PONDICHERRY ENGINEERING COLLEGE, PUDUCHERRY – 605 014

CURRICULUM AND SYLLABI FOR AUTONOMOUS STREAM

M.TECH. (ELECTRICAL DRIVES AND CONTROL) COURSES

(FOR STUDENTS ADMITTED FROM ACADEMIC YEAR 2015-16 ONWARDS)

CURRICULUM

I SEMESTER

Subject Code	Subjects	Category	Periods			Marks			Credits
			L	T	P	CA	SE	TM	
MA156	Mathematics	TY	3	1	0	40	60	100	4
EE151	Modern Control Theory	TY	3	1	0	40	60	100	4
EE152	Power Electronic Circuits and Systems	TY	3	1	0	40	60	100	4
EE153	Solid State Controlled Electrical Drives	TY	3	1	0	40	60	100	4
	Elective-I	TY	3	1	0	40	60	100	4
	Elective-II	TY	3	1	0	40	60	100	4
EE154	Solid State Systems Laboratory	LB	0	0	3	60	40	100	2
Total Credits									**26**

II SEMESTER

Subject Code	Subjects	Category	Periods			Marks			Credits
			L	T	P	CA	SE	TM	
EE155	Digital Control and Controller Design	TY	3	1	0	40	60	100	4
EE156	Vector Controlled AC Drives	TCM	3	0	2	50	50	100	4
	Elective-III	TY	3	1	0	40	60	100	4
	Elective-IV	TY	3	1	0	40	60	100	4
	Elective-V	TY	3	1	0	40	60	100	4
	Elective-VI	TY	3	1	0	40	60	100	4
EE157	Electrical Drives Laboratory	LB	0	0	3	60	40	100	2
EE158	Research Methodology	PR	0	0	3	100	-	100	1
Total Credits									**27**

III SEMESTER

Subject Code	Subjects	Category	Periods			Marks			Credits
			L	T	P	CA	SE	TM	
EE159	Project Phase - I	PR				150	150	300	9
Total Credits									**9**

IV SEMESTER

Subject Code	Subjects	Category	Periods			Marks			Credits
			L	T	P	CA	SE	TM	
EE160	Project Phase - II	PR				200	200	400	14
	Professional Development Courses (Two One Credit Courses)	PR				200		200	2
Total Credits									**16**

A representative list of processional development courses is given below:

a) Industrial training (Limited to one credit)
b) Specific field knowledge training (Limited to a maximum of two credits)
c) Seminar related with directed study (Limited to a maximum of two credits)
d) Paper presentation in SCI journals (Limited to one credit)

#CA-Continuous Assessment, SE-Semester examination, TM-Total marks,
*TY-Theory, TCM=Theory with mini project, LB-Laboratory, PR-Practice

LIST OF ELECTIVES

Sl. No.	Subject Code	Subjects	Category
1	**EEE51**	Adaptive Control Theory	TY
2	**EEE52**	Advanced Digital Signal Processing	TY
3	**EEE53**	Diagnosis and Protection for Solid State Systems	TY
4	**EEE54**	Embedded Systems	TY
5	**EEE55**	Flexible AC Transmission System Controllers	TY
6	**EEE56**	FPGA Based System Design	TY
7	**EEE57**	Fuzzy Control	TY
8	**EEE58**	Modern Power Electronic Converters	TY
9	**EEE59**	Neural Networks	TY
10	**EEE60**	Nonlinear Control Systems	TY
11	**EEE61**	Optimal Control Theory	TY
12	**EEE62**	Power Electronics in Power Systems	TY
13	**EEE63**	Power Quality	TY
14	**EEE64**	Wind Energy Conversion Systems	TY
15	**EEE65**	Special Electrical Machines	TY

SYLLABUS (Core Subjects)

Department : Mathematics		**Programme:** M.Tech. (Electrical Drives and Control)						
**Semester : ** One		**Category : ** TY						
Subject Code	**Subject Name**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
MA156	Mathematics	3	1	0	4	40	60	100
Prerequisite								
Objectives	• To introduce LPP ideas • To familiarize the students with ideas of Linear algebra • To introduce stochastic problem							
Outcome	• Understand LPP • Understand vector space and transformation can able to apply random process							

UNIT – I	**Vector Spaces**	**Hours: 9**

Vector spaces, subspaces, span of a set, linear independence and dependence, Dimension and Bases, inner product spaces - Gram-Schmidt orthogonalization.

UNIT – II	**Linear Transformations**	**Hours: 9**

Definition and examples, Range and Kernel of a linear map, rank and nullity, Inverse of a linear transformation, consequences of Rank-Nullity theorem, the space L (U, V), composition of linear maps, Matrix associated with a linear map and linear map associated with a matrix.

UNIT – III	**Linear Programming**	**Hours: 9**

Basic concepts – Graphical and Simplex methods - Big M-techniques – Two Phase methods.

UNIT – IV	**Dynamic and Quadratic Programming**	**Hours: 9**

Dynamic Programming – Solutions of Problems using dynamic programming techniques – Definitions of convex programming - Kuhn Tucker conditions – Quadratic Programming – Wolf's Method.

UNIT – V	**Random Process**	**Hours: 9**

Stochastic Process – Classification of Stochastic process - Poisson process -Gaussian process - Markov chains - Auto correlation - Cross correlation

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours: 60**

Text Books:

1. V. Krishnamurthy, V.P. Maiwa and J.L.Arora, "An Introduction to Linear Algebra", Affiliated East West Press Pvt. Ltd., New Delhi.
2. H.A.Taha, "Operations Research – An Introduction", Mac Millian Publishing Co., 1982.

Reference Books:

1. J.C.Pant, "Optimization and Operations Research", Jain Publishers, New Delhi.
2. Kishore S Trivedi, "Probability and Statistics with Reliability, Queuing and Computer Science Applications", John Wiley & Sons, 2002.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
**Semester : ** One		**Category : ** TY						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EE151	Modern Control Theory	3	1	0	4	40	60	100
Prerequisite								

Objectives

- The modeling of dynamic system in state space
- To analyze the dynamic system for controllability and observability
- The design of pole placement controller and state observers
- The stability of dynamic systems using Liapunov method
- To formulate the optimal control problems and solve them

Outcome

- Model any dynamic system using state space approach
- Analyze the dynamic systems for controllability, observability and stability
- Design controller and observer for systems modeled in state space
- Solve optimal control problems and design optimal controller

UNIT – I | **Introduction to State Space Approach** | **Hours: 9**

Modeling of physical systems using state space approach – advantages of state space approach over transfer function model. State diagram, state space and state trajectory – state space realization – controllable, observable, diagonal and Jordan canonical forms – Similarity transformation – Transformation into various canonical realizations. Solution of Linear Time Invariant (LTI) state equation – state transition matrix and its properties – computational techniques.

UNIT – II | **State Space Analysis** | **Hours: 9**

Eigen values and Eigen vectors – Cayley Hamilton theorem – minimal polynomial concept – Controllability and Observability – Tests – Kalman decomposition technique.

UNIT – III | **State Feedback Controller Design** | **Hours: 9**

Controller design by state feedback –Necessary and Sufficient condition forarbitrary pole placement- state regulator problem. Tracking (Servo) problem – State feedback with integral control. Eigen structure assignment. Observer Design – Full order/reduced order observer design – observer based state feedback control – separation principle.

UNIT – IV | **Stability Analysis** | **Hours: 9**

Stability concepts – BIBO Asymptotic stability - stability definitions in state space domain – stability theorems on local and global stability – Lyapunov stability analysis - Krasovskii Method.

UNIT – V | **Optimal Control** | **Hours: 9**

Linear quadratic optimal regulator (LQR) problem formulation – optimal regulator design by parameter adjustment (Lyapunov method) – optimal regulator design by Continuous - time Algebraic Riccatti Equation (CARE) - Introduction to Kalman filter – optimal controller design using LQG framework.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours: 60**

Text Books:

1. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India pvt. Ltd., New Delh, 1989.
2. Katsuhiko Ogata, "State Space Analysis of Control Systems", Prentice Hall Inc., New Jersey, 1967.

Reference Books:

1. Biswa Nath Datta, "Numerical Methods for Linear Control Systems", Elsevier, 2005.
2. Gene.F.Franklin, J.David Powell and Abbas Emami-Naeini, "Feedback Control of Dynamic Systems", Pearson Edu. Asia, 2002.
3. Chi-Tsong chen, "Linear System Theory and Design", Oxford Press, 1999.

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester : One</td><td colspan="7">Category : TY</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EE152</td><td>Power Electronic Circuits and Systems</td><td>3</td><td>1</td><td>0</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td>Objectives</td><td colspan="8">• To learn and design natural and forced commutated Power converters
• To learn various switching techniques</td></tr>
<tr><td>Outcome</td><td colspan="8">• Able to design and analyze the performance of various power electronics circuits.
• To construct improved converter topologies for specific applications</td></tr>
<tr><td>UNIT – I</td><td colspan="5">Natural Commutated Converters</td><td colspan="3">Hours: 9</td></tr>
<tr><td colspan="9">Single phase and three phase controlled rectifier – operation and performance analysis of half and fully controlled converter with RL, RLE loads with and without freewheeling diodes - converter - inverter operation - effect of source impedance -inverter limit - performance at input and output – harmonics - ripple. Load commutated and forced commutated operations – various modes, Dual converters, higher pulse converters.</td></tr>
<tr><td>UNIT – II</td><td colspan="5">Cyclo-Converter and Voltage Controller</td><td colspan="3">Hours: 9</td></tr>
<tr><td colspan="9">Principle of operation of cycloconverters - three phase to single phase - three phase to three phase - input and output performances - output voltage and frequency ranges - harmonics - pulse generation and controls for cycloconverter. Introduction to bi-directional switches - Single phase and three phase ac voltage controller - output voltage control – phase angle range – per unit plot for various loads - input and output performance – gating requirements – harmonics.</td></tr>
<tr><td>UNIT – III</td><td colspan="5">Forced Commutated Converters</td><td colspan="3">Hours: 9</td></tr>
<tr><td colspan="9">DC choppers - operation of choppers - forced commutated principle - voltage and current commutated choppers - choice of commutation circuit element – class A, B, C, D and E choppers – chopper design – applications – design principles. Inverters - Single phase forced commutated inverter – voltage source – current source - analysis with R and RL loads – applications - design principles.</td></tr>
<tr><td>UNIT – IV</td><td colspan="5">Modulation Techniques</td><td colspan="3">Hours: 9</td></tr>
<tr><td colspan="9">Single-phase inverters: Principle of operation of half and full bridge inverters –Performance parameters – Voltage control - various PWM techniques – square wave– SPMW – unipolar – bipolar operation - Discontinuous PWM - low and high frequency switching operation – performance comparison. Three-phase inverters: Principle of operation of 180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters - Voltage control techniques – SVPWM – Multiphase inverter operation for high power.</td></tr>
<tr><td>UNIT – V</td><td colspan="5">High Power Applications</td><td colspan="3">Hours: 9</td></tr>
<tr><td colspan="9">High power converters - higher pulse operation - series connected – parallel connected converters - high power inverters - phase shifted operation – parallel connected – cascaded connected inverters – inverters with/without transformer –design of high power converters and inverters. Introduction to multilevel inverters - diode clamped, flying capacitor, cascade type multilevel inverters -comparison of multilevel inverters – applications</td></tr>
<tr><td colspan="2">Total contact Hours: 45</td><td colspan="2">Total Tutorials: 15</td><td colspan="3">Total Practical Classes:</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="9">Text Books:</td></tr>
<tr><td colspan="9">1. M.D.Singh and K.B.Khanchandani, “Power Electronics”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003.
2. M.H. Rashid, “Power Electronics Circuits, Devices and Applications”, Prentice Hall India, New Delhi, 2004.
3. 3. Mohan, Underland and Robbins, “Power Electronics”, John Wiley &Sons, 1995</td></tr>
<tr><td colspan="9">Reference Books:</td></tr>
<tr><td colspan="9">1. Cyril Lander, “Power Electronics, McGraw Hill International Edition, 1993.
2. Derek A. Paice, “Power Electronics Converter Harmonics: Multi-pulse Methods for Clean Power”, Wiley-IEEE Press, 1999.
3. D.Grahame Holmes, Thomas A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, Wiley-IEEE Press.
4. J.Arrillaga, Yonghe H. Liu, N.R. Watson, N.J. Murray, Self-Commutating Converters for High Power Applications”, John Wiley & Sons, 2009.</td></tr>
</table>

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester : One		**Category : TY**						
Course Code	**Course Name**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EE153	Solid State Controlled Electrical Drives	**3**	**1**	**0**	**4**	**40**	**60**	**100**
Prerequisite:								
Objectives:	• To learn converter and chopper control of dc drives • To learn the concept of closed loop control of AC and DC drives • To learn about digital control of drives							
Outcome:	• Ability to determine the characteristics of drives • Ability to design converter fed dc drives and chopper fed dc drives • Ability to design of closed loop control of drives							
UNIT – I	**Speed Control of DC Motors**				**Hours: 9**			
Industrial motor drive requirements - typical load torque speed curves – energy savings - variable speed drives - load dynamics and modeling - load type and duty ratio - motor choice - speed control principles - constant torque - constant power – multi quadrant operations. Solid state controlled DC motor - converter fed - chopper fed – operating modes –configurations - speed control – torque control – speed reversal - braking -regeneration - closed loop regulation - Inching – jogging – effect of saturation.								
UNIT – II	**Design of Controller and Converter for DC Drives**				**Hours: 9**			
Closed loop operation - speed regulation – speed loop - current loop – tracing of waveforms – speed reversal – torque reversal – with/ without braking and regeneration – design of converters and choppers - firing scheme - simulation. Modeling of dc motors, converters, choppers - controller design, speed controller, current controller – performance analysis with and without current controller - simulation.								
UNIT – III	**Speed Control of Induction Motor–Stator Side**				**Hours: 9**			
Comparison of different ac power controllers – principles of speed control – variable voltage - variable frequency operation – constant flux operation - constant power operation – speed control of VSI and CSI fed drives - design examples. Closed loop control schemes - dynamic and regenerative braking - speed reversal – tracing of critical waveforms - effect of non- sinusoidal supply.								
UNIT – IV	**Speed Control of Induction Motor–Rotor Side**				**Hours: 9**			
Torque slip characteristics – speed control through slip - rotor resistance control- chopper controlled resistance – equivalent resistance – TRC strategy – characteristic relation between slip and chopper duty ratio - combined stator voltage control and rotor resistance control – design solutions – closed loop control scheme. Slip power recovery - torque slip characteristics - power factor considerations – sub and super synchronous operation - design solutions - closed loop control scheme.								
UNIT – V	**Speed Control of Synchronous Motor Drives**				**Hours: 9**			
Need for leading PF operation - open loop VSI fed drive – group drive applications. Self-control – margin angle control - torque angle control - power factor control -simple design examples Closed loop speed control scheme with various power controllers - starting methods– brush less excitation systems								
Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**				**Total Hours:60**		
Text Books:								
1. G.K.Dubey, “Power semiconductor controlled devices”, Prentice Hall International New Jersey, 1989. 2. R.Krishnan, “Electric Motor Drives –Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003. 3. J.M.D Murphy, F.G.Turnbull, “Thyristor control of AC motors, Pergamon Press, Oxford, 1988.								
Reference Books:								
1. Bin Wu, “High-Power Converters and AC Drives”, Wiley-IEEE Press. 2. Buxbaum, A.Schierau, and K.Staughen, “A design of control systems for DC drives”, Springer-Verlag, 1990. 3. Bimal K.Bose, “Modern Power Electronics and AC Drives”, Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003. 4. Jean Bonal and Guy Seguier, “Variable Speed Electric Drives, Lavoisier c/o Springer verlag, May, 2000. 5. Werner Leonhard, Control of Electrical Drives, 3 rd Edition, Springer, Sept., 2001. 6. AustinHughes, Newnes, Electric Motors and Drives: Fundamentals, Types and Applications, Jan 2006.								

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester : One</td><td colspan="7">Category : LB</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EE154</td><td>Solid State Systems Laboratory</td><td>-</td><td>-</td><td>3</td><td>2</td><td>60</td><td>40</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td>Objectives</td><td colspan="8">To provide a practical understanding of some of the concepts learnt in the theory course on electrical Drives.</td></tr>
<tr><td>Outcome</td><td colspan="8">The Students would have gained practical experience about some of the Theoretical concepts learnt in the electrical Drives.</td></tr>
</table>

List of Experiments:

Design and validation of solid state systems choosing any ten systems as listed below

1. Firing Pulse Generation Schemes for Two Pulse and Six Pulse Converters
2. Power Factor Improvement Methods
3. Higher-Pulse Converters
4. Thyristor Controlled Reactor
5. Thyristor Switched Capacitor
6. Thyristor Controlled Series Compensator
7. Three/Six Phase Delta Connected Thyristor Controlled Reactor
8. Static Tap Changing of Transformer
9. DC-DC Converters
10. Three Phase Voltage Source Inverter
11. Single Phase Sinusoidal PWM Inverter
12. Multi-Level Inverters

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester : Two</td><td colspan="7">Category : TY</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EE155</td><td>Digital Control and Controller Design</td><td>3</td><td>1</td><td>0</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">Modern Control Theory</td></tr>
<tr><td>Objectives</td><td colspan="8">• Basics of digital control systems
• The modeling of digital control system using state space approach
• The analysis of digital control system for controllability and observability
• The design of controllers using classical and state space approaches
• The stability of dynamic systems using Liapunov method
• To formulate the optimal control problems and solve them</td></tr>
<tr><td>Outcome</td><td colspan="8">• Understand the digital control concepts
• Model any sampled data system using state space approach
• Analyze the discrete time systems for controllability, observability and stability
• Design classical and pole placement controller and observer for systems modeled in state space
• Solve discrete time optimal control problems</td></tr>
<tr><td>UNIT – I</td><td colspan="4">Introduction</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Introduction to discrete time control system - Sampling and holding - sample and hold device - D/A, A/D conversion – sampling theorem – data interpolation – Z transform –properties - inverse Z transform - Pulse transfer function.</td></tr>
<tr><td>UNIT – II</td><td colspan="4">State Variable Technique</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">State equations of discrete time systems – solution of state equation – state transition matrix, its properties – state space realization and state diagram – pulse transfer function from state equation - characteristic equation - Eigen values -Eigen vectors - Similarity transformation – transformation into various canonical forms.</td></tr>
<tr><td>UNIT – III</td><td colspan="4">Controllability, Observability and Stability</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Controllability and observability of Llinear Time Invariant (LTI) discrete data systems – tests for controllability and observability - relationship between controllability, observability and pulse transfer functions. Stability of LTI discrete time systems - Jury’s stability tests – Bilinear transformation method - Lyapunov stability analysis.</td></tr>
<tr><td>UNIT – IV</td><td colspan="4">Controller Design – I</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Correlation between root locations in Z-plane and time response - direct digital design in Z and W plane (under bilinear transform)PID controllers – proportional, integral and derivative modes – discretization of continuous PID controller – conventional tuning procedures – Reaction curve method of Ziegler Nichols – stability method of Ziegler Nichols.</td></tr>
<tr><td>UNIT – V</td><td colspan="4">Controller Design – II</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">State feedback - Design via pole placement – observer based state feedback -Introduction to digital redesign - optimal controllers – quadratic optimal control –steady state quadratic optimal control –optimal state estimation – Kalman filter -Extended Kalman filter.</td></tr>
<tr><td colspan="2">Total contact Hours: 45</td><td colspan="2">Total Tutorials: 15</td><td colspan="3">Total Practical Classes:</td><td colspan="2">Total Hours:60</td></tr>
<tr><td colspan="9">Text Books:</td></tr>
<tr><td colspan="9">1. K.Ogata, “Discrete time control systems”, Pearson Edu., 2003.
2. Franklin, Powell, workman, “Digital control of Dynamic systems”, Pearson Edu., 2002.
3. Kannan M. Moudgalya, “Digital control”, John Willy, 2008.</td></tr>
<tr><td colspan="9">Reference Books:</td></tr>
<tr><td colspan="9">1. M.Gopal, “Digital Control and state variable methods”, Tata McGraw Hill, New Delhi, 2003.
2. Aashish Tiwari, “Modern control design with MATLAB and SIMULINK”, John Wiley and sons Ltd., 2002
3. Benjin.Kuo, ‘Digital Control systems’, 2nd Edition, Oxford University, 1992.</td></tr>
</table>

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
**Semester : ** Two		**Category : ** TCM						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EE156	Vector Controlled AC Drives	3	0	2	4	50	50	100
Prerequisite	Solid State Controlled Electric Drives							
Objectives	To introduce vector control concepts To apply vector control techniques to various AC Drives							
Outcome	Ability to incorporate closed loop control techniques using d-q transformation for various power converter applications Ability to develop high performance closed loop controller for AC drives							

UNIT – I | **Dynamic Modelling of Induction Motor** | **Hours: 9**

Dynamic modeling of induction machines- Dynamic d-q model, Axes transformation, Stationary a-b-c frame to d^s-q^s frame transformation, stationary d^s-q^s frame to synchronously rotating frame d^e-q^e transformation. Inverse transformations.

Synchronously rotating frame reference frame model-Kron equation, dynamic equivalent circuits; Stationary frame model-Stanley equations; Dynamic model state space equations. Generalized model in arbitrary, stator and rotor reference frames. Electromagnetic torque and flux linkage equations.

UNIT – II | **Direct Vector Control of Induction Motor** | **Hours: 9**

Principles of vector control- Scalar versus vector control, Vector control concept, DC motor analogy.

Direct vector control-FOC with rotor flux orientation, Flux vector estimation-voltage model and current model.

Implementations using VSI and CSI, Direct vector control of line side PWM rectifier.

UNIT – III | **Indirect and Stator Flux Oriented Vector Control of Induction Motor** | **Hours: 9**

Indirect vector control –phasor diagram, flux and slip speed estimation, implementation for servo drive with open loop flux control, synchronous current control.

Stator flux oriented control, Vector control of CSI fed drives, vector control of cycloconverter drive.

UNIT – IV | **Vector Control of Synchronous Motor Drives** | **Hours: 9**

D-q axis (Park) model of synchronous machines; Vector control of Synchronous motors – Field weakening mode; Control strategies- constant torque angle control, Unity power factor control, Constant mutual flux control, Optimum torque per ampere control and flux weakening control; Implementation using CSI.

UNIT – V | **Direct Torque Control** | **Hours: 9**

Direct torque and Flux Control- Torque expression with stator and rotor fluxes, Control strategy, DTC of Induction motor using Direct self control and space vector modulation.

Total contact Hours: 45	**Total Tutorials:**	**Total Practical Classes: 30**	**Total Hours: 75**

Text Books:

1. Bimal K.Bose, "Modern Power Electronics and AC Drives, Pearson Education (Singapore) Ltd., New Delhi, 2003.
2. R.Krishnan, Electric Motor Drives- Modeling, Analysis, and Control, Prentice-Hall of Indian Private Limited, New Delhi, 2003.

Reference Books:

1. I Boldea and S.A.Nasar, "Vector Control of AC Drives", CRC Press LLC, 1992.
2. D.W. Novotny and T.A.Lipo, "Vector control and dynamics of AC drives", Oxford Science Publications, 1996.
3. Paul, C, Krause, Oleg Wasynczuk and Scott D. Subhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Wiley Interscience, 2002.
4. Nguyen Phung Quang and Jorg-Andreas Dittrich, "Vector Control of Three- phase AC Machines", Springer-Verlag Berlin and Heidelberg GmbH & Co. KG, 2008.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
**Semester : ** Two		**Category : ** LB						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE157	Electrical Drives Laboratory	-	-	3	2	60	40	100
Prerequisite								
Objectives	To provide a practical understanding of some of the concepts learnt in the theory course on electrical Drives.							
Outcome	The Students would have gained practical experience about some of the Theoretical concepts learnt in the electrical Drives.							

List of Experiments:

Simulation study of following drive systems

1. Analysis of 1 phase angle controlled converter drives and case study on closed loop speed control.
2. Analysis of 3 phase angle controlled converter drives and case study on closed loop speed control.
3. Transfer function modelling of DC motor and design of speed and current loop feedback controllers.
4. Analysis of DC chopper drives and case study on closed loop speed control.
5. v/f control of PWM inverter based three phase Induction motor.
6. V/f control of three phased Induction motor using Cyclo-converters
7. Rotor resistance scheme in wound-rotor Induction motor.
8. Slip Power recovery scheme in Wound rotor Induction Machine.
9. Modeling of three Phase Square cage Induction Motor
10. Direct vector control of Induction Motor.
11. Modeling and control of Permanent Magnet Brushless DC motor.

***Demonstration Experiments**

1. Study of single phase Half controlled converter fed DC motor.
2. Study of three phased Inverter fed induction motor drives

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester : Two</td><td colspan="7">Category : PR</td></tr>
<tr><td rowspan="2">Subject code</td><td rowspan="2">Subject</td><td colspan="3">Hours/week</td><td>Credit</td><td colspan="3">Maximum marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EE158</td><td>Research Methodology</td><td>-</td><td>-</td><td>3</td><td>1</td><td>100</td><td>0</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">-</td></tr>
<tr><td>Objectives</td><td colspan="8">• To educate students to methods of selection of research problems
• To expose students to different research methods</td></tr>
<tr><td>Outcomes</td><td colspan="8">• Students will be capable to identify and narrow down to the area of research on the basis the requirements of industrial and global requirements
• Students will exhibit the domain skill to choose suitable research methods to execute research effectively
• Students will possess knowledge to further their academic program, namely, Ph.D program.</td></tr>
</table>

- **Definition of research:** Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Definition and Dimension of a Theory, Functions and Characteristics; Types of Theory: General Theory and Particular/ Empirical Theory. Cases and their Limitations; Causal Relations. Philosophy and validity of research. Objective of research.
- **Characteristics of research:** Various functions that describe characteristics of research such as systematic, valid, verifiable, empirical and critical approach.
- **Types of research:** Pure and applied research. Descriptive and explanatory research. Qualitative and quantitative approaches.
- **Research procedure:** Formulating the Research Problem, Literature Review, Developing the objectives, Preparing the research design including sample. Design, Sample size.
- **Considerations in selecting research problem:** Relevance, interest, available data, choice of data, Analysis of data, Generalization and interpretation of analysis.
- **Outcome of research:** Significance of report writing – Layouts of the research report – Types of reports – Oral presentation – Mechanics of writing research report – Precautions for writing research reports – Plagiarism and copy right violation – Patent writing and filing.

Total contact hours: -	Total tutorials: -	Total practical classes:15	Total hours: 15

Reference books:

1. Dawson, Catherine, Practical Research Methods, UBS Publishers and Distributors, New Delhi, 2002
2. Kothari, C.R., Research Methodology-Methods and Techniques, Wiley Eastern Limited, New Delhi, 1985.
3. Kumar, Ranjit, Research Methodology, A Step-by-Step Guide for Beginners, (2nd.ed), Pearson Education, Singapore, 2005.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
**Semester : ** Three		**Category : ** PR						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EE159	Project Phase-I	-	-	-	9	150	150	300
Prerequisite								
Objectives	To develop a solution to existing problem in Electric Drives and Control							
Outcome	The students can able to perform literature survey, indentify a problem and solve it							
Description: An individual project needs to be performed by each student under a supervisor. Specific research problem needs to be identified through detailed literature survey. The theoretical/simulation study needs to be carried out. The results along with the literature survey have be submitted as a report.								

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester : Four</td><td colspan="7">Category : PR</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EE160</td><td>Project Phase-II</td><td>-</td><td>-</td><td>-</td><td>14</td><td>200</td><td>200</td><td>400</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td>Objectives</td><td colspan="8">• To develop an additional solution or further improvement to the problem identified in Phase -I</td></tr>
<tr><td>Outcome</td><td colspan="8">• The students can able to compare their results with the state of the art contributions.
• Can provide improvements, perform an application specific design and development of proto-type models</td></tr>
<tr><td colspan="9">Description: The problem identified in the Phase-I may be further investigated. The improved solution may be provided. The prototype system may be developed with appropriate design. A separate report needs to be submitted.</td></tr>
</table>

SYLLABUS (Elective Subjects)

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE51	Adaptive Control Theory	3	1	0	4	40	60	100
Prerequisite								

Objectives

- To understand the basics of adaptive control
- To understand the concept of model reference adaptive systems
- To know the adaptation mechanisms such as auto-tuning and gain scheduling
- To know few applications of adaptive control

Outcome:

- Understands the model reference adaptive systems
- Know the auto-tuning and gain scheduling methods
- Understands the applications of adaptive control concepts to physical systems

UNIT – I	**Modeling and Simulation**	**Hours: 9**

Linear Feedback. Effect of process variations. Classifications of Adaptive control- Modeling , Frequency , Impulse, Step Response methods. Simulations of 1stand 2nd order systems.

UNIT – II	**Identification Technique**	**Hours: 9**

Off-line. on line methods . Least square. Recursive least square, fixed memory .maximum likelihood. Instrumental variable. Stochastic approximate method.

UNIT – III	**MRAS & STC**	**Hours: 9**

Introduction . the gradient approach . MIT rule Liapunov Functions. Controlpolicies . Pole placement control. minimum variance control . Predictive control.

UNIT – IV	**Auto-Tuning and Gain Scheduling**	**Hours: 9**

ID control . auto tuning technique . Transient response methods. Methods based on relay feedback. Relay oscillations . Principle and design of gain scheduling controllers. Non linear transformations. Applications of gain scheduling.

UNIT – V	**Applications and Expert Control**	**Hours: 9**

Industrial adaptive controllers. Process control. ship steering . Adaptive signal processing. Extremum control. expert control system . Learning systems. Introduction to Neuro-Fuzzy controllers.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Karl.J.Astrom, Bjorn Wittenmark, Adaptive Control, Pearson Education, pvt. Ltd 1995.
2. Goodwin G.C Sin KS New Jersey, Adaptive Filtering, Prediction and control, Prentice Hall inc. 1984.

Reference Books:

1. Harris C.J. Billings. S.A., Self tuning and Adaptive control, Peter pereginius Ltd., 1984.
2. Isermann R, Digital Control System vol. I & II, Narosa Publishing House, Reprint 1993.
3. Mendal JM, Marcel dekkas, Discrete Technique of Parameter Estimate, New York, 1973.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category :** TY						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE52	Advanced Digital Signal Processing	3	1	0	4	40	60	100

Prerequisite

Objectives

- To understand the concepts of digital signals and systems
- To understand the design of digital filters
- To know the concept of adaptive filters and to know its applications
- To understand the concept of sampling rate alteration
- To study and understand the different Digital signal processors.

Outcome

- Analyze and classify the digital signals and systems.
- Design digital filters, adaptive filters
- Do sampling rate alterations
- Understand and choose different digital signal processors for electrical control applications

UNIT – I | **Discrete Time Signals** | **Hours: 9**

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

UNIT – II | **Digital Filter Design** | **Hours: 9**

Design of IIR filter. filter structures . Design from analog filter; Design of FIR filters - structures. windowing - Design examples.

UNIT – III | **Adaptive Digital Filters** | **Hours: 9**

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

UNIT – IV | **Application of Sampling Rate Alteration** | **Hours: 9**

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

UNIT – V | **Digital Signal Processors** | **Hours: 9**

Digital signal processors. Introduction DSP processor memory Architecture. some example of DSP processors . pipelining - overview of TMS 320 family DSP processor .First generations TMS 320eix to sixth generation TMS 320cbx processor.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Sanjit K. Mitra, Digital signal processing: A Computer Based Approach, Tata McGraw hill Pub. Company Limited New Delhi, 2001.
2. Andreas Antoniou, Digital Filters: Analysis, Design and Application. Tata McGraw hill Pub. Company Limited New Delhi, 2001.

Reference Books:

1. Alan Oppenheim. V and Ronals W. Schafer, Digital Signal processing, Prentice Hall of India Private Limited, New Delhi, 1992.
2. Simon Haylaim and Barry van veen, Signals and systems, John wiley and sons India, 1998.
3. S.Salivahanan, Digital signal processing, Tata Mc Graw Hill Education Private Limited, New Delhi, 2010.

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester :</td><td colspan="7">Category : TY</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EEE53</td><td>Diagnosis and Protection for Solid State Systems</td><td>3</td><td>1</td><td>0</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
</table>

Objectives

- To understand the basics of adaptive control
- To understand the concept of model reference adaptive systems
- To know the adaptation mechanisms such as auto-tuning and gain scheduling
- To know few applications of adaptive control

Outcome

- Understands the model reference adaptive systems
- Know the auto-tuning and gain scheduling methods
- Understands the applications of adaptive control concepts to physical systems

UNIT – I **Protection and Fault Diagnosis of Converter Systems** **Hours: 9**

Protections to SCR based power conversion systems: devices, converters. naturally commutated converters . single and three phase converters . dual converters . cyclo-converters - higher pulse converters . forced commutated choppers/inverters. Fault diagnosis of converters: device failures - commutation failures . phase failures; Fault diagnosis of control loops: failure of controller and limiters, sensor and reference, starting and braking.

UNIT – II **Protection and Diagnosis of Solid State Devices in Power Systems** **Hours: 9**

Protections to solid state compensators/voltage regulator. TCR, TCS, SVC, TCSC, UPFC, solid state tap changer; Fault diagnosis through waveform/performance analysis of device failures, phase failures, sensor failures; Protection and fault diagnosis of filter. aging of passive components and detuning. auto tuning methods.

UNIT – III **Protection and Fault Diagnosis of Solid State DC Drives** **Hours: 9**

Protections to solid state DC drives. field failures, armature failures, commutator short/open, operations with converter/chopper failures . device, input source, filter component failures. Closed loop control failures. failure of controllers and limiters, sensor and references. Diagnosis of solid state dc drive systems faults - starting and braking.

UNIT – IV **Protection And Diagnosis Of Solid State AC Drives** **Hours: 9**

Protection to AC Machines - phase failures, slip-ring/brush failures, bearing failures; Effects of solid state converter/inverter systems failures of device, PWM modulators, input source, filter components - voltage/current ripple effects, closed loop failures: failure of controller . sensor - references. Diagnosis of solid state ac drive systems faults.

UNIT – V **Protection And Diagnosis Of HVDC, UPS And Excitation Systems** **Hours: 9**

Protection and faults in HVDC, UPS, Generator excitation systems: individual systems, multiple systems operating in parallel/series. redundancy - diagnosis of faults through characterization. Analysis of simple faults in complex solid state systems.

Total contact Hours: 45	Total Tutorials: 15	Total Practical Classes:	Total Hours:60

Text Books:

1. Mohan, Underland and Robbins, Power Electronics, John Wiley &Sons, 1995.
2. D.Grahame Holmes, Thomas A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, Wiley-IEEE Press, Year.
3. Jos Arrillaga, Yonghe H. Liu, Neville R. Watson, Nicholas J. Murray, Self-Commutating Converters for High Power Applications, John Wiley & Sons, 2009.
4. Bimal K.Bose, Modern Power Electronics and AC Drives, Pearson Education (Singapore) Ltd., New Delhi, 2003.
5. K.R.Padiyar, Facts Controllers in Power Transmission and Distribution, New Age International (P) Limited, New Delhi, 2007.

Reference Books:

1. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, John Wiley & Sons, 2010.
2. R. Mohan and R.K.Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems, IEEE

Press . A John Wiley and Sons, Inc. Publications. Year.
3. Bin Wu, High-Power Converters and AC Drives, Wiley-IEEE Press.
4. Vijay K. Sood, HVDC and FACTS Controller: Application of Static Converters in power systems, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston, 2004.
5. Vector Control of Three-Phase AC Machines: System Development in the Practice, Nguyen Phung Quang, Jörg-Andreas Dittrich, Springer, 2008.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE54	Embedded Systems	3	1	0	4	40	60	100
Prerequisite								

Objectives

- To know the concept of embedded system
- To understand the architecture of embedded system
- To know the peripherals used in embedded system
- To know the concept of RTOS
- To know the Testing and validation of embedded system

Outcome

- Understands the architecture of embedded system
- Knows the peripherals used in embedded system
- Understands the performance metrics of RTOS
- Knows the testing and validation of embedded systems

UNIT – I **Introduction to Embedded Systems** **Hours: 9**

Introduction to embedded system -Definition and Classification – Overview of Processors and hardware units in an embedded system – Software embedded into the system – Exemplary Embedded Systems – Embedded Systems on a Chip (SoC).

UNIT – II **Embedded System Architecture** **Hours: 9**

Microcontroller Architecture - Motorola 68HC11- PIC- Memory System Architecture -Caches - Virtual Memory - Memory Management Unit and Address Translation - I/0 Sub-system - Busy-wait I/0 - DMA - Interrupt driven I/0 - Co- processors and Hardware Accelerators - Processor Performance -Enhancement - Pipelining -Super-scalar Execution.

UNIT – III **Embedded Computing Platform** **Hours: 9**

CPU Bus - Bus Protocols - Bus Organization - Memory Devices and their Characteristics - RAM ROM, UVROM, EEPROM, Flash Memory - DRAM - I/O Devices - Timers and Counters -Watchdog Timers - Interrupt Controllers – DMA Controllers.

UNIT – IV **Real Time Operating Systems** **Hours: 9**

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

UNIT – V **Validation and Testing of Embedded Systems** **Hours: 9**

A/D and D/A Converters - Displays - Keyboards - Infrared devices - Component Interfacing - Memory Interfacing - I/O Device Interfacing - Interfacing Protocols - Implementation - Development Environment -Debugging Techniques - Manufacturing and Testing.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Rajkamal, “Embedded Systems Architecture, Programming and Design, Tata McGraw-Hill, First reprint Oct. 2003.
2. Embedded Systems Design, Second Edition, Steve Heath, Elsevier India Pvt.Ltd., 2007.

Reference Books:

1. Shibu K V, “Introduction to Embedded systems”, Tata McGraw Hill First print -2009.
2. David E.Simon, An Embedded Software Primer, Pearson Education Asia, 2000.
3. FrankVahid and Tony Givargis, “Embedded Systems Design – A unified Hardware /Software Introduction”, John Wiley, 2002.
4. Wayne Wolf, “Computers as Components; Principles of Embedded Computing System Design”, Morgan Kaufman Publishers, 2001.

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester :</td><td colspan="7">Category : TY</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EEE55</td><td>Flexible AC Transmission System Controllers</td><td>3</td><td>1</td><td>0</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td>Objectives</td><td colspan="8">• To emphasize the need for FACTS controllers.
• To learn the characteristics, applications and modeling of series and shunt FACTS controllers.
• To analyze the interaction of different FACTS controller and perform control coordination</td></tr>
<tr><td>Outcome</td><td colspan="8">• Ability to design and develop different various VAR compensators for transmission systems
• Able to identify optimum FACTS controller for specific application</td></tr>
<tr><td>UNIT – I</td><td colspan="4">Introduction</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.</td></tr>
<tr><td>UNIT – II</td><td colspan="4">Static VAR Compensator (SVC)</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis- Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.</td></tr>
<tr><td>UNIT – III</td><td colspan="4">THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC)</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Concepts of Controlled Series Compensation – Operation of TCSC and GCSCAnalysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC.</td></tr>
<tr><td>UNIT – IV</td><td colspan="4">Voltage Source Converter Based Facts Controllers</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Static synchronous compensator (STATCOM)- Static synchronous series compensator(SSSC)- Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies Applications.</td></tr>
<tr><td>UNIT – V</td><td colspan="4">Controllers and Their Coordination</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.</td></tr>
<tr><td colspan="2">Total contact Hours: 45</td><td colspan="2">Total Tutorials: 15</td><td colspan="3">Total Practical Classes:</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="9">Text Books:</td></tr>
<tr><td colspan="9">1. A.T.John, “Flexible AC Transmission System”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. Narain G.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, Standard Publishers, Delhi 2001.
3. V. K.Sood, “HVDC and FACTS controllers- Applications of Static Converters in Power System”, 2004, Kluwer Academic Publishers.</td></tr>
<tr><td colspan="9">Reference Books:</td></tr>
<tr><td colspan="9">1. Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.
2. K.R.Padiyar,” FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Ltd., Publishers New Delhi, Reprint 2008.</td></tr>
</table>

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester :</td><td colspan="7">Category : TY</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EEE56</td><td>FPGA Based System Design</td><td>3</td><td>1</td><td>0</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td>Objectives</td><td colspan="8">• To know various programmable logic devices
• To understand the FPGA based system design
• To know the FPGA based combinational and sequential logic designs
• To know the FPGA based large scale systems</td></tr>
<tr><td>Outcome</td><td colspan="8">• Understands various PLDs and its uses
• Ability to design FPGA based system
• Ability to design FPGA based combinational and sequential logic systems</td></tr>
<tr><td>UNIT – I</td><td colspan="4">Introduction</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Programmable Logic Devices-Types-PLA, PAL, FPGA-architectures, SRAM-based FPGAs, Permanently Programmed FPGAs, Chip I/O. Circuit Design of FPGA Fabrics. Architecture of FPGA Fabrics.</td></tr>
<tr><td>UNIT – II</td><td colspan="4">FPGA-Based Systems and VLSI Technology</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Introduction, Basic Concepts, Digital Design and FPGAs. FPGA-based system design. Manufacturing Processes, Transistor Characteristics, CMOS Logic Gates, Wires, Registers and RAM, Packages and Pads.</td></tr>
<tr><td>UNIT – III</td><td colspan="4">Combinational Logic</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">The Logic Design Process. Hardware Description Languages, combinational network delay. Power and energy optimization, arithmetic logic, logic implementation for FPGAs. Physical Design for FPGAs. The Logic Design Process.</td></tr>
<tr><td>UNIT – IV</td><td colspan="4">Sequential Machines</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">The sequential machine design process. Sequential design styles. Rules for Clocking. Performance Analysis. Power Optimization.</td></tr>
<tr><td>UNIT – V</td><td colspan="4">Large Scale Systems</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Architectures and Large Scale Systems, Behavioral Design, Design Methodologies. Design Example. Busses, Platform FPGAs, Multi-FPGA Systems, Novel Architectures.</td></tr>
<tr><td colspan="2">Total contact Hours: 45</td><td colspan="2">Total Tutorials: 15</td><td colspan="3">Total Practical Classes:</td><td colspan="2">Total Hours:60</td></tr>
<tr><td colspan="9">Text Books:</td></tr>
<tr><td colspan="9">1. Wayne Wolf, “FPGA-Based System Design”, Prentice Hall, 2004.
2. Wayne Wolf, “Modern VLSI Design”, Pearson Education 2002.</td></tr>
<tr><td colspan="9">REFERENCE BOOKS</td></tr>
<tr><td colspan="9">1. Michael D Ciletti, “Advanced Digital Design with Verilog HDL”, Pearson Education 2005
2. Verilog HDL, Samir Palnitkar, Pearson Education 2005.
3. J Bhaskar, “A Verilog HDL Primer”, B S Publications, 2007.
4. Kevin Skahill, “VHDL for Programmable Logic, Pearson Education, 2004.</td></tr>
</table>

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE57	Fuzzy Control	3	1	0	4	40	60	100
Prerequisite								

Objectives

- To understand fuzzification and defuzzification
- To know the design of fuzzy logic control
- To study few design examples of fuzzy control
- To understand the applications of fuzzy logic to nonlinear analysis and identification of system
- To know the applications of fuzzy logic to adaptive and machine learning controls

Outcome

- Knows the concept of fuzzy logic, fuzzification and defuzzification methods
- Able to design fuzzy logic controllers
- Able to use fuzzy logic for nonlinear analysis and identifications
- Know the application of fuzzy logic to adaptive control

UNIT – I	**Introduction**	**Hours: 9**

Crisp Sets, Fuzzy Sets, Linguistic Variables, Values and Rules, Rule Base, Fuzzification, Membership Functions-Types, Inference Mechanism, Defuzzification, Takagi-Sugeno Fuzzy Systems.

UNIT – II	**Fuzzy Control**	**Hours: 9**

Conventional Control System- Design. Fuzzy control system- choice of controller inputs and outputs, rule base using control knowledge, fuzzy quantification of knowledge, rule determination, converting decisions into actions.

UNIT – III	**Design Examples of Fuzzy Control**	**Hours: 9**

The inverted pendulum-scaling-tuning membership functions-basic design guidelines, real time implementation issues-computational time, memory requirements, typical design example.

UNIT – IV	**Nonlinear Analysis, Identification and Estimation**	**Hours: 9**

Parameterized fuzzy controllers, fuzzy-P, PI, PID controllers, Lyapunov stability Analysis -direct and indirect. Fuzzy identification, estimation- fitting functions to data, least squares method, gradient methods, clustering methods, and extraction of rules from data.

UNIT – V	**Adaptive and Supervisory Fuzzy Control**	**Hours: 9**

Fuzzy model reference learning control (FMRLC)-reference model, fuzzy controller, learning mechanism, knowledge based modifiers, design and implementation, casestudy. Supervision of fuzzy controllers, tuning, gain scheduling, supervision of fuzzy control-rule based supervision-case study.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Fuzzy Control, Kevin M. Passino and Stephen Yurkovich, Addison Wesley,1998.
2. Fuzzy logic with Engineering Applications, Timothy J.Ross, John Wiley & Sons,2010.

Reference Books:

1. Li-Xin Wang, A Course in Fuzzy Systems and Control, Prentice Hall PTR, 1997.
2. R.K. Yager, D.P.Filev, Essentials of Fuzzy Modeling and Control, John Wiley Sons inc, New York, 1994.
3. Klir G.J and B.O.Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, PHI, India, 1997.
4. Dimiter Driakov et al, An Introduction to Fuzzy Control, Narosa Publication House, 1993

Department : Electrical and Electronics Engineering			**Programme:** M.Tech. (Electrical Drives and Control)					
Semester :			**Category :** TY					
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE58	Modern Power Electronic Converters	3	1	0	4	40	60	100
Prerequisite								

Objectives

- To understand the design of SMPS
- To understand the operation of hard switched and soft switched converters

Outcome

- Students can able to design SMPS specific to application.
- Students can able to analyse recent AC-Dc, DC-AC, AC-DC converters

UNIT – I	**Switched Mode Power Supplies (SMPS)**	**Hours: 9**

DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs; Pump circuits - developed, transformer type and super lift pumps; Luo converters - positive, negative and double output; SEPIC converter. Voltage-lift converters and Super lift converters -types and basic circuit operation. Closed loop control and regulation; Design examples on converter and closed loop performance

UNIT – II	**AC-DC Converters**	**Hours: 9**

Switched mode ac-dc converters – synchronous rectification - single and three phase topologies - switching techniques - high input power factor – reduced input current harmonic distortion – improved efficiency – with and without input-output isolation – performance indices – closed loop control and regulation – design examples - Multi-converter systems – redundancy, reliability.

UNIT – III	**DC-AC Converters**	**Hours: 9**

Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters; Modulation schemes, waveforms and harmonic content; Comparison of topologies – device stress, losses, component count and dc link voltage balancing. Z - Source converters; Active filters – topologies, operation and closed loop control.

UNIT – IV	**AC-AC Converters with and without DC Link**	**Hours: 9**

Matrix converters – Basic topology of matrix converter; Commutation – current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only ac-dc converter; Vienna Rectifier – Principle of operation, main features and analysis, types and applications AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter; Performance comparison with matrix converter with DC link converters.

UNIT – V	**Soft-Switching Power Converters**	**Hours: 9**

Power electronic converters – analysis and determination of power losses – loss reduction techniques; Soft switching techniques – ZVS, ZCS, ZVT, quasi resonance operation; Performance comparison hard switched and soft switched converters –ac-dc converter, dc-dc converter, dc-ac converter – ac-ac converter; Resonant dc power supplies - bidirectional power supplies; Introduction to concept of integrated topologies.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Power Electronics Handbook, M.H.Rashid, Academic press, Newyork, 2000.
2. Advanced DC/DC Converters, Fang Lin Luo and Fang Lin Luo, CRC Press, NewYork, 2004.
3. Control in Power Electronics- Selected Problem, Marian P.Kazmierkowski,
4. R.Krishnan and Frede Blaabjerg, Academic Press (Elsevier Science), 2002.

Reference Books:

1. Issa Batarseh, Power Electronic Circuits, John Wiley and Sons, Inc.2004.
2. Frede Blaabjerg and Zhe Chen,Power Electronics for Modern Wind Turbines, Morgan & Claypool Publishers series, United States of America, 2006.
3. Mukund R.Patel, Wind and Solar Power Systems, CRC Press, New York, 1999.
4. Jai P Agarwal, Power Electronics: Converters, Applications, and Design, 3rd edition, Prentice Hall, 2000.
5. Johann W. Kolar, Uwe Drofenik, and Franz C. Zach, “VIENNA Rectifier II—A Novel Single-Stage High-Frequency Isolated Three-Phase PWM Rectifier System”, IEEE Transactions on Industrial Electronics, vol.46, no.4, pp.674-691, August 1999.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE59	Neural Networks	3	1	0	4	40	60	100
Prerequisite								

Objectives

- This paper exposes the student to the fundamental concepts of Neural Network architecture, algorithms and design.
- The capability and applicability of Neural Network based solutions for modeling, control and estimation would be covered.
- In the last unit the major applications of NN to power electronics and drives from literature is discussed.
- MATLAB based programming exercises and Simulink toolbox will be used.
- The knowledge and skill to build Neural network based systems would be covered in the course

Outcome

- The student would acquire the knowledge to identify the suitable Neural architecture and learning algorithm to design NN based solutions.
- Implement the same for problems in Electrical Drives and Control.

UNIT – I	**Introduction**	**Hours: 9**

Introduction – Biological neural network – Artificial Neural network – comparison, motivation and Development. Neuron model – single / multiple inputs, transfer functions. Network architecture – single /multiple layers – Recurrent networks Perceptron network – architecture, learning rule, linear severability limitation.

UNIT – II	**Supervised Learning**	**Hours: 9**

Learning mechanism – supervised learning – multiplayer perceptrons for pattern classification and function approximation. The back propagation algorithm – numerical examples. Drawbacks in Back propagation – Momentum method, variable learning rate, Levenburg Marguardt Algorithm. Other supervised learning methods – supervised Hebbs rule, Widrow Hoff learning rule – Adaline network.

UNIT – III	**Associative Networks**	**Hours: 9**

Associative learning – unsupervised Hebb’s rule – Instar learning rule – Kohonen rule, Outstar rule – Pattern association – Hetero associative, Auto associative and Bi-directional associative memory – Discrete Hopfield network – Architecture, algorithm.

UNIT – IV	**Competitive & Self Organizing Networks**	**Hours: 9**

Competitive networks – Fixed weight competitive network – Kohonen Self-organizing maps – architecture, algorithm – Learning vector quantisation – architecture, algorithm. Adaptive resonance theory – ART1; architecture, algorithm.

UNIT – V	**Applications to Electrical Drives and Control**	**Hours: 9**

Modelling – Space vector modulator, Estimation- Motor speed, flux , torque. Filtering using Neural Networks. Choice of Neural architectures and training algorithms for the various applications.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Martin T. Hagam, Howard B.Demuth and Mark Beale,Neural Network Design –Thomson learning 2002.
2. Laurene Faseff, Fundamentals of Neural Networks-architecture, algorithm and application, Pearson Education 2004.
3. Bimal K.Bose, Modern Power Electronics and AC Drives, Pearson Education (Singapore) Ltd., New Delhi, 2003.

Reference Books:

1. James A.Freemen and David M.Skapura, Neural Networks-algorithms, applications and programming techniques , Addison Wesley Publishing House 1992
2. Robert J.Schalfoll, Artificial Neural Network, Tata McGraw Hill Co, 1997.
3. Sathis kumar, Neural Network , Tata McGraw Hill 2004
4. Simon Haykin, Neural Networks: A Comprehensive Foundation, Prentice Hall of India, 2008.
5. Martin T. Hagan, Howard B. Demuth, Mark H. Beale, Neural Network Design, Thomson Learning, 1995.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE60	Nonlinear Control Systems	3	1	0	4	40	60	100

Prerequisite

Objectives

- To understand the different nonlinearities and their characteristics
- To analyze the stability analysis of non-linear system using Lyapunov method
- To know the different methods of linearization of nonlinear systems
- the analysis of nonlinear systems using phase plane and describing function methods

Outcome

- Identify different nonlinearities of physical systems
- Analyze the stability of nonlinear systems
- Linearize nonlinear systems
- Analyze nonlinear systems using phase plane analysis and describing function methods.

UNIT – I	**Properties of Nonlinear Systems**	**Hours: 9**

Basic mathematical and structural models of nonlinear systems – basic properties of nonlinear systems - Stability and Equilibrium States – basic properties of nonlinear functions - Typical Nonlinear Elements – basic nonlinearity classes.

UNIT – II	**Stability**	**Hours: 9**

Equilibrium States and Concepts of Stability - Stability of a Nonlinear System Based on Stability of the Linearized System - Lyapunov Stability - Definitions of Stability - Lyapunov Direct Method - Absolute Stability of Equilibrium States of an Unforced System (Popov Criterion) - Geometrical Interpretation of Popov Criterion - Absolute Stability with Unstable Linear Part - Absolute Stability of an Unforced System with Time-Varying Nonlinear Characteristic - Absolute Stability of Forced Nonlinear Systems.

UNIT – III	**Linearization Methods**	**Hours: 9**

Graphical Linearization Methods - Algebraic Linearization - Analytical Linearization Method - Evaluation of Linearization Coefficients by Least-Squares Method - Harmonic Linearization - Describing Function - Statistical Linearization - Combined (Dual-Input) Describing Functions.

UNIT – IV	**Phase Trajectories**	**Hours: 9**

Operating Modes of Nonlinear Control Systems - Self-Oscillations – Forced Oscillations - Effects of High-Frequency Signal-Dither - Methods of Dynamic Analysis of Nonlinear Systems - Phase Plane - Phase Trajectories of Linear and Non linear Systems - Methods of Defining Phase Trajectories - Examples of Application of Various Methods to obtain Phase Trajectories

UNIT – V	**Dynamic Analysis of Non-Linear Control Systems**	**Hours: 9**

Harmonic Linearization in Dynamic Analysis of Nonlinear Control Systems Operating in Stabilization Mode - Describing Function in Dynamic Analysis of Unforced Nonlinear Control Systems - Analysis of Symmetrical Self-Oscillations -Determination of Symmetrical Self-Oscillations - Asymmetrical Self-Oscillations-Forced Oscillations of Nonlinear Systems - Resonance Jump – Harmonic Linearization in Dynamic Analysis of Nonlinear Control Systems in Tracking Mode of Operation

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Shankar Sastry, Nonlinear Systems Analysis, Stability and Control, Springer,USA, 1999.
2. Hassan K. Khalil, Nonlinear systems, Prentice Hall, 2001.

Reference Books:

1. M. Vidyasagar, Nonlinear system analysis, SIAM, 2002.
2. Zoren Vukic, Ljubomir Kuljaca, Dali Donlagic andSejid Tesnjak, Nonlinear Control Systems, Marcel Dekker Inc, USA, 2003.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE61	Optimal Control Theory	3	1	0	4	40	60	100
Prerequisite	Modern Control Theory							
Objectives	• To know the formulation of optimal control problems • To understand the method of dynamic programming • To know the concept of functional and constrained optimization problems • To know the pontryagin's principle and to solve regulator problem • The numerical methods to solve optimal control problems							
Outcome	• Ability to Formulate optimal control problems • Ability to Solve optimal control problems using dynamic programming • Ability to Solve minimum time/minimum control effort problems • Ability to Solve optimal control problem using numerical methods							
UNIT – I	**Performance Measure**				**Hours: 9**			
Problem formulation - state variable representation of systems –performance measures for optimal control problems - selecting a performance measure.								
UNIT – II	**Dynamic Programming**				**Hours: 9**			
Optimal control law – principle of optimality – Application of Principle of optimality to decision making – Recurrence relation of Dynamic Programming – Imbedding Principle – computational procedure to solve optimal control problems – Discrete Linear regulator Problems – Hamilton – Jacobi Belman Equation – Continous linear regulator problems.								
UNIT – III	**Calculus of Variations**				**Hours: 9**			
Fundamental concepts – Functional of a single function – functionals involving several independent functions – piece wise smooth extremals – constrained extrema.								
UNIT – IV	**Variational Approach to Optimal Control Problem**				**Hours: 9**			
Necessary condition for optimal control – Linear regulator problems – Pontryagin's Minimum Principle and state inequality constraints – Minimum time Problems –Minimum Control – Effort problems – Singular intervals in optimal control Problem.								
UNIT – V	**Numerical Methods of Optimal Control**				**Hours: 9**			
Simplex Method – golden section Method – Hill climbing – Gradient – Penalty functions methods.								
Total contact Hours: 45		**Total Tutorials: 15**		**Total Practical Classes:**		**Total Hours:60**		

Text Books:

1. Donald.E.Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1962.
2. Brain D. O. Anderson and J. B. Moore, Optimal control, Prentice Hall, 1990.

Reference Books:

1. Andrew P. Sage, Optimum Systems Control, Prentice Hall N.H. 1968
2. Michael Athans and Peter L Falb, Optimal control, Dover publications, 2006.
3. Rao S.S., Optimization Theory and Application, Wiley Eastern, New Delhi, 1992.

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE62	Power Electronics in Power Systems	3	1	0	4	40	60	100
Prerequisite								
Objectives	•To study about reactive power compensators and the different VAR compensators •To study the Applications of converters in HVDC systems							
Outcome	•Ability to determine the characteristics of different types of VAR compensators •Ability to design different types of converters models for HVDC system based on LFA							

UNIT – I	**Reactive Power Requirements**	**Hours: 9**

Power system components – representation of single line diagram – uncompensated lines - compensators types and characteristics - conventional compensator -modern compensator - shunt compensator – series compensator - principles of reactive power control – introduction on load compensation - line compensation – P and Q control - phase angle regulation. Compensator requirements for solid state converters – determination of input power factor and harmonics for various converters – power factor improvement using Load and forced commutated converters.

UNIT – II	**Reactive Power Compensation and Regulation**	**Hours: 9**

Load compensation- voltage regulation - power factor correction - phase balance unsymmetrical loads.
Line compensations – increased power transfer capability – stability and transient limit – losses – harmonics - sub synchronous oscillations - mitigations.

UNIT – III	**Static Compensators and Components**	**Hours: 9**

Introduction to conventional compensators - – synchronous condenser – saturable core reactor – analysis and design of static compensators - TCR – TSC – SVC –TCSC – modeling and control of static compensators.

UNIT – IV	**Design Of UPFC and Static Tap Changers**	**Hours: 9**

UPFC components – shunt devices - series devices – operation and control – real and reactive power – UPFC parameters and design philosophy. Conventional tap changing methods – solid state tap changer – voltage regulation -different schemes – comparison – specifications – design methods.

UNIT – V	**HVDC AND Static Generator Excitation Systems**	**Hours: 9**

HVDC components - kinds of DC links – modern HVDC converters – commutation issues - control characteristics – constant phase angle control – constant current and extinction angle control - twelve and higher pulse operation - introduction to modern converters – protections - reactive power requirements – harmonics – filtertypes and design of various ac and dc filters. Solid state excitation of synchronous generators – different schemes – Generator excitation systems – redundancy and reliability.

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. Miller.T.J.E, Reactive power control in Electric systems, Wiley interscience, NewYork, 1982.
2. R.Mohan and R.K.Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems, IEEE Press – A John Wiley and Sons, Inc. Publications.2002.
3. K. R.Padiyar, HVDC Power Transmission Systems Technology and System Interactions, New Age International (p) Limited, New Delhi, 2003.

Reference Books:

1. Vijay K.Sood, HVDC and FACTS Controller: Application of Static Converters in power systems, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston, 2004.
2. Narani.G.Hingorani and Laszlo Gyugyi, Understanding FACTS, IEEE Power Engineering society sponsor, IEEE Press. 2000.
3. K.R.Padiyar, Facts Controllers in Power Transmission and Distribution, New Age International (P) Limited, Publishers, New Delhi, 2007.
4. “A Static alternative to the transformer on load tap changing”, IEEE Trans. on PAS, Vol.PAS-99, Jan. /Feb. 1980,
5. “Improvements in Thyristor controlled static on- load tap controllers for transformers”, IEEE Trans. on PAS, Vol.PAS-101, Sept.1982, pp3091-3095.
6. “Shunt Thyristor rectifiers for the Generator Excitation systems”, IEEE Trans. On PAS. Vol.PAS -96, July/August, 1977, pp1219-1225.

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester :</td><td colspan="7">Category : TY</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EEE63</td><td>Power Quality</td><td>3</td><td>1</td><td>0</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td>Objectives</td><td colspan="8">• To study the power quality problems in grid connected system and isolated systems
• To study the various power quality improvement techniques.
• To study about the various harmonics elimination methods.</td></tr>
<tr><td>Outcome</td><td colspan="8">• Ability to apply knowledge of power quality and harmonics in power systems and engineering to the analysis and design of electrical circuits
• Ability to design a system, components or process to meet desired needs within realistic constraints and to mitigate PQ problems such as economic, environmental, social, ethical, health and safety.
• Ability to function on multi-disciplinary teams.</td></tr>
<tr><td>UNIT – I</td><td colspan="4">Introduction</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Introduction -Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage Imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage- Power quality standards.</td></tr>
<tr><td>UNIT – II</td><td colspan="4">Non-Linear Loads</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.</td></tr>
<tr><td>UNIT – III</td><td colspan="4">Measurement and Analysis Methods</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error - Analysis: Analysis in the periodic steady state, Time domain methods Frequency domain methods: Laplace's, Fourier and Hartley transform - The Walsh Transform - Wavelet Transform.</td></tr>
<tr><td>UNIT – IV</td><td colspan="4">Analysis and Conventional Mitigation Methods</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion.
On-line extraction of fundamental sequence components from measured samples - Harmonic Indices - Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI) - Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing current balancing, Harmonic reduction, Voltage sag reduction.</td></tr>
<tr><td>UNIT – V</td><td colspan="4">Power Quality Improvement</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Utility-Customer interface -Harmonic filters: passive, Active and hybrid filters -Custom power devices:
Network reconfiguring Devices, Load compensation using DSTATCOM Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P~Q theory, Synchronous detection method. Custom power park –Status of application of custom power devices.</td></tr>
<tr><td colspan="2">Total contact Hours: 45</td><td colspan="2">Total Tutorials: 15</td><td colspan="3">Total Practical Classes:</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="9">Text Books:</td></tr>
<tr><td colspan="9">1. Arindam Ghosh,Gerard Ledwich, Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002.
2. G.T.Heydt, Electric Power Quality, McGraw-Hill Professional, 2007.</td></tr>
<tr><td colspan="9">Reference Books:</td></tr>
<tr><td colspan="9">1. 1. Roger C. Dugan, Mark F. McGranaghan,Surya Santos, H. Wayne Beaty, Electrical Power Systems Quality, McGraw Hill, New Delhi 2003.
2. 2. Derek A. Paice, Power electronic converter harmonics, IEEE Press, 1996.
3. 3. C.Sankaran, Power Quality, CRC Press, 2002.
4. 4. A.J. Arrillga, Neville.R.Watson, Power system harmonics - John Wiley Publishers, 2002.
5. 5. Math H. Bollen, Understanding Power Quality Problems, IEEE Press, 2000.
6. 6. J. Arrillaga, Power System Quality Assessment, John wiley, 2000.</td></tr>
</table>

Department : Electrical and Electronics Engineering		**Programme:** M.Tech. (Electrical Drives and Control)						
Semester :		**Category : TY**						
Subject Code	**Subject**	**Hours / Week**			**Credit**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**
EEE64	Wind Energy Conversion Systems	3	1	0	4	40	60	100

Prerequisite

Objectives

- To study the wind energy conversion systems in detail
- To study the application of power converters for wind electric systems.
- To study the concept of PV technology and it is application to the generation of electricity

Outcome

- Ability to investigate the performance of wind and PV systems
- Ability to design the power converters for grid connected and off grid applications

UNIT – I | Introduction | Hours: 9

Historical developments, state of art of wind energy technology, turbine rating, Indian scenario and worldwide developments, present status and future trends.
The nature and geographical variation in the wind resources –long term wind speed variation-annual and seasonal variations –diurnal variations, Turbulence, Gust wind Speeds –Extreme wind speeds – effect of height- wind rose – Power available in the wind.

UNIT – II | Aerodynamics of Wind Turbines | Hours: 9

Aerodynamics of aerofoil; lift; drag; stall; actuator disc concept; momentum theory and Betz coefficient; wind turbine blade; effect of stall and blade, turbulence and wakes - Site selection - Wind speed and direction measurements.

UNIT – III | Performance of Wind Turbines | Hours: 9

Fixed speed and variable speed WT-HAWT –VAWT–Power developed–Performance curves –rotor selection – effects of number of blades -Blade profile –power regulation –active and passive stall control, yaw control, pitch control, Braking systems- –modeling of Wind turbines for Power system studies.

UNIT – IV | Grid Connected Wind Energy Systems | Hours: 9

Types of generators - induction generator - equivalent circuit - efficiency - single phase operation of 3-phase induction generators - permanent magnet generator -synchronous generator – DFIG - fixed and variable speed operation - power control -braking systems - grid integration issues.

UNIT – V | Stand-Alone Wind Energy Systems | Hours: 9

Self-excitation process- effect of excitation capacitance equivalent circuit -voltage and frequency control techniques - power flow studies -- power quality issues - Direct Drive Generators- Small wind hybrid systems – Energy Storage – Batteries – Fuel Cells

Total contact Hours: 45	**Total Tutorials: 15**	**Total Practical Classes:**	**Total Hours:60**

Text Books:

1. N.Bhadra, D.Kastha and S. Banerjee, Wind electrical systems, Oxford University Press, 2005.
2. S.Ahmed, Wind Energy: Theory and Practice, PHI,2010.

Reference Books:

1. Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi, Hand Book of Wind Energy, John Wiley and sons, 2001
2. Manfred Stiebler, Wind Energy Systems for Electrical Power Generation, Springer, 2008.
3. Gary L. Johnson, Prentice hall Inc., Englewood Cliffs, Wind Energy System, New Jersey, 1985.
4. L. Lfreris, Wind energy conversion system, Prentice hall (U.K) Ltd., 1990.

<table>
<tr><td colspan="2">Department : Electrical and Electronics Engineering</td><td colspan="7">Programme: M.Tech. (Electrical Drives and Control)</td></tr>
<tr><td colspan="2">Semester :</td><td colspan="7">Category : TY</td></tr>
<tr><td rowspan="2">Subject Code</td><td rowspan="2">Subject</td><td colspan="3">Hours / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EEE65</td><td>Special Electrical Machines</td><td>3</td><td>1</td><td>0</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td>Objectives</td><td colspan="8">Understand the Construction and principle of operation and performance of various single phase machines.
Understand the Construction and principle of operation and performance of stepper motor and switched reluctance motor</td></tr>
<tr><td>Outcome</td><td colspan="8">The students are expected to understand the principle, construction operation and performance characteristic of various special machines
Students will be capable of carrying out projects work in the field for different analysis.</td></tr>
<tr><td>UNIT – I</td><td colspan="4">Single Phase Machines</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Principles and construction of split phase motors – Shaded pole motor – Repulsion motor - Universal motor – Unexcited synchronous single phase motor – Reluctance and Hysteresis motor – Schrage motor - Applications.</td></tr>
<tr><td>UNIT – II</td><td colspan="4">Stepper Motors</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Constructional features - Principle of operation - Modes of excitation – Types of motors – Drive systems and circuit for control of Stepper motor – Applications Dynamic characteristics.</td></tr>
<tr><td>UNIT – III</td><td colspan="4">Switched Reluctance Motors</td><td colspan="4">Hours:</td></tr>
<tr><td colspan="9">Constructional features - Principle of operation - Torque prediction – Power controllers - Characteristics and control - Applications.</td></tr>
<tr><td>UNIT – IV</td><td colspan="4">Permanent Magnet Brushless DC Motors</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Commutation in DC motors - Difference between mechanical and electronic commutators - permanent magnet brushless motor drives - Torque and EMF equation; Torque-Speed characteristics; Sensors - Controllers; Applications.</td></tr>
<tr><td>UNIT – V</td><td colspan="4">Three Phase AC Machines</td><td colspan="4">Hours: 9</td></tr>
<tr><td colspan="9">Principle of operation - Constructional features of Permanent Magnet synchronous motor- torque expressions - Phasor diagram - characteristics - Vector control -Applications. Principle and construction of Doubly Fed Induction generator- characteristics-control-Application in wind farm – merits and demerits.</td></tr>
<tr><td colspan="2">Total contact Hours: 45</td><td colspan="2">Total Tutorials: 15</td><td colspan="3">Total Practical Classes:</td><td colspan="2">Total Hours: 60</td></tr>
<tr><td colspan="9">Text Books:</td></tr>
<tr><td colspan="9">T.J.E. Miller, Brushless Permanent Magnet and Reluctance Motors Drives, Clarendon Press, Oxford, 1989.
T. Kenjo and S.Negamori, Permanent Magnet Brushless DC Motors, Clarend on Press, Oxford, 1989.</td></tr>
<tr><td colspan="9">Reference Books:</td></tr>
<tr><td colspan="9">P.P. Acarnley, Stepping Motors, A Guide to Modern Theory and Practice, Peter Peregrinus, London, 1990.
A. Hughes, Electric Motors and Drives, Affiliated East-west Pvt., Ltd., Madras,1990.
Kenjo, Stepping Motors and their Microprocessor Control, Clarendon Press, Oxford, 1989.
I.J.Nagrath & D.P.Kothari, Electrical Machines, Tata McGraw Hill, 1999.
Loi LeiLai, Tze Fun Chan, Distributed Generation: Induction and Permanent Magnet generators, Wiley Publishers, 2007
B.L.Theraja, A.K.Theraja, Electrical Technology, vol-II, AC & DC Machines, S.Chand & Company Ltd., 2005.</td></tr>
</table>