	VIVEKANANDHA COLLEGE OF ENGINEERING FOR WOMEN (Autonomous Institution Affiliated to Anna University, Chennai) Elayampalayam, Tiruchengode – 637 205				
Programme	**M.E.**	Programme Code	**202**	Regulation	**2014**
Department	**POWER SYSTEMS ENGINEERING / ELECTRICAL AND ELECTRONICS ENGINEERING**			Semester	**I**

CURRICULUM

(Applicable to the students admitted from the academic year 2014 - 2015 onwards)

Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
	THEORY							
P14PS101	Transient Over Voltages In Power Systems	3	0	0	3	50	50	100
P14PS102	Advanced Power System Analysis	3	0	0	3	50	50	100
P14PS103	Power System Stability	3	0	0	3	50	50	100
P14PS104	Advanced Power System Protection	3	0	0	3	50	50	100
	Elective I	3	0	0	3	50	50	100
	Elective II	3	0	0	3	50	50	100
	PRACTICAL							
P14PS105	Power System Computation Laboratory	0	0	3	2	50	50	100
P14PS106	Seminar and Minor Project – I	0	0	3	2	50	50	100
				Total Credits	**23**	**400**	**400**	**800**

CA - Continuous Assessment, ESE - End Semester Examination

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Department	**POWER SYSTEMS ENGINEERING / ELECTRICAL AND ELECTRONICS ENGINEERING**			Semester	**II**

CURRICULUM

(Applicable to the students admitted from the academic year 2014 - 2015 onwards)

Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
	THEORY							
P14PS207	Power System Operation and Control	3	0	0	3	50	50	100
P14PS208	High Voltage DC Transmission	3	0	0	3	50	50	100
P14PS209	Flexible AC Transmission Systems	3	0	0	3	50	50	100
P14PS210	Power System Restructuring and Pricing	3	0	0	3	50	50	100
	Elective III	3	0	0	3	50	50	100
	Elective IV	3	0	0	3	50	50	100
	PRACTICAL							
P14PS211	Power System Simulation Laboratory	0	0	3	2	50	50	100
P14PS212	Seminar and Minor Project - II	0	0	3	2	50	50	100
				Total Credits	**20**	**400**	**400**	**800**

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CURRICULUM
(Applicable to the students admitted from the academic year 2014 - 2015 onwards)

Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
THEORY								
	Elective V	3	0	0	3	50	50	100
	Elective VI	3	0	0	3	50	50	100
	Elective VII	3	0	0	3	50	50	100
PRACTICAL								
P14PS313	Project Phase - I	0	0	12	6	50	50	100
Total Credits					**15**	**200**	**200**	**400**

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CURRICULUM
(Applicable to the students admitted from the academic year 2014 - 2015 onwards)

Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
PRACTICAL								
P14PS414	Project Phase - II	0	0	24	12	50	50	100
				Total Credits	**12**	**50**	**50**	**100**

CA - Continuous Assessment, ESE - End Semester Examination

Cumulative Course Credit: 70

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CURRICULUM
(Applicable to the students admitted from the academic year 2014 - 2015 onwards)

LIST OF ELECTIVES

Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE01	Power Conversion Techniques	3	0	0	3	50	50	100
P14PSE02	Industrial Control Electronics	3	0	0	3	50	50	100
P14PSE03	System Theory	3	0	0	3	50	50	100
P14 PSE04	Analysis and Design of Artificial Neural Networks	3	0	0	3	50	50	100
P14PSE05	Advanced Digital Signal Processing	3	0	0	3	50	50	100
P14PSE06	Digital System Design	3	0	0	3	50	50	100
P14PSE07	Power Electronic Drives	3	0	0	3	50	50	100
P14PSE08	Digital Controllers in Power Electronics Applications	3	0	0	3	50	50	100
P14PSE09	Computer Networking	3	0	0	3	50	50	100
P14PSE10	Electrical Distribution Systems	3	0	0	3	50	50	100
P14PSE11	Fuzzy Systems	3	0	0	3	50	50	100
P14PSE12	Optimization Techniques	3	0	0	3	50	50	100
P14PSE13	Stochastic Models And Applications	3	0	0	3	50	50	100
P14PSE14	Renewable Power Generation Technologies	3	0	0	3	50	50	100
P14PSE15	Power System Planning And Reliability	3	0	0	3	50	50	100

P14PSE16	Modeling And Analysis Of Electrical Machines	3	0	0	3	50	50	100
P14PSE17	Power Quality	3	0	0	3	50	50	100
P14PSE18	Microcontroller Applications in Power Converters	3	0	0	3	50	50	100
P14PSE19	Computer Relaying And Wide Area Measurement Systems	3	0	0	3	50	50	100
P14PSE20	Advanced DSP Architecture And Programming	3	0	0	3	50	50	100
P14PSE21	Swarm Intelligent Techniques	3	0	0	3	50	50	100
P14PSE22	Smart Grid Technologies	3	0	0	3	50	50	100
P14PSE23	Electric Systems in Wind Energy	3	0	0	3	50	50	100
P14PSE24	Embedded Processors and Controllers	3	0	0	3	50	50	100
P14PSE25	Distributed Generation and Micro-grids	3	0	0	3	50	50	100
P14PSE26	Control Design Techniques for Power Electronic Systems	3	0	0	3	50	50	100
P14PSE27	Energy Auditing and Management	3	0	0	3	50	50	100
P14PSE28	Electric and Hybrid Vehicles	3	0	0	3	50	50	100

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Department	**POWER SYSTEMS ENGINEERING / ELECTRICAL AND ELECTRONICS ENGINEERING**			Semester	**I**

Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS101	**Transient Over Voltages In Power Systems**	3	0	0	3	**50**	**50**	**100**

Objective	• To make the students familiar with the theoretical basis for various forms of over voltages such as lighting strokes, surges, switching transients etc., • Introduce some of the protection measures against such over voltages are described. Also to depict the necessity and methods for generating impulse voltages and currents.		
Unit – I		Periods	**09**
Transients in electric power systems – Internal and external causes of over voltages -–Lightning strokes – Mathematical model to represent lightning, Travelling waves in transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations			
Unit – II		Periods	**09**
Switching transients – double frequency transients – abnormal switching transients –Transients in switching a three phase reactor - three phase capacitor			
Unit – III		Periods	**09**
voltage distribution in transformer winding – voltage surges-transformers – generators and motors - Transient parameter values for transformers, reactors, generators and transmission lines			
Unit – IV		Periods	**09**
Basic ideas about protection – surge diverters-surge absorbers - protection of lines and stations Modern lighting arrestors - Insulation coordination - Protection of alternators and industrial drive systems.			
Unit – V		Periods	**09**
Generation of high AC and DC-impulse voltages, currents - measurement using spheregaps-peak voltmeters - potential dividers and CRO			
		Total Periods	**45**

References

1.	Allen Greenwood, ‘Electrical transients in power systems’,Wiley Interscience, 1991.
2.	Bewley, L.V., ‘Travelling waves on Transmission systems’, Dover publications, New York,1963.
3.	Gallaghar, P.J. and Pearman, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 2001.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS102	**Advanced Power System Analysis**	3	0	0	3	**50**	**50**	**100**

Objective	• To perform steady state analysis and fault studies for a power system of any size and also to explore the nuances of estimation of different states of a power system. • To determine the operating condition of a system according to the demand without violating the technical and economic constraints.		
Unit – I		Periods	**09**
Network modeling – Single phase and three phase modeling of alternators, transformers and transmission lines, Conditioning of Y Matrix –- Incidence matrix method, Method of successive elimination, Triangular factorization			
Unit – II		Periods	**09**
Load flow analysis - Newton Raphson method, Fast Decoupled method, AC-DC load flow – Single and three phase methods – Sequential solution techniques and extension to multiple and multi-terminal DC systems**.**			
Unit – III		Periods	**09**
Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults			
Unit – IV		Periods	**09**
System optimization - strategy for two generator systems – generalized strategies –effect of transmission losses - ensitivity of the objective function - Formulation of optimal power flow-solution by Gradient method-Newton's method			
Unit – V		Periods	**09**
State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation			
		Total Periods	**45**

References

1.	Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' Tata McGraw hill, New Delhi, 2003.
2.	Hadi Saadat, 'Power System Analysis', Tata McGraw hill, New Delhi, 2002.
3.	Arrillaga, J and Arnold, C.P., 'Computer analysis of power systems' John Wiley and Sons, New York, 1997.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS103	**Power System Stability**	3	0	0	3	**50**	**50**	**100**

Objective	• To give basic knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modelling issues. • To analyse and understand the electromagnetic and electromechanical phenomena taking place around the synchronous generator.		
Unit – I		Periods	**09**
Power system stability considerations – definitions-classification of stability - rotor angle and voltage stability - synchronous machine representation – classical model – load modeling concepts - modeling of excitation systems - modeling of prime movers			
Unit – II		Periods	**09**
Transient stability - swing equation-equal area criterion - solution of swing equation- Numerical methods - Euler method-Runge - Kutte method - critical clearing time and angle -effect of excitation system and governors-Multimachine stability – extended equal area criterion - transient energy function approach			
Unit – III		Periods	**09**
Small signal stability – state space representation – eigen values - modal matrices – small signal stability of single machine infinite bus system – synchronous machine classical model representation - effect of field circuit dynamics - effect of excitation system-small signal stability of multi machine system			
Unit – IV		Periods	**09**
Voltage stability – generation aspects - transmission system aspects – load aspects – PV curve – QV curve – PQ curve – analysis with static loads – loadability limit – sensitivity analysis - continuation power flow analysis - instability mechanisms – examples			
Unit – V		Periods	**09**
Methods of improving stability – transient stability enhancement – high speed fault clearing – steam turbine fast valving - high speed excitation systems- small signal stability enhancement-power system stabilizers – voltage stability enhancement – reactive power control			
		Total Periods	**45**

References

1.	Kundur, P., 'Power System Stability and Control', McGraw-Hill International Editions, 1994.
2.	Van Cutsem, T. and Vournas, C., 'Voltage Stability of Electric Power Systems', Kluwer Academic Publishers, 1998.
3.	Abhijit Chakrabarti, D.P. Kothari, A.K. Mukhopadhyay and Abhinandan De, 'An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems', PHI Learning Private Ltd., 2010.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS104	**Advanced Power System Protection**	3	0	0	3	**50**	**50**	**100**

Objective	• To facilitate the students understand the basic concepts and recent trends in power system protection. • To enable the students design and work with the concepts of digital and numerical relaying		
Unit – I		Periods	**09**
General philosophy of protection - Classification and Characteristic function of various protective relays- basic relay elements and relay terminology - Development of relaying scheme			
Unit – II		Periods	**09**
Digital Protection of power system apparatus – protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer over current protection			
Unit – III		Periods	**09**
Bus bar protection - line protection - distance protection–long EHV line protection – Power line carrier protection			
Unit – IV		Periods	**09**
Reactor protection – Protection of boosters - capacitors in an interconnected power system			
Unit – V		Periods	**09**
Digital signal processing – digital filtering in protection relays - numeric protection – testing digital filtering in protection relays – digital data transmission – relay hardware – relay algorithms - Concepts of modern coordinated control system			
		Total Periods	**45**

References

1.	Lewis Blackburn, J., ‘Protective Relaying – Principles and Applications’, Marcel Dekkar, INC, New York, 2006.
2.	The Electricity Training Association, ‘Power System Protection Vol1-4’, The IEE, U.K., 2005.
3.	C. Russeil Mason, ‘The art and Science of Protective Relaying’, GE Publishers, 1962.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS105	**Power System Computation Laboratory**	0	0	3	2	**50**	**50**	**100**

Objective	• Acquire skills of using computer packages MATLAB coding and SIMULINK in power electronics and power system studies. • Acquire skills of using ETAP software for power system studies.

1. Solution of simultaneous Algebraic equations by
    - Gauss-Elimination
    - Crout's method
    - Cholesky method

2. Solution of Simultaneous differential equations by
    - RK-4
    - Modified Euler's method

3. Formation of Ybus using two dimensional arrays by inspection method

4. Formation of Ybus using Sparsity Technique

5. Load flow by Gauss Seidel, Newton Raphson and Fast Decoupled methods using
    - Two-dimensional arrays
    - Sparsity techniques
    - MATLAB

6. AC/DC load flow study

7. NR-load flow study with FACTS

Total Periods 45

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS207	**Power System Operation and Control**	3	0	0	3	**50**	**50**	**100**

Objective	• To understand the economics of power system operation with thermal and hydro units. • To realize the requirements and methods of real and reactive power control in power system.		
Unit – I		Periods	**09**
Economic operation - Load forecasting - Unit commitment – Economic dispatch problem of thermal units – Gradient method- Newton's method – Base point and participation factor method			
Unit – II		Periods	**09**
Hydro-thermal co-ordination-Hydroelectric plant models – short term hydrothermal scheduling problem - gradient approach – Hydro units in series - pumped storage hydro plants-hydro - scheduling using Dynamic programming and linear programming			
Unit – III		Periods	**09**
Automatic generation control - Review of LFC and Economic Dispatch control (EDC) using the three modes of control viz. Flat frequency – tie-line control and tie-line bias control – AGC implementation – AGC features - static and dynamic response of controlled two area system			
Unit – IV		Periods	**09**
MVAR control - Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators			
Unit – V		Periods	**09**
Power system security - Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow-Interior point algorithm-Bus incremental costs.			
		Total Periods	**45**

References

1.	Robert H. Miller, James H. Malinowski, 'Power system operation', Tata McGraw-Hill, 2009
2.	Allen J. Wood, Bruce F. Wollenberg, 'Power Generation, Operation and Control', Wiley India Edition, 2nd Edition, 2009.
3.	Abhijit Chakrabarti & Sunita Halder, 'Power system Analysis-Operation & Control', PHI, 3rd Edition, 2010.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS208	**High Voltage DC Transmission**	3	0	0	3	**50**	**50**	**100**

Objective	• To facilitate the students understand the basic concepts and recent trends in HVDC transmission as it an upcoming area of development. To enable the students decide, design and work with the concepts of HVDC transmission • To analyze the HVDC circuits and develop exquisite interest to work in the area of HVDC transmission		
Unit – I		Periods	**09**
Introduction to HVDC transmission, Comparison between HVAC and HVDC systems -economic, technical and reliability, limitations, choice of best topology for HVDC converters, types of HVDC links - monopolar, bipolar and homopolar links, Rectifier operation of Graetz circuit with and without overlap			
Unit – II		Periods	**09**
Inverter operation – analysis with and without overlap. Equivalent circuit model, Combined characteristics of HVDC system, basic means of control - desired features of control, power reversal			
Unit – III		Periods	**09**
Basic controllers - Constant Ignition Angle, Constant Current and Constant Extinction Advance angle control, power control, high level controllers. Converter faults - misfire, arc through, commutation failure. D.C. Reactor design - voltage and current oscillations.			
Unit – IV		Periods	**09**
Protection issues in HVDC – DC Circuit breakers, over voltage and over current protection.Characteristic and uncharacteristic harmonics - troubles due to harmonics – harmonic filters - active and passive filters - Reactive power control of converters			
Unit – V		Periods	**09**
Interaction between ac and dc systems. Recent trends in HVDC - VSC based HVDC – Multiterminal HVDC systems and Hybrid HVDC systems. Back to back chorister converter system.			
		Total Periods	**45**

References

1.	Padiyar, K.R., ‘HVDC transmission systems’, Wiley Eastern Ltd., 2010.
2.	S.Rao, ‘EHV-AC, HVDC Transmission and Distribution Engineering’, Khanna Publications,3rd Edition, 2012.
3.	S.Kamakshaiah and V.Kamaraju, ‘HVDC Transmission’, 1st Edition, Tata McGraw Hill,2011.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS209	**Flexible AC Transmission Systems**	**3**	**0**	**0**	**3**	**50**	**50**	**100**

Objective	• To analyze variety of high power-electronic controllers for active and reactive power in transmission lines.. • To model different FACTS controllers, form a basis for selecting a particular controller for a given application and analyze and compare the performance of various FACTS controllers		
Unit – I		Periods	**09**
Fundamentals of ac power transmission - transmission problems and needs - emergence of FACTS-FACTS control considerations - FACTS controllers			
Unit – II		Periods	**09**
Principles of shunt compensation – Variable Impedance type & switching converter type -Static Synchronous Compensator (STATCOM) configuration - characteristics and control			
Unit – III		Periods	**09**
Principles of static series compensation using GCSC, TCSC and TSSC – applications - Static Synchronous Series Compensator (SSSC)			
Unit – IV		Periods	**09**
Principles of operation - Steady state model and characteristics of a static voltage regulators and phase shifters - power circuit configurations			
Unit – V		Periods	**09**
UPFC - Principles of operation and characteristics - independent active and reactive power flow control - comparison of UPFC with the controlled series compensators and phase shifters			
		Total Periods	**45**

References

1.	Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
2.	Hingorani ,L.Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN –078033 4588.
3.	Mohan Mathur R. and Rajiv K.Varma , 'Thyristor - based FACTS controllers for Electrical transmission systems', IEEE press, Wiley Inter science , 2002.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS210	**Power System Restructuring and Pricing**	3	0	0	3	**50**	**50**	**100**

Objective	• To understand the electricity power business and technical issues in a restructured power system in both Indian and world scenario. • To become an entrepreneur or can become a consultant in power system business and operation		
Unit – I		Periods	**09**
Introduction – Market Models – Entities – Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world			
Unit – II		Periods	**09**
Operational and planning activities of a Genco - Electricity Pricing and Forecasting -Price Based Unit Commitment Design - Security Constrained Unit Commitment design. - Ancillary Services for Restructuring-Automatic Generation Control (AGC).			
Unit – III		Periods	**09**
Introduction-Components of restructured system-Transmission pricing in Open-access system-Open transmission system operation; Congestion management in Open-access transmission systems- FACTS in congestion management - Open-access Coordination Strategies; Power Wheeling-Transmission Cost Allocation Methods			
Unit – IV		Periods	**09**
Open Access Distribution - Changes in Distribution Operations- The Development of Competition – Maintaining Distribution Planning			
Unit – V		Periods	**09**
Power Market Development – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power- Competition- Indian power market- Indian energy exchange- Indian power exchange-Infrastructure model for power exchanges-Congestion Management-Day Ahead Market-Online power trading			
		Total Periods	**45**

References

1.	Loi Lei Lai, 'Power System Restructuring and Deregulation', JohnWiley & Sons Ltd., 2001
2.	Mohammad Shahidehpour, Hatim Yamin, 'Market operations in Electric power systems', JohnWiley & son ltd., 2002
3.	Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation' Taylor & Francis, 2006

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PS211	**Power System Simulation Laboratory**	0	0	3	2	**50**	**50**	**100**

Objective	• Acquire skills of using computer packages MATLAB coding and SIMULINK in power electronics and power system studies. • Acquire skills of using ETAP software for power system studies.

1. Simulation of Single Area and Two Area Systems using Matlab Package.

2. Study of load frequency control problem of (i) uncontrolled and (ii) controlled cases

3. Economic Dispatch of (i) Thermal Units and (ii) Thermal Plants using Conventional and ANN and GA algorithms

4. MVAR Compensation studies on normal and heavily loaded power systems using Mi-power package

5. Contingency evaluation and analysis of power system

6. Development of single line diagram of power system components

7. State estimation of power systems.

Total Periods **45**

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Department	**POWER SYSTEMS ENGINEERING / ELECTRICAL AND ELECTRONICS ENGINEERING**			Semester	

Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE01	**Power Conversion Techniques**	3	0	0	3	**50**	**50**	**100**

Objective	• To know the concepts of typical power electronic circuits: topologies and control. • To apply the mathematical skills to a number of practical problems.		
Unit – I		Periods	**09**
DC-DC converters - Buck converter, boost converter, buck - boost converter, averaged circuit modeling, input-output equations, ripple calculations, filter design			
Unit – II		Periods	**09**
DC-AC inverters -Single phase VSI, Three phase VSI, Single phase CSI, Three phase CSI,voltage control and harmonic reduction in inverters-standard PWM techniques			
Unit – III		Periods	**09**
AC-DC converters- Uncontrolled rectifiers, single and three phase fully controlled and semi controlled converters, continuous current conduction, discontinuous current conduction,Reactive compensation, Harmonic compensation techniques			
Unit – IV		Periods	**09**
AC-AC converters-single phase and three phase circuits employing Phase angle control,on-off control. AC choppers			
Unit – V		Periods	**09**
Loss calculations and thermal management: Device models for loss calculations, ratings,safe operating areas, data sheets, forward conduction loss, switching losses, heat sink design, snubber design drive and protection circuits, commutation circuits, Soft switching			
		Total Periods	**45**

References

1.	Ned Mohan, Undeland and Robbin, ‘Power Electronics: converters, Application and design’, John Wiley and sons. Inc, 3rd Edition, 2002
2.	Rashid M.H., ‘Power Electronics Circuits, Devices and Applications’, Prentice Hall India, 3rd Edition 2004.
3.	Singh M.D., Khanchandani K. B., ‘Power Electronics’, Tata McGraw-Hill, 2nd Ediition, 2008.

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P14PSE02	**Industrial Control Electronics**	3	0	0	3	**50**	**50**	**100**

Objective	• To analyze various control electronics used in the industries which combines the analog and digital concepts together with Power Electronics for the design of the controllers. • To design and analyze analog controllers for UPS, Switching regulators and inverters.		
Unit – I		Periods	**09**
Review of switching regulators and switch mode power supplies, Uninterrupted power supplies- off-line and on-line topologies-Analysis of UPS topologies, solid state circuit breakers, solid-state tap-changing of transformer			
Unit – II		Periods	**09**
Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, derivative overrun, integral windup, cascaded control, Feed forward control, Digital control schemes, control algorithms, programmable logic controllers			
Unit – III		Periods	**09**
Signal conditioners-Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters; Isolation circuits – cabling; magnetic and electro static shielding and grounding			
Unit – IV		Periods	**09**
Opto-Electronic devices and control , electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation, interrupter modules and photo sensors; Fibre-optics; Bar code equipment, application of barcode in industry			
Unit – V		Periods	**09**
Stepper motors – types, operation, control and applications; servo motors- types, operation, control and applications – servo motor controllers – servo amplifiers – linear motor applications-selection of servo motor.			
		Total Periods	**45**

References

1.	Michael Jacob, 'Industrial Control Electronics – Applications and Design', Prentice Hall,1995.
2.	Thomas E. Kissell, 'Industrial Electronics', Prentice Hall India, 2003
3.	James Maas, 'Industrial Electronics', Prentice Hall, 1995.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE03	**System Theory**	3	0	0	3	**50**	**50**	**100**

Objective	• To understand the fundamental of physical systems interms of its linear and nonlinear models. • To understand the state feedback control design. Stability analysis of nonlinear systems and its behavior.		
Unit – I		Periods	**09**
Introduction to state space modeling, modeling of physical systems. Solution to vector differential equations and state transition matrix.			
Unit – II		Periods	**09**
Stability analysis of linear systems. Controllability and Observability definitions and Kalman rank conditions. Detectability and Stabilizability, Kalman decomposition.			
Unit – III		Periods	**09**
State feedback controller design using pole placement. Observer design using Kalman filter algorithm. LQR and LQG controller design.			
Unit – IV		Periods	**09**
Introduction to nonlinear systems. Phase plane analysis of nonlinear system using linear approximation. Limit cycle and periodic solutions. Singular points (equilibrium points) and qualitative behavior near singular points.			
Unit – V		Periods	**09**
Stability of nonlinear systems. Lyapunov direct and indirect methods. Input-to-state stability and relative stability.			
		Total Periods	**45**

References

1.	Ogata, K., 'Modern Control Engineering', Prentice Hall of India, 2010
2.	C.T. Chen, 'Linear Systems Theory and Design'' Oxford University Press, 3rd Edition, 1999
3.	M. Vidyasagar, 'Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs,New Jersey 07632.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE04	**Analysis and Design of Artificial Neural Networks**	3	0	0	3	**50**	**50**	**100**

Objective

- To apply artificial neural networks in various electrical and electronics engineering applications.
- To innovate and build, smart and intelligent applications in electrical and electronics engineering.

Unit – I		Periods	**09**
Pattern classification –Learning and generalisation-structure of neural networks – ADA line and Mada line-perceptrons.			
Unit – II		Periods	**09**
Linear separability – Back propagation – XOR function-Back propagation algorithm-Hopfied and Hamming networks- Kohensen's network-Boltzmenn machine-in and out star network – Art 1 and Art 2 nets			
Unit – III		Periods	**09**
Neuro adaptive control applications-ART architecture – Comparison layer – Recognition layer – ART classification process – ART implementation – Examples			
Unit – IV		Periods	**09**
Character recognition networks, Neural network control application, connectionist expert systems for medical diagnosis Self organizing maps			
Unit – V		Periods	**09**
Applications of neural algorithms and systems -Character recognition networks, Neural network control application, connectionist expert systems for medical diagnosis			
		Total Periods	**45**

References

1.	Martin T. Hagan , Howard B.Demuth, M, and Mark H. Beale 'Neural network design', Vikas Publishing House, 2003.
2.	Zurada, J.M., 'Introduction to Artificial Neural Systems', Jaico publishing house, Bombay,1992.
3.	Zimmermann, H.J., 'Fuzzy set theory and its applications', Allied publishers limited, Madras,2001.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE05	**Advanced Digital Signal Processing**	3	0	0	3	**50**	**50**	**100**

Objective	• To understand the basic operations of sampling and quantization processes including quantization noise. • To perform discrete-time Fourier Transform and digital Fourier Transform, and perform Z-Transform.		
Unit – I		Periods	**09**
Review of Discrete – Time Signal & System representation in Z – Transform domain – Inverse Z – Transform – Properties – System characterization in Z – domain -- Equivalence between Fourier Transform and the Z - Transform of a Discrete signal			
Unit – II		Periods	**09**
Sampling in Fourier domain - Discrete Fourier Transform and its properties – Linear filtering using DFT – Resolution of DFT - FFT Algorithm – Radix-2 FFT Algorithm - DIT & DIF Structures - Higher Radix schemes			
Unit – III		Periods	**09**
Classification of filter design - Design of IIR filters – Bilinear transformation technique –Impulse invariance method – Step invariance method			
Unit – IV		Periods	**09**
FIR filter design – Fourier series method - Window function technique - Finite Word Length Effects			
Unit – V		Periods	**09**
Introduction to Multirate Signal Processing - Decimation - Interpolation – Introduction to STFT WT			
		Total Periods	**45**

References

1.	John G. Prokis and Dimitris G. Hanolakis, 'Digital Signal Processing, Principles, Algorithms & Apllications' 4th Edition, Pearson Education, 2006.
2.	Ludemann L. C., 'Fundamentals of Digital Signal Processing', Harper and Row publications,2009.
3.	Antoniou A., 'Digital Filters – Analysis and Design', Tata Mc-Graw Hill, 2001.

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		L	T	P	C	CA	ESE	Total
P14PSE06	**Digital System Design**	3	0	0	3	**50**	**50**	**100**

Objective	• To impart the knowledge on the advanced topics of Digital systems, design aspects and testing of the circuits. • To understands various digital circuits and techniques and will help to design excellent digital controllers which can be deployed in practical applications		
Unit – I		Periods	**09**
Review of sequential circuits - Mealy & Moore Models - Analysis & Synthesis of Synchronous sequential circuits			
Unit – II		Periods	**09**
Digital system design Hierachy - ASM charts - Hardware description language – Control logic Design Reduction of state tables - State Assignments**.**			
Unit – III		Periods	**09**
Analysis and synthesis of Asynchronous sequential circuits - critical and non - critical races - Essential Hazard			
Unit – IV		Periods	**09**
Combinational and sequential circuit design with PLD's - Introduction to CPLD's & FPGA's			
Unit – V		Periods	**09**
Fault classes and models – Stuck at faults, Bridging faults - Transition and Intermittent faults. Fault Diagnosis of combination circuits by conventional methods - Path sensitization technique - Boolean different method and Kohavi algorithm			
		Total Periods	**45**

References

1.	Donald D. Givone, 'Digital principles and design', Tata McGraw-Hill, 2003.
2.	Morris Mano, 'Digital Design', Prentice Hall India, 3rd Edition, 2007.
3.	Samuel C. Lee, 'Digital circuits and logic design', Prentice Hall India, 1984

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE07	**Power Electronic Drives**	3	0	0	3	**50**	**50**	**100**

Objective	• To introduce basic concepts of load and drive interaction, speed control concepts of ac and dc drives, speed reversal, regenerative braking aspects, design methodology. • To analyse, simulate and evaluate performance of variable speed drives.		
Unit – I		Periods	**09**
Basic power electronic drive system, components. Different types of loads, shaft-load coupling systems. Stability of power electronic drive.			
Unit – II		Periods	**09**
Conventional methods of D.C.motor speed control, single phase and three phase converter fed D.C motor drive. Power factor improvement techniques, four quadrant operation			
Unit – III		Periods	**09**
Chopper fed drives, input filter design. Braking and speed reversal of DC motor drives using choppers, multiphase choppers. PV fed DC drives.			
Unit – IV		Periods	**09**
Conventional methods of induction motor speed control. Solid state controllers for Stator voltage control, soft starting of induction motors, Rotor side speed control of wound rotor induction motors. Voltage source and Current source inverter fed induction motor drives			
Unit – V		Periods	**09**
Speed control of synchronous motors, field oriented control, load commutated inverter drives, switched reluctance motors and permanent magnet motor drives. Introduction to design aspects of machines.			
		Total Periods	**45**

References

1.	P.C Sen, 'Thyristor DC Drives', John Wiley and Sons, New York, 1991.
2.	R.Krishnan, 'Electric Motor Drives – Modeling, Analysis and Control', Prentice-Hall of India Pvt Ltd., New Delhi, 2003.
3.	Bimal K.Bose, 'Modern Power Electronics and AC Drives', Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE08	**Digital Controllers in Power Electronics Applications**	3	0	0	3	**50**	**50**	**100**

Objective	• To learn with digital controller concepts and its application in the field of Power Electronic System • To design digital controllers for the versatile control of Power electronic circuits.		
Unit – I		Periods	**09**
Introduction to the C2xx DSP core and code generation - The components of the C2xx DSP core - Mapping external devices to the C2xx core - peripherals and Peripheral Interface - System configuration registers - Memory - Types of Physical Memory - Memory addressing Modes - Assembly Programming using C2xx DSP - Instruction Set - Software Tools			
Unit – II		Periods	**09**
Pin Multiplexing (MUX) and General Purpose I/O Overview - Multiplexing and General Purpose I/O Control Registers - Introduction to Interrupts - Interrupt Hierarchy – Interrupt Control Registers - Initializing and Servicing Interrupts in Software			
Unit – III		Periods	**09**
ADC Overview - Operation of the ADC in the DSP - Overview of the Event manager (EV) -Event Manager Interrupts - General Purpose (GP) Timers - Compare Units - Capture Units And Quadrature Enclosed Pulse (QEP) Circuitry - General Event Manager Information			
Unit – IV		Periods	**09**
Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA – Xilinx XC3000 series - Configurable logic Blocks (CLB) - Input/Output Block (IOB) – Programmable Interconnect Point (PIP) – Xilinx 4000 series – HDL programming –overview of Spartan 3E and Virtex II pro FPGA boards-case study			
Unit – V		Periods	**09**
Controlled Rectifier - Switched Mode Power Converters - PWM Inverters - DC motor control -Induction Motor Control			
		Total Periods	**45**

References

1.	Hamid.A.Toliyat and Steven G.Campbell, 'DSP Based Electro Mechanical Motion Control' CRC Press New York , 2004
2.	XC 3000 series datasheets (version 3.1). Xilinx,Inc.,USA, 1998
3.	Wayne Wolf, 'FPGA based system design', Prentice hall, 2004.

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		L	T	P	C	CA	ESE	Total
P14PSE09	**Computer Networking**	3	0	0	3	**50**	**50**	**100**

Objective	• To provides an introduction to the computer networking fundamentals, design issues, functions and protocols of the network architecture. • To have an idea of Networking, network types, protocols and web services.		
Unit – I		Periods	**09**
Computer Network – Hardware and Software, OSI and TCP reference Model, Transmission media, Wireless transmission, public switched telephone network - Structure, multiplexing and switching.			
Unit – II		Periods	**09**
Data link layer - design issues, Data link protocols. Medium access sub layer – channel allocations, Multiple Access protocols, IEEE protocols.			
Unit – III		Periods	**09**
Network layer - Design issues, routing algorithms, congestion control algorithms, QoS ,Transport layer- Design issues, Connection management .			
Unit – IV		Periods	**09**
Application layer – DNs, Electronic mail, World Wide Web, multimedia, Cryptography			
Unit – V		Periods	**09**
Internet transport protocols - TCP and UDP			
		Total Periods	**45**

References

1.	James F. Kurose and Keith W. Ross, 'Computer Networking', Pearson Education, 2nd Edition, 2003.
2.	Tanenbaum, A.S., 'Computer Networks', Prentice Hall of India, 4th Edition, 2003
3.	Stallings W., 'Data and Computer Communication', Prentice Hall of India, 5th Edition, 2000.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE10	**Electrical Distribution Systems**	3	0	0	3	**50**	**50**	**100**

Objective

- To explain the principles of design and operation of electric distribution feeders and other components
- To make the students to understand the distribution system expansion planning and reliability analysis procedures

Unit – I	Periods	**09**

Industrial and commercial distribution systems – Energy losses in distribution system – system ground for safety and protection – comparison of O/H lines and under ground cable system . Network model – power flow - short circuit and loss calculations.

Unit – II	Periods	**09**

Distribution system - reliability analysis – reliability concepts – Markov model – distribution network reliability – reliability performance.

Unit – III	Periods	**09**

Distribution system expansion - planning – load characteristics – load forecasting – design concepts – optimal location of substation – design of radial lines – solution technique.

Unit – IV	Periods	**09**

Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems – loss reduction and voltage improvement.

Unit – V	Periods	**09**

System protection – requirement – fuses and section analyzers-over current - Under voltage and under frequency protection – coordination of protective device.

	Total Periods	**45**

References

1. Pabla, A.S., ‘Electrical Power Distribution System’, 5th edition,Tata McGraw hill, 2011.
2. Tuvar Goner, ‘Electrical Power Distribution System Engineering’, McGraw hill, 2008.
3. Sterling, M.J.H., ‘Power System Control’, Peter Peregrinus, 1986

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE11	**Fuzzy Systems**	3	0	0	3	**50**	**50**	**100**

Objective	• This course is designed to expose students to fuzzy methods of analyzing problems which involve incomplete or vague criteria rather than crisp values • The course investigates requirements analysis, logical design, and technical design of components for fuzzy systems development.		
Unit – I		Periods	**09**
Different faces of imprecision – inexactness, Ambiguity, Undecidability, Fuzziness and certainty, Probability and fuzzy logic, Intelligent systems.			
Unit – II		Periods	**09**
Fuzzy sets and crisp sets - Intersections of Fuzzy sets, Union of Fuzzy sets, the complement of Fuzzy sets.			
Unit – III		Periods	**09**
Fuzzy reasoning - Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference- Methods of decompositions, Defuzzification			
Unit – IV		Periods	**09**
Methodology of fuzzy design - Direct & Indirect methods with single and multiple experts, Adaptive fuzzy control, Rule base design using dynamic response			
Unit – V		Periods	**09**
Fuzzy logic applications to engineering, Fuzzy decision making, Neuro-Fuzzy systems, Fuzzy Genetic Algorithms.			
		Total Periods	**45**

References

1.	Zimmermann H. J., ‘Fuzzy set theory and its applications’, Allied publishers limited, Madras, 4thEdition, 2001.
2.	Klir G. J. and Folger T., ‘Fuzzy sets, uncertainty and information’, Prentice Hall of India , New Delhi,1991.
3.	EarlCox, ‘The Fuzzy Systems Handbook’, AP professional Cambridge, 1999.M.Tech. – Power Systems 19

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE12	**Optimization Techniques**	3	1	0	4	**50**	**50**	**100**

Objective	• To learn essential optimization techniques for applying to day to day problems. • Optimization techniques they can apply to engineering and other problems		
Unit – I		Periods	**09**
Linear programming – formulation - Graphical and simplex methods - Big-M method -Two phase method - Dual simplex method - Primal Dual problems			
Unit – II		Periods	**09**
Unconstrained one dimensional optimization techniques - Necessary and sufficient conditions – Unrestricted search methods - Fibonacci and golden section method -Quadratic Interpolation methods, cubic interpolation and direct root methods			
Unit – III		Periods	**09**
Unconstrained n dimensional optimization techniques – direct search methods – Random search – pattern search and Rosen brock's hill climbing method - Descent methods -Steepest descent, conjugate gradient, quasi - Newton method			
Unit – IV		Periods	**09**
Constrained optimization Techniques - Necessary and sufficient conditions – Equality and inequality constraints - Kuhn-Tucker conditions - Gradient projection method - cutting plane method - penalty function method			
Unit – V		Periods	**09**
Dynamic programming - principle of optimality - recursive equation approach -application to shortest route, cargo - loading, allocation and production schedule problems			
		Total Periods	**45**

References

1.	Rao S.S., 'Optimization :Theory and Application' Wiley Eastern Press, 2nd edition 1984..
2.	Taha,H.A., Operations Research –An Introduction,Prentice Hall of India,2003
3.	Fox, R.L., 'Optimization methods for Engineering Design', Addition Wiely, 1981.

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		L	T	P	C	CA	ESE	Total
P14PSE13	**Stochastic Models And Applications**	3	0	0	3	**50**	**50**	**100**

Objective	• This course is designed to expose students to stochastic models, process and applications.		
Unit – I		Periods	**09**
Probability Spaces - Discrete probability distributions - Continuous probability densities -Conditional probability, distribution and densities. Distribution functions - Multiple random variables and joint distributions.			
Unit – II		Periods	**09**
Expectations – moments - Characteristic functions and moments generating functions, sequence of random variables and Convergence Concepts.			
Unit – III		Periods	**09**
Law of large numbers – Discrete and continuous random variables; Central limit theorem –Bernoulli trials - Discrete and continuous independent trial			
Unit – IV		Periods	**09**
Stochastic processes - Markov chains – Transient analysis - Computation of equilibrium probabilities - Stationary distribution and Transient distribution of markov chains			
Unit – V		Periods	**09**
Poisson processes – Exponential distribution and applications - Birth-death processes and applications			
		Total Periods	**45**

References

1.	Hole, P.G., Port, S.C., and Stone,C.J., 'Introduction to Probability Theory', Indian Edition Universal Book Stall, New Delhi,1998
2.	Hole,P.G., Port, S.C., and Stone,C.J., 'Introduction to Stochastic Process', Indian Edition Universal Book Stall, New Delhi,2008.M.Tech. – Power Systems 21

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		L	T	P	C	CA	ESE	Total
P14PSE14	**Renewable Power Generation Technologies**	3	0	0	3	**50**	**50**	**100**

Objective	• To aware of various forms of renewable energy • To understand in detail the wind energy conversion system and photovoltaic conversion system		
Unit – I		Periods	**09**
Sun and Earth-Basic Characteristics of solar radiation-angle of sunrays on solar collector- Photovoltaic cell-characteristics-equivalent circuit-Photovoltaic modules and arrays			
Unit – II		Periods	**09**
PV Systems-Design of PV systems-Standalone system with DC and AC loads with and without battery storage-Grid connected PV systems-Maximum Power Point Tracking			
Unit – III		Periods	**09**
Wind energy – energy in the wind – aerodynamics - rotor types – forces developed by blades - Aerodynamic models – braking systems – tower - control and monitoring system - design considerations-power curve - power speed characteristics-choice of electrical generators			
Unit – IV		Periods	**09**
Wind turbine generator systems-fixed speed induction generator-performance analysis-semi variable speed induction generator-variable speed induction generators with full and partial rated power converter topologies -isolated systems-self excited induction generator-permanent magnet alternator -performance analysis			
Unit – V		Periods	**09**
Hybrid energy systems-wind-diesel system-wind-PV system-micro hydro-PV system-biomass-PV-diesel system-geothermal-tidal and OTEC systems			
		Total Periods	**45**

References

1.	Chetan Singh Solanki, 'Solar Photovoltaics-Fundamentals, Technologies and Applications',PHI Learning Pvt. Ltd., New Delhi, 2011
2.	Van Overstraeton and Mertens R.P., 'Physics, Technology and use of Photovoltaics',Adam Hilger, Bristol,1996.
3.	John F.Walker & Jenkins. N , 'Wind energy Technology', John Wiley and sons, Chichester,UK, 1997.

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		L	T	P	C	CA	ESE	Total
P14PSE15	**Power System Planning And Reliability**	3	0	0	3	**50**	**50**	**100**

Objective	• To acquire skills in planning and building reliable power system.		
Unit – I		Periods	**09**
Objectives of planning – Long and short term planning - Load forecasting – characteristicsof loads – methodology of forecasting – energy forecasting – peak demand forecasting –total forecasting – annual and monthly peak demand forecasting			
Unit – II		Periods	**09**
Reliability concepts – exponential distributions – meantime to failure – series and parallelsystem – MARKOV process – recursive technique. Generator system reliability analysis –probability models for generators unit and loads – reliability analysis of isolated andinterconnected system – generator system cost analysis – corporate model – energytransfer and off peak loading			
Unit – III		Periods	**09**
Transmission system reliability model analysis – average interruption rate - LOLP method -frequency and duration method			
Unit – IV		Periods	**09**
Two plant single load system - two plant two load system-load forecasting uncertainlyinterconnections benefits			
Unit – V		Periods	**09**
Introduction to system modes of failure – the loss of load approach – frequency & durationapproach – spare value assessment – multiple bridge equivalents			
		Total Periods	**45**

References

1.	Sullivan, R.L., ‘Power System Planning’, Heber Hill, 1987.
2.	Roy Billington, ‘Power System Reliability Evaluation’, Gordan & Breach Scain Publishers,1990.
3.	Eodrenyi, J., ‘Reliability modelling in Electric Power System’ JohnWiley, 1980.M.Tech. – Power Systems

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE16	**Modeling And Analysis Of Electrical Machines**	3	0	0	3	**50**	**50**	**100**

Objective	• To give a systematic approach for modeling and analysis of all rotating machines under both transient and steady state conditions.	
Unit – I	Periods	**09**
Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.		
Unit – II	Periods	**09**
Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.		
Unit – III	Periods	**09**
Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form; Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames		
Unit – IV	Periods	**09**
Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase nduction machine.		
Unit – V	Periods	**09**
Special Machines - Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self controlled operation; Analysis of Switch Reluctance Motors		
	Total Periods	**45**

References

1.	Charles Kingsley,Jr., A.E. Fitzgerald, Stephen D.Umans, ‘Electric Machinery’, Tata Mcgraw Hill, 5th Edition, 1992.
2.	R. Krishnan, ‘Electric Motor & Drives: Modeling, Analysis and Control’, Prentice Hall of India, 2nd Edition, 2001.
3.	Miller, T.J.E., ‘Brushless Permanent Magnet and Reluctance Motor Drives’, Clarendon Press, 1st Edition, 1989

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE17	**Power Quality**	3	0	0	3	**50**	**50**	**100**

Objective

- Understand the various power quality phenomenon, their origin and monitoring and mitigation methods.
- Understand the effects of various power quality phenomenon in various equipment.

Unit – I		Periods	**09**

Electric power quality phenomena - IEC and IEEE definitions - power quality disturbances - voltage fluctuations-transients-unbalance-waveform distortion-power frequency variations

Unit – II		Periods	**09**

Voltage variations - Voltage sags and short interruptions – flicker-longer duration variations - sources – range and impact on sensitive circuits-standards – solutions and mitigations – equipment and techniques

Unit – III		Periods	**09**

Transients – origin and classifications – capacitor switching transient – lightning-load switching – impact on users – protection – mitigation

Unit – IV		Periods	**09**

Harmonics – sources – definitions & standards – impacts - calculation and simulation –harmonic power flow - mitigation and control techniques – filtering – passive and active

Unit – V		Periods	**09**

Power Quality conditioners – shunt and series compensators-DStatcom - Dynamic voltage restorer - unified power quality conditioners - case studies

		Total Periods	**45**

References

1. Heydt, G.T., ‘Electric Power Quality’, Stars in a Circle Publications, Indiana,2nd edition 1996
2. Bollen, M.H.J., ‘Understanding Power Quality Problems: Voltage sags and interruptions’, IEEE Press, New York, 2000.
3. Arrillaga, J, Watson, N.R., Chen, S., ‘Power System Quality Assessment’, Wiley, New York, 2000

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE18	**Microcontroller Applications in Power Converters**	3	0	0	3	**50**	**50**	**100**

Objective	• Study the internal structure and operation of PIC 16F876 microcontroller and 8051 microcontroller; assembly language program for the generation of firing and control signals employing these microcontrollers.		
Unit – I		Periods	**09**
Use of microcontrollers for pulse generation in power converters - Overview of Zero- Crossing Detectors – typical firing/gate-drive circuits –firing / gate pulses for typical single- phase and three-phase power converters - PIC16F876 Micro-controller – device overview – pin diagrams.			
Unit – II		Periods	**09**
PIC16F876 micro-controller memory organization – Special Function Registers - I/O ports – Timers – Capture/ Compare/ PWM modules (CCP).			
Unit – III		Periods	**09**
Analog to Digital Converter module – Instruction set - instruction description – introduction to PIC microcontroller programming – oscillator selection – reset – interrupts – watch dog timer.			
Unit – IV		Periods	**09**
Introduction to MPLAB IDE and PICSTART plus – Device Programming using MPLAB and PICSTART plus – generation of firing / gating pulses for typical power converters.			
Unit – V		Periods	**09**
8051 microcontroller – architecture – addressing modes – I/O ports - instruction sets – simple assembly language programming			
		Total Periods	**45**

References

1.	PIC16F87X Datasheet 28/40 – pin 8 bit CMOS flash Microcontrollers, Microchip technology Inc., 2001. and MPLAB IDE Quick start guide, Microchip technology Inc., 2007.
2.	John B. Peatman, ‘Design with PIC Microcontrollers’, Prentice Hall, 2003
3.	Myke Predko, ‘Programming and customizing the PIC Microcontroller’, Tata McGraw-Hill, 3rd Edition, 2008.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE19	**Computer Relaying And Wide Area Measurement Systems**	3	0	0	3	**50**	**50**	**100**

Objective	• To understand the operating principles of a computer relays and wide area measurement systems. • To Learn about main classification of relay types, wide area measurement systems and their behavior.		
Unit – I		Periods	**09**
Historical background - Expected benefits – computer relay architecture - Analog to digital converters - Anti-aliasing filters - Substation computer hierarchy - Fourier series Exponential fourier series - Sine and cosine fourier series – Phasor			
Unit – II		Periods	**09**
Walsh functions - Fourier transforms - discrete fourier transform - Random processes - Filtering of random processes - Kalman filtering - Digital filters - Windows and windowing, - Linear phase Approximation - filter synthesis – Wavelets - Elements of artificial intelligence			
Unit – III		Periods	**09**
Introduction - Phasor representation of sinusoids - Fourier series and Fourier transform and DFT Phasor representation - Phasor Estimation of Nominal Frequency Signals - Formulas for updating phasors – Non recursive updates – Recursive updates – Frequency Estimation			
Unit – IV		Periods	**09**
A generic PMU - The global positioning system - Hierarchy for phasor measurement systems, - Functional requirements of PMUs and PDCs - Transient Response of Phasor Measurement Units-of instrument transformers, filters, during electromagnetic transients - Transient response during power swings			
Unit – V		Periods	**09**
State Estimation - History, Operator's load flow - weighted least square least square, -Linear weighted least squares - Nonlinear weighted least squares - Static state estimation - State estimation with Phasors measurements - linear state estimation - Adaptive protection - Differential and distance protection of transmission lines – Adaptive protection – Adaptive out-of-step protection			
		Total Periods	**45**

References

1.	A.G. Phadke, J.S. Thorp, 'Computer Relaying for Power Systems', John Wiley and Sons Ltd., ResearchStudies Press Limited,2nd Edition,2009
2.	A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE20	**Advanced DSP Architecture And Programming**	3	0	0	3	**50**	**50**	**100**

Objective	• To analyze the Digital signal processor architecture and its insights for the better usage of the architecture for power applications. • To extensively use the processor for power and control applications.		
Unit – I		Periods	**09**
Introduction to DSP - Example of DSP system A to D signal conversion - DSP Support tools, - code composer studio - compiler, assembler and linker - input and output with the DSK			
Unit – II		Periods	**09**
Introduction TMS321 C6x architecture - functional units - fetch and execute packets - pipe lining – registers - Liner and circular addressing modes			
Unit – III		Periods	**09**
Instruction set assembly directives, liner assembly - ASM statement within C – timers – interrupts - multi channel buffering serial ports - direct memory access - memory consideration - fixed and floating points format - code improvement and constraints - Fast Fourier Transform – Introduction - DIT FFT algorithm with Radix 2 - DIF FFT algorithm with Radix 2 - inverse fast Fourier transform - fast convolution, programming example using C language			
Unit – IV		Periods	**09**
Design of FIR filter - FIR lattice structure - FIR implementation using Fourier series - windows function - programming examples using C language - Real Time IIR Filtering - Design of IIR filter - IIR lattice structure - impulse invariance - bilinear transformation programming examples using C language			
Unit – V		Periods	**09**
Introduction to DSP/BIOS - RTDX using MATLAB provide interface between PC and DSK - RTDX using Lab VIEW - interface between PC and DSK			
		Total Periods	**45**

References

1.	Rulph Chassaing ,'Digital signal processing and applications C6713 and C6416 DSK', Wiely publication
2.	Nasser Kehtarnavaz ,'Real-Time digital signal processing based on the TMS320C6000', ELSEVIER publication
3.	Rulph Chassaing ,'DSP applications using C and theTMS320c6x DSK', Wiely publication.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE21	**Swarm Intelligent Techniques**	3	0	0	3	**50**	**50**	**100**

Objective	• To cater the knowledge of swarm intelligent techniques like genetic algorithm, particle swarm optimization, artificial bee colony algorithms, artificial immune systems, firefly algorithms, cuckoo search algorithms etc. • To extensively use the various swarm intelligent techniques for engineering applications.		
Unit – I		Periods	**09**

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing; Classification of meta-heuristic techniques- single solution based and population based algorithms – exploitation and exploration in population based algorithms; Properties of Swarm intelligent Systems; Application domain-discrete and continuous problems- single objective and multi-objective problems .

Unit – II		Periods	**09**

Evolutionary programs-genetic algorithms, genetic programming and evolutionary programming; Genetic Algorithm versus Conventional Optimization Techniques; Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators; Optimization problems using GA-discrete and continuous- single objective and multi-objective problems; Procedures in evolutionary programming.

Unit – III		Periods	**09**

Biological ant colony system - artificial ants and assumptions; Stigmergic communications; Pheromone updating- local-global; Pheromone evaporation; Pseudo-probabilistic decision making. Travelling salesman problem- ant System-ant quantity- ant density- ant cycle-ant colony system. ACO models-touring ant colony system-max min ant system-concept of elistic ants –continuous and discrete ACO; Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions-PSO topologies-swarm types-control parameters-constriction coefficient; ACO and PSO applications in electrical engineering applications.

Unit – IV		Periods	**09**

Task partitioning in honey bees-balancing foragers and receivers; artificial bee colony (ABC) algorithms-binary ABC and continuous ABC algorithms; Bacterial foraging techniques-taxes-elimination-dispersals-bacteria motility and swarming; Biological immune systems and artificial immune systems-affinity measures-representations; Basic immune models and algorithms-bone marrow models-negative selection algorithms-clonal selection algorithms-somatic hyper mutation-immune network models- applications in electrical

engineering.			
Unit – V		Periods	**09**
Differential search algorithms, harmony Search algorithms, cuckoo search algorithms, firefly algorithms, gravitational search Algorithms, Hybrid swarm intelligent systems; Applications in electrical engineering.			
		Total Periods	**45**

References

1.	Eric Bonabeau, Marco Dorigo and Guy Theraulaz, 'Swarm Intelligence-From natural to Artificial Systems', Oxford university Press, 1999
2.	David Goldberg, 'Genetic Algorithms in Search, Optimization and Machine Learning', Pearson Education, 2007.
3.	James Kennedy and Russel E Eberheart, 'Swarm Intelligence', The Morgan Kaufmann Series in Evolutionary Computation, 2001
4.	Castro, LeandroNunes, Timmis and Jonathan, 'Artificial Immune Systems- A new computational approach', Springer publications, 2002.
5.	N P Padhy, 'Artificial Intelligence and Intelligent Systems', Oxford University Press, 2005.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE22	**Smart Grid Technologies**	3	0	0	3	**50**	**50**	**100**

Objective	- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure. - To get familiarized with the power quality management issues in Smart Grid.		
Unit – I		Periods	**09**
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.			
Unit – II		Periods	**09**
Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control,Fault Detection, Isolation and service restoration, Outage management,High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).			
Unit – III		Periods	**09**
Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits,AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.			
Unit – IV		Periods	**09**
Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.			
Unit – V		Periods	**09**
Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Securityfor Smart Grid.			
		Total Periods	**45**

References

1.	Stuart Borlase ‘SmartGrid: Infrastructure,Technologyand Solutions’,CRC Press 2012.
2.	JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technologyand Applications’,Wiley, 2012.
3.	Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang ‘Smart Grid – The New and Improved Power Grid: A Survey’, IEEETransactionon Smart Grids.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE23	**Electric Systems in Wind Energy**	3	0	0	3	**50**	**50**	**100**

Objective

- To introduce the various electrical generators and appropriate power electronic controllers employed in wind energy systems
- To teach the students the steady-state analysis and operation of different existing configurations of electrical systems in wind energy and also the recent developments taking place in this field.

Unit – I		Periods	**09**
Principle of operation – steady-state analysis-characteristics of GCIGs- operation of GCIGs with different power electronic configurations.			
Unit – II		Periods	**09**
Process of self-excitation – steady-state equivalent circuit of SEIG and its analysis - performance equations - widening the operating speed-range of SEIGs by changing the stator winding connection with suitable solid state switching schemes - power electronic controllers used in standalone systems.			
Unit – III		Periods	**09**
Need for single-phase operation –typical configurations for the single-phase operation of three-phase GCIGs and SEIGs –stead state equivalent circuit and analysis using symmetrical components.			
Unit – IV		Periods	**09**
Different operating modes- steady-state equivalent circuit- performance analysis- DFIG for standalone applications- operation of DFIGs with different power electronic configurations for standalone and grid-connected operation.			
Unit – V		Periods	**09**
Operation of PMSGs- steady-state analysis- performance characteristics- operation of PMSGs with different power electronic configurations for standalone and grid-connected operation.			
		Total Periods	**45**

References

1.	Marcelo Godoy Simões and Felix A. Farret, 'Renewable Energy Systems: Design and Analysis with Induction Generators', CRC Press, ISBN 0849320313, 2004
2.	Ion Boldea, 'Variable speed Generators', CRC Press, ISBN 0849357152, 2006.
3.	S.N. Bhadra, D.Kastha and S.Banerje, 'Wind Electrical Systems', Oxford University Press, 2005.
4.	Siegfried Heier, Rachel Waddington, 'Grid Integration of Wind Energy Conversion Systems, 2nd Edition',Wiley, June 2006, ISBN: 978-0-470-86899-7.
5.	Freries LL , 'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE24	**Embedded Processors and Controllers**	3	0	0	3	**50**	**50**	**100**

Objective	• To enrich the learner with processor and controller design concepts with special concentration on system-on-chip and system-on-programmable chip. • To analyze the design and testing with embedded processors & controllers suited for varied applications.		
Unit – I		Periods	**09**
MSP 430 Microcontroller – Functional block diagram – memory – Interrupts and Resets – Input/ Output units – Instruction set – Addressing modes – Constant generator and Emulated Instructions.			
Unit – II		Periods	**09**
MSP 430 Timers – on-chip data conversion systems – ADC and DAC – on-chip communication peripherals – SPI, I^2C, UART – Programming concepts.			
Unit – III		Periods	**09**
ARM7TDMI – architecture overview - processor modes – data types – Registers – program status registers – Simple programs.			
Unit – IV		Periods	**09**
Introduction to Design of Systems on a chip – Core architectures for Digital media and compilation techniques – Microsystems technology and applications – Hardware/ software co-design concepts.			
Unit – V		Periods	**09**
Multi-core System-on-Chip (McSoC) design – Application specific McSoC design – QueueCore Architecture – Synthesis and evaluation results – Reconfigurable multi-core architectures.			
		Total Periods	**45**

References

1.	John H. Davies, ‘MSP 430 Microcontroller Basics’, Elsevier Ltd., 2008.
2.	William Hohl, ‘ARM Assembly Language, Fundamentals and Techniques’, CRC Press, 2009.
3.	Abderazek Ben Abdallah, ‘Multi-core systems on-Chip: Practical software and Hardware design’, Atlantis press, 2010.
4.	Ricardo Reis, Marcelo Lubaszewski, Jochen A.G. Jess, ‘Design of Systems on a chip: Design andTest’, Springer, 2006.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE25	**Distributed Generation and Micro-grids**	3	0	0	3	**50**	**50**	**100**

Objective

- To understand the planning and operational issues related to Distributed Generation and Micro-grids

Unit – I	Periods	**09**

Need for Distributed generation, 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.

Unit – II	Periods	**09**

Grid integration of DGs – Different types of interfaces - Inverter based DGs and rotating machine based interfaces - Aggregation of multiple DG units. Energy storage elements: Batteries, ultra-capacitors, flywheels.

Unit – III	Periods	**09**

Technical impacts of DGs – Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying – Impact of DGs upon transient and dynamic stabilityof existing distribution systems.

Unit – IV	Periods	**09**

Economic and control aspects of DGs –Market facts, issues and challenges - Limitations of DGs. Voltage control techniques, Reactive power control, Harmonics, Power quality issues. Reliabilityof DG based systems – Steady-state and Dynamic analysis

Unit – V	Periods	**09**

Introduction to micro-grids – Types of micro-grids – autonomous and non-autonomous grids – Sizing of micro-grids- modeling & analysis- Micro-grids with multiple DGs – Micro-grids with power electronic interfacing units. Transients in micro-grids - Protection of micro-grids – Case studies.

	Total Periods	**45**

References

1. H. Lee Willis, Walter G. Scott ,'Distributed Power Generation – Planning and Evaluation', Marcel DeckerPress, 2000.
2. M.Godoy Simoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators',CRC press.
3. Robert Lasseter, Paolo Piagi, ' Micro-grid: A ConceptualSolution', PESC 2004, June 2004.
4. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.
5. Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson 'Facility Microgrids', Subcontract report, May 2005, General ElectricGlobalResearchCenter, Niskayuna, New York.

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE26	**Control Design Techniques for Power Electronic Systems**	3	0	0	3	**50**	**50**	**100**

Objective	• To study the application of modern control theory to power electronic converters and drives. • To study about modern controller design techniques for power converters		
Unit – I		Periods	**09**
Review of basic control theory – control design techniques such as P, PI,PID and lead lag compensator design. Review of state space control design approach – state feedback controller and observer design.			
Unit – II		Periods	**09**
Control of DC-DC converters. State space modeling of Buck, Buck-Boost, Cuk, Sepic, Zeta Converters. Equilibrium analysis and closed loop voltage regulations using state feedback controllers and sliding mode controllers.			
Unit – III		Periods	**09**
Control of rectifiers. State space modeling of single phase and three phase rectifiers. State feedback controllers and observer design for output voltage regulation for nonlinear loads. Analysis of continuous and discontinuous mode of operation.			
Unit – IV		Periods	**09**
Modelling of Brushless DC motors and its speed regulations – State space model, sensorless speed control of BLDC motor and Sliding mode control design for BLDC motor. Modelling and control of switched reluctance motor.			
Unit – V		Periods	**09**
Modeling of multi input DC-DC converters and its application to renewable energy. Output voltage regulation of Multi input DC-DC converter using state feedback controllers.			
		Total Periods	**45**

References

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

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Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE27	**Energy Auditing and Management**	3	0	0	3	**50**	**50**	**100**

Objective	• To emphasize the energy management on various electrical equipments and metering. • To illustrate the energy management in lighting systems and cogeneration		
Unit – I		Periods	**09**
Basics of Energy – Need for energy management – energy accounting- energy monitoring, targeting and reporting-energy audit process			
Unit – II		Periods	**09**
Energy management for electric motors – Transformer and reactors-capacitors and synchronous machines, energy management by cogeneration –forms of cogeneration – feasibilityof cogeneration – electrical interconnection			
Unit – III		Periods	**09**
Energy management in lighting systems – task and the working space - light sources – ballasts – lighting controls – optimizing lighting energy – power factor and effect of harmonics, lighting and energystandards			
Unit – IV		Periods	**09**
Metering for energy management – units of measure - utility meters – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid state meters, metering location vs requirements, metering techniques and practical examples			
Unit – V		Periods	**09**
Economic analysis – economic models- time value of money - utility rate structures – cost of electricity – loss evaluation, load management – demand control techniques – utility monitoring and control system – HVAC and energymanagement – economic justification			
		Total Periods	**45**

References

1.	Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, 'Guide to Energy Management', 5th Edition, The Fairmont Press, Inc., 2006
2.	Amit K. Tyagi, 'Handbook on Energy Audits and Management', The Energy and Resources Institute, 2003
3.	IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.

	VIVEKANANDHA COLLEGE OF ENGINEERING FOR WOMEN (Autonomous Institution, Affiliated to Anna University, Chennai) Elayampalayam, Tiruchengode – 637 205				
Programme	**M.E.**	Programme Code	**202**	Regulation	**2014**
Department	**POWER SYSTEMS ENGINEERING / ELECTRICAL AND ELECTRONICS ENGINEERING**			Semester	-

Course Code	Course Name	Periods Per Week			Credit	Maximum Marks		
		L	T	P	C	CA	ESE	Total
P14PSE28	**Electric and Hybrid Vehicles**	3	0	0	3	**50**	**50**	**100**

Objective	• To introduce the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. • To understand the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc		
Unit – I		Periods	**09**
History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.			
Unit – II		Periods	**09**
Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.			
Unit – III		Periods	**09**
Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.			
Unit – IV		Periods	**09**
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems			
Unit – V		Periods	**09**
Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.			
		Total Periods	**45**

References

1.	Sira -Ramirez, R. Silva Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2006
2.	Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, 'Sliding mode control of switching Power Converters', CRC Press, 2011
3.	Bimal Bose, 'Power electronics and motor drives', Elsevier, 2006