

GOVERNMENT COLLEGE OF ENGINEERING, BARGUR**Regulation – 2017****AUTONOMOUS****Curriculum for Full Time – M.E. –Power Electronics and Drives**

From the Academic Year 2017-2018 onwards

SEMESTER I

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | L | T | P | C |
|-------------------|-------------|--|----------|-----------|----------|----------|-----------|
| THEORY | | | | | | | |
| 1. | 17PEFC01 | Applied Mathematics for Electrical Engineers | FC | 3 | 2 | 0 | 4 |
| 2. | 17PEPC02 | Power Semiconductor Devices | PC | 3 | 0 | 0 | 3 |
| 3. | 17PEPC03 | Analysis of Electrical Machines | PC | 3 | 0 | 0 | 3 |
| 4. | 17PEPC04 | Analysis and Design of Converters | PC | 3 | 0 | 0 | 3 |
| 5. | 17PEPC05 | Analysis and Design of Inverters | PC | 3 | 0 | 0 | 3 |
| 6. | | Professional Elective I | PE | 3 | 0 | 0 | 3 |
| PRACTICALS | | | | | | | |
| 7. | 17PEPC06 | Advanced Power Electronics Laboratory Circuits Lab | PC | 0 | 0 | 4 | 2 |
| TOTAL | | | | 18 | 2 | 4 | 21 |

SEMESTER II

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | L | T | P | C |
|-------------------|-------------|------------------------------|----------|-----------|----------|----------|-----------|
| THEORY | | | | | | | |
| 1 | 17PEPC07 | Solid State DC Drives | PC | 3 | 0 | 0 | 3 |
| 2. | 17PEPC08 | Solid State AC Drives | PC | 3 | 0 | 0 | 3 |
| 3. | 17PEPC09 | Special Electrical Machines | PC | 3 | 0 | 0 | 3 |
| 4. | 17PEPC10 | Power Quality | PC | 3 | 0 | 0 | 3 |
| 5. | | Professional Elective II | PE | 3 | 0 | 0 | 3 |
| 6. | | Professional Elective III | PE | 3 | 0 | 0 | 3 |
| PRACTICALS | | | | | | | |
| 7. | 17PEPC11 | Electrical Drives Laboratory | PC | 0 | 0 | 4 | 2 |
| TOTAL | | | | 18 | 0 | 4 | 20 |

SEMESTER III

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | L | T | P | C |
|-------------------|-------------|--------------------------|----------|----------|----------|-----------|-----------|
| THEORY | | | | | | | |
| 1 | | Professional Elective IV | PE | 3 | 0 | 0 | 3 |
| 2 | | Professional Elective V | PE | 3 | 0 | 0 | 3 |
| 3 | | Professional Elective VI | PE | 3 | 0 | 0 | 3 |
| PRACTICALS | | | | | | | |
| 4 | 17PEEE12 | Project Work Phase I | EEC | 0 | 0 | 12 | 6 |
| TOTAL | | | | 9 | 0 | 12 | 15 |

SEMESTER IV

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | L | T | P | C |
|-------------------|-------------|-----------------------|----------|----------|----------|-----------|-----------|
| PRACTICALS | | | | | | | |
| 1. | 17PEEE13 | Project Work Phase II | EEC | 0 | 0 | 24 | 12 |
| TOTAL | | | | 0 | 0 | 24 | 12 |

TOTAL NO. OF CREDITS: 68

CREDIT SUMMARY

| Sl. No | Subject Area | Credits per Semester | | | | Credits Total | % of Total Credits | Total no. of Subjects |
|--------|--------------|----------------------|----|-----|----|---------------|--------------------|-----------------------|
| | | I | II | III | IV | | | |
| 1 | FC | 4 | | | | 4 | 6 | 1 |
| 2 | PC | 14 | 14 | 0 | | 28 | 42 | 10 |
| 3 | PE | 3 | 6 | 9 | | 18 | 26 | 6 |
| 4 | EEC | | | 6 | 12 | 18 | 26 | 2 |
| | Total | 21 | 20 | 15 | 12 | 68 | 100 | 19 |

PROFESSIONAL ELECTIVES (PE)

| S.No | COURSE CODE | COURSE TITLE | CATEGORY | L | T | P | C |
|------|-------------|---|----------|---|---|---|---|
| 1. | 17PEPE01 | System Theory | PE | 3 | 0 | 0 | 3 |
| 2. | 17PEPE02 | Electromagnetic Field Computation and Modelling | PE | 3 | 0 | 0 | 3 |
| 3. | 17PEPE03 | Control System Design for Power Electronics | PE | 3 | 0 | 0 | 3 |
| 4. | 17PEPE04 | Analog and Digital Controllers | PE | 3 | 0 | 0 | 3 |
| 5. | 17PEPE05 | Flexible AC Transmission Systems | PE | 3 | 0 | 0 | 3 |
| 6. | 17PEPE06 | Modern Rectifiers and Resonant Converters | PE | 3 | 0 | 0 | 3 |
| 7. | 17PEPE07 | Electromagnetic Interference and Compatibility | PE | 3 | 0 | 0 | 3 |
| 8. | 17PEPE08 | MEMS Technology | PE | 3 | 0 | 0 | 3 |
| 9. | 17PEPE09 | Distributed Generation and Micro grid | PE | 3 | 0 | 0 | 3 |
| 10. | 17PEPE10 | Soft Computing Techniques | PE | 3 | 0 | 0 | 3 |
| 11. | 17PEPE11 | High Voltage Direct Current Transmission | PE | 3 | 0 | 0 | 3 |
| 12. | 17PEPE12 | Solar and Energy Storage Systems | PE | 3 | 0 | 0 | 3 |
| 13. | 17PEPE13 | Wind Energy Conversion Systems | PE | 3 | 0 | 0 | 3 |
| 14. | 17PEPE14 | Energy Management and Auditing | PE | 3 | 0 | 0 | 3 |
| 15. | 17PEPE15 | Electric Vehicles and Power Management | PE | 3 | 0 | 0 | 3 |
| 16. | 17PEPE16 | NonLinear Dynamics for Power | PE | 3 | 0 | 0 | 3 |
| 17. | 17PEPE17 | Smart Grid | PE | 3 | 0 | 0 | 3 |
| 18. | 17PEPE18 | Power Electronics for Renewable Energy Systems | PE | 3 | 0 | 0 | 3 |
| 19. | 17PEPE19 | Robotics and Control | PE | 3 | 0 | 0 | 3 |
| 20. | 17PEPE20 | Non Linear Control | PE | 3 | 0 | 0 | 3 |

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| 17PEFC01 | APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS | L | T | P | C |
| | | 3 | 2 | 0 | 4 |
| OBJECTIVES: | | | | | |
| • | To acquire knowledge of solving integrations involving derivatives, problems linked to matrix theory. | | | | |
| • | To familiarize to solve linear and nonlinear programming problems by various methods | | | | |
| • | To acquire knowledge of solving probability and random variables. | | | | |
| • | To acquire knowledge of solving integral equations | | | | |
| • | To acquire knowledge of formation of Fourier series | | | | |
| UNIT I | MATRIX THEORY | 12 | | | |
| Cholesky decomposition-Generalized Eigenvectors-Canonical basis –QR Factorization-Least squares method- Singular value decomposition | | | | | |
| UNIT II | CALCULUS OF VARIATIONS | 12 | | | |
| Concept of variation and its properties–Euler’s equation–Function all dependant on first and higher order derivatives–Functionals dependant on functions of several independent variables – Variational problems with moving boundaries–Isoperimetric problems –Direct methods: Ritz and Kantorovich methods. | | | | | |
| UNIT III | PROBABILITY AND RANDOM VARIABLES | 12 | | | |
| Probability– Axioms of probability –Conditional probability–Baye’s theorem-Random variables – Probability function–Moments–Moment generating functions and their properties–Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a random variable. | | | | | |
| UNIT IV | LINEAR PROGRAMMING | 12 | | | |
| Formulation–Graphical solution–Simplex method–Big method-Two phase method-Transportation and Assignment models. | | | | | |
| UNIT V | FOURIER SERIES | 12 | | | |
| Fourier trigonometric series: Periodic function as power signals–Convergence of series–Even and odd function :Cosine and sine series–Non periodic function :Extension to other intervals- Power signals : Exponential Fourier series – Parseval’s theorem and power spectrum – Eigen value problem sand orthogonal functions– Regular Sturm-Liouville systems–Generalized Fourier series.. | | | | | |
| | | | | | TOTAL :60 PERIODS |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | |
| • | Gain the skill of solving integrals with the derivatives and problems on generalized Eigen vectors, pseudo inverse and QR algorithm. | | | | |
| • | Perform solutions of integrals involving derivatives and formation of Fourier series | | | | |
| • | Compute probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable. | | | | |
| • | Understand the solutions of linear programming problems | | | | |

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| • | Fourier series analysis and its uses in representing the power signals. |
| TEXT BOOKS: | |
| 1. | Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt. Ltd., New Delhi, 2005. |
| 2. | Bronson, R. "Matrix Operation", Schaum's outline series, 2 nd Edition, McGraw Hill, 2011. |
| 3. | Elsolc, L. D. "Calculus of Variations", Dover Publications, New York, 2007. |
| REFERENCES: | |
| 1. | Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8 th Edition, 2015. |
| 2. | O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003. |
| 3. | Taha, H.A., "Operations Research, An Introduction", 9 th Edition, Pearson education, New Delhi, 2016. |
| 4. | Gupta, A.S., "Calculus of Variation and Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 1997 |
| 5. | Veerarajan, T — Higher engineering mathematics , Tata McGraw Hill publishing company Ltd., New Delhi 2015. |

| 17PEPC02 | POWER SEMICONDUCTOR DEVICES | L | T | P | C |
|---|--|----------|----------|----------|--------------------------|
| OBJECTIVES: | | 3 | 0 | 0 | 3 |
| • | To improve power semiconductor device structures for adjustable speed motor control applications. | | | | |
| • | To understand the static and dynamic characteristics of current controlled power semiconductor devices | | | | |
| • | To understand the static and dynamic characteristics of voltage controlled power | | | | |
| • | To enable the students for the selection of devices for different power electronics | | | | |
| • | To understand the control and firing circuit for different devices | | | | |
| UNIT I | INTRODUCTION | | | | 09 |
| 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. | | | | | |
| UNIT II | CURRENTCONTROLLED DEVICES | | | | 09 |
| BJT’s– Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; Thyristors–Physical and electrical principle under lying operating mode, Two transistor analogy –concept of latching; 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- Basics of GTO, MCT,FCT,RCT | | | | | |
| UNIT III | VOLTAGE CONTROLLED DEVICES | | | | 09 |
| Power MOSFETs and IGBTs–Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs- and IGCT. New semiconductor materials for devices–Intelligent power modules-Integrated gate commutated thyristor (IGCT)-GAN, SiC, IEGT-Comparison of all power devices. | | | | | |
| UNIT IV | FIRINGAND PROTECTING CIRCUITS | | | | 09 |
| Necessity of isolation , pulse transformer , opto coupler–Gate drives circuit :SCR,MOSFET, IGBTs and base driving for power BJT.-Overvoltage, over current and gate protections; Design of snubbers. | | | | | |
| UNIT V | THERMALPROTECTION | | | | 09 |
| 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-switching loss calculation for power device. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Determine the suitable device for the application. | | | | |
| • | Design of semiconductor device and its parameters. | | | | |
| • | Design of protection circuits. | | | | |
| • | Design of firing and control circuit. | | | | |
| • | Determine the reliability of the system. | | | | |

| TEXT BOOKS: | |
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| 1. | B.W.Williams ‘Power Electronics Circuit Devices and Applications’.. |
| 2. | Rashid M.H.,"Power Electronics Circuits ,Devices and Applications",Prentice Hall India, Third Edition, New Delhi,2004 |
| 3. | MD SinghandK.B Khanchandani,“PowerElectronics”,TataMcGrawHill,2001. |
| REFERENCES: | |
| 1. | <i>Mohan, Undeland and Robins, “Power Electronics–Concepts, applications and Design John Wiley and Sons, Singapore, 2000.</i> |
| 2. | <i>Joseph Vithayathil, Power Electronics:Principles and Applications, Delhi, Tata McGraw-Hill,2010.</i> |
| 3. | <i>Donald A.Neamen, —Semiconductor Physics and Devices, Tata McGraw Hill, New Delhi, Fourth Edition, 2012.</i> |
| 4. | <i>Kassakian,J.G.et.al., Principles of Power Electronics, Pearson Education India., 2012.</i> |

| 17PEPC03 | ANALYSIS OF ELECTRICAL MACHINES | L | T | P | C |
|---|--|-----------|----------|----------|--------------------------|
| OBJECTIVES: | | 3 | 0 | 0 | 3 |
| • | To provide knowledge about the fundamentals of magnetic circuits, energy, force and | | | | |
| • | To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer. | | | | |
| • | To provide the knowledge of theory of transformation of three phase variables to two phase variables. | | | | |
| • | To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation. | | | | |
| • | To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation. | | | | |
| UNIT I | PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION | 09 | | | |
| Magnetic circuits, permanent magnet, stored magnetic energy, co-energy – force and torque in singly and doubly excited systems–machine winding sand air gap mmf-winding inductances and voltage equations. | | | | | |
| UNIT II | DC MACHINES | 09 | | | |
| Elementary DC machine and analysis of steady state operation-Voltage and torque equations–dynamic characteristics of permanent magnet and shunt d.c. motors– Time domain block diagrams-solution of dynamic characteristic by Laplace transformation–digital computer simulation of permanent magnet and shunt D.C. machines. | | | | | |
| UNIT III | REFERENCE FRAME THEORY | 09 | | | |
| Historical back ground–phase transformation and commutator transformation–transformation of variables from stationary to arbitrary reference frame-variables observed from several frames of reference. | | | | | |
| UNIT IV | INDUCTION MACHINES | 09 | | | |
| Three phase induction machine, equivalent circuit and analysis of steady state operation–free acceleration characteristics–voltage and torque equations in machine variable sand arbitrary reference frame variables–analysis of dynamic performance for load torque variations. | | | | | |
| UNIT V | SYNCHRONOUS MACHINES | 09 | | | |
| Three phase synchronous machine and analysis of steady state operation –voltage and torque equations in machine variables and rotor reference frame variables (Park’s equations) – analysis of dynamic performance for load torque variations– Generalized theory of rotating electrical machine and Krons primitive machine. | | | | | |
| | | | | | TOTAL :45 PERIODS |

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| OUTCOMES: | After completion of this course, the student will be able to: |
| • | Understand the various electrical parameters in mathematical form. |
| • | Understand the different types of reference frame theories and transformation relationships. |
| • | Find the electrical machine equivalent circuit parameters. |
| • | Model of electrical machines. |
| TEXT BOOKS: | |
| 1. | Paul C. Krause, Oleg Waszczuk, Scott S. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010. |
| 2. | P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008. |
| REFERENCES: | |
| 1. | <i>A. E. Fitzgerald, Charles Kingsley, Jr, and Stephan D. Umans, "Electric Machinery", Tata McGraw Hill, 5th Edition, 1992</i> |
| 2. | <i>R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001</i> |

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|--|--|---|----------|----------|--------------------------|
| 17PEPC04 | ANALYSIS AND DESIGN OF CONVERTERS | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| <ul style="list-style-type: none"> To determine the operation and characteristics of controlled rectifiers. To apply switching techniques and basic topologies of DC-DC switching regulators. To introduce the design of power converter components. To provide an in depth knowledge about resonant converters. To comprehend the concepts of AC-AC power converters and their applications. | | | | | |
| UNIT I | SINGLE PHASE & THREE PHASE CONVERTERS | 09 | | | |
| Principle of phase controlled converter operation –single-phase full converter and semi-converter (RL,RLE load) –single phase and three phase dual converter– Three phase operation full converter and semi-converter(R ,RL, RLE load)–reactive power–power factor improvement techniques–PWM rectifiers. | | | | | |
| UNIT II | DC-DC CONVERTERS | 09 | | | |
| Limitations of linear power supplies ,switched mode power conversion , Non-isolated DC- DC converters : operation and analysis of Buck, Boost , Buck – Boost , Cuk & SEPIC–under continuous and discontinuous operation– Isolated converters : basic operation of Fly back, Forward and Push-pull topologies, Half and Full Bridge Converters. | | | | | |
| UNIT III | DESIGN OF POWER CONVERTER COMPONENTS | 09 | | | |
| Introduction to magnetic materials-hard and soft magnetic materials–types of cores , copper windings – Design of transformer –Inductor design equations –Examples of inductor design for buck/fly back converter-selection of output filter capacitors–selection of ratings for devices–input filter design | | | | | |
| UNIT IV | RESONANT DC-DC CONVERTERS | 09 | | | |
| Switching loss , hard switching , and basic principles of soft switching- classification of resonant converters-load resonant converters –series and parallel–resonant switch converters–operation and analysis of ZVS , ZCS converters comparison of ZCS/ZVS- Introduction to ZVT/ZCT PWM converters, Phase shift Full Bridge converters. | | | | | |
| UNIT V | AC-AC CONVERTERS | 09 | | | |
| Principle of on-off and phase angle control – single phase ac voltage controller– analysis with R & RL load–Three phase ac voltage controller–principle of operation of cyclo converter –single phase and three phase cyclo converters – Matrix converters. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | |
| | • | Demonstrate the basic concept of steady state operation of single and three phase AC-DC converters. | | | |
| | • | Analyze the operation of various DC-DC converters. | | | |
| | • | Design of power converter components. | | | |
| | • | Analyze the operation of AC voltage controllers.. | | | |
| | • | Analyze the operation of Cyclo converter. | | | |
| TEXT BOOKS: | | | | | |
| 1. | Ned Mo h a n , T . M Undeland a n d W.P Robbin, “Power Electronics: converters, Application and design” JohnWileyandsons.WileyIndiaedition,2006. | | | | |

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| 2. | RashidM.H.,“PowerElectronics Circuits,DevicesandApplications”, PrenticeHall India, ThirdEdition, New Delhi,2004. |
| 3. | P.C.Sen,“ModernPowerElectronics”,WheelerPublishingCo,FirstEdition, NewDelhi,1998. |
| REFERENCES: | |
| 1. | <i>P.S.Bimbra, “Power Electronics”, Khanna Publishers, EleventhEdition,2003</i> |
| 2. | <i>SimonAng, Alejandro Oliva, “Power-Switching Converters, Second Edition, CRC Press,Taylor& FrancisGroup, 2010.</i> |
| 3. | <i>V.Ramanarayanan, “Course material on Switched mode power conversion”,2007.</i> |
| 4. | <i>AlexVan den Bossche and Vencislav Cekov Valchev,“Inductors and Transformers for Power Electronics”, CRC Press, Taylor & Francis Group, 2005.</i> |
| 5. | <i>W. G. Hurley andW. H.Wolfle, “Transformers and Inductors for Power Electronics Theory, Design and Applications”,2013JohnWiley&SonsLtd.</i> |
| 6. | <i>Marian.K.Kazimierczuk and Dariusz Czarkowski, “Resonant Power Converters”, JohnWiley & Sonslimited, 2011</i> |

| 17PEPC05 | ANALYSIS AND DESIGN OF INVERTERS | L | T | P | C |
|---|---|-----------|----------|----------|--------------------------|
| OBJECTIVES: | | 3 | 0 | 0 | 3 |
| • | To Provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation. | | | | |
| • | To equip with required skills to derive the criteria for the design of inverters for | | | | |
| • | To analyse and comprehend the various operating modes of different configurations of inverters. | | | | |
| • | To design different single phase and three phase inverters. | | | | |
| • | To impart knowledge on multilevel inverters and modulation techniques | | | | |
| UNIT I | SINGLE PHASE INVERTERS | 09 | | | |
| Introduction to self-commutated switches: MOSFET and IGBT-Principle of operation of half and full bridge inverters-Performance parameters-Voltage control of single phase inverters using various PWM techniques –various harmonic elimination techniques-forced commutated thyristor inverters. | | | | | |
| UNIT II | THREE PHASE VOLTAGE SOURCE INVERTERS | 09 | | | |
| 180 degree and 120 degree conduction mode inverters with star and delta connected loads-voltage control of three phase inverters : single , multi pulse ,sinusoidal ,space vector modulation techniques. | | | | | |
| UNIT III | CURRENT SOURCE INVERTERS | 09 | | | |
| Operation of six-step thyristor inverter- inverter operation modes- load – commutated inverters- Auto sequential current source inverter(ASCI)- current pulsations- comparison of current source inverter and voltage source inverters-PWM techniques for current source inverters, Grid-tied Inverters | | | | | |
| UNIT IV | MULTILEVEL & BOOST INVERTERS | 09 | | | |
| Multilevel concept-diode clamped- flying capacitor-cascade type multilevel inverters- Comparison of multilevel inverters-application of multilevel inverters-PWM techniques for MLI-Single phase & Three phase Impedance source inverters. | | | | | |
| UNIT V | RESONANT INVERTERS AND POWER CONDITIONERS | 09 | | | |
| Series and parallel resonant inverters-voltage control of resonant inverters-Class E resonant inverter-resonant DC-link inverters.-power line disturbances-power conditioners-UPS: offline UPS , Online UPS-Variety types. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Suggest and Demonstrate the application of single phase inverters | | | | |
| • | Suggest and Demonstrate the application of three phase inverters | | | | |
| • | Analyze the operation of CSI inverter | | | | |
| • | Evaluate the performance of multilevel inverter. | | | | |
| • | Design and analyze the resonant inverter. | | | | |
| TEXT BOOKS: | | | | | |
| 1. | Rashid M.H.,“Power Electronics Circuits, Devices and Applications”, Prentice Hall India, Third Edition, NewDelhi,2004. | | | | |
| 2. | P.C.Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, NewDelhi,1998 | | | | |

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| 3. | P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition,2003 |
| REFERENCES: | |
| 1. | <i>Jai.P.Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002.</i> |
| 2. | <i>Bimal K.Bose "Modern Power Electronics and AC Drives", Pearson Education, Second Edition, 2003.</i> |
| 3. | <i>Ned Mohan,T.MUndelandandW.PRobbin, "Power Electronics:</i> |
| 4. | <i>PhilipT. krein, "Elements of Power Electronics" Oxford University Press -1998</i> |

| 17PEPC06 | ADVANCED POWER ELECTRONICS LABORATORY | | | L | T | P | C |
|--|---|--|--|---|---|---|---|
| | | | | 0 | 0 | 4 | 2 |
| OBJECTIVES: | | | | | | | |
| • | To provide an insight on the switching behaviours of power electronic switches | | | | | | |
| • | To make the students familiar with the digital tools used in generation of gate pulses for the power electronic switches | | | | | | |
| • | To make the students acquire knowledge on mathematical modeling of power electronic circuits and implementing the same using simulation tools | | | | | | |
| • | To facilitate the students to design and fabricate a power converter circuits at appreciable voltage/power levels | | | | | | |
| • | To develop skills on PCB design and fabrication among the students | | | | | | |
| <p>LIST OF EXPERIMENTS:</p> <ol style="list-style-type: none"> 1. Study of switching characteristics of Power electronics switches with and without Snubber (i)IGBT(ii)MOSFET 2. Modeling and system simulation of basic electric circuits using MATLAB-SIMULINK/SCILAB <ol style="list-style-type: none"> a) DC source fed resistive load and Resistive-inductive load b) DC source fed RLC load for different damping conditions c)DC source fed DC motor load 3. Modeling and System simulation of basic power electronic circuits using MATLAB-SIMULINK/SCILAB <ol style="list-style-type: none"> a) AC Source with Single Diode fed Resistive and Resistive- Inductive Load b) AC source with Single SCR fed Resistive and Resistive- Inductive Load 4. Modeling and System Simulation of SCR based full converter with different types of load using MATLAB-Simulink/SCILAB <ol style="list-style-type: none"> a) Full converter fed resistive load. b) Full converter fed Resistive- Back Emf (RE) load at different firing angles. c) Full Converter fed Resistive-Inductive Load at different firing angles. d) Full converter fed DC motor load at different firing angles. 5.Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB/SCILAB. <ol style="list-style-type: none"> a) Single phase square wave inverter. b) Three phase sine PWM inverter. c) Hybrid solar and wind based single phase power generation. d) Analysis of grid tied inverter. 6. Performance characteristics of multilevel inverter. | | | | | | | |

7. Performance evaluation of buck converter.
8. Performance evaluation of boost converter.
9. Performance evaluation of buck-boost converter.

TOTAL:60 PERIODS

OUTCOMES: After completion of this course, the student will be able to:

- Design, simulate and analyze various controlled rectifiers.
- Design, simulate and analyze various DC-DC converters.
- Design, simulate and analyze the single phase and three phase inverters
- Ability of the student to design and implement analog circuits for Power electroniccontrolapplications.

| 17PEPC07 | SOLID STATE DC DRIVES | | L | T | P | C |
|---|--|---|-----------|----------|----------|--------------------------|
| OBJECTIVES: | | | 3 | 0 | 0 | 3 |
| • | Summarize the concepts of conventional DC drives | | | | | |
| • | Study and analyze the operation of the converter fed DC drives, both qualitatively and quantitatively. | | | | | |
| • | Study and analyze the operation of the chopper fed DC drives, both qualitatively and quantitatively. | | | | | |
| • | Study and analyze the operation of closed loop control. | | | | | |
| • | Design of converters and develop intelligent controllers for DC drives | | | | | |
| UNIT I | DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS | | 09 | | | |
| DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation - Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating. | | | | | | |
| UNIT II | CONVERTER CONTROL | | 09 | | | |
| Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with free wheeling diode; Implementation of braking schemes; Drive employing dual converter. | | | | | | |
| UNIT III | CHOPPER CONTROL | | 09 | | | |
| Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control - Chopper based implementation of braking schemes; Multi-phase chopper; Related problems. | | | | | | |
| UNIT IV | CLOSED LOOP CONTROL | | 09 | | | |
| Modelling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Simulation of converter and chopper fed d.c drive. | | | | | | |
| UNIT V | DIGITAL CONTROL OF D.C DRIVE | | 09 | | | |
| Phase Locked Loop and micro-computer control of DC drives – Program flow chart for constant horse power and load disturbed operations; Speed detection and current sensing circuits. | | | | | | |
| | | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | | |
| • | Explain the basic concept of steady state operation and transient dynamics of a motor load system | | | | | |
| • | Design and analyze the operation of the various controlled rectifier fed DC drives. | | | | | |
| • | Design and analyze the operation of the various chopper fed DC drives | | | | | |
| • | Explain the concept of closed loop control | | | | | |
| • | Design and analyze of digital control of DC drives. | | | | | |

| TEXT BOOKS: | |
|--------------------|---|
| 1. | Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersey, 1989. |
| 2. | R.Krishnan, "Electric Motor Drives – Modelling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2010. |
| 3. | GopalK. Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, Second Edition ,2009 |
| REFERENCES: | |
| 1. | <i>Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.</i> |
| 2. | <i>P.C Sen "Thyristor DC Drives", John Wiley and sons, New York, 1981</i> |

| 17PEPC08 | SOLID STATE AC DRIVES | | L | T | P | C |
|---|---|---|---|---|---|--------------------------|
| | | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | | |
| • | To familiarize the students on the operation of VSI fed induction motor drives. | | | | | |
| • | To familiarize the students on the operation of CSI fed induction motor drives. | | | | | |
| • | To understand the rotor controlled induction motor drives. | | | | | |
| • | To understand the field oriented control of induction machines | | | | | |
| • | To impart knowledge on the control of synchronous motor drives | | | | | |
| UNIT I | INTRODUCTION TO INDUCTION MOTORS | | | | | 09 |
| Steady state performance equations – Rotating magnetic field – torque production, Equivalent circuit– Variable voltage, constant frequency operation – Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation, different braking methods. | | | | | | |
| UNIT II | VSI AND CSI FED INDUCTION MOTOR CONTROL | | | | | 09 |
| AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives comparison. | | | | | | |
| UNIT III | ROTOR CONTROLLED INDUCTION MOTOR DRIVES | | | | | 09 |
| Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives - power factor considerations – modified Kramer drives. | | | | | | |
| UNIT IV | FIELD ORIENTED CONTROL | | | | | 09 |
| Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy. | | | | | | |
| UNIT V | SYNCHRONOUS MOTOR DRIVES | | | | | 09 |
| Wound field cylindrical rotor motor – Equivalent circuits – performance equations of operation from a voltage source – Power factor control and V curves – starting and braking, self control – Load commutated Synchronous motor drives - Brush and Brushless excitation . | | | | | | |
| | | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | | |
| • | Be familiar with the concept of various operating regions of the induction motor drives | | | | | |
| • | Design and Analyze the operation of VSI & CSI fed induction motor control. | | | | | |
| • | Understand the rotor controlled induction motor drives. | | | | | |
| • | Understand the field oriented control of induction machines | | | | | |
| • | Design and Analyze the operation of synchronous motor drives | | | | | |
| TEXT BOOKS: | | | | | | |
| 1. | Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2002. | | | | | |

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| 2. | Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994. |
| 3. | Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., NewYersy, 1989. |
| REFERENCES: | |
| 1. | <i>R.Krishnan, "Electric Motor Drives – Modelling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.</i> |
| 2. | <i>W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992.</i> |
| 3. | <i>Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.</i> |

| 17PEPC09 | SPECIAL ELECTRICAL MACHINES | | L | T | P | C |
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| | | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | | |
| • | To review the fundamental concepts of permanent magnets and the operation of | | | | | |
| • | To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors. | | | | | |
| • | To develop the control methods and operating principles of switched reluctance motors. | | | | | |
| • | To introduce the concepts of stepper motors and its applications | | | | | |
| • | To understand the basic concepts of other special machines | | | | | |
| UNIT I | PERMANENT MAGNET BRUSHLESS DC MOTORS | | | | 09 | |
| Fundamentals of Permanent Magnets-Types-Principle of operation-Magnetic circuit analysis EMF and Torque equations-Characteristics and control. | | | | | | |
| UNIT II | PERMANENT MAGNET SYNCHRONOUS MOTORS | | | | 09 | |
| Principle of operation – EMF and Torque equations-Phasor diagram-Power controllers– Torque speed characteristics–Digital controllers–Constructional features, operating principle and characteristics of synchronous reluctance motor. | | | | | | |
| UNIT III | SWITCHED RELUCTANCE MOTORS | | | | 09 | |
| Constructional features –Principle of operation-Torque prediction–Characteristics-Power controllers–Control of SRM drive-Sensor less operation of SRM–Applications. | | | | | | |
| UNIT IV | STEPPER MOTORS | | | | 09 | |
| Constructional features–Principle of operation–Types–Torque predictions–Linear and Non-linear analysis –Characteristics– Drive circuits– Closed loop control –Applications. | | | | | | |
| UNIT V | OTHER SPECIAL MACHINES | | | | 09 | |
| Principle of operation and characteristics of Hysteresis motor–AC series motors –Linear motor –Applications. | | | | | | |
| | | | TOTAL :45 PERIODS | | | |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | | |
| • | Describe the construction and operating principles of special electrical machines. | | | | | |
| • | Analyze the characteristics and performance of special electrical machines. | | | | | |
| • | Understanding the characteristics of special Electrical Machines. | | | | | |
| • | Develop the controllers to control the machines. | | | | | |
| TEXT BOOKS: | | | | | | |
| 1. | T.J.E.Miller, ‘Brushless magnet and Reluctance motor drives’, Claredon press, London, 1989. | | | | | |
| 2. | R.Krishnan, ‘ Switched Reluctance motor drives’ , CRC press, 2001 | | | | | |
| 3. | T.Kenjo, ‘Steppingmotorsandtheirmicroprocessorcontrols’,OxfordUniversitypress, NewDelhi,2000. | | | | | |

| REFERENCES: | |
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| 1. | <i>T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988</i> |
| 2. | <i>R.Krishnan, 'Electric motor drives', Prentice hall of India, 2002.</i> |
| 3. | <i>D.P.Kothari and I.J.Nagrath, 'Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.</i> |
| 4. | <i>Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007.</i> |

| 17PEPC10 | POWER QUALITY | | | L | T | P | C |
|---|--|--|--|---|---|---|--------------------------|
| | | | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | | | |
| • | To understand the various power quality issues. | | | | | | |
| • | To understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads. | | | | | | |
| • | To understand the conventional compensation techniques used for power factor correction and load voltage regulation. | | | | | | |
| • | To understand the active compensation techniques used for power factor correction. | | | | | | |
| • | To understand the active compensation techniques used for load voltage regulation. | | | | | | |
| UNIT I | INTRODUCTION | | | | | | 09 |
| Introduction – Characterisation of Electric Power Quality : Transients , short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation , Power acceptability curves–power quality problems : poor load power factor , Nonlinear and unbalanced loads, DC offset in loads , Notching in load voltage, Disturbance in supply voltage– Power quality standards. | | | | | | | |
| UNIT II | ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM | | | | | | 09 |
| Single phase sinusoidal, non-sinusoidal source supplying linear and nonlinear loads –Three phase Balance system – Three phase unbalanced system– Three phase unbalanced and distorted source supplying on linear loads–Concept of PF–Three phase three wire–Three phase four wire system. | | | | | | | |
| UNIT III | CONVENTIONAL LOAD COMPENSATION METHODS | | | | | | 09 |
| Principle of Load compensation and Voltage regulation – Classical load balancing problem: Open loop balancing– Closed loop balancing , Current balancing–Harmonic reduction and voltages agreduction– Analysis of unbalance–instantaneous real and reactive powers– Extraction of fundamental sequence component. | | | | | | | |
| UNIT IV | LOAD COMPENSATION USING DSTATCOM | | | | | | 09 |
| Compensating single phase loads – Ideal three phase shunt compensator structure– Generating reference currents using instantaneous PQ theory –Instantaneous symmetrical components theory –Generating reference currents when the source is unbalanced– Realization and control of DSTATCOM–DSTATCOM in Voltage control mode. | | | | | | | |
| UNIT V | SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM | | | | | | 09 |
| Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure–voltage Restoration– Series Active Filter– Unified Power Quality Conditioner. | | | | | | | |
| | | | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | | | |
| • | Formulate,designandsimulatepowersuppliesforgenericloadandmachine loads. | | | | | | |
| • | Conduct harmonic analysis and load tests on power supplies and drive systems. | | | | | | |
| • | Understand and design load compensation methods useful for mitigating power quality problems. | | | | | | |
| • | Recognise the practical issues in the Power system. | | | | | | |
| • | Analyse the impact of Power Electronics Devices and techniques in power system. | | | | | | |

| TEXT BOOKS: | |
|--------------------|---|
| 1. | Arindam Ghosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002 |
| 2. | R.C.Duggan, Mark.F.McGranaghan, Surya Santoas and H.Wayne Beaty, “Electrical Power System Quality”, McGraw-Hill, 2004. |
| 3. | G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1994. |
| REFERENCES: | |
| 1. | <i>Bhim Singh, Ambrish Chandra, Kamal Al-Haddad , “Power Quality: Problems and Mitigation Techniques”, John Wiley & Sons, 2015.</i> |
| 2. | <i>Jos Arrillaga and Neville R. Watson, “Power system harmonics”, Wiley, 2003.</i> |
| 3. | <i>Derek A. Paice, “Power Electronics Converter Harmonics: Multipulse Methods for Clean Power”, Wiley, 1999.</i> |
| 4. | <i>Ewald Fuchs, Mohammad A.S. Masoum, “Power Quality in Power Systems and Electrical Machines”, Elsevier academic press publications, 2011.</i> |

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| 17PEPC11 | ELECTRICAL DRIVES LABORATORY | L | T | P | C |
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| OBJECTIVES: | | | | | |
| • | To design and analyse the various DC and AC drives. | | | | |
| • | To generate the firing pulses for converters and inverters using digital processors | | | | |
| • | Design of controllers for linear and nonlinear systems | | | | |
| • | Implementation of closed loop system using hardware simulation | | | | |
| LIST OF EXPERIMENTS | | | | | |
| <ol style="list-style-type: none"> 1. Speed control of Converter fed DC motor 2. Speed control of Chopper fed DC motor 3. V/f control of three-phase induction motor 4. Microcontroller based speed control of Stepper motor 5. Speed control of BLDC motor 6. DSP based speed control of SRM motor 7. Voltage Regulation of three-phase Synchronous Generator 8. Speed control of PMSM 9. Single phase Multi Level Inverter based induction motor drive 10. Study of power quality analyzer | | | | | |
| | | | | | TOTAL:60 PERIODS |
| OUTCOMES: After completion of this course, the student will be able to: | | | | | |
| • | Perform various measurements of input/output on power electronics converters/inverters and analyse the issues of results | | | | |
| • | Build and test various power electronic converters, inverters for drives applications by using different types of motor controllers | | | | |
| • | Design and implement analog circuits for Power electronic control applications. | | | | |
| • | Design and fabricate a power converter circuit at a reasonable power level | | | | |

| 17PEPE01 | SYSTEM THEORY | | L | T | P | C |
|---|--|---|---|---|--------------------------|-----------|
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| OBJECTIVES: | | | | | | |
| • | To understand the fundamentals of physical systems in terms of its linear and Non linear models. | | | | | |
| • | To educate on representing systems in state variable form | | | | | |
| • | To exploit the properties of linear systems such as controllability and observability | | | | | |
| • | To educate on stability analysis of systems using Lyapunov's theory | | | | | |
| • | To educate on modal concepts and design of state and output feedback controllers | | | | | |
| UNIT I | STATE VARIABLE REPRESENTATION | | | | | 09 |
| Introduction-Concept of State – State equations for Dynamic Systems-Time invariance and linearity- Non uniqueness of state model –Physical Systems and State Assignment-free and forced responses-State Diagrams. | | | | | | |
| UNIT II | SOLUTION OF STATE EQUATIONS | | | | | 09 |
| Existence and uniqueness of solutions to Continuous-time state equations-Solution of Linear Time Varying State equations - State transition matrix and its properties–Evaluation of matrix exponential- System modes-Role of Eigen values and Eigen vectors | | | | | | |
| UNIT III | STABILITY ANALYSIS OF LINEAR SYSTEMS | | | | | 09 |
| Controllability and Observability definitions and Kalman rank conditions – Stabilizability and Detectability-Test for Continuous time Systems-Time varying and Time invariant case- Output Controllability-Reducibility-System Realizations. | | | | | | |
| UNIT IV | STATE FEEDBACK CONTROL AND STATE ESTIMATOR | | | | | 09 |
| Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability – Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers. | | | | | | |
| UNIT V | LYAPUNOV STABILITY ANALYSIS | | | | | 09 |
| Introduction-Equilibrium Points–BIBO Stability-Stability of LTI Systems-Stability in the sense of Lyapunov – Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems–Krasovskil's and Variable-Gradient Method. | | | | | | |
| | | | | | TOTAL :45 PERIODS | |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | | |
| • | Construct the state space model for the given electrical/electro-mechanical systems. | | | | | |
| • | Design pole placement controller and/or observer for the given system to achieve desired specifications. | | | | | |
| • | | | | | | |
| • | Identify the stability of the given linear and nonlinear system using Lyapunov stability theory. | | | | | |
| TEXT BOOKS: | | | | | | |
| 1. | M.Gopal, “Modern Control System Theory”, New Age International, 2005. | | | | | |

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| 2. | K. Ogatta, "Modern Control Engineering", PHI,2002. |
| 3. | JohnS. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill,1999. |
| REFERENCES: | |
| 1. | <i>D.Roy Choudhury, "Modern Control Systems", NewAge International,2005.</i> |
| 2. | <i>JohnJ. D'Azzo, C.H.Houpis and S. N.Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis,2003.</i> |
| 3. | <i>Z.Bubnicki, "Modern Control Theory", Springer, 2005.</i> |
| 4. | <i>C.T.Chen, "Linear Systems Theory and Design" Oxford University Press, 3rd Edition, 1999.</i> |
| 5. | <i>M.Vidyasagar, "Nonlinear Systems Analysis", 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.</i> |

| 17PEPE02 | ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING | | L | T | P | C |
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| OBJECTIVES: | | | | | | |
| • | To Provide the fundamentals of Electromagnetic Field Theory | | | | | |
| • | To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods. | | | | | |
| • | To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems. | | | | | |
| • | To introduce the concept of mathematical modeling and design of electrical apparatus | | | | | |
| UNIT I | INTRODUCTION | | | | | 09 |
| Review of basic field theory–Maxwell’s equations–Constitutive relationships and Continuity equations–Laplace, Poisson and Helmholtz equation– principle of energy conversion– force/torque calculation. | | | | | | |
| UNIT II | BASIC SOLUTION METHODS FOR FIELD EQUATIONS | | | | | 09 |
| Limitations of the conventional design procedure ,need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method–variable separable method–method of images, solution by numerical methods- Finite Difference Method. | | | | | | |
| UNIT III | FORMULATION OF FINITE ELEMENT METHOD (FEM) | | | | | 09 |
| Variational Formulation–Energy minimization–Discretization–Shape functions–Stiffness matrix–1D and 2D planar and axial symmetry problems | | | | | | |
| UNIT IV | COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES | | | | | 09 |
| Basic quantities–Energy stored in Electric Field–Capacitance–Magnetic Field–Linked Flux– Inductance–Force–Torque–Skin effect– Resistance. | | | | | | |
| UNIT V | DESIGN APPLICATIONS | | | | | 09 |
| Design of Insulators–Cylindrical magnetic actuators–Transformers–Rotating machines. | | | | | | |
| | | | | | TOTAL :45 PERIODS | |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | | |
| • | Provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods | | | | | |
| • | Impart in-depth knowledge on Finite Element Method in solving Electromagnetic field Problems | | | | | |
| • | Know mathematical modeling and design of electrical apparatus | | | | | |
| TEXT BOOKS: | | | | | | |
| 1. | Matthew.N.O.Sadiku,“Elements of Electromagnetics”, Fourth Edition, Oxford University Press, First Indian Edition 2007 | | | | | |
| 2. | K.J.Binns,P.J.Lawrenson,C.W.Trowbridge,“The analytical and numerical solution of Electric and magnetic fields”, John Wiley & Sons, 1993. | | | | | |

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| 3. | NicolaBiyanchi,“ElectricalMachineanalysisusingFiniteElements”,TaylorandFrancis Group, CRC Publishers, 2005. |
| REFERENCES: | |
| 1. | <i>Nathan Ida, Joao P.A.Bastos, “Electromagnetics and calculation of fields”, SpringerVerlage, 1992.</i> |
| 2. | <i>S.JSalon, “Finite Element Analysis of Electrical Machines” Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India</i> |
| 3. | <i>Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, 1983.</i> |

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| 17PEPE03 | CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To explore conceptual bridges between the fields of Control Systems and Power Electronics. | | | | |
| • | To Study Control theories and techniques relevant to the design of feedback controllers in Power Electronics. | | | | |
| • | To analyse and design of controller. | | | | |
| • | To explore non-linear controller design. | | | | |
| • | To study predictive control of power converters. | | | | |
| UNIT I | MODELLING OF DC-TO-DC POWER CONVERTERS | 09 | | | |
| Modelling of Buck Converter, Boost Converter, Buck-Boost Converter, Cuk Converter , Sepic Converter, Zeta Converter, Quadratic Buck Converter, Double Buck-Boost Converter, Boost-Boost Converter General Mathematical Model for Power Electronics Devices | | | | | |
| UNIT II | SLIDING MODE CONTROLLER DESIGN | 09 | | | |
| Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding Mode Control Implementation of Boost Converter, Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost-Boos Converter | | | | | |
| UNIT III | APPROXIMATE LINEARIZATION CONTROLLER DESIGN | 09 | | | |
| Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design , Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter ,Buck-Boost Converter | | | | | |
| UNIT IV | NONLINEAR CONTROLLER DESIGN | 09 | | | |
| Feedback Linearization Isidori's Canonical Form ,Input-Output Feedback Linearization ,State Feedback Linearization , Passivity Based Control , Full Order Observers , Reduced Order Observers. | | | | | |
| UNIT V | PREDICTIVE CONTROL OF POWER CONVERTERS | 09 | | | |
| Basic Concepts, Theory, and Methods ,Application of Predictive Control in Power Electronics, AC-DC-AC Converter System , Faults and Diagnosis Systems in Power Converters. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Understand an overview on modern linear and nonlinear control strategies for power electronics devices | | | | |
| • | Model modern power electronic converters for industrial applications | | | | |
| • | Design appropriate controllers for modern power electronics devices. | | | | |

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| TEXT BOOKS: | |
| 1. | Hebertt Sira- Ramírez PhD, Ramón Silva-Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer 2012 |
| 2. | Mahesh Patil, Pankaj Rodey, “Control Systems for Power Electronics: A Practical Guide”, Springer India, 2015. |
| 3. | Blaabjerg José Rodríguez, “Advanced and Intelligent Control in Power Electronics and Drives”, Springer, 2014. |
| REFERENCES: | |
| 1. | <i>Enrique Acha, Vassilios Agelidis, Olimpo Anaya, TJE Miller, “Power Electronic Control in Electrical Systems”, Newnes, 2002</i> |
| 2. | <i>Marija D. Aranya Chakraborty, Marija, “Control and Optimization Methods for Electric Smart Grids”, Springer, 2012.</i> |

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| 17PEPE04 | ANALOG AND DIGITAL CONTROLLERS | L | T | P | C |
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| OBJECTIVES: | | | | | |
| • | To provide a overview of the control system and converter control methodologies | | | | |
| • | To provide an insight to the analog controllers generally used in practice | | | | |
| • | To introduce Embedded Processers for Digital Control | | | | |
| • | To study on the driving techniques, isolation requirements, signal conditioning and protection methods | | | | |
| • | To provide a Case Study by implementing an analog and a digital controller on a converter | | | | |
| UNIT I | CONTROL SYSTEM- OVERVIEW | 09 | | | |
| Feedback and Feed-forward control, Right Half Plane Zero, Gain margin and Phase Margin, Stability, Analysis and Transfer function of PI and PID controllers and its effects . Voltage mode control, Peak Current mode Control, Average Current mode Control for Converters – Need, advantages and disadvantages. | | | | | |
| UNIT II | ANALOG CONTROLLERS | 09 | | | |
| Major components of a controller–Op-Amp based PI and PID controller–Proportional ,Integral and Differential gains in terms of Resistance and Capacitance , Error Amplifiers ,PWM generator using Ramp or Triangular generator and comparator , and Driver ,Voltage mode controller design using UC3524,Peak Current mode controller design using UC3842, Average Current mode controller design using UC3854, PFC-CCM (UCC28070). | | | | | |
| UNIT III | DIGITAL CONTROLLERS | 09 | | | |
| Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control–A/D , Capture , Compare and PWM , Analog Comparators for instantaneous overcurrent detection, interrupts ,Discrete PI and PID equations ,Algorithm for PI and PID implementation, Example Code for PWM generation. | | | | | |
| UNIT IV | SIGNAL CONDITIONING, DRIVER, ISOLATION AND PROTECTION | 09 | | | |
| Voltage feedback sensing circuits , Hall effect sensors and Shunts for current feedback sensing, Low off set Op-Amps for signal conditioning, Single and dual supply op-amps, To tempole drivers, Need for isolated drivers, Optically isolated drivers, low side drivers, high side drivers with boot strap power supply, Vcesat sensing , CT based Device current sensing and pulse blocking. | | | | | |
| UNIT V | CONTROLLER IMPLEMENTATION | 09 | | | |
| Analog and Digital Controller Design for Buck Converter–Power circuit transfer function and bode plot , PI controller bode plot , Combined bode plot with required Gain and Phase margins, Implementation of Analog controller and Digital controller. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Understand control systemand convertercontrolmethodologies. | | | | |
| • | Design of digital controllers. | | | | |
| • | Understand signal conditioning and protection | | | | |

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| • | Execute the controller implementation technique. |
| TEXT BOOKS: | |
| 1. | <i>I.J.Nagrath and M. Gopal, "Control Systems Engineering", NewAge International Publishers.</i> |
| 2. | R.C.Duggan, Mark.F.McGranaghan, SuryaSantoasandH.WayneBeaty, "Electrical Power System Quality", McGraw-Hill, 2004. |
| 3. | G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994. |
| REFERENCES: | |
| 1. | <i>TI Application notes, Reference Manuals and Data Sheets.</i> |
| 2. | <i>Agilent Data Sheets</i> |
| 3. | <i>Microchip Application notes, Reference Manuals and Data Sheets.</i> |

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| 17PEPE05 | FLEXIBLE AC TRANSMISSION SYSTEMS | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To emphasis the need for FACTS controllers | | | | |
| • | To analyze the interaction of different FACTS controller and perform control coordination | | | | |
| • | To learn the characteristics, applications and modelling of series FACTS controllers. | | | | |
| • | To learn the characteristics, applications and modelling of shunt FACTS controllers. | | | | |
| • | To elucidate the utilization of power electronic circuits in power system to improve the performance | | | | |
| UNIT I | INTRODUCTION | 09 | | | |
| Review of basics of power transmission networks-control of power flow in AC transmission line Analysis of uncompensated AC Transmission line-Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer-Need for FACTS controllers- types of FACTS controllers. | | | | | |
| UNIT II | STATIC VAR COMPENSATOR (SVC) | 09 | | | |
| Configuration of SVC-voltage regulation by SVC-Modelling of SVC for load flow analysis Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system – Applications :transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line. | | | | | |
| UNIT III | THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC) | 09 | | | |
| Concepts of Controlled Series Compensation– Operation of TCSC and GCSC-Analysis of TCSC-GCSC–Modelling of TCSC and GCSC for load flow studies-modeling TCSC and GCSC for stability studied-Applications of TCSC and GCSC. | | | | | |
| UNIT IV | VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS | 09 | | | |
| Static synchronous compensator (STATCOM) – Static synchronous series compensator (SSSC)- Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC-Modelling of STATCOM and SSSC for power flow and transient stability studies–operation of Unified and Interline power flow controllers (UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies-Applications. | | | | | |
| UNIT V | CONTROLLERS AND THEIR COORDINATION | 09 | | | |
| FACTS Controller interactions– SVC–SVC interaction-co-ordination of multiple controllers using linear control techniques –Quantitative treatment of control coordination. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | |
| • | Understand and analyse power system operation, stability, control and protection. | | | | |
| • | Understand the operation of the compensator and its applications in power system. | | | | |
| • | Model the hardware of power electronics circuit to upgrade the power system. | | | | |
| • | Understand the various emerging Facts controllers | | | | |
| • | Know about the genetic algorithm used in Facts controller coordination. | | | | |

| TEXT BOOKS: | |
|--------------------|---|
| 1. | A.T.John, “Flexible AC Transmission System”, Institution of Electrical and Electronic Engineers (IEEE), 1999. |
| 2. | NarainG.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, Standard Publishers, Delhi 2001. |
| 3. | V. K.Sood, “HVDC and FACTS controllers- Applications of Static Converters in Power System”, 2004, Kluwer Academic Publishers. |
| REFERENCES: | |
| 1. | <i>Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.</i> |
| 2. | <i>K.R.Padiyar, ” FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Ltd., Publishers New Delhi, Reprint 2008.</i> |

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| 17PEPE06 | MODERN RECTIFIERS AND RESONANT CONVERTERS | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To gain knowledge about the harmonics standards and operation of rectifiers in CCM & DCM. | | | | |
| • | To analyze and design power factor correction rectifiers for UPS applications. | | | | |
| • | To know the operation of resonant converters for SMPS applications. | | | | |
| • | To carry out dynamic analysis of DC- DC Converters. | | | | |
| • | To introduce the source current shaping methods for rectifiers. | | | | |
| UNIT I | POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS | 09 | | | |
| Average power-RMS value of waveform–Effect of Power factor-. current and voltage harmonics–Effect of source and load impedance –AC line current harmonic standards IEC1000-IEEE519-CCM and DCM operation of single phase full wave rectifier-Behaviour of full wave rectifier for large and small values of capacitance-CCM and DCM operation of three phase full wave rectifier- 12 pulse converters-Harmonic trap filters. | | | | | |
| UNIT II | PULSE WIDTH MODULATED RECTIFIERS | 09 | | | |
| Properties of Ideal single phase rectifiers-Realization of nearly ideal rectifier-.Single-phase converter system sin incorporating ideal rectifiers-Losses and efficiency in CCM high quality rectifiers-single-phase PWM rectifier-PWM concepts-device selection for rectifiers-IGBT based PWM rectifier, comparison with SCR based converters with respect to harmonic content –applications of rectifiers | | | | | |
| UNIT III | RESONANT CONVERTERS | 09 | | | |
| Soft Switching-classification of resonant converters-Quasi resonant converters-basics of ZVS and ZCS –half wave and full wave operation(qualitative treatment)-multi resonant converters-operation and analysis of ZVS and ZCS multi resonant converter-zero voltage transition PWM converters –zero current transition PWM converters | | | | | |
| UNIT IV | DYNAMIC ANALYSIS OF SWITCHING CONVERTERS | 09 | | | |
| Review of linear system analysis-State Space Averaging-Basic State Space Average Model-State Space Averaged model for an ideal Buck Converter ,ideal Boost Converter ,ideal Buck Boost Converter and an ideal Cuk Converter .Pulse Width modulation–Voltage Mode PWM Scheme-Current Mode PWM Scheme – design of PI controller. | | | | | |
| UNIT V | SOURCE CURRENT SHAPING OF RECTIFIERS | 09 | | | |
| Need for current shaping-power factor- functions of current shaper –input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods –boost rectifier employing peak current control-average current control-Hysteresis control- Nonlinear carrier control. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: After completion of this course, the student will be able to: | | | | | |
| • | Applytheconcept ofvarious typesof rectifiers. | | | | |
| • | Simulateanddesigntheoperationof resonantconverterandits importance. | | | | |
| • | Identify theimportanceoflinear system,statespace model,PI controller. | | | | |
| • | DesigntheDC powersuppliesusingadvancedtechniques. | | | | |

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| • | Understand the standards for supply current harmonics and its significance. |
| TEXT BOOKS: | |
| 1. | Robert W. Erickson and Dragomir Maksimovic, "Fundamentals of Power Electronics", Second Edition, Springer science and Business media, 2001. |
| 2. | William Shepherd and Lizhang, "Power Converters Circuits", Marcel Dekker, 2005. |
| 3. | Simon Ang and Alejandro Oliva, "Power ", Taylor & Francis Group, 2010. |
| REFERENCES: | |
| 1. | <i>Andrzej M. Trzynadlowski, "Introduction To Modern Power Electronics", John Wiley & Sons, 2016.</i> |
| 2. | <i>Marian K. Kazimierczuk and Dariusz Czarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011.</i> |
| 3. | <i>Keng C. Wu, "Switch Mode Power Converters – Design and Analysis" Elsevier Academic Press, 2006.</i> |
| 4. | <i>Abraham I. Pressman, Keith Billings and Taylor Morey, "Switching Power Supply Design" McGraw-Hill, 2009</i> |
| 5. | <i>V. Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Bangalore, 2007.</i> |
| 6. | <i>Christophe P. Basso, Switch-Mode Power Supplies, McGraw-Hill, 2014</i> |

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| 17PEPE07 | ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility. | | | | |
| • | To study the important techniques to control EMI and EMC | | | | |
| • | To provide knowledge in grounding and cabling. | | | | |
| • | To provide fundamental knowledge on balancing, filtering and shielding. | | | | |
| • | To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement. | | | | |
| UNIT I | INTRODUCTION | 09 | | | |
| Definitions of EMI/EMC -Sources of EMI- Inter systems and Intra system- Conducted and radiated interference-Characteristics-Designing forelectromagneticcompatibility (EMC)-EMC regulation typical noise path-EMI predictions and modelling ,Cross talk- Method soft eliminating interferences. | | | | | |
| UNIT II | GROUNDING AND CABLING | 09 | | | |
| Cabling-types of cables, mechanism of EMI emission/ coupling in cables–capacitive coupling inductive coupling-shielding to prevent magnetic radiation-shield transfer impedance, Grounding–safety grounds–signal grounds-single point and multi point ground systems hybrid grounds- functional ground layout–grounding of cable shields—guard shields-isolation, neutralizing transformers ,shield grounding at high frequencies ,digital grounding-Earth measurement Methods | | | | | |
| UNIT III | BALANCING, FILTERING AND SHIELDING | 09 | | | |
| Power supply decoupling-decoupling filters-amplifier filtering–high frequency filtering-EMI filters characteristics of LPF,HPF,BPF,BEF and power line filter design-Choice of capacitors, inductors ,transformers and resistors ,EMC design components-shielding–near and far fields shielding effectiveness-absorption and reflection loss-magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings-grounding of shields | | | | | |
| UNIT IV | EMI IN ELEMENTS AND CIRCUITS | 09 | | | |
| Electromagnetic emissions ,noise from relays and switches ,non-linearities in circuits ,passive intermodulation, transients in power supply lines ,EMI from power electronic equipment ,EMI as combination of radiation and conduction | | | | | |
| UNIT V | ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES | 09 | | | |
| Static Generation-human body model-static discharges-ESD versus EMC ,ESD protection in equipments-standards –FCC requirements– EMI measurements– Open area test site measurements and precautions-Radiated and conducted interference measurements, Control requirements and testing methods | | | | | |
| | | | | | TOTAL :45 PERIODS |

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| OUTCOMES: | After completion of this course, the student will be able to: |
| • | Recognize the sources of Conducted and radiated EMI in Power Electronic Converters and consumer appliances and suggest remedial measures to mitigate the problems |
| • | Assess the insertion loss and design EMI filters to reduce the loss |
| • | Design EMI filters, common-mode chokes and RC-snubber circuits measures to keep the interference within tolerable limits |
| TEXT BOOKS: | |
| 1. | V.P.Kodali, "Engineering Electromagnetic Compatibility", S.Chand, 1996 |
| 2. | Henry W.Ott, "Noise reduction techniques in electronic systems", John Wiley & Sons, 1989 |
| 3. | Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 Canton street, Norwood, MA 02062 USA) 1987. |
| REFERENCES: | |
| 1. | <i>Bridges, J. E. Millett J. and Ricketts. L. W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976</i> |
| 2. | <i>William Duff G., & Donald White R. J., "Series on Electromagnetic Interference and Compatibility", Vol.</i> |
| 3. | <i>Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.</i> |

| 17PEPE08 | MEMS TECHNOLOGY | | L | T | P | C |
|---|---|--|---|---|---|--------------------------|
| | | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | | |
| • | To teach the students properties of materials ,microstructure and fabrication methods. | | | | | |
| • | To teach the design and modeling of Electrostatic sensors and actuators. | | | | | |
| • | To teach the characterizing thermal sensors and actuators through design and modeling | | | | | |
| • | To teach the fundamentals of piezoelectric sensors and actuators through exposure | | | | | |
| UNIT I | MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS | | | | | 09 |
| Overview of micro fabrication–Silicon and other material based fabrication processes– Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor. | | | | | | |
| UNIT II | ELECTROSTATIC SENSORS AND ACTUATION | | | | | 09 |
| Principle ,material ,design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications | | | | | | |
| UNIT III | THERMAL SENSING AND ACTUATION | | | | | 09 |
| Principle ,material ,design and fabrication of thermal couples ,thermal bimorph sensors, thermal resistor sensors-Applications | | | | | | |
| UNIT IV | PIEZOELECTRIC SENSING AND ACTUATION | | | | | 09 |
| Piezoelectric effect-cantilever piezoelectric actuator model-properties of piezoelectric materials-Applications. | | | | | | |
| UNIT V | CASE STUDIES | | | | | 09 |
| Piezo resistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices Note: Classroom discussions and tutorial scan include the following guidelines for improved teaching/learning process : Discussions/Exercise/Practice on Work bench : on the basics/device model design aspects of thermal/peizo/resistive sensors etc. | | | | | | |
| | | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After the completion of this course the student will be able to: | | | | | |
| • | Understand basics of micro fabrication, develop models and simulate electrostatic and electromagnetics ensors and actuators | | | | | |
| • | Understand material properties important for MEMS system performance, analyse dynamics of resonant micromechanical structures | | | | | |
| • | The learning process delivers insight onto design of micro sensors, embedded sensors & Actuators in power aware systems like grid. | | | | | |
| • | Understand the design process and validation for MEMS devices and systems, and learn the state of the art in optical micro systems. | | | | | |
| • | Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded systems design. | | | | | |

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| TEXT BOOKS: | |
| 1. | ChangLiu, “FoundationsofMEMS”,Pearson International Edition,2006. |
| 2. | MarcMadou, “Fundamentals of microfabrication”,CRC Press, 1997 |
| 3. | Boston, “Micro machined Transducers Source book”,WCB McGraw Hill,1998. |
| REFERENCES: | |
| 1. | <i>M.H.Bao “Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.</i> |

| 17PEPE09 | DISTRIBUTED GENERATION AND MICROGRID | L | T | P | C |
|---|---|-----------|---|---|--------------------------|
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To illustrate the concept of distributed generation | | | | |
| • | To analyze the impact of grid integration. | | | | |
| • | To study concept of Micro grid and its configuration | | | | |
| • | Understand and analyse of micro grid operations. | | | | |
| UNIT I | INTRODUCTION | 09 | | | |
| Conventional power generation : advantages and disadvantages, Energy crises ,Non-conventional energy(NCE) resources : review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines ,biomass, and tidal sources. | | | | | |
| UNIT II | DISTRIBUTED GENERATIONS (DG) | 09 | | | |
| Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework ,Standards for inter connecting Distributed resources to electric power systems: IEEE1547. DG installation classes, security issues in DG implementations .Energy storage elements: Batteries ,ultra -capacitors ,flywheels .Captive power plants | | | | | |
| UNIT III | IMPACT OF GRID INTEGRATION | 09 | | | |
| Requirements for grid interconnection ,limitson operational parameters,: voltage, frequency, THD ,response to grid abnormal operating conditions ,islanding issues .Impact of grid integration with NCE sources on existing power system: reliability ,stability and power quality issues. | | | | | |
| UNIT IV | BASICS OFAMICROGRID | 09 | | | |
| Concept and definition of microgrid ,microgrid drivers and benefits ,review of sources of microgrids, typical structure and configuration of a microgrid ,AC and DC microgrids ,Power Electronics interfaces in DC and AC microgrids | | | | | |
| UNIT V | CONTROL AND OPERATION OF MICROGRID | 09 | | | |
| Modes of operation and control of microgrid : grid connected and is landed mode ,Active and reactive power control ,protection issues ,anti –islanding schemes : passive ,active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards ,Microgrid economics ,Introduction to smart microgrids. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After thecompletionof thiscoursethestudentwill beableto: | | | | |
| • | Knowledge on the various schemes of conventional and nonconventional power generation. | | | | |
| • | Knowledge on the topologies and energy sources of distributed generation. | | | | |
| • | Learn about the requirements for grid interconnection and its impact with NCE sources | | | | |
| • | Understand the fundamental concept of Micro grid. | | | | |
| • | Improve Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded systems design. | | | | |

| TEXT BOOKS: | |
|--------------------|---|
| 1. | Amirnaser Yezdani, and RezaIravani, “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, IEEE JohnWiley Publications,2010. |
| 2. | DorinNeacsu, “Power Switching Converters: Medium and High Power”, CRC Press, Taylor&Francis, 2006 |
| 3. | ChetanSinghSolanki, “Solar Photo Voltaics”, PHI learning Pvt. Ltd., NewDelhi,2009. |
| REFERENCES: | |
| 1. | <i>J.F. Manwell,J.G. McGowan “Wind Energy Explained, theory design and applications”, Wileypublication2010.</i> |
| 2. | <i>D.D. Hall andR. P. Grover, “Biomass Regenerable Energy”,John Wiley, NewYork, 1987.</i> |
| 3. | <i>JohnTwidell and TonyWeir, “Renewable Energy Resources” Tyalor and Francis Publications, Secondedition2006.</i> |

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| 17PEPE10 | SOFT COMPUTING TECHNIQUES | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To expose 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 expose the ideas about genetic algorithm. | | | | |
| • | To provide adequate knowledge about of FLC and NN toolbox. | | | | |
| UNIT I | INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS | 09 | | | |
| Introduction to intelligent systems-Soft computing techniques-Conventional Computing versus Swarm Computing-Classification of meta-heuristic techniques –Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems-Neuron-Nerve structure and synapse-Artificial Neuron and its model-activation functions-Neural network architecture-single layer and multilayer feed forward networks-McCulloch Pitts neuron model-perceptron model- Adaline and Madaline -multilayer perception model-back propagation learning methods-effect of learning rule coefficient –back propagation algorithm- factors affecting back propagation training-applications. | | | | | |
| UNIT II | ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY | 09 | | | |
| Counter propagation network-architecture- functioning& characteristics of counter Propagation network-Hopfield/Recurrent network configuration-stability constraints associative memory and characteristics-limitations and applications-Hopfield v/s Boltz man machine-Adaptive Resonance Theory-Architecture-classifications- Implementation and training- Associative Memory. | | | | | |
| UNIT III | FUZZY LOGIC SYSTEM | 09 | | | |
| Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning .Introduction to fuzzy logic modeling and control-Fuzzification inferencing and de fuzzification- Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for non linear systems. Self organizing fuzzy logic control-Fuzzy logic control for nonlinear time delay system. | | | | | |
| UNIT IV | GENETIC ALGORITHM | 09 | | | |
| Evolutionary programs –Genetic algorithms, genetic programming and evolutionary programming-Genetic Algorithm versus Conventional Optimization Techniques-Genetic representations and selection mechanisms ; Genetic operators-different types of crossover and mutation operators-Optimization problems using GA-discrete and continuous-Single objective and multi-objective problems-Procedures in evolutionary programming. | | | | | |
| UNIT V | HYBRID CONTROL SCHEMES | 09 | | | |
| Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS–Fuzzy Neuron-Optimization of membership function and rule base using Genetic Algorithm–Introduction to Support Vector Machine-Evolutionary Programming-Particle Swarm Optimization-Case study–Familiarization of NN,FLC and ANFISTool Box. | | | | | |
| | | | | | TOTAL :45 PERIODS |

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| OUTCOMES: | After the completion of this course the student will be able to: |
| • | Know the basic ANN architectures, algorithms and their limitations. |
| • | Know the different operations on the fuzzy sets. |
| • | Developing ANN based models and control schemes for non-linear System |
| • | Expertise to use of different ANN structures and online training algorithm. |
| • | Knowledge to use Fuzzy logic for modeling and control of non-linear systems. |
| • | Competent to use hybrid control schemes and P.S.O and support vect Regressive. |
| TEXT BOOKS: | |
| 1. | Laurene V.Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications", Pearson Education. |
| 2. | Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India, 2008 |
| 3. | Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011 |
| REFERENCES: | |
| 1. | <i>David E. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009.</i> |
| 2. | <i>W.T. Miller, R.S. Sutton and P.J. Webrose, "Neural Networks for Control" MIT Press", 1996.</i> |
| 3. | <i>Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", MIT Press, 2004.</i> |
| 4. | <i>Corinna Cortes and V. Vapnik, "Support –Vector Networks, Machine Learning" 1995.</i> |

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| 17PEPE11 | HIGH VOLTAGE DIRECT CURRENT TRANSMISSION | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To impart knowledge on operation, modelling and control of HVDC link. | | | | |
| • | To perform steady state analysis of AC/DC system. | | | | |
| • | To expose various HVDC simulators. | | | | |
| UNIT I | DC POWER TRANSMISSION TECHNOLOGY | 09 | | | |
| Introduction–Comparison of AC and DC transmission–Application of DC transmission–Description of DC transmission system–Planning for HVDC transmission–Modern trends in DC transmission– DC breakers– Cables, VSC based HVDC. | | | | | |
| UNIT II | THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL | 09 | | | |
| Pulse number, choice of converter configuration–Simplified analysis of Graetz circuit- Converter bridge characteristics– characteristics of a twelve pulse converter-detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy -Firing angle control–Current and extinction angle control– Generation of harmonics and filtering-power control –Higher level controllers-Valve tests. | | | | | |
| UNIT III | MULTI TERMINAL DC SYSTEMS | 09 | | | |
| Introduction–Potential applications of MTDC systems – Types of MTDC systems -Control and protection of MTDC systems –Study of MTDC systems. | | | | | |
| UNIT IV | POWER FLOW ANALYSIS IN AC/DC SYSTEMS | 09 | | | |
| Per unit system for DC Quantities-Modelling of DC links-Solution of DC load flow-Solution of AC-DC power flow– Unified, Sequential and Substitution of power injection method | | | | | |
| UNIT V | SIMULATION OF HVDC SYSTEMS | 09 | | | |
| Introduction– DC LINK Modelling ,Converter Modeling and State Space Analysis ,Philosophy and tools–HVDC system simulation, On line and OFF lines simulators —Dynamic interactions between DC and AC systems. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After the completion of this course the student will be able to: | | | | |
| • | Know DC power transmission technology | | | | |
| • | Know thyristor control HVDC. | | | | |
| • | Analyse power flow in DC and AC | | | | |
| • | Demonstrate the control of HVDC transmission system for performance improvement | | | | |
| • | Model and simulate HVDC system | | | | |
| TEXT BOOKS: | | | | | |
| 1. | P.Kundur, “Power System Stability and Control”, McGraw-Hill,1993 | | | | |
| 2. | K.R.Padiyar,, “HVDC Power Transmission Systems”, New Age International (P)Ltd., NewDelhi,2002 | | | | |

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| 3. | J.Arrillaga, , “High Voltage Direct Current Transmission”, Peter Pregrinus,London,1983 |
| REFERENCES: | |
| 1. | <i>ErichUhlmann, “ Power Transmission by Direct Current”, BS Publications,2004</i> |
| 2. | <i>V.K.Sood, HVDC and FACTS controllers –Applications of Static Converters in Power System,APRIL2004, Kluwer Academic Publishers.</i> |

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| 17PEPE12 | SOLAR AND ENERGY STORAGE SYSTEMS | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To Study about solar modules and PV system design and their applications. | | | | |
| • | To Deal with Standalone PV System | | | | |
| • | To Deal with grid connected PV systems. | | | | |
| • | To Discuss about different energy storage systems. | | | | |
| UNIT I | INTRODUCTION | 09 | | | |
| Characteristics of sunlight–semiconductors and P-N junctions–behavior of solar cells–cell properties–PV cell interconnection | | | | | |
| UNIT II | STANDALONE PV SYSTEM | 09 | | | |
| Solar modules–storage systems–power conditioning and regulation-MPPT-protection–Standalone PV systems design–sizing | | | | | |
| UNIT III | GRID CONNECTED PV SYSTEMS | 09 | | | |
| PV systems in buildings–design issues for central power stations–safety–Economic aspect – Efficiency and performance- International PV programs | | | | | |
| UNIT IV | ENERGY STORAGE SYSTEMS | 09 | | | |
| Impact of intermittent generation–Battery energy storage–solar thermal energy storage–Pumped hydro electric energy storage | | | | | |
| UNIT V | APPLICATIONS | 09 | | | |
| Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After the completion of this course the student will be able to: | | | | |
| • | Develop more knowledge on solar energy storage systems | | | | |
| • | Develop basic knowledge on standalone PV system | | | | |
| • | Understand the issues in grid connected PV systems | | | | |
| • | Modeling of different energy storage systems and their performances | | | | |
| • | Attain more knowledge on different applications of solar energy. | | | | |
| TEXT BOOKS: | | | | | |
| 1. | Solanki C.S., “Solar Photovoltaics:Fundamentals,Technologies AndApplications”, PHILearningPvt.Ltd.,2015. | | | | |
| 2. | Stuart R.Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, “Applied Photovoltaics”, 2007, Earthscan, UK. | | | | |
| 3. | EduardoLorenzoG. Araujo, “Solar electricity engineering of photovoltaic systems”, Progensa,1994. | | | | |
| REFERENCES: | | | | | |
| 1. | <i>FrankS. Barnes& JonahG.Levine, “Large Energy storage Systems Handbook”, CRC Press, 2011.</i> | | | | |
| 2. | <i>McNeils, Frenkel, Desai, “Solar & Wind Energy Technologies”, Wiley Eastern, 1990</i> | | | | |
| 3. | <i>S.P.Sukhatme, “Solar Energy”, TataMcGrawHill,1987</i> | | | | |

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|---|---|-----------|----------|----------|--------------------------|
| 17PEPE13 | WIND ENERGY CONVERSION SYSTEMS | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To learn the design and control principles of Wind turbine. | | | | |
| • | To understand the concepts of fixed speed and variable speed, wind energy conversion | | | | |
| • | To analyze the grid integration issues. | | | | |
| UNIT I | INTRODUCTION | 09 | | | |
| Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine. | | | | | |
| UNIT II | WIND TURBINES | 09 | | | |
| HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No .of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction. | | | | | |
| UNIT III | FIXED SPEED SYSTEMS | 09 | | | |
| Generating Systems-Constant speed constant frequency systems-Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator-Model of Wind Speed-Model wind turbine rotor-Drive Train model-Generator model for Steady state and Transient stability analysis. | | | | | |
| UNIT IV | VARIABLE SPEED SYSTEMS | 09 | | | |
| Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator-DFIG-PMSG-Variable speed generators modeling -Variable speed variable frequency schemes. | | | | | |
| UNIT V | GRID CONNECTED SYSTEMS | 09 | | | |
| Wind interconnection requirements ,low-voltage ride through (LVRT), ramp rate limitations ,and supply of ancillary services for frequency and voltage control, current practices and industry trends wind inter connection impacton steady-state and dynamic performance of the power system including modelling issue. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Acquire knowledge on the basic concepts of Wind energy conversion system. | | | | |
| • | Understand the mathematical modelling and control of the Wind turbine | | | | |
| • | Develop more understanding on the design of Fixed speed system | | | | |
| • | Study about the need of Variable speed system and its modelling. | | | | |
| • | Learn about Grid integration issues and current practices of wind interconnections with power system. | | | | |
| TEXT BOOKS: | | | | | |
| 1. | L.L.Freris“Wind Energy conversion Systems”,Prentice Hall,1990 | | | | |
| 2. | S.N.Bhadra, D.Kastha, S.Banerjee, ”Wind Electrical Sytems”,Oxford University Press,2010. | | | | |
| 3. | IonBoldea, “Variable speed generators”,Taylor & Francis group, 2006 | | | | |

| REFERENCES: | |
|--------------------|---|
| 1. | <i>E.W.Golding “The generation of Electricity by wind power”, Red wood burn Ltd.,Trowbridge,1976.</i> |
| 2. | <i>N.Jenkins, “Wind Energy Technology”JohnWiley&Sons,1997.</i> |
| 3. | <i>S.Heir “Grid Integration of WECS”, Wiley1998</i> |

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|--|--|-----------|----------|----------|--------------------------|
| 17PEPE14 | ENERGY MANAGEMENT AND AUDITING | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To study the concepts behind economic analysis and Load management. | | | | |
| • | To emphasize the energy management on various electrical equipments and metering. | | | | |
| • | To illustrate the concept of lighting systems and cogeneration. | | | | |
| UNIT I | INTRODUCTION | 09 | | | |
| Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting- energy audit process. | | | | | |
| UNIT II | ENERGY COST AND LOAD MANAGEMENT | 09 | | | |
| Important concepts in an economic analysis-Economic models-Time value of money-Utility rate structures-cost of electricity-Loss evaluation-Load management :Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification. | | | | | |
| UNIT III | ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT | 09 | | | |
| Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines. | | | | | |
| UNIT IV | METERING FOR ENERGY MANAGEMENT | 09 | | | |
| Relationships between parameters-Units of measure-Typical cost factors- Utility meters- Timing of meter disc for kilowatt measurement-Demand meters –Paralleling of current transformers-Instrument transformer burdens-Multitasking solid-state meters-Metering location vs .requirements-Metering techniques and practical examples. | | | | | |
| UNIT V | LIGHTING SYSTEMS & COGENERATION | 09 | | | |
| Concept of lighting systems-The task and the working space-Light sources-Ballasts- Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality-Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration- feasibility of cogeneration- Electrical interconnection | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Learn about the need for energy management and auditing process | | | | |
| • | Learn about basic concepts of economic analysis and load management. | | | | |
| • | Understand the energy management on various electrical equipments. | | | | |
| • | Have knowledge on the concepts of metering and factors influencing cost Function | | | | |
| • | Learn about the concept of lighting systems, light sources and various forms of cogeneration | | | | |

| TEXT BOOKS: | |
|--------------------|--|
| 1. | Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc 2006 |
| 2. | Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, 1990. |
| 3. | Reay D.A, "Industrial Energy Conservation", 1 st edition, Pergamon Press, 1977. |
| REFERENCES: | |
| 1. | <i>"IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities", IEEE, 1996</i> |
| 2. | <i>Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003</i> |

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|---|--|-----------|----------|----------|--------------------------|
| 17PEPE15 | ELECTRIC VEHICLES AND POWER MANAGEMENT | L | T | P | C |
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To understand the concept of electrical vehicles and its operations | | | | |
| • | To understand the need for energy storage in hybrid vehicles | | | | |
| • | To provide knowledge about various possible energy storage technologies that can be used in electric vehicles | | | | |
| UNIT I | ELECTRIC VEHICLES AND VEHICLE MECHANICS | 09 | | | |
| Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparison of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics. | | | | | |
| UNIT II | ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS | 09 | | | |
| Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes. | | | | | |
| UNIT III | CONTROL OF DC AND AC DRIVES | 09 | | | |
| DC/DC chopper based four quadrant operations of DC drives– Inverter based/f Operation (motoring and braking) of induction motor drive system– Induction motor and permanent motor based vector control operation– Switched reluctance motor (SRM) drives. | | | | | |
| UNIT IV | BATTERY ENERGY STORAGE SYSTEM | 09 | | | |
| Battery Basics, Different types, Battery Parameters, Battery modelling, Traction Batteries. | | | | | |
| UNIT V | ALTERNATIVE ENERGY STORAGE SYSTEMS | 09 | | | |
| Fuel cell– Characteristics– Types– hydrogen Storage Systems and Fuel cell EV– Ultra capacitors. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Understand the operation of Electric vehicle | | | | |
| • | Knowledge on various energy storage technologies for electrical vehicles | | | | |
| TEXT BOOKS: | | | | | |
| 1. | Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Second Edition” CRC Press, Taylor & Francis Group, Second Edition (2011). | | | | |
| REFERENCES: | | | | | |
| 1. | Ali Emadi, Mehrdad Ehsani, John M. Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel Dekker, Inc 2010. | | | | |

| 17PEPE16 | NON-LINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS | L | T | P | C |
|--|--|-----------|---|---|---|
| | | 3 | 0 | 0 | 3 |
| Objectives | | | | | |
| • | To understand the non linear behavior of power electronic converters. | | | | |
| • | To understand the techniques for investigation on non linear behavior of power electronic converters | | | | |
| • | To analyze the non linear phenomena in DC to DC converters | | | | |
| • | To analyze the non linear phenomena in AC and DC Drives. | | | | |
| • | To introduce the control techniques for control of non linear behavior in power electronic systems. | | | | |
| UNIT I | BASICS OF NON-LINEAR DYNAMICS | 09 | | | |
| Basics of Nonlinear Dynamics: System, state and state space model, Vector field- Modelling of Linear ,nonlinear and Linearized systems ,Attractors, chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collisionbifurcation. | | | | | |
| UNIT II | TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA | 09 | | | |
| Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analysing stability | | | | | |
| UNIT III | NONLINEAR PHENOMENA IN DC-DC CONVERTERS | 09 | | | |
| Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control. | | | | | |
| UNIT IV | NONLINEAR PHENOMENA IN DRIVES | 09 | | | |
| Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives ,Nonlinear Phenomenon in PMSM Drives | | | | | |
| UNIT V | CONTROL OF CHAOS | 09 | | | |
| Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives. | | | | | |
| TOTAL :45 PERIODS | | | | | |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Find the non-linear phenomena | | | | |
| • | Analyze the behaviour of non-linearity in DC-DC Converters | | | | |
| • | Understand the concepts of chaos in power converters. | | | | |
| TEXT BOOKS: | | | | | |
| 1. | George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press 3. | | | | |

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|--------------------|---|
| 2. | StevenH Strogatz, Non linear Dynamics and Chaos, Westview Press |
| REFERENCES: | |
| 1. | <i>C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press, 2003</i> |

| 17PEPE17 | SMARTGRID | L | T | P | C |
|---|--|-----------|---|---|--------------------------|
| | | 3 | 0 | 0 | 3 |
| Objectives | | | | | |
| • | To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure. | | | | |
| • | To familiarize the power quality management issues in Smart Grid. | | | | |
| • | To familiarize the high performance computing for Smart Grid applications. | | | | |
| UNIT I | INTRODUCTION TO SMART GRID | 09 | | | |
| Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid ,Smart grid drivers, functions ,opportunities, challenges and benefits ,Difference between conventional &Smart Grid, National and International Initiatives in Smart Grid. | | | | | |
| UNIT II | SMART GRID TECHNOLOGIES | 09 | | | |
| Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plugin Hybrid Electric Vehicles(PHEV). | | | | | |
| UNIT III | SMART METERS AND ADVANCED METERING INFRASTRUCTURE | 09 | | | |
| Introduction to Smart Meters, Advanced Metering infrastructure(AMI) drivers and benefits, AMI protocols, standards and initiatives ,AMI needs in the smart grid ,Phasor Measurement Unit(PMU),Intelligent Electronic Devices(IED)&their application for monitoring & protection. | | | | | |
| UNIT IV | POWER QUALITY MANAGEMENT IN SMART GRID | 09 | | | |
| Power Quality &EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid ,Web based Power Quality monitoring, Power Quality Audit. | | | | | |
| UNIT V | HIGH PERFORMANCE COMPUTING FOR SMARTGRID APPLICATIONS | 09 | | | |
| Local Area Network(LAN) ,House Area Network(HAN), Wide Area Network(WAN), Broad band over Power line(BPL),IP based Protocols ,Basics of Web Service and CLOUD Computing to make Smart Grids smarter | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Develop more understanding on the concepts of Smart Grid and its present developments. | | | | |
| • | Develop about different Smart Grid technologies. | | | | |
| • | Acquire knowledge about different smart meters and advanced metering infrastructure. | | | | |
| • | Have knowledge on power quality management in Smart Grids | | | | |
| • | Develop more understanding on LAN,WAN and Cloud Computing forS mart Grid applications. | | | | |

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| TEXT BOOKS: | |
| 1. | Stuart Borlase“Smart Grid: Infrastructure, Technology and Solutions”, CRC Press2012. |
| 2. | JanakaEkanayake, NickJenkins, KithsiriLiyanage, JianzhongWu, AkihikoYokoyama, “Smart Grid: Technology and Applications”,Wiley2012. |
| REFERENCES: | |
| 1. | <i>VehbiC. Güngör, DilanSahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, CarloCecati, and Gerhard P. Hancke, “Smart Grid Technologies: Communication Technologies and Standards” IEEE Transactions On Industrial Informatics, Vol.7,No.4, November2011.</i> |
| 2. | <i>Xi Fang, Satyajayant Misra, GuoliangXue, and DejunYang “Smart Grid –The New and Improved Power Grid: A Survey”, IEEE Transaction on Smart Grids,vol.14,2012.</i> |

| 17PEPE18 | POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS | L | T | P | C |
|---|---|-----------|----------|----------|--------------------------|
| | | 3 | 0 | 0 | 3 |
| Objectives | | | | | |
| • | To provide knowledge about the stand alone and grid connected renewable energy systems. | | | | |
| • | To equip with required skills to derive the criteria for the design of power converters for renewable energy applications | | | | |
| • | To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems. | | | | |
| • | To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems. | | | | |
| • | To develop maximum power point tracking algorithms | | | | |
| UNIT I | INTRODUCTION | 09 | | | |
| Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) -Qualitative study of different renewable energy resources ocean ,Biomass ,Hydrogen energy systems :operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area. | | | | | |
| UNIT II | ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION | 09 | | | |
| Review of reference theory fundamentals-principle of operation and analysis :IG,PMSG,SCIG and DFIG. | | | | | |
| UNIT III | POWER ELECTRONICS FOR SOLAR | 09 | | | |
| Block diagram of solar photovoltaic system : line commutated converters(inversion-mode) – Boost stand buck-boost converters-selection of inverter, battery sizing ,array sizing-standalone PV systems- Grid tied and grid interactive inverters-grid connection issues. | | | | | |
| UNIT IV | POWER ELECTRONICS FOR WIND | 09 | | | |
| Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters-Standalone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues-Grid integrated PMSG and SCIG Based WECS. | | | | | |
| UNIT V | HYBRID RENEWABLE ENERGY SYSTEMS | 09 | | | |
| Need for Hybrid Systems-Range and type of Hybrid systems-Case studies of Wind-PV- Maximum Power Point Tracking(MPPT). | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Analyze the impacts of renewable energy generation on environment. | | | | |
| • | Understand the importance and qualitative analysis of solar and wind energy sources. | | | | |
| • | Apply the principle of operation of electrical machines for wind energy conversion and their performance characteristics. | | | | |
| • | Design suitable power converters for solar PV and wind energy systems. | | | | |

| TEXT BOOKS: | |
|--------------------|--|
| 1. | S.N.Bhadra,D. Kastha,& S.Banerjee “Wind Electrical Systems”, Oxford University Press, 2009. |
| 2. | Rashid .M.H “Power electronics Handbook”, Academic press, 2001. |
| 3. | Rai.G.D, “Non-conventional energy sources”, Khanna publishes,1993. |
| 4. | Rai.G.D, “Solar energy utilization”,Khannapublishes,1993 |
| REFERENCES: | |
| 1. | <i>Gray,L. Johnson, “Wind energy system”, prentice hall linc,1995.</i> |
| 2. | <i>B.H.Khan, " Non-conventional Energy sources", Tata McGraw- hill Publishing Company.</i> |
| 3. | <i>P.S.Bimbhra, “Power Electronics”, Khanna Publishers, 3rd Edition,2003.</i> |
| 4. | <i>FangLinLuoHongYe, “ Renewable Energy systems”, Taylor & Francis Group,2013.</i> |
| 5. | <i>R.Seyezhai and R.Ramaprabh, “Power Electronics for Renewable Energy Systems”, Scitech Publications, 2015.</i> |

| 17PEPE19 | ROBOTICS AND CONTROL | L | T | P | C |
|--|---|---|---|---|--------------------------|
| | | 3 | 0 | 0 | 3 |
| OBJECTIVES: | | | | | |
| • | To introduce robot terminologies and robotic sensors | | | | |
| • | To educate direct and inverse kinematic relations | | | | |
| • | To educate on formulation of manipulator Jacobians and introduce path planning techniques | | | | |
| • | To educate on robot dynamics. | | | | |
| • | To introduce robot control techniques. | | | | |
| UNIT I | INTRODUCTION AND TERMINOLOGIES | 09 | | | |
| Definition-Classification-History-Robots components-Degrees of freedom-Robot joints-coordinates-Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors-vision system-social issues. | | | | | |
| UNIT II | KINEMATICS | 09 | | | |
| Mechanism-matrix representation-homogenous transformation-DH representation-Inverse kinematics solution and programming-degeneracy and dexterity | | | | | |
| UNIT III | DIFFERENTIAL MOTION AND PATH PLANNING | 09 | | | |
| Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian-Robot Path planning. | | | | | |
| UNIT IV | DYNAMIC MODELLING | 09 | | | |
| Lagrangian mechanics-Two-DOF manipulator-Lagrange-Euler formulation-Newton-Euler formulation-Inverse dynamics | | | | | |
| UNIT V | ROBOT CONTROL SYSTEM | 09 | | | |
| Linear controls schemes-joint actuators-decentralized PID control- Extended Kalman Filter-computed torque control-force control- hybrid position force control- Impedance/ Torque control. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | | After completion of this course, the student will be able to: | | | |
| • | Understand the components and basic terminology of Robotics | | | | |
| • | Model the motion of Robots and analyze the workspace and trajectory Panning of robots | | | | |
| • | Ability to develop application based Robots | | | | |
| • | Formulate models for the control of mobile robots in various industrial applications | | | | |
| TEXT BOOKS: | | | | | |
| 1. | R.K.Mittal and I J Nagrath, "Robotics and Control", Tata MacGraw Hill, Fourth edition. | | | | |
| 2. | Saeed B. Niku, "Introduction to Robotics ", Pearson Education, 2002 | | | | |

| REFERENCES: | |
|--------------------|---|
| 1. | <i>Fu, Gonzalez and Lee Mcgra hill, "Robotics", international edition.</i> |
| 2. | <i>R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, AnIntegrated approach", Prentice Hall of India, 2003</i> |

| 17PEPE20 | NON LINEAR CONTROL | L | T | P | C |
|--|---|-----------|---|---|--------------------------|
| | | 3 | 0 | 0 | 3 |
| Objectives | | | | | |
| • | To impart knowledge on phase plane analysis of non-linear systems. | | | | |
| • | To impart knowledge on Describing function based approach to non-linear systems | | | | |
| • | To educate on stability analysis of systems using Lyapunov's theory | | | | |
| • | To introduce the concept of sliding mode control. | | | | |
| UNIT I | PHASE PLANE ANALYSIS | 09 | | | |
| Concepts of phase plane analysis-Phase portraits-singular points-Symmetry in phase plane portraits-Constructing Phase Portraits-Phase plane Analysis of Linear and Non linear Systems-Existence of Limit Cycles.simulation of phase portraits in matlab. | | | | | |
| UNIT II | DESCRIBING FUNCTION | 09 | | | |
| Describing Function Fundamentals-Definitions-Assumptions-Computing Describing Functions- Common Nonlinearities and its Describing Functions-Nyquist Criterion and its Extension- Existence of Limit Cycles-Stability of limit Cycles. Simulation of limit cycles in matlab. | | | | | |
| UNIT III | LYAPUNOV THEORY | 09 | | | |
| Nonlinear Systems and Equilibrium Points-Concepts of Stability-Linearization and Local Stability- Lyapunov's Direct Method-Positive definite Functions and Lyapunov Functions- Equilibrium Point Theorems-Invariant Set Theorems-LTI System Analysis based on Lyapunov's Direct Method- Krasovski' s Method-Variable Gradient Method-Physically- Control Design based on Lyapunov's Direct Method. | | | | | |
| UNIT IV | FEEDBACK LINE ARIZATION | 09 | | | |
| Feedback Linearization and the Canonical Form-Mathematical Tools-Input-State Linearization of SISO Systems-input-Output Linearization of SISO Systems-Generating a Linear Input-Output Relation-Normal Forms-The Zero-Dynamics-Stabilization and Tracking-Inverse Dynamics and Non-Minimum-Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design. Simulation of tracking problems in matlab. | | | | | |
| UNIT V | SLIDING MODE CONTROL | 09 | | | |
| Sliding Surfaces-Continuous approximations of Switching Controllaws-The modelling/Performance Trade-Offs- MIMO Systems. simulation of sliding mode controller in matlab. | | | | | |
| | | | | | TOTAL :45 PERIODS |
| OUTCOMES: | After completion of this course, the student will be able to: | | | | |
| • | Understand the concepts of non-linear control system. | | | | |
| • | Analyze the stability of the system | | | | |
| • | Illustrate the sliding mode control and implementation in MATLAB. | | | | |
| TEXT BOOKS: | | | | | |
| 1. | JA E SlotineandWLi, Applied Non-linear control, PHI, 1991. | | | | |
| 2. | K.P. Mohandas,Modern Control Engineering, Sanguine, India,2006 | | | | |
| 3. | HasanKhalil,“Non-linear systems and control”, PrenticeHall. | | | | |

| REFERENCES: | |
|--------------------|--|
| 1. | <i>S H Zak, "Systems and control", Oxford University Press,2003</i> |
| 2. | <i>Torkel Glad and Lennart Ljung, "Control Theory –Multi variable and Non-linear Methods", Taylor & Francis, 2002.</i> |
| 3. | <i>G. J.Thaler, "Automatic control systems", Jaico publishers,2006.</i> |