering techniques for harmonic cancellation and isolation - case studies. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 7121** | **INDUSTRIAL INSTRUMENTATION** | **3-0-0-3** | **2015** |

**Prerequisite:** Basic idea about instrumentation and control

**Course Objectives**

*To create an awareness of the different transducers used in industry and signal conditioning*
*To familiarize the process control elements and their control characteristics*

**Syllabus**

Signal Conditioning – Process Control Principles - Identification of elements, stability, regulation, evaluation criteria, and cyclic response. Final Control Element: Final control operation, signal conversions, digital electrical signals, Direct action – pneumatic signals, Actuators – fluid valves. Signal Conditioning of Transducers- Controller Principles - Process characteristics, control system parameters, controller modes. Analog Controllers – Direct action, reverse action, proportional mode, integral mode, derivative mode, composite controller modes - Pneumatic controllers – implementation of PI, PID, PD - Design consideration. Control Loop Characteristics: Control system configurations, Adaptive control, control system quality – loop disturbance, optimum control, Stability.

**Course Outcome**

At the end of course, the student will be able to:

- Know about transduces used in industrial instrumentation
- Signal conditioning Techniques
- Apply in process control

**References**


1. Curtis D. Johnson, "*Process Control Instrumentation Technology*", Pearson Education
2. Curtis D. Johnson, "*Microprocessors in Process Control*", PHI
3. George Stephanopoulis, "*Chemical Process Control*"
4. Caughner, "*Process Analysis and Control*"
5. Deshpande and Ash, "*Elements of computer process control of Industrial processes*", ISA
6. Jayantha K. Paul, "*Real- Time microcomputer control of Industrial processes*", Kluwer Publications, Netherlands
7. S. K. Singh, "*Computer Aided Process Control*", PHI
8. Dale E. Seborg, Thomas F. Edgar, Duncan A. Mekkichamp, "*Process Dynamics and Control*", Wiley India


**COURSE PLAN**

**COURSE NO: 07EE 7121 COURSE TITLE: INDUSTRIAL INSTRUMENTATION**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Signal Conditioning – Analog – Digital - Signal conversions - Process Control Principles - Identification of elements, block diagram, the loop, control system evaluation | 6 | 15 |
| II | Stability, regulation, evaluation criteria, and cyclic response. Final Control Element: Final control operation, signal conversions, analog electrical signal, digital electrical signals - case studies. | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Direct action – pneumatic signals, Actuators – electrical actuators, pneumatic actuators, control elements – fluid valves. Signal Conditioning of Transducers- Temperature Transducers - flow transducers. | 6 | 15 |
| IV | Controller Principles - Process characteristics, control system parameters, controller modes, discontinuous controller modes, continuous controller modes, composite controller modes. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |

| | | | |
|---|---|---|---|
| V | Analog Controllers - Electronic controller – Direct action, reverse action, proportional mode, integral mode, derivative mode, composite controller modes - Pneumatic controllers – implementation of PI, PID, PD - Design consideration. | 6 | 20 |
| VI | Control Loop Characteristics: Control system configurations, cascade control, multivariable control, feed forward control, Split range control, inferential control, Adaptive control, control system quality – loop disturbance, optimum control, measure of quality, Stability, process loop tuning - case studies. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7131 | DIGITAL SIGNAL PROCESSORS | 3-0-0-3 | 2015 |

**Prerequisite:** Concept about microcontrollers and Signals & Systems

**Course Objectives**

*To familiarize the student the use digital processors for mathematical processing and control applications. Develop software and implement it.*

**Syllabus**

Introduction to Microprocessors- Microcontrollers- Digital Signal controllers and Digital Signal Processors- basic building blocks of a typical Digital Signal Processor. Hardware multipliers-Barrel shifter-MAC Unit-Modified Hardware architecture-RISC versus CISC-pipelining. Architecture of dsPIC30F3011-instruction set-addressing modes-assembly language and C programming-MPLABASM30 Assembler and C30 compiler. Peripherals-ports-tiers-input capture-output compare-ADC-MCPWM-QEI-UART.Architecture of TMS320LF28xx DSP-instruction set- programming-Code Composer Studio application Development- implementation of PI controller. Filter Algorithms- Clark and Park transformations- SPWM and SVPWM, PLL and Unit sine wave generation.

**Course Outcome**

At the end of course, the student will be able to:

- Familiar with digital signal processors, the programing language, method of interfacing and application in power electronics circuits, electric drives.

**References**


1. dsPIC30F Family Reference Manual
2. TMS320F240 Technical Reference Manual
3. Toliyat, Hamid A and Steven Campbell, “DSP Based Electromechanical Motion Control”, CRC Press 2003.
4. Application notes on DSP based Motor Control, and www.ti.com


**COURSE PLAN**

**COURSE NO: 07EE 7131 COURSE TITLE: DIGITAL SIGNAL PROCESSORS**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Introduction to Microprocessors- Microcontrollers- Digital Signal controllers and Digital Signal Processors- basic building blocks of a typical Digital Signal Processor | 6 | 15 |
| II | Hardware multipliers-Barrel shifter-MAC Unit-Modified Hardware architecture-RISC versus CISC-pipelining | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |

| | | | |
|---|---|---|---|
| III | Architecture of dsPIC30F3011-instruction set-addressing modes-assembly language and C programming-MPLABASM30 Assembler and C30 compiler | 6 | 15 |
| IV | Peripherals-ports-tiers-input capture-output compare-ADC-MCPWM-QEI-UART. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Architecture of TMS320LF28xx DSP-instruction set-programming-Code Composer Studio application Development- implementation of PI controller | 6 | 20 |
| VI | Filter Algorithms- Clark and Park transformations- SPWM and SVPWM, PLL and Unit sine wave generation. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

# ELECTIVES V

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7103 | SPECIAL ELECTRICAL MACHINES AND DRIVES | 3-0-0-3 | 2015 |

**Prerequisite:** Attended courses on Electric Drives – [07EE 6105] and Advanced Electric Drives – [07EE 6106]

**Course Objectives**

*To introduce special types of electric machines and their controls for special applications.*

**Syllabus**

Stepping Motors- Variable Reluctance (VR) stepping motor- Dynamic characteristics- Stepping motor drivers- Unipolar drive schemes- Dual voltage drive - Starting/stopping rate- Velocity profiling- Closed-loop control of stepping motors-Switched Reluctance Motors- inductance profile- Torque equation- motoring and generating mode - Energy conversion loop- Energy effectiveness- Power controllers, Characteristics and control- Permanent Magnet Brushless DC Motors - BLDC motor- Torque and emf equation, Sensors, radial and axial flux BLDC motors- Drive schemes - State space modelling and simulation of BLDC motor- Permanent Magnet Synchronous Motors - EMF, power input and torque expressions, Torque speed characteristics, Control Methods.

**Course Outcome**

At the end of course, the student will be able to:

- Know the principles of special electrical machines
- Theory of torque generation and speed control
- Applications of machines in drive

**References**


1. Kenjo T, Sugawara A, "*Stepping Motors and Their Microprocessor Control*", Clarendon, Press, Oxford
2. Paul Acarnley, "*Stepping motors - a guide to theory and practice*", 4th Edn. IET UK, 2002
3. Miller T J E, "*Switched Reluctance Motor and their Control*", Clarendon Press, Oxford
4. Miller T J E, "*Brushless Permanent Magnet and Reluctance Motor Drives*", Clarendon
5. Press, Oxford
6. B K Bose, "*Modern Power Electronics & AC drives*", Pearson Education
7. R Krishnan, "*Electric Motor Drives – Modeling, Analysis and Control*", PHI
8. R Krishnan, "*Permanent Magnet Synchronous and brushless dc drives*", CRC Press, 2010


**COURSE PLAN**

**COURSE NO: 07EE 7103 COURSE TITLE: SPECIAL ELECTRICAL MACHINES AND DRIVES**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Stepping Motors-Types of stepping motors- variable reluctance, permanent magnet and hybrid motors- Constructional features, principle of operation, modes of excitation- torque production in variable Reluctance (VR) stepping motor- Static torque characteristics- position error due to load torque- performance parameters- resolution, single step response and accuracy- Dynamic characteristics, resonance, pull-in and pull-out characteristics | 6 | 15 |
| II | Stepping motor drivers- Unipolar drive schemes- Dual voltage drive- voltage multiplying drive- Bipolar drive schemes- Bifilar drive scheme- open loop position control- Starting/stopping rate- Velocity profiling- single phase stepping motors- Micro stepping- Closed-loop control of stepping motors- Torque computation- gears, belts and lead screw- selection of stepping motor rating | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Switched Reluctance Motors-Constructional features, principle of operation, inductance profile- Torque equation- motoring and generating mode- low speed and high speed operation- magnetization characteristics- flux linkage vs current- partition of input energy- Derivation of Torque equation- Energy conversion loop- Energy effectiveness- Power controllers, Characteristics and control- Six switch converter- Split dc supply converter-R dump- C dump converters- initial rotor position estimation. | 6 | 15 |
| IV | Permanent Magnet Brushless DC Motors- Permanent magnet materials and characteristics- typical demagnetization curves- air gap line and operating point- BLDC motor- operating principle- Torque and emf equation, Torque-speed characteristics, Hall sensors, Optical sensors | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Radial and axial flux BLDC motors- Drive schemes, soft current chopping and hard chopping- low cost drive schemes- extended speed of operation with phase angle control- State space modelling and simulation of BLDC motor- Torque ripple- Sensorless control- third harmonic voltage detection method - back emf detection method - starting process- comparison of BLDC motor with dc motors and induction motors. | 6 | 20 |
| VI | Permanent Magnet Synchronous Motors- radial and parallel magnetization- Halbach arrays- Principle of operation, SPM and IPM machines- EMF, power input and | 6 | 20 |

| | | | |
|---|---|---|---|
| | torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self-control, Field oriented control- constant torque-angle control, Current control schemes | | |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

| | |
|---|---|
| First Internal Test | – 15 Marks |
| Second Internal Test | – 15 Marks |
| Assignments/Term Paper/Seminar | – 10 Marks |

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7213 | SOFT COMPUTING TECHNIQUES | 3-0-0-3 | 2015 |

**Prerequisite:** Nil

**Course Objectives**

*To acquaint the students with soft computing methodologies such as neural networks, fuzzy logic, genetic algorithms and hybrid algorithms and enable the students to implement real time intelligent and adaptive systems.*

**Syllabus**

Introduction to Fuzzy logic - Membership Functions- Fuzzification-Methods of Membership value Assignments- Fuzzy Rule Base-Defuzzification- Fuzzy logic controller (Block Diagram) Artificial Neural Networks-Neural network Architectures- Feed forward network-Characteristics of Neural Networks-Learning methods. Perceptron networks-Back Propagation networks-Radial base function network-Hopfield network- Kohonen Self organizing maps-ART. Fundamentals of genetic algorithms: working principle – encoding – different methods – fitness function – reproduction-Genetic modelling-inheritance- Crossover - mutation-convergence of genetic algorithm. Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids – Neuro fuzzy hybrids- neuro genetic hybrids-Fuzzy genetic hybrids- Fuzzy back propagation networks -fuzzy logic controlled genetic algorithms

**Course Outcome**

At the end of course, the student will be able to:

- Understand different soft computing techniques, application of soft computing techniques in control systems & optimizations

**References**


1. S.Rajasekharan, G.A.Vijayalakshmi Pai, "*Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications"*, Prentice Hall India.
2. S.N.Sivanandam, S.N.Deepa, "*Principles of Soft Computing"*, Wiley India.
3. Timothy J Ross, "*Fuzzy logic with Engineering Applications"*, McGraw Hill, New York.
4. S.Haykins, "*Neural Networks a Comprehensive foundation"*, Pearson Education.
5. D.E.Goldberg, "*Genetic Algorithms in Search Optimisation and Machine Learning"*, Pearson Education.
6. Recent Literature.


**COURSE PLAN**

**COURSE NO: 07EE 7213 COURSE TITLE: SOFT COMPUTING TECHNIQUES (L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks |
|---|---|---|---|
| I | Introduction to Fuzzy logic: Fuzzy sets- Fuzzy set operations- Fuzzy relations-Cardinality of Fuzzy relations-Operations on Fuzzy relations-Properties of Fuzzy relations-Membership Functions-Features of Membership functions- Fuzzification-Methods of Membership value Assignments- Fuzzy Rule Base | 6 | 15 |
| II | Defuzzification- Deffuzzification methods- Fuzzy logic controller (Block Diagram). Artificial Neural Networks: | 6 | 15 |

| | | | |
|---|---|---|---|
| | Basic concepts-Neural network Architectures-Single layer feed forward network-Multilayer feed forward network-Recurrent Networks | | |
| **FIRST INTERNAL EXAM** | | | |
| III | Characteristics of Neural Networks-Learning methods. Perceptron networks-Back Propagation networks-Radial base function network-Hopfield network- Kohonen Self organizing maps-ART | 6 | 15 |
| IV | Fundamentals of genetic algorithms: Basic concepts-working principle – encoding – different methods – fitness function – reproduction-different methods. Genetic modelling-inheritance- Crossover mutation-convergence of genetic algorithm. | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids – Neuro fuzzy hybrids- neuro genetic hybrids-Fuzzy genetic hybrids | 6 | 20 |
| VI | Genetic algorithm based back propogation network-Fuzzy back propagation networks -fuzzy logic controlled genetic algorithms | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7123 | ELECTROMAGNETIC COMPATIBILITY | 3-0-0-3 | 2015 |

**Prerequisite:** Knowledge in Field theory

**Course Objectives**

*To study EMI issues and its reduction techniques*

**Syllabus**

Electromagnetic Compatibility (EMC): Designing for EMC, EMC regulations, typical noise path, methods of reducing interference in electronic system. Cabling of Electronic Systems, inductive coupling, effect of shield on magnetic coupling- Grounding and Shielding Safety grounds, Common Mode Choke -shield grounding at high frequencies, guarded instruments. Near fields and far fields, characteristic and wave impedances, shielding effectiveness, absorption and reflection loss - Conducted Emissions- Design for EMC –PCB layout and stack up- General Printed Circuit Board Design considerations – Electrostatic Discharge(ESD) - ESD protection in equipment design, Transient and Surge Fourier spectrum - decoupling - PCB layout considerations: PCB-to-chassis ground connection - PCB layer stack up - multilayer boards - general PCB design procedure, mixed-signal PCB layout - analog and digital ground pins, mixed-signal power distribution.

**Course Outcome**

At the end of course, the student will be able to:

- Know the importance of EMI, EMC & ESD in electronic circuits
- Importance of shielding in electronic circuits from power circuits
- Design PCB with shielding
- Importance of ground connections of power and signals
- Design a completely shielded electronic circuit

**References**


1. Henry W.Ott, "*Electromagnetic Compatibility Engineering*", Wiley Interscience, 2009
2. Henry W.Ott, "*Noise Reduction Techniques in Electronic Systems*", 2/e, Wiley Interscienc
3. Clayton R.Paul , "*Introduction to Electromagnetic Compatibility*", 2/e
4. Sonia Ben Dhia, Mohamed Ramdani, Etienne Sicard, "*Electromagnetic Compatibility of Integrated Circuits Techniques for low emission and susceptibility*", Springer, 2006
5. David Morgan, "*A Handbook for EMC Testing and Measurement*", 1/e, IET Electrical Measurement Series 8,
6. Mark I. Montrose, "*EMC and the Printed Circuit Board*", John Wiley & Sons, 1998.
7. Howard W. Johnson and Martin Graham, "*High Speed Digital Design*", Prentice Hall, 1993.


**COURSE PLAN**

**COURSE NO: 07EE 7123 COURSE TITLE: ELECTROMAGNETIC COMPATIBILITY**

**(L-T-P: 3-0-0) CREDITS: 3**

| Module | Contents | Contact Hours | Sem.Exam Marks: % |
|---|---|---|---|
| I | Electromagnetic Compatibility (EMC): Designing for EMC, EMC regulations, typical noise path, methods of noise coupling, methods of reducing interference in electronic system. Cabling of Electronic Systems-Capacitive coupling, effect of shield on capacitive coupling, inductive coupling, effect of shield on inductive coupling, effect of shield on magnetic coupling, magnetic coupling between shield and inner conductor, shielding toprevent magnetic radiation, shielding a receptor against magnetic fields | 6 | 15 |
| II | Inductive coupling-shielding properties of various cable configurations, coaxial cable versus shielded twisted pair, braided shields, ribbon cables. Grounding and Shielding Safety grounds, signal grounds, single-point and multipoint-point ground systems, hybrid grounds, functional ground layout, practical low frequency grounding, hardware grounds, grounding of cable shields, ground loops, Common Mode Choke -shield grounding at high frequencies, guarded instruments. | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Near fields and far fields, characteristic and wave impedances, shielding effectiveness, absorption and reflection loss, shielding with magnetic material, apertures, conductive gaskets, conductive windows, conductive coating, grounding of shields | 6 | 15 |
| IV | Conducted Emissions- power line Impedance-Switched Mode Power supplies- Power line Filters- power supply Instability-Magnetic field Emissions System Design for EMC –PCB layout and stack up- General Printed Circuit Board Design considerations –PCB chassis and Ground connection, Return Path Discontinuities- PCB layer Stack up Electrostatic Discharge(ESD) | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Static generation, human body model, static discharge, ESD protection in equipment design, Transient and Surge Protection Devices, software and ESD protection, ESD versus EMC, ESD Testing.Digital circuit power distribution: power supply decoupling, transient power supply currents, transient load current, Fourier spectrum, decoupling capacitors, effective decoupling strategies, multiple decoupling capacitors, target impedance, embedded PCB capacitance, power supply isolation, the effect of decoupling on radiated emissions, decoupling capacitor selection, placement and mounting. | 6 | 20 |

| | | | |
|---|---|---|---|
| VI | PCB layout considerations: PCB-to-chassis ground connection, return path discontinuities, slots in ground/power planes, split ground/power planes, changing reference planes, ground fill, PCB layer stack up, one- and two-layer boards, multilayer boards, four-layer boards, six-layer boards, eight-layer boards, general PCB design procedure, mixed-signal PCB layout, split ground planes, micro-strip ground plane current distribution, analog and digital ground pins, mixed-signal power distribution. | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7133 | ELECTRIC SYSTEMS FOR WIND AND SOLAR ENERGY | 3-0-0-3 | 2015 |

**Prerequisite:** Knowledge in Renewable energy Technology and Attended course on Advanced Electric Drives – [07EE 6106]

**Course Objectives**

*To introduce the various electrical generators and appropriate power electronic controllers employed in wind and photovoltaic energy systems.*

**Syllabus**

Wind energy - Aerodynamic models – braking systems – tower - control and monitoring system - design considerations-power curve - power speed characteristics. Choice of electrical generators Wind turbine generator systems-fixed speed induction generator-performance analysis-semi variable speed induction generator-variable speed induction generators with full and partial rated power converter topologies -isolated systems-self excited induction generator- permanent magnet alternator -performance analysis. Sun and Earth-Basic Characteristics of solar radiation-angle of sunrays on solar collector- Photovoltaic cell-characteristics-equivalent circuit-Photovoltaic modules and arrays. PV Systems-Design of PV systems-Standalone system with DC and AC loads with and without battery storage-Grid connected PV systems-Maximum Power Point Tracking

**Course Outcome**

At the end of course, the student will know:

- Method of taping wind and solar energy
- Estimation of wind power and solar power from environment
- Conversion to electric power
- Utilisation by an isolated load and by grid

**References**


1. Marcelo Godoy Simões and Felix A. Farret, "*Renewable Energy Systems: Design and Analysis with Induction Generators*", CRC Press, ISBN 0849320313, 2004.
2. Ion Boldea, "*Variable Speed Generators"*, CRC Press, ISBN 0849357152, 2006.
3. S.N. Bhadra, D.Kastha and S.Banerje, "*Wind Electrical Systems"*, Oxford Uni Press, 2005.
4. Siegfried Heier, Rachel Waddington, "*Grid Integration of Wind Energy Conversion Systems"*, 2nd Edition', Wiley, 2006,
5. Freries LL , "*Wind Energy Conversion Systems"*, Prentice Hall, U.K., 1990
6. Chetan Singh Solanki, "*Solar Photovoltaics-Fundamentals, Technologies and Applications"*, PHI Learning Pvt. Ltd., New Delhi, 2011
7. Van Overstraeton and Mertens R.P., "*Physics, Technology and use of Photovoltaics"*, Adam Hilger, Bristol,1996.
8. John F.Walker & Jenkins. N , "*Wind Energy Technology*", John Wiley and sons, Chichester, UK, 1997.
9. Freries LL ,"*Wind Energy Conversion Systems"*, Prentice Hall, U.K., 1990

| COURSE PLAN<br>COURSE NO: 07EE 7133 COURSE TITLE: ELECTRIC SYSTEMS FOR WIND AND SOLAR ENERGY (L-T-P: 3-0-0) CREDITS: 3 | | | |
|---|---|---|---|
| **Module** | **Contents** | **Contact Hours** | **Sem.Exam Marks: %** |
| I | Wind energy – energy in the wind – aerodynamics - rotor types – forces developed by blades - Aerodynamic models – braking systems – tower - control and monitoring system | 6 | 15 |
| II | Design considerations-power curve - power speed characteristics. Choice of electrical generators Wind turbine generator systems-fixed speed induction generator-performance analysis | 6 | 15 |
| **FIRST INTERNAL EXAM** | | | |
| III | Semi variable speed induction generator-variable speed induction generators with full and partial rated power converter topologies -isolated systems-self excited induction generator- permanent magnet alternator - performance analysis. | 6 | 15 |
| IV | Sun and Earth-Basic Characteristics of solar radiation-angle of sunrays on solar collector | 6 | 15 |
| **SECOND INTERNAL EXAM** | | | |
| V | Sun and Earth-Basic Characteristics of solar radiation-angle of sunrays on solar collector- Case Studies | 6 | 20 |
| VI | PV Systems-Design of PV systems-Standalone system with DC and AC loads with and without battery storage-Grid connected PV systems-Maximum Power Point Tracking- Case Studies | 6 | 20 |

**Internal Continuous Assessment: 40 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

First Internal Test – 15 Marks
Second Internal Test – 15 Marks
Assignments/Term Paper/Seminar – 10 Marks

**End Semester Examination: 60 marks**

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7105 | SEMINAR II | 0-0-2-2 | 2015 |

**Course Objectives**

*To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self-esteem and courage that are essential for an engineer.*

**Syllabus**

Individual students are required to choose a topic of their interest from power electronic related topics preferably from outside the M.Tech syllabus. And give a seminar on that topic in about 45 minutes. By the end of the semester student will demonstrate the simulation of system/circuit presented. A committee consisting of at least three faculty members (preferably specialized in power electronics) shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of his seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation and simulation.

**Internal Continuous Assessment: 100 marks**

i) Marks for the report: 30%
ii) Presentation: 40%
iii) Ability to answer questions on the topic: 30%

| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| 07EE 7107 | PROJECT (PHASE 1) | 0-0-12-6 | 2015 |

**Course Objectives**

*To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.*

**Syllabus**

The project work can be a design project/experimental project and/or computer simulation project on any of the topics in power electronics/drives related topics. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to carry out their main project outside the parent institute, subject to the conditions specified in the MTech regulations.

The student is required to undertake the project (phase 1) during the third semester and the same is continued in the 4$^{th}$semester (Phase 2). Phase 1 consist of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4$^{th}$ semester.

**Project Evaluation:**

Progress evaluation by the Project Supervisor: 20 Marks

Presentation and evaluation by the committee: 30 Marks

Total marks for the Project Phase 1: 50 Marks

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# SEMESTER 4

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| Course No. | Course Name | L-T-P-Credits | Year of Introduction |
|---|---|---|---|
| **07EE 7102** | **PROJECT (PHASE 2)** | **0-0-21-12** | **2015** |

**Course Objectives**

*To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.*

**Syllabus**

Project (Phase 2) is a continuation of project phase 1 started in the third semester. There would be two reviews in the fourth semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work, presentation and discussion. Second review would be a pre-submission presentation before the evaluation committee to assess the quality and quantum of the work done. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis.

**Project Evaluation:**

Project evaluation by the supervisor/s: 30 Marks
Presentation & evaluation by the Committee: 40 Marks
Evaluation by the External expert: 30 Marks
Total marks for the Project Phase 2: 100 Marks