MASTER OF TECHNOLOGY
in
POWER ELECTRONICS AND DRIVES

Scheme & Syllabi

w. e. f. 2020-21

DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITTUE OF TECHNOLOGY ANDHRA PRADESH

NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF ELECTRICAL ENGINEERING

VISION

To be at the forefront of education, research and transformational technologies that have the potential to address the societal challenges faced in India today with regard to energy.

MISSION

- Impart quality education using instrumental teaching-learning methods and state-of-the-art resources to produce globally competent electrical engineers.
- To prepare students for the full range of career opportunities in the research/high technology marketplace, enabling them to reach their fullest potential as a professional and as a responsible member of the society.
- Nurture scientific temperament, professional ethics and industrial collaboration

GRADUATE ATTRIBUTES

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation.These attributes are generic and are common to all engineering programs.These Graduate Attributes are identified by National Board of Accreditation.

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/Development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Department of Electrical Engineering

M. Tech. in Power Electronics and Drives

Program Educational Objectives (PEOs)

PEO1	To arm the engineering graduates with latest technology and skills in the areas of Power Electronics and Drives so as to excel in higher education and/or industry and/or teaching and/orresearch.
PE02	To transform engineering graduates to expert engineers so that they could comprehend, analyse, design and create novel products and solutions to problems in the areas of Power Electronics and Drives that are technically sound, economically feasible and socially acceptable.
PE03	To train engineering graduates to exhibit professionalism, keep up ethics in their profession and relate engineering issues to address the technical and social challenges
PE04	To improve the communication skills, willingness to work in groups and to develop multidisciplinary approach in problem solving

Department of Electrical Engineering

M. Tech. in Power Electronics and Drives

Program Outcomes (POs)

Students will:

PO1	have an ability to evaluate and analyse problems related to Power Electronics and incorporate the principles in the state of art drives
P02	be able to investigate critical power electronics and drives problems and to arrive at possible solutions independently, by applying theoretical and practical considerations
P03	be able to work on small, well-defined projects with particular goals to provide real time solutions pertaining to power electronics and drives
P04	be able to choose, learn, apply and develop appropriate control techniquesincluding prediction for modern power electronic and drives using sophisticated digital controllers and IT tools.
PO5	be able to participate in collaborative-multidisciplinary engineering / research tasks and work as a team member giving due consideration to ecological and economical intricacies, and lead the team in specific areas
PO6	be able to confidently interact with the industrial experts for providing consultancy
PO7	be a responsible professional with intellectual integrity, code of conduct and ethics of research, being aware of the research outcomes and serve towards the sustainable development of the society

Department of Electrical Engineering

M. Tech. in Power Electronics and Drives

Course Structure

I - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Electrical Machine Analysis	4	0	0	4	PCC
2		Power Converters for DC Loads	4	0	0	4	PCC
3		DC Drive Systems	4	0	0	4	PCC
4		Department Elective – I	3	0	0	3	DEC
5		Open Elective – I	3	0	0	3	OEC
6		Power Electronics and DC Drives Lab	0	0	3	2	PCC
7		Seminar-I	0	0	2	1	PCC
		Total	18	0	5	21	

I - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Power Converters for AC Loads	4	0	0	4	PCC
2		AC Drive Systems	4	0	0	4	PCC
3		Department Elective – II	3	0	0	3	DEC
4		Department Elective - III	3	0	0	3	DEC
5		Open Elective – II	3	0	0	3	OEC
6		AC Drives Lab	0	0	3	2	PCC
7		Seminar – II	0	0	2	1	PCC
		Total	17	0	5	20	

II - Year I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Mandatory Elective Course - I * (ERA/NPTEL/SWAYAM/MIT)				2	PCC
2		Mandatory Elective Course - II * (ERA/NPTEL/SWAYAM/MIT)				2	PCC
3		Comprehensive Viva				2	PCC
4		Dissertation Part A				8	PCC
		Total				**14**	

**The student can register for two number of online courses at any point of time since their admission. However, the course completion cum pass certificates shall be submitted by the end of third semester for fulfilling the curriculum.*

II - Year II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Dissertation Part B				16	PCC
		Total				16	

List of Electives

Department Elective I:

1. Advanced Power System Analysis
2. Linear and Non-Linear Systems Theory
3. Artificial Intelligence Techniques and Applications
4. Digital Signal Processing

Department Elective II:

1. Converters for Renewable Energy Systems
2. Application of Power Electronics in Power Systems
3. Power Electronic Circuit Applications in Industry
4. Embedded Systems

Department Elective III:

1. Special Machines
2. Hybrid Electric Vehicles
3. Electric Traction
4. Industrial Control Electronics

Open Elective I:

1. Energy Management & Audit

Open Elective II:

1. Renewable Energy Systems

Course Title:ELECTRICAL MACHINE ANALYSIS

Course Objective: This course deals with the development of mathematical models for electrical machines, suitable for transient analysis of machine performance. This course gives a comprehensive understanding of various reference frame theory used in electrical machine analysis; mathematical transformations for decoupling variables. Mathematical modeling of induction motor and synchronous motor. Further an overview of Special Machines like PMSM, stepper, SRM is given.

Pre-requisites: Basic course in Electric Machines, electric and magnetic circuits.

Course Outcomes: At the end of the course the student will be able to:

1. Determine the developed torque in an electrical machine using the concepts of field Energy and co-energy.
2. Understand the concept of various reference frames and determine the dynamic model of an induction machine based on the dq0 Transformation
3. Determine instantaneous torque developed in an induction Machine and advanced control strategies such as vector control and direct torque control.
4. Determine the torque developed in a salient pole synchronous machine using the Park's transformation and identify contribution of saliency torque- damping torque and excitation torque.

Course contents:

Basic Principles of Electrical Machine Analysis:
Basics of magnetic circuits- Analysis with singly excited electromechanical system- linear and nonlinear magnetics using energy and co-energy principles.

Reference Frame Theory:
Stationary Reference Frame- arbitrary speed reference frame- synchronous reference frame- rotating reference frame- power invariance and non-power invariance.

Symmetrical Induction Machines:
Introduction to steady state and transient modelling of electrical machines- derivation of dq0 model for a symmetrical induction machine-voltage, flux and torque equations - analysis of steady state and state-space model of induction machine- small signal modelling of induction machine.

Synchronous Machines:
Review of steady state modelling of synchronous motors- voltage, flux, and torque- derivation of dq0 model for a salient pole synchronous machine- torque expression

Reference Books:

1. L.F Blume, 'Transformer Engineering', *John Wiley & Sons, Inc*, New York, 1967.
2. Fitzgerald & Kingsley, 'Electric Machinery' *McGraw Hill Co*. New Delhi, 2004.
3. Langsdorf A., 'Theory of Alternating Current Machinery', *McGraw Hill Co*. New Delhi, 2004.
4. BoldeaI. &S.A.Nasar, 'Induction Machine Handbook', *CRC Press*, New York, 2002.
5. C.M.Ong, 'Dynamic Simulation of Electric Machinery using Matlab/Simulink', *Prentice Hall PTR*, New Jercy, 1998.

Course Title:POWER CONVERTERS FOR DC LOADS

Course Objective: To apply systematic approach for transient and steady state analysis of all power electronic converters with passive and active loads

Course Outcomes:
Upon completion of the course, the students will be able to
1. To study and analyse transient response of basic power electronic circuits.
2. To understand the working of commonly used power Converters.
3. To analyse and design various power converter systems.

Prerequisites: Power Electronics in UG

Course contents:

Three-phase uncontrolled Rectifiers, Three-phase controlled half wave, full bridge, Semi/Half rectifiers – Analysis of output and input parameters in detail-continuous and discontinuous mode of operation.

Multi-pulse rectifiers – Analysis, PWM rectifiers - operation and control

DC/ DC Converters – Buck, Boost, Buck-Boost, Cuk – Analysis of output and input parameters-continuous and discontinuous mode of operation

Soft-switching DC - DC converters: Zero-voltage-switching converters, zero-current - Switching converters, Cascaded DC/DC converters – ripple reduction and its advantages

Analysis of HVDC Converters, Rectifier and Inverter operation of Graetz circuit without and with overlap. Output voltage waveforms and DC voltage in both rectifier and inverter operation

Reference Books:

1. Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons. Inc, Newyork, 2006.
2. Rashid M.H.,‘ Power Electronics-Circuits, Devices and Applications‘, Prentice Hall India, New Delhi, 2009.
3. P.C Sen., ‘Modern Power Electronics’, Wheeler publishing Company, 1st Edition, New Delhi, 2005.
4. Batarseh, ‘Power Electronic Circuits’, John Wiley, 2nd Edition, 2004.
5. Kimbark, E.W., ‘Direct Current Transmission-vol.1’, Wiley Inter science, New York, 1971.

Course Title:DC DRIVE SYSTEMS

Course Objective: To introduce basic concepts of load and drive interaction, speed control concepts of ac and dc drives, speed reversal, regenerative braking aspects, design methodology.

Prerequisites: A course in Power Electronics and electrical machines.

Course Outcomes:
Upon completion of the course, the students will be able to

1. Understand basic drive system and analyze dc motor drives.
2. Simulate and study motor characteristics with different converter configurations
3. Operation and control of special motors

Course contents:

Basic power electronic drive system, components - Different types of loads, shaft-load coupling systems - Stability of power electronic drive.

Conventional methods of D.C. motor speed control - single phase and three phase converter fed D.C motor drive - Power factor improvement techniques, four quadrant operation.

Chopper fed drives, input filter design - Braking and speed reversal of DC motor drives using choppers, multiphase choppers - PV fed DC drives.

Stepper motors – types, operation, control and applications; servo motors- types, operation, control and applications – servo motor controllers – servo amplifiers – linear motor applications-selection of servo motor.

Reference Books:

1. P.C Sen, ‘Thyristor DC Drives’, John Wiley and Sons, New York, 1991.
2. R. Krishnan, ‘Electric Motor Drives – Modeling, Analysis and Control’, Prentice-Hall of India Pvt. Ltd., New
3. Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons. Inc, Newyork, 2006.
4. Rashid M.H.,‘ Power Electronics-Circuits, Devices and Applications‘, Prentice Hall India, New Delhi, 2009.

Course Title:POWER ELECTRONICS AND DC DRIVES LAB

Course Objective: Analysis of basic power electronic circuitsusing simulation software and experimentation.

Prerequisites: A course in Power Electronics and electrical machines.

Course Outcomes:

Upon completion of the course, the students will be able to

1. Test and analyse the basic rectifier circuits
2. Test and analyse DC-DC Converters
3. Develop DC drive

Course contents:

Simulation and Experimentation*:

1. Single Phase half-controlled rectifier
2. Single Phase full-controlled rectifier
3. Single Phase half-controlled rectifier
4. Single Phase full-wave controlled rectifier
5. Three Phase half-controlled rectifier
6. Three Phase full-controlled rectifier
7. DC/DC Boost converter
8. DC/DC Buck converter
9. DC/DC Buck-boost converter
10. DC/DC interleaved converter
11. DC/DC bidirectional converter
12. Fly-back converter
13. Forward converter
14. Open-loop control of DC motor
15. Closed loop control of DC motor
16. Voltage control method for DC drive
17. Modelling of DC motor
18. Speed control techniques using controlled rectifiers
19. DC/DC Resonant Converter

*Minimum 10 number of experiments should be performed to fulfil curriculum

Reference Books:

1. P.C Sen, ‘Thyristor DC Drives’, John Wiley and Sons, New York, 1991.
2. R. Krishnan, ‘Electric Motor Drives – Modeling, Analysis and Control’, Prentice-Hall of India Pvt. Ltd., New
3. Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons. Inc, Newyork, 2006.
4. H. W. Whittington, B. W. Flynn, D. E. Macpherson, ‘Switched Mode Power Supplies’, John Wiley & Sons Inc., 2nd Edition, 1997.

Course Title:POWER CONVERTERS FOR AC LOADS

Course Objective:
To analyse single and three phase inverter and ac-ac converter circuits and address relevant advanced topological and control techniques.

Prerequisites: Power Electronics in UG

Course Outcomes:
At the end of the course student will be able to
1. Analyse inverter and ac-ac converters
2. Develop control strategies for the ac output power converters
3. Review advanced converter topologies

Course contents:

Single phasePWM techniques- VSI-Analysis. Single phasePWM techniques- CSI-Analysis. Three phasePWM techniques- VSI-Analysis. Three phase CSI.

Single phaseCyclo-converters-working-Analysis-various modes-operation and Three phase Cyclo-converters-working-Analysis-various modes-operation

Single phase Voltage regulators-operation-Analysis and Three phase Voltage regulators-operation-Analysis

Advanced inverters: Matrix converters- Multi-phase inverters-operation-control-applications

Advance converter topologies- Interleaved converters, multi-level converters: Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor – operation

Reference Books

1. Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons. Inc, Newyork, 2006.
2. Rashid M.H.,‘ Power Electronics-Circuits, Devices and Applications‘, Prentice Hall India, New Delhi, 2009.
3. P.C Sen., ‘Modern Power Electronics’, Wheeler publishing Company, 1st Edition, New Delhi, 2005.
4. Andrzej M Trzynadlowski, ‘Introduction to Modern Power Electronics, John Wiley and sons. Inc, New York, 1998
5. BIN Wu, ' High Power Converters and AC Drives', IEEE press Wiley Interscience, a John wiley& sons Inc publication 2006

Course Title: AC DRIVE SYSTEMS

Course Objective: This course gives a comprehensive understanding of various variable speed controls used in electrical drives. In addition, mathematical modeling of vector and direct torque control methods for induction motor, DFIM, and synchronous motor and an overview of BLDC motor control is given.

Pre-requisites: Electrical Machines Analysis.

Course Outcomes: At the end of the course the student will be able to:

1. Understand the concept of vector-controlled induction motor drive and understand the operation of DFIM.
2. Develop vector control of PMSM drive.
3. Design direct torque control techniques for BLDC motor.
4. Develop sensor-less speed control techniques for electrical machines.

Course contents:

Induction Motor Drives:
Introduction of variable speed controls- scalar, vector control, Direct and indirect field orientation-Field weakening- Direct torque control- Direct torque control with space vector modulation-comparison; Doubly Fed Induction Motor -modes of operation- Active and reactive power control- Vector control-Identification of Parameters.

Synchronous Motor Drives:
Introduction of Synchronous Motor- Field oriented control -Direct torque control- Parameter estimation- sensorless control techniques.

PM Synchronous Motor:
Introduction to PM Synchronous Motor- Various configurations - Sinusoidal Back-Emf PMSM- Field oriented - Direct torque control- Interior PM Machine

SensorlessSpeed Control:
Signal injection- Observer based methods-Model based methods-Back EMF-Rotor-Flux, Active/Reactive power- Resistance estimation

References books:

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff: “Analysis of Electric Machinery & Drive systems” *IEEE Press*, 2002.
2. Rama Krishnan: Electric motor drives: modeling, analysis, and control, *Prentice Hall*, 2001.
3. Rik De Doncker, Duco W. J. Pulle, André Veltman, ‘Advanced Electrical Drives: Analysis, Modeling, Control’ *Springer*, 2011.
4. Bimal K. Bose, ‘Modern Power Electronics & AC Drives’ *Phi Learning Pvt. Ltd*, 2nd Edition, New Delhi, 2002.
5. Fitzgerald & Kingsley, ‘Electric Machinery’ *McGraw Hill Co*. New Delhi, 2004.
6. D.W.Novotny, T.A. Lipo, and T.M. Jahns, ‘Introduction to Electric Machines and Drives’*University of Wisconsin*, 1st Edition, 2010.

Course Title:AC DRIVES LAB

Course Objective: Analysis of AC Drivesusing simulation software and experimentation.

Prerequisites: A course in Power Electronics and electrical machines.

Course Outcomes:

Upon completion of the course, the students will be able to

1. Test and analyse the inverter circuits
2. Test and analyse AC-AC regulators
3. Develop AC drive

Course contents:

Simulation and Experimentation*:

1. Single Phase inverter
2. Analysis of 2-Level PWM Techniques - simulation
3. Three Phase inverter 120^0 mode operation
4. Three Phase inverter 180^0 mode operation
5. Multi-phase inverter
6. Diode Clamped MLI
7. Cascaded H-bridge MLI
8. Asymmetrical MLI topology
9. Analysis of MLI PWM Techniques
10. V/F control of Induction Motor Drive – open loop
11. V/F control of Induction Motor Drive – closed loop
12. Direct field-oriented control of IMD
13. In-direct field-oriented control of IMD
14. Parameter estimation of IM
15. BLDC motor drive
16. Inductor Generator operation
17. V/F control of PMSM drive
18. DTC of IMD - simulation
19. Sensor-less speed control of IMD – simulation

*Minimum 10 number of experiments should be performed to fulfil curriculum

Reference Books:

1. P.C Sen, ‘Thyristor DC Drives’, John Wiley and Sons, New York, 1991.
2. R. Krishnan, ‘Electric Motor Drives – Modeling, Analysis and Control’, Prentice-Hall of India Pvt. Ltd., New
3. Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons. Inc, Newyork, 2006.
4. H. W. Whittington, B. W. Flynn, D. E. Macpherson, ‘Switched Mode Power Supplies’, John Wiley & Sons Inc., 2nd Edition, 1997.

Course Title: ADVANCED POWER SYSTEM ANALYSIS

Course Objective:
To perform steady state analysis and fault studies for a power system of any size and also to explore the nuances of estimation of different states of a power system.

Prerequisites: Power Systems in UG

Course Outcomes:
Upon completion of the course, the students will be able to

1. To construct models of power system components and apply them
2. To solve ac and dc load flow for single and three phase systems
3. To analyse the faults in the power system networks
4. To apply the concepts of optimization in power system.
5. To explain the concept of state estimation in power system and the role of statistics in state estimation.

Network modeling – Single phase and three phase modeling of alternators, transformers and transmission lines, Conditioning of Y Matrix –- Incidence matrix method, Method of successive elimination, Triangular factorization – Sparse matrix

Load flow analysis - Newton Raphson method, Fast Decoupled method, AC-DC load flow –Single and three phase methods – Sequential solution techniques and extension to multiple and multi-terminal DC systems.

Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults.

System optimization - strategy for two generator systems – generalized strategies – effect of transmission losses - Sensitivity of the objective function - Formulation of optimal power flow-solution by Gradient method-Newton's method.

State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

Reference Books:

1. Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' Tata McGraw hill, NewDelhi, 2003.
2. HadiSaadat, 'Power System Analysis', Tata McGraw hill, New Delhi, 2002.
3. Arrillaga, J and Arnold, C.P., 'Computer analysis of power systems' John Wiley and Sons, New York, 1997.
4. Pai, M.A., 'Computer Techniques in Power System Analysis', Tata McGraw Hill, New Delhi, 2006

Course Title:LINEAR AND NON-LINEAR SYSTEMS THEORY

Course Objective: The main objective of the course is to understand the fundamental of physical systems in terms of its Linear and Non-Linear models. Exploit the properties of Linear systems such as Controllability and Observability

Prerequisites: Basic control, Linear algebra

Course Outcomes: Upon completion of the course, the students will be able to

1. model physical systems using state vectors.
2. Analyse the stability of linear systems.
3. Design state feedback controllers and observers.
4. Analyse non-linear systems using linear approximations.
5. Inspect the stability of non-linear systems by direct and indirect methods.

Course contents:

Introduction to State Space Modelling, Modelling of Physical systems. Solution to vector Differential equations and State Transition Matrix.

Stability analysis of Linear systems. Controllability and Observability definitions and Kalman rank conditions. Detectability and Stabilizable, Kalman decomposition.

State feedback controller design using Pole placement. Observer design using Kalman filter algorithm. LQR and LQG controller design

Introduction to Non-Linear systems. Phase plane analysis of nonlinear system using linear approximation. Limit cycle and periodic solutions. Singular points (equilibrium points) and qualitative behaviour near singular points.

Stability of Non-Linear systems. Lyapunov direct and indirect methods. Input-to-state stability and relative stability

Applications of Linear and Non-Linear Control Systems in Power and Energy systems.

Reference Books:

1. Ogata, K., ‘Modern Control Engineering’, Prentice Hall of India, 2010.
2. C.T. Chen, ‘Linear Systems Theory and Design’, Oxford University Press, 3rd Edition, 1999.
3. M. Vidyasagar, ‘Nonlinear Systems Analysis’, 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey 07632.
4. Hassan K. Khalil, ‘Nonlinear Systems’, Pearson Educational International Inc. Upper Saddle River, 3rd Edition.

Course Title: ARTIFICIAL INTELLIGENCE TECHNIQUES AND APPLICATIONS

Course Objective:
The course is designed to expose the students to various artificial intelligence techniques and its applications to engineering field.

Prerequisites: NA

Course Outcomes: Upon completion of the course, the students will be able to
1. Understand ANN and apply ANN for controlling energy systems
2. Develop Fuzzy Logic components for solving electrical engineering problems
3. Program Bio-inspired optimization techniques and apply for solving few engineering problems

Course Content:

Introduction to AI
Artificial neural networks (ANN): introduction, Neural network models, Architectures, Knowledge representation, ANN learning process-case studies

Fuzzy Logic Fundamentals: introduction, Fuzzy sets, Membership function, Fuzzy inference, Defuzzification methods- -case studies

GA-Selection of optimization parameters, termination criterion, -case studies

PSO-Selection of optimization parameters, termination criterion, -case studies

Reference Books:

1. M.N. Cirstea, A. Dinu, J.G. Khor and M. McCormick: Neural and Fuzzy Logic Control of Drives and Power System, Newnes, 2002.
2. P. Vas: Artificial-Intelligence-Based Electrical Machines and Drives: Application of Fuzzy, Neural, Fuzzy- Neural, and Genetic-Algorithm-Based Techniques, Oxford University Press, 1999.
3. T. J. Ross: Fuzzy Logic with Engineering Application, 3rd Edition, John Wiley and Sons, 2010.
4. Dan Simon, Evolutionary Optimization Algorithms. 1st Edition, John Wiley and Sons, 2013.

Course Title: DIGITAL SIGNAL PROCESSING

Course Objective: This course gives a comprehensive understanding of various digital filters designs, elaborates methodology to design adaptive filters and systems with estimators to effectively handle non-stationary signals, understand the impact of round-off or quantization error on system stability.

Prerequisites:NA

Course Outcomes:
Upon completion of the course, the students will be able to

1. Design FIR and IIR type digital filters.
2. Compare the performance of adaptive filter algorithms
3. Model autoregressive systems

Course contents:
DISCRETE FOURIER TRANSFORM (DFT): Efficient computation of DFT algorithms - Radix 2 (DIT & DIF), Radix 4, Split radix algorithms. Linear filtering approach to computation of DFT - Goertzel algorithm, Chirp z transform.

DIGITAL FILTER DESIGN: Linear phase FIR filter, characteristic response, location of zeros, Design of FIRfilter - Windowing, Frequency sampling, Least mean square. Design of IIR filters from Analog filters - Impulse invariance, Bilinear transformation, Matched z-transform. Quantization of filter coefficients - Sensitivity to Quantization of filter coefficients.

ADAPTIVE FILTER THEORY: Least mean square (LMS) algorithm, Normalized LMS and RLS filters-Properties, stability, analysis and convergence; Prediction, filtering, smoothing, noise cancellation and blind deconvolution.

LINEAR PREDICTION: Gram-Schmidt Orthogonality, sequential regression, AR, MA and ARMAmodels adaptive recursive filters, lattice structure, Wiener filter, Kalman filters, minimum mean square estimation for scalar random variables, practical aspects.

Reference Books:

1. Simon Haykin, Adaptive Filter Theory, Prentice Hall, 2nd Edition, 2001
2. S.K.MITRA, Digital Signal Processing – A computer Based Approach, MGH, 2nd Edition, 2001
3. J.G.PROAKIS & D.G.MANOLAKIS, Digital Signal Processing - Principles, algorithms & Applications, PHI, 2000.

Course Title: CONVERTERS FOR RENEWABLE ENERGY SYSTEMS

Course Objective: This course offers a comprehensive understanding and analysis of various power electronic converters topologies used in renewable energy systems applications.

Prerequisites: Fundamental knowledge about power electronic circuits, renewable energy systems.

Course Outcomes: Upon completion of the course, the students will be able to

1. To design the power electronic converter circuits for renewable energy systems applications.
2. To classify the different configurations of power electronic converters used in integration of renewable energy systems.
3. To analyse the topologies and working principles of the various power electronic converter circuits used in renewable energy systems integration.
4. This is a higher level of subject that will help to work in demanding areas of power electronics in renewable energy systems

Course Contents

Advanced Converters bidirectional power flow studies
Drawbacks of conventional converters & Inverters, Multi-pulse converters & Inverters, Improved power quality ac-dc converters such as single-phase buck, boost, buck-boost ac/dc converters, PWM (Pulse width modulated) based single- phase, three-phase VSC (Voltage source converters), Grid connection and power capability for RES applications

Multilevel Converters/ Inverters support for RES grid integration
Advance converter topologies for PEE - Interleaved converters, multilevel converters (Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor) multi pulse PWM current source converters, advanced control schemes, Capacitor unbalance – handling in RES

PWM Schemes
Conventional PWM schemes & their performance, Multilevel PWM Schemes, Hybrid PWM schemes, Power converter topologies for solar and wind– Control of dc-dc converter, inverters and relevant – problems in integrating with RES-solutions

Case Studies
Literature- MLI Applications in Drives and power quality, Hybrid converters- Inverters- Closed Loop Renewable Energy conversion systems- PV power conversion using MLIs.

Reference Books

1. N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics Converter Application and Design, ThirdEdition, John Willey & Sons, 2004.
2. M. H. Rashid, Power Electronics, Circuits, Devices and Applications, Pearson, 2002, India.
3. K. Billings, Switch Mode Power Supply Handbook, McGraw-Hill, 1999, Boston.
4. Bin Wu, High-Power Converters and AC Drives, IEEE Press, A John Wiley & Sons, Inc Publication, New York,2006.
5. Relevant literature review for case studies and course applications.

Course Title: APPLICATION OF POWER ELECTRONICS IN POWER SYSTEMS

Course Objective: This course primarily serves to highlight the requirements of modern transmission and distribution systems and specific power electronic solutions to realize them. Transmission system behaviour is analysed in great detail in the basic and advanced courses on power systems.

Prerequisites: Fundamental knowledge about Power electronic circuits and power systems.

Course Outcomes: Upon completion of the course, the students will be able to

1. Classify and explain the functioning of FACTS devices.
2. Understanding the harmonics and compensation techniques using power electronics
3. Design of filter for transmission systems

Course contents:

Steady state and dynamic problems in AC systems: Flexible AC transmission systems (FACTS),

Principles of series and shunt compensation, Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC), modes of operation, Voltage regulator and Phase Angle Regulator (PAR), Multi functional FACTS controller - Unified power flow controller (UPFC), Interline power flow controller.

Harmonics: Harmonics creating loads, modeling, harmonic propagation, Series and parallel resonances, harmonic power flow, Mitigation of harmonics,

Filters: passive filters, Active filters, shunt active filter and analysis

Reference Books:

1. N.G. Hingorani& Laszlo Gyugyi , Understanding FACTS , IEEE Press.

2. K.R. Padiyar, FACTS controllers in power transmission and distribution, New Age International publishers.

3. E. F. Fuchs & Mohammad A.S. Masoum, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press.

4. Antonio L., Steven H., Hand Book of Photovoltaic science and Engineering, 2nd Edition 2010

Course Title: POWER ELECTRONIC CIRCUIT APPLICATIONS IN INDUSTRY

Course Objective: This course helps in devising the suitable power converters for various engineering applications.

Prerequisites: Fundamental knowledge about Power electronic circuits.

Course Outcomes: Upon completion of the course, the students will be able to

1. Analyze the Power Electronic Application requirements.
2. Develop improved power converters for any stringent application requirements.
3. Improvise the existing control techniques to suit the application

Course contents:

Overview of the course- Power converter topologies for Induction heating- Welding- Lighting

High voltage power supplies - power supplies for X-ray applications - power supplies for radar applications - power supplies for space applications - Low voltage high current power supplies

Power Conditioners – UPS - Active Power Filters - Shunt active power filters - Series active power filters - Hybrid active power filters - UPQC

Electric Vehicle – batteries, chargers, inverters, bi-directional DC-DC converters, motors, Automotive Electronics

Reference Books:

1. Ali Emadi, A. Nasiri, and S. B. Bekiarov: Uninterruptible Power Supplies and Active Filters, CRC Press, 2005.
2. M. Ehsani, Y. Gao, E. G. Sebastien and A. Emadi: Modern Electric, Hybrid Electric and Fuel Cell Vehicles, 1st Edition,CRC Press, 2004.
3. William Ribbens: Understanding Automotive Electronics, Newnes, 2003.

Course Title: EMBEDDED SYSTEMS

Course Objective: This course gives a comprehensive understanding of hardware and software basicsdemanded by embedded industry, evaluating an embedded system, introduces ARM Cortex M series coresemployed for building application specific programmes.

Prerequisites:NA

Course Outcomes: Upon completion of the course, the students will be able to

1. Implement and test an embedded system.
2. Develop programs on embedded system for an application.
3. Understand the architectural features of ARMcortex M4 microcontrollers.
4. Understand the exception, interrupts and interrupt handling schemes

Course contents:

Introduction to Embedded Systems: Embedded systems Overview, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics of embedded computing applications, Design Challenges, Common Design Metrics.

Embedded System Development: Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off The Shelf Components (COTS).

Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer Communication Interface: Onboard and External Communication Interfaces.

ARM processors: Evolution of ARM processors, pipeline organization, ARM Processor cores and CPU cores. ARM Cortex-M Processors, ARM Cortex-M4 processor’s architecture, Programmer’s model, Special registers, Operation Modes, Assembly basics, Instruction set, Data transfer, Data processing, conditional and branch instructions, barrier and saturation operations.

Reference Books:

1. Introduction to Embedded Systems -Shibu K.V, McGraw Hill
2. Embedded Systems Design –Santanu Chattopadhyay, PHI, 2013.
3. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications;Third Edition, 2013.
4. David E. Simon -An Embedded Software Primer -, Pearson Education

Course Title:SPECIAL MACHINES

Course Objective: This course imparts knowledge on Construction, Principle of Operation and Performance of special machines and development of control techniques for driving special machines.

Prerequisites: Fundamental knowledge about Electrical Machines.

Course Outcomes: Upon completion of the course, the students will be able to

1. To understand the construction of various special machines.
2. To understand the operation and performance of special machines.
3. To develop control schemes for converters which drive special machines

Course contents:

STEPPER MOTORS:
Constructional Features – Principle of Operation – Variable Reluctance Motor – Hybrid Motor – Single and Multi Stack Configurations – Torque Equations – Modes of Excitation – Characteristics – Drive Circuits – Microprocessor Control of Stepper Motors – Closed Loop Control-Concept of Lead Angle– Applications.

PERMANENT MAGNET BRUSHLESS D.C. MOTORS:
Permanent Magnet Materials – Minor Hysteresis Loop and Recoil Line-Magnetic Characteristics – Permeance Coefficient -Principle of Operation – Types – Magnetic Circuit Analysis – EMF And Torque Equations –Commutation – Power Converter Circuits and Their Controllers – Motor Characteristics and Control–Applications.

PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM):
Principle of Operation – Ideal PMSM – EMF And Torque Equations – Armature MMF – Synchronous Reactance – Sine Wave Motor with Practical Windings – Phasor Diagram – Torque/Speed Characteristics – Power Controllers – Converter Volt-Ampere Requirements– Applications.

SYNCHRONOUS RELUCTANCE MOTORS:
Constructional Features –Operating Principles – Applications.

Reference Books:

1. K. Venkataratnam, ‘Special Electrical Machines’, Universities Press (India) Private Limited, 2008.
2. T.J.E. Miller, ‘Brushless Permanent Magnet and Reluctance Motor Drives’, Clarendon Press, Oxford, 1989.
3. T. Kenjo, ‘Stepping Motors and Their Microprocessor Controls’, Clarendon Press London, 1984.
4. P.P. Aearnley, ‘Stepping Motors – A Guide to Motor Theory and Practice’, Peter Perengrinus London, 1982.
5. T. Kenjo And S. Nagamori, ‘Permanent Magnet and Brushless DC Motors’, Clarendon Press, London, 1988.
6. E.G. Janardanan, ‘Special Electrical Machines’, PHI Learning Private Limited, Delhi, 2014.

Course Title: HYBRID ELECTRIC VEHICLES

Course Objective: This course introduces the fundamental concepts, analysis and design of hybrid and electric vehicles

Prerequisites: Fundamental knowledge about Electrical Machines, power converters.

Course Outcomes: Upon completion of the course, the students will be able to

1. Understand mathematical models, performance and characteristics of hybrid electric vehicles.
2. Analyse the concepts, topologies and power flow control of electric traction systems
3. Appraise the configuration and control of various hybrid electric motor drives
4. Plan and design appropriate vehicle management system.

Course contents:

History of hybrid electric vehicles, social and environmental importance of hybrid electric vehicles,impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power sourcecharacterization, transmission characteristics, mathematical models to describe vehicle performance.

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control inhybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, power flow control in hybrid drive-train topologies, fuel efficiencyanalysis.

Introduction to electric components used in hybrid electric vehicles, Configuration and control of DCMotor drives, Configuration and control of Introduction Motor drives, configuration and control of PermanentMagnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsionmotor, sizing the power electronics, selecting the energy storage technology, Communications, supportingsubsystems.

Reference Books:

1. Sira -Ramirez, R. Silva Ortigoza, ‘Control Design Techniques in Power Electronics Devices’, Springer,2006
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, ‘Sliding mode control of switching Power Converters’, CRCPress, 2011
3. Bimal Bose, ‘Power electronics and motor drives’, Elsevier, 2006
4. Ion Boldea and S.A Nasar, ‘Electric drives’, CRC Press, 2005

Course Title:ELECTRIC TRACTION

Course Objective: The course gives comprehensive understanding of motoring, braking, battery management and protection system components of electric traction.

Prerequisites: Fundamental knowledge about Electrical Machines.

Course Outcomes: At the end of the course the student will be able to:

1. Design an electric line for traction services
2. Develop braking mechanisms for traction drives
3. Develop schemes to achieve efficient battery management
4. Design protection schemes for electrical equipment

Course contents:

Traction systems:Present Scenario of Indian Railways
Methods of traction - track electrification-DC system - single phase and three-phase low frequency and high frequency system - composite system - kando system - comparison between AC and DC systems - problems of single-phase traction with current unbalance and voltage balance.

Traction Mechanics:
Mechanics of traction movement - speed-time curves for different services - trapezoidal and quadrilateral speed-time curves - tractive effort requirements and problems - power - specific energy consumption - effect of varying acceleration and braking - Retardation - adhesive weight and braking retardation - coefficient of adhesion.

Traction motors:
Desirable characteristics of traction motors - suitability of series motor for traction - single phase series motor - repulsion motor - linear induction motor.

Traction motor control and braking:
Control of DC traction motors - series-parallel control - shunt and bridge transition - types of braking-plugging - rheostatic braking - regenerative braking of DC and three phase induction motors
Power supply arrangements:

Introduction of Traction substation requirements

Reference Books:

1. H. Partab: Modern Electric Traction - Dhanpat Rai & Co, 2007.
2. S. Rao: EHV AC and HVDC Transmission Engineering and Practice, 3rd edition, Khanna Pub, 1997.
3. R.B. Brooks, Electric traction hand book, Sir Isaac Pitman and Sons Ltd.
4. J. Udadhyay, S.N Mahendra, Electric Traction, Allied Publications Ltd. - Dhanpat Rai and Sons.

Course Title: INDUSTRIAL CONTROL ELECTRONICS

Course Objective: This course gives a comprehensive understanding of various control circuits used in industries. Digital and analog control concepts are elaborated for design of various power electronic circuits. Further an overview of PLC's, stepper motor and servomotor with associated control circuits is given.

Prerequisites: Fundamental knowledge about analog, digital and Power electronic circuits.

Course Outcomes: Upon completion of the course, the students will be able to

1. To understand the working of various Power electronic circuits and components used in industrial applications.
2. To analyze various analog controllers and signal conditioning circuits.
3. To design control circuits for industrial application

Course contents:

Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, derivative overrun, integral windup, cascaded control, Feed forward control, Digital control schemes.

Sensors for high voltage and current applications

Signal conditioners-Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters; Isolation circuits – cabling; magnetic and electro static shielding and grounding Opto-Electronic devices and control, electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation, interrupter modules and photo sensors; Fibre-optics; Bar code equipment, application of barcode in industry.

Programmable logic controllers – Logic Systems- PLC Programming- PLC Wiring and Ladder Programmes

Stepper motors – types, operation, control and applications; servo motors- types, operation, control and applications – servo motor controllers – servo amplifiers – linear motor applications-selection of servo motor.

Reference Books:

1. Michael Jacob, 'Industrial Control Electronics – Applications and Design', Prentice Hall, 1995.
2. Petruzella, Frank D.. Programmable Logic Controllers, 3rd ed. McGraw Hill
3. Thomas E. Kissell, 'Industrial Electronics', Prentice Hall India, 2003
4. James Maas, 'Industrial Electronics', Prentice Hall, 1995

Course Title: ENERGY MANAGEMENT & AUDIT

Course Objective: To understand Energy audit procedure and apply energy conservation measures for various user segments.

Prerequisites: NA

Course Outcomes:

1. Identification of energy conservation opportunities in various industrial processes
2. Gain knowledge on tools and techniques employed in energy auditing
3. Comprehend an Energy Audit report, including economic parameters

Course contents:

Introduction to Energy Management

Energy Management –I Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manger, Qualities and functions, language, Questionnaire - check list for top management.

Energy Audit Basics- Definition and Objectives -Energy Profiling -Energy Flow diagram -Types of Energy- Audit Duties of Energy Auditor & Manager

Energy Audit Procedure-Energy Audit Procedure Tools/ Techniques/ Equipment -Energy Audit Report-Financing EEC Activities

Energy Analytics and building management

Case Studies / Best Practices

Reference Books:

1. W.R. Murphy & G. Mckay Butter worth, Energy management, Heinemann publications.
2. LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization (Hemisphere Publishing Corporation, Washington, 1998).
3. Paul o' Callaghan , Energy management, Mc-graw Hill Book company-1st edition, 1998
4. W.C.Turner, , Energy management hand book, John wiley and sons
5. Energy management and good lighting practice: fuel efficiency-booklet12-EEO,
6. EA/EMGuideBooks(http://www.em-ea.org/)

Websites

1. National Productivity Council (http://www.npcindia.gov.in/)
2. Bureau of Energy Efficiency (https://www.beeindia.gov.in/)

Course Title: RENEWABLE ENERGY SYSTEMS

Course Objective: This course gives a comprehensive understanding of various renewable energy systems and its design

Prerequisites: NA

Course Outcomes:

1. Thoroughly understand the NEED for Renewable Energy Technologies
2. Understand the different technologies available for capitalization and map them as a solution for identified problems for India.
3. Design a solar power plant on PV system and meet current industrial design standards
4. Analyse the wind data to determine feasibility of a wind farm and build DPR
5. New and upcoming renewable energy technologies and their potential application for India.

Course contents:

Effects of Conventional Energy Generation Methods: Availability of natural energy sources, Impact of Energy on Economy, Impact of conventional power plants on the environment, Harmful effects on human and other biological life forms.

Renewable Energy Sources: Understand the basic working of each of the renewable energy generating methods like Hydro, Solar, Wind, Biomass, Tidal and Geo-Thermal, Fuel cells etc.

Working and Design of Solar Photovoltaic system: Electrical and Mechanical parameters of Solar Cells and Panels, Solar Power Plant Design using software simulation, Detailed Project Report generation taking technical and economicaspects into account New avenues for growth of solar like floating solar, Solar Trees etc.

Working and Design of Wind Turbines: Feasibility study, Basic working and wind turbine design, Generation of DPR with technical and economic aspects taken into account, Modern Trends in wind turbine Technology.

Modern Trends in Renewable Energy: This refers to the new and low adopted technologies that could have significant impact on energy generation like thoseusing evaporation.

Reference Books:

1. Joseph Burdick and Philip Schmidt -Install Your Own Solar Panels: Designing and Installing a Photovoltaic System to Power Your Home.
2. William H Kemp -The Renewable Energy Handbook: A Guide to Rural Energy Independence, Off-Grid and Sustainable Living
3. Tony Burton,NickJenkins,DavidSharpe,ErvinBossanyi, Wind Energy Handbook 2nd Edition