# ELECTRICAL ENGINEERING DEPARTMENT

## M.TECH. ELECTRICAL DRIVES

**Course of Study & Scheme of Examination**
**2016-17**


**Maulana Azad National Institute of Technology,**
**Bhopal**

# SCHEME

## M.TECH. (ELECTRICAL DRIVES)

### *First Semester*

| Course Number | Subject | Scheme of Studies Periods per week | | | Total Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| ED511 | Power Controller | 3 | - | - | 3 |
| ED512 | Electrical Drives | 3 | - | - | 3 |
| ED513 | Modeling & Analysis of Electrical Machines | 3 | - | - | 3 |
| ED531-542 | Departmental Elective - 1 | 3 | - | - | 3 |
| ED531-542 | Departmental Elective - 2 | 3 | - | - | 3 |
| ED551-556 | Open Elective-1 | 3 | - | - | 3 |
| ED514 | Digital Controller Lab | - | - | 3 | 2 |
| ED515 | Seminar I | - | 3 | - | 2 |
| Total credit 22 | | | | | |

### *Second Semester*

| Course Number | Subject | Scheme of Studies Periods per week | | | Total Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| ED521 | Advanced Power Electronics | 3 | - | - | 3 |
| ED522 | Advanced Control System | 3 | - | - | 3 |
| ED523 | DSP & Its Applications | 3 | - | - | 3 |
| ED531-542 | Departmental Elective - 3 | 3 | - | - | 3 |
| ED531-542 | Departmental Elective - 4 | 3 | - | - | 3 |
| ED551-556 | Open Elective-2 | 3 | - | - | 3 |
| ED524 | Machine & Drives Lab | - | - | 3 | 2 |
| ED525 | Seminar II | - | 3 | - | 2 |
| Total credit 22 | | | | | |

***Third Semester***

| Course Number | Subject | Scheme of Studies Periods per week | | | Total Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| ED611 | Dissertation Phase-I | - | - | 16 | 16 |
| | | | | Total credit 16 | |

***Fourth Semester***

| Course Number | Subject | Scheme of Studies Periods per week | | | Total Credits |
|---|---|---|---|---|---|
| | | L | T | P | |
| ED621 | Dissertation Phase-II | - | - | 30 | 30 |
| | | | | Total credit 30 | |

**List of Departmental Electives**

ED531 Power Quality
ED532 Traction Drives
ED533 Advanced Electrical Drives
ED534 Reactive Power Control and FACTS
ED535 Microcomputer Controlled Drives
ED536 Non-conventional Energy Sources and Converters
ED537 Special Machines
ED538 EHV AC & DC Transmission
ED539 Principle of Data Converter
ED541 PWM Techniques
ED542 Smart Grid Technologies

**List of Open Electives**

ED551 Finite Element Method
ED552 Microcomputer & its Application
ED553 Evolutionary Techniques
ED554 Economics of Regulation and Restructuring of Energy Industries
ED555 Instrumentation
ED556 Reliability Engineering

# SYLLABUS

**Course Number** : ED511

**Title of Course** : POWER CONTROLLER

**Designation as a required or elective course**: Required

**Pre-requisites** : Fundamental knowledge of Basic Electrical, Electronics and Control

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Acquire knowledge of power converters and applications

**Topics:**

Review of power semiconductor devices, series-parallel operation, various firing/driving circuit, Switching loss calculations, SOA and Heat Sink design, Analysis of 1-$\phi$ / 3-$\phi$ AC/DC bridge converter with and without freewheeling diode, Effect of source impedance, Multi pulse (12,18,24) rectifier, PWM rectifier, Analysis of non-isolated Buck, Boost, Buck-boost, Sepic & Cuk Converter in CCM and DCM with ideal and non-ideal components, Analysis of Isolated flyback, forward, push-pull, full bridge, half-bridge, & current fed DC-DC converter with ideal components. Interleaved Converters, Dynamic modelling of DC/DC converter and controller design. Analysis of 1-$\phi$ & 3-$\phi$ VSI (180° mode, 150° mode & 120° mode of conduction), Amplitude & harmonic control/reduction techniques, 1-$\phi$ and 3-$\phi$ CSI Inverter. Analysis of various 1-$\phi$ / 3-$\phi$ ac-ac regulator circuit.

**Reference Books :**

1. G.K.Dubey Doradla, Joshi, Sinha, Thyristorised Power Controllers, illustrated, New Age International, 1986
2. C.W.Lander, Power Electronics, 3 Sub edition, McGraw-Hill Europe;, April 1, 1994
3. Rashid M.H., Power Electronics, 4 edition, Pearson Prentice Hall;, 19 July 2013
4. B. R. PELLY, Thyristorised power controlled converters & cycloconverters, , Wiley-Blackwell, 1 January 1971
5. Joseph Vithayathi, Power Electronics appliCation, , McGraw Hill Education, 9 April 2010
6. Philip Kranes, Power Electronics, 1 edition, OUP, 1997**,** Ned Mohan,Tore M. Undeland, William P. Robbins, Power Electronics, 3rd Revised edition, Wiley, 8 November 2002

**Course Number** : ED512

**Title of Course** : ELECTRICAL DRIVES

**Designation as a required or elective course**: Required

**Pre-requisites** : Fundamental knowledge of Electrical Machines, Electronics and Control

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Acquire knowledge of electrical drives and their industrial applications

**Topics:**

Basics of Electrical Drives, Choice of Electrical Drives, Dynamics of Electrical Drives, Concept of Multi-quadrant operation, Components of load torques. Selection of motor power rating, Energy conservation in ED. D. C. Drives-Speed control. Starting & Braking, Controlled Techniques, Transient Analysis. IM Drives- Mathematical Modelling and Performance analysis, Operation with Unbalanced, Analysis of I.M. fed from Non-sinusoidal voltage supply, Starting, Braking, Transient and stability analysis, Speed Control by power electronics converter, , Rotor Resistance Control, Slip Power Control, Multi quadrant Drives of Induction Motor and Field Oriented Control.Single Phase I.M., Close Loop Control of I.M. Drives. SM Drives, Cylindrical Rotor Wound Field Motor, Salient Pole Wound Field Motor, Hysteresis Synchronous Motor, Operation from Fixed Frequency Supply, Starting, Braking, SM Variable Speed Drives.

**Reference Books:**

1. G.K.Dubey, Power semi conductor controlled drives, Prentice Hall, 1 December 1988
2. G.K.Dubey, Fundamentals of Electrical Drives, 2nd Revised edition, Alpha Science International Ltd, 15 October 2001
3. P.C.Sen, Electrical Machine & Power Electronics, 3rd edition, Wiley, September 23, 2013
4. S.A. Nasar, Electrical Drives, Second Edition, by CRC Press, 2005

**Course Number**: ED 513
**Title of Course**: MODELLING AND ANALYSIS OF ELECTRICAL MACHINES

**Designation as a required or elective course**: Required

**Pre-requisites**: Knowledge of electrical machines, Steady state and transient analysis

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: To acquire knowledge of electrical machine model for performance evaluation under normal and abnormal conditions.

**Topics:**

Primitive Machine, Voltage-current and torque equation for Kron"s Model, Park"s Transformation, Reference frame theory, steady state and transient analysis of DC, synchronous and induction machine using generalized approach, DC machine: time domain block diagram and state equation; Synchronous machine: Power angle characteristic, equivalent circuit analysis, calculation of reactance and time constant; Induction machine: unbalanced operation.

Modelling of AC and DC drive.

**Reference Books**:

1. P.C.Krause, Analysis of Electric Machinery,2 edition, Wiley IEEE Press, March 5, 2002
2. B.Adkins, The General theory of Electrical Machines, , Chapman and Hall, December 1964
3. B.Adkins & R.G.Harley, The General theory of AC Machines, Edition 1975, Springer, 4, 2013
4. P.S.Bhimbra, Generalised theory of Electrical m/c, , Khanna Publisher,
5. David C. Woodson, Herbert H. White, Electro Mechanical Energy Conversion, Wiley, 1959

**Course Number** : ED521

**Title of Course** : ADVANCED POWER ELECTRONICS

**Designation as a required or elective course** : Required

**Pre-requisites** : Fundamental knowledge Power Electronics, Basic Electronics and Control

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** :

- To learn drawbacks of power electronic converters and their solutions
- Learn and understand applications of Power Electronic converters
- Study and understanding of new breed of power converters

**Topics:**

Review of 1-phase and 3-phase Controlled Converters, Harmonics and Power Factor Calculations, High Power Factor Converters, DC-DC Switch Mode converter, Power Supplies, Switched Mode Inverters, Space Vector Modulation, Multilevel Inverters, Resonant Converters, Design of Magnetic Components.

Design and selection of components, Datasheet Ratings for Power Semiconductor Devices, Applications for Power Electronic Converters.

**Reference Books** :

1. N. Mohan,, Power Electronics Converters, Applications & Design, 3rd Revised edition, John Wiley & Sons, 8 November 2002
2. M. H. Rashid, Power Electronics Circuits Devices and Application, 4 edition, Pearson Prentice Hall, 19 July 2013
3. Joseph Vithayathil, Power Electronics:Principles and Applications, 1 edition, Delmar Cengage Learning, August 3, 2001
4. Philip T Krein, Elements of Power Electronics, OUP USA, 27 November 1997
5. P S Bimbhra, Power Electronics, Khanna Publishers, 1 January 2012

**Course Number**: ED 522

**Title of Course**: ADVANCED CONTROL SYSTEM

**Designation as a required or elective course**: Required

**Pre-requisites**: Knowledge of Linear control system

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Application of advanced control principles in linear and non-linear systems

**Topics:**

Controllers and compensators, state space representation, Transfer matrix, state model for linear continuous time systems. Eigen values, eigen vectors, Solution of state equation, concept of controllability and observability. Pole placement by state feedback, Discrete time control systems, time domain approach and z domain approach. Pulse transfer function, Controllability and observability of discrete time systems, stability analysis in z plane, Different types of nonlinearities, limit cycles, phase plane methods, Describing functions, popov criterion, Liapunov functions, Various techniques of system model order reduction, Introduction to adaptive control system, Principle of optimality, Linear optimal regulator problem, Hamilton Jacobi equation, Riceati equation (Algebraic & differential), steady state solutions (LQR), optimal state estimation, Kalman filter, Output feedback control (LQG).

Design and implementation of Modern controllers for digital and analogue systems.

**Reference Books**:

1. M.Gopal, Digital Control Engineering, Wiley-Blackwell, 25 May1988
2. A.P.Sage & Landue, Adaptive and Optimal Control
3. Katsuniko Ogata, Discrete Time Control System, 2 edition, Pearson, January 19, 1995
4. Nagarth Gopal, Modern Control Engineering, 5 edition, Pearson, 25 August 2009

**Course Number** : ED523

**Title of Course** : DSP & ITS APPLICATIONS

**Designation as a required or elective course** : Required

**Pre-requisites** : Fundamental knowledge of digital electronics and microprocessor

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Acquire knowledge of modern digital controllers and their industrial applications

**Topics:**

Architectural Overview & Central Processing Unit, Memory map, CPU Architecture of TMS320F2812, Details of CPU Registers & Accumulator, Introduction to Interrupts of TMS320F2812, Emulation Logic, CPU Interrupts Overview, CPU Interrupt Vectors and Priorities, Maskable Interrupts, Nonmaskable Interrupts, Pipeline: Pipelining of Instructions, Instruction-Fetch Mechanism, Address Counters FC, IC, and PC, Pipeline Protection, Avoiding Unprotected Operations, Addressing Modes: Types of Addressing Modes, details of various Addressing Modes, Alignment of 32-Bit Operations. Assembly Language Instructions and emulation: Instruction Set Summary (Organized by Function), Register Operations, Overview of Emulation Features, Debug Interface.

Applications of DSP for Power Electronics & Drives Control.

**Reference Books:**

1. W.D.Stanley, Digital Signal Processing
2. Ashok Ambardar, Analog & Digital Signal Processing
3. S. Mitra, Digital Signal Processing, 4 edition, Pearson, 28 March 2006
4. Reference manual from Texas Instrument
5. www.ti.com

## DEPARTMENTAL ELECTIVES

**Course Number** : ED531

**Title of Course** : POWER QUALITY

**Designation as a required or elective course** : Elective

**Pre-requisites** : Fundamental knowledge of Power System and Power Electronics

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Monitoring and improvement of Power Quality

**Topics**:

Power Definition and Components with sinusoidal and non-sinusoidal voltage & current, Understanding Power quality, Causes and effects of power quality disturbances, Causes and effects of harmonics, converter configuration and their contribution to supply harmonics. Elimination/suppression of harmonics, classical solutions & their drawbacks, elimination/suppression of harmonics, passive and active solutions, topologies and their control methods, design of passive and active filters, EMI Issues, Wiring & Grounding,

PQ standards, Power quality monitoring and analysis of utilities, distribution system and industrial customers, Power quality measuring instruments.

**Reference Books** :

1. R.C. Duggan, Mark F McGranaghan, H Wayne Beaty, Electrical Power Systems Quality, 3 edition, Mc-Graw-Hill, 1 March 2012
2. Derek A. Paice, Power Electronic Converter Harmonics, (IEEE Press) IEEE Inc. New York, 31 January 1996
3. Math H J Bollen,, Understanding Power Quality Problems, (IEEE Press) Standard Publishers Distributors, Delhi,Wiley-Blackwell, 24 September 1999
4. T J E Miller, Reactive Power Control in Electric Systems, Wiley, 2010
5. J. Arrillga, N R Watson, Power system harmonics, 2nd Revised edition, Wiley-Blackwell, 3 October 2003

**Course Number** : ED532

**Title of Course** : TRACTION DRIVES

**Designation as a required or elective course** : Departmental Elective

**Pre-requisites** : Fundamental knowledge of Power System and Electrical Machines

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Application of Power System and Electrical Machines in traction systems

**Topics:**

Introduction to Electric Traction Systems, preliminary investigations of energy consumption, Traction Drives rating, Traction Motors, Conventional DC & AC traction drives, Semiconductor converter controlled drives, Polyphase AC motors for traction drives, Battery operated vehicles, Diesel-Electric Traction systems Conservation of Electrical energy.

Battery operated vehicles.

**Reference Books :**

A.T.Dover, Electric Traction, 4th edition, Sir Isaac Pitman & Sons Ltd, 1963

1. G.K.Dubey, Dorodla, Joshi & Sinha, Thyristorised Power Controllers, Wiley, (November 12, 1986)
2. Pratab, Modern Electric Traction, Pritam Surat & Brothers, 1973

**Course Number** : ED533

**Title of Course** : ADVANCED ELECTRICAL DRIVES

**Designation as a required or elective course** : Departmental Elective

**Pre-requisites** : Fundamental knowledge of Electrical Machines and power electronics

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Application of Power Electronic Converters and Control System in Industrial Drives

**Topics:**

Introduction to Electrical Drives: Their dynamics & control, Induction Motor Drives. Starting & braking, VSI control, CSI control, Synchronous Motor and Brushless Dc Motor Drives, Brushless dc drive, Permanent Magnet SM Drive, control fundamentals, converter configuration, synchronization, trapezoidal and sinusoidal drive control structure, performance, Switched Reluctance Motors, performance characteristics, Stepper motor and switch reluctance motor drives, solar and battery powered drives.

**Reference Books :**

1. G.K.Dubey, Power semi conductor controlled drives, Prentice Hall, January 1989
2. G.K.Dubey, Fundamentals of Electrical Drives, 2nd Revised edition, Alpha Science International Ltd, 15 October 2001
3. B.K. Bose, Power electronics and variable frequency drives, Wiley-Blackwell, 21 September 1996

**Course Number** : ED534

**Title of Course** : REACTIVE POWER CONTROL AND FACTS
**Designation as a required or elective course** : Departmental Elective

**Pre-requisites** : Fundamental knowledge of Power System, Electrical Machines and power electronics

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Application of Power Electronics in Power System

**Topics:**

Reactive Power Requirement and necessity of Compensation, Objectives in Load Compensation, Dynamic Power Compensation, Passive Compensation: SVC, TCR etc. Classification of FACTS devices. Shunt Compensators: STATCOM - Characteristics and Device selection (GTO/SCR/IGBTs), STATCOM Control Strategies and applications. Series Compensation: SSSC - Compensator characteristics and control Strategies, SSC applications. TCSC- Compensator characteristics and control Strategies, TCSC applications Series-shunt Compensation: UPFC - Principle of operation, configuration and control, Simulation of UPFC, Steady State Model of UPFC.

Sub synchronous resonance and its mitigation with FACTS devices, Power system Control using FACTS devices.

**Reference Books :**

1. T J E Miller, Reactive Power Control in Power Systems, John Wiley, 1982
2. Prabha Kundur, Power system Stability and control, McGraw-Hill Education, 1 March 1994
3. N G Hingorani and L Gyugyi, Understanding FACTS, IEEE Press, 2000
4. Yong-Hua Song and Xi-Fan Wang,Operation of market oriented power systems, Springer-Verlag London
5. Y.H. Song and A.T. Johns, Flexible ac Transmission Systems (FACTS), IEE Press, 1999

**Course Number** : ED535

**Title of Course** : MICROCOMPUTER CONTROLLED DRIVES
**Designation as a required or elective course** : Departmental Elective

**Pre-requisites** : Fundamental knowledge of Electrical Machines and basic electronics and microprocessor

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Application of digital controllers in electrical drives

**Topics:**

DC Drives- Converters, Microcontroller hardware circuit, Performance characteristics of DC drive. Chopper fed DC Drives, hardware, circuits and waveforms. Performance Characteristic of AC Drives - Description and Performance behavior of 3-phase IM drive, Microcomputer controlled inverter fed AC drive Waveforms for 1-phase, 3-phase non PWM and 3-phase PWM inverter fed induction drives, Sampling techniques for PWM inverter. Mathematical modeling of frequency controlled induction drive, mathematical model of the system for steady state and dynamic behavior, Study of stability based on the dynamic model of the system.
Close loop control of microcomputer based Drives.

**Reference Books**:

1. Dubey G.K., Power semiconductor controlled drives, Prentiee-HALL, 1989
2. Bose B.K., Power electronics and variable frequency drives, IEEE Press, 1997
3. Bose B.K, Microcomputer control of power electronics and drive, IEEE Publications U.S., 1 June 1987
4. V. Subramanyam, Thyristor control of Electronic drive, McGraw Hill Education, 16 December 1987
5. Bose B.K, Adjustable AC drive
6. Leonard W, Control of electric drives, 3rd edition, Springer, September 21, 2001

**Course Number** : ED536

**Title of Course** : NON-CONVENTIONAL ENERGY SOURCES AND ENERGY CONVERTERS
**Designation as a required or elective course** : Departmental Elective
**Pre-requisites** : Fundamental knowledge of Conventional Energy Systems

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Exploring new and renewable energy sources

**Topics:**

Energy for sustainable development, Renewable and Non-renewable Energy sources, mini-micro hydro, small hydro systems, Different type of turbines, generators & controls, Wind energy: Wind Energy Conversion, Potential, Site selection, Types of wind turbines, Wind Generation and Control. Solar Radiation, Measurement and Estimation, Solar Thermal Conversion Devices and Storage and Applications, Solar Photovoltaic Conversion, applications of solar PV, Stand alone/grid connected, Energy Alternatives: The Nuclear Option, Wave and Tidal Energy, Geothermal, Bio energy, Ocean thermal energy systems, MHD & fuel cells.

**Reference Books**:

1. Chetan Singh Solanki, Solar Photovoltaics: Fundamental Technologies and Applications, 2 edition, Prentice Hall India Learning Private Limited, 2011
2. Chetan Singh Solanki, Renewable Energy Technologies: Practical Guide for Beginners, Prentice Hall India Learning Private Limited, 2008
3. Sawhney G.S., Non-conventional Energy Resources, Khanna, 1 December 2004
4. By Philip R Pryde, Non-conventional Energy Resources, McGraw Hill Education, 26 May 2009
5. R. K. Rajput, Non-conventional Energy Sources and Utilization, S.Chand (G/L) & Company Ltd, 2012
6. B. H. Khan, Non-conventional Energy Resources, 2 edition, TMH Publication, 26 May 2009
7. G. D. Rai, Non-conventional Energy Resources, Khanna Publication, 1 December 2004

**Course Number**: ED-537

**Title of Course**: SPECIAL MACHINES

**Designation as a required or elective course**: Departmental Elective

**Pre-requisites**: Knowledge of Power Electronics, Electrical Machines and Drives, Power converters

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Exploring possibilities of special machines in industrial applications

**Topics:**

Review of drives. Principle, construction, operation & control of special machines: switch reluctance motor, brushless DC motor, stepper motor, linear induction motor, hysteresis motor. Energy efficient motors.

Control and applications of special machines.

**Reference Books:**

J.M.D. Murphy, Power electronics control of AC machine, 1st edition, Franklin Book Co, March 1988

1. T.J.E. Miller, BrushlessPermanent-magnet and reluctance motor Drives, Clarendon Press, 2 March 1989
2. B.K.Bose, Power electronics and variable frequency drives edited, IEEE Press, 1997
3. J.C. Andreas, Energy efficient electric motors, 3 edition, CRC Press, August 30, 2004
4. K Venkataratnam, Special Electrical Machines, First edition, Universities Press, 2008

**Course Number**: ED-538

**Title of Course**: EHV AC & DC TRANSMISSION

**Designation as a required or elective course**: Departmental Elective

**Pre-requisites**: Knowledge of Power Electronics, Electrical Machines and Power System

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Application of power electronics and control in EHV AC & DC Systems

**Topics:**

Long line theory, corona power loss and audible noise. Reactive Power compensation of EHV AC lines, FACTs devices, Sequential impedances of AC systems EHVAC transmission overvoltages, insulation design of lightning and switching over voltages. High voltage testing of AC equipments, Comparison of EHV AC & DC transmission HVDC system configuration and components conversion and inversion, Analysis of three phase bridge converter and Performance equations, Control of HVDC system, Principle of DC link control, current and Extinction angle control, Transmission power control, alternative inverter control modes, Harmonics and AC/DC filters, Interaction responses to DC and AC system faults, Modelling of HVDC system.

**Reference Books:**

1. Begemudre R.D., “EHVAC Transmission Engineering” – Willy Eastern Ltd.
2. P.Kundur “Power System Stability and Control” - Mc Graw Hill Publication.
3. Arrillaga J., “HVDC Transmission” - Peter Peregrinus Pub.
4. Rao S., “EHV AC & HVDC Transmission Systems” - Khanna Pub.
5. Padiyar K.R., “HVDC Power Transmission Systems” – Willy Eastern Ltd.

**Course Number**: ED-539

**Title of Course**: PRINCIPLE OF DATA CONVERTERS

**Designation as a required or elective course**: Open Elective

**Pre-requisites**: Knowledge of Discrete system and Electronics devices.

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Knowledge of data converters employed in Processors and embedded systems. .

**Topics**:
Review of Discrete Time Signals**,** Fourier Series and Transforms, Z-transform. Nyquist Sampling Theorem, Different types of Sample and Hold circuits, Voltage References. Design Fundamentals for Analog ICs**:** MOSFETs and MOS devices, Op-Amp circuits design. Advanced Filters: Gm-C Filters, MOSFET-C Filters. Switched Capacitor Circuits: Switched Capacitor Amplifiers, Integrators and Switched Capacitor Filters. Nyquist Rate ADC: Flash, Interpolating, Folding Flash, SAR and Pipelined architectures.

Nyquist Rate DAC: Voltage, Current and Charge mode converters, Hybrid and Segmented Converters. Oversampled A/D and D/A converters, Delta-Sigma data converters, Data Converters in μC, DSP and Embedded systems.

**Reference Books:**

1. R. Jacob Baker: CMOS Mixed Signal Circuits Design, Willey-IEEE 2nd edition 2008
2. ***R. Gregorian and Ternes: Analog MOS integrated circuits for signal processing, JosseyBass, 1986.***
3. R.Gregorian: Introduction to CMOS OP-AMPs and comparators, John-Wiley, 1999.
4. D.Johns and K.Martin: Analog integrated circuit design, John-Wiley, 1997.
5. B.Razavi: Monolithic Phase-locked loops and clock recovery circuits: Theory and design, Wiley-IEEE Press, 2008.
6. R. J. Baker: CMOS: Mixed-Signal Circuit Design, (2nd edition) 2008

**Course Number** : ED-541

**Title of Course** : PWM TECHNIQUES FOR POWER CONVERTERS

**Designation as a required or elective course** : Elective

**Pre-requisites** : Fundamental knowledge of Power Electronics and Basic Electronics

**Contact hours** : 03

**Type of Course** : Lecture

**Course Assessment methods** : Both continuous and semester-end assessment

**Course Outcomes** : Effective control of Power Converters

**Topics:**

Introduction to Power Electronic converters and need of modulation schemes, fundamentals of Pulse Width Modulation, Modulation of one inverter phase leg, Modulation of 1-phase and 3-phase VSI, Fundamental of SPWM and SVPWM Techniques, Over modulation of converters, Active switch pulse width determination, Active switch pulse placement within a switching period, Active switch pulse sequence between phase legs and across switching periods, pulse width modulation for multilevel inverters, Implementation of modulation controller, Continuing developments in modulation as random PWM, PWM for voltage unbalance, Effect of minimum pulse width and dead time.

**Reference Books:**

1. D. Grahame Holmes, Thomas A.Lipo, Pulse width modulation of Power Converter: Principles and Practice, John Wiley & Sons, 03-Oct-2003.
2. Bin Wu, High Power Converter, Wiley Publication
3. Marian K.Kazimicrczuk, Pulse width modulated dc-dc power converter, Wiley Publication
4. N. Mohan, Power Electronics : Converters, Applications & Design, John Wiley & Sons, Pearson Education
5. nptel.ac.in and IEEE papers

**Course Number**: ED542

**Title of Course**: SMART GRID TECHNOLOGIES

**Designation as a required or elective course**: ELECTIVE

**Pre-requisites**: Distribution systems and Measuring instruments.

**Outcome:** After undergoing the course, the students would get acquainted with the smart technologies, smart meters and power quality issues in smart grids.

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods:** Both continuous and semester-end assessment

**Topics**:

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

Smart energy resources, Smart substations, Wide area monitoring, Protection and control, Phasor Measurement Unit (PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection Distribution systems: DMS, Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, Phase Shifting Transformers.

Plug in Hybrid Electric Vehicles (PHEV). Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid. Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, IP based Protocols, Cyber Security for Smart Grid.

**Reference Books:**

1. StuartBorlase, „SmartGrid:Infrastructure,Technologyand Solutions", CRC Press2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, „Smart Grid: Technology and Applications",Wiley ,2012.
3. Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, „Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions On Industrial Informatics,Vol. 7, No.4, November 2011.
4. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang „Smart Grid – The New and Improved Power Grid: A Survey", IEEE Transaction on Smart Grids, 2011.

## OPEN ELECTIVES

**Course Number**: ED-551

**Title of Course**: FINITE ELEMENT METHODS

**Designation as a required or elective course**: Open Elective

**Pre-requisites**: Fundamental Knowledge of mathematics and system theory

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Analysis and Simulation of electrical system using FEM approach

**Topics:**

Various approaches in FEM, direct stiffness method, energy approach and galerkin‟s approach, detailed method for stress and vibration analysis problems, various elements, development of element stiffness matrices. Applications to bar, beam, truss, spring, shafts, plates and shells. Isoparametric elements, plate bending and shell elements, Axi-symmetric problem, vibration problem, software such as IDEAS, ANSYS, Norton, used in FEM, Nonlinear FEA.

**Reference Books:**

1. O.C. Zienciwicz., Finite element method, 7 edition, Butterworth-Heinemann, 2 Oct. 2013
2. C.S. Krishnamurthy, Finite element method, 2 edition, McGraw Hill Education, 15 June 2001
3. Logon, Finite element method, 5th edition, Cengage Learning, 15 April 2010
4. Heubner, Finite element method, 4th Revised edition, John Wiley & Sons, 9 November 2001

**Course Number**: ED-552

**Title of Course**: MICROCOMPUTER AND IT"S APPLICATIONS

**Designation as a required or elective course**: Open Elective

**Pre-requisites**: Fundamental Knowledge of digital electronics and microprocessor

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Application of digital controllers in electrical systems

**Topics:**

Programmable Peripheral Devices: PPI 8255, various operating modes, fixing diagram, PIT 8253, programming and modes of operation, PIC 8259, operating modes.

Interfacing of peripherals, A/D & D/A converters, 8255, 8253, 8259 with 8/16 bit microprocessor/Data Acquisition system. Microcontroller - 8051 Architecture, Counter/Timers, Instructions, Programming, Interfacing, Applications, Comparison of 8085, 8086, 8057 etc. Programmable logic controller: PLC Architecture, programming, Counter/Timers and its applications.

Applications of Microcontroller and PLC for Drives Control.

**Reference Books:**

1. Gaonkar, Microprocessor Architecture programming & applications, 6th edition, Penram International Publishing,1 October 2013
2. D.V.Hall, Microprocessors & interfacing, McGraw-Hill Inc., 1 June 1986
3. Gary Dunning, Introduction to programmable logic controller, 3rd edition, Thomson/Delmar Learning, December 16, 2005
4. K.J.Ayala, The 8051 Microcontroller, 2 nd edition, pearson,
5. B.Ram., Fundamental of microprocessor and microcomputers, Dhanpat Rai Publications (P) Ltd., 2012

**Course Number**: ED-553

**Title of Course**: EVOLUTIONARY TECHNIQUES

**Designation as a required or elective course**: Open Elective

**Pre-requisites**: Fundamental Knowledge of computer programming

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Application of AI techniques in electrical systems

**Topics:**

Optimization: single objective, multi-objective and constraint problem, linear, non-linear and NP hard problem, combinatorial optimization, Conventional optimization method (lambda and differential). greedy optimization technique, Simple genetic algorithm, Multi-objective genetic algorithm. Artificial neural network, Fuzzy logic, Ant colony optimization, Particle swarm optimization, Basic simulated annealing. Basic tabu search method, Bacteria forging and Fish schooling optimization. Bee flying optimization.

AI Application in Electrical Systems.

**Reference Books** :

1. J.M.Zurada, Introduction to Artificial Neural System , Jaico Publ. House Bombay
2. V.Rao & H.Rao, C++ Neural Networks and Fuzzy Logic, 2 Pap/Dsk edition, M & T Books, October 1995
3. Marco Dorigo and Thomas Stutzle, Ant Colony Optimization, A Bradford Book, June 4, 2004
4. D.E. Goldberg, Genetic Algorithm in Search Optimization and machine learning, 13th edition, Addison Wesley, 1 January 1989

**Course Number**:ED-554

**Title of Course**: ECONOMICS OF REGULATION AND RESTRUCTURING OF ENERGY INDUSTRIES

**Designation as a required or elective course**: Open Elective

**Pre-requisites**: Fundamental Knowledge of electrical power market

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Acquiring knowledge of restructuring of electrical power utilities

**Topics:**

Introduction to economic regulation, principles of regulation, Monopoly, competition and its Regulation, Traditional regulation, rate of return regulation, problems with rate of return regulation, restructuring options and understanding restructuring issues, Transmission Network and Wholesale Market Institutions, Retail Competition and Customer Choice.

The Economics and Politics of Government Ownership, Concept of economic regulation of energy industries.

**Reference Books:**

1. Hunt, S, Making competition work in electricity, John Wiley & Sons, 2002
2. Hunt, S. and G. Shuttleworth, Competition and Choice in electricity, Wiley, 1996
3. Newbery DMG, Privatisation, restructuring and regulation of network Utilities, MIT Press, 2000
4. W. K. Viscusi, JM, Vernon and JE Harrington, Economics of Regulation and Anti-trust, 3rd edition, MIT Press, 2000

**Course Number**: ED-555

**Title of Course**: INSTRUMENTATION

**Designation as a required or elective course**: Open Elective

**Pre-requisites**: Fundamental Knowledge of electrical measurements

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Industrial application of electrical and electronics instrumentation

**Topics:**

Transducers - Measurement of Displacement. Resistive potentiometers, strain gauges, differential transformer, synchros, induction potentiometers, piezoelectric, optical, Digital displacement transducers, Magnetic, speed, torque, voltage, current, power, frequency, power factor and phase angle measurement. Signal Conditioning - Necessity, Instrumentation amplifiers, chopper stabilized amplifiers, Impedance converters, Noise problems, shielding and grounding, Active & Passive filters, Dynamic compensation, Linearization, Concept of A/D and D/A Converters, Sample/hold amplifiers, Microprocessor applications in signal conditioning, Data Transmission & Recording.

Microprocessor Based Measurement of Electrical Quantities, Computerized Data Acquisition System.

**Reference Books**:

1. Ernest O.Docbelin., Measurement systems, Application and Design, 4th Revised edition, McGraw Hill Higher Education, 1 January 1990
2. A.K.Shawny, Electrical and electronic measurement, 19 th edition, Dhanpat Rai & Company, 2014
3. B.Ram, Fundamental of microprocessor and microcomputers

**Course Number**: ED556

**Title of Course**: RELIABILITY ENGINEERING

**Designation as a required or elective course**: Open Elective

**Pre-requisites**: Basic concepts of Probability theory

**Contact hours**: 03

**Type of Course**: Lecture

**Course Assessment methods**: Both continuous and semester-end assessment

**Course Outcomes**: Knowledge of reliability theory will enable students in understanding system planning with greater efficacy.

**Topics:**

Basic Concepts of Reliability-indices and criteria, use of probability theory for reliability evaluation, System Reliability Evaluation using Probability Distributions- series, parallel and series-parallel, MTTF, MTBF, concept of redundancy, Markov Modelling, Frequency and Duration techniques, Generating System Reliability Analysis-recursive model building, Distribution System Reliability analysis-application to radial networks, Effect of protection system and their failures.

Case studies concerning reliability analysis of power and distribution system.

**Reference Books**:

1. R. Billinton, R.N.Allan,, Reliability Evaluation of Engg. System
2. G.H.Sandler, System Reliability Engg.
3. Endreynil, Probabilistic Reliability Evaluation