GOVERNMENT COLLEGE OF TECHNOLOGY, COIMBATORE – 641 013

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING (FULL TIME)

2018A REGULATIONS: VERTICALS CURRICULA AND SYLLABI

PROFESSIONAL ELECTIVE COURSES: VERTICALS

S.NO	**VERTICAL I** POWER ENGINEERING	**VERTICAL II** DRIVES AND ENERGY TECHNOLOGIES	**VERTICAL III** INSTRUMENTATION AND CONTROL	**VERTICAL IV** DIVERSIFIED COURSES	**VERTICAL V** ELECTRIC VEHICLE TECHNOLOGY
1	18EPE$03 POWER SYSTEM ECONOMICS	18EPE$14 SPECIAL MACHINES AND CONTROLLERS	18EPE$10 POWER PLANT INSTRUMENTATION (Common to EEE & EIE Branches)	18EPE$22 OPTIMIZATION TECHNIQUES	18EPE$30 ELECTRIC VEHICLE ARCHITECTURE
2	18EPE$09 POWER SYSTEM STABILITY	18EPE$23 ELECTRICAL MACHINE DESIGN	18EPE$19 BIOMEDICAL INSTRUMENTATION (Common to EEE & EIE Branches)	18EPE$02 NEURAL AND FUZZY SYSTEMS	18EPE$31 DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES
3	18EPE$05 HVDC TRANSMISSION SYSTEMS	18EPE$20 INDUSTRIAL DRIVES AND CONTROL	18EPE$01 PRINCIPLES OF VIRTUAL INSTRUMENTATION	18EPE$08 AUTOMOTIVE ELECTRONICS FOR ELECTRICAL ENGINEERING	18EPE$32 HYBRID ELECTRIC AND FUEL CELL VEHICLES
4	18EPE$06 FACTS CONTROLLERS	18EPE$04 POWER QUALITY ENGINEERING	18EPE$18 MEMS AND APPLICATIONS	18EPE$11 DIGITAL SIGNAL PROCESSING AND PROCESSORS	18EPE$33 DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM
5	18EPE$07 ENERGY AUDITING AND MANAGEMENT	18EPE$21 ENERGY STORAGE TECHNOLOGY	18EPE$15 LOGIC AND DISTRIBUTED CONTROL SYSTEMS	18EPE$12 COMPUTER SYSTEM ARCHITECTURE	18EPE$34 TESTING OF ELECTRIC VEHICLES
6	18EPE$17 SOLID STATE RELAYS	18EPE$26 DISTRIBUTED GENERATION AND MICROGRID	18EPE$25 MODERN CONTROL THEORY	18EPE$13 PRINCIPLES OF EMBEDDED SYSTEMS	18EPE$35 GRID INTEGRATION OF ELECTRIC VEHICLES
7	18EPE$24 SMART GRID TECHNOLOGY	18EPE$29 RENEWABLE ENERGY TECHNOLOGY	18EPE$27 ELECTRONIC CIRCUIT DESIGN (Common to EEE & EIE Branches)	18EPE$28 ELECTRONIC SYSTEM DESIGN AND PRODUCTIZATION (Common to EEE & EIE Branches)	18EPE$36 INTELLIGENT CONTROL OF ELECTRIC VEHICLES.
8	18EPE$16 RESTRUCTURED POWER SYSTEMS				

PROFESSIONAL ELECTIVE COURSES : VERTICALS

VERTICAL I

POWER ENGINEERING

S. NO.	COURSE CODE	COURSE TITLE	CAT	CA MARKS	END SEM MARKS	TOTAL MARKS	CREDITS			
							L	T	P	C
1	18EPE$03	POWER SYSTEM ECONOMICS	PE	40	60	100	3	0	0	3
2	18EPE$05	HVDC TRANSMISSION SYSTEMS	PE	40	60	100	3	0	0	3
3	18EPE$06	FACTS CONTROLLERS	PE	40	60	100	3	0	0	3
4	18EPE$07	ENERGY AUDITING AND MANAGEMENT	PE	40	60	100	3	0	0	3
5	18EPE$09	POWER SYSTEM STABILITY	PE	40	60	100	3	0	0	3
6	18EPE$16	RESTRUCTURED POWER SYSTEMS	PE	40	60	100	3	0	0	3
7	18EPE$17	SOLID STATE RELAYS	PE	40	60	100	3	0	0	3
8	18EPE$24	SMART GRID TECHNOLOGY	PE	40	60	100	3	0	0	3

VERTICAL II

DRIVES AND ENERGY TECHNOLOGIES

S. NO.	COURSE CODE	COURSE TITLE	CAT	CA MARKS	END SEM MARKS	TOTAL MARKS	CREDITS			
							L	T	P	C
1	18EPE$14	SPECIAL MACHINES AND CONTROLLERS	PE	40	60	100	3	0	0	3
2	18EPE$20	INDUSTRIAL DRIVES AND CONTROL	PE	40	60	100	3	0	0	3
3	18EPE$23	ELECTRICAL MACHINE DESIGN	PE	40	60	100	3	0	0	3
4	18EPE$04	POWER QUALITY ENGINEERING	PE	40	60	100	3	0	0	3
5	18EPE$21	ENERGY STORAGE TECHNOLOGY	PE	40	60	100	3	0	0	3
6	18EPE$26	DISTRIBUTED GENERATION AND MICROGRID	PE	40	60	100	3	0	0	3
7	18EPE$29	RENEWABLE ENERGY TECHNOLOGY	PE	40	60	100	3	0	0	3

VERTICAL III

INSTRUMENTATION AND CONTROL

S. NO.	COURSE CODE	COURSE TITLE	CAT	CA MARKS	END SEM MARKS	TOTAL MARKS	CREDITS			
							L	T	P	C
1	18EPE$01	PRINCIPLES OF VIRTUAL INSTRUMENTATION	PE	40	60	100	3	0	0	3
2	18EPE$10	POWER PLANT INSTRUMENTATION (Common to EEE & EIE Branches)	PE	40	60	100	3	0	0	3
3	18EPE$18	MEMS AND APPLICATIONS	PE	40	60	100	3	0	0	3
4	18EPE$19	BIOMEDICAL INSTRUMENTATION (Common to EEE & EIE Branches)	PE	40	60	100	3	0	0	3
5	18EPE$15	LOGIC AND DISTRIBUTED CONTROL SYSTEMS	PE	40	60	100	3	0	0	3
6	18EPE$25	MODERN CONTROL THEORY	PE	40	60	100	3	0	0	3
7	18EPE$27	ELECTRONIC CIRCUIT DESIGN (Common to EEE & EIE Branches)	PE	40	60	100	3	0	0	3

VERTICAL IV

DIVERSIFIED COURSES

S. NO.	COURSE CODE	COURSE TITLE	CAT	CA MARKS	END SEM MARKS	TOTAL MARKS	CREDITS			
							L	T	P	C
1	18EPE$02	NEURAL AND FUZZY SYSTEMS	PE	40	60	100	3	0	0	3
2	18EPE$11	DIGITAL SIGNAL PROCESSING AND PROCESSORS	PE	40	60	100	3	0	0	3
3	18EPE$12	COMPUTER SYSTEM ARCHITECTURE	PE	40	60	100	3	0	0	3
4	18EPE$13	PRINCIPLES OF EMBEDDED SYSTEMS	PE	40	60	100	3	0	0	3
5	18EPE$08	AUTOMOTIVE ELECTRONICS FOR ELECTRICAL ENGINEERING	PE	40	60	100	3	0	0	3
6	18EPE$22	OPTIMIZATION TECHNIQUES	PE	40	60	100	3	0	0	3
7	18EPE$28	ELECTRONIC SYSTEM DESIGN AND PRODUCTIZATION (Common to EEE & EIE Branches)	PE	40	60	100	3	0	0	3

VERTICAL V

ELECTRIC VEHICLE TECHNOLOGY

S. NO.	COURSE CODE	COURSE TITLE	CAT	CA MARKS	END SEM MARKS	TOTAL MARKS	CREDITS			
							L	T	P	C
1	18EPE$30	ELECTRIC VEHICLE ARCHITECTURE	PE	40	60	100	3	0	0	3
2	18EPE$31	DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES	PE	40	60	100	3	0	0	3
3	18EPE$32	HYBRID ELECTRIC AND FUEL CELL VEHICLES	PE	40	60	100	3	0	0	3
4	18EPE$33	DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM	PE	50	50	100	2	0	2	3
5	18EPE$34	TESTING OF ELECTRIC VEHICLES	PE	50	50	100	2	0	2	3
6	18EPE$35	GRID INTEGRATION OF ELECTRIC VEHICLES	PE	40	60	100	3	0	0	3
7	18EPE$36	INTELLIGENT CONTROL OF ELECTRIC VEHICLES.	PE	50	50	100	2	0	2	3

VERTICAL I

POWER ENGINEERING

18EPE$03	POWER SYSTEM ECONOMICS

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

* To acquire knowledge on analyzing and synthesizing various methods of achieving economic operation of generating plants in power system.

UNIT – I CHARACTERISTICS AND OPERATION OF POWER PLANTS	**(9 Periods)**
Characteristics operation of Power Plants – Choice of Power Plants – Hydro, thermal and Nuclear- Size of Plant – Input / Output Curves – Review of Economic dispatch and loss formula calculations.	
UNIT – II : OPTIMAL OPERATION OF GENERATING PLANTS	**(9 Periods)**
Economic scheduling -Cost and Loss Calculation for Optimum Economy – Practical Calculation, Evaluation and application of Generation - Analog and Digital methods – Simple problems.	
UNIT – III : HYDRO THERMAL COORDINATION	**(9 Periods)**
Long term co-ordination – Mathematical formulation- short term co-ordination: methods and scheduling by Kirchmayer's method –gradient approach – hydro units in series – Evaluation and applications of Economic Scheduling of Thermal and Hydro Stations.	
UNIT – IV : UNIT COMMITMENT	**(9 Periods)**
Constraints in unit commitment for thermal and hydro plants –Cost function formulation- solution methods : priority list , dynamic programming methods- optimal UC with security constraint	
UNIT – V : GENERATION SYSTEM RELIABILITY ANALYSIS	**(9 Periods)**
Purpose and classification of Load forecasting and system reliability – Generation system reliability – Co-ordination methods – economic operation of power systems – Simple problems	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Elgerd O.I "**Electric Energy System Theory an Introduction**" Tata McGraw Hill, New Delhi, 2008*
2. *Sivanagaraju. S and Sreenivasan.G "**Power System Operation and Control**", Pearson Education Indiai, 2010*
3. *Kirchmayer E. K "**Economic Operation of Power Systems**" John Wiley and sons, New Delhi, 1985*

REFERENCE BOOKS:

1. *Allen Wood J. and Wollenberg B.F.,"**Power Generation Operation and Control**", John Wiley and sons, New Delhi, 2007*
2. *Hawany E.L., and Christensen G.S.,"**Optimal Economic Operation of Electric Power Systems**", Academic Press, New York, 1979*
3. *Sullivan R.L., "**Power System Planning**", McGraw Hill, New York, 1977*

COURSE OUTCOMES:

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

CO1: Understand the Thermal and Hydro generator characteristics

CO2: Evaluate the optimal operating point of generators

CO3: Apply mathematical tool to examine the performance of different generating sources in coordination

CO4: Evaluate the optimal scheduling of generators in power system using conventional optimization techniques

CO5: Analyze the importance of maintaining reliability of generation system

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	H	L	L	L	M	H	H	L	L	M	M	-	M	H
CO2	M	H	M	H	M	H	L	M	M	M	M	M	H	H	M
CO3	M	H	M	H	H	M	H	M	L	L	H	H	M	H	H
CO4	M	H	M	H	M	H	L	M	M	M	M	M	-	M	M
CO5	M	H	L	L	L	M	H	H	L	L	M	M	H	H	M
18EPE$03	M	H	M	M	M	M	M	M	L	L	M	M	H	H	M

L - Low, M - Moderate (Medium), H – High

18EPE$05	HVDC TRANSMISSION SYSTEMS

Category : PE

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To understand about HVDC transmission system and its control.

UNIT – I GENERAL ASPECTS OF HVDC AND HVAC TRANSMISSIONS	**(9 Periods)**
Introduction - Comparison between AC and DC transmissions - DC links - DC cables and line insulators - Comparison between ac and dc cables - Important HVDC projects - Components of a HVDC system.	
UNIT – II : CONVERTER CIRCUITS AND ANALYSIS	**(9 Periods)**
Three Phase bridge converter using SCRs - Operating principles - Waveforms - Gate control and overlap – Voltage, current and power factor relations – Commutating resistance – Inversion – Equivalent circuits – Analysis and charts only for overlap less than 60º - Simple problems	
UNIT – III : CONVERTER CONTROL	**(9 Periods)**
Principle of control – Control characteristics – Constant minimum firing angle control – Constant current control – Constant extinction angle control – Tap changer control – Power and frequency control – Stability control – Starting and stopping of DC link- Power control	
UNIT – IV : FAULTS AND PROTECTION	**(9 Periods)**
Bypass valve – SCR valves malfunctions – Over voltage and current oscillations – DC circuit breakers – DC lightning arrestors – Simple problems**.**	
UNIT – V : HARMONICS, FILTERS AND GROUND RETURN	**(9 Periods)**
Characteristic and uncharacteristic harmonics – Harmonic ac and dc filters – Interference with communication systems – Ground return – land, shore and sea electrodes – Cathodic protection – DC corona.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Kimbark E.W "**Direct Current Transmission**" Vol I, Wiley – Interscience, New york,1971.*
2. *Padiyar K.R "**HVDC Transmission Systems**" New Age International Pvt. Ltd, 2016.*

REFERENCE BOOKS:

1. *Adamson and Hingorani H.G., "**High Voltage DC Power Transmission**", Garaway Ltd. England 1960.*
2. *WadhwaC.L.,"**Electrical Power Systems**", New Age International Pvt. Ltd, New Delhi, 2011.*
3. *Arillaga J., "**High Voltage Direct Current Transmission**", Peter Peregrinus, London, 1998*

COURSE OUTCOMES:

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

CO1: Identify the merits and necessity of HVDC transmission.
CO2: Analysis about the converter circuits.
CO3: Concepts of converter control and power flow.
CO4: Ability to discuss firing angle control
CO5: Select suitable protection method for various converter faults.
CO6: Illustrate about harmonic filtering in HVDC systems.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	M	-	-	-	-	-	-	-	L	H	M	M
CO2	H	H	M	M	-	-	-	-	-	-	-	L	H	H	M
CO3	H	M	M	M	-	-	-	-	-	-	-	-	M	M	M
CO4	H	M	H	M	-	-	-	-	-	-	-	-	M	M	H
CO5	H	M	H	M	-	-	-	-	-	-	-	L	H	H	H
CO6	H	M	H	H	-	-	-	-	-	-	-	-	H	H	M
18EPE$05	H	M	H	M	-	-	-	-	-	-	-	L	H	H	M

L - Low, M - Moderate (Medium), H - High

18EPE$06	FACTS CONTROLLERS

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

* To enhance the transmission capability of transmission system by shunt and series compensation using static controllers.

UNIT – I : INTRODUCTION TO POWER TRANSMISSION CONTROL	(9 Periods)
The concept of flexible AC transmission - Reactive power control in electrical power transmission lines - Uncompensated transmission line – Series and shunt compensation. Calculation of surge impedance loading and midpoint voltage, Transmission problems and needs: the emergence of FACTS- Challenges of Deregulation, Objectives of FACTS - Thyristor Controlled FACTS Controllers and Converter Based FACTS Controllers	
UNIT – II : STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS	**(9 Periods)**
Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage. Applications - Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability.	
UNIT – III : THYRISTOR CONTROLLED SERIES CAPACITOR(TCSC) AND APPLICATIONS	**(9 Periods)**
Operation of the TCSC - Different modes of operation – Modeling of TCSC – Variable reactance model. – Modeling for stability studies. Applications - Improvement of the system stability limit – Enhancement of system damping – Voltage collapse prevention.	
UNIT – IV : EMERGING FACTS CONTROLLERS	**(9 Periods)**
Static Synchronous Compensator (STATCOM) – Operating principle – V-I characteristics Unified Power Flow Controller (UPFC) – Principle of operation - Modes of operation – Applications – Modeling of UPFC for power flow studies, Interline Power Flow Controllers (IPFC) - Basic Operating Principles and Characteristics, Control Structures.	
UNIT – V : CO-ORDINATION OF FACTS CONTROLLERS	**(9 Periods)**
FACTs Controller interactions – SVC–SVC interaction - Co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Mohan Mathur, R., Rajiv. K. Varma "**Thyristor – Based Facts Controllers for Electrical Transmission Systems**" IEEE press and John Wiley & Sons, Inc., 2002*
2. *K.R.Padiyar, "**FACTS Controllers in Power Transmission and Distribution**", New Age International (P) Limited, Publishers, New Delhi, 2008.*

REFERENCE BOOKS:

1. *Yong Huo Song, A.T.John, "**Flexible AC Transmission System**", Institution of Electrical Engineers(IEE), 1999.*
2. *Xiao – Ping Zang, Christian Rehtanz and Bikash Pal, "**Flexible AC Transmission System: Modelling And Control**" Springer, 2012.*
3. *Narain G.Hingorani, Laszio. Gyugyl, "**Understanding FACTS Concepts and Technology of Flexible AC Transmission System**", IEEE Press, A John Wiley & Sons, Inc. Publication, 2000.*

COURSE OUTCOMES:

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

CO1: Understand the problems and issues associated with AC transmission systems.

CO2: Comprehend the operation and control of various FACTS Controllers.

CO3: Develop the modeling of various FACTS Controllers.

CO4: Analyze the performance of Power System with FACTS Controllers.

CO5: Suggest suitable FACTS device for enhancing the transmission capability.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	M	M	M	L	M	M	L	L	M	M	H	L	L
CO2	M	M	H	L	M	M	L	M	L	L	H	M	M	M	M
CO3	M	M	H	M	L	L	L	M	L	L	H	M	M	M	M
CO4	H	M	H	H	L	M	L	L	M	L	M	M	H	H	H
CO5	H	H	H	M	M	L	L	L	L	L	M	H	L	H	H
18EPE$06	H	M	H	M	M	M	L	M	L	L	M	M	M	M	M

L - Low, M - Moderate (Medium), H – High

18EPE$07	ENERGY AUDITING AND MANAGEMENT

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Electrical Machines - I
2. Electrical Machines - II

COURSE OBJECTIVES:

* To comprehend energy management schemes and perform economic analysis and load management in electrical systems.

UNIT – I : BASICS OF ENERGY MANAGEMENT	(9 Periods)
Energy Scenario – Energy Sector Reforms – Impact on environment – Strategy for future and conservation – Basics of Energy and it forms (Thermal and Electrical). Energy Audit: Need – Types and Methodology - Audit Report – Energy Cost, Benchmarking and Energy performance – System Efficiency. Facility as an energy system – Methods for preparing process flow, Material and energy balance diagrams.	
UNIT – II : ACTION PLANNING AND MONITORING	**(9 Periods)**
Energy Management System – Performance assessment – Goal setting by Manager – Action plan implementation – Financial Management: Investment - Financial analysis techniques, ROI, Risk and sensitivity analysis, role of Energy Service Companies. Project management: Steps in detail. – Energy monitoring and interpretance of variances for remedial actions. Environmental concerns: UNFCC – Kyoto protocol – COP – CDM – PCF – Sustainable development.	
UNIT – III : STUDY OF THERMAL UTILITIES	**(9 Periods)**
Combustion of Oil, Coal and Gas – Performance Evaluation of Boilers – Boiler blow down – Boiler water treatment – Energy Conservation Opportunity – Cogeneration: Principal – Options - Classification – Influencing Factors and technical parameters. Waste heat recovery: Classification – application – benefits - Different heat recovery devices.	
UNIT – IV : STUDY OF ELECTRICAL UTILITIES	**(9 Periods)**
Electricity Billing – Electricity load management – Motor efficiency and tests – Energy efficient motors – Factors affecting motor efficiency and loss minimization – Motor load survey. Lighting System: Types and features – recommended luminance levels – Lighting system energy efficiency study – Energy Efficient Technologies: Maximum demand controllers – Intelligent PF controllers – Soft starters and VFDs – Variable torque load uses – Energy efficient transformers, Light controllers and Electronic ballasts.	
UNIT – V : ENERGY ASSESSMENT IN UTILITY SYSTEMS	**(9 Periods)**
Performing Financial analysis: Fixed and variable costs – Payback period – methods – factors affecting analysis – Waste Minimization Techniques: Classification – Methodology. Performance assessment of HVAC Systems: Measurements, Procedure – Evaluation. Assessment of Pumps: Measurements, Procedure – Evaluation.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Murphy W.R. and G.Mckay Butter worth , "**Energy Management**", Heinemann Publications, 2013.*
2. *Paul o' Callaghan, "**Energy Management**", Mc-Graw Hill Book Company – 1st edition; 2012.*

REFERENCE BOOKS:

1. *John.C.Andreas, **"Energy Efficient Electric Motors",** Marcel Dekker Inc Ltd – 2nd edition; 2015.*
2. *W.C.Turner**, "Energy Management Handbook",** John Wiley and Sons, Fifth edition, 2013.*
3. *www.em-ea.org/gbook1.asp*

COURSE OUTCOMES:

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

CO1: Possess knowledge on energy management.
CO2: Analyze the feature of energy audit methodology and documentation of report.
CO3: Able to plan energy management action and develop the understanding of implementation
CO4: Familiarize with thermal utilities.
CO5: Familiarize with electrical utilities.
CO6: Perform assessment of different systems.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	-	-	-	-	-	-	M	-	-	-	M	M	M
CO2	H	-	M	M	-	-	-	-	-	-	-	-	M	M	M
CO3	M	M	H	M	-	-	M	-	H	-	-	-	M	M	M
CO4	M	-	M	-	-	-	-	-	-	-	-	-	M	M	M
CO5	M	M	M	-	-	-	-	-	-	-	-	-	M	M	M
CO6	H	M	-	-	M	-	-	-	M	-	-	-	M	M	M
18EPE$07	M	M	M	M	M	-	M	-	M	-	-	-	M	M	M

L - Low, M - Moderate (Medium), H - High

18EPE$09	POWER SYSTEM STABILITY

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

* To furnish knowledge and analyze about various stability problems in electrical power system.

UNIT-I : INTRODUCTION TO STABILITY	**(9 Periods)**
Stability of power system – Simple two machine stability problems – Mechanical Analogy of power transmission systems – Importance of stability to system operation and design – Effect of instability – Representation of power system components – Stability studies on network analysis	
UNIT-II : STEADY STATE STABILITY	**(9 Periods)**
Introduction to stability of electric power systems – Significance of steady state stability – Power limit of transmission system – Two machine system with negligible losses – Clarke diagram for two machine system with negligible losses – Power angle characteristic and steady state stability limit of salient pole synchronous machines– Two machine system with losses – Clarke diagram for two machine system with resistance – Steady state stability with automatic voltage regulators.	
UNIT-III : TRANSIENT STABILITY-SWING EQUATION	**(9 Periods)**
General background - Swing equation for synchronous machine – Numerical solution of swing equation – Multi machine stability – Factors affecting transient stability	
UNIT-IV : TRANSIENT STABILITY -EQUAL AREA CRITERION	**(9 Periods)**
Concepts of equal area criterion – Application of equal area criterion to stability studies under fault conditions – Determination of critical clearing angle – Reduction of a power system to a single equivalent machine connected to infinite bus – Equivalent power angle curve of two finite machines – Graphical integral method of swing curve determination.	
UNIT-V : EXCITATION SYSTEM AND ITS EFFECT ON STABILITY	**(9 Periods)**
Introduction – Definition of terms – Quick response excitation systems – Compounding the excitation of generators – Modern trend in excitation systems – Voltage regulator capability to improve transient stability – Super-excitation for stability – Two axis excitation control – High initial response excitation systems – Exciter response - Determination by graphical integration – Point by point method of calculation.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

*1.Gangadhar K.A "**Power System Analysis and Stability**" Khanna Publishers, New Delhi, 6th reprint 2004*

*2.Kimbark E.W "**Power System Stability**" Volume III, Wiley – IEEE Press Thrid Reprint, year.*

REFERENCE BOOKS:

*1. P. Kundur, "**Power System Stability and Control**", Tata Mc Graw Hill, 3rd reprint, 2007.*

*2. M.A.Pai,K.Sengupta and K. R.Padiyar, Tata- McGraw hills."**Small Signal Analysis of Power System**", Alpha Science International, 2004.*

*3. Paul M.Anderson and A.A. Fouad, "**Power system Control and stability**" IEEE Press, 2003.*

COURSE OUTCOMES:

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

CO1: Establish the modeling of power system suitable for performing stability analysis.

CO2: Analyze the stability of simple power systems using Analytical and graphical approach.

CO3: Apply computer simulation tools for stability analysis of large power systems.

CO4: Apply control methods for tuning of turbine of voltage controllers in power system.

CO5: Evaluate the power system for stable operation.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	M	-	M	M	-	M	M	-	M	M	M	H	M	L
CO2	H	M	M	-	M	-	M	M	-	M	M	M	H	M	M
CO3	M	H	H	M	M	-	M	-	M	H	M	M	M	H	H
CO4	M	H	H	H	M	-	M	-	M	H	M	M	M	H	H
CO5	M	M	-	M	H	M	M	M	M	H	M	M	M	H	H
18EPE$09	M	M	H	M	M	M	M	M	M	H	M	M	M	H	M

L - Low, M - Moderate (Medium), H – High

18EPE$16	RESTRUCTURED POWER SYSTEMS

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

- To provide a comprehensive treatment towards understanding of the new dimensions associated with the power systems tackling issues involving techno-commercial solutions, fundamentals of microeconomics, design of power markets and market architectural aspects and new operational challenges like congestion management and ancillary service management.

UNIT – I: INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY	**(9 Periods)**
Introduction, Reasons for restructuring / deregulation of power industry, Understanding the restructuring process - Entities involved, The levels of competition, The market place mechanisms, Sector-wise major changes required. Introduction to issues involved in deregulation, Reasons and objectives of deregulation of various power systems across the world. Fundamentals of Economics -Introduction, Consumer behavior, Supplier behavior. Market equilibrium, Short-run and Long-run costs, Various costs of production, Relationship between short-run and long-run average costs, Perfectly competitive market.	
UNIT – II : MARKET MODELS AND TRANSMISSION CONGESTION MANAGEMENT	**(9 Periods)**
Introduction, Market models based on contractual arrangements, Comparison of various market models, Electricity vis-à-vis other commodities, Four pillars of market design. Market architecture. Definition of congestion, Reasons for transfer capability limitation, Importance of congestion management in deregulated environment, desired features of congestion management schemes. Classification of congestion management methods, Calculation of ATC - Definition of various terms, ATC calculation using PTDF and LODF based on DC model, Calculation of ATC using AC model. Non-market methods, Market based methods, Nodal pricing, Inter-zonal Intra-zonal congestion management, Price area congestion management, Capacity alleviation method.	
UNIT – III : LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS	**(9 Periods)**
Mathematical preliminaries, Fundamentals of locational marginal pricing, Lossless DCOPF model for LMP calculation, Loss compensated DCOPF model for LMP calculation, ACOPF model for LMP calculation, Introduction to Financial Transmission Rights, Risk Hedging Functionality Of financial Transmission Rights, Simultaneous feasibility test and revenue adequacy, FTR issuance process, Treatment of revenue shortfall, Secondary trading of FTRs, Flow Gate rights, FTR and market power, FTR and merchant transmission investment.	

UNIT – IV : ANCILLARY SERVICE MANAGEMENT, PRICING OF TRANSMISSION NETWORK USAGE AND LOSS ALLOCATION	**(9 Periods)**
Introduction to ancillary services, Types of ancillary services, Classification of ancillary services, Load-generation balancing related services, Voltage control and reactive power support services, Black start capability service, Co-optimization of energy and reserve services, International comparison. Pricing of transmission network usage and loss allocation - Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing methods, Rolled-in transmission pricing methods, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits and de-merits of different paradigms, Debated issues in transmission pricing, Introduction to loss allocation, Classification of loss allocation methods and comparison.	
UNIT – V : MARKET POWER, GENERATORS BIDDING & REFORMS IN INDIAN POWER SECTOR	**(9 Periods)**
Attributes of a perfectly competitive market, The firm's supply decision under perfect competition, Imperfect competition, Market power, Financial markets associated with electricity markets, Introduction to optimal bidding by a generator company, Optimal bidding methods. Reforms in Indian power sector - Introduction, Framework of Indian power sector, Reform initiatives during 1990-1995. Availability Based Tariff (ABT), The Electricity Act 2003, Open Access issues, Power exchange, Reforms in near future.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Fundamentals of Power System economics, "**Daniel Kirschen and Goran Strbac**", John Wiley & Sons Ltd, 2004.*

REFERENCE BOOKS:

1. *Sally Hunt, "**Making competition work in electricity**", John Wiley & Sons, Inc., 2002.*
2. *Kankar Bhattacharya, Jaap E. Daadler, Math H.J Bollen, **"Operation of restructured power systems"** , Kluwer Academic Pub., 2001.*

COURSE OUTCOMES:

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

CO1: Understand the new dimensions associated with the power systems with techno-commercial issues
CO2: Apply various solutions for the commercial problems through study of fundamentals of micro economics
CO3: Design power markets and market architectural aspects as per the restructuring of power system
CO4: Identify Operational Challenges and manage the same with optimum solution
CO5: Suggest reform practices in developing countries with special focus on Indian power system

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	H	H	L	L	L	L	L	L	M	L	L	L	L
CO2	H	H	H	H	H	L	M	M	M	L	H	M	H	L	L
CO3	H	H	H	H	M	M	L	M	L	H	H	M	L	L	L
CO4	H	H	H	H	M	M	L	M	L	H	H	M	L	M	L
CO5	M	M	M	M	M	M	M	L	M	L	M	M	L	L	M
18EPE$16	H	H	H	H	M	M	L	M	L	M	H	M	L	L	L

L - Low, M - Moderate (Medium), H – High

18EPE$17	SOLID STATE RELAYS

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES: NIL

COURSE OBJECTIVES:

* To gain knowledge on the operational characteristics of relays and to design the relay circuits using Analogue and Digital IC's and processors.

UNIT-I : INTRODUCTION TO STATIC RELAYS	**(9 Periods)**
Advantages of Static Relays - Generalized characteristics and operational equations of relays - Steady state and transient performance of signal driving elements - Signal mixing techniques and measuring techniques - CT's and PT's in relaying schemes - Saturation effects.	
UNIT-II: OVER CURRENT RELAYS	**(9 Periods)**
Static relay circuits (Using Analog and Digital IC's) for over current, inverse – Time characteristics, differential relay and directional relay	
UNIT-III : DISTANCE AND FREQUENCY RELAYS	**(9 Periods)**
Static relay circuits for generator loss of field, under frequency. Distance relays - impedance, reactance, mho, reverse power relays	
UNIT-IV : CARRIER CURRENT PROTECTION AND TESTING	**(9 Periods)**
Static relay circuits for carrier current protection - Steady state and transient behaviour of static relays - Testing and maintenance - Tripping circuits using thyristors	
UNIT-V : MICROPROCESSOR BASED RELAYS	**(9 Periods)**
Hardware and software for the measurement of voltage, current, frequency, phase angle - Microprocessor implementation of over current relays - Inverse time characteristics - Impedance relay - Directional Relay - Mho Relay.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Rao T.S.M "**Power System Protection- Static Relays**" Tata McGraw Hill, Reprint 2011*
2. *Rao "**Digital Numerical Relays**" McGraw Hill, First Ed. 2005*

REFERENCE BOOKS:

1. *Van C. Warrington, "**Protective Relays - Their Theory and Practice**", Chapman and Hall.1968*
2. *Ravindranath B. and Chander M., "**Power System Protection and Switchgear**", Wiley Eastern, 2007*

COURSE OUTCOMES:

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

CO1: Illustrate the operational characteristics of relays

CO2: Explain the functional blocks of various protections relaying schemes

CO3: Analyze different applications of static the relay

CO4: Gain knowledge on different protection circuits and maintenance of equipment

CO5: Test the different high frequency static relays

CO6: Compare and evaluate the conventional and digitized relaying techniques

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	H	L	-	-	-	-	-	-	-	H	H	-
CO2	H	H	H	H	L	-	-	-	-	-	-	H	H	H	-
CO3	H	H	H	H	L	-	-	-	-	-	-	H	H	H	-
CO4	H	H	H	H	H	-	-	-	-	-	-	H	H	H	H
CO5	H	H	H	H	L	M	-	-	-	-	-	H	H	H	H
CO6	H	H	H	H	L	H	-	M	M	M	H	H	M	M	H
18EPE$17	H	H	H	H	L	H	M	M	M	M	H	H	H	H	H

L - Low, M - Moderate (Medium), H – High

18EPE$24	SMART GRID TECHNOLOGY

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

* To gain knowledge on the fundamentals of smart grid technologies, its architecture and its managements, learn many of the challenges facing the smart grid as part of its evolution.

UNIT – I : SMARTGRIDS: MOTIVATION, STAKES AND PERSPECTIVES	**(9 Periods)**
Introduction – Information and Communication technologies serving the electrical system – Integration of advanced technologies – Definitions of Smart Grids – Objectives addressed by the Smart Grid concept – Socio-economic and environmental objectives – Stakeholders involved the implementation of the Smart Grid concept – Research and scientific aspects of the Smart Grid – Smart Grids from the customer's point of view.	
UNIT – II : INFORMATION AND COMMUNICATION TECHNOLOGY	**(9 Periods)**
Data Communication, Dedicated and shared communication channels, Layered architecture and protocols, Communication technology for smart grids, standards for information Exchange, Information security for the smart grid - Cyber Security Standards - IEEE1686 - IEC62351.	
UNIT – III : SENSING AND MEASUREMENT	**(9 Periods)**
Synchro Phasor Technology – Phasor Measurement Unit, Smart metering and demand side integration - Communication infrastructure and protocol for smart metering – Data Concentrator, Meter Data Management System. Demand side Integration – Services, Implementation and Hardware Support of DSI.	
UNIT – IV : CONTROL AND AUTOMATION	**(9 Periods)**
Distribution automation equipment – Substation automation equipments: current transformer, potential transformer, Intelligent Electronic Devices, Bay controller, Remote Terminal Unit. Distribution management systems – SCADA: modeling and analysis tools, applications	
UNIT – V : REGULATION OF SMARTGRIDS AND ENERGY STORAGE SYSTEMS	**(9 Periods)**
Regulation and Economic models – Evolution of the value chain – The emergence of a business model for smart grids – Regulation can assist in the emergence of Smart Grids – The standardization of Smart Grids - Energy Storage Technologies-Methods - Batteries, Flow Battery, Fuel Cell and Hydrogen Electrolyser, Flywheel, Super-Conducting magnetic energy storage system, Super Capacitor	

Contact Periods:

Lecture: 45 Periods   Tutorial: 0 Periods   Practical: 0 Periods   Total: 45 Periods

TEXT BOOKS:

1. *Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage "**Smart Grid Technologies and applications**" John Wiley Publishers Ltd., 2012*
2. *Lars T. Berger, Krzysztof Iniewski "**Smart Grid applications, Communications and Security**" John Wiley Publishers Ltd., 2012*

REFERENCE BOOKS:

1. *Yang Xiao, **"Communication and Networking in Smart Grids",** CRC Press Taylor and Francis Group, 2012.*
2. *Caitlin G. Elsworth, **"The Smart Grid and Electric Power Transmission"**, Nova Science Publishers Inc, August 2010.*
3. *Nouredine Hadjsaid, Jean-Claude Sabonnadiere "**Smart Grids**" Wiley Publishers Ltd., 2012.*

COURSE OUTCOMES:

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

CO1: Develop and demonstrate the various aspects of the smart grid, including Technologies, Components, Architectures, Applications

CO2: Design a smart grid and to meet the needs of a utility, including Meeting a utility's objectives, helping to adopt new technologies into the grid

CO3: Create a framework for knowledgeable power engineers to operate the grid more effectively.

CO4: Transfer the available information from any part of the power system to centralized control centre.

CO5: Handle the smart meter, sensors and intelligent devices to measure the electrical quantity.

CO6: Control the Electrical quantity from remote place

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	-	-	L	L	M	H	L	M	M	M	H	M	H	M
CO2	L	L	M	M	M	M	M	L	M	M	M	M	M	M	H
CO3	M	-	-	M	M	M	M	M	M	M	M	H	M	M	M
CO4	L	-	-	M	M	M	H	-	M	M	M	H	M	H	H
CO5	M	-	L	M	M	M	M	-	M	M	M	M	M	M	M
CO6	L	L	M	L	M	M	L	-	M	M	M	M	M	M	M
18EPE$24	M	L	M	M	M	M	M	L	M	M	M	H	M	M	M

L - Low, M - Moderate (Medium), H - High

VERTICAL II

DRIVES AND ENERGY TECHNOLOGIES

18EPE$14	SPECIAL MACHINES AND CONTROLLERS

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Field Theory

COURSE OBJECTIVES:

* To grasp the working of special electrical machines and to cater the knowledge to real world applications.

UNIT – I : STEPPING MOTORS	(9 Periods)
Constructional features – Principle of operation – Modes of excitation – Torque production in Variable Reluctance (VR) stepping motor – Dynamic characteristics – Drive systems and circuit for open loop control– Closed loop control of stepping motor	
UNIT – II : SWITCHED RELUCTANCE MOTORS	**(9 Periods)**
Constructional features – Principle of operation – Torque equation – Power controllers – Characteristics and control –Microprocessor based controller.	
UNIT – III : SYNCHRONOUS RELUCTANCE MOTORS	**(9 Periods)**
Constructional features –Types –Axial and radial air gap motors –Phasor diagram –Characteristic– Vernier motor.	
UNIT – IV : PERMANENT MAGNET BRUSHLESS DC MOTORS	**(9 Periods)**
Commutation in DC motors – Difference between mechanical and electronic commutators – Hall sensors – Optical sensors – Multiphase Brushless motor – Square wave permanent magnet brushless motor drives – Torque and emf equation – Torque – Speed characteristics – Microprocessor based controller.	
UNIT – V : PERMANENT MAGNET SYNCHRONOUS MOTORS	**(9 Periods)**
Principle of operation – EMF, power input and torque expressions – Phasor diagram – Power controllers – Torque –Speed characteristics –Self control – Vector control – Current control schemes.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

REFERENCE BOOKS:

1. *Ramakrishnan, **"Switched Reluctance Motor Drives",** CRC press, 2001*
2. *Jacek F Gieras and Micheal Wing, **"Permanent Magnet Motor Technology",** CRC press, 2002*
3. *P. P. Acarnely, **"Stepping Motors",** 4th Ed., IFT Publishers, 2002*

COURSE OUTCOMES:

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

CO1: Develop the deep knowledge in concepts of electromechanical energy conversion
CO2: Understand and determination of characteristics of special electrical machines
CO3: Review of modern power electronic converter for special electrical machines
CO4: Design of control circuits for power converters
CO5: Able to choose the right machine for specific applications.
CO6: Explore the ideas to improve the shortcomings of performance of special electrical machines

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	H	M	-	-	-	-	-	-	-	-	H	-	-
CO2	H	H	M	M	M	-	-	-	-	-	-	-	H	-	-
CO3	H	M	M	M	H	L	-	-	-	-	-	-	H	-	-
CO4	M	M	H	M	M	-	-	-	-	-	-	L	-	H	M
CO5	M	M	M	H	-	-	L	-	-	M	-	-	-	H	M
CO6	M	H	M	H	M	-	M	-	-	M	-	M	-	M	H
18EPE$14	H	M	M	M	M	L	M	-	-	M	-	M	H	H	M

L - Low, M - Moderate (Medium), H – High

18EPE$20	INDUSTRIAL DRIVES AND CONTROL

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Electrical Machines - I
2. Electrical Machines - II
3. Power Electronics Devices and Circuits.

COURSE OBJECTIVES:

* To learn the concepts of electrical drives and their applications in carrying out modern industry processes.

UNIT – I : SPEED CONTROL OF DC MOTORS	**(9 Periods)**
Concept of Electric Drive – Classification of Electric Drives – Speed/Torque characteristics Braking methods –Methods of speed control – Ward Leonard drives –Semi, Full converter fed DC drives – Single, Two and Four quadrant operations –Dual converter fed DC drives.	
UNIT – II : DIGITAL CONTROL OF DC MOTORS	**(9 Periods)**
Digital technique in speed control of DC motors – Advantages – Limitations – Closed loop control of DC drives – Analog, Digital and Hybrid speed control –Microprocessor applications to control of DC motor.	
UNIT – III : SPEED CONTROL OF AC MOTORS	**(9 Periods)**
Speed control of AC motors – Speed / Torque characteristics – Braking methods. AC -AC controller fed AC drives, Inverter fed AC drives, Frequency control, V/F control of induction and synchronous motor - Self control, Margin angle control and power factor control.	
UNIT – IV : ROTOR SIDE CONTROL OF FREQUENCY CONTROLLED INDUCTION MOTOR DRIVES	**(9 Periods)**
Rotor side control of Slip ring Induction motor with thyristor chopper – Static control of Rotor resistance – Slip-Energy recovery scheme – Static Scherbius and Kramer systems – Applications of Microprocessor to AC motor speed control .	
UNIT – V : INDUSTRIAL APPLICATIONS	**(9 Periods)**
Choice of selection of motors – Electric drive applications – Steel rolling mills – Cement mills – Paper mills – Textile mills – Sugar mills – Coal mines – Machine Tools.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Dubey G.K* ***"Fundamentals of Electrical Drives"****, Narosa Publishing House, New Delhi, 2nd Ed. 2002.*
2. *Sen, P.C.,* ***"Thyristor DC Drives"****, Krieger Publishing Company 1991*

REFERENCE BOOKS:

1. *Vedam Subramaniam,* ***"Electrical Drives and Applications"****, Tata McGraw Hill, New Delhi, 2nd 2010.*
2. *Murphy J.M.D.,* ***"Thyristor Control of AC Motors"****, Pergamon Press, NewYork, 1973.*
3. *Krishnan R.,* ***"Electric Motor and Drives: Modeling, Analysis and Control"****, Pearson Education,NewDelhi,2001*
4. *Pillai S.K.,* ***"A First Course on Electrical Drives"****, Wiley Eastern Ltd., Bombay, 2nd Ed. 2007.*

COURSE OUTCOMES:

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

CO1: Illustrate the role of power electronics in modern drives.
CO2: Design the digital controller for drives.
CO3: Understand the speed control techniques for AC drives.
CO4: Select drive for particular application considering the present and future needs of industries.
CO5: Understand microprocessors in control of electric drives.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	M	M	L	M	L	-	-	-	-	-	L	H	M
CO2	H	H	H	M	M	L	L	-	-	-	-	-	M	M	H
CO3	H	H	H	M	M	L	L	-	-	-	-	-	H	M	H
CO4	H	M	M	M	H	M	H	-	-	-	-	-	M	M	H
CO5	H	M	L	M	M	L	M	-	-	-	-	-	H	L	L
18EPE$20	H	M	M	M	M	L	M	-	-	-	-	-	M	M	M

L - Low, M - Moderate (Medium), H – High

18EPE$23	ELECTRICAL MACHINE DESIGN

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Electrical Machines - I
2. Electrical Machines - II

COURSE OBJECTIVES:

* To impart knowledge on designing of static and Rotating machines based upon fundamental theories.

UNIT – I :INTRODUCTION TO ELECTRICAL MACHINE DESIGN	**(9 Periods)**
Major considerations in Electrical Machine Design - Electrical Engineering Materials – Space factor – Choice of Specific Electrical and Magnetic loadings- Concept of magnetic circuit- MMF calculation for various types of electrical machines - Thermal considerations - Heat flow –Temperature rise and Insulating Materials - Rating of machines – Standard specifications.	
UNIT – II : DESIGN OF DC MACHINES	**(9 Periods)**
Output Equations – Main Dimensions – Choice of Specific Electric and Magnetic Loading – Magnetic Circuits Calculations - Carter's Coefficient - Net length of Iron – Selection of number of poles – Design of Armature, commutator, air gap, field poles, field coil and brushes – Performance prediction using design values	
UNIT – III : DESIGN OF TRANSFORMERS	**(9 Periods)**
Output Equations – Main Dimensions - kVA output for single and three phase transformers – Window space factor – Design of core, yoke and winding – Overall dimensions – Operating characteristics – No load current – Temperature rise in Transformers – Design of Tank and cooling tubes of transformers	
UNIT – IV : DESIGN OF INDUCTION MOTORS	**(9 Periods)**
Output equation of Induction motor – Main dimensions - Design of stator – Choice of Average flux density – Length of air gap- Rules for selecting rotor slots of squirrel cage machines – Design of rotor bars, slots and end rings – Design of wound rotor – Magnetic leakage calculations – Leakage reactance of polyphase machines - Magnetizing current - Short circuit current – Operating characteristics - Losses and Efficiency.	
UNIT – V : DESIGN OF SYNCHRONOUS MACHINES	**(9 Periods)**
Output equations – Choice of Electrical and Magnetic Loading – Design of salient pole machines –Short circuit ratio – Shape of pole face – Armature design – Estimation of air gap length – Design of rotor and damper winding – Determination of full load field mmf – Design of field winding – Design of turbo alternators – Rotor design.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *K. G. Upadhyay,' **Design of Electrical Machines'**, New Age International, 2011*
2. *Padi A.K.Sawhney, '**A Course in Electrical Machine Design**', Dhanpat Rai and Sons, New Delhi, 2005.*
3. *S.K.Sen, '**Principles of Electrical Machine Design with Computer Programmes**', Oxford and IBH Publishing Co.Pvt Ltd., New Delhi, 1987.*

REFERENCE BOOKS:

1. *Thomas A. Lipo,'* ***Introduction to AC Machine Design****', John Wiley & Sons, 2017*
2. *R.K.Agarwal, '****Principles of Electrical Machine Design****',S.K.Kataria and Sons, Delhi,2002.*
3. *V.N.Mittle and A.Mittle, '****Design of Electrical Machines****', Standard Publications Distributors, Delhi, 2002.*

COURSE OUTCOMES:

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

CO1: Illustrate the design procedure of rotating machines and Transformers.
CO2: Familiarize the importance of magnetic, thermal and electric loadings.
CO3: Identify suitable materials according to design criteria.
CO4: Develop model and analyze the static and rotating machines.
CO5: Evaluate the optimal design of electrical power apparatus.
CO6: Examine the design of electrical machines according to standards.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	H	L	L	M	H	M	M	H	H	H	M	M
CO2	H	H	L	L	L	L	L	L	L	L	L	L	H	M	M
CO3	M	M	H	H	L	L	M	H	M	M	H	H	M	H	M
CO4	M	H	H	H	M	L	M	H	M	M	H	H	M	H	M
CO5	M	M	H	H	L	L	M	H	M	M	H	H	M	H	H
CO6	M	M	H	H	L	L	M	H	M	M	H	H	M	H	H
18EPE$23	M	H	H	H	L	L	M	H	M	M	H	H	M	H	M

L - Low, M - Moderate (Medium), H – High

18EPE$04	POWER QUALITY ENGINEERING

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

* To acquire knowledge on power quality issues, monitoring equipment and mitigation techniques.

UNIT-I : INTRODUCTION TO POWER QUALITY	**(9 Periods)**
Overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices.	
UNIT-II : VOLTAGE SAGS AND INTERRUPTIONS	**(9 Periods)**
Sources of sags and interruptions - Estimating voltage sag performance - Motor starting sags - Estimating the sag severity mitigation of voltage sags - Active series compensators - Static transfer switches and fast transfer switches.	
UNIT-III : OVERVOLTAGES	**(9 Periods)**
Sources of over voltages: Capacitor switching – Lightning - Ferro resonance - Mitigation of voltage swells – Surge arresters low pass filters - Power conditioners – Lightning protection- Shielding - Line arresters - Protection of transformers and cables computer analysis tools for transients - PSCAD and EMTP	
UNIT-IV : HARMONICS	**(9 Periods)**
Harmonic distortion: Voltage and current distortion - Harmonic indices - Harmonic sources from commercial and industrial loads - Locating harmonic sources - Power system response characteristics – Resonance – Harmonic distortion evaluation - Devices for controlling harmonic distortion - Passive filters - Active filters - IEEE and IEC standards.	
UNIT-V : POWER QUALITY MONITORING	**(9 Periods)**
Monitoring considerations: Power line disturbance analyzer - Power quality measurement equipment - Harmonic / spectrum analyzer - Flicker meters - Disturbance analyzer - Applications of expert system for power quality monitoring.	

Contact Periods:

Lecture: 45 Periods   Tutorial: 0 Periods   Practical: 0 Periods   Total: 45 Periods

TEXT BOOKS:

1. *Roger.C.Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty "**Electrical Power Systems Quality**" McGraw Hill, 2003.*
2. *Kusko Alexander Thomson Marc. T "**Power Quality in Electrical Systems**" McGraw Hill,Professional,2007*
3. *Mat H. J. Bollen and Ireen G.U "**Signal Processing of Power Quality Disturbance**" Willey, IEEEpress, 2006.*
4. *G.T.Heydt, "**Electric power quality**", Stars in a Circle Publications, 1991*
5. *Math H. Bollen , "**Understanding Power Quality Problems**", IEEE Press,2000.*

REFERENCE BOOKS:

1. PSCAD User Manual

COURSE OUTCOMES:

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

CO1: Study and understand the basics and necessity of power quality.

CO2: Understand the basics of voltage sag and interruption.

CO3: Examine and compute the harmonic distortion.

CO4: Identify methods to manage the overvoltage.

CO5: Understand and design the active and passive filters.

CO6: Understand and design the power quality monitoring equipment.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	L	L	L	-	-	-	-	-	-	H	L	-
CO2	M	M	L	-	-	L	-	-	-	-	-	-	H	M	-
CO3	L	H	L	-	M	L	L	-	-	-	-	-	-	L	M
CO4	H	L	M	-	-	M	-	-	-	-	-	-	L	M	-
CO5	L	L	M	H	M	L	-	-	-	L	L	L	M	M	-
CO6	L	L	L	L	L	-	-	-	-	M	M	H	M	H	-
18EPE$04	M	M	L	M	M	L	L	-	-	M	M	M	M	M	M

L - Low, M - Moderate (Medium), H – High

18EPE$21	ENERGY STORAGE TECHNOLOGY

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To explore the fundamentals, technologies and applications of energy storage.

UNIT-I : ENERGY STORAGE: HISTORICAL PERSPECTIVE, INTRODUCTION AND CHANGES	**(9 Periods)**
Storage Needs - Variations in Supply and energy demand Interruptions in Energy Supply- Transmission Congestion - Demand for Portable Energy-Demand and scale requirements - Environmental and sustainability issues.	
UNIT-II : TECHNICAL METHODS OF STORAGE	**(9 Periods)**
Introduction: Energy and Energy Transformations, Potential energy (pumped hydro, compressed air, springs)- Kinetic energy (mechanical flywheels)- Thermal energy without phase change passive (adobe) and active (water)-Thermal energy with phase change (ice, molten salts, steam)- Chemical energy (hydrogen, methane, gasoline, coal, oil)- Electrochemical energy (batteries, fuel cells)- Electrostatic energy (capacitors), Electromagnetic energy (superconducting magnets)- Different Types of Energy Storage Systems.	
UNIT-III PERFORMANCE FACTORS OF ENERGY STORAGE SYSTEMS	**(9 Periods)**
Energy capture rate and efficiency- Discharge rate and efficiency- Dispatch ability and load flowing characteristics, scale flexibility, durability – Cycle lifetime, mass and safety – Risks of fire, explosion, toxicity- Ease of materials, recycling and recovery- Environmental consideration and recycling , Merits and demerits of different types of Storage.	
UNIT-IV : APPLICATION CONSIDERATION	**(9 Periods)**
Comparing Storage Technologies- Technology options- Performance factors and metrics- Efficiency of Energy Systems- Energy Recovery - Battery Storage System: Introduction with focus on Lead Acid and Lithium- Chemistry of Battery Operation, Power storage calculations, Reversible reactions, Charging patterns, Battery Management systems, System Performance, Areas of Application of Energy Storage: Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles.	
UNIT-V : HYDROGEN FUEL CELLS AND FLOW BATTERIES	**(9 Periods)**
Hydrogen Economy and Generation Techniques, Storage of Hydrogen, Energy generation - Super capacitors: properties, power calculations – Operation and Design methods - Hybrid Energy Storage: Managing peak and Continuous power needs, options - Level 1: (Hybrid Power generation) Bacitor "Battery + Capacitor" Combinations: need, operation and Merits; Level 2: (Hybrid Power Generation) Bacitor + Fuel Cell or Flow Battery operation-Applications: Storage for Hybrid Electric Vehicles, Regenerative Power, capturing methods.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *DetlefStolten,**"Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications"**, Wiley, 2014.*
2. *Jiujun Zhang, Lei Zhang,Hansan Liu, Andy Sun, Ru-Shi Liu**, "Electrochemical Technologies for Energy Storage and Conversion",** John Wiley and Sons, 2012.*

REFERENCE BOOKS:

1. *Francois Beguin and ElzbietaFrackowiak,**"Super capacitors"**, Wiley, 2015.*
2. *Doughty Liaw, Narayan and Srinivasan, **"Batteries for Renewable Energy Storage"**, The Electrochemical Society, New Jersy, 2016.*

COURSE OUTCOMES:

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

CO1: Recollect the historical perspective and technical methods of energy storage

CO2: Learn the basics of different energy storage methods.

CO3: Evaluate the performance factors of energy storage systems.

CO4: Identify the field of applications for renewable energy systems.

CO5: Understand the basics of Hydrogen Fuel Cell and flow batteries.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	M	L	-	M	-	L	-	M	-	L	L	L
CO2	M	M	M	L	L	-	M	-	L	-	L	-	L	L	L
CO3	L	-	M	M	L	M	M	-	L	-	-	-	L	L	L
CO4	M	L	M	L	L	-	L	-	M	-	-	-	L	L	L
CO5	L	M	L	M	-	-	M	-	M	-	-	-	L	L	L
18EPE$21	M	L	M	M	L	M	M	-	L	-	M	-	L	L	L

L - Low, M - Moderate (Medium), H – High

18EPE$26	DISTRIBUTED GENERATION AND MICROGRID

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

* To study about the theory of distributed generations, operation, control and protection of Micro grid in standalone and grid integrated mode.

UNIT – I : INTRODUCTION TO DISTRIBUTED GENERATION	(9 Periods)
Renewable sources in distributed generation – Current scenario in distributed generation – Planning of DGs – Siting and sizing of DGs – Optimal placement of DG sources in distribution systems. Standards for interconnecting Distributed resources to electric power systems: IEEE 1547	
UNIT – II : DISTRIBUTED GENERATIONS	**(9 Periods)**
Solar energy - Photo voltaic system-Solar cells-PV modules-System design - Solar water heating- Types; Solar thermal power generation - water pumping applications; Wind power generation-power extraction-types of Wind Mills. Fuel cells- types- losses in fuel cell –applications.	
UNIT – III : GRID INTEGRATION OF DGs AND ENERGY STORAGE SYSTEMS	**(9 Periods)**
Different types of interfaces – Inverter based DGs and rotating machine based interfaces – Aggregation of multiple DG units – Energy storage systems – Batteries, ultra-capacitors, flywheels.	
UNIT – IV : MICROGRIDS	**(9 Periods)**
Types of micro-grids – Autonomous and non-autonomous grids – Sizing of micro-grids – Modeling and analysis - Micro-grids with power electronic interfacing units - AC and DC microgrids.	
UNIT – V OPERATION OF MICROGRID	**(9 Periods)**
Modes of operation: grid connected and islanded mode - Transients in micro-grids – Protection of microgrids - power quality issues in microgrids, microgrid economics - Introduction to smart microgrids - Case studies.	

Contact Periods:

Lecture: 45 Periods   Tutorial: 0 Periods   Practical: 0 Periods   Total: 45 Periods

TEXT BOOKS:

1. *G.D. Rai, "**Non Conventional energy Sources**", Khanna Publications ,New Delhi.2004*
2. *H. Lee Willis, Walter G. Scott , **"Distributed Power Generation – Planning and Evaluation"**, Marcel Decker Press, 2000.*
3. *Robert Lasseter, Paolo Piagi, **"Micro-grid: A Conceptual Solution"**, PESC 2004, June 2004.*

REFERENCE BOOKS:

1. *Loi Lei Lai, Tze Fun Chan, **"Distributed Generation- Induction and Permanent Magnet Generators"**, IEEE Press, John Wiley & Sons, Ltd., England. 2007.*
2. *John Twidell and Tony Weir, **"Renewable Energy Resources"**, Taylor and Francis Publications, Second edition 2006.*

COURSE OUTCOMES:

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

CO1: Understand the technical impacts of DGs in power systems

CO2: Comprehend the technical and economical issues occur during the grid integration of DGs

CO3: Familiarize the different Distributed Energy Resources of PV, Wind, fuel cell.

CO4: Operate and control the DC and AC Microgrid

CO5: Analyze the performance of Microgrid

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	M	M	L	L	L	-	-	-	-	L	M	H	L
CO2	H	H	M	M	L	L	M	-	-	-	-	L	M	H	L
CO3	H	H	M	M	L	L	M	-	-	-	-	L	M	H	L
CO4	H	H	H	H	H	M	M	-	-	-	M	M	M	H	M
CO5	H	M	H	H	H	M	M	-	-	-	M	M	M	H	M
18EPE$26	H	H	M	M	M	L	M	-	-	-	M	L	M	H	L

L - Low, M - Moderate (Medium), H – High

18EPE$29	RENEWABLE ENERGY TECHNOLOGY

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To elucidate the technologies used for generation and utilization of power from renewable energy resources.

UNIT – I	RENEWABLE ENERGY SOURCES	8 Periods
Conventional energy sources - Environmental consequences - Renewable energy sources - Types of RE sources - Limitations - Present Indian and International scenario of Conventional and RE sources and policies		
UNIT – II	**SOLAR ENERGY AND THERMAL ENERGY**	**10 Periods**
Solar Radiation, Radiation Measurement : solar spectra-latitude and longitude, Declination angle, solar window, cosine law, seasonal variations, hour angle, calculation of angle of incidence, angstroms equation and constants - Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems-Types - Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Efficiency - series and parallel connections, maximum power point tracking, Applications. Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM		
UNIT – III	**WIND ENERGY**	**9 Periods**
Wind energy - Power in the Wind- wind data and energy estimation, site selection,- Basic principle of wind energy conversion system - components of wind energy conversion systems - design consideration of horizontal axis wind mill- merits and limitations- Grid integration issues of Wind Power Plant – applications		
UNIT – IV	**BIOMASS ENERGY**	**9 Periods**
Biomass, sources of biomass, thermo-chemical and bio-chemical conversion of biomass - Pyrolysis, gasification, combustion and fermentation. Gasifiers – Up draft, downdraft and fluidized bed gasifier. Digesters- Fixed and floating digester biogas plants- Hydrogen Production and Storage- Fuel cell : Principle of working- various types - construction and applications. Energy Storage System- Hybrid Energy Systems		
UNIT – V	**OCEAN AND GEOTHERMAL ENERGY**	**9 Periods**
Ocean energy resources - Principles of ocean thermal energy conversion systems - ocean thermal power plants - Principles of ocean wave energy conversion and tidal energy conversion - Difference between tidal and wave power generation, Economics of OTEC. Definition and classification of Geothermal resources, Utilization for electricity generation and direct heating, Wellhead power generating units. Overview of micro and mini hydel power generation.		

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS

1 Chetan Singh Solanki, " Solar Photovoltaics : Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2011
2 Pai and Ramaprasad, "Power Generation through Renewal sources", Tata McGraw Hill – 1991

REFERENCES

1 Shobh Nath Singh, 'Non-conventional Energy resources' Pearson Education 2015
2 Godfrey Boyle, "Renewable energy", Open University, Oxford University Press in association with the Open University, 2004.
3 Roland Wengenmayr, Thomas Buhrke, "Renewable energy: Sustainable energy concepts for the future", Wiley-VCH, 1st edition, 2008
4 Bansal NK, Kleeman and Meliss, M "Renewable Energy Sources and Conversion Techniques", Tata McGraw Hill, 1996
5 Sunil S. Rao and Dr. B.B. Parulekar, "Energy Technology", Khanna Publishers, Second Ed. 1997
6 Rai , G.D., "Non Conventional sources of Energy", Khanna Publishers , IV Ed.,2009

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Describe the principles of operation of the broad spectrum of renewable energy Technologies
CO2 Measure and estimate the parameters of the solar system
CO3 Develop the real time applications of Renewable energy technologies
CO4 Analyze energy technologies from a systems perspective
CO5 Discuss economic, technical and sustainability issues involved in the integration of renewable energy systems

COURSE ARTICULATION MATRIX:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	L	M	M	-	-	M	M	-	-	-	-	L	M	L	L
CO2	M	H	M	H	-	-	-	-	-	-	-	L	H	H	L
CO3	H	M	L	H	-	-	-	-	-	-	-	M	H	H	L
CO4	H	M	L	-	-	-	-	-	-	-	-	M	H	M	M
CO5	M	L	L	-	-	M	H	-	-	-	-	M	M	M	M
18EPE$29	M	M	L	H	-	M	H	-	-	-	-	M	H	M	L

L – Slight, M– Moderate, H – Substantial

VERTICAL III

INSTRUMENTATION AND CONTROL

18EPE$01	PRINCIPLES OF VIRTUAL INSTRUMENTATION

PRE-REQUISITES: **Category: PE**

1. Electrical and Electronic Measurements

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To understand the Virtual instrumentation concepts towards measurements and control

UNIT – I : VIRTUAL INSTRUMENTATION	(9 Periods)
Introduction - Block diagram and architecture of a virtual instrument - Conventional Instruments versus Virtual Instruments – Data flow techniques, graphical programming in data flow, comparison with conventional programming	
UNIT – II : GRAPHICAL PROGRAMMING	**(9 Periods)**
Front panel - Block diagram - VIs - Sub-VIs - Simple examples - Looping: For loop, while loop - Shift registers - case and sequence; structures, formula nodes. Arrays - Clusters, charts and graphs - Local and global variables - Property node, string and file I/O. Publishing measurement data in the web.	
UNIT – III : DATA ACQUISITION	**(9 Periods)**
DAQ – Components - Buffers - Triggering - Analog I/O - Digital I/O - Counters and timers - DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements.	
UNIT – IV : INSTRUMENT CONTROL	**(9 Periods)**
VI Chassis requirements. Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. Bus Interfaces: USB, PCMCIA, VXI, SCSI, PCI, PXI, compact RIO - Firewire. PXI system controllers - Ethernet control of PXI. Networking basics for office - Industrial applications- VISA and IVI.	
UNIT – V : APPLICATION OF VIRTUAL INSTRUMENTATION	**(9 Periods)**
VI toolsets, Distributed I/O modules Instrument Control -process database management system - Simulation of systems using VI - Development of Control system - Industrial Communication- Image acquisition and processing - Motion control.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Sanjay Gupta and Joseph John “**Virtual Instrumentation using LabVIEW**” Tata McGraw-Hill, Second Ed. 2010*
2. *Jovitha Jerome “**Virtual Instrumentation Using LabVIEW**” PHI Learning Pvt. Ltd 1st Ed., 2010*

REFERENCE BOOKS:

1. *Lisa K Wells and Jeffrey Travels, “**LabVIEW for everyone**”, Prentice Hall, 3rd Ed. 2009*
2. *S. Gupta, J.P. Gupta, “**PC interfacing for data acquisition and process control**”, 2nd Ed., Instrument Society of America, 1994*
3. *Gary Johnson, Richard Jennings “**LabVIEW graphical programming**”, Tata McGraw Hill, 2011*

COURSE OUTCOMES:

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

CO1: Explain the concepts of virtual instruments

CO2: Apply the programming concepts using LabVIEW

CO3: Create simple measurement system using LabVIEW programs

CO4: Demonstrate the program in LabVIEW for system monitoring, processing and controlling operations

CO5: Comply the basics of interfacing and programming using related hardware

CO6: Develop real time applications using LabVIEW

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	M	M	H	-	-	-	-	-	-	L	H	M	M
CO2	M	H	M	M	H	-	-	-	-	-	-	L	H	H	M
CO3	M	H	H	H	H	-	-	-	-	-	-	L	H	H	H
CO4	M	H	H	H	H	-	-	-	-	-	-	-	H	H	H
CO5	H	M	M	M	H	-	-	-	-	-	-	-	H	M	M
CO6	M	H	H	H	H	-	-	-	-	-	-	L	H	H	H
18EPE$01	M	H	H	H	H	-	-	-	-	-	-	L	H	H	H

L - Low, M - Moderate (Medium), H – High

18EPE$10	**POWER PLANT INSTRUMENTATION** ***(Common to EEE & EIE Branches)***

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. 18EPC406 Electrical and Electronic Measurements
2. 18EPC502 Power Generation, Transmission and Distribution

COURSE OBJECTIVES:

* To understand the important process variables and their measurements and thereby develop control loops for optimal performance of power plant.

UNIT - I : METHODS OF POWER GENERATION	**(9 Periods)**
Methods of power generation – hydro, thermal, nuclear, solar and wind power –Importance of instrumentation in power generation – basic building block for all types of power generation plants - details of boiler processes – P and I diagram of boiler - cogeneration.	
UNIT - II : MEASUREMENTS IN POWER PLANTS	**(9 Periods)**
Measurement of feed water flow, air flow, steam flow and coal flow – Drum level measurement– Steam pressure and temperature measurement – Turbine speed and vibration measurement – Flue gas analyzer – Fuel composition analyzer.	
UNIT - III : ANALYZERS IN POWER PLANTS	**(9 Periods)**
Analysis of impurities in feed water and steam- Flue gas oxygen analyzer - dissolved oxygen analyzer - chromatography - pH Meter - Fuel analyzer -pollution monitoring instruments.	
UNIT - IV : CONTROL LOOPS IN BOILER	**(9 Periods)**
Combustion Control-air/fuel ratio control - furnace draft control - drum level control - main steam and reheat steam temp control - super heater control - attemperator – de-aerator control - distributed control system in power plants - interlocks in boiler operation.	
UNIT - V ; TURBINE AND CONTROL	**(9 Periods)**
Types of steam turbines – impulse and reaction turbines – compounding – Turbine governing system– Speed and Load control – Transient response rise – Free governor mode operation – Automatic Load Frequency Control – Turbine oil system – Oil pressure drop relay – Oil cooling system– Turbine run up system.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

*1. Sam Dukelow "**Control of Boilers**" Instrument Society of America, 1991*

*2. Gill.A.B "**Power Plant performance**" Butterworth and Co (Publishers) Ltd, 2003.*

REFERENCE BOOKS:

1. *Liptak B.G., "**Instrumentation in Process Industries"** Chilton Book Company, 2005.*
2. *Jain R.K., "**Mechanical and Industrial Measurements**" Khanna Publishers, New Delhi, 1999.*
3. *Krishnaswamy, K. and Ponnibala.M., "**Power Plant Instrumentation**" PHI Learning Pvt. Ltd., New Delhi, 2011.*

COURSE OUTCOMES:

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

CO1: Understand the operation of hydro, thermal, nuclear, wind and solar power plants.
CO2: Select instruments for monitoring various parameters related to thermal power plant.
CO3: Analyze and select appropriate control strategy for Boiler.
CO4: Gain knowledge on turbine monitoring system and able to analyze the problems related to turbine governing.
CO5: Design instrumentation systems for generating plants.
CO6: Apply the instrumentation and control in Power plants

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	M	M	-	-	-	-	-	-	-	L	H	H	M
CO2	H	M	M	M	M	-	-	-	-	-	-	M	H	H	H
CO3	H	H	M	H	-	-	-	-	-	-	-	L	H	M	M
CO4	H	M	M	M	-	-	-	-	-	-	-	-	H	M	M
CO5	H	H	H	M	M	-	-	-	-	-	-	M	H	H	H
CO6	H	M	H	M	-	-	-	-	-	-	-	M	H	M	H
18EPE $10	H	M	M	M	M	-	-	-	-	-	-	M	H	H	H

L - Low, M - Moderate (Medium), H – High

18EPE$18	MEMS AND APPLICATIONS

Category : PE

PRE-REQUISITES:

1. Electrical and Electronic Measurements

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To provide the introduction of micro electro mechanical systems and to teach critical thinking in micro engineering process, material and design issues.

UNIT – I : FUNDAMENTALS OF MEASUREMENT SYSTEMS	(9 Periods)
Basic principles of measurement systems - Primary Transduction Mechanisms Physical variables – Sensor defects – Sensing mechanisms – Enabling Technologies – Silicon – Thick film – Optical.	
UNIT – II : TRANSDUCER MODELLING	**(9 Periods)**
Electronic Techniques – Bridge circuits – Amplifiers – Data conversion – Noise and recovery of signal from noise – Sensor Networks and Protocols.	
UNIT – III : SMART TRANSDUCERS	**(9 Periods)**
Concepts – Software structures – Hardware structures – Fundamentals and limitations of photolithography – Pattern transfer with etching techniques – Pattern transfer with other physical and chemical techniques.	
UNIT – IV : : MICROMACHINING	**(9 Periods)**
Bulk micromachining – Surface micromachining – Other micromachining techniques – Packaging techniques – Micro scaling considerations	
UNIT – V : APPLICATIONS	**(9 Periods)**
Applications in automotive industry – Applications in biomedical industry – DNA sensors, Electronic noise – Future developments-Nanotechnology – Carbon Nano Tube (CNT).	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Chang Liu "**Foundations of MEMS**" Prentice Hall, 2012.*
2. *Marc Madou "**Fundamental of Microfabrication**" CRC Press,3rd Ed, 2011.*
3. *Richard C. Jaeger "**Introduction to Microelectronic Fabrication**" Addison- Wesley, 2002*

REFERENCE BOOKS:

1. *Gad-El-Hak, **"MEMS Handbook,"** CRC Press, 2005.*
2. *N.T. Nguyen and S.Wereley, "**Fundamentals and Applications of Microfluidics**", Artech House,2006.*
3. *Nitaigour Premchand Mahalik, "**MEMS**",TMH, I Reprint, 2008.*
4. *Tai Ran Hsu, "**MEMS and Microsystems Design and Manufacture**", TMH, VII Reprint, 2012.*

COURSE OUTCOMES:

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

CO1: Understand the basics of electro and mechanical system

CO2: Understand the basics of micro fabrication

CO3: Develop models and simulate electrostatic sensors.

CO4: Develop models and simulate different types of actuators

CO5: Recognize the materials properties of MEMS performance

CO6: Recognize the importance of MEMS performance.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	L	-	-	-	-	-	-	-	-	-	H	-	-
CO2	H	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	L	L	M	H	L	L	-	-	-	-	-	-	-	M	L
CO4	L	L	M	H	L	L	-	-	-	-	-	-	-	M	L
CO5	-	-	L	L	L	L	-	-	-	-	-	-	M	L	-
CO6	-	-	L	L	L	-	L	-	-	-	-	-	L	-	H
18EPE$18	M	M	L	M	L	L	L	-	-	-	-	-	M	M	M

L - Low, M - Moderate (Medium), H – High

18EPE$19	**BIOMEDICAL INSTRUMENTATION** *(Common to EEE & EIE Branches)*

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Electrical and Electronic Measurements

COURSE OBJECTIVES:

* To understand the basics of human physiology and learn the operating principle of necessary Instrumentation associated with it.

UNIT – I : PHYSIOLOGY	**(9 Periods)**
Cell and its structure – Resting and action potential – Propagation of action potentials – The heart and cardiovascular system - Electrophysiology of cardiovascular system – Physiology of the respiratory system – Nervous system - Central nervous system and Peripheral nervous system – Electrode theory – Bio-potential electrodes - Transducers for biomedical applications.	
UNIT - II : ELECTRO PHYSIOLOGICAL MEASUREMENT	**(9 Periods)**
ECG – Vector cardiographs – EEG – EMG – ERG – EOG – Lead system and recording methods – Typical waveforms. Electrical safety in medical environment, shock hazards– leakage current- Instruments to protect against electrical hazards.	
UNIT - III : NON- ELECTRICAL PARAMETER MEASUREMENTS	**(9 Periods)**
Measurement of blood pressure, blood flow and cardiac output – Plethysmography – Measurement of heart sounds – Gas analysers – Blood gas analysers – Oximeters.	
UNIT - IV : MEDICAL IMAGING AND TELEMETRY	**(9 Periods)**
X-ray machine – Echocardiography – Computer tomography – MRI – Diagnostic ultrasound – PET – SPECT – Electrical impedance tomography – Thermograph – Biotelemetry.	
UNIT - V : ASSISTING AND THERAPEUTIC DEVICE	**(9 Periods)**
Pacemakers – Defibrillators – Ventilator – Anaesthesia machine – Nerve and muscle stimulator – Heart lung machine – Kidney machine – Audiometers – Diathermy –Endoscopes – Lasers in biomedicine.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Leslie Cromwell “**Biomedical Instrumentation and Measurement**” PHI, New Delhi, 2007.*
2. *Khandpur. R.S “**Handbook of Biomedical Instrumentation**” 2nd edition, Tata McGraw Hill, 2011.*

REFERENCE BOOKS:

1. *Joseph J Carr and John M.Brown, **“Introduction to Biomedical Equipment Technology’’**, John Wiley and sons, New York, 4th edition, 2012*
2. *John G. Webster, **“Medical Instrumentation Application and Design”**, John Wiley and sons,New York, 2009.*
3. *Ed. Joseph D. Bronzino **“The Biomedical Engineering Handbook”** Third Edition, BocaRaton, CRC Press LLC, 2014.*
4. *M.Arumugam, **“Bio-Medical Instrumentation”**, Anuradha Agencies, 2018.*

COURSE OUTCOMES:

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

CO1: Understand the physical foundations of biological systems

CO2: Realize the various electro physiological measurements in the human body.

CO3: Acquire knowledge on the measurement of non-electrical parameters in the human body.

CO4: Analyze the various medical imaging techniques and their applications.

CO5: Apply the concepts on the working of medical assisting and therapy equipment.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	L	-	L	L	H	H	-	-	-	-	-	-	L	L	-
CO2	L	-	L	L	H	H	-	-	-	-	-	-	L	L	-
CO3	L	-	L	L	H	H	-	-	-	-	-	-	L	L	-
CO4	L	-	L	L	H	H	-	-	-	-	-	-	L	L	-
CO5	L	-	L	L	H	H	-	-	-	-	-	-	L	L	-
18EPE$19	L	-	L	L	H	H	-	-	-	-	-	-	L	L	-

L - Low, M - Moderate (Medium), H - High

18EPE$15	LOGIC AND DISTRIBUTED CONTROL SYSTEMS

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Control Systems Engineering

COURSE OBJECTIVES:

- To study the fundamentals of PLC, exploring the intermediate and advanced functions, design and analysis of DCS with communication standards.

UNIT – I : PROGRAMMABLE LOGIC CONTROLLER (PLC) BASICS	**(9 Periods)**
Definition – Overview of PLC systems – Input and output modules – Power supplies – Isolators – General PLC programming procedures – Programming on-off outputs – Auxiliary commands and functions – Creating ladder diagrams from process control descriptions – Register basics – Timer functions – Counter functions	
UNIT – II : PLC INTERMEDIATE AND ADVANCED FUNCTIONS	**(9 Periods)**
Arithmetic functions – Number comparison functions – Skip and MCR functions – Data move systems – PLC advanced intermediate functions – Utilising digital bits – Sequencer functions – Matrix functions – Alternate programming languages – Analog PLC operation – Networking of PLC – PID control of continuous processes – PLC installation – Troubleshooting and maintenance – Controlling a Robot.	
UNIT – III : INTERFACE AND BACKPLANE BUS STANDARDS FOR INSTRUMENTATION SYSTEMS	**(9 Periods)**
Field bus: Introduction – Concept – International field bus standards – HART protocol: Method of operation – Structure – Operating conditions – Applications – Foundation Field bus - Profibus.	
UNIT – IV : DISTRIBUTED CONTROL SYSTEMS OPERATION	**(9 Periods)**
Evolution of DCS – Building blocks – Detailed descriptions and functions of field control units – Process – Interfacing issues - Operator stations– Data highways – Redundancy concepts	
UNIT – V : COMMUNICATION IN DCS	**(9 Periods)**
DCS – Supervisory computer tasks and configuration – System Integration with PLC and computers - Special requirement of networks used for control – Protocols – Link access mechanisms – Manufacturers automation protocols – Case studies in DCS.	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *John. W. Webb and Ronald A. Reis "**Programmable Logic Controllers–Principles and Applications**" 4th Ed., Printice Hall Inc., New Jersy, 5th Ed. 2002*
2. *.Frank D. Petruzella "**Programmable Logic Controllers**" McGraw Hill Book Company Book, third Ed. 2005*
3. *Lukcas M.P "**Distributed Control Systems**" Van Nostrand Reinhold Company, New York, 1986*

REFERENCE BOOKS:

1. *Krishna Kant, "**Computer based Industrial Control**", Prentice Hall of India, 10th Printing 2009*
2. *Curtis D.Johnson, "**Process control Instrumentation Technology**", 8th Ed. Pearson Education 2006*
3. *Bela. G.Lipkak, "**Process software and digital networks –** vol 3", CRC press, 4th edition ,2012.*

COURSE OUTCOMES:

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

CO1: Recognize and develop ladder diagrams, testing the capability of PLC’s control and troubleshooting of PLC.

CO2: Configure PLC's to perform various tasks in the process environment.

CO3: Configure and integrate DCS with PLC and Computers, developing software for these systems.

CO4: Identity Logical process control in automation.

CO5: Develop basic PLC Programmes.

CO6: Gain knowledge on data acquisition system.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	H	H	M	M	L	H	H	H	H	H	M	H
CO2	H	H	H	H	H	L	L	L	H	L	H	H	H	L	H
CO3	H	M	H	M	M	L	L	L	M	L	H	H	H	L	H
CO4	H	H	M	M	L	L	L	L	M	L	H	H	H	L	M
CO5	H	H	H	L	H	M	L	L	M	L	H	H	H	L	L
CO6	H	H	H	M	M	L	L	L	M	L	M	M	H	L	L
18EPE$15	H	H	H	M	M	L	L	L	M	L	H	H	H	L	M

L - Low, M - Moderate (Medium), H – High

18EPE$25	MODERN CONTROL THEORY

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:
1. Principles of Signals and Systems
2. Control Systems Engineering

COURSE OBJECTIVES:
* To understand the concepts of Non-Linear system, Optimal Control and analyze the stability of Non-Linear system.

UNIT I : Z – TRANSFORM AND SAMPLED DATA SYSTEMS	(9 Periods)
Sampled data theory – Sampling process – Sampling theorem – Signal reconstruction – Sample and hold circuits – Z Transform – Theorems on Z Transforms – Inverse Z Transforms. Pulse transfer function-Response of sampled data system to step and ramp inputs- Steady state error- Stability studies- Jury's test and bilinear transformation.	
UNIT II : STATE SPACE ANALYSIS OF DISCRETE SYSTEMS	**(9 Periods)**
State variables – Canonical forms – Diagonalisation – Solutions of state equations – Controllability and observability – Effect of sampling time on controllability – Pole placement by state feedback – Linear observer design – First order and second order problems.	
UNIT III : NON-LINEAR SYSTEMS	**(9 Periods)**
Types of non linearity – Typical examples –Singular points – Limit cycles. Describing function –Stability analysis of Non-Linear systems through describing functions. Phase plane analysis — Construction of phase trajectories.	
UNIT IV : STABILITY ANALYSIS	**(9 Periods)**
Liapunov stability analysis – Stability in the sense of Liapunov – Definiteness of scalar functions – Quadratic forms- Second method of Liapunov – Liapunov stability analysis of linear time invariant systems and non-linear system.	
UNIT V : OPTIMAL CONTROL	**(9 Periods)**
Introduction to Optimal Control, statement of the optimal control problem, general introduction to the principle of optimality, discrete time linear quadratic problem, optimal state feedback solution. Formation of optimal control problems- Hamiltonian formulation-solution of optimal control problems-Evaluation of Riccati s equation State and output Regulator problems	

Contact Periods:
Lecture: 45 Periods   Tutorial: 0 Periods   Practical: 0 Periods   Total: 45 Periods

TEXT BOOKS:

1. *Gopal M., "**Digital Control and State Variable Methods**", Tata MC Graw Hill, 3rd Edition2008*
2. *Richard C. Dorf and Robert H. Bishop, "**Modern Control Systems**", 12th Edition, Pearson Education, 2004.*
3. *D.E. Kirk, "**Optimal Control Theory-An Introduction**", Prentice Hall, 2nd Edition 1998.*

REFERENCE BOOKS:

1. *Nagrath I.J. and Gopal M., "**Control Systems Engineering**", Wiley Eastern Limited, New Delhi, 5th Ed. 2008.*
2. *B.C. Kuo, "**Digital Control Systems**", Oxford University Press, Second Edition, 2007.*
3. *Loan D. Landau, Gianluca Zito, "**Digital Control Systems, Design, Identification and Implementation**", Springer, 2006.*
4. *Katsuhiko Ogato, "**Discrete-Time Control Systems**", Pearson Education Pvt., New Delhi, 2nd Edition, 2001.*

COURSE OUTCOMES:

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

CO1: Realization of the discrete systems and mathematical modeling.
CO2: Examine the properties of non-linear systems.
CO3: Analyze the stability of nonlinear systems
CO4: Design and Evaluate the optimal controller.
CO5: Able to apply advanced control strategies to practical engineering problems.

COURSE ARTICULATION MATRIX:

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	H	H	H	M	H	M	L	L	M	M	M	H	H	L	-
CO2	H	H	H	H	M	M	L	L	M	M	M	H	M	M	-
CO3	H	H	H	H	M	M	M	M	M	L	L	H	M	L	-
CO4	H	H	H	H	H	M	M	M	M	M	H	H	M	M	L
CO5	H	H	M	M	L	L	L	M	L	M	L	H	M	M	M
18EPE$25	H	H	H	H	M	M	L	M	M	M	M	H	M	M	M

L - Low, M - Moderate (Medium), H – High

18EPE$27	**ELECTRONIC CIRCUIT DESIGN** **(Common to EEE & EIE Branches)**

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* Understand broad knowledge of the electronic circuit design from power supplies to SoCs including the connectivity solutions.
* Understand the nuances of electronic product design
* Understand the practical aspects of circuit design and analysis
* Analyze circuits for their static and dynamic behavior through Simulation

UNIT – I	INTRODUCTION TO ADAS, POWER SUPPLY, SWITCH AND DRIVES	(9 Periods)
Introduction: SAE ADAS Levels – Sensors - Connectivity Solutions - AI/ML - HW requirements - Design Challenges. Non-ideal behavior of Components – Resistors , Capacitors; Inductors; Ferrite Beads; Fundamentals of BJT, MOSFET and IGBT gate driver circuits - Effect of Impedance mismatch and Signal Quality – Terminations & TDR. Linear and Switching regulators- Buck and Boost Converters - Stability, Performance, Dynamic Behavior - Voltage References - EMI Filters - high-side and low-side switches - H-bridge - Current Sensing Techniques.		
UNIT – II	**DATA CONVERTERS AND I/O INTERFACES**	**(9 Periods)**
Digital IOs; PWM, Frequency Inputs; Data conversion; Quantization; Reference Voltages; Sampling Time; Resolution; ADC Errors – Non-linearity; Offset; Gain; Noise – reference Voltage signal - Dynamic Range – ENOB - Parasitic capacitance - Channel cross-talk - ADC/DAC interface – Design and Case Study		
UNIT – III	**SYSTEM ON CHIP (SOC)**	**(10 Periods)**
Need for SoC - Components of a SoC - Heterogeneous processing cores : microprocessors, DSPs, hardware processing engines like audio, video, accelerators, memories, and I/O interfaces - System level On-chip Communication Architectures – Bus and NoC based, Application Specific Hardware Accelerators – GPU, Neural, MMA - device management, memory hierarchy, and data movement, virtualization - security, and power - Challenges and optimization of Interconnects, Partitioning and Mapping of a software function to hardware - Power/Performance/Area Trade Offs vs Reliability - Safety and Security Features - Interfaces – External Memory, I/O, ADC/DAC, UART, CAN, Ethernet, USB, MIPI; Insight into SoC Design Process (from RTL to Chip, Requirements and Design Iteration) - Dealing with Design Complexity (Buying IP and Reconfiguration); Comparison of SoCs from iMx8 (NXP); Jacinto 7(TI); Orin (nVidia); SDA series (Qualcomm) - MobiliEye (Intel); SoC from Tesla - Case studies from Automotive (ADAS)		

UNIT – IV	PMICs and WIRED COMMUNICATIONS	(9 Periods)
Need for PMIC – On Chip Power Management, State Machine, Compensation Techniques - Voltage and Frequency Scaling - Applications; Examples – PF8101 (NXP), TPS659119-Q1 (TI), MAX20430 (Maxim) - Input and Output Supply Ranges - Power Sequence – Supervisory - Watchdog Operation. High Speed Links – Transmitter, Channel, Receiver - Common Mode Rejection – Serializer, De-Serializer - Controller Area Networks (CAN) - Ethernet (Automotive)-MII, RGMII, SGMII, XFI - Universal Serial Bus (USB) - Camera Interfaces (FPD or GMSL) - Power over Data Link (PoDL).		
UNIT – V	**WIRELESS COMMUNICATIONS**	**(8 Periods)**
Fundamentals of RF-Transmission Lines, Resonators, Antennas, Wave Propagation, Transmitters, Receivers - Digital Modulation Techniques - Channel Impairments - MIMO; WLAN; Bluetooth; Cellular – LTE/5G - Navigation Systems - Identification Systems-NFC, RFID; UWB; Case Study with WLAN (TI-CC3200 series)		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 Ke-Horng Chen, Power Management for Integrated Circuit Design, Wiley, 2016
2 G. Manganaro, Advanced Data Converters. Cambridge: Cambridge Univ. Press, 2012
3 Michael.J. Flynn and Wayne Luk, Computer System Design: System-On-Chip, Hoboken, New Jersey: Wiley 2011

REFERENCES:

1 W. A. Kester, Data Conversion Handbook. Amsterdam: Elsevier Newnes, 2005
2 Beuchat R D, et.al, Fundamentals of System-on-Chip Design on Arm Cortex-M Microcontrollers, Arm Education Media, 2021
3 Joseph Yiu, System-on-Chip Design with Arm Cortex-M Processors: Reference Book, Cambridge: ARM Education Media, 2019
4 Mona M. Hella, and Patrick Mercier, Eds., Power management integrated circuits, CRC Press, 2016
5 Forouzan B A, Data Communications and Networking, 5th ed. India: McGraw-Hill, 2017
6 Maniktala S, Power over ethernet interoperability, New York, NY: McGraw-Hill, 2013.
7 Qizheng GU – RF System Design of Transceivers for Wireless Communications

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Given an application, break down a product into various functional blocks and realize an effective Hw architecture	Create
CO2	Read through data sheets and identify right devices for each functional block	Evaluate
CO3	Design a practical circuit for each functional block	Create
CO4	Analyze a functional circuit for its static and dynamic behavior through simulation using existing models	Analyze

COURSE ARTICULATION MATRIX:

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	**H**	**H**	**H**	**H**	**M**	**-**	**L**	**-**	**-**	**L**	**L**	**-**	**M**	**M**	**M**
CO2	**H**	**H**	**H**	**H**	**L**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**M**	**M**	**L**
CO3	**H**	**H**	**H**	**H**	**H**	**M**	**H**	**-**	**M**	**L**	**M**	**H**	**H**	**M**	**M**
CO4	**H**	**H**	**H**	**H**	**H**	**M**	**H**	**-**	**M**	**L**	**M**	**H**	**H**	**H**	**M**
18EPE$27	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**-**	**M**	**L**	**M**	**H**	**H**	**M**	**M**

L - Low, M - Moderate (Medium), H – High

VERTICAL IV

DIVERSIFIED COURSES

18EPE$02	NEURAL AND FUZZY SYSTEMS

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To apply the intelligent human characters such as generalization, learning and vagueness in artificial intelligent systems for the betterment of Engineering.

UNIT-I : INTRODUCTION TO NEURAL NETWORKS	**(9 Periods)**
Introduction – Biological and Artificial neural networks - Learning rules – Training - ADALINE - MADALINE – BAM – Discrete Hopfield networks.	
UNIT-II : ARTIFICIAL NEURAL NETWORKS	**(9 Periods)**
Theory, Architecture and Applications of Back propagation network – Counter propagation network – Kohenen's Self Organising Maps.	
UNIT-III : INTRODUCTION TO FUZZY LOGIC	**(9 Periods)**
Fuzzy sets and membership – Chance Vs ambiguity – Classical sets – Fuzzy sets – Fuzzy relations – Tolerance and Equivalence relations – Value assignments.	
UNIT-IV : FUZZIFICATION AND DEFUZZIFICATION	**(9 Periods)**
Fuzzification – Membership value assignments – Fuzzy to Crisp conversions - Lambda – Cuts for Fuzzy sets and relations – Defuzzification methods	
UNIT-V : FUZZY ARITHMETIC, NUMBERS, VECTORS AND EXTENSION PRINCIPLE	**(9 Periods)**
Extension principle – Fuzzy numbers – Interval analysis in arithmetic – Approximate methods of extension: Vertex method, DSW algorithm, Restricted DSW algorithm – Fuzzy vectors – Classical predicate logic – Approximate reasoning – Fuzzy tautologies, contradictions, Equivalence and Logical proofs.	

Contact Periods:
Lecture: 45 Periods   Tutorial: 0 Periods   Practical: 0 Periods   Total: 45 Periods

TEXT BOOKS:

1. *LaureneFausett "**Fundamentals of Neural Networks**" Prentice Hall, New Jersey, 2004*
2. *S.Rajasekaran, G.A.Vijayalakshmi Pai **"Neural Networks, Fuzzy Logic and Evolutionary Algorithm: Synthesis and Applications"** PHI Learning Pvt. Ltd., 2017*
3. *Timothy J.Ross "**Fuzzy logic with Engineering Applications**" Wiley India Pvt. Ltd., 3rd Ed., 2010*

REFERENCE BOOKS:

1. *Robert .J.Schalkoff,"**Artificial Neural Networks**", McGraw Hill, Singapore, 2011*
2. *Driankov D., Helledorn H., M.Reinframe, "**An Introduction to fuzzy control**", Narosa Publishing Co., New Delhi, 1996*
3. *Kosko.B, "**Neural Network and fuzzy systems**"- Prentice Hall of India Pvt. Ltd., New Delhi, 2007*
4. *Fakhreddine O. Karray and Clarence De Silva., **"Soft Computing and Intelligent Systems Design, Theory, Tools and Applications",** Pearson Education, India, 2009*
5. *S N Sivanandam., S N Deepa, "**Principles of Soft Computing**", Wiley India Pvt. Ltd., 2nd Ed., 2011*

COURSE OUTCOMES:

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

CO1: Understand the behavior of human neural network and concept of fuzziness.

CO2: Explore the methods of training of Artificial Intelligent systems

CO3: Able to implement human intelligent concepts in AI.

CO4: Methods to formulate the input and to evaluate the output of the AI systems.

CO5: Learning the different architectures and able to differentiate them

CO6: Select suitable AI technique for engineering applications.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	M	M	M	M	-	-	-	-	-	H	L	H	-	-
CO2	H	M	M	H	-	-	-	-	M	-	-	M	H	-	-
CO3	H	M	H	M	-	M	-	-	-	-	-	-	M	H	M
CO4	M	H	M	H	-	-	-	-	-	M	-	-	-	H	M
CO5	M	M	H	H	-	-	-	-	-	-	-	-	-	M	H
CO6	H	M	H	M	-	M	-	-	-	-	-	M	-	H	M
18EPE$02	H	M	H	H	M	M	-	-	M	M	H	M	H	H	M

L - Low, M - Moderate (Medium), H – High

18EPE$11	DIGITAL SIGNAL PROCESSING AND PROCESSORS

Category : PE

PRE-REQUISITES:

L	T	P	C
3	0	0	3

1. Linear Algebra, Numerical methods and Transform Calculus
2. Control Systems Engineering

COURSE OBJECTIVES:

* To emphasize intuitive understanding of the concepts of Digital Signal Processing .To design theoretically the FIR and IIR Filters and to acquire knowledge on DSP processors and their applications in simple control systems.

UNIT – I : DISCRETE TIME LINEAR SYSTEMS	**(9 Periods)**
Discrete Linear systems – Time invariance –Causality, Stability, Difference Equations-Transfer functions of linear discrete systems – Impulse, step and frequency response – Linear and circular convolution-Recursive and non-recursive filters – Digital filter realization – Direct, Canonic, Cascade, Parallel and ladder realizations.	
UNIT – II : TRANSFORMATIONS IN DSP	**(9 Periods)**
Discrete Fourier Transform – Properties – IDFT- Convolution: Linear and Circular-Fast Fourier Transform: Introduction to Radix- 2 FFT – Properties – Decimation in time – Decimation in frequency – Computation of IDFT using DFT.	
UNIT – III : DIGITAL FILTERS - IIR	**(9 Periods)**
Approximation of analog filters – Butterworth -Chebyshev – Properties of IIR filter – IIR filter design-Bilinear transformation and Impulse invariance method – Digital transformation – Characteristic of FIR filter - Frequency response of linear phase FIR filter - Design of FIR filter – Fourier series method–Window function- Rectangular, Kaiser and Bartlett window methods.	
UNIT – IV : DIGITAL SIGNAL CONTROLLER	**(9 Periods)**
dsPIC30F4011 – Architecture - MCU and DSP features - Hardware DMA - Interrupt Controller - Digital I/O, On-chip Flash, Data EE and RAM - Peripherals - Timers, Communication Modules Motor Control Peripherals - Capture/Compare/PWM, Analog-to-Digital Converters	
UNIT – V : DIGITAL SIGNAL PROCESSOR	**(9 Periods)**
Introduction to DSP architecture- computational building blocks - Address generation unit, Program control and sequencing- Parallelism, Pipelining - Architecture of TMS320LF2407 - Addressing modes-I/O functionality, Interrupt. ADC, PWM, Event managers, Elementary Assembly Language Programming for control applications.	

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *B.Venkataramni, M.Bhaskar, "**Digital Signal Processors – Architecture, Programming and Applications**", Tata McGraw Hill, Fourth Edition, 2010.*
2. *C. Ramesh Babu Durai, **"DFFeigital Signal Processing",** Tata McGraw Hill, Fourteenth Reprint, 2008.*

REFERENCE BOOKS:

1. *John.G.Proakis, Dimitrias.G. and Manolakis. "**DSP Principles Algorithms and Applications",** Prentice Hall of India – Fourth Edition, 2014.*
2. *Emmanuel C.Ifeachor, University of Plymouth. Barrie.W.Jervis, Sheffield Hallam University, "**Digital Signal Processing. A Practical Approach"**, Pearson Education, II Edition, 2015.*
3. *SanjitK.Mitra, "**Digital Signal Processing: A computer Based approach**" Tata Mc Graw Hill, Fourth Edition, 2014.*
4. *Farzad Nekoogar, Gene moriarty. "**Digital Control Using Digital Signal Processing"** P.H. International Inc. New Jersey.2012.*

COURSE OUTCOMES:

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

CO1: Classify the digital signals and systems and apply various transformation techniques to solve problems.

CO2: Develop the ability to realize simple filter for difference equation.

CO3: Design digital IIR and FIR filters for the given specifications.

CO4: Design and simulate digital filters with signal processing algorithm.

CO5: Examine the DSP controllers and understand its functioning for control applications.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	-	L	-	-	-	-	-	-	-	M	M	-
CO2	M	M	-	-	-	-	-	-	-	-	-	M	M	-
CO3	M	M	-	L	L	-	-	-	-	-	-	M	M	-
CO4	L	L	-	M	L	-	-	-	M	-	-	M	M	-
CO5	M	M	-	M	L	-	L	-	M	-	-	M	M	-
18EPE$11	M	M	-	M	L	-	L	-	M	-	-	M	M	-

L - Low, M - Moderate (Medium), H – High

18EPE$12	COMPUTER SYSTEM ARCHITECTURE

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Digital Circuits
2. Microprocessors, Microcontrollers and Applications

COURSE OBJECTIVES:

* To impart knowledge about the basic principles and current practices of computer architectures and organizations.

UNIT-I : DATA REPRESENTATION, MICRO-OPERATIONS AND ORGANIZATION	**(9 Periods)**
Data representation - Data types - Complements – Fixed point representation – Floating point representation - Other binary codes - Error detection codes - Register transfer and micro operations - Register transfer language - Register transfer - Bus and memory transfers - Arithmetic micro-operations - Logic micro-operations - Shift micro-operations - Arithmetic logic shift unit - Basic computer organization and design - Instruction codes - Computer registers - Computer instructions - Timing and control - Instruction cycle - Memory reference instructions - Input-output - Interrupt - Design of accumulator logic**.**	
UNIT-II : CONTROL AND CENTRAL PROCESSING UNIT	**(9 Periods)**
Micro programmed control - Control memory - Address sequencing - Micro-program example - Design of control unit. Central processing unit: general register organization - Stacks organization - Instruction formats - Addressing modes - Data transfer and manipulation - Program control - Reduced instruction set computer**.**	
UNIT-III : PIPELINE, VECTOR PROCESSING AND COMPUTER ARITHMETIC	**(9 Periods)**
Parallel processing – Pipelining - Arithmetic pipeline - Instruction pipeline - RISC pipeline - Vector processing - array processors - Addition and subtraction algorithms - Multiplication algorithms - Division algorithms - Floating-point arithmetic operations - Decimal arithmetic unit - Decimal arithmetic operations.	
UNIT-IV : INPUT-OUTPUT ORGANIZATION	**(9 Periods)**
Input-output organization - Peripheral devices - Input-output interface - Asynchronous data transfer - Modes of transfer - Priority interrupt - Direct memory access - Input-output processor - Serial communication.	
UNIT-V : MEMORY ORGANIZATION	**(9 Periods)**
Memory organization: Memory hierarchy - Main memory - Auxiliary memory - Associative memory - Cache memory - Virtual memory - Memory management hardware**.**	

Contact Periods:
Lecture: 45 Periods   Tutorial: 0 Periods   Practical: 0 Periods   Total: 45 Periods

TEXT BOOKS:

1. *Morris Mano M., "**Computer System Architecture**" Pearson Education, 3rd Ed., 2008.*

REFERENCE BOOKS:

1. *Vincent P.Heuring and Harry F.Jordan, T.G Venkatesh, "***Computer Systems Design and Architecture***", Pearson Education Asia Publications, 2nd Ed., 2008.*
2. *John P.Hayes, "***Computer Architecture and Organization***", Tata McGraw Hill, 3rd Ed., 2012.*
3. *Andrew S.Tanenbaum, "***Structured Computer Organization***", 6th Ed., Pearson Education, 2010.*
4. *William Stallings, "***Computer Organization and Architecture***", 10th Ed., Pearson Education, 2016.*

COURSE OUTCOMES:

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

CO1: Demonstrate the organisation of computer hardware and execute a software program expressed in assembly language.

CO2: Illustrate the computer hardware that provides software with the illusion that fast memory and other resources are unlimited, even though they are not.

CO3: Design and analyze the pipe lined control units

CO4: Communicate with I/O devices and standard I/O interfaces.

CO5: Design memory organization

CO6: Evaluate quantitatively and improve computer system performance.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	M	M	H	M	L	L	H	M	M	M	H	L	L
CO2	M	L	M	M	H	M	L	L	H	M	M	M	H	L	L
CO3	H	M	H	H	M	H	M	M	M	M	M	M	H	H	L
CO4	M	L	M	M	M	M	L	L	M	H	M	M	H	L	L
CO5	H	M	H	H	M	H	M	M	M	M	M	M	H	H	L
CO6	H	M	H	H	M	H	M	M	M	M	M	M	H	H	L
18EPE$12	H	M	H	H	M	H	M	M	M	M	M	M	H	M	L

L - Low, M - Moderate (Medium), H - High

18EPE$13	PRINCIPLES OF EMBEDDED SYSTEMS

Category : PE

L	T	P	C
3	0	0	3

PRE-REQUISITES:

1. Programming in C
2. Object Oriented Programming with C++
3. Microprocessors, Microcontrollers and applications.

COURSE OBJECTIVES:

* To impart the knowledge on embedded systems and to make familiarity with tools used to develop in an embedded environment.

UNIT – I : FUNDAMENTALS OF EMBEDDED SYSTEMS	**(9 Periods)**
Classification of Embedded Systems - Embedded System on Chip - Structural Units in a Processor – Processor Selection - Memory Selection - Allocation of Memory to Segment - Block Memory Map of a System – Serial Communication using PC bus and CAN bus - Parallel Communication using ISA and PCI busses.	
UNIT – II : INTERRUPTS AND SOFTWARE ARCHITECTURES	**(9 Periods)**
Interrupt Basics - Shared Data Problem - Interrupt Latency - Round Robin Architecture - Round Robin with Interrupts - Function - Queues - Scheduling Architecture - Real Time Operating System Architecture – Selecting an Architecture.	
UNIT – III : REAL TIME OPERATING SYSTEMS	**(9 Periods)**
Tasks and Task States - Tasks and Data - Semaphores and Shared Data - Message Queues, Mailboxes and Pipes - Timer Functions – Events - Memory Management - Interrupt Routines in RTOS Environment	
UNIT – IV : DESIGN USING RTOS	**(9 Periods)**
Overview - Principles - Encapsulating Semaphores and Queues - Hard Real-time Scheduling Consideration - Saving Memory Space - Saving Power.	
UNIT – V : EMBEDDED SOFTWARE DEVELOPMENT TOOLS	**(9 Periods)**
Host and Target Machines - Linker / Locators for Embedded Software - Getting Embedded Software into Target - Testing on Host Machine - Instructions Set Simulators	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *David E. Simon "**An Embedded Software Primer**", Pearson Education, Reprint 2008*
2. *Navabi "**Embedded Core Design with FPGA's**", Tata McGraw-Hill, First Ed. 2008*
3. *Raj Kamal "**Embedded Systems**" Tata McGraw-Hill, Second Ed. 2008*

REFERENCE BOOKS:

1. *Peckol, "**Embedded system Design**", John Wiley & Sons, 2010.*
2. *Lyla B Das, "**Embedded Systems-An Integrated Approach**", Pearson, 2013.*

COURSE OUTCOMES:

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

CO1: Acquire the functional understanding of communication between digital system.

CO2: Able to model the organization and understand the digital system.

CO3: Demonstrate the practical use of embedded system.

CO4: Interpret the software and hardware components and their usage.

CO5: Provide in-depth knowledge of embedded processor architecture behavior of embedded system.

CO6: Explain the embedded software development tool.

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	M	-	-	-	-	-	-	-	L	H	M	M
CO2	H	H	M	M	-	-	-	-	-	-	-	L	H	H	M
CO3	H	M	M	M	-	-	-	-	-	-	-	-	M	M	M
CO4	H	M	H	M	-	-	-	-	-	-	-	-	M	M	H
CO5	H	M	H	M	-	-	-	-	-	-	-	L	H	H	H
CO6	H	M	H	H	-	-	-	-	-	-	-	-	H	H	M
18EPE$13	H	M	H	M	-	-	-	-	-	-	-	L	H	H	M

L - Low, M - Moderate (Medium), H – High

18EPE$08	AUTOMOTIVE ELECTRONICS FOR ELECTRICAL ENGINEERING

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To familiarize the role of power train, In-vehicle networking and comfort/safety in automotive electronics development.

UNIT-I : FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS	**(9 Periods)**
Evolution of electronics in automobiles, emission laws, introduction to Euro standards, equivalent Bharat standards, Charging systems: Working and design of charging circuit, alternators, requirements of starting system, starter motors and starter circuits.	
UNIT-II : IGNITION AND INJECTION SYSTEMS	**(9 Periods)**
Ignition systems: Ignition fundamentals, Electronic Ignition system, programmed ignition, distribution less ignition, direct ignition, spark plugs, Electronic fuel control, basics of combustion, engine fuelling and exhaust emission, electronic control of carburetion, petrol fuel injection, diesel fuel injection.	
UNIT-III : SENSORS AND ACTUATORS	**(9 Periods)**
Working principle and characteristics of airflow rate, engine crank shaft angular position, hall effect, throttle angle, temperature, exhaust gas oxygen sensors. Fuel injector, exhaust gas recirculation actuators, stepper motor actuator and vacuum operated actuator.	
UNIT-IV : ENGINE CONTROL SYSTEM	**(9 Periods)**
Control modes for fuel control, engine control subsystems, ignition control methodologies, different ECUs used in engine management. Vehicle networks: CAN standard. Diagnostic systems in modern automobiles.	
UNIT-V : CHASSIS AND SAFETY SYSTEMS	**(9 Periods)**
Traction control system, cruise control system, electronic control of automatic transmission, antilock braking system, electronic suspension system, working of airbag, centralised door locking system, climate control of cars.	

Contact Periods:

Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOKS:

1. *Tom Denton, "***Automobile Electrical and Electronic Systems***", Arnold Publishers, Fourth Edition 2012.*
2. *William B Ribbens, "***Understanding Automotive Electronics***", Sixth Edition, Newness Publishers, sixth edition, 2003.*

REFERENCE BOOKS:

1. *V A W Hillier "***Fundamentals of Automotive Electronics***", OUP Oxford, Second Edition 2001.*
2. *Ronald K Jurgen, "***Automotive Electronic Handbook***", McGraw Hill, Second Edition, 1999.*
3. *Robert Bosch, "***Automotive Electrics and Automotive Electronics***", Springer, Fifth Edition, 2014.*
4. *Bogdan M. Wilamowski, J. David Irwin "***The Industrial Electronics Handbook***", CRC Press, Second Edition, 2011.*

COURSE OUTCOMES:

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

CO1: Perceive the electronics involved in automotive systems
CO2: Understand the fundamentals involved in ignition systems
CO3: Choose appropriate sensors for automobiles based on applications
CO4: Work as a team and implement simple and safe control systems in automobiles
CO5: Analyze the safety issues that occur in automotive systems

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	L	L	L	L	-	-	-	-	-	-	-	H	M	L
CO2	H	M	L	L	L	-	-	-	-	-	-	-	H	M	L
CO3	H	H	H	H	L	M	-	-	-	-	H	-	H	M	M
CO4	M	M	H	M	L	L	-	M	H	M	M	M	H	H	H
CO5	M	M	H	L	L	M	-	H	M	M	L	M	M	H	H
18EPE$08	H	M	M	M	L	M	-	H	H	M	M	M	H	M	M

L - Low, M - Moderate (Medium), H – High

18EPE$22	OPTIMIZATION TECHNIQUES

Category : PE

PRE-REQUISITES:

1. Linear Algebra, Numerical methods and Transform Calculus

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* To understand the concept of optimization techniques and algorithms for solving various electrical engineering problems.

UNIT – I: CLASSICAL OPTIMIZATION TECHNIQUES	(9 Periods)
Single variable optimization - Multivariable optimization with no constraints: Semi definite case, Saddle point - Multivariable optimization with Equality constraints: Solution by direct substitution, Solution by the method of constrained variation, Solution by the method of Lagrange Multipliers - Multivariable optimization with Inequality constraints: Kuhn-Tucker conditions, constraint qualification	
UNIT – II : SIMPLEX METHOD	**(9 Periods)**
Standard form of a Linear programming problem - Geometry of linear programming problems - Definitions and theorems - Solution of a system of linear simultaneous equations - Pivotal reduction of a general system of equations - Motivation of the simplex method - Simplex algorithm - Revised simplex method.	
UNIT – III : UNCONSTRAINED & CONSTRAINED OPTIMIZATION TECHNIQUES	**(9 Periods)**
Unconstrained optimization techniques: Gradient of a function - Steepest descent (Cauchy) method - Newton's method - Marquardt method -Quasi-Newton methods – Broydon – Fletcher – Goldfarb - Sanno method. Constrained optimization techniques: Characteristics of a constrained problem - Generalized reduced gradient method - Sequential quadratic programming - Augmented Lagrange Multiplier method - Checking convergence of constrained optimization problems.	
UNIT – IV : EVOLUTIONARY ALGORITHM	**(9 Periods)**
Genetic Algorithms (GA) -principles of random search methods- Similarities and differences between GAs and traditional methods - GAs for constrained optimization- GAs operators - Real-coded GAs - Advanced GAs - solution of simple problems. Particle Swarm Optimization (PSO) – Background, operation and basic flow of PSO – Applications of PSO. Ant Colony Optimization (ACO): Ant Foraging behavior-Theoretical considerations-ACO algorithm-- Comparison between GA, PSO and ACO.	
UNIT – V : OPTIMIZATION TOOLBOX	**(9 Periods)**
Relevant software basics: Introduction - Matrices and vectors - Matrix and array operations - Built-in functions - Saving and loading data - Script files - Function files. Optimization Toolbox: Linear least squares with linearity constraints - Nonlinear curve fitting via least square with bounds - Linear programming - Quadratic programming– Use of GA toolbox	

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOKS:

1. *Singiresu S.Rao "**Engineering Optimization – Theory and Practice**" John Wiley & Sons, 4th Ed.2009*
2. *Kalyanmoy Deb "**Optimization For Engineering Design**" Prentice Hall of India, New Delhi,2nd edition 2012.*
3. *S.N.Sivanandam, S.N.Deepa, **— " Introduction of Genetic Algorithms"**, Springer, Newyork, 2010.*

REFERENCE BOOKS:

1. *Rudra Pratap "**Getting Started with MATLAB 7**" Oxford University Press, 2005.*
2. *"**Optimization Toolbox Manual**", The Mathworks Inc., 2000,* www.mathworks.com

COURSE OUTCOMES:

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

CO1: Understand the fundamental concept of optimization techniques.

CO2: Formulate deterministic mathematical programs for practical system

CO3: Interpret the results of the model and present the insights

CO4: Recognize the limitations of different solution methodology

CO5: Impact the knowledge on the concepts of various classical and modern methods for constrained and unconstrained with single and multivariable form of problems

CO6: Analyze real life problems through the use of mathematical modeling techniques

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	L	M	M	-	-	-	L	-	-	-	L	L	-
CO2	H	H	M	M	L	M	-	-	-	-	-	H	H	L	M
CO3	L	H	M	M	H	-	-	-	-	-	-	-	L	H	L
CO4	M	M	H	M	M	L	L	-	-	-	-	-	H	L	L
CO5	H	H	H	H	H	M	M	-	-	-	-	-	M	L	-
CO6	H	H	H	H	H	M	L	-	-	-	-	-	L	-	M
18EPE$22	H	H	M	M	M	M	L	-	L	-	-	H	M	L	M

L - Low, M - Moderate (Medium), H – High

18EPE$28	**ELECTRONIC SYSTEM DESIGN AND PRODUCTIZATION** ***(Common to EEE & EIE Branches)***

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

* Understand broad knowledge of the design, development and fabrication of electronic products, printed circuit boards and systems
* Understand manufacturability requirements of an electronic product
* Understand the nuances of designing a "Reliable" product
* Understand Product Safety, Compliance & Certification; and knows what it takes to bring a product to the market

UNIT – I	**PCB DESIGN, RULES, AND MANUFACTURABILITY**	**(8 Periods)**
PCB Technology – Component Packaging, Layer Stackup, Via Technology, HDI Concept; PCB Materials – Grades and Specification, example - FR4, Weaving Concept, Low Loss & High Performance Materials, Mechanical and Thermal Properties; Layer Stackup – Copper Foil, Pre-pegs and Base Material (Core), Dimensional Stability, CAF Growth; PCB Design Process – Influence from Package types, Material Choices, Fabrication Methods, Lead-free Assembly; Current Capacity; Thermal Signatures, File Format, Rule Checks – ERC and DRC, Power, Ground, and Signal Trace Consideration; Choice of CAD tools; IPC Standards for PCB – Introduction.		
UNIT – II	**ELECTROMAGNETIC COMPATIBILITY AND COMPLIANCE**	**(10 Periods)**
Introduction – History of Accidents, Impact of Technology Evolution, Importance of EMC and Regulations; EMC Concepts – Conducted, Radiated, Emissions, Susceptibility/Immunity; EMC Control Methods – Impedance Matching, Resonances, Balancing, Filtering, ESD Protection, Shielding, Grounding; PCB Design; Enclosure Design; EMC Prediction using Simulations; EMC Compliance – CISPR Test Setups, IEC Test Standards; Government Regulatory Requirements – FCC, RED, UNCECR10.		
UNIT – III	**THERMAL MANAGEMENT FOR ELECTRONICS AND LAB VISIT**	**(10 Periods)**
Introduction, Heat Transfer Theory; Concept of thermal resistance; Use of datasheets; Passive and Active Cooling – Forced Air, Liquid, Thermo Electric Cooling; Aspects of Heat Sink Design; Thermal Modeling and Measurement – CFD; Heat Management in Automotive Applications. Lab Visit : EMS Facility and EMC Test Lab.		
UNIT – IV	**DESIGN FOR RELIABILITY AND MANUFACTURING**	**(8 Periods)**
Basic Concepts – Quality and Reliability Assurance; Analysis during the Design Phase; Qualification tests for Components and Assemblies; Design guidelines for Reliability and Maintainability; Statistical Quality Control and Reliability Tests; Check lists for Design Reviews; Design FMEA/DRBFM; MTBF Calculation.		

UNIT – V	PRODUCT SAFETY, SECURITY, COMPLIANCE AND CERTIFICATION	(9 Periods)
Need for Product Safety; Examples – Automotive; CE/ISO/IEC/BIS; Safety Education: Products-Hazards-Age; Voltage Faults – Surge, Ringing, Polarity reversal, Current fault – short circuit, Inrush, Reverse; Thermal – Over temperature, thermal protection; Battery Safety Standards; Product Construction Requirements; Resistance to Fire and Flame Rating; Human Factors – Ergonomic Hazards; Safety Instructions - Cautions and Warnings. Regulatory compliance – Product Specific - EMC, Safety, & RF; Substance Regulation – RoHS, WEEE, REACH etc; Labeling, Documentation, Marking, Packaging and Testing; Industry Compliance – Industry specific; Technical documentation; EU declaration of conformity; Regional (states, districts) Specific compliance – data security and material; Usage Instructions; Traceability; IATF 16949; ISO 9000; ISO140000; ASPICE; GDPR. Process of Certification : ISO/IEC 17065 Conformity Assessment; ISO 17011; Certifying Bodies; Standards; Marking/Certificate; Accreditation Bodies; IAF, FCC, CE, BIS, NABL.		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK:

1 Clyde F. Coombs and Happy Holden – Printed Circuits Handbook, 7th Edition
2 Clayton R. Paul – Introduction to Electromagnetic Compatibility, Wiley 2006;
3 T. Yomi Obidi, Thermal Management in Automotive Applications, Warrendale, Pennsylvania, USA, SAE International 2015

REFERENCES:

1 Wilson, P, The Circuit Designer's Companion, 3rd Edition, Oxford, Newnes, 2011
2 Terence Rybak and Mark Stefafika – Automotive EMC, Kluwer Academic Publishers
3 Ralph Remsburg, Thermal Design of Electronic Equipment, CRC Press 2001
4 Alessandro Birolini – Reliability Engineering: Theory and Practice, 8 th Edition;
5 K. C. Kapur and M. Pecht, Reliability engineering, Hoboken, NJ; Wiley, 2014.
6 Swart, Jan, et.al, Electrical Product Compliance and Safety Engineering; Artech House, 2017
7 J. Doherty, Wireless and Mobile Device Security, 2nd ed. Jones and Bartlett Learning, 2021
8 Swart, Jan, et.al, Electrical Product Compliance and Safety Engineering; Artech House, 2017

COURSE OUTCOMES: On completion of the course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Engineer a product for large scale production	Create
CO2	Analyze a design for its failure modes; and design a reliable, safe product and compute its failure rate or MTBF	Analyze, Evaluate
CO3	Identify and fulfil all requirements for the Product compliance and certification considering EMC, RF, Safety and Security	Apply

COURSE ARTICULATION MATRIX:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	H	H	H	H	M	-	-	L	M	-	M	M	H	H	H
CO2	H	H	H	H	M	M	M	L	M	M	L	M	M	M	M
CO3	H	H	H	H	M	M	M	M	M	M	M	M	M	M	H
18EPE$28	H	H	H	H	M	M	M	L	M	M	M	M	M	M	H

L - Low, M - Moderate (Medium), H – High

VERTICAL V
ELECTRIC VEHICLE TECHNOLOGY

18EPE$30	ELECTRIC VEHICLE ARCHITECTURE

PRE-REQUISITES: NIL

Category : PE

L	T	P	C
3	0	0	3

Course Objectives	To explore and learn about the architecture, various components and control strategies of electric vehicles. .	
UNIT – I	**VEHICLE MECHANICS**	**(9 periods)**
Vehicle mechanics: Roadway fundamentals, Laws of motion, Vehicle Kinetics, Dynamics of vehicle motion, propulsion power, velocity and acceleration, Tire –Road mechanics, Propulsion System Design.		
UNIT – II	**VEHICLE ARCHITECTURE AND SIZING**	**(9 periods)**
History- and Evolution of Electric Vehicle -Series, Parallel and Series parallel Architecture, Micro and Mild architectures - Mountain Bike - Motorcycle- Electric Cars and Heavy Duty-EVs. -Details and Specifications.		
UNIT – III	**POWER COMPONENTS AND BRAKES**	**(9 periods)**
Powertrain Component sizing :Gears, Clutches, Differential, Transmission and Vehicle Brakes -EV Powertrain sizing-HEV Powertrain sizing- Example.		
UNIT – IV	**HYBRID VEHICLE CONTROL STRATEGY**	**(9 periods)**
Vehicle supervisory controller-Mode selection strategy: Mechanical Power-split hybrid modes, series-parallel hybrid modes- Modal Control strategies: series, parallel, series-parallel,\energy Storage system and regenerative control strategies		
UNIT – V	**PLUG-IN HYBRID ELECTRIC VEHICLE**	**(9 periods)**
Introduction-Comparison with Electrical and Hybrid Electric Vehicle-Construction and working of PHEV-Block diagram and components-Charging mechanisms-Advantages of PHEVs.		
Contact Periods: **Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods**		

TEXT BOOKS:

1 *Iqbal Husain "***Electric and Hybrid vehicles :Design Fundamentals",** *second edition, CRC press,2011.*

2 *Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi*, **"Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design**", *CRC Press, 2018.*

REFERENCES

1 *Wei Liu "***Hybrid Electric Vehicle System Modeling and Control",***Second Edition ,Wiley, 2017*

2 *Chris Mi,M. Abul Masrur* "**Hybrid Electric Vehicles Principles and Applications with Practical Perspectives" ,***Second Edition,Wiley,2018.*

3 *Nil Patel, Akash Kumar Bhoi,Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen* "**Electric Vehicles: Modern Technologies and Trends**", *Springer,2020.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Gain knowledge on history and evaluation of Electric Vehicles

CO2 Understand the scientific concepts related to Electric Vehicles

CO3 Learn the various components in Electric Vehicles

CO4 Analyze the control strategies of Electric Vehicles

CO5 Familiarize the fundamental operating mechanism of a hybrid Electric Vehicle

COURSE ARTICULATION MATRIX:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	M	M	M	M	M	M	-	-	L	M	H	H	H	L
CO2	H	M	M	M	M	-	M	-	-	L	M	-	M	H	L
CO3	H	H	L	M	M	-	-	-	-	-	-	M	M	H	M
CO4	H	H	M	M	M	H	M	M	L	L	M	-	H	M	H
CO5	H	H	L	M	M	-	-	-	-	-	-	M	M	M	M
18EPE$30	H	H	M	M	M	H	M	M	L	L	M	M	M	H	M
L – Slight, M– Moderate, H – Substantial															

18EPE$31	DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
3	0	0	3

Course Objectives	To expose the functions, types of different power converters, motors and controllers for Electric Vehicle.	
UNIT – I	**POWER CONVERSION CIRCUITS**	**(9 periods)**
Non-Isolated Power Converters: Half-Bridge Buck-Boost Bidirectional Converter, Buck Converter, Boost Converter - Inductor Sizing - Capacitor Sizing - Isolated Power Converters: Forward Converter - Sizing the Transformer - Full-Bridge Converter - Resonant Power Conversion - Desirable Converter Characteristics for Inductive Charging - Three-Phase Inverters - Modulation Schemes.		
UNIT – II	**DC MOTOR DRIVES**	**(9 periods)**
DC Machines: speed torque characteristics - power, losses and efficiency – starting and speed control methods – regenerative braking – closed loop speed control – design criteria of DC motor drives for EVs – Application of DC motor drives in EVs. PMBLDC Motor - operation – speed torque characteristics – speed control techniques – inverters requirements - closed loop control - outer rotor PMBLDC motor drive - Design criteria of PMBLDC - Application of PMBLDC drives in EVs.		
UNIT – III	**INDUCTION MOTOR DRIVES**	**(9 periods)**
Operation - speed torque characteristics – starting methods - speed control and braking techniques – inverters for induction motor – PWM techniques – closed loop speed/torque control – Field Oriented Control (FOC) – Direct Torque Control (DTC) - design criteria of induction motor drives for EVs.		
UNIT – IV	**PERMANENT MAGNET SYNCHRONOUS MOTOR AND SWITCHED RELUCTANCE MOTOR DRIVES**	**(9 periods)**
Permanent Magnet Synchronous Motor (PMSM): – operation – speed torque characteristics – speed control techniques – inverters requirements - closed loop control – Planetary geared PMSM drive - Design criteria of PMSM drives for EVs. Switched Reluctance Motor (SRM): Geometry structure - principle of operation –converter topologies for SRM – closed loop control – torque ripple reduction techniques - Design criteria of SRM drives for EVs.		
UNIT – V	**CONTROL OF ELECTRIC DRIVE**	**(9 periods)**
Introduction - Feedback Controller Design Approach - Modeling the Electromechanical System - Mechanical System -PM DC Machine - DC-DC Power Converter - PI Controller - Designing Torque Loop Compensation - Determining Compensator Gain Coefficients for Torque Loop - Designing Speed Control Loop Compensation - Determining Compensator Gain Coefficients for Speed Loop - Acceleration of Battery Electric Vehicle (BEV) using PM DC Machine.		

Contact Periods:
Lecture: 45 Periods **Tutorial: 0 Periods** **Practical: 0 Periods** **Total: 45 Periods**

TEXT BOOK:

1 *Chau K.T., **"Electric Vehicle Machines and Drives: Design, Analysis and Application"**, Wiley – IEEE Press, 2015.*
2 *John G. Hayes, G. Abas Goodarzi, **"Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles"** John Wiley & Sons Ltd., 1st edition, 2018.*

REFERENCES:

1 *Iqbal Hussain, **"Electric and Hybrid Vehicles: Design Fundamentals, Second Edition"** CRC Press, Taylor & Francis Group, Third Edition 2021.*
2 *Bimal K Bose, **"Modern Power Electronics and AC drives"**, Pearson Education, 1st Edition, 2015.*
3 *Krishnan R., **"Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design and Applications"**, CRC Press, 2001.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Illustrate various types of converter/inverter circuits and closed loop operation.
CO2 Enrich knowledge about working principles, performance and speed - torque characteristics of various types of electrical machines.
CO3 familiarize various starting methods, regenerative braking and speed control techniques in electrical machines.
CO4 Demonstrate various control techniques for electrical drives.
CO5 use an appropriate electric machine for electric vehicle application.

COURSE ARTICULATION MATRIX :

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	M	M	H	M	M	M	L	-	–	-	H	H	M	L
CO2	H	L	L	M	L	M	M	-	-	-	-	M	M	H	L
CO3	M	M	M	M	M	M	L	L	-	-	-	M	L	M	H
CO4	M	M	M	H	M	M	M	-	-	-	-	M	M	H	M
CO5	M	M	M	M	M	-	M	L	-	-	-	M	H	H	M
18EPE$31	H	M	M	H	M	M	M	L	-	-	-	H	H	H	M
L – Slight, M– Moderate, H – Substantial															

18EPE$32	HYBRID ELECTRIC AND FUEL CELL VEHICLES

PRE-REQUISITES: NIL

Category : PE

L	T	P	C
3	0	0	3

Course Objectives	To learn the basics of EV and vehicle mechanics and to understand the hybrid electric and fuel cell vehicle architecture	
UNIT – I	**Hybrid Electric Vehicles**	**(9 periods)**
Concept of Hybrid Electric Drive Trains- Architectures of Hybrid Electric Drive Trains- Series/Parallel - Torque-Coupling Parallel Hybrid Electric Drive Trains - Speed-Coupling Parallel Hybrid Electric Drive Trains-Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains		
UNIT – II	**Electric Propulsion Systems**	**(9 periods)**
Principle and Operation of DC Motor Drives- Induction Motor Drives-Permanent Magnet Brush-Less DC Motor Drives- Switched Reluctance Motor Drives		
UNIT – III	**Series Hybrid Electric Drive Train Design**	**(9 periods)**
Operation Patterns- Control Strategies- Sizing of the Major Components - Design of Traction Motor, Gear Ratio, Acceleration Performance, Gradeability, Engine/Generator Size, Power and Energy Capacity.		
UNIT – IV	**Mild Hybrid Electric Drive Train Design**	**(9 periods)**
Energy Consumed in Braking and Transmission- Parallel Mild Hybrid Electric Drive Train- Series–Parallel Mild Hybrid Electric Drive Train- Configuration- Operating Modes and Control- Control Strategy		
UNIT – V	**Fuel Cell Vehicles**	**(9 periods)**
Operating Principles of Fuel Cells-Electrode Potential and Current–Voltage Curve-Fuel and Oxidant Consumption-Fuel Cell System Characteristics-Fuel Cell Technologies-Fuel Supply-Nonhydrogen Fuel Cells		

Contact Periods:
Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Total: 45 Periods

TEXT BOOK :

1 *Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi*, **"Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design**", *CRC Press, 2018.*
2 *Iqbal Husain,**"Electric and Hybrid Vehicles, Design Fundamentals"**, Third Edition, CRC Press, 2021*

REFERENCES :

1 *Ali Emadi, Mehrdad Ehsani, John M.Miller, **"Vehicular Electric Power Systems",** Special Indian Edition, Marcel dekker, Inc 2003, 1st Edition.*
2 *C.C. Chan and K.T. Chau, '**Modern Electric Vehicle Technology',** OXFORD University Press, 2001, 1st Edition.*
3 *Wie Liu, **"Hybrid Electric Vehicle System Modeling and Control"**, Second Edition, John Wiley & Sons, 2017, 2nd Edition.*
4 *Chee Mun Ong, **"Dynamic Simulation of Electric Machinery using MATLAB",** Prentice Hall,1997, 1st Edition.*
5 *Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, **"Electrical Machine Fundamentals with Numerical Simulation using MATLAB/ SIMULINK**", Wiley, 2021, 1st Edition.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Describe the concepts related with EV, HEV and to compare the same with internal combustion engine vehicles

CO2 Understand the electric drives used in HEV

CO3 Analyse and design the hybrid electric train components

CO4 Explain the concepts related with series/parallel hybrid electric drive train

CO5 Understand the architecture of fuel cell vehicle.

COURSE ARTICULATION MATRIX :

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	M	M	H	M	H	M	L	-	-	-	H	H	M	H
CO2	M	M	L	M	L	M	M	-	-	-	-	M	M	L	M
CO3	H	L	M	M	M	M	L	M	-	-	-	M	M	H	L
CO4	M	M	M	M	M	M	H	-	-	-	-	M	L	M	H
CO5	L	M	M	M	M	-	M	L	-	-	-	H	H	L	H
18EPE$32	M	M	M	H	M	H	M	M	-	-	-	H	H	M	H
L – Slight, M– Moderate, H – Substantial															

18EPE$33	DESIGN OF ELECTRICAL VEHICLE CHARGING SYSTEM

PRE-REQUISITES: NIL

Category : PE

L	T	P	C
2	0	2	3

Course Objectives	To learn and demonstrate the concepts of power converters in charging Electric Vehicles and power factor correction techniques.	
UNIT – I	**CHARGING STATIONS AND STANDARDS**	**(6 periods)**
Introduction-Charging technologies- Conductive charging, EV charging infrastructure, International standards and regulations - Inductive charging, need for inductive charging of EV, Modes and operating principle, Static and dynamic charging, Bidirectional power flow, International standards and regulations.		
UNIT – II	**POWER ELECTRONICS FOR EV CHARGING**	**(6 periods)**
Layouts of EV Battery Charging Systems-AC charging-DC charging systems- Power Electronic Converters for EV Battery Charging- AC–DC converter with boost PFC circuit, with bridge and without bridge circuit - Bidirectional DC–DC Converters- Non-isolated DC–DC bidirectional converter topologies- Half-bridge bidirectional converter.		
UNIT – III	**EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS**	**(6 periods)**
Introduction- - EV charger topologies , EV charging/discharging strategies - Integration of EV charging-home solar PV system , Operation modes of EVC-HSP system , Control strategy of EVCHSP system - fast-charging infrastructure with solar PV and energy storage.		
UNIT – IV	**WIRELESS POWER TRANSFER**	**(6 periods)**
Introduction - Inductive, Magnetic Resonance, Capacitive types. Wireless Chargers for Electric Vehicles - Types of Electric Vehicles - Battery Technology in EVs -Charging Modes in EVs - Benefits of WPT. - WPT Operation Modes - Standards for EV Wireless Chargers, SAE J2954, IEC 61980. ISO 19363.		
UNIT – V	**POWER FACTOR CORRECTION IN CHARGING SYSTEM**	**(6 periods)**
Need for power factor correction- Boost Converter for Power Factor Correction, Sizing the Boost Inductor, Average Currents in the Rectifier and calculation of power losses		
LAB COMPONENT: 30 PERIODS		
1. Simulation and analysis for bi-directional charging V2G and G2V. 2. Design and demonstrate solar PV based EV charging station. 3. Simulate and infer wireless power charging station for EV charging. 4. Simulation of boost converter based power factor correction.		

Contact Periods:
Lecture: 30 Periods Tutorial: 0 Periods Practical: 30 Periods Total: 60 Periods

TEXT BOOK :

1 ***Mobile Electric Vehicles Online Charging and Discharging***, *Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016, 1st Edition.*

2 *Alicia Triviño-Cabrera, José M. González-González, José A. Aguado,* ***Wireless Power Transferor Electric Vehicles: Foundations and Design Approach****, Springer Publisher 1st Edition. 2020.*

REFERENCES :

1 *Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, "**Electric Vehicles Modern Technologies and Trends**", Springer Publisher 1st Edition, 2021.*
2 *Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, **"Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration"**, IET 2021, 1st Edition.*
3 *James D Halderman, **"Electric and Hybrid Electric Vehicles"**, Pearson, 2022, 1st Edition.*
4 *Ali Emadi, **"Handbook of Automotive Power Electronics and Motor Drives"**, Taylor & Francis, 2005.*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Illustrate various charging techniques and to know charging standards and regulations.
CO2 Demonstrate the working of DC-DC converters used for charging systems and principles
CO3 Illustrate the advantages of renewable system based charging systems
CO4 Demonstrate the principles of wireless power transfer.
CO5 Analyze the standards for wireless charging.

COURSE ARTICULATION MATRIX :

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	M	M	H	L	H	M	-	-	-	-	M	H	M	H
CO2	M	M	M	H	M	M	H	-	-	-	-	H	H	M	L
CO3	M	L	M	H	M	M	L	L	-	-	-	M	M	M	H
CO4	M	M	L	M	M	M	H	-	-	-	-	M	M	H	M
CO5	H	M	M	H	M	-	H	L	-	-	-	M	H	M	M
18EPE$33	H	M	M	H	M	H	H	L				H	H	H	H
L – Slight, M– Moderate, H – Substantial															

18EPE$34	TESTING OF ELECTRIC VEHICLES

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
2	0	2	3

Course Objectives	To know various standardization procedures, learn the testing procedures for EV & HEV components ,functional safety and EMC,realize the effect of EMC in EVs ,study the effect of EMI in motor drives and in DC-DC converter system	
UNIT – I	**EV STANDARDIZATION**	**(6 periods)**
Introduction - Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in countries like Japan. The International Electro Technical Commission - Standardization of Vehicle Components		
UNIT – II	**TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES**	**(6 periods)**
Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test - Motor Test and Controller Test (Controller Only). - Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.		
UNIT – III	**FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC**	**(6 periods)**
Functional safety life cycle - Fault tree analysis - Hazard and risk assessment - re development - Process models - Development assessments - Configuration management - Reliability - Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality - Standards - Functional safety of autonomous vehicles.		
UNIT – IV	**EMC IN ELECTRIC VEHICLES**	**(6 periods)**
Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC-DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements		
UNIT – V	**EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM**	**(6 periods)**
Overview -EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path		

LAB COMPONENT: (30 periods)

1. Design and simulate motor controller for hybrid electric vehicle applications
2. Simulation of EMC analysis for Wireless power transfer EV charging.
3. Design and simulation of EMI filter

Contact Periods:
Lecture: 30 Periods Tutorial: 0 Periods Practical: 30 Periods Total: 60 periods

TEXT BOOK

1 Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005, 1st Edition.
2 Electromagnetic Compatibility of Electric Vehicle, Li Zhai, Springer 2021, 1st Edition.

REFERENCES:

1 EMC and Functional Safety of Automotive Electronics, Kai Borgeest, IET 2018, 1st Edition.
2 EMI/EMC Computational Modeling Handbook, Druce Archam beault, colin branch, Omar M.Ramachi ,Springer 2012, 2nd Edition.
3 Automotive EMC, Mark Steffika, Springer 2013, 1st Edition
4 Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative, Beate Müller, Gereon Meyer, Springer 2015, 1st Edition.

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Describe the status and other details of standardization of EVs
CO2 Illustrate the testing protocols for EVs and HEV components
CO3 Analyze the safety cycle and need for functions safety for EVs
CO4 Analyze the problems related with EMC for EV components.
CO5 Evaluate the EMI in the motor drive and DC-DC converter system.

COURSE ARTICULATION MATRIX :

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	L	L	-	-	-	M	-	-	-	-	-	H	-	M
CO2	H	L	L	-	-	-	L	-	-	-	-	-	H	-	M
CO3	H	L	L	-	-	-	M	-	-	-	-	-	H	-	M
CO4	H	L	L	-	-	-	L	-	-	-	-	-	H	-	M
CO5	H	L	L	-	-	-	M	-	-	-	-	-	H	H	H
18EPE$34	H	L	L	-	-	-	M	-	-	-	-	-	H	H	M
L – Slight, M– Moderate, H – Substantial															

18EPE$35	GRID INTEGRATION OF ELECTRIC VEHICLES

PRE-REQUISITES: NIL

Category : PE

L	T	P	C
3	0	0	3

Course Objectives	1.To know the basic details of V2G 2.To study the benefits & challenges of V2G 3.To learn EV & V2G on the smart grids renewable energy systems 4.To know the grid integration	
UNIT – I	**DEFINITION, And STATUS Of V2G**	**(9 periods)**
Defining V2G - History and Development of V2G. Incorporating V2G to the EV, Auditing and Metering , V2G in Practice , V2G, Power Markets and Applications . Electricity Markets and V2G Suitability , Long-Term Storage, Renewable Energy, and Other Grid Applications , Beyond the Grid: Other Concepts Related to V2G.		
UNIT – II	**BENEFITS AND CHALLENGES OF V2G**	**(9 periods)**
Benefits of V2G, Technical Benefits: Storage Superiority and Grid Efficiency, Economic Benefits: EV Owners and Societal Savings, Environment and Health Benefits: Sustainability in Electricity and Transport, Other Benefits.		
UNIT – III	**CHALLENGES TO V2G**	**(9 periods)**
Technical Challenges-Battery Degradation, Charger Efficiency, Aggregation and Communication, V2G in a Digital Society. The Economic and Business Challenges to V2G - Evaluating V2G Costs and Revenues , EV Costs and Benefits , Adding V2G Costs and Benefits , Additional V2G Costs , The Evolving Nature of V2G Costs and Benefits. Regulatory and Political Challenges to V2G , V2G and Regulatory Frameworks , Market Design Challenges. Other V2G Regulatory and Legal Challenges		
UNIT – IV	**IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS**	**(9 periods)**
Introduction - Types of Electric Vehicles - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Impact on Drivers and the Smart Grid - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.		
UNIT – V	**GRID INTEGRATION AND MANAGEMENT OF EVS**	**(9 periods)**
Introduction-M2M in distributed energy management systems - M2M communication for EVs - M2M communication architecture (3GPP) - Electric vehicle data logging - Scalability of electric vehicles - M2M communication with scheduling.		

Contact Periods:
Lecture:45 Periods   Tutorial: Periods   Practical: Periods   Total:45 Periods

TEXT BOOK

1 Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017, 1st Edition.
2 Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna , Farhad Shahnia and Arindam Ghosh,Springer,2015, 1st Edition

REFERENCES

1 ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor 1; Jesus Fraile-Ardanuy, IET 2020, 1st Edition..
2 Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
3 Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicleto-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019, 1st Edition.

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Explain the concepts related with V2G.
CO2 Study the grid connection of 3 phase Q inverter
CO3 Explain technical, economics. business, regulatory & political challenges related with V2G
CO4 Demonstrate the impact of EV and V2G on smart grid and renewable energy system
CO5 Explain the concept of grid integration and management of EVs.

COURSE ARTICULATION MATRIX :

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	-	-	-	-	-	M	L	-	M	-	-	H	-	L
CO2	H	H	-	-	H	-	M	L	-	M	-	-	H	-	-
CO3	H	-	-	-	-	-	M	L	-	M	-	-	H	-	-
CO4	H	-	-	-	-	-	M	L	-	M	-	-	H	-	M
CO5	H	-	-	-	-	-	M	L	-	M	-	-	H	-	H
18EPE$35	H	H	-	-	H	-	M	L	-	M	-	-	H	H	M
L – Slight, M– Moderate, H – Substantial															

18EPE$36	INTELLIGENT CONTROL OF ELECTRIC VEHICLES

Category : PE

PRE-REQUISITES: NIL

L	T	P	C
2	0	2	3

Course Objectives	To design and drive the mathematical model of a BLDC motor and its characteristics and to learn the different control schemes for BLDC motor and implement in fuzzy/FPGA.	
UNIT – I	**ANALYSIS OF BLDC MOTOR**	**6 Periods**
Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Mathematical Model, Differential Equations, Transfer Functions, State-Space Equations. Characteristic Analysis, Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients.		
UNIT – II	**CONTROLLERS FOR BLDC MOTOR**	**6 Periods**
Introduction -PID Control Principle, Anti-windup Controller, Intelligent Controller - Fuzzy Logic- Control applied to BLDC motor		
UNIT – III	**FPGA ARCHITECTURE**	**6 Periods**
Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7.		
UNIT – IV	**FPGA PROGRAMMING**	**6 Periods**
VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs : arithmetic, sorting, PWM generation, Speed detection, Speed Control.		
UNIT – V	**REAL TIME IMPLEMENTATION**	**6 Periods**
Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of BLDC motor using FPGA		
LAB COMPONENT:		**30 Periods**
1. Design and simulate speed controller for BLDC in EV for both dynamic and steady state performance. 2. Code VHDL programming for the control of BLDC motors. 3. Fuzzy logic control of BLDC motor using FPGA in real time .		

Contact Periods:
Lecture:30 Periods **Tutorial: 0 Periods** **Practical: 30 Periods** **Total:60 Periods**

TEXT BOOK

1 *John G. Hayes, G. Abas Goodarzi,* ***Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles****, Wiley 1st Edition 2018.*

2 *Jayaram Bhasker,* ***VHDL Primer****, (3rd Edition), Prentice Hall, 1 st Edition 2015.*

REFERENCES

1 *Iqbal Hussain, "**Electric and Hybrid Vehicles: Design Fundamentals, Third Edition**" CRC Press, Taylor & Francis Group, 2021, 1 st Edition.*
2 *Chang-liang, "**Permanent Magnet Brushless DC Motor Drives and Controls**", Wiley 2012, 1 st Edition.*
3 *M.N. Cirstea, A. Dinu, J.G. Khor,M. McCormick, "**Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications**", 1 st Edition, 2002.*
4 *Wei Liu, "**Hybrid Electric Vehicle System Modeling and Control**", Wiley 2017, 2nd Edition*

COURSE OUTCOMES:

On completion of the course, the students will be able to:

CO1 Understand the mathematical model of a BLDC motor and to discuss about its characteristics
CO2 Demonstrate the PID control, anti windup controller, Intelligent Controller and Vector Control applied to BLDC motor.
CO3 Understand the basics of fuzzy logic system.
CO4 Understand and apply the basics of VHDL & FPGA applied to control of EVs.
CO5 Design and implement of fuzzy logic control scheme for BLDC motor using FPGA in real time.

COURSE ARTICULATION MATRIX:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	M	M	H	L	H	M	-	-	-	-	M	H	H	M
CO2	M	M	M	H	M	M	H	-	-	-	-	H	M	H	M
CO3	M	L	M	H	M	M	L	L	-	-	-	M	H	H	M
CO4	M	M	M	M	M	M	H	-	-	-	-	M	H	H	M
CO5	H	M	M	H	M	-	H	L	-	-	-	M	M	H	M
18EPE$36	M	M	M	H	M	M	M	L	-	-	-	M	H	H	M
L – Slight, M– Moderate, H – Substantial															