ELECTRICAL AND ELECTRONICS ENGINEERING DEPARTMENT

Structure and syllabus

Of

M. Tech. (Electrical Drives and Control)

With effect from July 2017

Program Educational Objectives:

1. To prepare graduates meet the challenges of modern society through viable engineering solutions.
2. To prepare graduates to develop economically viable cutting edge technology for local industry. Need.
3. To prepare graduates to inspire next generation graduates as successful engineer/ entrepreneur, scientist and researcher.

Program Outcomes:

1. Ability to apply knowledge of science, mathematics, and engineering principles for solving problems.
2. Ability to identify, formulate and solve electrical power system problems
3. Ability to understand and use different software tools in the domain of Power electronics, power system and control system simulations.
4. Ability to design and conduct experiments and analyze and interpret data.
5. Ability to coherently work in a multidisciplinary team.
6. Demonstrate sensitivity towards professional and ethical responsibility.
7. Ability to communicate effectively in writing as well as through public speaking.
8. Demonstrate ability to appreciate and engage in lifelong learning.
9. Demonstrated knowledge of contemporary issues.
10. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
11. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

ELECTRICAL AND ELECTRONICS ENGINEERING DEPARTMENT

Proposed Teaching and Examination Scheme for
M. Tech. (Electrical Drives and Control) w. e. f. July 2017

SEMESTER I

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTEDC101	Modern Control System	03	01	--	04	60	20	20	--	100
MTEDC102	Electrical Machine Modelling and Analysis	03	01	--	04	60	20	20	--	100
MTEDC103	DC Drives	03	01	--	04	60	20	20	--	100
MTEDC104	Elective-I	03	-	--	03	60	20	20	--	100
MTEDC105	Elective-II	03	-	--	03	60	20	20	-	100
MBS106	Communication Skills	02	-	--	02	-	-	25	25	50
MTEDC107	PG Lab-I	--	-	03	02			25	25	50
	Total	**17**	**03**	**03**	**22**	**300**	**100**	**150**	**50**	**600**

Elective-I MTEDC104	Elective-II MTEDC105
1) Advanced Digital Signal Processing 2) Special Electrical Machines 3) Power Quality Assessment and Mitigation	1) Modern Power Electronics 2) Advanced Process Control 3) Embedded Systems

SEMESTER II

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTEDC201	Adaptive Control System	03	01	--	04	60	20	20	--	100
MTEDC202	AC Drives	03	01	--	04	60	20	20	--	100
MTEDC203	Elective-III	03	-	--	03	60	20	20	--	100
MTEDC204	Elective-IV	03	-	--	03	60	20	20	--	100
MTEDC205	Elective-V (Open)	03	-	--	03	60	20	20	-	100
MTEDC206	Seminar-I	--	-	04	02	-	-	50	50	50
MTEDC107	PG Lab-II or Mini Project	--	-	04	02	-	-	50	50	50
	Total	**15**	**02**	**08**	**21**	**300**	**100**	**200**	**100**	**700**

Elective-III MTEDC203	Elective-IV MTEDC204	Elective-V MTEDC205
1) Intelligent Control 2) Power Electronics for Renewable Energy Systems 3) Electric Traction	1) Robotic and Control 2) Electric and Hybrid Vehicles 3) Electromagnetic Interference & Compatibility In Power Electronic System	1) Modern Optimization Techniques. 2) Sustainable energy system 3) Energy Management and Auditing. 4) Energy storage system. 5) Research Methodology 6) Finance management 7) Intelligent systems

M. Tech. (ELECTRICAL DRIVES and CONTROL)

SEMESTER–III

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTME301	**Project Management and Intellectual Property Rights** (Self Study)*	--	--	--	02	--	--	50	50	100
MTEDC302	**Project work Phase-I**	--	--	--	14	--	--	50	50	100
	Total	**--**	**--**	**--**	**16**	**--**	**--**	**100**	**100**	**200**

SEMESTER–IV

Subject Code	Name of the Subject	Teaching Scheme (Hours/Week)			Credit	Examination Scheme				
						Theory		CA	PR/OR	Total
		L	T	P		TH	Tests			
MTEDC401	**Project work Phase-II**	--	--	--	28	--	--	100	100	200
	Total	**--**	**--**	**--**	**28**	**--**	**--**	**100**	**100**	**200**

SEMESTER I

MTEDC101: MODERN CONTROL SYSTEM

COURSE OUTCOMES:

1) Analyze dynamics of a linear system by State Space Representation.
2) Determine the stability of a linear system using pole-placement technique.
3) Design state observers.
4) Analyze basics of Non-linear control system.
5) Determine the stability of Non-linear systems.
6) Formulate and solve deterministic optimal control problems in terms of performance indices.
7) Realize the structure of a discrete time system and model its action mathematically.

COURSE CONTENTS:

UNIT I: STATE SPACE ANALYSIS (09 Hours)

The Concept of State and State Models, State Diagram, State Space and State Trajectory, State Space Representation using Phase Variable and Canonical Variables, Solution of State Equation, State Transition Matrix and its Properties, Eigen Values, Eigen Vectors, Model Matrix, Diagolization, Generalized Eigen vectors, Computation of State Transition Matrix using Laplace Transformation, Power Series Method, Cayley-Hamilton Method, Similarity Transformation Method. Controllability and Observability Tests: Kalman's test, Gilbert's Test, Controllability and Observability Canonical Forms.

UNIT II: POLE PLACEMENT TECHNIQUES (07 Hours)

Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design, Full Order/Reduced Order Observer Design, Observer Based State Feedback Control, Separation Principle.

UNIT III: NONLINEAR CONTROL SYSTEM (10Hours)

Introduction, Properties of Nonlinear System, Behavior of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead-Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance. Phase-Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, Describing Functions Method, Stability Analysis by Describing Function Method. Lyapunov’s Stability Analysis, Lyapunov’s Stability Criterion, Direct Method of Lyapunov and the Linear Systems, Method of Construction of Lyapunov Functions for Nonlinear Systems.

UNIT IV: OPTIMAL CONTROL (08 Hours)

Introduction to Optimal Control, Parameter Optimization: Servomechanism, Optimal Control Problem: Transfer Function and State Variable Approach, State Regulator Problem, Infinite Time Regulator Problem, Output Regulator and the Tracking Problem, Parameter Optimization: Regulators.

UNIT V: DIGITAL CONTROL SYSTEMS (08 Hours)

Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation.

REFERENCES:

1) Katsuhiko Ogata, Modern Control Engineering Prentice-Hall of India, New Delhi.
2) I. J. Nagarath and M. Gopal, Control system Engineering, New Age International (P) Ltd.
3) Katsuhiko Ogata, State Space Analysis of Control Systems, Prentice Hall Inc, New Jersey.
4) Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, 8th Edition, John Wiley & Sons.
5) H. Khalil, Nonlinear Control systems, Prentice Hall Inc, New Jersey.
6) Brogan W. L., Modern Control theory, Prentice Hall International, New Jersey.
7) Jean-Jacques E, Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall Inc., New Jersey.
8) Donald Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc, Englewood Cliffs, New Jersey.
9) Brain D., Anderson and J. B. Moore, Optimal Control, Prentice Hall.
10) Andrew P., Sage, Optimum Systems Control, Prentice Hall.
11) M. Gopal , Digital Control & State Variable Methods, TMH.
12) A. Nagoor Kani, Control System, RBA Publications.

SEMESTER I

MTEDC102: ELECTRICAL MACHINES MODELING AND ANALYSIS

COURSE OUTCOMES:

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

1) Develop models for linear and nonlinear magnetic circuits
2) Determine the developed torque in an electrical machine of field energy and co energy and determine the dynamic model of a DC machine.
3) Use the reference frame theory for developing machine models
4) Determine the dynamic model of an induction machine based on the dq0 Transformation
5) Determine the torque developed in a salient pole synchronous machine using the Park's transformation.

COURSE CONTENTS:

UNITI: BASIC PRINCIPLES OF ELECTRICAL MACHINE ANALYSIS (09 Hours)

Magnetically coupled circuits: review of basic concepts, magnetizing inductance, Modeling linear and nonlinear magnetic circuits

Electromechanical energy conversion: principles of energy flow, concept of field energy and co energy ,Derivation of torque expression for various machines using the principles of energy flow and the principle of co energy, Inductance matrices of induction and synchronous machines.

UNITII: THEORY OF DC MACHINES (08 Hours)

Review of the DC machine- State-space model of a DC machine- reduced order model & transfer functions of the DC machine.

UNIT III: REFERENCE FRAME THEORY (09 Hours)

Concept of space vector- types of transformation- condition for power invariance- zero-sequence component - expression for power with various types of transformation - transformations between reference frames - Clarke and Park's Transformations - variables observed from various frames.

UNIT IV: THEORY OF SYMMETRICAL INDUCTION MACHINES (09 Hours)

Voltage and torque in machine variables - derivation of *dq0* model for a symmetrical induction machine - voltage and torque equation in arbitrary reference frame variables - analysis of steady-state operation - state-space model of induction machine in '*d-q'* variables.

UNIT V: THEORY OF SYNCHRONOUS MACHINES (07 Hours)

Equations in arbitrary reference frame, Park's transformation, derivation of *dq0* model for a salient pole synchronous machine with damper windings, torque expression of a salient pole synchronous machine with damper windings and identification of various components.

REFERENCES:

1) P.C. Krause, "Analysis of Electric Machinery, McGraw Hill", NY.
2) C.V. Jones, "The unified Theory of Electrical Machines", Butterworth,-London.
3) Stevenson, "Power System Analysis", McGraw Hill, NY.
4) Dhar R.N., "Computer Aided Power System Operation and Analysis", Tata McGraw Hill.
5) P.S. Bhimbra, "The Generalised Theory of Electrical Machines", Tata McGraw Hill
6) B.Adkins and R.G.Harley, "The General theory of AC Machines", Tata McGraw Hill
7) R. Krishnan, "Electric Motor Drives – Modelling, Analysis and Control", PHI.

SEMESTER I

MTEDC103: DC DRIVES

COURSE OUTCOMES:

1) Explain the basics of Electrical Drives.
2) Specify the appropriate power circuit configuration amongst the phase controlled rectifiers for the speed control of DC motor drives.
3) Specify the appropriate power circuit configuration amongst the chopper for the speed control of DC motor drives.
4) Develop the closed loop controlled DC drives.
5) Describe the modern trends of DC Dives.

COURSE CONTENTS:

UNIT I: INTRODUCTION (06 Hours)
Electrical Drives, advantages, elements of drive system, drive characteristics, criteria for selection of drive components, dynamics of D.C. motor drives, steady-state stability.

UNIT II: PHASE CONTROLLED D.C. MOTOR DRIVES (10 Hours)
Introduction, principle of DC motor speed control, phase controlled converters, steady state analysis of three phase converter controlled DC motor Drive, two quadrant three phase controlled DC drive.

UNIT III: CHOPPER CONTROLLED DC MOTOR DRIVES (10 Hours)
Introduction, Principle of operation of the chopper, Chopper controlled drives, Duty-ratio control, current-limit control, steady state analysis, four quadrant chopper circuit, chopper for inversion, chopper with other power devices, mode of chopper, input to the chopper, steady state analysis of chopper controlled DC Drives, pulsating torques, DC motor Drive with field weakening, four quadrant DC motor drives, converter selection and characteristics

UNIT IV: CLOSED-LOOP CONTROL OF DRIVES (10 Hours)
Introduction- Basic features of an Electric Drive- Block diagram representation of Drive systems, signal flow graph representation of the systems, Transfer functions, transient response of closed loop drives systems. Speed control of a separately excited DC drive with inner current loop and outer speed loop,

UNIT V: DC DRIVES APPLICATION (06 Hours)
Harmonics and it's associated problems, modern trends in Electrical Drive, DSP controlled Electrical Drive, Heating/cooling and insulation in motors. Choice of motors and rating. Electromagnetic Control of Motors; .

REFERENCES:

1) G.K.Dubey, Power Semi conductor controlled Drives, New Age Int. Pub.
2) S.B.Dewan, G.R.Slemon & A.Stranghan, Power Semi conductor controlled Drives, Johnwiley Pub.
3) Shepherd Hullay & Liag, Power Electronics & Motor Control: Cambridge Univ. Press
4) R.Krishnan, Electric Motor drives – Modelling, Analysis & Control:, PHI India,Ltd.
5) Vedam Subramanyam, Thyristor Control of Electric Drives.

SEMESTER I

ELECTIVE I: MTEDC104: ADVANCED DIGITAL SIGNAL PROCESSING

COURSE OUTCOMES:

1) Apply digital signal processing techniques to analyze LTI systems in time and frequency domain.
2) Design and Analyze FIR digital filters.
3) Design and Analyze IIR digital filters.
4) Understand and be able to implement adaptive signal processing algorithms.
5) Acquire the basics of multirate digital signal processing.
6) Explain and implement digital signal processing techniques on general purpose Digital signal processors.

COURSE CONTENTS:

UNIT I: DISCRETE TIME SIGNALS (08 Hours)

Introduction to Discrete time signals LTI system-stability-properties-sampling frequency domain Representation of discrete time signals and systems, discrete random signals-transforms, Properties, Inverse Z transforms.

UNIT II: DIGITAL FIR FILTER DESIGN (08 Hours)

Design of FIR filters - structures, windowing method, optimal method, Frequency sampling method.

UNIT III: DIGITAL IIR FILTER DESIGN (06 Hours)

Design of IIR filter: Impulse invariant method, Matched z-transform method, bilinear method.

UNIT IV: ADAPTIVE DIGITAL FILTERS (08 Hours)

Adaptive filters, Examples of Adaptive filtering, the minimum mean square error criterion; The Windrow and Hoff LMS Algorithm, Recursive least square Algorithm, Applications.

UNIT V: MULTI RATE DIGITAL SIGNAL PROCESSING (06 hours)

The basic sample rate Alteration Devices-Filters with sampling rate Alteration systems, Multistage Design of Decimators and Interpolators, Arbitrating rate sampling rate converter, Polyphase decomposition, digital filter design –Application.

UNIT VI: GENERAL PURPOSE DIGITAL SIGNAL PROCESSORS (06 hours)

Architecture of general purpose Digital signal processors, Implementation of DSP algorithms on general purpose processors.

REFERENCES:

1) Digital signal processing: A Practical Approach, Emmanuel C. Ifeachor, Barrie W. Jervis, Pearson Education.
2) Digital Signal Processing Principal, Algorithms and Applications, John G. Proakis, Dimitris G. Manolakis Pearson
3) Digital signal processing: A Computer Based Approach, Sanjit K. Mitra, Tata McGraw hill Pub, Company Limited New Delhi, 2001.
4) Digital signal processing, Alan Oppenheim, V and Ronals W. Schafer, Prentice Hall of India Private Limited, New Delhi, 1992.
5) Signals and systems, Simon Haylaim and Barry van veen, John wiley and sons India.
6) Digital signal processing, S,Salivahanan, Tata Mc Graw Hill Education Private Limited, New Delhi, 2010.

SEMESTER I

ELECTIVE I: MTEDC104: SPECIAL ELECTRICAL MACHINES

COURSE OUTCOMES:

After the completion of the course the students will be able to:

1) Describe the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
2) Explain the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
3) Develop the control methods and operating principles of switched reluctance motors.
4) Introduce the concepts of stepper motors and its applications.
5) Explain the basic concepts of other special machines.

COURSE CONTENTS:

UNIT I: Permanent Magnet Brushless DC Motors (08 Hours)

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Characteristics and control.

UNIT II: Permanent Magnet Synchronous Motor (08 Hours)

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 Hours)

Constructional features –Principle of operation- Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensor less operation of SRM – Applications.

UNIT IV: STEPPER MOTORS (10 Hours)

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control –Applications.

High-Speed Operation of Stepper-Motors: Pull-out torque/speed, characteristics of Hybrid stepper motors, calculation of pull-out torque, pull-out torque/speed characteristics for the VR stepper-motors, calculation of the pull out torque.

UNIT V: OTHER SPECIAL MACHINES (07 Hours)

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

REFERENCES:

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, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000.
4) T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988.
5) R.Krishnan, 'Electric motor drives' , Prentice hall of India,2002.
6) D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.

SEMESTER I

ELECTIVE I: MTEDC104: POWER QUALITY ASSESSMENT AND MITIGATION

COURSE OUTCOMES:

Upon successful completion of this course the student will be able to:

1) Understand the different power quality problems and standards.
2) Identify waveform distortion, sources, causes and apply the various ways to reduce the waveform distortion.
3) Describe the voltage sag and interruption and apply techniques to reduce the sag in system.
4) Understand the use of power monitoring procedure to access the power quality
5) Apply the mitigation techniques to reduce the adverse effects of power quality on system and equipment.

COURSE CONTENTS:

UNIT I: INTRODUCTION (7 Hours)

Importance of power quality, terms and definitions of power quality as per IEEE std. 1159 such as transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, imbalance, flickers and transients. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of groundings. Good grounding practices and problems due to poor grounding.

UNIT II: FLICKERS AND TRANSIENT VOLTAGE (7 Hours)

RMS voltage variations in power system and voltage regulation per unit system, complex power. Principles of voltage regulation. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term and long term flickers. Various means to reduce flickers. Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages

UNIT III: VOLTAGE SAG AND INTERRUPTIONS (7 Hours)

Definitions of voltage sag and interruptions. Voltage sags versus interruptions. Economic impact of voltage sag. Major causes and consequences of voltage sags. Voltage sag characteristics. Voltage sag assessment. Influence of fault location and fault level on voltage sag. Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag requirements for computer equipment, CBEMA, ITIC, SEMI F 42 curves. Representation of the results of voltage sag analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions

UNIT IV: WAVEFORM DISTORTION (7 Hours)

Definition of harmonics, interharmonics, subharmonics. Causes and effect of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices. A.C. quantities under non-sinusoidal conditions. Triplen harmonics, characteristics and non-characteristics harmonics. Harmonics series and parallel resonances. Consequences of harmonic resonance. K-rated transformer. Principles for controlling harmonics. Reducing harmonic currents in loads. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Harmonic filtering, passive and active filters. Modifying the system frequency response. IEEE Harmonic standard 519-1992.

UNIT V: POWER QUALITY MONITORING (7 Hours)

Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality Instrumentation. Selection of power quality monitors, selection of monitoring location and period. System wide and discrete power quality monitoring. Setting thresholds on monitors, data collection and analysis. Selection of transducers. Harmonic monitoring, transient monitoring, event recording and flicker monitoring.

UNIT VI: POWER QUALITY ASSESSMENT AND MITIGATION (7 Hours)

Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion, voltage and current unbalances. Power assessment under waveform distortion conditions. Power quality state estimation, State variable model, observability analysis, capabilities of harmonic state estimation. Test systems. Mitigation techniques at different environments

REFERENCES:

1) Understanding Power Quality Problems, voltage sag and interruptions - M. H. J. Bollen, IEEE press, 2000, series on power engineering.
2) Electrical Power System Quality - Pogei G. Dugan, Mark F. McGranghan, Surya santoso, H. Wayne Beaty, second edition, McGraw Hill Pub.
3) Power system Quality Assessment - J. Arrillaga, M.R. Watson, S. Ghan, John Wiley and sons.
4) Power Quality – R.C. Dugan, Tata McGraw Hill Publications.
5) Power Quality in Power Systems and Electrical Machines - Ewald Fuchs, Mohammad A. S. Masoum, Elsevier Academic Press.
6) IEEE standards 519 and 1159

SEMESTER I

ELECTIVE II: MTEDC105: MODERN POWER ELECTRONICS

COURSE OUTCOMES:

1) Analyze the AC to DC and DC to DC converter.
2) Analyze the DC to AC converter.
3) Apply the modulation techniques for the various types of inverters.
4) Analyze the AC to AC converter.
5) Use the various firing and protection circuit.
6) Demonstrate the multi level inverter

COURSE CONTENTS:

UNIT I: AC TO DC AND DC TO DC CONVERTER (08 Hours)

Fully controlled converters with R-L, R-L-E loads and free-wheeling diodes – continuous and discontinuous modes of operation, Performance parameters: harmonics, ripple, distortion, and power factor – Power factor improvement, effect of source impedance. Dual converters, higher pulse converters, Selection of converter circuit, multiphase star rectifier.

Classification of chopper, Operation of Jones, multiphase chopper, Performance parameter of converter, Control strategies, Chopper circuit Design, detailed analysis of buck converter, boost converter and buck-boost converter.

UNIT II: DC TO AC CONVERTER (06 Hours)

Single-phase inverters: Principle of operation of half and full bridge inverters, detailed analysis. Three-phase Inverter: Principle of operation, Performance parameters, detailed analysis.

UNIT III: MODULATION TECHNIQUES (06 Hours)

Voltage control PWM techniques (Simple PWM, Multiple PWM, Sinusoidal PWM, and Modified Sinusoidal PWM). Low and high frequency switching operation. Voltage control of three phase inverters – Space Vector PWM. Application of modulation techniques

UNIT IV: AC TO AC CONVERTER (08 Hours)

Principle of operation of cyclo-converters - three phase to single phase - three phases to three phase - input and output performances - output voltage and frequency ranges - harmonics - pulse generation and controls for cyclo-converter.

Single phase and three phase ac voltage controller-output voltage control. Phase angle range, Input and output performance.

UNIT V: PROTECTION AND FIRING CIRCUIT (08 Hours)

Over-voltage and over-current protection,Gate protection, EMI, Snubber circuit, Different Heat sinks, Commutation circuit.

Firing Circuit: R, RC firing circuit, micro-processor based firing scheme for three phase full bride converter.

UNIT VI: DC-AC MULTILEVEL CONVERTERS (06 Hours)

Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters.

REFERENCES:

1) Power Electronics Handbook, M.H. Rashid, Academic press, Newyork, 2000.

2) Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons. Inc, Newyork, 1995.
3) M.D. Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
4) P.S. Bimbhra, "Power Electronics" Khanna Publication.
5) Power Electronic Circuits, Issa Batarseh, John Wiley and Sons, Inc.2004.
6) Power Electronics for Modern Wind Turbines, Frede Blaabjerg and Zhe Chen, Morgan & Claypool Publishers series, United States of America, 2006.
7) Wind and Solar Power Systems, Mukund R. Patel, CRC Press, New York, 1999.
8) Power Electronics: Converters, Applications, and Design, 3rd edition, Jai P Agarwal, Prentice Hall, 2000.

SEMESTER I

ELECTIVE II: MTEDC105: ADVANCED PROCESS CONTROL

COURSE OUTCOMES:

Upon successful completion of this course, a student should be able to:

1) Understand the application of different process control systems.
2) Analyze the application of different controllers and their applications to suitable process.
3) Understand the constructional details, principle of operation, and performance of different unit operations and their Instrumentation.
4) Analyze the advanced control concepts, system identification and process modelling.
5) Perform Testing, Erection, Commissioning of typical process industry

COURSE CONTENTS:

UNIT I: INTRODUCTION TO PROCESS CONTROL (08 Hours)

Introduction to performance characteristics of different transducers and systems, Dynamic analysis of measurement systems, errors in instrumentation systems. Introduction to process control, representative process control problems, classification of process control strategies, Major steps in control system developments. Introduction to Unit Operations and theoretical modeling, concept of Unit and Unit Operation, Material Balance and Energy Balance, Introduction to Evaporation, Distillation, Crystallization processes and associated Instrumentation and control. Introduction to process equipments like Continuous Stirred Tank Reactor (CSTR), Heat Exchanger, liquid storage systems and their modeling, dynamic behavior of first and second order processes, dynamic response of the processes, development of empirical models for process data.

UNIT II: OVERVIEW OF PROCESS CONTROL SYSTEM DESIGN (06 Hours)

Introduction, degree of freedom for process control, selection of controlled, manipulated and measured variable, process safety and process control.

Unit III: FEEDBACK CONTROL AND PID CONTROLLER FOR PROCESS CONTROL (10 Hours)

Process System Instrumentation, Introduction, Basic Control Modes, Elements of The Feedback Loop, Block Diagram, Control Performance Measures for Common Input Changes, Selection of Variables for Control, On-Off Controller, Features of PID Controller, PID Controller Design, PID Controller Tuning for Dynamic Performance - Determining Tuning Constants for Good Control Performance, Ziegler-Nichols Method, Correlations for Tuning Constants, Fine-Tuning the Controller Tuning Constants, Controller tuning Based on Stability –Dead Beat and Self Tuning Controller, Trouble Shootings, Digital Version of PID Controller, Electronic/Pneumatic/Hydraulic Controller, Optimum Control Settings, Transducers, Transmitters, Transmission Lines, Final Control Elements and their Calculations and Selection.

UNIT IV: CASCADE CONTROL, RATIO AND FEED FORWARD CONTROL (06 Hours)

Introduction to Feed forward and ratio control, cascade control and their design consideration, controller algorithm, tuning.

UNIT V: MULTIVARIABLE CONTROL (07 Hours)

Modeling and Transfer Functions, Influence of interaction on the Possibility of Feedback Control, Process Interaction - Important Effects on Multivariable System Behavior, Process Interaction - The Relative Gain Array (RGA), Effect of Interaction on Stability and Tuning of Multi loop Control Systems. Typical multivariable process control system.

UNIT VI: PROCESS TESTING, ERECTION, COMMISSIONING (05 Hours)

Project Documentation, Specification Sheet, Index Sheet, Flow Diagram, Schedules used in typical process industry erection.

Testing, Erection, Commissioning of typical process industry.

REFERENCES:

1) Process dynamics and control by Dale E. Seborg, Thoman F. Edgar, Dyncan A. Mellichamp, IInd Edition, Willey publication.
2) Instrument Engineers Handbook by B. G. Liptak Vol. I and II, Third Edition, Chilton and
3) Book Company, 1990.
4) Process control by Peter Harriot Tata McGraw hill.
5) Automatic process control by D. Ekman, Wiley Eastern Ltd.
6) Process control system Application, Design and tunning by F.G. Shinsky McGraw hill.
7) Unit operation and chemical engineering by Mc Cabe McGraw hill Publication.
8) Chemical process industries by Shreve McGraw hill Publication.

SEMESTER I

ELECTIVE II: **MTEDC105: EMBEDDED SYSTEMS**

COURSE OUTCOMES:

1) Define and explain embedded systems and the different embedded system design technologies explain the various metrics or challenges in designing an embedded system
2) Become aware of the architecture of the ARM processor and its programming aspects (assembly Level)
3) Foster ability to understand the internal architecture Processor LPC 2148
4) Understand key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices
5) Design real time embedded systems using the concepts of RTOS.
6) Analyze various examples of embedded systems based on ARM processor.

COURSE CONTENTS:

UNIT I: INTRODUCTION TO EMBEDDED SYSTEMS (08 Hours)

Introduction to embedded system -Definition and Classification, Design challenges, Optimizing design metrics, time to market, applications of embedded systems and recent trends in embedded systems, memory management, Overview of Processors and hardware units in an embedded system, Software embedded into the system, communication protocols like SPI, I2C, CAN etc.

UNIT II: ARCHITECTURE OF ARM7TDMI (05 Hours)

Introduction to ARM core architecture, ARM extension, family, Pipeline, memory management, Bus architecture, Programming model, Registers, Operating modes, instruction set, Addressing modes, memory interface.

UNIT III: ON CHIP PERIPHERALS AND INTERFACING LPC2148 (08 Hours)

Study of on-chip peripherals – Input/ output ports, Timers, Interrupts, on-chip ADC, DAC, RTC modules, WDT,PLL, PWM,USB, I2C, SPI, CAN etc.

UNIT IV: INTERFACING WITH LPC2148 (08 Hours)

Need of interfacing, interfacing techniques, interfacing of different displays including Graphic LCD, controlling a DC motor using PWM, Keypad controllers, stepper motor controllers.

UNIT V: REAL TIME OPERATING SYSTEMS (08 Hours)

Definitions of process, tasks and threads, I/O Subsystems, Interrupt Routines Handling in RTOS, RTOS Task scheduling models, Handling of task scheduling and latency and deadlines as performance metrics, Co-operative Round Robin Scheduling, Case Studies of Programming with RTOS.

UNIT VI: INTRODUCTION TO ARM 9 (05 Hours)

ARM926EJ-S, Features, Specifications (LPC314x /LPC315x As reference controllers)

REFERENCES:

1) Embedded Systems Architecture, Programming and Design, Rajkamal, TATA McGraw-Hill, First reprint Oct, 2003.
2) Embedded Systems Design, Second Edition, Steve Heath, Elsevier India Pvt. Ltd. 2007.
3) Andrew Sloss, Andew Sloss, “ARM System Developers Guide”
4) Introduction to Embedded systems, Shibu K V, Tata McGraw Hill First print – 2009.

5) An Embedded Software Primer, David E,Simon, Pearson Education Asia, 2000.
6) Embedded Systems Design, A unified Hardware /Software Introduction, Frank Vahid and Tony Givargis, John Wiley, 2002.
7) Computers as Components; Principles of Embedded Computing System Design Wayne Wolf, Harcourt India, Morgan Kaufman Publishers, First Indian Reprint 2001.

SEMESTER-I

MTEDC106: COMMUNICATION SKILLS

COURSE OUTCOMES:

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

1) Students are found to be confident while using English.
2) Engage in analysis of speeches or discourses and several articles.
3) Identify and control anxiety while delivering speech.
4) Write appropriate communications (Academic/Business).
5) Prepared to take the examinations like GRE/TOFEL/IELTS.
6) Identify and control the tone while speaking.
7) Develop the ability to plan and deliver the well-argued presentations.

COURSE CONTENTS:

UNIT I: COMMUNICATION AND COMMUNICATION PROCESSES (04 Hours)

Introduction to Communication, Forms and functions of Communication, Barriers to Communication and overcoming them, Verbal and Non-verbal Communication, Ways of Effective Communication.

UNIT II: ORAL COMMUNICATION (06 Hours)

Use of Language in Spoken Communication, Features of Good Communication, Principles and Practice of Group Discussion, Public Speaking (Addressing Small Groups and Making Presentation), Interview Techniques, Appropriate Use of Non-verbal Communication, Presentation Skills, Telephonic Etiquettes, Extempore, Elocution, Describing Experiences and Events.

UNIT III: STUDY OF SOUNDS IN ENGLISH (04 Hours)

Introduction to phonetics, Study of Speech Organs, Study of Phonemic Script, Articulation of Different Sounds in English, Stress Mark.

UNIT IV: ENGLISH GRAMMAR (04 Hours)

Grammar: Forms of Tenses, Articles, Prepositions, Use of Auxiliaries and Modal Auxiliaries, Synonyms and Antonyms, Common Errors, Sentence Formation and Sentence Structures, Use of Appropriate Diction.

UNIT V: WRITING SKILLS (06 Hours)

Features of Good Language, Difference between Technical Style and Literary Style, Writing Emails, Formal and Informal English, Business Writing, Advertisements, Essay Writing, (Technical, Social, and Cultural Topics), Technical Reports: Report Writing: Format, Structure and Types, Writing Memorandum, Circulars, Notices, Agenda and Minutes, Technical Manuals, Brochures

Letter Writing: Types, Parts, Layouts, Letters and Applications, Use of Different Expressions and Style, Writing Job Application Letter and Resume.

UNIT VI: READING SKILLS & LISTENING SKILLS (04 Hours)

Reading: Introduction to Reading, Barriers to Reading, Types of Reading: Skimming, Scanning, Fast Reading, Strategies for Reading, Comprehension.

Listening: Importance of Listening, Types of Listening, Barriers to Listening.

REFERENCES:

1) Mohd. Ashraf Rizvi, Communications Skills for Engineers, Tata McGraw Hill.

2) Sanjay Kumar, Pushp Lata, Communication Skills, Oxford University Press, 2016.
3) Meenakshi Raman, Sangeeta Sharma, Communication Skills, Oxford University Press, 2017.
4) Teri Kwal Gamble, Michael Gamble, Communication Works, Tata McGraw Hill Education, 2010.

SEMESTER-I

MTEDC107: PG LAB-I

Students are instructed to frame and perform laboratory assignment based on each of theory Course. The assignment should encompass the hardware and engineering computation software such as MATLAB, PSCAD, ETAP etc. techniques/tools introduced in the concerned subjects and should prove to be useful for the PG program in the relevant field with moderate to high complexity. Assignment should be a full-fledged system design problems with multidimensional solutions suggested.

SEMESTER II

MTEDC201: ADAPTIVE CONTROL SYSTEM

COURSE OUTCOMES:

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

1) Design and Implement System Identification Experiments.
2) Estimate Parameters in Dynamical System.
3) Use System Identification Methods to Design Adaptive Controllers.
4) Design Direct and Indirect Self-Tuning Regulators via Minimum Degree Pole Placement.
5) Design Model Reference Adaptive Controllers via the MIT Rule.
6) Design Model Reference Adaptive Controllers via Lyapunov's Stability Theory.
7) Explain the Advantages and Disadvantages of Adaptive Control Relative to Other Control Approaches.

COURSE CONTENTS:

Unit I: INTRODUCTION TO ADAPTIVE CONTROL (07 Hours)

Introduction: Definitions, History of Adaptive Control, Essential Aspects of Adaptive Control, Adaptive Control Versus Conventional Feedback Control, Adaptive Control Versus Robust Control, Classification of Adaptive Control System: Feedback Adaptive Controllers, Feed Forward Adaptive Controllers, Open Loop Adaptive Control, Direct Adaptive Control, Indirect Adaptive Control, Basic Adaptive Control Schemes, Adaptive Control Problems, Applications.

Unit II: PARAMETER ESTIMATION (07 Hours)

Introduction, Least Squares and Regression Models: Statistical Properties of Least Squares Estimation, Recursive Least Squares Estimation (RLS), Continuous Time Least Squares Estimation. Estimating Parameters in Dynamical System: Finite-Impulse Response (FIR) Models, Transfer Function Models, Nonlinear Models, Stochastic Models. Experimental Conditions, Simulation of Recursive Estimation.

Unit III SELF-TUNING REGULATORS (STR) (07 Hours)

Introduction, Pole Placement Design, Indirect Self-tuning Regulators, Continuous Time Self-tuners, Direct Self Tuning Regulators, Effect of Disturbances with Known Characteristics, Design of Minimum-Variance and Moving-Average Controllers, Stochastic Self-tuning Regulators, Direct Self-tuning Regulators, Linear Quadratic STR, Adaptive Predictive Control.

Unit III: MODEL REFERENCE ADAPTIVE SYSTEM (07 Hours)

Introduction, The MIT Rule, Determination of Adaptation Gain, Lyapunov Theory, Design of MRAS using Lyapunov Theory, Bounded Input Bounded Output Stability, Applications to Adaptive Control, Output Feedback, Relations Between MRAS and STR, Nonlinear Systems.

Unit V: GAIN SCHEDULING (07 Hours)

Gain Scheduling: Introduction, The Basic Principle, Design and Implementation of Gain Scheduling Controllers, Nonlinear Transformations, Adaptation of a Feed Forward Gain, PID Control, Auto Tuning Techniques, Applications.

Unit VI: ADAPTIVE CONTROL APPLICATIONS (07 Hours)

Industrial Adaptive Controllers, Process Control, Machine and Drive Control, Ship Steering, Flight Control, Fuel-Air Control in Car Engine, Autopilot Control, Chemical Reactor Control, Neuro-Fuzzy Adaptive Controllers.

REFERENCES:

1) Ljung “System Identification: Theory for the user” Second edition, Prentice Hall Information and System Sciences Series.
2) Landau I. D., “Adaptive Control: The Model Reference Approach” Marcel Dekker, New York.
3) Astrom K. J., and Bjorn Wittenmark “Adaptive control” Second edition, Pearson education publications
4) Widrow B., and S. D. Stearns “Adpative Signal processing” Englewood Cliffs, N. J. Prentice Hall.
5) Isermann R., Lashmann K. and Marko D., “Adaptive Control Systems”, Printice-Hall.
6) Roffel B., Vermeer P. J. and Chin P. A., “Simulation and Implementation of Self Tuning Controllers”, Prentice-Hall.
7) Astrom K. J., Anton J. J. and Arzen K. E., “Expert control” Automatica 22(3):277-286.

SEMESTER II

MTEDC202: AC DRIVES

COURSE OUTCOMES:

1) Explain the basics methods of speed control of Induction motor.
2) Apply the various speed control methods for controlling the speed of Induction motor.
3) Apply the various speed control methods for controlling the speed of synchronous motor.
4) Use vector control method for controlling the Induction motor drive.
5) Use vector control method for controlling the synchronous motor drive.

COURSE CONTENTS:

UNIT I: AC DRIVES (08 Hours)
Principles of speed control , Various methods of Induction motor drive, Variable voltage operation, Variable frequency operation, Constant flux operation, Torque-Slip characteristic, Constant Torque and Constant power operation, Implementation of V/f control with slip compensation scheme

UNIT II: SPEED CONTROL OF INDUCTION MOTOR (09 Hours)
Speed control of VSI and CSI fed drives - design examples. Closed loop control schemes - dynamic and regenerative braking - speed reversal.
Torque slip characteristics- speed control through slip - rotor resistance control- chopper controlled resistance equivalent resistance combined stator voltage control and rotor resistance control- design solutions. Closed loop control scheme. Slip power recovery - torque slip characteristics - power factor considerations.

UNIT III: SPEED CONTROL OF SYNCHRONOUS MOTOR (08 Hours)
Need for leading PF operation - open loop VSI fed drive - group drive applications. Self control - margin angle control - torque angle control - power factor control - simple design examples.

UNIT IV: VECTOR CONTROL OF INDUCTION MOTOR DRIVE (08 Hours)
Review of dq0 model of 3-Ph IM, Principle of vector control of IM - Direct vector control - Indirect vector control with feedback - Indirect vector control with feed-forward - Indirect vector control in various frames of reference, Decoupling of vector control with feed forward compensation - Direct Torque Control of IM

UNIT V: VECTOR CONTROL OF SYNCHRONOUS MOTOR DRIVES (09Hours)
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.
Types of PM Synchronous motors - Torque developed by PMSM - Model of PMSM - Implementation of vector control for PMSM

REFERENCES:

1) Modern Power Electronics & AC Drives – B.K. Bose - Pearson, First Edition.
2) Electric Motor Drives: Modeling, Analysis and Control – R. Krishnan – Prentice Hall.

3) Vector Control of AC Drives, I. Boldea and S. A. Nasar, CRC Press LLC, 1992.

SEMESTER II

ELECTIVE III: MTEDC203: INTELLIGENT CONTROL

COURSE OUTCOMES:

After completing the course, students will be able to:

1) Identify the basic neural networks paradigms.
2) Describe the basic concepts of training in neural networks.
3) Describe the concept of fuzziness involved in various systems.
4) Understand the basic concepts of about fuzzy set theory.
5) Analyze the different techniques used for modelling and control of the AC and DC drives.
6) Apply neural network and fuzzy techniques for designing successful applications.

COURSE CONTENTS:

UNIT I: ARTIFICIAL NEURAL NETWORKS (08 hours)

Biological Neuron and Their Artificial Model; Models of Artificial Neural Network: Single Layer and Multilayer, Feed-forward Network, Feedback Network; Neural Processing; Types of Neuron Activation Function; Learning Strategy: Supervised, Unsupervised, Reinforcement; Learning Rules; Auto-Associative and Hetro-Associative Memory.

UNIT II: BACK PROPAGATION NETWORKS (08 hours)

Architecture: Perceptron model, Single-Layer Perceptron Network, Multilayer Perception Model; Back Propagation Learning Methods; Generalized Delta Learning Rule; Back Propagation Algorithm; Factors Affecting Back-Propagation Training; Learning Factors: Initial Weights, Steepness of the Activation Function, Learning Constant, Momentum Factor, Necessary Number of Hidden Neurons.

UNIT III: INTRODUCTION TO FUZZY LOGIC (08 hours)

Classical Sets and Fuzzy Sets: Operations and Properties; Classical relations and fuzzy relations: Cartesian product, Crisp relations, Fuzzy relations, Operations on fuzzy relations, Properties of Fuzzy Relations, Fuzzy Cartesian Product and Composition; Tolerance and Equivalence Relations; Fuzzy Tolerance and Equivalence Relations; Value Assignments.

UNIT IV: FUZZY LOGIC SYSTEM (08 hours)

Membership Function: Various Forms, Membership Value Assignments; Fuzzification and Defuzzification Module, Rule Base, Choice of Variable and Contents of Rules, Derivation of Rules, Data Base, Fuzzy Inference System, Choice of Membership Function and Scaling Factors, Choice of Fuzzification and Defuzzification Procedure, Various Methods; Fuzzy Associative Memories.

UNIT V: APPLICATIONS OF NEURAL NETWORKS AND FUZZY LOGIC (10 hours)

Speed Control of DC Motor, Induction Motor, Switched Reluctance, Brushless DC Motor, Synchronous Machine, Modelling and Control of DC and AC Drive, Hybrid Neuro-Fuzzy Applications.

REFERENCES:

1. B. Yegnanarayana, "Artificial neural networks", Prentice Hall of India, Private limited, New Delhi.
2. J. M. Zurada, "Introduction to Artificial Systems", Singapore: Info Access and distributions/ West Publishing Company.
3. James A. Anderson, "An Introduction to Neural Networks", Practice Hall India Publication.
4. D. Drainkov, H. Hellendoorn and M. Reinfrank, "An Introduction to Fuzzy Control", Narosa Publishing House.
5. Siman Haykin, "Neural Networks", Prentice Hall of India.
6. T. J. Ross, "Fuzzy Logic with Engineering Applications", John Wiley & Sons.
7. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural network, Fuzzy logic and Genetic Algorithm", Prentice Hall of India.
8. S. N. Sivanandam, S. Sumathi, S. N. Deepa, "Introduction to Neural Network Using MATLAB 6.0", Tata McGraw Hill.

SEMESTER II

ELECTIVE III: MTEDC203: POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

COURSE OUTCOMES:

1) Provide knowledge about the stand alone and grid connected renewable energy systems.
2) Equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
3) Analyze and comprehend the various operating modes of wind electrical generators and solar energy systems.
4) Design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
5) Develop maximum power point tracking algorithms.

COURSE CONTENTS:

UNIT I: INTRODUCTION (08 Hours)

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 (08 Hours)

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III: POWER CONVERTERS (09 Hours)

Solar: Block diagram of solar photo voltaic system, line commutated converters,(inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV: ANALYSIS OF WIND AND PV SYSTEMS (09 Hours)

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system, Grid connection Issues, Grid integrated PMSG and SCIG Based WECS, Grid Integrated solar system

UNIT V: HYBRID RENEWABLE ENERGY SYSTEMS (08 Hours)

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV-Maximum Power Point Tracking (MPPT).

REFERENCES:

1) S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electricaal Systems”, Oxford University Press, 2009
2) Rashid M. H. “Power Electronics Hand book”, Academic press, 2001.
3) Rai G.D., “Non Conventional Energy Sources”, Khanna publishes, 1993.
4) Rai. G.D.,” Solar Energy Utilization”, Khanna publishes, 1993.

SEMESTER II

ELECTIVE III: MTEDC203: ELECTRIC TRACTION

COURSE OUTCOMES:

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

1) Understand the basics of Electric Traction System.
2) Identify different Traction Drives and controlling techniques.
3) Develop protection system for Electric Locomotive
4) Design the Electric Traction Sub-Systems (Overhead Equipment).
5) Analyze Train signaling and conditioning.

COURSE CONTENTS:

UNIT I: ELECTRIC TRACTION- PRINCIPLE AND HISTORY (08 Hours)

Systems of traction, The Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy for the 21st century, Advantages of Electric Traction over other systems of traction, Choice of traction system - Diesel- Electric or Electric. Mechanics of train movement, Speed - time curve for train movement, Requirement of tractive effort and T-N curve of a typical train load, Specific energy consumption & Factors affecting SEC Adhesion & Coefficient of adhesion, Suspension and mechanism of torque transmission, Concept of Weight Transfer & Effect of un-sprung mass and wheel diameter

UNIT II: TRACTION MOTOR DRIVES- PRINCIPLES AND GEAR (10 Hours)

Type of traction motor best suited for traction duties, Available motor characteristics and their suitability for traction duties, Optimization of design and construction features for improved power to weight ratio, Power Factor and Harmonics, Tractive Effort and Drive Ratings, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor Converter Controlled Drives, DC Traction using Chopper Controlled Drives, Poly phase AC motors for Traction Motors, DC /AC Traction employing Poly-phase motors, Diesel Electric Traction, Traction control of DC locomotives and EMU's, Traction control system of AC locomotives, Control gear, PWM control of induction motors, Power & Auxiliary circuit equipment (Other than traction motors)

UNIT III: PROTECTION OF ELECTRIC LOCOMOTIVE EQUIPMENT AND CIRCUITS (09 Hours)

Broad strategy for protection, Surge protection, Overload protection of main power circuits, Earth fault protection of power of auxiliary circuits, Protection from over-voltage and under-voltage, Differential protection of traction circuits, Protection against high and low air pressure in the compressed air circuit, Temperature monitoring, Protection of transformer by Bucholz relay, Protection against accidental contact with HT equipment Protection against fires.

UNIT-IV: ELECTRIC TRACTION SUB-SYSTEMS (OVERHEAD EQUIPMENT) (09 Hours)

Overhead Equipment (OHE), Sectionalizing, Bonding of Rails and Masts, Materials Employed in OHE Electric Traction Sub-Systems (Power Supply Installations): Lay out design of 137/25 KV Traction Substation/ Protection, Booster Transformers and Return Conductor, Salient 2x25 Kv AC System/ SCADA.

UNIT-V: RAILWAY SIGNALING: (06 Hours)

Block Section Concept, Track Circuits, Interlocking Principle, Train speed and signaling, Solid state Interlocking, Automatic Warning Systems, CAB signaling, Signaling level crossing.

REFERENCES:

1) Upadhayay J. & Mahindra S.N., "Electric Traction", Allied Publishers Ltd., 1st Ed.
2) Rao P.S., "Principle of 25 KV Overhead Equipments, Printpack Pvt Ltd, 1st Edition.
3) Gopal K Dubey, "Fundamentals of Electric Drives" , Narosa Publishing.
4) Partab ,"Modern Electric Traction", Dhanpat Rai & Sons.

SEMESTER II

ELECTIVE IV: MTEDC204: ROBOTICS AND CONTROL

COURSE OUTCOMES:

1) Understand robot terminologies and robotic sensors.
2) Analyze direct and inverse kinematic relations.
3) Formulate manipulator Jacobians and introduce path planning techniques.
4) Analyze robot dynamics.
5) Apply robot control techniques to real world applications.

COURSE CONTENTS:

UNIT I: INTRODUCTION AND TERMINOLOGIES (09 hours)

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 (08 hours)

Mechanism, matrix representation, homogenous transformation, DH representation Inverse kinematics, solution and programming, degeneracy and dexterity.

UNIT III: DIFFERENTIAL MOTION AND PATH PLANNING (08 hours)

Jacobian, differential motion of frames, Interpretation, calculation of Jacobian, Inverse Jacobian, Robot Path planning.

UNIT IV: DYNAMIC MODELLING (08 hours)

Lagrangian mechanics, Two-DOF manipulator, Lagrange-Euler formulation, Newton Euler formulation, Inverse dynamics.

UNIT V: ROBOT CONTROL SYSTEM (09 hours)

Linear control schemes, joint actuators, decentralized PID control, computed torque control, force control, hybrid position force control, Impedance/ Torque control.

REFERENCES:

1) R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., New Delhi.
2) K. S. Fu., R. C. Gonzalez, C. S. G. Lee, "Robotics: Control Sensing, Vision and Intelligence", International Edition, McGraw Hill Book Co.
3) Richard D. Klafter, Thomas A. Chemielewski, Michael Neign "Robotic Engineering – An Integral Approach", Prentice Hall of India Pvt. Ltd., New Delhi.
4) Arthur J. Critchlow, "Introduction to Robotics", Macmillan Publishers Limited, 1985.
5) Robert J. Schilling, "Fundamentals of Robotics: Analysis and Control", Prentice Hall of India, New Delhi.
6) John J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson Education.
7) Saeed B. Niku ,''Introduction to Robotics '', Pearson Education, 2002
8) Reza N.Jazar, Theory of Applied Robotics Kinematics, Dynamics and Control, Springer, Fist

Indian Reprint 2010.
9) Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, "Industrial Robotics: Technology, Programming and Applications", McGraw Hill Book Company.

SEMESTER II

ELECTIVE IV: MTEDC204: ELECTRIC AND HYBRID VEHICLES

COURSE OUTCOMES:

CO1	Describe the configuration and performance of Electric vehicles
CO2	Design the structure of Hybrid Electric Vehicle
CO3	Describe the operation of Fuel Cells
CO4	Explain Electric propulsion system and Motor control systems
CO5	Discuss energy storage devices and generators

CO-PO Mapping

	1	2	3	4	5	6	7	8	9	10	11	12
CO1	2					1						
CO2		2				1	1					
CO3	2						1					
CO4	2											
CO5	2					1						1

COURSE CONTENTS:

UNIT I ELECTRIC VEHICLES (08 Hours)
Introduction, Layout of an Electric Vehicle, Performance of Electric Vehicles a) Traction Motor Characteristics b) Tractive Effort and Transmission Requirements c) Vehicle Performance , Energy Consumption, Advantages and Limitations, Specifications, System Components, Electronic Control System.

UNIT II: HYBRID VEHICLES (08 Hours)
Concepts of Hybrid Electric Drive Train, Architectures of Series Hybrid Electric Drive Trains, Architectures of Parallel Hybrid Electric Drive Trains, Merits and Demerits, Series Hybrid Electric Drive Train Design, Parallel Hybrid Electric Drive Train Design.

UNIT III: FUEL CELLS & SOLAR CARS (08 Hours)
Photovoltaic Cells, Tracking, Efficiency, Solar Cars, Fuel Cells - Construction & Working, Equations, Possible Fuel Sources, Fuel Reformer, Design, Cost Comparison.

UNIT IV: ELECTRIC PROPULSION SYSTEM AND MOTOR CONTROL SYSTEM (10 Hours)

DC Motors Characteristics, Speed and Torque Control, Regenerative Braking.
AC Motors Characteristics, Speed and Torque Control.
PM- BLDC Motors Characteristics, Speed and Torque Control.
Reluctance Motors Characteristics, Speed and Torque Control, Regenerative Braking.

UNIT V: ENERGY STORAGES & GENERATORS (08 Hours)

Electrochemical Batteries: Types of Batteries, Lead-Acid Batteries, Nickel Based Batteries, Lithium Based Batteries, Electro Chemical Reactions, Thermodynamic Voltage, Specific Energy, Specific Power, Energy Efficiency, Ultra Capacitors, DC Generators, AC Generators, Voltage and Frequency Regulations

REFERENCES:

1) Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC Press, 2004.
2) James Larminie and John Loury, "Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
3) Sandeep Dhameja, "Electric Vehicle Battery Systems", Butterworth – Heinemann, 2002.
4) Ronald K Jurgen, "Electric and Hybrid – Electric Vehicles", SAE, 2002.
5) Ron Hodkinson and John Fenton, "Light Weight Electric/Hybrid Vehicle Design", Butterworth – Heinemann, 2001.
6) Iqbal Husain, "Electric and Hybrid Vehicles- Design Fundamentals" CRC Press, 2011.

SEMESTER II

ELECTIVE IV: MTEDC204: ELECTROMAGNETIC INTERFERENCE & COMPATIBILITY IN POWER ELECTRONIC SYSTEM

COURSE OUTCOMES:

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

1) Recognize the sources of conducted and radiated EMI in Power Electronic converters and consumer appliances and suggest remedial measures to mitigate the problems.
2) Assess the insertion loss and design EMI filters to reduce the loss.
3) Design EMI filters, common mode chokes, and snubber circuits measures to keep the interference within tolerable limits.

COURSE CONTENTS:

UNITI: INTRODUCTION (10 Hours)

Fundamentals of EMI and EMC Electromagnetic Fields: static, quasi-static and high frequency fields, Sources of EMI and their classifications, propagation and crosstalk, effect of EMI on devices and systems, general interference control techniques, Human exposure limits to EM fields measuring instruments, conducted EMI references, EMI in power electronic equipment EMI from power semiconductors circuits.

UNIT II: EMC COMPLIANCE (11 Hours)

Need for EMC compliance, EMC standards, Measurement and testing, general EMC design principles for power electronic systems ,EMI/ EMC Design for PCBs Fundamentals, sources, grounding, return circuit design, controlling EMI sources, decoupling power/ground planes.

UNIT III: NOISE (10 Hours)

Noise suppression in relay systems: AC switching relays, shielded transformers, capacitor filters, EMI generation and reduction at source, influence of layout and control of parasites. Troubleshooting and solutions for minimization of emissions, Software and hardware tools for EMC.

UNIT IV: Filters (11 Hours)

EMI filter elements: Capacitors, choke coils, resistors, EMI filter circuits.EMI filter design for insertion loss: Worst case insertion loss, design method for mismatched impedance condition and EMI filters with common mode choke-coils.

REFERENCES:

1) "Power Electronics, Converters, Applications & Design",N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt.Ltd.
2) "PCB Design for Real World EMI Control", Bruce R. Archambeault , Kluwer Academic Publishers Group, 2002.
3) "Electromagnetic Compatibility in Power Systems", Francesco Larrarulo, Elsevier, 2002.
4) "EMI Troubleshooting Techniques" Michel Mardiguin, McGrawHill, 2000
5) "Principles and Techniques of Electromagnetic Compatibility", Christos Christopoulous, CRC Press, Second edition
6) "Electromagnetic Modelling of Power Electronic Converters", J.A Ferreira, Kluwer Academic Publishers Group.

SEMESTER II

ELECTIVE V: MTEDC205: ENERGY MANAGEMENT AND AUDITING

COURSE OUTCOMES:

Upon successful completion of this course the student will be able to:

1) Identify and describe present state of energy security and its importance.
2) Identify and describe the basic principles and methodologies adopted in energy audit of utility.
3) Describe the energy performance evaluation of some common electrical and thermal installations and identify the energy saving opportunities.
4) Analyze the data collected during performance evaluation and recommend energy saving measures

COURSE CONTENTS:

UNIT I: BASIC PRINCIPLES OF ENERGY AUDIT (08 Hours)

Energy audit- definitions, concept, types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit Need for energy management – energy basics – designing and starting an energy management program – energy audit process. Need for energy management – energy basics – designing and starting an energy management program – energy accounting – energy monitoring, targeting and reporting.

UNIT II: ENERGY COST AND LOAD MANAGEMENT (06 Hours)

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 EFFICIENT MOTORS (06 Hours)

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance - over motoring - motor energy audit applications to Systems and equipment such as: electric motors – transformers and reactors – capacitors and synchronous machines.

UNIT IV: METERING FOR ENERGY MANAGEMENT (06 Hours)

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 AND COGENERATION (08 Hours)

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.

UNIT VI: ECONOMIC ASPECTS AND ANALYSIS (08 Hours)

Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

REFERENCES:

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

SEMESTER II

ELECTIVE V: MTEDC205: RESEARCH METHODOLOGY

COURSE OUTCOMES:

After the completion of the course the students will be able to:

1) Understand the research meaning apply the same for doing the research work
2) Identify and formulate the research problem.
3) Design the research work in the proper structured manner using sample techniques.

COURSE CONTENTS:

UNIT I: Foundations of Research (0 7 Hours)

Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process

UNIT II: Problem Identification & Formulation (0 7 Hours)

Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance.

UNIT III: Research Design (0 7 Hours)

Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

UNIT IV: Qualitative and Quantitative Research (0 7 Hours)

Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches.

UNIT V: Sampling **(0 7 Hours)**

Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample – Practical considerations in sampling and sample size.

UNIT VI: Data Analysis **(0 7 Hours)**

Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.

REFERENCES:

1) Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
2) Business Research Methods – Alan Bryman& Emma Bell, Oxford University Press.

SEMESTER II

ELECTIVE V: MTEDC205: MODERN OPTIMIZATION TECHNIQUES

COURSE OUTCOMES:

After the completion of the course the student will be able to

1) Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
2) Understand the relationship between a linear program and its dual, including strong duality and complementary slackness.
3) Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
4) Solve specialized linear programming problems like the transportation and assignment problems.
5) Solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
6) Understand the applications of, basic methods for, and challenges in integer programming

COURSE CONTENTS:

UNIT I: FUNDAMENTALS OF OPTIMIZATION **(08 hours)**

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, PSO, Application of fuzzy set theory).

UNIT II: EVOLUTIONARY COMPUTATION TECHNIQUES **(10 hours)**

Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution-Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

UNIT III: PARTICLE SWARM OPTIMIZATION (08 hours)

Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues-Convergence issues- PSO based applications to Drive Control

UNIT IV: ADVANCED OPTIMIZA TION METHODS (08 Hours)

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

UNIT V: MULTI OBJECTIVE OPTIMIZATION (08 Hours)

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function- MOGA-Multiobjective PSO and its application in Drive Control.

REFERENCES:

1) D. P. Kothari and J. S. Dhillon, “Power System Optimization”, 2ndEdition, PHI learning private limited, 2010.
2) Kalyanmoy Deb, “Multi objective optimization using Evolutionary Algorithms”, John Wiley and Sons, 2008.
3) Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice hall of India first edition, 1988.
4) Carlos A. Coello Coello, Gary B. Lamont, David A. Van Veldhuizen, “Evolutionary Algorithms for solving Multi Objective Problems”, 2ndEdition, Springer, 2007.
5) Kwang Y. Lee, Mohammed A. ElSharkawi, “Modern heuristic optimization techniques”, John Wiley and Sons, 2008.

SEMESTER II

MTEDC206: SEMINAR-I

Seminar-I shall be on state of the art topic of student’s own choice based on relevant specialization approved by an authority. Student should deliver seminar on the state of the art topic in front of the external examiners/internal examiners, staff and student colleagues. Prior to presentation student should carry the details of literature survey form standard references such as international journals and periodicals, recently published reference books etc. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and Head of the department/institute. The assessment shall be based on selection of topic its relevance to present context, report documentation and presentation skills.

SEMESTER II

MTEDC207: PGLAB-II or MINI PROJECT

Students are instructed to frame and perform laboratory assignment/experiments based on each of theory Course. The assignment should encompass the hardware and engineering computation software such as MATLAB, PSCAD, ETAP etc. techniques/tools introduced in the concerned subjects and should prove to be useful for the PG program in the relevant field with moderate to high complexity. Assignment should be a full-fledged system design problems with multidimensional solutions suggested.

Or

The student should select a small project (as suggested by faculty adviser) relevant to Electrical Drives or Control System. Project work based on signal analysis, signal conditioning, state of art, professional software acquaintance like MATALAB, ETAP, PSCAD, PSIM similar work.

SEMESTER III

MTME301: PROJECT MANAGEMENT AND INTELLECTUAL PROPERTY RIGHTS

COURSE OUTCOMES:

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

1) Enumerate and demonstrate fundamental terms such as copy-rights, Patents, Trademarks etc.
2) Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration Processes to register own project research.
3) Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies.
4) Develop awareness at all levels (research and innovation) of society to develop patentable technologies.
5) Apply trade mark law, copy right law, patent law and also carry out intellectual property audits.
6) Manage and safeguard the intellectual property and protect it against unauthorized use.

COURSE CONTENTS:

A. PROJECT MANAGEMENT:

UNIT I:

Introduction to Project management**:** Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Work definition: Defining work content, Time Estimation Method, Project Cost

Estimation and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure, LRC, Gantt charts, CPM/PERT Networks.

UNIT II:
Developing Project Plan (Baseline), Project cash flow analysis, Project scheduling with resource constraints: Resource Leveling and Resource Allocation. Time Cost Trade off: Crashing Heuristic.

UNIT III:
Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, Project Procurement Management. Post-Project Analysis.

B. IPR:

UNIT IV:
Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Patents ;their definition; granting; infringement; searching & filing; Utility Models an introduction.

UNIT V:
Copyrights; their definition; granting; infringement; searching & filing, distinction between related and copy rights; Trademarks, role in commerce, importance, protection, registration; domain names.

UNIT VI:
Industrial Designs ; Design Patents; scope; protection; filing infringement; difference between Designs & Patents' Geographical indications , international protection; Plant varieties; breeder's rights, protection; biotechnology& research and rights managements; licensing, commercialization; legal issues, enforcement ;Case studies in IPR.

REFERENCES:

1) Shtub, Bard and Globerson, Project Management: Engineering, Technology, and Implementation, Prentice Hall, India.
2) Lock, Gower, Project Management Handbook.
3) Prabuddha Ganguli, IPR published by Tata McGraw Hill 2001.

SEMESTER III

MTEDC302: PROJECT STAGE-I

The dissertation Seminar will consist of a type written report covering the topic selected for Final Dissertation. This should include the Extensive literature survey, technical details, Data collection from R&D organizations/Industries/etc, Study of the viability, applicability and scope of the dissertation, Detailed Design (H/W and S/W as applicable) and related data required for the proposed dissertation work. The candidate will make a comprehensive project Phase-I make a comprehensive project Phase-I report in detail and make the presentations along with the future work towards fulfillment of the dissertation and deliver the dissertation seminar on the topic which will be judged by two examiners appointed by the University (one external and one internal guide). The assessment shall be based on selection of topic its relevance to present context, report documentation and presentation skills, utility of the dissertation work & publications based on the same.

SEMESTER IV

MTEDC401: PROJECT STAGE-II

The student shall be allowed to submit the dissertation- II report only after the completion of dissertation- I. Student should deliver Viva-Voca Presentation on topic of Dissertation-II in front of the external examiners and internal examiners appointed by the University, staff and student colleagues. The assessment shall be based on design and implementation aspects, report documentation and presentation skills, utility of the dissertation work & publications based on the same.

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY LONERE

Model lesson plan

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

Lesson Plan for the academic year 2016-17

Class: M.Tech (EPS) Semester: I Subject: Electrical and hybrid vehicle

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Electric Vehicles** Introduction	Chalk and board
	02	Layout of an Electric Vehicle	PP T &Chalk and board
	03	Performance of Electric Vehicles	PP T &Chalk and board
	04	a) Traction Motor Characteristics	PP T &Chalk and board
	05	b) Traction Effort and Transmission Requirements	Chalk and board
	06	c) Vehicle Performance	Chalk and board
	07	Energy Consumption	Chalk and board
	08	Advantages and Limitations	Chalk and board
	09	Specifications	Chalk and board
	10	System Components	Chalk and board
	11	Electronic Control System	Chalk and board
02	**12**	**Hybrid vehicles** Introduction	
	13	Concepts of Hybrid Electric Drive Train	PP T &Chalk and board
	14	Architectures of Series Hybrid Electric Drive Trains	PP T &Chalk and board
	15	Architectures of Parallel Hybrid Electric Drive Trains	PP T &Chalk and board
	16	Merits and Demerits	PP T &Chalk and board
	17	Series and parallel Hybrid Electric Drive Train Design	
03	**18**	**Fuel cells and solar car** Introduction	PP T &Chalk and board
	19	Photovoltaic Cells	Chalk and board
	20	Tracking	PP T &Chalk and board
	21	Efficiency	PP T &Chalk and board
	22	Solar Cars	PP T &Chalk and board
	19	Fuel Cells - Construction & Working	PP T &Chalk and board
	20	Equations	PP T &Chalk and board
	21	Possible Fuel Sources	PP T &Chalk and board
	22	Fuel Reformer	PP T &Chalk and board
	23	Design	PP T &Chalk and board
	24	Cost Comparison	PP T &Chalk and board
04	**25**	**Electric Propulsion System and Motor Control system** Introduction	Chalk and board
	26	DC Motors Characteristics Speed and Torque Control System Principle Regenerative Braking	Chalk and board
	27	AC Motors	PP T &Chalk and board

		Characteristics Speed and Torque Control	
	28	PM- BLDC Motors Characteristics Speed and Torque Control	PP T &Chalk and board
	29	Reluctance Motors Characteristics Speed and Torque Control Regenerative Braking	PP T &Chalk and board
05	**30**	**Energy Storages & Generators** Introduction	PP T &Chalk and board
	31	Electrochemical Batteries	PP T &Chalk and board
	32	Types of Batteries Lead-Acid Batteries Nickel Based Batteries Lithium Based Batteries	PP T &Chalk and board
	33	Electro Chemical Reactions Thermodynamic Voltage	Chalk and board
	34	Specific Energy Specific Power Energy Efficiency	Chalk and board
	35	Ultra Capacitors	Chalk and board
	36	DC Generators	Chalk and board
	37	AC Generators	Chalk and board
	38	Voltage and Frequency Regulations	PP T &Chalk and board
	39	Ultra Capacitors	Chalk and board
	40	DC Generators	PP T &Chalk and board
	41	AC Generators	PP T &Chalk and board
	42	Voltage and Frequency Regulations	PP T &Chalk and board

Text Book

1. Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC Press, 2004.

Reference Books

1. James Larminie and John Loury, " Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
2. Sandeep Dhameja, "Electric Vehicle Battery Systems", Butterworth – Heinemann, 2002.
3. Ronald K Jurgen, "Electric and Hybrid – Electric Vehicles", SAE, 2002.
4. Ron Hodkinson and John Fenton, "Light Weight Electric/Hybrid Vehicle Design", Butterworth – Heinemann, 2001.

Iqbal Husain, " Electric and Hybrid Vehicles- Design Fundamentals" CRC Press, 2011.