KERALA TECHNOLOGICAL UNIVERSITY

CLUSTER

ERNAKULAM WEST

SCHEME AND SYLLABUS

FOR

M. Tech. DEGREE PROGRAMME

IN

POWER ELECTRONICS AND POWER SYSTEMS

(2015 ADMISSION ONWARDS)

SCHEME AND SYLLABUS FOR M. Tech. DEGREE PROGRAMME IN POWER ELECTRONICS AND POWER SYSTEMS

SEMESTER-1

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06 EE 6015	Advanced Mathematics	4-0-0	40	60	3	4
B	06 EE 6025	Analysis of Power Electronic Systems I	4-0-0	40	60	3	4
C	06 EE 6035	Advanced Power System Analysis	4-0-0	40	60	3	4
D	06 EE 6045	Advanced Power System Stability	3-0-0	40	60	3	3
E	06 EE 6X55	Elective I	3-0-0	40	60	3	3
	06 EE 6065	Research Methodology	0-2-0	100	0	0	2
	06 EE 6075	Seminar I	0-0-2	100	0	0	2
	06 EE 6085	Power System Simulation Laboratory	0-0-3	100	0	0	1

Credits: 23

Elective – I (06 EE 6X55)	
06 EE 6155*	Systems Theory
06 EE 6255	Digital Protection of Power Systems
06 EE 6355**	Digital Simulation of Power Electronic Systems
06 EE 6455	Power System Planning and Reliability

* Common to IDAC/PEPS

** Common to IDAC/PE/PEPS

SEMESTER-II

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06 EE 6016	Analysis of Power Electronic Systems II	4-0-0	40	60	3	4
B	06 EE 6026	Power System Operation and control	3-0-0	40	60	3	3
C	06 EE 6036	Flexible AC Transmission Systems	3-0-0	40	60	3	3
D	06 EE 6X46	Elective II	3-0-0	40	60	3	3
E	06 EE 6X56	Elective III	3-0-0	40	60	3	3
	06 EE 6066	Mini Project	0-0-4	100	0	0	2
	06 EE 6076	Power Electronics Laboratory	0-0-3	100	0	0	1

Credits: 19

Elective – II(06 EE 6X46)		**Elective – III (06 EE 6X56)**	
06 EE 6146*	Power Quality	06 EE 6156	Switch Mode Power Converters
06 EE 6246	Introduction to Electric Drives	06 EE 6256	Computer Application of Power Systems
06 EE 6346	Transient analysis in Power System	06 EE 6356*	Smart Grid Technology and Applications
06 EE 6446*	Robotics and Automation	06 EE 6456	Deregulation in Power System

* Common to IDAC/PE/PEPS

SEMESTER-III

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06 EE 7X15	Elective IV	3-0-0	40	60	3	3
B	06 EE 7X25	Elective V	3-0-0	40	60	3	3
C	06 EE 7035	Seminar II	0-0-2	100	0	0	2
D	06 EE 7045	Project (Phase 1)	0-0-12	50	0	0	6

Credits: 14

Elective – IV (06 EE 7X15)		**Elective – V (06 EE 7X25)**	
06 EE 7115*	Power Electronic Control of Special Electrical Machines	06 EE 7125*	Soft Computing Techniques
06 EE 7215*	Power Electronics for Renewable Energy Systems	06 EE 7225*	Distributed Generation and Control
06 EE 7315*	Embedded Controllers	06 EE 7325*	High voltage DC transmission
06 EE 7415	Renewable Energy Systems	06 EE 7425	Energy Auditing, Conservation and Management

* Common to IDAC/PE/PEPS

SEMESTER-IV

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06 EE 7016	Project (Phase 2)	0-0-21	70	30		12

Credits: 12

Total Credits for all semesters: 68

L – Lecture T-Tutorial P-Practical

SEMESTER -I

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6 01 5	ADVANCED MATHEMATICS	4-0-0: 4	2015

PRE – REQUISITES:

1. Basics of Complex analysis
2. Single variable calculus
3. Vector methods.

COURSE OBJECTIVES:

To give an understanding of (1) complex transformations (2) various types of optimization methods (3) some properties of probability distributions which are essential for the core specialization.

SYLLABUS:

Analytic functions, Transformations, Probability distributions, Markov Process, Correlation, Linear programming, Optimization methods.

COURSE OUTCOME:

Takers will know the Mathematical tools required to understand the core courses they have to undergo for their graduate programme.

TEXT BOOKS &REFERENCES

1. Ahlfors, Complex Analysis, McGraw Hill
2. Peter Henrici, Applied & Computational Complex Analysis, John Wiley
3. A Papoulis, Probability, Random variables and Stochastic Processes, McGraw Hill.
4. S.S. Rao, Optimization theory and Applications, Wiley Eastern.

COURSE PLAN			
MODULE	COURSE NO:**06 EE 6015**	**L – T – P : 4 – 0 – 0**	
	COURSE NAME:**ADVANCED MATHEMATICS**	**CREDITS : 4**	
	CONTENTS	**Contact hrs**	**End Sem Marks %**
I	Analytic functions, Cauchy Riemann equations, Complex integration, Liovilli's theorem, Poisson's integral formula, Conformal mapping, Schwarz – Christoffels transformation	**10**	**25%**
II	Density functions, Markov chain, Markov process	**6**	**25%**
FIRST INTERNAL EXAM			
II	Correlation, Auto correlation, cross correlations	**6**	
III	Linear programming, Simplex method, Big M method, Integer programming, Gomory's cutting plane method.	**12**	**25%**
SECOND INTERNAL EXAM			
IV	Optimization: search methods, Hooke – Jeeves method, Conjugate direction method, Steepest descent method, Interpolation method (quadratic), Lagrange multiplier, Kuhn tucker conditions.	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6025	ANALYSIS OF POWER ELECTRONIC SYSTEMS I	4-0-0: 4	2015

PRE – REQUISITES:

1. Electric circuit theory
2. Network Analysis

COURSE OBJECTIVES:

To provide an in depth knowledge about the operation and analysis of power converter circuits.

SYLLABUS

Overview of Power Semiconductor Devices, Analysis of rectifier circuits, Operation and analysis of DC Choppers, Operation and analysis of AC voltage controllers and Cycloconverters, Analysis and control strategies of single phase and three phase inverters , Multilevel Inverters

COURSE OUTCOME:

The students will be able to

1. Acquire knowledge about the concepts and techniques used in power electronics circuits
2. Design and analyze various power converter circuits.

TEXTBOOKS:

1. K.R.Varmah, Chikku Abraham, Power Electronics, 1st edition, Elsevier, 2014
2. Ned Mohan, Undeland, Robbins, Power Electronics,3rd edition, John Wiley, 2003

REFERNCES:

1. Daniel W. Hart, Power Electronics, McGrawHill, 2011
2. Muhammad H Rashid, Power Electronics, 3rd edition, Pearson,2007
3. Joseph Vithayathil, Principles of Power Electronics, McGrawHill-1994

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6025**	**L – T – P : 4 – 0 – 0**	
	COURSE NAME:**ANALYSIS OF POWER ELECTRONIC SYSTEMS I**	**CREDITS : 4**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	**Overview of Power Semiconductor Devices:** Ideal and Real switches - static and dynamic performance, loss calculation and selection of heat sink. Power diode, Thyristor, Power BJT, Power MOSFET, IGBT - Static and Dynamic Performance, Driver circuits, Turn ON, Turn OFF and Over Voltage Snubbers for switching devices. **Rectifiers:** Line current Distortion, THD, DPF, PF, Form factor, Ripple factor, Crest factor, active, reactive, apparent and distortion power. Effect of Single Phase Rectifiers on Neutral Currents in a Three Phase Four wire System. Controlled Rectifiers-Single phase and three phase- Half wave fully controlled and semi controlled - Analysis with R, RL, RLE loads, RL and RLE loads with Freewheeling Diode- Effect of source inductance – Inversion mode of operation.Dual converters- Circulating and Non circulating modes - Applications.	**15**	**25%**
FIRST INTERNAL EXAM			
	DC Choppers Principle of operation, analysis of single quadrant		

II	chopper, two and four quadrant choppers, PWM control, Forced commutation-Voltage and Current commutated choppers –multiphase chopper.	**13**	**25%**
III	**AC voltage controllers and Cycloconverters** Single Phase and Three phase AC Voltage Controllers-Principle of operation-analysis with R and RL loads, Thyristor Controlled Inductor.**Cycloconveters:** Circulating and Non circulating types - Analysis with R and RL loads.	**13**	**25%**
SECOND INTERNAL EXAM			
IV	Single phase half bridge and full bridge inverters - Analysis with R and RL loads.Three phase inverters - 120 and 180 degree conduction mode -Analysis with star connected R load, Voltage control in inverters-Sine triangle modulation- Unipolar and Bipolar modulation, Reduction of Harmonics in inverters.Current source inverter-Single phase and Three phase, Resonant inverters-series and parallel, Multilevel Inverters-Type	**15**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6035	ADVANCED POWER SYSTEM ANALYSIS	4-0-0: 4	2015

PRE – REQUISITES:

A basic knowledge on the subjects Power System Analysis, Network Analysis and AC machines.

COURSE OBJECTIVES:

1. Modelling of power system components and to perform load flow studies.
2. To provide a knowledge in the analysis of larger power systems under balanced and unbalanced condition.
3. To understand the techniques of estimating power system states.

SYLLABUS

Network modelling – Load Flow Studies – Three-phase Load Flow –AC DC Load Flow – Fault Analysis using Z_{bus} – Power System State Estimation

COURSE OUTCOME:

The students will be able to

1. Model the power system components for system analysis.
2. Investigate the state of a large scale power system and analyze the practical system under steady state and fault conditions.
3. Estimate the state of power system for different operating conditions.

TEXTBOOKS:

1. Arrillaga, J and Arnold, C.P. “Computer analysis of power systems” John Wiley and Sons, New York, 1997
2. Grainger, J.J. and Stevenson, W.D. “ Power System Analysis” - McGraw Hill, New Delhi, 2003

REFERNCES:

1. Pai, M.A, “Computer Techniques in Power System Analysis”, Tata McGraw hill, New Delhi, 2006.
2. Allen J Wood, Bruce F Wollenberg, “Power Generation, Operation and Control”, John Wiley& Sons, New York, II Edition, 1984.
3. G.L.Kusic, “Computer Aided Power System Analysis”, Prentice Hall, 1986.

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6035**	**L – T – P : 4 – 0 – 0**	
	COURSE NAME:**ADVANCED POWER SYSTEM ANALYSIS**	**CREDITS : 4**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	**Load Flow Studies:**Network modeling – Transformer modeling– Conditioning of Y Matrix – Newton Raphson Load Flow – Decoupled Newton Load Flow– Fast decoupled Load Flow –Three-phase load flow – Formulation of three phase load flow problem – Fast Decoupled three phase algorithm – DC power flow.	**16**	**25%**
II	**AC DC Load Flow:** Single phase and Three phase AC-DC load flow – Formulation of Load Flow Problem – Fast Decoupled Solution – DC system model – Sequential Solution Techniques –Multiple and/or Multi-terminal DC systems – DC convergence tolerance	**8**	
FIRST INTERNAL EXAM			
II	**Optimal load flow:** Optimal load flow in power systems – Formulation of optimal power flow solution by Gradient method, Newton's method.	**4**	**25%**
III	**Fault Analysis:** Fault Studies – Analysis of balanced and unbalanced three phase faults $-Z_{bus}$ building algorithm – Short circuit and open circuit faults calculations using Z bus.	**16**	**25%**
SECOND INTERNAL EXAM			
	State Estimation: State Estimation –Method of Weighted Least Squares – Test for bad data – Structure		

IV	and formation of H_x matrix – Power System state estimation – Line Power flow state estimator-State estimation by orthogonal decomposition – Network observability and pseudo measurements.	**12**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6045	ADVANCED POWER SYSTEM STABILITY	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of power systems.
2. Steady-state operation principles of electrical machines

COURSE OBJECTIVES:

1. Identify the various conditions under which different stability issues occur.
2. Derive and apply mathematical model of power system components for stability studies.
3. Analyze transient stability problems and describe means to protect the system against transient stability problems
4. Analyze small-signal stability problems by applying small-signal analysis

SYLLABUS

Power system stability and modelling of components; Types of stability; Classical model of SMIB; Modelling of power system components; Synchronous Machine; Excitation system and Types; Modelling of prime movers ;Hydraulic and steam turbines; Small signal stability; Fundamental Concepts of Stability of Dynamic Systems; State-space representation; Effects of synchronous machine field circuit dynamics; effects of excitation system;Transient stability;swing equation-equal area criterion; Direct method of transient stability analysis; transient energy function approach; Methods to improve transient stability.

COURSE OUTCOME:

The students will be able to

1. Define and differentiate different power system stability issues
2. Derive the mathematical model of power system components for power system stability studies
3. To understand transient stability of power system and to identify the methods to

improve transient stability of a system

4. To understand small signal stability of power system and to analyze the same for a system.

TEXTBOOKS:

1. Kundur P, 'Power System Stability and Control', TMH.
2. Anderson and Fourd , 'Power System Control and Stability" , John Wiley, second edition

REFERENCES:

1) Nagrath, Kothari , 'Modern power system analysis', TMH
2) KR Padiyar, 'Power System Dynamics', 2nd Edition, B.S. Publishers.
3) E W Kimbark, 'Power System Stability', Wiley & IEEE Press

COURSE PLAN			
MODULE	COURSE NO:**06 EE 6045**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **ADVANCED POWER SYSTEM STABILITY**	**CREDITS : 3**	
	CONTENTS	**Contact hrs**	**End Sem Marks %**
I	**Power system stability and modelling of components**: Power System Stability: Concept of Power system stability-Types of stability, Classical model of single machine connected to infinite bus system Modelling of power system components: Synchronous Machine - Mathematical Description of a Synchronous Machine - Basic equations of a synchronous machine - dq0 Transformation- per unit representation- equivalent circuits for direct and quadrature axes. Modelling of Excitation system: Types of excitation system- IEEE (1992) Type DC1A, AC1A and ST1A models. Modelling of prime movers – Hydraulic turbine transfer function, modelling of steam turbine.	**12**	**25%**
II	**Small signal stability**: Fundamental Concepts of Stability of Dynamic Systems: State-space representation- stability of dynamic system - Linearization, Eigen properties of the state matrix.	**6**	**25%**
FIRST INTERNAL EXAM			
II	**Small signal stability**: Small Signal Stability of Single Machine Infinite Bus (SMIB) System: Generator represented by the classical model -Effects of synchronous machine field circuit dynamics- effects of excitation system.	**5**	
	Transient stability: Transient stability-swing equation-		

III	equal area criterion, numerical solution of swing equation- Euler method, Runge-Kutta method, critical clearing time and angle – effect of clearing time on stability. Direct method of transient stability analysis - transient energy function approach.	**11**	**25%**
SECOND INTERNAL EXAM			
IV	**Methods of improving stability**: **Transient stability enhancement:** High speed fault clearing, Reduction of transmission system reactance, regulated shunt compensation, dynamic braking, steam turbine fast valving, generator tripping, controlled system separation and load shedding, high speed excitation systems.	**8**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6155	SYSTEMS THEORY	3-0-0: 3	2015

PRE – REQUISITES:

1. Matrix Operations
2. Linear Algebra
3. Ordinary Differential Equations

COURSE OBJECTIVES:

The course intends to provide knowledge in

1. the analysis of continuous time and discrete time linear systems
2. Lyapunov stability techniques.

SYLLABUS

A Primer to State Representations and Solution – Modeling of Power Electronic Converters – Analysis of Continuous time systems – Design of Continuous and Discrete Time Systems – Lyapunov Stability Techniques.

COURSE OUTCOME:

A student who completes the course will

1. Be able to do the analysis and design of continuous time and discrete time linear systems.
2. Have an in depth knowledge of Lyapunov stability techniques.

TEXTBOOKS:

1. C.T.Chen, Linear system theory and design, New York,Holt Rinechart and Winston , 1984

2. M.Gopal, Digital Control and State Variable methods, TMH, 1997

REFERNCES:

1. Thomas Kailath, Linear systems, Prentice Hall Inc

2. K.Ogata, Modern control Engg (Second Edition), Prentice Hall Inc, 1990

3. Richard.C.Dorf and R.T Bishop, Modern Control System, P.H.I

COURSE PLAN			
MODULE	COURSE NO:**06 EE 6155**	**L-T-P: 3-0-0**	
	COURSE NAME: **SYSTEMS THEORY**	**CREDITS : 3**	
	CONTENTS	**Contact Hrs**	**End Sem Marks %**
I	**A Primer to State Representations and Solution:** Concept of state, state variable, state space, state trajectory – Significance of eigen values and eigen vector – State Variable Representations – Diagonalization – Similarity transformations – State variable representation of discrete time systems – Discretization of continuous time systems – Solution of homogeneous and non homogeneous state equation.	**10**	**25%**
II	**Modeling of Power Electronic Converters:** State variable modeling of buck converter, boost converter.	**5**	**25%**
FIRST INTERNAL EXAM			
II	**Analysis of Continuous Time Systems:** Controllability and Observability for continous time systems. Kalman and Gilbert test for controllability and observability.	**5**	
III	**Design of Continuous and Discrete Time Systems:** Pole placement by state feedback – Design of state observers – Full order observer and reduced order observer.	**10**	**25%**
SECOND INTERNAL EXAM			
IV	**Lyapunov Stability Techniques:** Stability in the sense of Lyapunov – Concept of Asymptotic Stability and Exponential Stability – Local Stability and Global Stability – Lyapunov's indirect method (linearization method) – Lyapunov's direct method (second method) – Lyapunov's stability analysis of LTI continuous time and discrete time systems – Lyapunov's stability	**12**	**25%**

	analysis of non linear system – Krasovski method.		
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6255	DIGITAL PROTECTION OF POWER SYSTEMS	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of Electric & Magnetic Circuits
2. Knowledge about Electric Power Transmission System

COURSE OBJECTIVES:

To provide an in depth knowledge about Power System Protection And Relaying

SYLLABUS

The Philosophy of Protective Relaying, Fundamental Relay-Operating Principles and

Characteristics, Reactance relay, Impedance relay, Distance relay, Numerical relays, Hardware and software for the measurement for numerical relays, Differential Relays, Wire-Pilot Relays.

COURSE OUTCOME:

The students will be able to

1. Explain the basic structure of a relay
2. Explain the working of different types of relays.
3. Implement different algorithms used in numerical relays.
4. Describe the importance of SCADA in power systems.

TEXTBOOKS:

1. The Art and Science of Protective Relaying, Mason, C.R, Wiley**,** 1964
2. Y.G.Paithankar , S.R.Bhide, " Fundamentals of Power System Protection", Prentice – Hall India, 2004
3. Badri Ram and DN Vishwakarma, "Power system protection and Switchgear", Tata McGraw Hill, NewDelhi, 2003.

REFERENCES:

4. T.S.M.Rao, "Digital / Numerical Relays", Tata McGraw Hill,2005
5. Y.G.Paithankar , S.R.Bhide, " Fundamentals of Power System Protection", Prentice – Hall India, 2004

<table>
<tr><td colspan="4">COURSE PLAN</td></tr>
<tr><td rowspan="3">MODULE</td><td>COURSE NO:06 EE 6255</td><td colspan="2">L – T – P : 3 – 0 – 0</td></tr>
<tr><td>COURSE NAME: DIGITAL PROTECTION OF POWER SYSTEMS</td><td colspan="2">CREDITS : 3</td></tr>
<tr><td>CONTENTS</td><td>Contact hrs</td><td>End Sem Marks %</td></tr>
<tr><td>I</td><td>General philosophy of protection – Characteristic functions of protective relays – basic relay elements and relay terminology – Classification of Relays – Construction and operation of Electromagnetic relays – A review of conventional protection schemes for Transmission lines and station apparatus (Qualitative treatment only).</td><td>10</td><td>25%</td></tr>
<tr><td>II</td><td>Static relays – Solid state devices used in static protection – Amplitude comparator and phase comparator – Static Overcurrent relays: Non-directional, Directional - Synthesis of Mho relay,</td><td>6</td><td rowspan="3">25%</td></tr>
<tr><td colspan="2">FIRST INTERNAL EXAM</td></tr>
<tr><td>II</td><td>Reactance relay, Impedance relay and Quadrilateral Distance relay using Static comparators, Differential relay.(Qualitative treatment only).</td><td>5</td></tr>
<tr><td>III</td><td>Hardware and software for the measurement of voltage, current, frequency, phase angle – Microprocessor implementation of over current relays – Inverse time characteristics – Directional relay – Impedance relay– Mho relay, Differential relay – Numerical relay algorithms</td><td>10</td><td rowspan="2">25%</td></tr>
<tr><td colspan="2">SECOND INTERNAL EXAM</td></tr>
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IV	Pilot relay protection: Wire pilot relaying, Carrier current pilot relaying, Microwave pilot relaying – Fibre-optic based relaying – Apparatus Protection: Digital protection of generators, Digital protection of Transformers – Protection of Long and short lines – Protection based on Artificial Intelligence – SCADA: Architecture, Use of SCADA in interconnected power systems.(Qualitative treatment only)	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6355	DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS	3-0-0: 3	2015

PRE – REQUISITES:

1. Power Electronics
2. Electric Drives
3. Knowledge in MATLAB software

COURSE OBJECTIVES:

To provide an in depth knowledge about modelling of Power Electronic Circuits and to analyze the behaviour and performance of Power Electronic circuits

SYLLABUS

Application of numerical methods to solve transients in D.C; Extension to AC circuits; Modelling of Power semiconductor switches using simulation; Introduction to electrical machine modelling; Simulation of basic electric drives; stability aspects; Dynamic modelling and simulation of DC-DC converters using MATLAB; Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers; Simulation of power factor correction schemes; Simulation of converter fed dc motor drives ; Simulation of thyristor choppers; Simulation of single and three phase inverters with thyristors and self-commutated devices.

COURSE OUTCOME:

The students will be able to

1. Model Power Electronic Circuits.
2. Analyze the behavior of Power Electronic Circuits.

TEXTBOOKS:

1. Power Electronics Devices, Circuits and Applications: Muhammed H Rashid
2. Simulink Reference Manual, Math works, USA

REFERNCES:

1. Robert Ericson, 'Fundamentals of Power Electronics', Chapman & Hall, 1997.

2. Issa Batarseh, 'Power Electronic Circuits', John Wiley, 2004Simulink Reference Manual, Math works, USA.

3. Jai P. Agrawal, Power Electronic Systems-Theory and Design, Pearson- 2001

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6355**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS**	**CREDITS : 3**	
	CONTENTS	**Contact hrs**	**End Sem Marks %**
I	**Review of numerical methods**. Application of numerical methods to solve transients in D.C.Switched R, L, R-L, R-C and R-L-C circuits. Extension to AC circuits. Modelling of diode in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Modelling of SCR, TRIAC, IGBT and Power Transistors in simulation. Simulation of gate/base drivecircuits, simulation of snubber circuits.	**10**	**25%**
II	**State space modelling and simulation of linear systems**. Introduction to electrical machinemodelling: induction, DC, and synchronous machines.	**5**	**25%**
FIRST INTERNAL EXAM			
II	Simulation of basic electric drives,stability aspects. Dynamic modelling and simulation of DC-DC converters using MATLAB	**5**	
III	Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers, converters with self commutated devices- simulation of power factor correction schemes, Simulation of converter fed dc motor drives ,Simulation of thyristor choppers with voltage, current and load commutation schemes, Simulation of chopper fed dc motor.	**10**	**25%**
SECOND INTERNAL EXAM			
	Modelling and simulation of inverters using MATLAB. Simulation of single and three phase inverters with thyristors and self-commutated devices, Space vector		

IV	representation, pulse-width modulation methods for voltage control, waveform control. Simulation of inverter fed induction motor drives.	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6455	POWER SYSTEM PLANNING AND RELIABILITY	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of power generation system.
2. Knowledge in power system analysis.

COURSE OBJECTIVES:

To impart knowledge in forecasting, planning the transmission and distribution system.

SYLLABUS

Long and short term load forecasting, Energy forecasting, generation planning and reliability, Planning and expansion of transmission system, Planning and expansion of distribution system.

COURSE OUTCOME:

The students will be able to

1. Forecast the long and short term demand,
2. Learn generation planning and reliability.
3. Plan the transmission system.
4. Plan the distribution system.

TEXTBOOKS:

1. R.L .Sullivan, “Power System Planning”,. McGraw Hill New York
2. Roy Billington and Ronald .N. Allan: “Reliability evaluation of power systems”, Plenum Press 1984

REFERNCES:

1. TuranGonen, “Electric power distribution system engineering”, McGraw Hill, 1986.
2. Roy Billinton and Allan Ronald, “Power System Reliability”.

3. Generation of Electrical Energy – B.R. Gupta, S.Chand Publications

4. Modern Power System Planning – X. Wang & J.R. McDonald, McGraw Hill Book Company.

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6455**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **POWER SYSTEM PLANNING AND RELIABILITY**	**CREDITS : 3**	
	CONTENT	**Contact Hrs**	**End Sem Marks %**
I	Objectives of planning–Long and short term planning, Load forecasting –characteristics of loads –methodology of forecasting –energy forecasting –peak demand forecasting –total forecasting –annual and monthly peak demand forecasting.	**11**	**25%**
II	Objectives & Factors affecting Generation Planning,Generation Sources, Integrated Resource Planning, Generation System Model, Loss ofLoad (Calculation and Approaches), Outage Rate	**5**	**25%**
FIRST INTERNAL EXAM			
II	Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System,Factors Affecting Interconnection under Emergency Assistance.	**5**	
III	Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.	**11**	**25%**
SECOND INTERNAL EXAM			
IV	Introduction to distribution system planning, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6065	RESEARCH METHODOLOGY	0-2-0: 2	2015

COURSE OBJECTIVES:

- To develop understanding of the basic framework of research process and research design
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting research.
- Appreciate the components of scholarly writing and evaluate its quality.

SYLLABUS

Introduction to Research Methodology; Type of research; Stages of Research process; Research Formulation; Literature review; Research design and methods; Data Collection; Data Processing and Analysis strategies; Meaning of interpretation and inference; Presentation of reports; Ethics in research, Plagiarism.

COURSE OUTCOME:

1. It prepares students for scientific research and development of thesis.
2. Helps the students to understand research practice and research cycle in general through critical examination of methods associated with decision making, critical thinking, and ethical judgment.

TEXTBOOKS:

1. C. R. Kothari, Research Methodology, Methods and techniques (New Age International Publishers, New Delhi, 2004).
2. R. Panneerselvam, Research Methodology (Prentice Hall of India, New Delhi, 2011).
3. Ranjit Kumar, Research Methodology, A step by step approach (Pearson Publishers, New Delhi, 2005.

REFERNCES:

1. Management Research Methodology : K. N. Krishnaswami, Appa Iyer and M Mathirajan, Pearson Education, Delhi, 2010
2. Hand Book of Research Methodology : M N Borse, Sree Nivas Publications, Jaipur, 2004
3. Business Research Methods: William G Zikmund, South – Western Ltd, 2003
4. Research Methods in Social Science: P K Majumdar, Viva Books Pvt Ltd, New Delhi, 2005
5. Analyzing Quantitative Data: Norman Blaikie, SAGE Publications , London, 2003

COURSE PLAN			
MODULE	COURSE NO:**06 EE 6065**	**L – T – P : 0 – 2 – 0**	
	COURSE NAME: **RESEARCH METHODOLOGY**	**CREDITS : 2**	
	CONTENT	**Contact Hrs**	**End Sem Marks %**
I	**Introduction to Research Methodology** - Objectives and Motivation towards research- Criteria for good research - Research methods *vs.* Methodology- Type of research: Descriptive *vs.* Analytical, Applied *vs.* Fundamental, Quantitative *vs.* Qualitative, and Conceptual *vs.* Empirical,Stages of Research process .	**5**	**25%**
II	**Research Formulation** - Defining and formulating the research problem -Selecting the problem - Importance of literature review in defining a problem. Literature review:Primary and secondary sources.	**3**	**25%**
FIRST INTERNAL EXAM			
II	**Research design and methods:** Research design - Basic Principles- Need for research design -Exploration, Description, Diagnosis, Experimentation and sample designs.	**3**	
III	**Data Collection and analysis**: Execution of the research - Observation and Collection of data - Methods of data collection – Questionnaire and schedule for field surveys, interview, observation, simulation, experimental and case study methods. Collection, recording, editing, coding and scaling of data. Measurement of validity and reliability.Sampling Methods:probability and non-probability sampling.**Data Processing and Analysis strategies:**Descriptive and inferential statistics - Hypothesis Testing, Test for correlation and regression – standard error of the estimate.	**10**	**25%**

SECOND INTERNAL EXAM			
IV	**Meaning of interpretation and inference:** importance and care for interpreting results. **Presentation of reports:** popular reports and technical reports - structure and style. Oral and written presentations: Parts of a research report. Guidelines for writing research papers and reports – Writing different sections of a research paper – Introduction, Methodology, Results, Discussion, Conclusion, Abstract – Writing the title. Methods of giving references and appendices: referencing styles. Use of LaTeX in report writing. Ethics in research, Plagiarism.Sample studies and survey on the recent research activities in the area of Power Electronics and Power system.	**6**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6075	SEMINAR I	0-0-2: 2	2015

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

To improve presentation skills and searching ability of research publications in the relevant area of specialization

SYLLABUS:

The student has to register for the seminar and select a topic in consultation with any of the faculty members in the department (or the faculty member offering courses for the programme). A detailed report on the topic of seminar is to be prepared in the prescribed format given by the department. The seminar shall be of 30 minutes duration and a committee with the Head of the Department as the chairman and two faculty members from the department as members shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee.

COURSE OUTCOME:

Takers will

(1) improve the searching ability to find research publications in the area of specialization
(2) be aware of recent developments in the area of specialization
(3) improve their presentation skills

Reference:

IEEE Xplore , Elsevier- Science Direct, Springer Journals etc

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6085	POWER SYSTEM SIMULATION LABORATORY	0-0-3: 1	2015

PRE – REQUISITES:

1.Basic knowledge on subject Power System Analysis

2. Basics of MATLAB software.

COURSE OBJECTIVES:

1. To train students in using the application software's like MATLAB, PSCAD, MiPower / ETAP
2. To educate students to develop programs and models for analysing Power System using software packages.

SYLLABUS:

Simulation / Program Experiments using MATLAB- Simulation experiments using PSCAD Simulation experiments using MiPower/ETAP

COURSE OUTCOME:

The students will be able to

1. Perform steady state and dynamic analysis of power system.
2. Analyze fault in the power system
3. Develop programs to study power system problems

REFERENCES:

1. Power System Analysis – Hadi Saadat - McGraw Hill, 1999.

COURSE PLAN		
COURSE NO: **06 EE 6085**	**L – T – P : 0-0-3**	
COURSE NAME: **POWER SYSTEM SIMULATION LABORATORY**	**CREDITS : 1**	
LIST OF EXPERIMENTS	**Contact hrs**	**End Sem Marks %**
1. Formation of Bus Admittance Matrix and Bus Impedance Matrix using MATLAB. 2. Formation of Jacobian for s system not exceeding 4 buses (no PV buses) in polar co-ordinates using MATLAB. 3. Sequence Components of Power System Network with Single Line to Ground Fault using MATLAB SIMULINK. 4. Modeling of Single machine Power System using SIMULINK. 5. Short circuit studies of power system using ETAP/PSCAD/MiPower. 6. Load flow analysis using Gauss Seidel Method, Newton Raphson Method, Fast De-coupled for both PQ and PV Buses using ETAP/PSCAD/MiPower. 7. DC Load flow analysis using SIMULINK. 8. Simulation and analysis of magnetic circuits using SIMULINK. 9. Simulation and measurements of Three Phase circuits using SIMULINK. 10. Modeling of Automatic Generation Control for a two area network using SIMULINK. 11. To Determine 1) Swing curve 2) Critical clearing time for a single machine connected to infinite bus through a pair of identical transmission lines, three phase fault on one of the lines for variation of inertia constant/line parameters/fault locations/ clearing time/pre fault electrical output using MATLAB/C-Program <u>Optional Experiments</u> 1. Analysis of Static Var Compensators. 2. Analysis of STATCOM. 3. Load forecasting using ETAP/MiPower 4. Power Quality studies using PSCAD.	**30**	**100 %**

5. Transient Stability Analysis and formation of Swing Curves using MATLAB/SIMULINK. 6. Modeling of Surge Arresters using PSCAD. 7. Modeling of FACTS devices using SIMULINK. 8. Transformer Tests using SIMULINK/ETAP. 9. Fault Analysis of synchronous Generator using PSCAD. 10. Execute optimal power flow problem using ETAP/PSCAD/MiPower. 11. Analysis of voltage stability of a SLIB (Single Load Infinite Bus) system while delivering maximum power using MATLAB.		
Additionalexperiments can also be given by the department.		
END SEMESTER – EXAM		

SEMESTER -II

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6016	ANALYSIS OF POWER ELECTRONIC SYSTEMS II	4-0-0: 4	2015

PRE – REQUISITES:

1. Fundamental concepts of power electronic circuits
2. Characteristics of power semiconductor devices
3. Electric circuit theory & Network Analysis

COURSE OBJECTIVES:

To provide an in depth knowledge about the operation and analysis of modern power converter circuits.

SYLLABUS

Pulse width modulation (PWM) strategies for Inverters, DC-DC Switch Mode Converters , SMPS topologies, Resonant Converters, PWM Rectifiers and Matrix Converters

COURSE OUTCOME:

The students will be able to

1.Acquire knowledge about the PWM techniques used in inverter circuits

2.Design and analyze modern power converter circuits

TEXTBOOKS:

1. Daniel W. Hart, Power Electronics, McGrawHill, 2011
2. Ned Mohan, Undeland, Robbins, Power Electronics,3rd edition, John Wiley, 2003
3. D. Grahame Holmes, Thomas A Lipo, Pulse Width Modulation for Power converters-Principles and Practice, John Wiley and sons,2003.

REFERNCES:

1. K.R.Varmah, Chikku Abraham, Power Electronics, 1st edition, Elsevier, 2014
2. B K Bose, Modern Power Electronics and AC Drives, Pearson Education, 2002.
3. William Shepherd, Li Zhang, Power Converter Circuits, Marcel Decker, 2004

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6016**	**L – T – P : 4 – 0 – 0**	
	COURSE NAME: **ANALYSIS OF POWER ELECTRONIC SYSTEMS II**	**CREDITS : 4**	
	CONTENT	**Contacthrs**	**End Sem Marks %**
I	**PWM Strategies for Inverters:** Modulation of one inverter phase leg- Fundamental concepts of PWM- Naturally sampled PWM-Regular sampled PWM. Modulation of single and three phase voltage source inverters-introduction only, Space Vector Modulation- comparison of SVM and regular sampled PWM, Overmodulation of an Inverter- Naturally sampled overmodulation of one leg of an inverter. Space vector PWM for multilevel inverters.	**14**	**25%**
II	**DC-DC Switch Mode Converters:** **DC-DC converters**- Buck, Boost, Buck-Boost and Cuk converters, State space modeling of DC-DC converters.	**5**	**25%**
FIRST INTERNAL EXAM			
II	**SMPS Topologies**- Transformer models- Basic Operation-Waveforms-modes of operation – Output voltage ripple, Push-Pull and Forward Converter Topologies-Basic operation-Waveforms-Voltage Mode Control. Half and Full Bridge Converters - Basic Operation and Waveforms, Fly back Converter, Continuous and Discontinuous mode operation, Waveforms.	**9**	
III	**Module 3:Resonant Converters** Classification of Resonant Converters, Basic Resonant		

	Circuit Concepts, Load Resonant Converter, Resonant Switch Converter, Zero Voltage Switching - Zero current switching – ZVS Clamped Voltage Topologies, Resonant dc-link inverters	**14**	**25%**
SECOND INTERNAL EXAM			
IV	**PWM Rectifiers and Matrix Converters:** Single phase and three phase PWM Rectifiers - Basic topologies - Control principles. Introduction to Matrix Converters-Matrix converter switches and circuit- control strategies-Venturini control method.	**14**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6026	POWER SYSTEM OPERATION AND CONTROL	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of power system analysis
2. Knowledge in power system structuring

COURSE OBJECTIVES:

To acquaint electric power engineering students with power generation system, their operation in an economic mode, and their control.

SYLLABUS

Economic dispatch and unit commitment, Hydro-thermal coordination, Probabilistic cost programming and power system operating states, Modelling of AGC and Computer Aided Power System

COURSE OUTCOME:

The students will be able to

1. Solve economic and unit commitment problems.
2. Schedule hydro thermal plants
3. Perform cost calculation methods
4. Modelling AGC and know basics of computer aided power system

TEXTBOOKS:

1. Allen J Wood, Bruce F Wollenberg, “Power Generation, Operation and Control”, John Wiley& Sons, New York, II Edition, 1984
2. Kundur P, “Power System Stability and Control”, McGraw Hill, 2006.

REFERNCES:

1. Mahalanabis AK, Kothari DP and Ahson SI, “Computer Aided Power System Analysis and Control”, McGraw Hill Publishing Ltd., 1984.

2. Krichmayer L, “Economic operation of power system”, John Wiley & Sons, New York, II Edition, 1959

3. Prof. P. S. R. Murty **“**Operation and Control in Power Systems” BS Publication.

	COURSE PLAN		
MODULE	COURSE NO: **06 EE 6026**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **POWER SYSTEM OPERATION AND CONTROL**	**CREDITS : 3**	
	CONTENT	**Contact Hrs**	**End Sem Marks %**
I	Economic Dispatch Problems-Thermal System Dispatching With Network Losses Considered – Equal Incremental Method – The Lambda-Iteration Method – Linear Cost Function Method – Base And Participation Factor – Constraints In Unit Commitment – Unit Commitment Solutions Using Priority List Scheme Dynamic Programming, Forward DP Approach,Lagrangian Relaxation Method	**11**	**25%**
II	Characteristics of Thermal and Hydro Generating Stations, Scheduling Methods – Maximum Hydro Efficiency Method, Problem Definition and Mathematical Model of Hydro Thermal Scheduling	**5**	**25%**
FIRST INTERNAL EXAM			
II	Pumped Storage Hydro Scheduling – Solution of Hydro Thermal Scheduling Using Dynamic and Linear Programming – Hydraulically Coupled System – Cogeneration Plant.	**5**	
III	Uses And Types of Production Cost Program – Production Cost Using Load Duration Curve, Probabilistic Production Cost Programs-Sample Calculation – No Forced Outage – Forced Outage Included – Interchange of Power And Energy – System Operating States by Security Control Functions – Monitoring, Evaluation of System State by Contingency Analysis – Corrective Controls (Preventive, Emergency And Restorative)	**11**	**25%**

SECOND INTERNAL EXAM			
IV	Generation Control – Generator Model, Load Model, Prime Mover Model, Governor Model, Tie Line Model – Energy control centre – SCADA systems – Functions- Monitoring – Data Acquisition and Controls – Energy Management Systems	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6036	FLEXIBLE AC TRANSMISSION SYSTEMS	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of Power Electronics and Power System.
2. Knowledge about Power System stability.

COURSE OBJECTIVES:

To provide an in depth knowledge about different FACTS devises. Here, basic mathematical models and control strategies will be derived.

SYLLABUS

Fundamental Concepts of FACTS and ac power transmission - Principles of static shunt - Principles of static series compensation compensation - UPFC and IPFC

COURSE OUTCOME:

The students will be able to

1. Understand the working of different FACTS devices.
2. Analyze the impact of these components on power system stability.

TEXTBOOKS:

1. Song Y.H. and Allan T. John, 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

REFERNCES:

1. R M Mathur and R K Varma, Thyristor based FACTS Controllers for Electrical Transmission,IEEE Press.
2 K.R.Padiyar, 'FACTS controllers for transmission and Distribution systems' New Age international Publishers 1st edition -2007

COURSE PLAN			
MODULE	COURSE NO:**06 EE 6036**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**FLEXIBLE AC TRANSMISSION SYSTEMS**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	**FACTS concept and general system considerations-** Fundamentals of ac power transmission**,** transmission problems and needs, emergence of FACTS controllers, FACTS control considerations, Benefits from FACTS technology.	**10**	**25%**
II	Principles of static shunt compensation**:** Variable Impedance type shunt compensators- Operation, characteristics and control of TCR, TSR, TSC, FC-TCR, & TSC-TCR	**5**	**25%**
FIRST INTERNAL EXAM			
II	**Switching converter type Var compensator** (STATCOM) configuration, characteristics and control. Comparison between STATCOM & SVC-STATCOM for transient and dynamic stability enhancement.	**5**	
III	Principles of static series compensation: Variable Impedance type series compensators- Operation, characteristics and control of GCSC, TSSC, and TCSC applications, Static Synchronous Series Compensator (SSSC)- Operation and control. Static voltage and phase angle regulators- TCVR and TCPAR- operation and control	**10**	**25%**
SECOND INTERNAL EXAM			
IV	UPFC: Principles of operation and characteristics, conventional transmission control capabilities Comparison of UPFC with the controlled series compensators and	**10**	**25%**

	phase shifters. Control structure. Interline power flow controller (IPFC) Basic operating principle and characteristics. Generalized and multifunctional FACTS controller		
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6146	POWER QUALITY	3-0-0: 3	2015

COURSE OBJECTIVES:

1. To study the various issues affecting power quality, their production, suppression and mitigation.
2. To study the production of voltages sags, overvoltages and harmonics and methods of control.
3. To understand the effects of various power quality phenomenon in various equipments
4. To understand their mitigation using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR).

SYLLABUS

Introduction to Electric power quality phenomena, Transient Overvolatges - Types, sources and mitigation, Grounding Problems And Solutions, Harmonics -Sources, effects, and mitigation methods, Voltage sags & interruptions – sources & mitigation methods.

COURSE OUTCOME:

Upon successful completion of this course, students will be able to understand the basic power quality issues, their sources and effects on power system. This course helps to gain knowledge about the various mitigation methods custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR).

REFERENCES:

1. "Electrical Power Systems Quality" by Roger C Dugan, Mark. F. Mc Grananaghan- 2nd Edition - McGraw Hill Publications.
2. "Understanding Power Quality Problems" by Math H J Bollen - IEEE Press
3. Selected Topics in Power Quality and Custom Power, Course book for STTP, 2004, Ashok S
4. "Harmonics and power systems" - Francisco C. De La Rosa Published in 2006 by CRC Press Taylor & Francis Group
5. "FACTS controllers in power transmission and distribution" -K.R Padiyar -New Age International.

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6146**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**POWER QUALITY**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	Electric power quality phenomena- - IEC and IEEE definitions-General classes of power frequency variations-Transients-Long duration voltage variations-Short duration voltage variations-voltage imbalance-Wave form distortion-voltage fluctuations-power frequency variations-Power quality terms-Power Quality Standards and Guidelines**.**	**7**	**25%**
II	Transients-Impulsive transients-oscillatory transients-Sources of transient over voltages	**4**	**25%**
FIRST INTERNAL EXAM			
II	Devices for overvoltage protection-switching transient problems with load.Grounding- Definition - reasons for grounding-Wiring and grounding problems –solutions for wiring and grounding problems.	**5**	
III	Harmonics:- Definition –harmonic distortion -- harmonic phase sequences – triplen harmonics.-Sources of harmonics-Effects of Harmonics-Harmonic Standard-The IEC Standard-IEEE 519-1992- Harmonic Indices-Power system quantities under non sinusoidal conditions:-Active, reactive and apparent Power - power factor-displacement and true power factor-Harmonic distortion evaluation.Harmonic resonance-series and parallel. Passive filters-Active Harmonic Filtering-Shunt Injection Filter for single phase , three-phase three-wire and three-	**15**	**25%**

	phase four-wire systems . d-q domain control of three phase shunt active filters. Series active power filtering techniques for harmonic cancellation and isolation.		
SECOND INTERNAL EXAM			
IV	Voltage sag and interruptions-sources of voltage sag and interruptions-Estimating voltage sag performance - Equipment sensitivity to voltage sag - CBEMA and ITIC curve–Fundamental principles of protection-solutions at the end user level-sags due to starting of induction motor DStatcom-Dynamic voltage restorer-unified power quality conditioners.	**11**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6246	INTRODUCTION TO ELECTRIC DRIVES	3-0-0: 3	2015

PRE – REQUISITES:

1. Power Electronics
2. Fundamentals of electric machines.
3. Calculus

COURSE OBJECTIVES:

To provide a complete knowledge of operation and control of DC and AC drives.

SYLLABUS

Electric Drives – dynamics of electric drives - dc motors & their performance analysis of separately excited & series motor with 1-phase and 3-phase converters – dual converter – two quadrant DC motor drive with field weakening – Four Quadrant DC motor drive - analysis of chopper controlled DC drives – closed loop operation – Induction motor drives- Speed control of Induction motors-Principle of vector control-Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors.

COURSE OUTCOME:

1. The students will be able to design and set up converters for drive applications
2. The student will acquire sound knowledge in DC and AC drives.

TEXTBOOKS:

1. G.K.Dubey, Fundamentals of Electrical Drives, Narosa- 2013
2. R. Krishnan, Electrical Motor Drives, PHI-2003
3. Bimal. K. Bose, Modern power Electronics and AC Drives, Pearson Education-2009.

REFERNCES:

1. G.K.Dubey, Power semiconductor controlled drives, Prentice Hall- 1989

2. S.A. Nasar, Boldea , Electrical Drives, Second Edition, CRC Press - 2006
3. M. A. ElSharkawi , Fundamentals of Electrical Drives , Thomson Learning -2000
4. W. Leohnard, Control of Electric Drives,-Springer- 2001
5. Murphy and Turnbull, Power Electronic Control of AC motors, Pergamon Press.

	COURSE PLAN		
MODULE	COURSE NO: **06 EE 6246**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**INTRODUCTION TO ELECTRIC DRIVES**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**EndSem Marks %**
I	Electric drives-dynamics of electric drives - torque equation - equivalent values of drive parameters- components of load torques- types of load - four quadrant operation of a motor – steady state stability – load equalization – effect of gearing- Selection of motor power rating.	**8**	**25%**
II	DC motor drives – dc motors & their performance (shunt, series, compound, dc servomotor)- transfer function of self, separately excited DC motors– Speed control methods - braking methods – converter control of dc motors – analysis of separately excited & series motor with 1-phase and 3-phase converters – dual converter – two quadrant DC motor drive with field weakening – Four Quadrant DC motor drive - analysis of chopper controlled dc drives – closed loop operation .	**10**	**25%**
FIRST INTERNAL EXAM			
III	Induction motor drives – stator voltage control of induction motor – torque-slip characteristics – operation with different types of loads –stator frequency control – variable frequency operation – V/F control, controlled current and controlled slip operation – effect of harmonics and control of harmonics – PWM inverter drives – multiquadrant drives – rotor resistance	**12**	**25%**

	control – slip torque characteristic – torque equations, constant torque operation – slip power recovery scheme – torque equation – torque slip characteristics – power factor – methods of improving power factor – limited sub synchronous speed operation – super synchronous speed operation. Principle of vector control.		
SECOND INTERNAL EXAM			
IV	Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – principles of synchronous motor control – voltage source inverter drive with open loop control – self controlled synchronous motor with electronic commutation – self controlled synchronous motor drive using load commutated thyristor inverter.	**12**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6346	TRANSIENTS ANALYSIS IN POWER SYSTEM	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of power system analysis
2. Knowledge in power quality.

COURSE OBJECTIVES:

To impart knowledge in modelling transmission line considering transients, protection against transients and measurement of high electrical parameters.

SYLLABUS

Modeling of transmission lines, Travelling wave and its propagation, Protection against various transients, Generation and measurement of high current and voltage

COURSE OUTCOME:

The students will be able to

1 Modelling of transmission lines as distributed parameter systems.
2 Introducing concepts of travelling waves and propagation
3 introducing system protection against transients
4 familiarizing methods of high voltage and current generation and measurements

TEXTBOOKS:

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc.New York, 1991

2. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-HillPublishing Company Ltd., New Delhi, 2004.

REFERNCES:

1. Pritindra Chowdhari, “Electromagnetic transients in Power System”,John Wiley and Sons Inc., 1996

2.Bewley L.W, ”travelling waved and transmission systems” Dover publications New York 1963

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6346**	**L – T – P : 3 – 0– 0**	
	COURSE NAME: **TRANSIENT ANALYSIS IN POWER SYSTEM**	**CREDITS : 3**	
	CONTENT	**Contact Hrs**	**End Sem Marks %**
I	Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams –Attenuation and Distortion – Multi-conductor system and Velocity wave.	**11**	**25%**
II	Double frequency transients-capacitance switching-restriking phenomena.	**5**	**25%**
FIRST INTERNAL EXAM			
II	Transformer magnetizing inrush current-ferroresonance.	**5**	
III	Protection of transmission lines against lighting-surge suppressor and lighting arrestor-Application of surge arrestor-surge suppressor for direct current circuit-surge capacitor-surge reactor.	**11**	**25%**
SECOND INTERNAL EXAM			
IV	Generation of high AC and DC-impulse voltages, currents-measurements using sphere gaps-peak voltmeters-potential divider-CRO	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6446	ROBOTICS AND AUTOMATION	3-0-0: 3	2015

PRE – REQUISITES:

1. Drive systems.
2. Programming languages.
3. Advanced mathematics.

COURSE OBJECTIVES:

To provide a complete knowledge of robotics and automation

SYLLABUS

Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors– End effectors – Control systems. Robot programming languages.Direct and inverse kinematics – Rotation matrices. Lagrange – Euler formulation, joint velocities. General consideration on trajectory planning joint interpolation & Cartesian path trajectories.

COURSE OUTCOME:

The student will acquire sound knowledge in robotics and automation.

TEXTBOOKS:

1. 1. Fu K S, Gonazlez R C and Lee C S G, Robotics (Control, Sensing, Vision and Intelligence), McGraw-Hill, 1987.
2. Wesley, E Sryda, Industrial Robots: Computer Interfacing and Control. PHI, 1985.
3. Asada and Slotine, Robot Analysis and Control, John Wiley and Sons, 1986.
4. Philippe Coiffet, Robot Technology, Vol. II (Modeling and Control), Prentice Hall INC, 1981.

REFERNCES:

1. Saeed B Niku, Introduction to Robotics, Analysis, Systems and Applications, Pearson Education, 2002.

2.Groover M P, Mitchell Wesis, Industrial Robotics Technology Programming and

Applications, Tata McGraw-Hill, 1986.

3. Sciavicco L, B Siciliano, Modeling & Control of Robot Manipulators, 2nd Edition,Springer Verlag, 2000.
4. Gray J O, D G Caldwell (Ed), Advanced Robotics & Intelligent Machines,The Institution of Electrical Engineers, UK, 1996.
5. Craig John J, Introduction to Robotics: Mechanics and Control, Pearson, 1989.

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6446**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**ROBOTICS AND AUTOMATION**	**CREDITS : 3**	
	CONTENTS	**Contact hrs**	**End Sem Marks %**
I	Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors-– End effectors – Control systems – Robot programming languages and applications –Introduction to robotic vision.	**10**	**25%**
II	**Robot Arm Kinematics** Direct and inverse kinematics – Rotation matrices – Composite rotation matrices – Euler angle-representation – Homogenous transformation – Denavit Hattenberg representation and various arm configurations.	**10**	**25%**
FIRST INTERNAL EXAM			
III	**Robot Arm Dynamics** Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion-equations – Generalized D'Alembert equations of motion.	**10**	**25%**
SECOND INTERNAL EXAM			
IV	**Planning of Manipulator Trajectories** General consideration on trajectory planning joint interpolation & Cartesian path trajectories.-Control of Robot Manipulators-PID control computed, torque technique – Near minimum time control – Variable structure control – Non-linear decoupled feedback control – Resolved motion control and adaptive control.	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6156	SWITCHED MODE POWER CONVERTERS	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of Power Electronic Circuits
2. State space analysis

COURSE OBJECTIVES:

To provide an in depth knowledge about modelling and analysis of switched mode power converters.

SYLLABUS

DC-DC Converters without Galvanic Isolation, Switching dc power supplies with isolation and control, Switch mode dc-ac converters, Introduction to resonant converters and modelling of basic converters.

COURSE OUTCOME:

The students will be able to

1. Analyze switched mode power converters.
2. Model, control and design switched mode power converters

TEXTBOOKS:

1. Ned Mohan et al, , Power Electronics, John Wiley ,1989
2. Pressman A.I, Switching Power Supply Design, McGraw Hill, 2nd edition, 1999
3. Muhammad H Rashid, Power Electronics, 3rd edition, Pearson, 2007

REFERENCES:

1. Mitchell D.M, DC-DC Switching Regulator Analysis, McGraw Hill ,1988
2. Otmar Kingenstein Switched Mode Power Supplies in Practice, John Wiley, 1994
3. Billings K.H., Handbook of Switched Mode Power Supplies, McGraw Hill, 1989.
4. Nave M.J, Power Line Filter Design for Switched-Mode Power Supplies, Van Nostrand Reinhold, 1991.

COURSE PLAN			
MODULE	COURSE NO:**06EE 6156**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **SWITCHED MODE POWER CONVERTERS**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	DC-DC Converters without Galvanic Isolation - linear power supplies - overview of switching power supplies - introduction to dc - dc switched mode converters - step down converters - continuous conduction mode - boundary between continuous and discontinuous conduction - discontinuous conduction mode - output voltage ripple - step up converter - continuous conduction mode - boundary between continuous and discontinuous conduction - discontinuous conduction mode - buck boost converter - continuous conduction mode - boundary between continuous and discontinuous conduction - discontinuous conduction mode - output voltage ripple - cuk dc-dc converter - full bridge dc-dc converter - PWM with bipolar and unipolar voltage switching - dc-dc converter comparison.	**10**	**25%**
II	Switching dc power supplies with isolation - dc-dc converters with electrical isolation - flyback converters - double ended flyback converter - forward converters - double ended forward converter - push pull converters - half bridge converters - full bridge converters-	**6**	**25%**
FIRST INTERNAL EXAM			
II	Voltage mode control of SMPS - loop gain and stability considerations - shaping the error amp frequency response - error amp transfer function - transconductance error amps - study of popular PWM Control Ics (SG 3525,TL	**5**	

	494,MC34060 etc.) Current mode control of SMPS - current mode control advantages - current mode Vs voltage mode - current mode deficiencies - slope compensation - study of a typical current mode PWM control IC UC3842		
III	Switch mode dc-ac converters - basic concepts of switch mode converters - PWM switching scheme - square wave switching scheme - single phase inverters - half bridge and full bridge inverters - SPWM with bipolar and unipolar voltage switching - push pull inverters - switch utilization in single phase inverters - three phase inverters - SPWM in three phase voltage source inverters - square wave operation - switch utilisation - ripple in the inverter output - conduction of switches in three phase inverters - effect of blanking time on voltage in PWM inverters - square wave pulse switching - programmed harmonic elimination switching - current regulated modulation - Single Phase Switched Mode Rectifier and its control. Single phase utility interface - input current harmonic considerations - single phase boost type active power factor correction stage - basic operation - waveforms - current control strategies - output voltage control - power limits - power circuit design considerations - study of popular PFC Control ICs MC34062 and UC 3854	**11**	**25%**
SECOND INTERNAL EXAM			
IV	Introduction to modelling of switched mode power supplies - state space averaging - state space averaged models - equivalent circuits and small signal transfer functions for basic converters. Introduction to resonant converters - classification of	**10**	**25%**

	resonant converters - basic resonant circuit concepts - load resonant converter - resonant switch converter - zero voltage switching clamped voltage topologies - resonant DC link inverters with zero voltage switching - high frequency link integral half cycle converter		
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6256	COMPUTER APPLICATION OF POWER SYSTEMS	3-0-0: 3	2015

PRE – REQUISITES:

A basic knowledge on the subjects Power System Analysis, computing programming and Matrix manipulation.

COURSE OBJECTIVES:

1. Modelling of power system network and to perform short circuit analysis of larger power systems
2. To get insight of contingency analysis problem and the solution methods
3. An introduction of Multiphase systems and its feasibility.

SYLLABUS

Network Formulation- Short Circuit Studies- Contingency Analysis- Introduction to multiphase systems- Sparsity techniques.

COURSE OUTCOME:

The students will be able to

1. Model the power system network for system analysis.
2. Perform contingency analysis on a system.
3. Analyze multiphase system and its feasibility.

TEXTBOOKS AND REFERNCES:

1. Computer methods in Power system Analysis – Stagg and El Abiad – McGraw Hill. 1968.
2. Power System Analysis - Grainger, J.J. and Stevenson, W.D. - McGraw Hill, New Delhi, 2003.
3. Advanced Power Systems Analysis and Dynamics – L.P.Singh – New Age Intl. Publishers, 1983.
4. Computer Aided Power System Analysis – G.L.Kusic, Prentice Hall, 1986.
5. Computer Techniques in Power System Analysis, Pai, M.A, Tata McGraw hill, New Delhi, 2006.

COURSE PLAN			
MODULE	COURSE NO: **06EE 6256**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **COMPUTER APPLICATION OF POWER SYSTEMS**	**CREDITS : 3**	
	CONTENTS	**Contact hrs**	**End Sem Marks %**
I	**Network Formulation:** Network equations – Elementary linear graph theory – Incidence matrices – Development of network matrices from Graph theoretic approach (singular transformation) – Building algorithm for Bus impedance matrix – Modification of Z_{Bus} matrix due to changes in primitive network.	**10**	**25%**
II	Power system components and their representation – Synchronous machine, transmission system, three phase power network.	**2**	**25%**
FIRST INTERNAL EXAM			
II	**Short Circuit Studies:** Short circuit study of a large power system networks - Algorithm for calculating system conditions after fault for balanced three phase network using Z_{bus}.	**8**	
III	**Contingency Analysis:** Contingency Analysis for power systems - Network sensitivity factors- Analysis of Single Contingencies -Analysis of Multiple Contingencies- Contingency Analysis by dc Model- Contingencies using Z_{bus} in a superposition method – Browns Z_{bus} method for contingencies.	**10**	**25%**
SECOND INTERNAL EXAM			
IV	Introduction to multiphase systems –Feasibility of multiphase (six phase) systems – mathematical modelling of multiphase (six phase) elements. Sparsity techniques – Triangular factorization – Optimally Ordered Triangular	**12**	**25%**

	factorization- Near Optimal ordering.		
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06EE 6356	SMART GRID TECHNOLOGY AND APPLICATIONS	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of power systems, computer and communication networks
2. Knowledge of probability and random variables, linear algebra and complex optimization
3. Basic knowledge in renewable energy resources

COURSE OBJECTIVES:

1. After successfully completing this course, the student will have gained an understanding of various aspects of the smart grid, including technologies, components, architectures and applications.
2. To understand various Smart grid control elements required to monitor and control the grid, such as smart meters, sensors and phasor measurement units.

SYLLABUS

Evolution of Electric Grid; Concept, Need, functions, Opportunities & Barriers of Smart Grid; Resilient & Self-Healing Grid; Smart Meters; Automatic Meter Reading(AMR);Outage Management System(OMS); Plug in Hybrid Electric Vehicles(PHEV);Home & Building Automation; Smart Substations; Geographic Information System (GIS);Intelligent Electronic Devices(IED); Smart storage; Wide Area Measurement System(WAMS); Phase Measurement Unit(PMU); Micro grid, need & applications; Issues of interconnection; protection & control of micro grid; Plastic, Organic and Thin film solar cells; Variable speed wind generators; micro turbines; Captive power plants; Integration of renewable energy sources.

COURSE OUTCOME:

The students will be able to

1. Describe the smart grid technologies, components, architectures and applications.
2. Categorise various Smart grid control elements required to monitor and control

the grid

3. Explain the smart grid applications within the industry, and design criteria's
4. Learn the need , issues and applications of micro grids and distributed energy sources

TEXTBOOKS:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.

REFERNCES:

1. Janaka Ekanayake, Kithsiri Liyanage,Jianzhong.Wu, AkihikoYokoyama, Nick Jenkins, "Smart Grid: Technology and Applications"- Wiley
2. Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell
3. Peter S. Fox-Penner, "Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities"
4. James Momoh, "Smart Grid: Fundamentals of Design and Analysis"-Wiley, IEEE Press, 2012.

COURSE PLAN			
MODULE	COURSE NO:**06 EE 6356**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **SMART GRID TECHNOLOGY AND APPLICATIONS**	**CREDITS : 3**	
	CONTENTS	**Contact hrs**	**End Sem Marks %**
I	Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid.	**11**	**25%**
II	Part 1:Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS)	**6**	
FIRST INTERNAL EXAM			
II	Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.	**5**	**25%**
III	Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System (GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).	**10**	**25%**
SECOND INTERNAL EXAM			
IV	Concept of micro grid, need & applications of micro grid, formation of micro grid, Issues of interconnection, protection & control of micro grid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind	**10**	**25%**

	generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources		
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6456	DEREGULTION IN POWER SYSTEM	3-0-0: 3	2015

PRE – REQUISITE: Power systems

COURSE OBJECTIVES:

1. To introduce deregulation in power industry.
2. To provide in-depth understanding of operation of deregulated electricity market systems.
3. To enable students to analyze various types of electricity market operational and control issues.

SYLLABUS

The Electric Industry and Its Traditional Regulated Structure; Electric Utility Functions and Systems;De-Regulation; Concepts and Evolution; The Electric Utility Industry under De-Regulation; Distributed Generation and Storage; Types of Distributed Generators; Understanding Electric Utilities and De-Regulation; Goals for and Effects of De-Regulation ; Comparing Four Approaches to Regulation and De-Regulation; De-Regulation at the Wholesale Power Level: The Power Grid in the De-Regulated Industry: Generation and Transmission in a De-Regulated Industry ;Transmission Service Pricing; Deregulation Scenario in India.

COURSE OUTCOME:

The students will be able to

1. Understand the operation of deregulated electricity market systems and typical issues in electricity markets
2. To analyze various types of electricity market operational and control issues.

REFERENCES:

1. Understanding Electric Utilities and De-Regulation, 2nd Edition, Lorrin Philipson H.

Lee Willis. CRC Press

2. Yong-Hua Song, Xi-Fan Wang, Operation of market-oriented power systems, Springer, Germany.
3. Loi Lei Lai,"Power System Restructuring and Deregulation", John Wiley & Sons Ltd
4. http://www.cdeep.iitb.ac.in/nptel/Electrical%20Engineering/Power%20System%20Operation%20and%20Control/Module%207/L01-Introduction%20to%20Deregulation-1.pdf

COURSE PLAN			
MODULE	COURSE NO: **06 EE 6456**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**DEREGULATION IN POWER SYSTEM**	**CREDITS : 3**	
	CONTENT	**Contact Hrs**	**End Sem Marks %**
I	The Electric Industry and Its Traditional Regulated Structure: Electric Utility Functions and Systems – Electric Utility Resources and Organization -Vertical Integration and Monopoly Regulation - Electric Utility Business Frameworks - Government Regulatory Agencies and Commissions. The Electric Industry under De-Regulation – An Overview: De-Regulation: Concepts and Evolution, Competition at the Wholesale Generation Level, Independently Operated Regional Transmission Grids, - The Electric Utility Industry under De-Regulation.	**11**	**25%**
II	Distributed Generation and Storage: Distributed Power Generation - Types of Distributed Generators - Distributed Power Storage.	**6**	**25%**
FIRST INTERNAL EXAM			
II	Regulation and De-Regulation: Understanding Electric Utilities and De-Regulation. The Good and Bad of Utility Regulation -Goals for and Effects of De-Regulation - Comparing Four Approaches to Regulation and De-Regulation - Increased Services From and Financial Pressures On LDCs .	**5**	
III	De-Regulation at the Wholesale Power Level: The Wholesale Power Marketplace – bidding of electricity - Buying Energy vs. Buying Capacity - Wholesale Power Pricing. The Power Grid in the De-Regulated Industry: Generation and Transmission in a De-Regulated Industry – The Wholesale Transmission Level - Transmission Service	**10**	**25%**

	Pricing- Location Based Pricing. Deregulation Scenario in India.		
SECOND INTERNAL EXAM			
IV	Service Reliability and Aging Infrastructures: Aging T&D Infra structures, Sustainable-Point analysis of aging infrastructures, Outages and Reliability.Blackouts: An Overview, Reason for blackouts	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6066	MINI PROJECT	0-0-4: 2	2015

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

To learn the simulation and/or hardware implementation of a topic based on a research publication in the relevant area of specialization.

SYLLABUS:

The student has to select a topic and do simulation and/or hardware in consultation with any of the faculty members in the department (or the faculty member offering courses for the programme). A detailed report on the mini project is to be prepared in the prescribed format given by the Department. A committee with the Head of the Department as the chairman and two faculty members from the department as members shall evaluate the mini project based on coverage of the topic, simulation and/or hardware implementation, presentation and ability to answer the questions put forward by the committee.

COURSE OUTCOME:

Students will

(1) be aware of recent developments in the area of work

(2) improve their simulation and hardware implementation skills

REFERENCES:

(1) Simulation tools – MATLAB/Simulink , PSIM, PSpice etc

(2) IEEE Xplore , Elsevier- Science Direct, Springer Journals etc

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 6076	POWER ELECTRONICS LAB	0-0-3: 1	2015

PRE – REQUISITES:

Basic knowledge in Power Electronics circuits

COURSE OBJECTIVES:

The student will be able to,

(1) Design and analyse different power converters and firing circuits.

(2) Modeland analyse different power converters.

SYLLABUS

Design and analysis of firing circuits and power converters; Simulation of power converters using MATLAB/Simulink.; Speed control of electric drives.

COURSE OUTCOME:

Ability to

1. Design and analyze various firing circuits.
2. Design and analyze various power converter circuits.
3. Simulate the power converter circuits and observe the waveforms.
4. Apply micro controllers and DSP based processors in power converter circuits.

TEXTBOOKS:

1. K.R.Varmah, Chikku Abraham, Power Electronics, 1st edition, Elsevier, 2014
2. Muhammad H Rashid, Power Electronics, 3rd edition, Pearson,2007.

REFERENCES:

1. Ned Mohan, Undeland, Robbins, Power Electronics,3rd edition, John Wiley, 2003.
2. Joseph Vithayathil, Principles of Power Electronics, McGrawHill-1994.

COURSE PLAN

COURSE NO:**06 EE 6076**	**L – T – P : 0-0-3**	
COURSE NAME: **POWER ELECTRONICS LAB**	**CREDITS : 1**	
LIST OF EXPERIMENTS	**Contact hrs**	**End Sem Marks %**
1. Firing schemes for converters. 2. Single Phase Semi-converter with R-L loads for continuous and discontinuous conduction modes. 3. Single phase full- converter with R-L loads for continuous and discontinuous conduction modes. 4. Three phase full-converter with R and R-L load. 5. Controlled and Uncontrolled rectifier with different types of filters-continuous and discontinuous modes of operation. 6. Voltage and current commutated choppers. 7. MOSFET, IGBT based Choppers. 8. IGBT and MOSFET based inverters. 9. Current source inverter. 10. Single phase AC voltage controller. 11. Resonant Converters. 12. Closed loop control of chopper fed DC motor drives. 13. VSI fed three phase induction motor drive. 14. Industrial Drive Control by V F D 15. Simulation of Buck, Boost and Buck-Boost Converters 16. Simulation of PWM inverters 17. Simulation of hysteresis current control of inverters.	**33**	**100 %**

18. PC based control of power electronic devices. 19. Microcontroller and DSP based control of dc-dc converters. 20. P L C based control system 21. Study of harmonic pollution by power electronics loads.		
(At least 15 experiments in the list are to be conducted in the laboratory. Additionalexperiments and simulation assignments can also be given by the department).		
END SEMESTER – EXAM		

SEMESTER -III

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7115	POWER ELECTRONIC CONTROL OF SPECIAL ELECTRICAL MACHINES	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of Power Electronic control circuits
2. Knowledge of construction & working of Machines

COURSE OBJECTIVES:

To provide a fundamental understanding of the special types of electric machines and their controls for various applications.

SYLLABUS

Stepping Motors, Construction and principle of operation, characteristics and control- Switched Reluctance Motors & Synchronous Reluctance Motors: Constructional, principle of operation, Characteristics and control- Permanent Magnet Brushless DC Motors : Mechanism of Commutation, different sensors, torque and emf equation, Torques speed characteristics, controllers and control schemes- Permanent Magnet Synchronous Motors: Principle of operation, emf, power input and torque expressions, Phasor diagram, controllers, characteristics, and control schemes.

COURSE OUTCOME:

The students will be able to

1. Model the control circuit for Special Electric Machines.
2. Perform the sensor and sensor less control of Special Electric Machines using different digital controllers.

TEXTBOOKS:

1. Kenjo T, Sugawara A, Stepping Motors and Their Microprocessor Control, Clarendon Press,Oxford, 1994.
2. V.V.Athani, Stepper Motor Fundamentals, Application and Design, New Age International(P) Ltd, Publishers, New Delhi, 1997.
3. Miller T J E, Switched Reluctance Motor and Their Control, Clarendon Press, Oxford,1993.
4. Miller T J E, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press,Oxford,1989.
5. R.Krishnan, Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications, CRC Press, New York, 2001.

REFERNCES:

1. R Krishnan, Electric Motor Drives – Modeling, Analysis and Control, PHI, 2003.
2. B K Bose, Modern Power Electronics & AC drives, Pearson, 2002.
3. Kenjo, T and Naganori, S, “Permanent Magnet and brushless DC motors”, Clarendon Press, Oxford, 1989.
4. Venkataraman,”Special Electric Machines”,OrientBlackSwan/ Universities Press, 2008

COURSE PLAN			
MODULE	COURSE NO:**06 EE 7115**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**POWER ELECTRONIC CONTROL OF SPECIAL ELECTRICAL MACHINES**	**CREDITS : 3**	
	CONTENTS	**Contacthrs**	**End Sem Marks %**
I	**Stepping Motors:** Constructional features, principle of operation, modes of excitation, single phase stepping motors, torque production in variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive System s and circuit for open loop control, Closed loop control of stepping motor, microprocessor based controller	**10**	**25%**
II	**Switched Reluctance Motors&Synchronous Reluctance Motors:** Switched Reluctance Motors-Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control. Microprocessor based controller. Sensor less control.	**5**	**25%**
FIRST INTERNAL EXAM			
II	**Switched Reluctance Motors&Synchronous Reluctance Motors:**Synchronous Reluctance Motors-Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque –Phasor diagram, motor characteristics.	**5**	
III	**Permanent Magnet Brushless DC Motors:** Introduction-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, Torques speed characteristics, Controllers-	**11**	**25%**

	Microprocessor based controller. Sensorless control.		
SECOND INTERNAL EXAM			
IV	**Permanent Magnet Synchronous Motors:**Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes,sensorless control.	**11**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7215	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of renewable energy system
2. Knowledge of power electronics

COURSE OBJECTIVES:

1. To study the various renewable energy options.
2. To conduct qualitative study of power converters

SYLLABUS

Introduction to Renewable energy system; Qualitative study of different renewable energy resources; Electrical machines for Renewable Energy conversion; Review of reference theory; Power converters for solar and wind energy system; Case studies of Wind- PV system; Maximum Power Point Tracking(MPPT).

COURSE OUTCOME:

Upon successful completion of this course, students will be able to:

1. Understand technology behind green energy harnessing
2. Understand power electronic application to renewable
3. Undertake projects based on grid interconnected green power system.

TEXTBOOKS:

1. Rashid .M. H, Power Electronics Handbook, Academic press, 2nd edn., 2001.

2. Rai. G.D, Non-conventional Energy Sources, Khanna publishers, 1993.

3. P.S Bimbra, Generalised theory of Electrical machines

REFERENCES:

1. Rai. G.D, Solar Energy Utilization, Khanna Publishers, 1993.

2. Gary, L. Johnson, Wind Energy System, Prentice Hall Inc, 1995.

3. B.H. Khan, Non-conventional Energy Resources, Tata McGraw-Hill Publishing Company, NewDelhi.

4. Leon Freris, David Infield, Renewable Energy in Power Systems, John Wiley & Sons., 2008

COURSE PLAN			
MODULE	COURSE NO: **06 EE 7215**	**L – T – P :3-0-0**	
	COURSE NAME: **POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**	**CREDITS : 3**	
	CONTENTS	**Contact hrs**	**End Sem Marks %**
I	Introduction: Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.	**11**	**25%**
II	Electrical machines for Renewable Energy conversion**:** Review of reference theory.	**5**	
FIRST INTERNAL EXAM			
II	Fundamentals principle of operation and analysis: IG, PMSG, SCIG and DFIG.	**6**	**25%**
III	Power converters - Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing and array sizing. Wind: three phase AC voltage controllers- AC-DC-AC converters: PWM Inverters, Grid Interactive Inverters - matrix converters.	**10**	**25%**
SECOND INTERNAL EXAM			
IV	Hybrid Renewable Energy systems –		

	Need for Hybrid Systems- Wind and PV systems -Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system. Case studies of Wind-PV-Maximum Power Point Tracking(MPPT).	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7315	EMBEDDED CONTROLLERS	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of 8 bit Microcontrollers
2. Knowledge of working of AC & DC drives

COURSE OBJECTIVES:

To make the students able to design digital measuring and control circuits for power electronic devices

SYLLABUS:

Use of a typical 8 bit (Intel 8051) Microcontroller for measuring and control of electrical quantities - Architecture and use of peripherals of PIC 16F877Microcontroller(8bit) - Use of microcontrollers for control of Power converters - Fundamentals of DSP controller(TMS LF2407)architecture.DSP based control of Converters

COURSE OUTCOME:

The students will be able to

1. Design digital metering circuits for electrical measurements
2. Design embedded controllers for converters, inverters choppers

TEXTBOOKS:

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, The 8051Microcontroller and Embedded Systems- Using Assembly and C, Prentice Hall of India, New Delhi, 2007
2. John B. Peatman, Design with PIC Microcontrollers, Pearson, 2003.
3. Bimal K Bose, Modern Power Electronics & AC Drives, Pearson Education, 2002
4. DSP based electro mechanical motion control- Hamid A Toliyat and Steven G

Campbell , CRC press

REFERNCES:

1. Richard H. Barnett, Larry O' Cull, Sarah Alison Cox, Embedded C Programming and the Microchip PIC, Volume 1, Thomson Delmar Leaning.

2. Subrata Ghoshal, "Embedded Systems & Robots: Projects Using The 8051 Microcontroller", Cengage Learning, 1st Edition, 2009.

COURSE PLAN			
MODULE	COURSE NO:**06 EE 7315**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **EMBEDDED CONTROLLERS**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	**Intel 8051**: Architecture - Memory Organization – Instruction set – Addressing modes – Basic Programming. Peripheral: Parallel Ports – Timers and Counters – Interrupts – Serial Communication –ADC, DAC,LCD and keyboard interfacing with 8051. – Assemblers and Compilers – embedded C programming _Generation of .LST and .HEX files for applications using Keil / RIDE IDE. Measurement of voltage, current, speed, power and power factor ,Frequency and PWM implementation using 8051.	**10**	**25%**
II	**Microchip PIC 16F877**: Architecture of PIC 16F877 microcontroller- PIC memory organization - Interrupt structure – Timers / Counters – Capture / Compare / PWM modules - Master Synchronous Serial Port (MSSP) module – USART – A / D Converter module Timers, Comparator module	**5**	**25%**
FIRST INTERNAL EXAM			
II	Instruction set – Different addressing modes. Instruction set – Programming - .LST and .HEX files generation for applications using MpLab IDE. Measurement of voltage, current, speed, power and power factor - Frequency measurement - PWM implementation using PIC	**5**	
	Digital controllers :Overview of Zero Crossing Detectors - Generation of gating signals for		

III	Converters, Inverters and chopper circuit - Control of AC/DC electric drives - Implementation of PID controller - Power quality/power factor correction - Solar Power Conditioning (MPPT)	**10**	**25%**
SECOND INTERNAL EXAM			
IV	DSP controller:Introduction toTMS LF2407 DSP controller –peripherals -physical memory – C2xx DSP CPU core-Instruction set -addressing modes – assembly programming - software tools . GPIO – interrupt handling-ADC-Event managers - DSP based implementation of DC_DC BUCK BOOST converter. DSP based control of stepper motor. Space vector PWM technique – DSP implementation	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7415	RENEWABLE ENERGY SYSTEMS	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of renewable energy systems.

COURSE OBJECTIVES:

To impart in depth knowledge about various renewable energy sources such as Solar, wind, Bio-mass, chemical and geothermal energy, energy from oceans, waves and tides.

SYLLABUS

Solar energy; Measurement and estimation; Thermal conversion systems; Photovoltaic systems; Applications; Wind energy; Data and estimation; Wind energy conversion systems, Electric generators, Applications; Biomass conversion technologies; Photosynthesis; Energy from waste; Fuel cells; Work out and emf; Hydrogen production methods; Storage and utilization; Energy from Ocean; OTEC; Tidal; ;Basic principles of operation; Geothermal energy

COURSE OUTCOME:

The students will be able to

1. To calculate amount of solar energy available at a particular site.
2. To illustrate about wind energy systems.
3. To apprise efficient use of bio mass energy.
4. To describe about various renewable energy sources such as chemical energy,geothermal energy, energy from oceans, waves and tides.

TEXTBOOKS:

1. G D Rai, “Non Conventional Energy Sources”, Khanna Publications, 2011.
2. D P Kothari, K C Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging

Technologies, Prentice Hall of India, New Delhi, 2009.

REFERNCES:

1. SP Sukatme, "Solar Energy – Principles of thermal collection and storage, second edition, Tata McGraw Hill, 1991.
2. B.H. Khan, Non-Conventional Energy Resources, 2nd ,Tata McGraw Hill, New Delhi, 2010.
3. Chetan Singh Solanki, Renewable Energy Technologies, Prentice Hall of India, New Delhi, 2009.
4. Siraj Ahmed, Wind Energy- Theory and Practice, Prentice Hall of India, New Delhi, 2010.
5. D.D. Hall and R.P. Grover, "Bio-Mass Regenerable Energy, John Wiley, Newyork, 1987.
6. J. Twidell and T. Weir, "Renewable Energy Resources", E&FN Spon Ltd., London, 1986.

COURSE PLAN			
MODULE	COURSE NO:**06 EE 7415**	**L – T – P : 3-0-0**	
	COURSE NAME: **RENEWABLE ENERGY SYSTEMS**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	Solar Energy-Introduction to solar energy: solar radiation, availability, measurement and estimation – Solar thermal conversion devices- water heating systems, space heating and cooling of buildings, solar cooking, solar ponds, solar green houses, solar thermal electric systems - storage of solar energy – solar cells and photovoltaic conversion – Applications of PV systems – MPPT.	**12**	**25%**
II	Wind Energy-Introduction – Basic principles of wind energy conversion – wind data and energy estimation – site selection consideration	**4**	**25%**
FIRST INTERNAL EXAM			
II	Basic components of wind energy conversion system – Types of wind machines – basic components of wind electric conversion systems - applications of wind energy – Inter connected systems.	**4**	
III	Energy from biomass: Biomass conversion technologies, photosynthesis, classification of biogas plants, Biomass Energy conversion, Energy from waste. Chemical Energy Sources-Introduction – fuel cells – principles of operation – classification of fuel cells – conversion efficiency of fuel cells. Types of electrodes, emf of fuel cell, Applications of fuel cells. Hydrogen energy: Introduction – hydrogen production – electrolysis, thermochemical methods, Westinghouse Electro-chemical	**12**	**25%**

	thermal sulphur cycle.		
SECOND INTERNAL EXAM			
IV	Energy from oceans-Introduction, ocean thermal electric conversion (OTEC), methods of ocean thermal electric power generation, open cycle OTEC system, closed OTEC cycle. Energy from tides: Basic principles of tidal power, component of tidal power plants, operation methods of utilization of tidal energy - advantages and limitations of tidal power generation. Ocean waves, energy and power from the waves, wave energy conversion devices. Geothermal energy - nature of geothermal fields, classification of geothermal sources - schematic of geothermal power plants - operational and environmental problems.	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7125	SOFT COMPUTING TECHNIQUES	3-0-0: 3	2015

PRE – REQUISITES:

1. Basics of Engineering Mathematics
2. Knowledge of MATLAB software

COURSE OBJECTIVES:

To provide an in depth knowledge about the artificial intelligence techniques and modelling of various systems using this soft computing techniques.

SYLLABUS:

Artificial Neural Networks and its applications, Fuzzy Logic controllers and applications, System identification and modelling using Least square method, Computer simulation of continuous and discrete systems, Genetic Algorithms and hybrid models.

COURSE OUTCOME:

The students will be able to

3. Model any system using soft computing techniques like ANN, Fuzzy and GA.
4. Model any hybrid systems like Neuro Fuzzy for electrical drives control.

TEXTBOOKS:

1. J S R Jang, C T Sun, Mizutani, Neuro Fuzzy and Soft Computing.
2. SRajasekharan, VijayaLakhmiPai, Neural Network, Fuzzy logic and Genetic Algorithm, PHI, 2002.

REFERNCES:

1. Simon Haykin, Neural networks.
2. David E Goldberg, Genetic Algorithms.
3. C T Lin, C S G Lee, Neural Fuzzy Systems.

COURSE PLAN			
MODULE	COURSE NO: **06 EE 7125**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**SOFT COMPUTING TECHNIQUES**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	**Neural Network:** Different architectures-supervised learning-perceptron- Adaline-Back Propagation-Unsupervised learning-Competitive learning-Kohenonself organizing network-Hebbian learning-Hopfield network- ART network-NNW applications in control, identification and pattern recognition.	**10**	**25%**
II	**Fuzzy Logic:** Basic concepts-set theoretic operations-membership function-fuzzy rules-fuzzy reasoning, fuzzy inference systems	**5**	**25%**
FIRST INTERNAL EXAM			
II	Mamdani and Sugeno type -defuzzification- fuzzy controllers-applications in electric drives.	**5**	
III	**System Identification:** Least Square Method-LSE for non linear load- Validation of simulation model-Computer simulation of continuous and discrete system using Matlab Simulink.	**11**	**25%**
SECOND INTERNAL EXAM			
IV	**Hybrid Models:** Modeling - Neuro fuzzy inference system-controllers-Back propagation through recurrent learning- Reinforced learning. Genetic Algorithms-Basic concepts-design issues-modeling hybrid models.	**11**	**25%**
END SEMESTER EXAM			

COUERSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7225	DISTRIBUTED GENERATION AND CONTROL	3-0-0:3	2015

PRE – REQUISITES

1. Electrical power system
2. Power electronics

COURSE OBJECTIVES

- To set a firm and solid foundation in distributed generation.
- To analyze the issues related with grid integration and power quality.
- To study the economic aspects and environmental issues in DG.

SYLLABUS

Distributed Generation Definition; Wind power; Solar technology; Biomass; Tidal; Micro turbine; Energy storage; Grid interconnection; Standards; Different topologies;Protection; Power islanding and power quality issues; Economic and environmental aspects.

COURSE OUTCOME

Student will be able to

- Appreciate the role of distributed generation in current scenario.
- Analyze the issues related with grid interconnection.

TEXT BOOKS

1. GD Rai, "Non Conventional Energy Sources Khanna Publishers", 2011
2. SP Sukatme, "Solar Energy – Principles of thermal collection and storage, Tata McGraw Hill, 1996

REFERENCES

1. D.Mukherjee, S.Chakrabarti, "Fundamentals of renewable energy systems "New Age International Publishers.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez "Grid Converters for Photovoltaic and Wind Power Systems ", Wiley Publishers.
3. Power Electronics and Renewable Energy Systems: Proceedings of ICPERES 2014 edited by Chinnaraj Kamalakannan, Padma Suresh, Subhransu Sekhar Dash, Bijaya Ketan Panigrahi
4. Arindam Ghosh, Gerard Ledwich "Power Quality Enhancement Using Custom Power Devices"
5. Smart Grids: Infrastructure, Technology, and Solutions edited by Stuart Borlas, CRC press, 2013
6. Stand-Alone and Hybrid Wind Energy Systems: Technology, Energy Storage and application edited by J K Kaldellis, CRC, 2010

COURSE PLAN			
MODULE	COURSE NO: **06 EE 7225**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME:**DISTRIBUTED GENERATION AND CONTROL**	**CREDITS : 3**	
	CONTENTS	**Contacthrs**	**End Sem Marks %**
I	Distributed Generation Definition– Wind Power– wind turbine and rotor types, wind speed –power curve – power coefficient – Tip speed ratio – wind energy distribution. Photovoltaic – Solar cell technology – Photovoltaic power characteristics – MPPT – Applications of PV Systems – solar energy collectors and storages– Biomass Power – Fuel cells types –Tidal power generation schemes–different types – mini and micro hydro power schemes – Energy Storage for use with Distributed Generation – Battery Storage – Capacitor Storage – ultra capacitors – Mechanical Storage – Flywheels – Pumped and Compressed Fluids	**12**	**25 %**
II	Standards of interconnection –Power electronic converters in PV, wind power generation – Various control techniques for power converters (Inverters, converters) in grid interactive and stand–alone applications.	**4**	**25 %**
FIRST INTERNAL EXAM			
II	Phase locked loops – synchronization and phase locking techniques – current control. Protection of the converter – DC bus control during grid faults – converter faults during grid parallel and stand – alone operation	**6**	

III	Intentional and unintentional islanding of distribution systems – Various islanding issues –anti islanding schemes – Active – Passive.	**5**	**25 %**
SECOND INTERNAL EXAM			
III	Reactive power support using DG – Power quality issues in DG environment – voltage dip – Voltage fluctuation – Flicker – Harmonics	**5**	
IV	Economic aspects of DG– Generation cost, investment – Hybrid energy systems – integrated wind – solar systems –Wind–diesel systems–Distributed generation in the Indian scenario – case studies– permanent magnet alternators – self–excited induction generators –. Merits and demerits of DG.	**10**	**25 %**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7325	HIGH VOLTAGE DC TRANSMISSION	3-0-0: 3	2015

PRE – REQUISITES:

1. Fundamental knowledge of electrical power systems

COURSE OBJECTIVES:

1. Enable the students to compare HVAC and HVDC transmission systems and explain the advantages and disadvantages of both.
2. Provide an in depth knowledge about the various parts of a typical HVDC transmission system.
3. Provide an indepth knowledge about the performance of HVDC transmission systems, the methods of control and protection.

SYLLABUS

Comparison between HVAC and HVDC transmission, Analysis and characteristics of HVDC Converters, Principle of DC link control, Protection of DC lines.AC and DC filters, MTDC systems, Simulation of HVDC systems.

COURSE OUTCOME:

The students will be able to

1. Explain the applications of HVDC transmission systems and their advantages over the conventional HVAC transmission systems.
2. Explain the different components of HVDC transmission systems and their applications.
3. Simulate HVDC transmission systems using suitable simulation software.

TEXTBOOKS:

1. K.R.Padiyar, " HVDC Power Transmission Systems"- New Age International

REFERENCES:

1. E.W .Kimbark, " Direct Current Transmission", Vol I (New York)- John Wiley
2. E.Uhlmann, "Power Transmission by Direct Current", Springer– Verlag
3. J.Arrillaga, "High Voltage Direct Current Transmission", (London) Peter Peregrinus.

COURSE PLAN			
MODULE	COURSE NO:**06 EE 7325**	**L – T – P : 3 – 0 – 0**	
	COURSE NAME: **HIGH VOLTAGE DC TRANSMISSION**	**CREDITS : 3**	
	CONTENT	**Contact hrs**	**End Sem Marks %**
I	DC power transmission – comparison of AC and DC transmission – Economics of Power transmission – Technical performance – Advantages and disadvantages of DC transmission – Reliability – Application of DC transmission. Types of DC links. Converter Station – Converter Units. Planning for HVDC transmission – Choice of voltage level – Modern trends in DC transmission. Thyristor valve – valve firing – valve design consideration – Grading and dampercircuit design – valve protection. Valve tests – Dielectrical and operational tests.	**10**	**25%**
II	HVDC Converters – Analysis, Pulse number. Choice of Converter configuration – valve rating – transformer rating Graetz circuits (simplified analysis only) - with and without overlap. Analysis of 2&3 valve conduction mode and 3 &4 valve conduction mode	**7**	**25%**
FIRST INTERNAL EXAM			
II	Converter bridge characteristics – Rectifier and Inverter characteristics of a 6 pulse and 12 pulse converter	**4**	
III	Principles of DC link control. Converter control characteristics – modification of control characteristics – system control hierarchy- firing angle control- individual phase control – equidistant pulse control. Current and extinction angle control. Starting and stopping of Dc link – power control. Stabilization of AC ties. Converter faults and protection – Converter faults, protection against over current and voltages in a converter station – Surge arrestor- protection against over voltage.	**11**	**25%**
SECOND INTERNAL EXAM			
	Smoothing reactors – DC lines – DC line insulators – DC		

IV	breakers – basic concept, characteristics, types and applications. Sources of reactive power- static VAR systems- Thyristor controlled reactor – Types of AC filters (Basic concept only)- DC filters – Carrier frequency and RI noise. Multiterminal DC system –Potential. Application and type. Modeling of DC network. Simulation of HVDC system – system simulation – philosophy and tools only.	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7425	ENERGY AUDITING,CONSERVATION AND MANAGEMENT	3-0-0: 3	2015

PRE – REQUISITES:

1. Energy Management and Auditing covered in Power Generation and Distribution
2. Economic Aspects involved in Power Generation and Distribution
3. Basic Electrical Engineering

COURSE OBJECTIVES:

To provide an overview about Energy Auditing ,Energy efficient control of Electric motors and drives, Transformer loading effect and analysis , Electrical Energy conservation and management in industrial lighting

SYLLABUS

Electrical energy audit ; Electric Motors -Energy efficient controls and analysis; Transformer Loading and Efficiency analysis; Peak Demand controls; Electrical Energy conservation in industrial lighting; Energy efficiency and demand management.

COURSE OUTCOME:

The students will be able to

1. Conduct Energy Auditing
2. Will be able to suggest a suitable motor and suitable drive for a specific application
3. Will be able to suggest the effective loading of a transformer, and exact location of the capacitor so that required reactive compensation is obtained.
4. Will be able suggest energy efficient lighting system.

REFERNCES:

1. Donald R. Wulfingoff, “Energy Efficiency Manual”, Energy Institute Press, 1999.
2. Sreejith.P.G., “Electrical Safety Auditing”, Electrical India, May’04, pp.38-46.
3. Albert Thumann, Handbook of Energy Audits, Fairmont Press 5th Edition, 1998
4. Handbook on Energy Audit and Environment Management, Y P Abbi and Shashank

Jain, TERI, 2006

5. http://www.keralaenergy.gov.in/pdf/EMC%20Energy%20Audit%20Draft%20Manual.pdf
6. Ashok Bajpai, "Key Role of Energy Accounting and Audit in Power System", Electrical India, Apr'04, pp.38-47.
7. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2nd edition (1994)
8. Sasi.K.K. & Isha.T.B., "Energy Conservation in Industrial motors", Electrical India, Apr'04,pp.48-51.
9. Howard E. Jordan, Energy-Efficient Electric Motors and their Applications, Pleneum Pub Corp. 2nd edition, 1994
10. Anthony J. Pansini, Kenneth D. Smalling, Guide to Electric Load Management., Pennwell Pub; (1998)
11. http://www.keralaenergy.gov.in/pdf/EMC%20Energy%20Audit%20Draft%20Manual.pdf
12. Thokal.S.K., "Electrical Energy Conservation by Improvement of Power factor", Electrical India, Jul'04,pp.38-41.
13. Tripathy S.C., "Electrical Energy Utilization and Conservation", TMH, 1991.
14. Openshaw Taylor E., "Utilisation of Electric Energy", Orient Longman Ltd, 2003
15. Dr .Omprakash G. Kulkarni, "Load End Energy Management", Electrical India – December, Annual Issue, 2004.pp.58-67.
16. http://www.keralaenergy.gov.in/pdf/EMC%20Energy%20Audit%20Draft%20Manual.pdf

<table>
<tr><th colspan="4">COURSE PLAN</th></tr>
<tr><td rowspan="3">MODULE</td><td>COURSE NO:06 EE 7425</td><td colspan="2">L – T – P : 3 – 0 – 0</td></tr>
<tr><td>COURSE NAME: ENERGY AUDITING CONSERVATION AND MANAGEMENT</td><td colspan="2">CREDITS : 3</td></tr>
<tr><td>CONTENTS</td><td>Contact hrs</td><td>End Sem Marks %</td></tr>
<tr><td>I</td><td>Electrical energy audit – tools forelectrical energy audit - billing elements - tariff system, energy and demand charge, electrical demand and load factor improvement, power factor correction, power demand control, demand shifting – Electrical Safety Auditing.</td><td>11</td><td>25%</td></tr>
<tr><td>II</td><td>Electric motor:Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis- Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors.</td><td>6</td><td rowspan="3">25%</td></tr>
<tr><td colspan="2">FIRST INTERNAL EXAM</td></tr>
<tr><td>II</td><td>Variable speed drives: Pumps and Fans-Efficient Control strategies- Optimal selection and sizing -Optimal operation and Storage; Case study</td><td>5</td></tr>
<tr><td>III</td><td>Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power management: Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance, case study.
Peak Demand controls- Methodologies-Types of Industrial loads-Optimal Load scheduling-case study.</td><td>10</td><td>25%</td></tr>
<tr><td colspan="4">SECOND INTERNAL EXAM</td></tr>
<tr><td></td><td>Electrical Energy conservation in industrial lighting- Choice of lighting - energy saving – control of lighting -</td><td></td><td></td></tr>
</table>

IV	lighting standards – light meter audit - methods to reduce costs – summary of different lighting technologies – Case Studies. Energy efficiency and demand management-Basic concepts – Co-generation – importance of demand side management – virtues of DSM – efficiency gains - estimation of energy efficiency potential, cost effectiveness, payback period, barriers for energy efficiency and DSM – Case Studies.	**10**	**25%**
END SEMESTER EXAM			

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7035	SEMINAR II	0-0-2: 2	2015

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

To improve presentation skills and searching ability of research publications in the relevant area of specialization

SYLLABUS:

The student has to register for the seminar and select a topic in consultation with any of the faculty members in the department (or the faculty member offering courses for the programme).

A detailed report on the topic of seminar is to be prepared in the prescribed format given by the department. The seminar shall be of 30 minutes duration and a committee with the Head of the Department as the chairman and two faculty members from the department as members shall evaluate the seminar based on the coverage of the topic, presentation and ability to answer the questions put forward by the committee.

COURSE OUTCOME:

Takers will

(1) Improve the searching ability to find research publications in the area of specialization
(2) Be aware of recent developments in the area of specialization
(3) Improve their presentation skills

Reference:

IEEE Xplore , Elsevier- Science Direct, Springer Journals etc

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7045	PROJECT PHASE I	0-0-12: 6	2015

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

(1) Conduct literature survey in the area of specialization

(2) Select a research topic based on literature survey

(3) Simulation of the selected research topic

SYLLABUS:

The project (phase-I) shall consist of research work done by the student or acomprehensive and critical review of any recent development in the subject or adetailed report of project work consisting of experimentation/numerical work, design and/or development work that the student has executed.

In phase-I, the student should decide a topic of project, whichis useful in the field or practical life. The student should refer national andinternational journals, proceedings of national and international conferences. Emphasisshould be given to the introduction to the topic, literature review, and scope of theproposed work along with some preliminary work / experimentation carried out on the project topic.

Student should submit two copies of Phase-I project report covering the content mentioned above and highlighting the features of work to be carried out in part-I of the project. The studentshould follow standard practice of thesis writing.

The student will deliver a presentation on the project work and the assessment will be made by a panel of internal examiners one of which will bethe Project Supervisor (internal guide). These examiners may give suggestions in writing to the student to be incorporated in project (phase-II).

Project evaluation weights shall be as follows:-

Project Progress evaluation: 50 Marks

Progress evaluation by the Project Supervisor : 20 Marks

Presentation and evaluation by the committee : 30 Marks

COURSE OUTCOME:

Students will be able to

(1) Simulate and analyze the research topic

(2) Identify the drawback of the simulated system

(3) Propose solutions to improve the performance of the system

REFERENCES:

(1) IEEE Xplore , Elsevier- Science Direct, Springer Journals etc

(2) Simulation tools – MATLAB/ Simulink , PSIM, P Spice, PSCAD etc

SEMESTER -IV

COURSE NO:	COURSE NAME	CREDITS	YEAR
06 EE 7016	PROJECT PHASE II	0-0-21: 12	2015

PRE – REQUISITES: Project phase I

COURSE OBJECTIVES:

(1) Hardware implementation of project phase I simulation

(2) Publish research work in a reputed Conference and/or journal

SYLLABUS:

In the fourth semester the student has to continue the project (phase-I). After the successful completion of the work the student should submit a detailed report (Thesis).

The work carried out should lead to a publication in a National / International Conference.

Specific weightage will be given to the papers accepted in reputed Conferences/Journals at the time of final project evaluation.

Project evaluation weights shall be as follows:-

Total Marks: 100 Marks

Project evaluation by the supervisor/s : 30 Marks

Evaluation by the External expert : 30 Marks

Presentation & evaluation by the Committee : 40 Marks

COURSE OUTCOME:

Students will be able to

(1) analyze and implement the research work

(2) publish the research work in a reputed conference and/or journal

REFERENCES:

(1) IEEE Xplore , Elsevier- Science Direct, Springer Journals etc

(2) Hardware – IEEE standards, data sheets of Microchip/Texas Instruments/Atmel make microcontrollers, IC's etc.