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| **KERALA TECHNOLOGICAL UNIVERSITY**  http://ktu.edu.in/images/logo_final.png  **SCHEME AND SYLLABUS**  **FOR**  **M. Tech. DEGREE PROGRAMME**  **IN**  **ELECTRICAL AND ELECTRONICS ENGINEERING**  **WITH SPECIALIZATION**  **POWER ELECTRONICS AND POWER SYSTEMS**  **CLUSTER 05 (ERNAKULAM II)**  **KERALA TECHNOLOGICAL UNIVERSITY CET Campus, Thiruvananthapuram Kerala, India -695016**  **(2015 ADMISSION ONWARDS)** |

**KERALA TECHNOLOGICAL UNIVERSITY**

**SCHEME AND SYLLABUS FOR M. Tech. DEGREE PROGRAMME**

**Branch: ELECTRICAL AND ELECTRONICS ENGINEERING**

**Specialization: POWER ELECRONICS AND POWER SYSTEMS**

**SEMESTER I**

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| ***Exam Slot*** | ***Course No*** | ***Subjects*** | **L-T-P** | **Internal Marks** | **End Semester Exam** | | **Credits** |
| Marks | Duration  (hrs) |
| A | 05EE 6101 | Optimization techniques | 3-1-0 | 40 | 60 | 3 | 4 |
| B | 05EE 6103 | Advanced Power System analysis | 3-1-0 | 40 | 60 | 3 | 4 |
| C | 05EE 6105 | Power converters | 3-1-0 | 40 | 60 | 3 | 4 |
| D | 05EE 6107 | Power system operation and control | 2-1-0 | 40 | 60 | 3 | 3 |
| E | 05EE 611x | Elective I | 2-1-0 | 40 | 60 | 3 | 3 |
|  | 05EE 6177 | Research Methodology | 1-1-0 | 100 | 0 | 0 | 2 |
|  | 05EE 6191 | Power system Simulation Lab | 0-0-2 | 100 | 0 | 0 | 1 |

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| **Elective – I** | |
| **Course No** | **Subjects** |
| 05EE 6111 | Modern Control Systems |
| 05EE 6113 | Power Quality |
| 05EE 6115 | Digital Protection of Power systems |

**SEMESTER – II**

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| ***Exam Slot*** | ***Course No*** | ***Subjects*** | ***L-T-P*** | ***Internal Marks*** | ***End Semester Exam*** | | ***Credits*** |
| Marks | Duration  (hrs) |
| A | 05EE 6102 | Flexible Ac transmission systems | 3-1-0 | 40 | 60 | 3 | 4 |
| B | 05EE 6104 | Advanced Power system stability | 2-1-0 | 40 | 60 | 3 | 3 |
| C | 05EE 6106 | Artificial Neural Network and Fuzzy systems | 2-1-0 | 40 | 60 | 3 | 3 |
| D | 05EE 612x | Elective II | 2-1-0 | 40 | 60 | 3 | 3 |
| E | 05EE 613x | Elective III | 2-1-0 | 40 | 60 | 3 | 3 |
|  | 05EE 6166 | Seminar I | 0-0-2 | 100 | 0 | 0 | 2 |
|  | 05EE 6188 | Mini project | 0-0-4 | 100 | 0 | 0 | 2 |
|  | 05EE 6192 | Power Electronic Simulation Lab | 0-0-2 | 100 | 0 | 0 | 1 |

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| **Elective – II** | |
| **Course No** | **Subjects** |
| 05EE 6122 | Modeling of Electrical Machines |
| 05EE 6124 | Renewable Energy Systems |
| 05EE 6126 | Solid State DC and AC Drives |

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| **Elective – III** | |
| **Course No** | **Subjects** |
| 05EE 6132 | Advanced Microprocessors and Microcontrollers |
| 05EE 6134 | HV DC Transmission Systems |
| 05EE 6136 | Robotics and Automation |

**SEMESTER – III**

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| ***Exam Slot*** | ***Course No*** | ***Subjects*** | ***L-T-P*** | ***Internal Marks*** | ***End Semester Exam*** | | ***Credits*** |
| Marks | Duration(hrs) |
| A | 05EE 714x | Elective IV | 2-1-0 | 40 | 60 | 3 | 3 |
| B | 05EE 705x | Elective V | 2-1-0 | 40 | 60 | 3 | 3 |
|  | 05EE 7167 | Seminar II | 0-0-2 | 100 | 0 | 0 | 2 |
|  | 05EE 7187 | Project (Phase1) | 0-0-8 | 50 | 0 | 0 | 6 |

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| **Elective – IV** | |
| **Course No** | **Subjects** |
| 05EE 7141 | Microcontroller Applications in Power Converters |
| 05EE 7143 | Electrical energy Conservation and Management |
| 05EE 7145 | Microcontroller and Real time Systems |

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| **Elective – V** | |
| **Course No** | **Subjects** |
| 05EE 7151 | Advanced Power Electronic Systems |
| 05EE 7153 | Advanced controllers for Embedded systems |
| 05EE 7155 | Special Electric Machines and Drives |

**SEMESTER – IV**

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| ***Exam Slot*** | ***Course No*** | ***Subjects*** | ***L-T-P*** | ***Internal Marks*** | ***End Semester Exam*** | | ***Credits*** |
| Marks | Duration(hrs) |
|  | 05EE 7188 | Project (Phase 2) | 0-0-21 | 70 | 30 | - | 12 |
| Total Credit 68 | | | | | | | |

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| **COURSE CODE** | | **COURSE NAME** | **L-T-P-C** | **YEAR** | |
| **05EE 6101** | | [**Optimization**](#bookmark6) **Techniques** | **3-1-0-4** | **2015** | |
| **COURSE OBJECTIVES:**  The objective of this course is to   * to impart mathematical background for studying power electronics and power system subjects. * to understand the theory of optimization methods and algorithms developed for solving various optimization problems. * to develop and promote research interest in applying optimization techniques in problems of engineering technology.   **COURSE OUTCOMES:**  On successful completion of this course, students are able   * to understand basic theoretical principles in optimization. * to formulate, implement and analysis of optimization models. * to use the techniques for engineering practice. | | | | | |
| **MODULE** | **COURSE CONTENT (36 hrs)** | | | | **HRS** |
| **I** | **Linear programming:** Statement and classification of optimization problems overview of optimization techniques, standard Linear programming – standard form of linear programming problems-definitions and theorems- Graphical solutions-simplex method – Revised simplex method-Duality - Dual simplex method- Big-M method and Two phase method. | | | | **9** |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | **Unconstrained one dimensional optimization techniques:**  Necessary and sufficient conditions –search methods -unrestricted Fibonacci and golden – Interpolation methods-Quadratic, cubic and direct root methods-Newton, quasi newton and secan methods. | | | | **9** |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | **Unconstrained n dimensional optimization techniques:** Direct search methods –Random search –pattern search-univarite and powell’s method and Rosen brooch’s method of rotating co-ordinates and hill claiming method- Descent methods-Steepest descent, conjugate gradient, quasi Newton and DFP method. | | | | **8** |
| **IV** | **Constrained optimization Techniques and Dynamic Programming:** Necessary and sufficient conditions –Equality and inequality constraints-Kuhn-Tucker conditions- Rosen’s Gradient projection method- Gomory’s cutting plane method and SLP - penalty function method-Interior and exterior (basic concept). Dynamic Programming -Principle of optimality- recurrence relation –computational procedure- continuous dynamic programming-Solution of LPP by dynamic Programming. | | | | **10** |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Rao,S.S.,`Optimization :Theory and Application’ Wiley Eastern Press, 1978. 2. Kalyanmoy Deb, ‘Optimization for Engineering Design’,PHI,2010. 3. Raju N V S ‘Optimization methods for Engineers’, PHI 4. Dantzig, ‘Optimization theory with applications’, John Wiley and sons,1969 5. Dantzig, `Linear Programming and Extensions’, Princetion University press, 1963. 6. R Panneerselvam, ‘Operational Research’, PHI, 2011. 7. A P Verma, ‘Operational Research’, S K Kataria & sons, 2011 8. Hadely, G., `Linear Programming’, Addition-Wesley, 1962. 9. Gottfried, B.S., 'Introduction to Optimization Theory’, John Weisman, Prentice Hall Inc., 1973. 10. Walsh, G.R., 'Methods of Optimization’, John Wiley & Sons, 1979. 11. Beightier, C.S., `Phillips D.J., Wilde, D.J., `Foundation of Optimization’, Prentice Hall of India, 1982. 12. K V Mithal, ‘Optimization methods’, Wiley Eastern Press. | | | | | |
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| **COURSE CODE** | | **COURSE NAME** | **L-T-P-C** | **YEAR** | |
| **05EE 6103** | | **Advanced Power System Analysis** | **3-1-0-4** | **2015** | |
| **COURSE OBJECTIVES:**  To understand and acquire knowledge about various power semiconductor devices so that a suitable device can be selected for a particular application.  **COURSE OUTCOMES:**  On successful completion of this course, students are able to understand the various power electronics devices and basics of power electronic protection circuits. | | | | | |
| **MODULE** | **COURSE CONTENT (36 hrs)** | | | | **HRS** |
| **I** | **Load Flow Studies:** Network modelling – Transformer modelling– Conditioning of Y Matrix – Newton Raphson Load Flow – Decoupled Newton Load Flow– Fast decoupled Load Flow –Three-phase load flow – Formulation of three phase load flow problem – Fast Decoupled three phase algorithm – DC power flow. | | | | **9** |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | **AC DC Load Flow :** Single phase and Three phase AC-DC load flow – Formulation of Load Flow Problem – Fast Decoupled Solution – DC system model – Sequential Solution Techniques –Multiple and/or Multi-terminal DC systems – DC convergence tolerance. Optimal load flow in power systems – Formulation of optimal power flow solution by Gradient method, Newton’s method. | | | | **9** |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | **Fault Analysis:** Fault Studies – Analysis of balanced and unbalanced three phase faults –Zbus building algorithm – Short circuit and open circuit faults calculations using Z bus. | | | | **8** |
| **IV** | State Estimation –Method of Weighted Least Squares – Test for bad data – Structure and formation of Hx  matrix – Power System state estimation – Line Power flow state estimator-State estimation by orthogonal decomposition – Network observability and pseudo measurements – External system equivalencing | | | | **10** |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. 1 Arrillaga, J and Arnold, C.P.”Computer analysis of power systems” John Wiley and Sons, New York, 1997 2. Power System Analysis - Grainger, J.J. and Stevenson, W.D. - McGraw Hill, New Delhi, 2003. 3. Pai, M.A, “Computer Techniques in Power System Analysis”, Tata McGraw hill, New Delhi, 2006. 4. Allen J Wood, Bruce F Wollenberg, “Power Generation, Operation and Control”, John Wiley& Sons, New York, II Edition, 1984. 5. Computer Aided Power System Analysis – G.L.Kusic, Prentice Hall, 1986. 6. Power System Analysis – Hadi Saadat - McGraw Hill, 1999. 7. Computer Modeling of Electrical Power Systems – J.Arrilaga and N.R.Watson – Wiley, 2001. 8. Modern Power System Analysis – I.J.Nagrath and D.P.Kothari – Tata McGraw Hill, 1980. | | | | | |
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| **COURSE CODE** | | **COURSE NAME** | **L-T-P-C** | **YEAR** | |
| **05EE 6105** | | **Power Converters** | **3-1-0-4** | **2015** | |
| **COURSE OBJECTIVES:**  To give a systematic approach for transient and steady state analysis of all power electronic  converters with passive and active loads..  **COURSE OUTCOMES:**  The student will be able to comprehensively understand and carry out transient and steady state  analysis of different power converters of different types of loads and switching sequences. | | | | | |
| **MODULE** | **COURSE CONTENT (36 hrs)** | | | | **HRS** |
| **I** | **Analysis of switched circuits:** Ideal models power switches –analysis of thyristor controlled half wave rectifier- R, L, R L, RC load circuits –load circuit with electromotive force. | | | | 9 |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | **Controlled Rectifiers :** Continuous and discontinuous modes of single phase half and full wave rectifiers – half controlled configurations- RL circuit with electromotive force. Effect of transformer leakage reactance- operating domains of three phase full converters and semi converters. | | | | 9 |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | **DC- DC switch mode converters:** DC- DC converter systems- control of DC-DC converters. Buck converters- continuous and discontinuous modes. Boost converters- continuous and discontinuous modes. Buck Boost converters continuous and discontinuous modes. Cuk converters continuous and discontinuous modes. DC-DC converter comparison. | | | | 8 |
| **IV** | **Choppers and Inverters:** Classification of DC chopper circuits- analysis of type A chopper and type B chopper- voltage, current and load commutation of choppers- step up chopper- pulse width modulated A.C. Choppers- Circuit topologies and Harmonic elimination methods. Inverters: Characteristics- output voltage and waveform control- bridge inverters – single phase and three phase versions- MOSFET, IGBT inverters, Mc Murray Inverters- Current source inverter with induction motor load. | | | | 10 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Ned Mohan, Undeland and Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Inc, Newyork, 1995. 2. 2. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, New Delhi, 1995. 3. P.C Sen.," Modern Power Electronics ", Wheeler publishing Co, First Edition, 4. New Delhi, 1998. 5. M.D.Singh and K.B.Khanchandam,”Power Electronics”, Tata Mc Grew Hill Publishing Company, New Delhi, 1998 6. 5. P.S.Bimbra, “ Power Electronics”, Khanna Publishers, Eleventh Edition, 2003. | | | | | |
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| **COURSE CODE** | | **COURSE NAME** | **L-T-P-C** | **YEAR** | |
| **05EE 6107** | | **Power System Operation and Control** | **2-1-0-3** | **2015** | |
| **COURSE OBJECTIVES:**   * To know the general concepts of load forecasting, economic operation, unit commitment and solution method. * To impart the concepts of hydro thermal scheduling, automatic generation control and AGC implementation. * To study the concept of voltage control using compensation devices. * To gain the knowledge about interchange of power and energy, the power system security and contingency analysis.   **COURSE OUTCOMES:**  Students will be able to   * Explain methods for economic load dispatch and unit commitment. * Apply control and compensations schemes on a power system. * Adopt contingency analysis and selection methods to improve system security. | | | | | |
| **MODULE** | **COURSE CONTENT (34 hrs)** | | | | **HRS** |
| **I** | **Economic operation:** Load forecasting-classification-method of Least Squares Curve fit-Unit Commitment-constraints in Unit Commitment- solution methods- Economic Dispatch problem of thermal units-Gradient method-Newton’s method-Base point and participation factor method-Unit Commitment versus Economic Dispatch. | | | | 9 |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | **Hydro thermal Co-ordination:** Hydro electric plant models- scheduling problems- short term hydro thermal scheduling problem-Gradient approach-Hydro units in series- Pumped storage hydro plants- Dynamic programming solution to hydro thermal scheduling problem. | | | | 9 |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | **Automatic Generation Control and Voltage Control:** Review of Load Frequency Control and Economic Dispatch Control in a single area system- Tie- line bias control in a two area system- static and dynamic response of controlled two area system- AGC implementation-AGC features – Methods of voltage control- -synchronous condenser- transformer taps –static var compensators-Thyristor switched capacitors-Thyristor controlled reactors. | | | | 8 |
| **IV** | **Power system Security and Interchange of Power & Energy:** Factors affecting power system security- Contingency analysis – linear sensitivity factors-A C power flow method- contingency selection- -security constrained optimal power flow.  Economy interchange between interconnected utilities- inter utility economy energy evaluation- interchange evaluation with Unit Commitment- multiple utility interchange transactions- other types of interchange- Power Pools. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Allen J. Wood And Wollenberg B.F., ‘Power Generation Operation and Control’, John Wiley & Sons, NY, 1996 2. S.Sivanagaraju and G. Sreenivasan., ‘Power System Operation and Control’, Pearson Education 3. Nagrath, I.J. and Kothari S D.P., ‘Modern Power System Analysis, TMH, New Delhi, 1980. | | | | | |
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| **COURSE CODE** | | **COURSE NAME** | **L-T-P-C** | **YEAR** | |
| **05EE 6111** | | [**Modern**](#bookmark17) **Control Systems** | **2-1-0-3** | **2015** | |
| **COURSE OBJECTIVES:**   * To study concepts and techniques of linear and non- linear control systems’ analysis and synthesis. * To study the fundamentals of optimal control.   **COURSE OUTCOMES:**   * The student will be able to apply the modelling concepts in state space. * Students will be equipped with stability analysis of linear and non- linear systems. * Students will have an idea of optimal design of control systems.. | | | | | |
| **MODULE** | **COURSE CONTENT (34 hrs)** | | | | **HRS** |
| **I** | **Review** of fundamental concepts of system’s state-state space modeling of physical systems-diagonalization –controllable canonical form- observable canonical form-determination of STM-controllability and observability of linear time invariant systems- state feedback and pole placement-observer design-reduced order observer. | | | | 9 |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | **Non linear systems**: describing functions for various types of non-linearities-on off relay, deadzone, saturation, saturation and deadzone- describing function analysis of non-linear systems-closed loop stability- stability of limit cycles.Phase plane analysis-Analytical methods for the construction of phase trajectory- Graphical methods-Isocline method-delta method-Analysis and classification of singular points. | | | | 9 |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | **Concept of stability:** Equilibrium points-stability by the method of Lyapunov-First method of Lyapunov- Sign definiteness of scalar function- Lyapunov’s method for linear continuous time systems-Stability of nonlinear systems by the method of Lyapunov- -Krasovskii’s theorem on Lyapunov’s function-variable gradient method of constructing Lyapunov function. | | | | 8 |
| **IV** | **Introduction to optimal control:**  Formulation of the optimal control problem Typical optimal control performance measures Optimal control based on Quadratic performance measures Infinite time regulator problem Solution of reduced matrix Ricatti equation. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Dr. K.P Mohandas, ‘Modern Control Engineering’, Snguine Technical Publications,2006. 2. Stefani,shahir, Savand, Hestetter, ‘Design of Feedback Control Systems’ Oxford,2010. 3. Stanis law H Zak,’Systems and Control’ ,Oxford,2002. 4. Ogata K, ’Modern Control Engineering’ ,Prentice hall of India, 1981. 5. Gopal M, ‘Modern Control Systems Theory’ , Wiley Eastern Ltd. ,1990 | | | | | |
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| **COURSE CODE** | | **COURSE NAME** | **L-T-P-C** | **YEAR** | |
| **05EE 6113** | | **Power Quality** | **2-1-0-3** | **2015** | |
| **COURSE OBJECTIVES:**   * To study about the different power quality problems occurring in our power systems * To study the effect of harmonic in our power system and its elimination using power quality conditioner   **COURSE OUTCOMES:**   * Students will be able to Understand different power quality disturbance and voltage variations in a power system * Students will have a full understanding of the presence of harmonics and different power quality conditioners. | | | | | |
| **MODULE** | **COURSE CONTENT (34 hrs)** | | | | **HRS** |
| **I** | **Power Quality**: Introduction**-** voltage quality-overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices. | | | | 9 |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | **Harmonics**: individual and total harmonic distortion-RMS value of a harmonic waveform-triplex harmonics-important harmonic introducing devices-SMPS-Three phase power converters-arcing devices- saturable devices-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.  Modeling of networks and components under non-sinusoidal conditions-transmission and distribution systems-shunt capacitors-transformers-electric machines-ground systems-loads that cause power quality problems-power quality problems created by drives and its impact on drives | | | | 9 |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | **Power factor improvement**: Passive Compensation. Passive Filtering . Harmonic Resonance . Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter. static var compensators-SVC and STATCOM | | | | 8 |
| **IV** | **Active Harmonic Filtering**: Shunt Injection Filter for single phase , three-phase three-wire and three-phase four-wire systems . d-q domain control of three phase shunt active filters uninterruptible power supplies-constant voltage transformers- series active power filtering techniques for harmonic cancellation and isolation . Dynamic Voltage Restorers for sag , swell and flicker problems. Grounding and wiring-introduction-NEC grounding requirements-reasons for grounding-typical grounding and wiring problems-solutions to grounding and wiring problems. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. .heydt g.t, Electric power quality 2. Math H. Bollen, Understanding Power Quality Problems 3. Arrillaga J., .Power System Quality Assessment., John wiley, 2000 4. Arrillaga J, B.C. Smith, N.R. Watson & A. R.Woo , Power system Harmonic Analysis. , Wiley, 1997 5. Selected Topics in Power Quality and Custom Power, Course book for STTP, 2004, Ashok S. 6. [Surya Santoso](http://www.amazon.com/exec/obidos/search-handle-url/index=books&field-author-exact=Surya%20Santoso&rank=-relevance%2C%2Bavailability%2C-daterank/102-8184890-9045759), [H. Wayne Beaty](http://www.amazon.com/exec/obidos/search-handle-url/index=books&field-author-exact=H.%20Wayne%20Beaty&rank=-relevance%2C%2Bavailability%2C-daterank/102-8184890-9045759), [Roger C. Dugan](http://www.amazon.com/exec/obidos/search-handle-url/index=books&field-author-exact=Roger%20C.%20Dugan&rank=-relevance%2C%2Bavailability%2C-daterank/102-8184890-9045759), [Mark F. McGranaghan](http://www.amazon.com/exec/obidos/search-handle-url/index=books&field-author-exact=Mark%20F.%20McGranaghan&rank=-relevance%2C%2Bavailability%2C-daterank/102-8184890-9045759), Electrical Power System Quality , MC Graw Hill, 2002 | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 7115** | | **Digital Protection of Power Systems** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To understand the working and classification of relays and its application in power systems. * To understand and working concepts of different kinds of static relays and its practical realization. * To understand and work with hardware and software implementation of relays using microprocessors. * To understand and work with different kinds of pilot relay protection, digital protection and use of Artificial Intelligence in protection.  COURSE OUTCOMES:  * Candidate should be able to understand the working and classification of relays and its application in power systems. * Candidate should be able to understand the working concepts of different kinds of static relays and its practical realization. * Candidate should be able to work with hardware and software implementation of relays using microprocessors. * Candidate should be able to work with the different kinds of pilot relay protection, digital protection and use of Artificial Intelligence in protection. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | General philosophy of protection – Characteristic functions of protective relays – basic relay elements and relay terminology Classification of Relays – Construction and operation of Electromagnetic relays, A review of conventional protection schemes for Transmission lines and station apparatus (Qualitative treatment only). | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | Static relays – Solid state devices used in static protection – Amplitude comparator and phase comparator Static Over current relays: Non-directional, Directional - Synthesis of Mho relay, Reactance relay, Impedance relay and Quadrilateral Distance relay using Static comparators, Differential relay.(Qualitative treatment only). | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | Hardware and software for the measurement of voltage, current, frequency, phase angle, Microprocessor implementation of over current relays – Inverse time characteristics, Directional relay – Impedance relay– Mho relay, Differential relay | | | | 8 |
| **IV** | Pilot relay protection: Wire pilot relaying, Carrier current pilot relaying, Microwave pilot relaying – Fibre-optic based relaying – Apparatus Protection: Digital protection of generators, Digital protection of Transformers – Protection of Long and short lines – Protection based on Artificial Intelligence, SCADA: Architecture, Use of SCADA in interconnected power systems.(Qualitative treatment only) | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Y.G.Paithankar , S.R.Bhide, “ Fundamentals of Power System Protection”, Prentice – Hall India, 2004 2. L.P.Singh, “ Digital protection, Protective Relaying from Electromechanical to Microprocessor”, John Wiley & Sons, 1995 3. A.G.Phadke, J.S.Thorpe,” Numerical relaying for Power Systems”, John-Wiley and Sons, 1988 4. T.S.M.Rao, “Digital / Numerical Relays”, Tata McGraw Hill,2005 5. Badri Ram and DN Vishwakarma, “Power system protection and Switchgear”, Tata McGraw Hill, NewDelhi, 2003. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6177** | | **RESEARCH METHODOLOGY** | 1-1-0-2 | 2015 | |
| COURSE OBJECTIVES:   * To familiarize the students with different stages of research process. * To get an idea about descriptive and inferential statistics. * To familiarize the students with the nature of research and scientific writing.   **COURSE OUTCOMES:**   * The students should be able to understand the basic concepts of research and its methodologies. * Students are able to understand different statistical test and parameters. * The student should be able to define appropriate research problem and write a research report.   **SYLLABUS** | | | | | |
| MODULE | COURSE CONTENT (18hrs) | | | | HRS |
| **I** | Introduction to research methodology. Types of research, research methods Vs methodology - stages of research process. Literature review – Problem definition- Research design for exploratory, descriptive and experimental research – Brief introduction to completely randomized design, randomized block design and Latin square designs (description only). | | | | 4 |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | Sampling fundamentals -Types of sampling: probability and non-probability sampling. Sampling theory, sampling distribution and sample size determination. Tools and techniques of data collection: Questionnaire and schedule for field surveys, interview, observation, simulation, experimental and case study methods. Collection, recording, editing, coding and scaling of data. Scale classification and types. Measurement of validity, reliability and practicality. Cronbach’s Alpha. | | | | 5 |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | Descriptive and inferential statistics - Data analysis and interpretation –testing of hypothesis, testing of population mean, variance and proportion –Z test – t test – F test - chi square test. Test for correlation and regression –standard error of the estimate. Testing goodness of fit. Brief introduction to non-parametric tests, factor analysis, discriminant analysis and path analysis (description only). Use of SPSS and other software. | | | | 4 |
| **IV** | Meaning of interpretation and inference: importance and care for interpreting results. Presentation of reports: popular reports and technical reports - structure and style. Oral and written presentations: Parts of a research report. Guidelines for writing research papers and reports – Writing different sections of a research paper – Introduction, Methodology, Results, Discussion, Conclusion, Abstract – Writing the title. Methods of giving references and appendices: referencing styles. Ethics in research. Use of computers and internet in research. | | | | 5 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. C. R. Kothari, "Research Methodology, Methods and techniques", New Age International Publishers, New Delhi, 2004. 2. R. Panneerseklvam, "Research Methodology", Prentice Hall of India, New Delhi, 2011. 3. Ranjit Kumar, "Research Methodology, A step by step approach", Pearson Publishers, New Delhi, 2005. 4. K. N. Krishnaswami, Appa Iyer and M Mathirajan, "Management Research Methodology", Pearson Education, Delhi, 2010. 5. M N Borse, "Hand Book of Research Methodology", Sree Nivas Publications, Jaipur, 2004. 6. William G Zikmund,"Business Research Methods", South – Western Ltd, 2003. 7. P K Majumdar, "Research Methods in Social Science", Viva Books Pvt Ltd, New Delhi, 2005. 8. Norman Blaikie, "Analyzing Quantitative Data", SAGE Publications , London, 2003 9. Samuel B. Green, Neil J. Salkind, "SPSS for Windows" Pearson Education New Delhi, 2007. | | | | | |
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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05EE 6191** | **Power System Simulation Laboratary** | 0-0-2-2 | 2015 |
| **LIST OF EXPERIMENTS**   1. Formation of Bus Admittance Matrix and Bus Impedance Matrix using MATLAB. 2. Formation of Jacobian for s system not exceeding 4 buses (no PV buses) in polar co-ordinates using MATLAB. 3. Sequence Components of Power System Network with Single Line to Ground Fault using MATLAB SIMULINK. 4. Modeling of Single machine Power System using SIMULINK. 5. Short circuit studies of power system using ETAP/PSCAD. 6. Load flow analysis using Gauss Seidel Method, Newton Raphson Method, Fast De-coupled for both PQ and PV Buses using ETAP/PSCAD. 7. DC Load flow analysis using SIMULINK. 8. Simulation and analysis of magnetic circuits using SIMULINK. 9. Simulation and measurements of Three Phase circuits using SIMULINK. 10. Modeling of Automatic Generation Control for a two area network using SIMULINK. 11. To Determine 1) Swing curve 2) Critical clearing time for a single machine connected to infinite bus through a pair of identical transmission lines, three phase fault on one of the lines for variation of inertia constant/line parameters/fault locations/ clearing time/pre fault electrical output using MATLAB/C-Program 12. Modeling and Simulation of Non Conventional Energy Systems using MATLAB   **Optional Experiments**   1. Analysis of Static Var Compensators. 2. Analysis of STATCOM. 3. Load forecasting using ETAP. 4. Power Quality studies using PSCAD. 5. Substation layout using AutoCAD Electrical. 6. Transient Stability Analysis and formation of Swing Curves using MATLAB/SIMULINK. 7. Modeling of Surge Arresters using PSCAD. 8. Modeling of FACTS devices using SIMULINK. 9. Transformer Tests using SIMULINK/ETAP. 10. Fault Analysis of synchronous Generator using PSCAD. 11. Execute optimal power flow problem using ETAP/PSCAD. 12. Analysis of voltage stability of s SLIB (Single Load Infinite Bus) system while delivering maximum power using MATLAB. 13. Continuation Power Flow (CPF) analysis using MATLAB.   **Note: In addition to the above, the Dept. can offer a few newly developed experiments.** | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6102** | | **Flexible AC Transmission Systems** | 3-1-0-4 | 2015 | |
| COURSE OBJECTIVES:   * To understand the power transmission problems and the need for FACT controllers * To develop a deeper knowledge on various control and implementation techniques for fact devices. * To introduce the special purpose fact devices for improving power quality.  COURSE OUTCOMES:  * The students will be able to use FACT controllers for various power quality issues. * An ability to develop and promote research interests, in controllers for reducing difficulties of power systems. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | **Power transmission problems and emergence of facts solutions:** Fundamentals of ac power transmission, transmission problems, power flow, controllable parameters. Power quality – basic concept. Voltage regulation and reactive power flow control- Needs, emergence of FACTS- Types of FACTS controllers-Advantages and disadvantages - shunt compensation - Series compensation -Phase angle control –basic relationships | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Shunt and Series compensators:** Objectives-shunt SVC-TCR, TSC, combined TCR and TSC configurations, static synchronous compensator (STATCOM) configuration and control, comparison between SVC and STATCOM. Static series compensation –Objectives- TSSC, TCSC - Sub synchronous characteristics- Basic NGH SSR Damper. Static Synchronous Series Compensator (SSSC): Principle of operation, configuration and control scheme. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Unified power flow controller (UPFC):**Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC to the controlled series compensators, control structure and dynamic performance. Interline Power Flow Controller (IPFC) – Basic operating Principles and Characteristics and control schemes. | | | | 10 |
| **IV** | **Special purpose FACT controllers: (basic concept)-**Static voltage & phase angle regulator –objectives- - TCVL- TCVR- TCBR -Distribution STATCOM – Dynamic Voltage Restorer – Unified Power Quality Conditioner – Application of D-STATCOM, DVR and UPQC. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Song, Y.H and Allan. T. Johns, ‘Flexible Ac Transmission Systems (FACTS); Institution Of Electrical Engineers Press, London, 1999 2. Hingorani, L Gyugyi “Concepts and Technology Of Flexible Ac Transmission System’, IEEE Press New Yourk, 2000 Isbn- 078033 4588. 3. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International Publishers, 2007 4. IEE Tutorials on ‘Flexible Ac Transmission Systems’ Published in Power Engineering Journal, IEE Press, 1995. 5. Miller, T J E “Reactive Power Control in Power Systems”   John Wiley, 1982. 6. Padiyar K.R. “Facts Controllers In Power Transmission and Distribution”, New Age International Publishers, June 2007. 7. S Denesh Kumar, ‘Flexible AC Transmission System’, Anuradha Publishers, 2013. 8. R Sreramkumar, ‘Flexible AC Transmission System’, Institution of Engineers. 9. Abhijitchakrabarti,‘Power System Analysis, Operation and Control’, PHI. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6104** | | **ADVANCED POWER SYSTEM STABILITY** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * This course aims to give basic knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modeling issues.   **COURSE OUTCOMES:**   * Students will be able to analyse and understand the electromagnetic and electromechanical phenomena taking place around the synchronous generator. * Students will be able to solve the reactive power problems in power system | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Power system stability and modeling of components:** Power System Stability: Concept of Power system stability-Types of stability, Classical model of single machine connected to infinite bus system  Modeling of power system components: Synchronous Machine - Mathematical Description of a Synchronous Machine - Basic equations of a synchronous machine - dq0 Transformation- per unit representation- equivalent circuits for direct and quadrature axes.  Modeling of Excitation system: Types of excitation system- IEEE (1992) Type DC1A, AC1A and ST1A models. Modelling of prime movers – Hydraulic turbine transfer function, modelling of steam turbine. | | | | 9 |
| **INTERNAL TEST 1(Module 1)** | | | | | |
| **II** | **Small signal stability:** Fundamental Concepts of Stability of Dynamic Systems: State-space representation- stability of dynamic system - Linearization, Eigen properties of the state matrix. Small Signal Stability of Single Machine Infinite Bus (SMIB) System: Generator represented by the classical model -Effects of synchronous machine field circuit dynamics- effects of excitation system. | | | | 9 |
| **INTERNAL TEST 2(Module 2)** | | | | | |
| **III** | **Transient stability:** Transient stability-swing equation-equal area criterion, numerical solution of swing equation- Euler method, Runge-Kutta method, critical clearing time and angle – effect of clearing time on stability. Direct method of transient stability analysis - transient energy function approach. | | | | 8 |
| **IV** | **Methods of improving stability:** Transient stability enhancement: High speed fault clearing, Reduction of transmission system reactance, regulated shunt compensation, dynamic braking, steam turbine fast valving, generator tripping, controlled system separation and load shedding, high speed excitation systems. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Kundur P, ‘Power System Stability and Control’, TMH. 2. Nagrath , Kothari , ‘Modern power system analysis’, TMH 3. Anderson and Fourd , 'Power System Control and Stability", John Wiley, second edition. 4. K R Padiyar, 'Power System Dynamics'*,* 2nd Edition, B.S. Publishers. 5. E W Kimbark, 'Power System Stability'*,* Wiley & IEEE Press | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6106** | | **Artificial Neural Networks and Fuzzy Systems** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES: To cater the knowledge of Neural Networks and Fuzzy Logic Control and use these for controlling real time systemsCOURSE OUTCOMES:  * To expose the students to the concepts of feed forward neural networks. * To provide adequate knowledge about feedback neural networks. * To teach about the concept of fuzziness involved in various systems. To provide adequate knowledge about fuzzy set theory. * To provide adequate knowledge of application of fuzzy logic control to real time systems. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | Biological foundations, ANN models, Types of activation function, Introduction to Network architectures : Multi Layer Feed Forward Network (MLFFN), Recurrent Neural Network (RNN). Training ANNs – perceptrons – Exclusive OR problem – Linear seperability – perceptron learning - Hebbian learning rule - Delta rule. Learning process . Supervised and unsupervised learning. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | Back propagation algorithm - Applications in engineering problems. Counter propagation Networks – Architecture of the counter propagation network – Kohonen layer – Training the Kohonen layer – preprocessing the input vectors – initializing the weight vectors. Training the Grossberg layer – Applications. | | | | 9 |
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| **III** | Fuzzy sets . Fuzzy set operations . Properties, Membership functions, Linguistic variables, Fuzzy Rules and Fuzzy Reasoning - Fuzzy Relations – Fuzzy Compositions- Max-min and max-product compositions –– Mamdani and Sugeno Fuzzy Models– Input Space Partitioning and Fuzzy Modeling. Fuzzy If-Then Rules - methods of defuzzification- max membership, centroid, weighted average methods. | | | | 8 |
| **IV** | Fuzzy Inference Systems - Methodology of fuzzy design and Applications – Implementation of Batch Least Square, Recursive Least Square and Gradient descent algorithms in fuzzy systems. Typical fuzzy logic applications in Engineering. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. J.M. Zurada, .Introduction to artificial neural systems, Jaico Publishers, 1992. 2. Simon Haykins, .Neural Networks. A comprehensive foundation., Macmillan College, Proc, Con, Inc, New York, 1994. 3. D. Driankov, H. Hellendorn, M. Reinfrank, .Fuzzy Control. An Introduction. , Narora Publishing House, New Delhi, 1993. 4. H.J. Zimmermann, .Fuzzy set theory and its applications, III Edition, Kluwer Academic Publishers, London. 2001 5. G.J. Klir, Boyuan, .Fuzzy sets and fuzzy logic., Prentice Hall of India (P) Ltd., 1997. 6. Stamatios V Kartalopoulos, .Understanding neural networks and fuzzy logic .basic concepts and applications., Prentice Hall of India (P) Ltd., New Delhi, 2000. 7. Timothy J. Ross, .Fuzzy logic with engineering applications. McGraw Hill, New York. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6122** | | **Modeling of Electrical machines** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To derive the developed torque in an electrical machine using the concepts of field energy and co-energy. * To study the generalized machine theory and dynamic modeling of D C machines. * To understand reference frame theory and dynamic modeling of three phase induction machinein various reference frames * To derive dynamic modeling of 2-phase induction machine and 3-phase synchronous machine in various reference frames  COURSE OUTCOMES: After completion of this course the students will be able to   * Apply theoretical concepts in modeling of conventional electrical machines * To derive dynamic modeling of D C machines, three phase induction machine**,** 2- phase induction machine and 3-phase synchronous machine in various reference frames. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Basic Principle of Electro mechanical Energy Conversion:** Introduction to magnetic circuits- Flux, flux linkage, mmf, reluctance, inductance and energy- Self, leakage, magnetizing and mutual inductances- AC excitation- Principles of electromechanical energy conversion- Analysis of singly excited electromechanical system- General expressions of stored magnetic energy, co-energy and force/torque- Analysis of doubly excited rotational system- Electrical and mechanical equations. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Generalized Machine Theory-** Unified approach to the analysis of electrical machines- Basic two-pole machine- Transformer and rotational voltages in the armature- Kron’s primitive machine- Voltage, power and torque equations- Resistance, inductance and torque matrices.  **Modeling of DC Machines-** Voltage, power and torque equations of separately excited, shunt, series and compound wound machines. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Reference Frame Theory and Modeling of Three Phase Induction Machine:** Calculation of air gap mmf and per phase machine inductances using physical machine data.  **Reference frame theory**: Equations of transformation- Commonly used reference frames- Transformation between reference frames.  **Three Phase Symmetrical Induction Machine**: Dynamic modeling of three phase symmetrical induction machine in phase variable form - Voltage and torque equations in machine variables- Application of reference frame theory to three phase symmetrical induction machine- Dynamic direct and quadrature axis model in arbitrary reference frame- Equivalent circuits- Commonly used reference frames for induction machine. | | | | 8 |
| **IV** | **Modeling of 2 phase induction machine and 3 phase synchrounous machine**: Dynamic modeling of two phase unsymmetrical induction machine in machine variables- Voltage and torque equations- Application of reference frame theory to two phase unsymmetrical induction machine- Voltage and torque equations of unsymmetrical 2- phase induction machine in stationary reference frame variables- Equivalent circuits.  **Three Phase Synchronous Machine**: Dynamic modeling of three phase salient pole synchronous machine in phase variable form- Voltage and torque equations in machine variables- Application of reference frame theory to three phase salient pole synchronous machine- Dynamic direct and quadrature axis model in arbitrary reference frame - Derivation of rotor reference frame model- Park’s equations- Equivalent circuits. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, *‘Analysis of Electric Machinery and Drive Systems’*, Wiley, Second Edition 2. Charles Kingsley,Jr., A.E. Fitzgerald, Stephen D.Umans, *‘Electric Machinery’*, Tata Mcgraw Hill, sixth Edition. 3. Dr.P.S. Bimbhra, *‘Generalized Theory of Electrical Machines’*, Khanna Publishers 4. R. Krishnan, *‘Electric Motor & Drives: Modeling, Analysis and Control’*, Prentice Hall of India 5. P.C.Sen, *‘Principles of Electric Machines and Power Electronics’*, John Wiley, Second Edition | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6124** | | **Renewable Energy Systems** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To understand the difference between renewable and nonrenewable energy resources. * To demonstrate understanding of the different types of renewable energy technologies that are currently available, and how they are used to provide energy..  COURSE OUTCOMES: Students will be able   * to create a list of renewable energy technologies that can be used in a particular situation, based on the situational factors. * to evaluate the environmental and social impacts of renewable and nonrenewable energy use. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | Solar Energy-Introduction to solar energy: solar radiation, availability, measurement and estimation Solar thermal conversion devices and storage – solar cells and photovoltaic conversion. PV systems – MPPT. Applications of PV Systems – solar energy collectors and storages. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | Wind Energy-Introduction – Basic principles of wind energy conversion – wind data and energy estimation – site selection consideration. basic components of wind energy conversion system –Types of wind machines – basic components of wind electric conversion systems. Schemes for electric generations – generator control, load control, energy storage – applications of wind energy – Inter connected systems. | | | | 9 |
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| **III** | Chemical Energy Sources-Introduction – fuel cells – design and principles of operation of a fuel cell – classification of fuel cells. Types of fuel cells – conversion efficiency of fuel cells. Types of electrodes, work output and emf of fuel cell, Applications of fuel cells. Hydrogen energy: Introduction – hydrogen production – electrolysis, thermochemical methods, Westinghouse Electro-chemical thermal sulphur cycle. Fossil fuel methods. Hydrogen storage, Utilization of hydrogen gas. | | | | 8 |
| **IV** | Energy from oceans-Introduction, ocean thermal electric conversion (OTEC), methods of ocean thermal electric power generation, open cycle OTEC system, closed OTEC cycle. Energy from tides: Basic principles of tidal power, component of tidal power plants, operation methods of utilization of tidal energy, site requirements, storage, advantages and limitations of tidal power generation. Ocean waves, energy and power from the waves, wave energy conversion devices. Geothermal energy-Introduction, estimation of geothermal power, nature of geothermal fields, geothermal sources, inter connection of geothermal fossil systems, prime movers for geo thermal energy conversion. Energy from biomass: Biomass conversion technologies, photosynthesis, classification of biogas plants. Biomass Energy conversion, Energy from waste. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. SP Sukatme, “Solar Energy – Principles of thermal collection and storage, second edition, Tata McGraw Hill, 1991. 2. GD Rai, “Non Conventional Energy Sources”. 3. J.A. Duffie and W.A. Beckman, “Solar Engineering of Thermal Processes”, Second Edition, John Wiley, New York, 1991. 4. D.Y. Goswami, F. Kreith and J.F. Kreider, “Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000. 5. D.D. Hall and R.P. Grover, “Bio-Mass Regenerable Energy, John Wiley, Newyork, 1987. 6. J. Twidell and T. Weir, “Renewable Energy Resources”, E&FN Spon Ltd., London, 1986. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6126** | | **Solid State DC And AC Drives** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To introduce basic concepts of load and drive interaction, speed control concepts of ac and dc drives, speed reversal, regenerative braking aspects.  COURSE OUTCOMES:  * The student will be able to analyse, simulate and evaluate performance of variable speed drives. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Single phase dc drives:** Single phase drives-motor and input supply performance parameters separately excited d.c. motor drives basic equations –waveforms-power factor improvement – semiconductor operation of full converters. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Three phase dc drives:** Three phase drives-operation of semi conductors and full converters-dual converters-non – circulating current and circulating current mode-dual mode dual converters-reversible drives armature current reversal field current reversal drives selection. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Chopper fed dc drives:** Single quadrant, two quadrant and four quadrant choppers chopper details –performance characteristics- separately excited d.c. motor – d.c. series motor input filters, multiphase choppers-dynamic and regenerative braking of chopper controlled drives. | | | | 8 |
| **IV** | **Inverter fed induction motors:** Voltage control – operation of induction motor with non- sinusoidal waveform-air gap mmf-hamonic behavior motor losses-harmonic torques-vector control of induction motors. Stator voltage control schemes-slip power recovery schemes rotor resistance control-cyclo conveters principle of operation-cyclo-converter fed drives. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Sen, P.C.’Thyrisore DC Drives; John Wiley % Sons, 1981. 2. Murphy, J.M.D & Turnbull, F.G., ‘Power Electronic Control Of AC Motors’, Pergamon Press, 1988. 3. Shephered, W. & Hulley, L.N., ‘Power Electronics and Motor Control’, Cambridge University Press, 1988. 4. Remamoorthy, M., “An Introduction to Thyristors and Their Applications, East West Press, 1977. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6132** | | [**Advanced**](#bookmark85) **Microprocessors and Microcontrollers** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To impart knowledge about 8051 micro controller and to enrich students knowledge in programming concepts * To develop skills in designing microcontroller based system. * To study the architecture, operating modes and features of microprocessors 80286, 80386, 80486 and Pentium.  COURSE OUTCOMES:  * An ability to apply knowledge about 8051 and program 8051 micro controllers. * Able to map real world problems into 8051 programming language. * Understand basic concepts of pipelining, paging, superscalar architecture and branch prediction. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Intel 8051:** Architecture - Memory Organization – Instruction set – Addressing modes – Basic Programming. **Peripheral:**Parallel Ports – Timers and Counters – Interrupts – Serial Communication –Assembly language and C Programming- Typical examples like reading and writing through the ports-sine and square wave generation- Interfacing ADC, DAC and LCD Display– Assemblers and Compilers – Generation of .LST and .HEX files for applications using Keil / RIDE IDE. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **80286 Processor :** Introduction to 80X86 Microprocessor Family- 80286 Processor- salient features- Register organization of 80286- Flags- pins & signals- Internal Functional block diagram-modes of operation-real address mode and protected virtual address mode–Physical address calculation in PVAM-memory protection mechanism and privilege level. | | | | 9 |
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| **III** | **80386 Processor:** Register organization of 80386- Flags- pins & signals- Internal Functional block diagram–– modes of operation-real address mode and protected virtual address mode –address computation in PVAM(paging disabled)-paging mechanism- address computation –virtual 8086 mode.  **80486 processor:** pins & signals –architecture of 80486 -5 stage pipeline-on chip cache and control unit- memory system. | | | | 8 |
| **IV** | **Pentium Microprocessor:** Introduction to Pentium processor-salient features-superscalar architecture- Branch prediction- Architecture of Pentium processor – Register organization-flags- Special Pentium registers -memory system- Memory management and paging unit. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. A.K. Ray, Advanced Microprocessors and Peripherals 2. Barry, B. Brey, ‘The Intel Microprocessor 8086/8088, 8086/8088, 80286, 80386,   80486, Pentium and Pentium preprocessor architecture, programming and Interfacing’, PHI, 4th edition, 1997.   1. A.Nagoorkani ,Microprocessor 8086 Programming & Interfacing. 2. Ajay V Deshmukh, Microcontrollers. 3. Kenneth Ayala, “The 8051 Microcontroller (With CD)”, Cengage Learning, 3rd Edition, 2007. 4. David Calcutt, Fred Cowan, Hassan Parchizadeh, *8051* Microcontrollers - An Application based Introduction, Elsevier, 2006. 5. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, The 8051Microcontroller and Embedded Systems- Using Assembly and C**,** Prentice Hall of India, New Delhi, 2007. 6. Intel Data Book on MCS 51 family. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6134** | | **HVDC Transmission** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To deal with the importance of HVDC Transmission and HVDC Converters * To deal with power conversion between Ac to DC and DC to AC * To deal with firing angle of HVDC System. * To deal with Reactive power control of HVDC system. * To deal with Power factor improvement of HVDC system.  COURSE OUTCOMES:  * Students will be able to understand the importance of Transmission power through HVDC. * Ability to calculate power conversion between Ac to DC and DC to AC. * Ability to control reactive power through HVDC. * Ability to discuss power flow analysis HVDC. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **General aspects and converter circuits:** Historical developments- HVAC and HVDC links-comparison-economic, technical performance-reliability-limitation-properties of thyristor converter circuits-assumptions-choice of best circuit for HVDC converters-transformer connections. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Bridge converters-analysis and control:** Analysis with gate control but no overlap-with overlap less than 60 degrees-operation of inverters-basic means of control-power reversal – desired features of control-actual control characteristics. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Misoperation of converters and protection:** Converter disturbance-by pass action in bridges-commutation failure-basics of protection-DC reactors-voltage and current oscillations-circuit breakers-over voltage protection. | | | | 8 |
| **IV** | **Harmonics, filters and converter charts:** Characteristic and uncharacteristic harmonics-troubles due to harmonics harmonic filters – converter charts of direct current and voltage-active and reactive power. Interaction between a.c. and d.c. systems: voltage interaction-harmonic instabilities-d.c. power modulation –design considerations of thyristor converter m- transformers-smoothing reactions-overhead lines-cable transmission-earth electrodes-design of back to back thyristor converter system. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Kimbark, E.W., ‘Direct Current Transmission-Voi.1’, Whley Interscience, New York, 1971 2. Arrilage, J., High Voltage Direct Current Transmission’, Peter Pereginver Ltd., London, U.K. 1983. 3. Padiyar, K.R., ‘HVDC Transmission Systems., Wiley Eastern Ltd., New Delhi, 1992. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 6136** | | **Robotics and Automation** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To be familiar with the automation and brief history of robotand applications. * To give the student familiarities with the kinematics of robots. * To give knowledge about robot end effectors and their design.  COURSE OUTCOMES:  * Students will be familiarized with the kinematic motions of robot. * Students will be equipped with the principles of various Sensors and their applications in robots | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Introduction:** Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors-– End effectors – Control systems – Robot programming languages and applications –Introduction to robotic vision. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Robot Arm Kinematics:** Direct and inverse kinematics – Rotation matrices – Composite rotation matrices – Euler angle-representation – Homogenous transformation – Denavit Hattenberg representation and various arm configurations. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Robot Arm Dynamics:** Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion-equations – Generalized D’Alembert equations of motion. | | | | 8 |
| **IV** | **Planning of Manipulator Trajectories:** General consideration on trajectory planning joint interpolation & Cartesian path trajectories.-Control of Robot Manipulators-PID control computed, torque technique – Near minimum time control – Variable structure control – Non-linear decoupled feedback control – Resolved motion control and adaptive control. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **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. | | | | | |

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05EE 6166** | **Seminar 1** | 0-0-2-2 | 2015 |
| COURSE OBJECTIVES:   * To improve the professional competency and research aptitude. * To motive and energize talent. * To improve presentation skills.   **COURSE OUTCOMES:**  After successful completion of the seminar presentation, the students will be able to analyse and present technological and research topics more effectively  Each student shall present a seminar on any topic of interest related to the courses offered in the M.Tech Programme. He / she shall select the topic based on the references from international journals of repute, preferably IEEE journals. They should get the paper approved by the Programme Co-ordinator / Faculty member in charge of the seminar. The students should undertake a detailed study on the topic and submit a report at the end of the semester. | | | |

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05EE 6188** | **MINI PROJECT** | 0-0-4-2 | 2015 |
| COURSE OBJECTIVES:   * To improve professional competency, research aptitude and team work skills. * To motive and energize talent. * To develop an aptitude to deliver commitments and manage time and stress pressures.   **GUIDELINES:** | | | |
| A list of Mini Projects should be prepared by the faculty before the commencement of the semester. The specifications and time plan should be clearly defined. The students should select a Project from the specified list and it can be done individually or in a group of two. The same project should not be selected by more than one group. Hardware design and fabrication is mandatory for all the projects.  The sequence of tasks may be   1. Schematic design and simulation 2. PCB layout design 3. Software/Firmware design and simulation 4. System integration and demonstration 5. Mini project report preparation | | | |
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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05EE 6192** | **Power Electronics Simulation Lab** | 0-0-2-1 | 2015 |
| COURSE OBJECTIVES:   * To simulate various power converter circuits and to analyse the performance of the converters.   **COURSE OUTCOMES:**   * Students will be able to design and simulate various power converters using MATLAB/SIMULINK | | | |
| LIST OF EXERCISES / EXPERIMENTS (18 hrs) | | | |
| **List of Experiments:-**   1. Simulation of single phase Semiconverter, Fully controlled converters with R, RL and RLE Load using MATLAB/Simulink. 2. Simulation of Three phase semi converter using MATLAB/Simulink. 3. Simulation of Three phase fully controlled converter using MATLAB/Simulink. 4. Simulation of Single phase full bridge inverter using MATLAB/Simulink. 5. Simulation of Three phase full bridge inverter using MATLAB/Simulink. 6. Simulation of PWM inverters using MATLAB/Simulink. 7. Simulation of Three phase AC voltage Controller using MATLAB/Simulink. 8. Modeling of FACTS devices using SIMULINK using MATLAB/Simulink | | | |
| **INTERNAL TEST** | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 7141** | | **Micro controller Applications in Power Converters** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To impart the knowledge about PIC 16F77 microcontroller programming and interfacing * To familiarize with interface application of ARM processors and FPGA. * To provide experience in the programming using different controllers for power converters  COURSE OUTCOMES:  * The students will be able to write the programs using assembly languages and high level languages * An ability to design and implement the real time systems and process. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Microchip PIC 16F877:** Device overview**-** Architecture of PIC 16F877 microcontroller- PIC memory organization- ports - Interrupt structure – Timers / Counters – Capture / Compare / PWM modules – Master Synchronous Serial Port (MSSP) module – USART – A / D Converter module Timers, Comparator module-Reset- WDT- oscillator configuration- Different addressing modes. Instruction set – Programming –Assemblers and compilers .LST and .HEX files generation for applications using MpLab IDE- Gate driver- IR2111& TLP 250. **PIC18F4580** - Device overview- Architecture – Memory Organisation - **dsPIC30F4011 -** Device overview- Architecture - MCU and DSP features –special features . | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | Overview of ARM architecture – RISC concepts - ARM organization and implementation - ARM instruction set - The thumb instruction set - Basic ARM Assembly language program - ARM CPU cores.  LPC 1769 - Device overview- Architecture - MCU and DSP features –special features. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **FPGA Based System Design using VHDL:** Overview of Hardware Description Languages – VHDL Introduction, Behavioral, Data flow, Structural Models - Simulation Cycles - Test bench; Design at different levels with special emphasis on FPGA - Design of sequential and Combinatorial circuits-generation of sine and square wave –Spartan 3/6 - Device overview- Architecture. | | | | 8 |
| **IV** | **Typical functions of microcontrollers in power electronic systems:** **(necessary diagrams with explanations, Algorithm and programs)** Measurement of voltage, current, speed, power and power factor - Frequency measurement - -Feedback control and processing of feedback signals(Monitoring, sequencing, diagnostics and miscellaneous computation and control)- Interfacing LCD Display – Keyboard Interfacing. Zero Crossing Detectors - PWM implementation -Generation of gating signals for Converters, Inverters and chopper circuit - Control circuit for AC/DC electric drives - Implementation of PID controller -  Solar Power Conditioning (MPPT). | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Myke Predko, “ Programming and customizing the PIC Microcontroller”, 3rd edition, Tata McGraw – Hill, 2008. 2. John B. Peatman, *Design with PIC Microcontrollers,* Pearson, 2003. 3. Richard H. Barnett, Larry O'Cull, Sarah Alison Cox, Embedded C Programming and the Microchip PIC, Volume 1, Thomson Delmar Leaning 4. Subrata Ghoshal, “Embedded Systems & Robots: Projects Using The 8051 Microcontroller”, Cengage Learning, 1st Edition, 2009. 5. Kenjo.T, "Power electronics for microprocessor Age", Clarendon press, Oxford, 1999 6. Bimal K Bose, "Power Electronics and Variable Frequency Drives: Technology and Applications", Wiley-IEEE Press, 1996 7. Gourab Sen Gupta, Subhas Chandra Mukhopadhyay, “Embedded Microcontroller Interfacing, Designing Integrated Projects”, Springer, 2010 8. *PIC16F87XA Data Sheet – DS39582B*, Microchip Technology Inc., 2003 9. PIC18F4580 Data Sheet – DS39637D, Microchip Technology Inc., 2009 10. dsPIC30F4011 Data Sheet – 70135C, Microchip Technology Inc., 2005 11. C. Maxfield, “The Design Warrior's Guide to FPGAs: Devices, Tools and flows”, Newnes, 2004 12. 8. D. Pellerin and S. Thibault, “Practical FPGA Programming in C”, Prentice-Hall, 2005. 13. W. Wolf, “FPGA Based System Design”, Prentice-Hall, 2004. 14. Brown, S. D. and Vranesic, Z. G., "Fundamentals of Digital Logic with VHDL Design", Second or Third Edition, McGraw-Hill 15. Wakerly J. F., Digital Design – Principles and Practices, 4/e,Pearson Education 16. Roth C. H., Digital System Design Using VHDL, Cengage Learning, 2008. 17. Steave Furber, "ARM system - on - chip architecture", Addison Wesley, 2000 18. Andrew N Sloss, Dominic Symes, Chris Wright, ARM System Developer`s Guide , Elseveir 19. Computers as Components-principles of Embedded computer system design, Wayne Wolf, Elseveir | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 7143** | | **Electrical Energy Conservation and Management** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES: To emphasize the energy management on various electrical equipments and metering.  * To study the concepts behind the economic analysis and load management.  COURSE OUTCOMES: Upon completion of this course , students will be able to   * Apply energy management schemes in electrical systems * Perform economic analysis and load management | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Electrical Energy and safety audit :** Overview of Electricity Act – Energy conservation act - Electrical energy audit – tools for electrical energy audit - billing elements - tariff system, energy and demand charge, electrical demand and load factor improvement, power factor correction, power demand control, demand shifting – Electrical Safety Auditing. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Electric motors:** Motors efficiency, idle running - motor selection – factors affecting motor performance, efficiency at low load – high efficiency motors - reduce speed/variable drives, load reduction - high-starting torque, rewound motors, motor generator sets, energy efficiency in transformers - Case studies. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Electrical energy conservation in driven equipments:** Input electrical energy requirements in pumps – fans and compressors – load factor estimation in the equipments – different types of VFD, energy conservation potential – electrical energy conservation in refrigeration and A/C system, operation and maintenance practices for electrical energy conservation case studies. | | | | 8 |
| **IV** | **Electrical Energy conservation in industrial lighting and demand management:**  Choice of lighting - energy saving - control of lighting - lighting standards – light meter audit - methods to reduce costs – summary of different lighting technologies – Case Studies.  **Energy efficiency and demand management:** Basic concepts – Co-generation – importance of demand side management – virtues of DSM – efficiency gains - estimation of energy efficiency potential, cost effectiveness, payback period, barriers for energy efficiency and DSM – Case Studies. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Openshaw Taylor E., “Utilisation of Electric Energy”, Orient Longman Ltd, 2003 2. Donald R. Wulfingoff, “Energy Efficiency Manual”, Energy Institute Press, 1999. 3. Tripathy S.C., “Electrical Energy Utilization and Conservation”, TMH, 1991. 4. Cyril G. Veinott, Joseph E. Martin, “Fractional & Sub Fractional HP Electric Motor”, McGraw Hill, 1987. 5. Abhay Jain, “How to Achieve Energy Conservation”, Electrical India, Feb’04, pp.48-53. 6. Ashok Bajpai, “Key Role of Energy Accounting and Audit in Power System”, Electrical India, Apr’04, pp.38-47. 7. Sasi.K.K. & Isha.T.B., “Energy Conservation in Industrial motors”, Electrical India, Apr’04, pp.48-51. 8. Sreejith.P.G., “Electrical Safety Auditing”, Electrical India, May’04, pp.38-46. 9. Sreejith.P.G., “Electrical Safety Auditing”, Electrical India, Jun’04, pp.38-45. 10. Thokal.S.K., “Electrical Energy Conservation by Improvement of Power factor”, Electrical India, Jul’04,pp.38-41. 11. Dr.Omprakash G. Kulkarni, “Load End Energy Management”, Electrical India –December Annual Issue, 2004.pp.58-67. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 7145** | | **Microcontroller and Real Time systems** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES: To impart the knowledge about 8051 microcontrollers, PIC 16F877 and DSP programming and interfacing.COURSE OUTCOMES: Upon completion of this course students will be able to design and implement the real time systems and process. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | 8051 microcontroller - Assembly Language programming and C Programming- Instruction set – Interrupts - Timers – Memory- I/O ports – Serial Communication - Interfacing –Key board, LED display, External memory, ADC, DAC, LCD, RTC – Typical applications- DC motor speed control, speed measurement, Temperature control, Stepper motor control, PID control. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | Introduction to real time systems - interrupt driven systems-context switching-scheduling - round robin – preemptive - rate monotonic - Foreground and Background systems - Intertask communication - Buffering data – Mailboxes - Critical regions – Semaphores – Deadlock - Process stack management - Dynamic allocation - Response time calculation - Interrupt latency. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | RISC concepts - PIC processors - overview-16F877 - Architecture – Elementary Assembly Language Programming - Interrupts – Timers – Memory – I/O ports – SPI – I2C bus - A/D converter - USART- PWM – Interfacing. Introduction to FPGA Devices | | | | 8 |
| **IV** | Introduction to DSP architecture- computational building blocks - Address generation unit - Program control and sequencing - Speed issues - Harvard Architecture, Parallelism, Pipelining. TMS 320F2407 - Architecture- Addressing modes - I/O functionality, Interrupts, ADC, PWM, Event managers- Elementary Assembly Language Programming - Typical applications - buck boost converter, stepper motor control - Software and Hardware Development Tools. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Mazidi and Mazidi., Embedded system design using 8051 Microcontroller, Pearson- 2005 2. Ajay V.DeshMukh , Microcontrollers -Theory and Applications , TMH-2005 3. Phillip A. Laplante, Real Time Systems design and Analysis, PHI-2005 4. Daniel W Lewis, Fundamentals of Embedded software, Pearson-2002 5. Sen M Kuo, Woon .Seng. Gan, Digital signal Processors-Architecture, implementation and applications, Pearson, 2005 6. H.A. Toliyat, S.Campbell, DSP based Electro Mechanical Motion Control, CRC Press-2004 7. Avtar Singh and S. Srinivasan, Digital Signal Processing, Thomson- Brooks - 2004 8. Phil Lapsley, Bler, Sholam, E.A.Lee , DSP Processor fundamentals, IEEE Press,1997 9. Wayne Wolf, FPGA based System Design, Pearson - 2004 10. Scott Hauck, The Roles of FPGAs in Reprogrammable Systems, Proceedings of the IEEE, Vol. 86, No. 4, pp. 615-639, April, 1998. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 7151** | | **Advanced Power Electronic Systems** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES: To provide an in depth knowledge about the operation and analysis of modern power converter circuits.COURSE OUTCOMES: The students will be able to   * Acquire knowledge about the PWM techniques used in inverter circuits * Design and analyze modern power converter circuits | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **PWM Strategies for Inverters:**Modulation of one inverter phase leg- Fundamental concepts of PWM- Naturally sampled PWM-Regular sampled PWM. Modulation of single and three phase voltage source inverters-introduction only, Space Vector Modulation-comparison of SVM and regular sampled PWM, Over modulation of an Inverter- Naturally sampled over modulation of one leg of an inverter. Space vector PWM for multilevel inverters. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **SMPS Topologies**- Transformer models- Basic Operation-Waveforms-modes of operation – Output voltage ripple, Push-Pull and Forward Converter Topologies-Basic operation-Waveforms-Voltage Mode Control. Half and Full Bridge Converters - Basic Operation and Waveforms, Fly back Converter, Continuous and Discontinuous mode operation, Waveforms. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | Classification of Resonant Converters, Basic Resonant Circuit Concepts, Load Resonant Converter, Resonant Switch Converter, Zero Voltage Switching - Zero current switching – ZVS Clamped Voltage Topologies, Resonant dc-link inverters | | | | 8 |
| **IV** | **PWM Rectifiers and Matrix Converters:**  Single phase and three phase PWM Rectifiers - Basic topologies - Control principles. Introduction to Matrix Converters-Matrix converter switches and circuit- control strategies-Venturini control method. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Daniel W. Hart, Power Electronics, McGrawHill, 2011 2. Ned Mohan, Undeland, Robbins, Power Electronics,3rd edition, John Wiley, 2003 3. D. Grahame Holmes, Thomas A Lipo, Pulse Width Modulation for Power converters- Principles and Practice, John Wiley and sons,2003. 4. K.R.Varmah, Chikku Abraham, Power Electronics, 1st edition, Elsevier, 2014 5. B K Bose, Modern Power Electronics and AC Drives, Pearson Education, 2002. 6. William Shepherd, Li Zhang, Power Converter Circuits, Marcel Decker, 2004 | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 7153** | | **Advanced Controllers for Embedded systems** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To expose the fundamentals of PIC 18F4580 controller based system design * To introduce advanced dsPIC30F4011 motor control and power conversion controller for developing embedded system. * To familiarize FPGA based system design for power electronic devices * To introduce ARM processors for the development of embedded systems  COURSE OUTCOMES:  * The student will able to develop embedded systems using advanced microcontrollers. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **PIC 18F4580**  PIC18F4580 - Architecture – Memory Organisation Timers– I/O ports – Interrupts – CCP/ECCP – SPI – I2C bus - A/D converter – USART, PWM Elementary Assembly Language Programming – Development Support. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **dsPIC30F4011 - Motor Control and Power Conversion:**  dsPIC30F4011 – Architecture - MCU and DSP features - Hardware DMA - Interrupt Controller - Digital I/O On-chip Flash, Data EE and RAM - Timers/Capture/Compare/PWM - Communication Modules Motor Control Peripherals - Analog-to-Digital Converters - MPLAB Integrated Development Environment (IDE). | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **FPGA Based System Design using VHDL**  Overview of Hardware Description Languages – VHDL Introduction, Behavioural, Data flow, Structural Models - Simulation Cycles - Test bench; Design at different levels with special emphasis on FPGA and PLD, Design of sequential and Combinatorial circuits, Xilinx 4000 Series FPGAs and Altera Flex 10K series CPLDs. | | | | 8 |
| **IV** | **High Performance RISC Architecture**  Overview of ARM architecture – RISC concepts - ARM organization and implementation, ARM instruction set - The thumb instruction set - Basic ARM Assembly language program - ARM CPU cores. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Muhammad Ali Mazidi, JaniceGillispie Mazidi, Rolin D. McKinlay, PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18, Prentice Hall of India, New Delhi, 2007. 2. C. Maxfield, “The Design Warrior's Guide to FPGAs: Devices, Tools and flows”, Newnes, 2004 3. W. Wolf, “FPGA Based System Design”, Prentice-Hall, 2004. 4. Wakerly J. F., *Digital Design – Principles and Practices*, **4/e**,Pearson Education 5. Peatman, Design with PIC Microcontrollers, Pearson, 2003 6. PIC18F4580 Data Sheet – DS39637D, Microchip Technology Inc., 2009 7. dsPIC30F4011 Data Sheet – 70135C, Microchip Technology Inc., 2005 8. Lucio Di Jasio, T Wilmshurst, Dogan Ibrahim, John Morton, Martin P. Bates, Jack Smith, D W Smith, C Hellebuyck, PIC Microcontrollers: Know It All: Know It All, [Newnes](https://books.google.co.in/url?id=s8DBXs-jIRQC&pg=PP1&q=http://www.elsevierdirect.com/newnes&clientid=ca-print-elsevier-newnes&linkid=1&usg=AFQjCNF8BsKmLSkXPSruIB0LsZhzhhoSZg&source=gbs_pub_info_r) - 2008 | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05EE 7155** | | **Special Electrical Machines & Drives** | 2-1-0-3 | 2015 | |
| COURSE OBJECTIVES:   * To understand construction, principle of operation and performance of special electric machines.  COURSE OUTCOMES: Students will be   * Able to understand construction, principle of operation, control and performance of stepper motors. * Able to understand construction, principle of operation, control and performance of switched reluctance motors. * Able to understand construction, principle of operation, control and performance of permanent magnet brushless D.C. motors. * Able to understand construction, principle of operation and performance of permanent magnet synchronous motors. | | | | | |
| MODULE | COURSE CONTENT (34 hrs) | | | | HRS |
| **I** | **Stepper Motors:** Constructional features, principle of operation, modes of excitation, single phase stepping motors, torque production in variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, microprocessor based controller. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Switched Reluctance Motors**: Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control. Microprocessor based controller. Sensor less control..Synchronous Reluctance Motors-Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – Phasor diagram, motor characteristics. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Permanent Magnet Brushless DC Motors:** Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller. Sensor less control. | | | | 8 |
| **IV** | **Permanent Magnet Synchronous Motors :** Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes. Sensor less control. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Miller T J E, Switched Reluctance Motor and Their Control, Clarendon Press, Oxford, 1993. 2. Miller T J E, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford,1989. 3. Bose B K, Modern Power Electronics & AC drives, Pearson, 2002. 4. Athani V.V. “stepper motors – Fundamentals, Applications &Design” New Age International 5. Kenjo T, Sugawara A, Stepping Motors and Their Microprocessor Control, Clarendon   Press, Oxford, 1994.  6. Kenjo T, Power Electronics for the Microprocessor Age, Oxford University Press, 1990.  Ali Emadi (Ed), Handbook. | | | | | |

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05EE 7167** | **Seminar II** | 0-0-2-2 | 2015 |
| Each student should present a seminar on any topic related to the core / elective courses offered in the first semester of the M. Tech. Programme. The selected topic should be based on the papers published in reputed international journals preferably IEEE/ACM. The selected paper should be approved by the Programme Co-ordinator / Faculty member before presentation. The students should undertake a detailed study on the topic and submit a report at the end of the semester. Marks will be awarded based on the topic, presentation, participation in the seminar and the report. | | | |

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05EE 7187** | **PROJECT PHASE I** | 0-0-8-6 | 2015 |
| In Project Phase-I, the students are expected to select an emerging research area in Power electronics/Power systems or related fields, after conducting a detailed literature survey, they should compare and analyze research work done and review recent developments in the area and prepare an initial design of the work to be carried out as Master’s Thesis. It is expected that the students should refer National and International Journals and conference proceedings while selecting a topic for their thesis. He/She should select a recent topic from a reputed International Journal, preferably IEEE/ACM. Emphasis should be given for introduction to the topic, literature survey, and scope of the proposed work along with some preliminary work carried out on the thesis topic.  Students should submit a copy of Phase-I thesis report covering the content discussed above and highlighting the features of work to be carried out in Phase-II of the thesis.  The candidate should present the current status of the thesis work and the assessment will be made on the basis of the work and the presentation, by a panel of examiners. This panel can be a committee headed by the head of the department with two other faculty members in the area of the project, of which one shall be the project supervisor .If the project is done outside the college, the external supervisor associated with the student will also be a member of the committee. The examiners should give their suggestions in writing to the students so that it should be incorporated in the Phase–II of the thesis. | | | |

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05EE 7188** | **PROJECT PHASE II** | 0-0-21-12 | 2015 |
| In the fourth semester, the student has to continue the thesis work and after successfully finishing the work, he / she have to submit a detailed thesis report. The work carried out should lead to a publication in a National / International Conference or Journal. The papers received acceptance before the M.Tech evaluation will carry specific weightage.  Final evaluation of the project will be taken up only on completion of the project. This shall be done by a committee constituted for the purpose by the principal of the college. The concerned head of the department shall be the chairman of this committee. It shall have two senior faculty members from the same department, project supervisor and external supervisor, if any, of the student and an external expert either from an academic /R&D organization or from industry as members. | | | |