APJ Abdul Kalam Technological University

Cluster 4: Kottayam

M. Tech Program in Electrical Engineering (Industrial Drives and Control)

Scheme of Instruction and Syllabus: 2015 Admissions

Compiled By

Rajiv Gandhi Institute of Technology, Kottayam

July 2015

APJ Abdul Kalam Technological University

(Kottayam Cluster)

M. Tech Program in Industrial Drives and Control

Scheme of Instruction

Credit requirements : 67 credits (22+19+14+12)
Normal Duration : Regular: 4 semesters; External Registration: 6 semesters;
Maximum duration : Regular: 6 semesters; External Registration: 7 semesters.
Courses: Core Courses: Either 4 or 3 credit courses; Elective courses: All of 3 credits
Allotment of credits and examination scheme:-

Semester 1 (Credits: 22)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits (22)
					Marks	Duration (hrs)	
A	04 MA 6301	Advanced Mathematics	3-0-0	40	60	3	3
B	04 EE 6301	Power Electronic Devices & Circuits	4-0-0	40	60	3	4
C	04 EE 6201	Dynamics of Electrical Machines	4-0-0	40	60	3	4
D	04 EE 6203	Fundamentals of Electric Drives	3-0-0	40	60	3	3
E	04 EE 6XXX*	Elective - I	3-0-0	40	60	3	3
	04 GN 6001	Research Methodology	0-2-0	100	0	0	2
	04 EE 6291	Seminar - I	0-0-2	100	0	0	2
	04 EE 6390	Power Electronics Lab	0-0-2	100	0	0	1
		Total	**23**				**22**

**See List of Electives-I for slot E*

List of Elective - I Courses

Exam Slot	COURSE NO.	COURSE TITLE
E	04 EE 6003	Optimization Techniques
E	04 EE 6103	System Theory
E	04 EE 6305	Digital Simulation of Power Electronic Systems
E	04 EE 6407	Power Quality

M. Tech (Industrial Drives & Control)

Semester 2 (Credits: 19)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits (19)
					Marks	Duration (hrs)	
A	04 EE 6302	Switched Mode Power Converters	4-0-0	40	60	3	4
B	04 EE 6202	Advanced Control of AC Drives	3-0-0	40	60	3	3
C	04 EE 6204	Special Electrical Machines and Drives	3-0-0	40	60	3	3
D	04 EE 6XXX*	Elective - II	3-0-0	40	60	3	3
E	04 EE 6XXX^	Elective - III	3-0-0	40	60	3	3
	04 EE 6292	Mini Project	0-0-4	100	0	0	2
	04 EE 6294	Electrical Drives Lab	0-0-2	100	0	0	1
		Total	**22**				**19**

**See List of Electives -II for slot D* ^*See List of Electives -III for slot E*

List of Elective - II Courses

Exam Slot	COURSE NO.	COURSE TITLE
D	04 EE 6106	Stochastic Modelling and Applications
D	04 EE 6104	Digital Control Systems
D	04 EE 6208	Computer Aided Design of Electrical Machines
D	04 EE 6300	Advanced Power Semiconductor Devices

List of Elective - III Courses

Exam Slot	COURSE NO.	COURSE TITLE
E	04 EE 6002	Soft Computing Techniques
E	04 EE 6118	Advanced Digital Signal Processing
E	04 EE 6308	Analysis, Design and Grid Integration of Photovoltaic Systems
E	04 EE 6604	Digital Controllers for Power Applications

M. Tech (Industrial Drives & Control)

Summer Break

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits (0)
					Marks	Duration (hrs)	
NA	04 EE 7290	Industrial Training	0-0-4	NA	NA	NA	Pass /Fail
		Total	4				0

Semester 3 (Credits: 14)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	End Semester Exam		Credits (14)
					Marks	Duration (hrs)	
A	04 EE 7XXX*	Elective - IV	3-0-0	40	60	3	3
B	04 EE 7XXX^	Elective - V	3-0-0	40	60	3	3
	04 EE 7291	Seminar - II	0-0-2	100	0	0	2
	04 EE 7293	Project (Phase - I)	0-0-12	50	0	0	6
		Total	20				14

**See List of Electives-IV for slot A* *^See List of Electives-V for slot B*

List of Elective - IV Courses

Exam Slot	COURSE NO.	COURSE TITLE
A	04 EE 7101	Estimation Theory
A	04 EE 7305	Power Electronic Applications in Power Systems
A	04 EE 7103	Optimal Control Theory
A	04 EE 7105	Robotics and Automation

List of Elective - V Courses

Exam Slot	COURSE NO.	COURSE TITLE
B	04 EE 7001	Bio-Inspired Algorithms
B	04 EE 7107	Adaptive Control
B	04 EE 7109	Robust Control Design
B	04 EE 7115	Data Acquisition and Signal Conditioning

Semester 4 (Credits: 12)

Exam Slot	Course No:	Name	L- T - P	Internal Marks	External Evaluation Marks	Credits (12)
NA	04 EE 7294	Project (Phase -II)	0-0-21	70	30	12
		Total	**21**			**12**

Total: 67

Course No	Course Title	Credits	Year
04 MA 6301	Advanced Mathematics	3-0-0: 3	2015

Pre-requisites:

Course Objectives:

1. To equip the students with advanced mathematical tools in Complex Analysis
2. To equip the students with advanced mathematical tools in Functional Analysis
3. To equip the students with advanced mathematical tools in Probability and Random Processes
4. To enable the students to use mathematical programming concepts in engineering optimization problems.

Syllabus

Complex Variables - Conformal Transformation, Partial differential equations - Boundary Value Problems- Functional Analysis - Vector Spaces - Linear Transformations - Random Processes - Stochastic Processes - Introduction to Mathematical Programming.

Course Outcome:

- Students who successfully complete this course will have demonstrated an ability to apply advanced mathematical tools of Complex Analysis, Functional Analysis and Random Processes.

- Students will be able to formulate, analyse and solve optimization problems in engineering applications.

Text Books:

1. Erwin Kreyszig, "Introductory Functional Analysis with Applications," John Wiley & Sons, 2004.
2. B. S. Grewal, "Higher Engineering Mathematics," Khanna Publishers.

References:

1. A Papoulis, "Probability, Random Variables and Stochastic Processes," 3rd edition, Mc- Graw Hill.
2. Kalyanmoy Deb, "Optimization for Engineering Design," PHI-2002.
3. Simmons D M, "Non Linear Programming for Operations Research," PHI.
4. Elsgoltis, "Differential Equations and Calculus of Variations," MIR publication.
5. Ochi M K, "Applied Probability and Stochastic Processes," John Wiley & Sons, 1992.
6. D G Luenberger, "Optimization by Vector Space Method," John Wiley.

COURSE PLAN

COURSE NO:	COURSE TITLE		CREDITS:
04 MA 6301	**ADVANCED MATHEMATICS**		**3-0-0:3**
MODULES		**Contact hours**	**Sem. Exam Marks;%**
MODULE : 1 **Complex Variables and Partial Differential Equations** Cauchy's integral formula, Poisson's integral formula, Liovilli's Theorem, Conformal Transformation, Schwarz-Christoffels transformation, Partial differential equation-Laplace equation in two dimension(Cartesian and polar), Boundary Value Problems, Green's Theorem.		8	15
MODULE : 2 **Functional Analysis** Definition of Vector spaces – examples-isomorphism of vector spaces-Linear independence and basis. Dimension of vector space - Fundamentals of Normed linear spaces-Basic concept of linear transformations.		8	15
FIRST INTERNAL TEST			
MODULE : 3 **Random Processes** Probability concepts- Variables and distribution function- PDF, Markov Chains.		6	15
MODULE : 4 **Stochastic Processes** – Characteristics- Markov Processes – Correlation-Auto Correlation – Cross Correlations– Response of linear discrete time systems to white noise.		8	15
SECOND INTERNAL TEST			
MODULE : 5 **Introduction to Mathematical Programming** Nonlinear Programming Problems-Unconstrained optimization, optimality criteria, Direct Search Methods: Hooke-Jeeves Pattern Search, Powell's		6	20

COURSE NO:	COURSE TITLE		CREDITS:
04 MA 6301	**ADVANCED MATHEMATICS**		**3-0-0:3**
MODULES		**Contact hours**	**Sem. Exam Marks;%**
conjugate direction method.			
MODULE : 6 Gradient based methods: steepest descent method- Newton's method, Constrained optimization: Lagrange multiplier- Kuhn Tucker conditions.		6	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6301	POWER ELECTRONIC DEVICES AND CIRCUITS	4-0-0:4	2015

Pre-requisites:

Course Objectives:

To give the Student:-

- A foundation in the fundamentals of power electronic devices and circuits;
- Ability to design and analytical formulation of various power electronic circuits.

Syllabus

Fundamental concepts and overview of power semiconductor devices; Driver circuits; Study and Analysis phase controlled rectifiers; DC Choppers; Inverters; AC voltage controller and Cyclo converters; Introduction to matrix converters and PWM rectifiers.

Course Outcome:

Students who successfully complete this course will have an ability to understand the fundamental principles and applications of power electronics circuits; Compare and analyze the various types of power converters

Text Books:

1. Mohan, Undeland, Robbins, Power Electronics; Converters, Applications and Design. -3rd edition, John Wiley and Sons, 2003

References:

1. Daniel W. Hart, Power Electronics, Tata McGraw-Hill, 2011
2. L Umanand, Power Electronics Essentials and Applications, Wiley Publications, 2013
3. William Shepherd, Li Zhang, Power Converter Circuits, Marcel Decker, 2004.
4. V. Ramanarayanan, Course Material on Switch Mode Power Conversion, Electrical Department, IISc, Bangalore, 2006.
5. B K Bose, Modern Power Electronics and AC Drives, Pearson Education, 2002.
6. B W Williams, Power Electronics; Principles and Elements, University of Strathclyde Glasgow, 2006.
7. D Grahame Holmes, Thomas A Lipo, Pulse Width Modulation for Power Converters:
8. Principles and Practice, IEEE Press, 2003.
9. M H Rashid (Ed), Power Electronics Handbook: Devices, Circuits and Applications, Academic Press 2010.

COURSE PLAN

COURSE NO:	COURSE TITLE:	CREDITS	
04 EE 6301	Power Electronics Devices and Circuits	4-0-0:4	
MODULES		Contact hours	Sem. Exam Marks; %
MODULE : 1 - Overview of solid state devices Ideal and Real switches, Power diodes, Power Transistors, Power MOSFETS, IGBTs, Thyristor, GTO, TRIAC- Static and Dynamic Performance, Driver circuits. Turn on; Turn off and Over voltage Snubbers for switching devices.		8	15
MODULE : 2 – Phase controlled Rectifiers Single phase and Three phase converters, half and full wave, fully controlled and semi controlled, Analysis with RL, RLE loads-Performance, Inversion mode of operation, Effect of source inductance-Dual converters-Circulating and Non circulating type		8	15
FIRST INTERNAL TEST			
MODULE : 3 DC Choppers Analysis of DC choppers; two quadrant and four quadrant choppers, PWM control, Forced commutation, Voltage and Current commutated choppers, filter circuits, multiphase chopper.		10	15
MODULE : 4 Inverters Half Bridge and Full Bridge Inverters- Single phase and Three phase. Analysis with delta and star connected RL loads-Harmonics and Voltage control in inverters; PWM principles. Sine triangle modulation, Unipolar and Bipolar modulation, Blanking time and maximum attainable DC Voltage switch utilization, output filter design, Introduction to Multilevel Inverters		10	15
SECOND INTERNAL TEST			
MODULE : 5 - AC voltage and Cyclo controllers Single Phase and Three phase AC Voltage Controllers-Principle operation-analysis with R and RL loads, Thyristor Controlled Reactor, Cycloconverters-circulating and non-circulating type-Analysis with R and RL loads.		10	20

MODULE : 6 - Introduction to Matrix converters and PWM rectifiers Introduction to Matrix Converters- Matrix converter switches and circuits-Control strategies, Single phase and three phase PWM rectifiers -Basic topologies - Control principles.	10	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6201	DYNAMICS OF ELECTRICAL MACHINES	4-0-0-4	2015

Pre-requisites:

Course Objectives:

To enable the students to:

- Analyse and model dc, synchronous and induction machines.

Syllabus

Unified approach to modelling of electrical machines – Transformations to various reference frames – Application of generalised theory to model dc machines, induction machines, synchronous machines. Speed control of induction motors- Vector control

Course Outcome:

Text Books:

PS. Bhimbra, Generalized Theory of Electrical Machines, Khanna Publishers

References:

1. Krauss, Wasyncsuk and Sudholf, Analysis of Electrical Machines and Drive Systems, John Wiley
2. A. E. Fitzgerald, Kingsley, Umans, Electric Machinery, McGraw Hill
3. Adkins and Harley, General Theory of AC Machines
4. Bimal K. Bose, Modern Power Electronics & AC Drives, Pearson Education

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 6201	DYNAMICS OF ELECTRICAL MACHINES	4-0-0: 4	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE : 1 Introduction to magnetic circuits – Flux, flux linkage, mmf, reluctance, inductance and energy- Self, leakage, magnetizing and mutual inductances. AC excitation – Magnetic effect of an electromagnet- Principles of electromechanical energy conversion. Analysis of singly excited electromechanical system - General expression of stored magnetic energy, co-energy and force/torque. Analysis of the doubly excited two-phase rotational system –Electrical and mechanical equations. Basic Concepts of Rotating Machines – Calculation of air gap mmf and per phase machine inductance using physical machine data. Generalized Machine Theory – Unified approach to the analysis of electrical machines-Basic two-pole machine-Kron's primitive machine – transformer and rotational voltages in the armature – Voltage, power and torque equation – Resistance, inductance and torque matrices - Linear transformation from three phase to two phase .		12	15
MODULE :2 Transformation from rotating axes to stationary axes – power invariance – park's transformation for 3-phase synchronous and induction machines. DC machines – application of generalized theory to separately excited, shunt, series and compound machines – sudden short circuit of separately excited generator - separately excited dc motor - steady state and transient analysis – transfer functions of separately excited dc generator & motor. Transient Simulation of dc motors (Assignment/Project)		10	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 Polyphase Synchronous machines – generalized machine equations – Steady state analysis of salient pole and non salient pole machines – phasor diagrams – power angle characteristics – reactive power – short circuit ratio. Dynamic modelling of three phase salient pole synchronous machine in phase variable form – 3-phase to 2-phase transformation - Dynamic direct and quadrature axis model in arbitrarily rotating reference frame – Voltage and torque equations.		10	15
MODULE 4:		6	15

Synchronous Machines: Derivation of rotor reference frame model – Equivalent circuits. Transient analysis – sudden 3-phase short circuit at generator terminals – reactance – time constants – transient power angle characteristics. Analysis of steady state operation – torque equation. Determination of synchronous machine dynamic equivalent circuit parameters - Measurements.		
INTERNAL TEST 2 (MODULE 3 & 4)		
MODULE: 5 Three phase Induction Machine: Dynamic modelling of three phase symmetrical induction machine in phase variable form – 3-phase to 2-phase transformation – Voltage and torque equations -Application of reference frame theory to three phase symmetrical induction machine. Dynamic direct and quadrature axis model in arbitrarily rotating reference frame – Voltage and torque equations. Derivation of stationary reference frame model – Equivalent circuits. Rotor reference frame model and synchronously rotating reference frame model from arbitrarily rotating reference frame model. Analysis of steady state operation – Equivalent circuit for steady state operation – Torque-Speed characteristics. Effect of voltage and frequency variations – electric transients in induction machines.	10	20
MODULE: 6 Dynamic modelling of two phase symmetrical and asymmetrical induction machine in machine variables – Voltage and torque equations. Derivation of stator reference frame model of two phase asymmetrical induction machine- Equivalent circuits. Application of reference frame theory to two phase asymmetrical induction machine. Steady state analysis of two phase asymmetrical induction machine and equivalent circuits. Conditions for balanced operation. Dynamic d-q model of capacitor start single phase induction machine – steady state analysis – Equivalent circuits.	8	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6203	FUNDAMENTALS OF ELECTRIC DRIVES	3-0-0-3	2015

Pre-requisites:

Course Objectives:

To enable the students

- To evaluate and select a suitable drive for a particular application.
- To analyse the basic drive system dynamics and arrive at operating point characteristics.
- To develop the basic design of an electric drive system.

Syllabus

Electric Drive System- Dynamics and steady state stability - dc motor drives -closed loop control of dc drives - AC induction motor drives -PWM converter-fed Induction Motor drives - Synchronous motor drives - Converter-fed Synchronous Motor Drives.

Course Outcome:

Students will be able to select a suitable drive for a particular application.

Students will be able to develop basic design of an electric drive system, analyse its steady state stability.

Text Books:

R. Krishnan, Electrical Motor Drives, PHI-2003

References:

1. G.K.Dubey, Power semiconductor controlled drives, Prentice Hall- 1989
2. G.K.Dubey, Fundamentals of Electrical Drives, Narosa- 1995
3. S.A. Nasar, Boldea , Electrical Drives, Second Edition, CRC Press - 2006
4. M. A. ElSharkawi , Fundamentals of Electrical Drives , Thomson Learning -2000
5. W. Leohnard, Control of Electric Drives,-Springer- 2001
6. Murphy and Turnbull, Power Electronic Control of AC motors, Pergamon Press
7. Vedam Subrahmaniam, Electric Drives, TMH-1994

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 6203	FUNDAMENTALS OF ELECTRIC DRIVES	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 Components of electrical Drives – electric machines, power converter, controllers - dynamics of electric drive - 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 – classes of motor duty- determination of motor rating.		8	15
MODULE 2: DC motor drives – dc motors & their performance (shunt, series, compound, permanent magnet motor, universal motor, dc servomotor) – braking – regenerative, dynamic braking, plugging –Transient analysis of separately excited motor – converter control of dc motors – analysis of separately excited & series motor with 1-phase and 3-phase converters – dual converter –analysis of chopper controlled dc drives – converter ratings and closed loop control – transfer function of self, separately excited DC motors – linear transfer function model of power converters – sensing and feeds back elements – current and speed loops, P, PI and PID controllers – response comparison – simulation of converter and chopper fed DC drive		8	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 Induction motor drives – stator voltage control of induction motor – torque-slip characteristics – operation with different types of loads – operation with unbalanced source voltages and single phasing – analysis of induction motor fed from non-sinusoidal voltage supply – stator frequency control – variable frequency operation – V/F control, controlled current and controlled slip operation – effect of harmonics and control of harmonics.		7	15
MODULE 4: PWM inverter drives for Induction Motors – multi quadrant drives – rotor resistance 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.		7	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – principles of synchronous motor		6	20

control – voltage source inverter drive with open loop control –		
MODULE: 6 Self controlled synchronous motor with electronic commutation – self controlled synchronous motor drive using load commutated thyristor inverter.	6	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6003	OPTIMIZATION TECHNIQUES	2-1-0:3	2015

Pre-requisites: NIL

Course Objectives:

To give the Student:-

- A foundation in the theory of optimization methods
- An awareness of the usefulness and limitation of optimization and the framework through which further studies/application in the area can be conducted.
- Practice in some of the well-known optimization techniques and their applicability in a real setting.

Syllabus

Fundamental concepts and overview of Optimization Theory; Linear Programming; Unconstrained Optimization Techniques; Constrained Optimization; Recent Developments in Optimization

Course Outcome:

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

- Understand the basic principles in Optimization Theory
- Formulate Optimization Problems
- Use appropriate Optimization algorithms for solving Engineering Problems
- Be familiar with Recent Developments in Optimization

Text Books:

1. Rao S. S., Engineering Optimization: Theory and Practice, Wiley, New York, 1996.
2. Pierre, D. A., Optimization Theory with Applications, Dover Publications, INC., New York,1969.

References:

1. Fox, R. L., Optimization method for Engineering Design, Addison –Wesley Pub. Co., 1971
2. Hadley, G., Linear Programming, Addison- Wesley Pub. Co., 1963
3. Bazaara M. S., Sherali H.D., Shetty C.M., Non-linear Programming, John Wiley and Sons, 2006.
4. D.E. Goldberg, Genetic Algorithm in Search, Optimization, and Machine Learning, Addison-Wesly, 1989.
5. Glover F., Laguna M., Tabu Search, Kluwer Academic Publishers, 1997.
6. Marco Dorigo, Vittorio Miniezza and Alberto Colorni, "Ant System:Optimization by a colony of Cooperation Agent", IEEE transaction on system man and Cybernetics-Part B:cybernetics, Volume 26, No 1, pp. 29-41,1996.
7. Shi, Y. Eberhart, R. C., "A Modified Particle Swarm Optimizer", Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998.

COURSE PLAN

Course No:	Course Title:		CREDITS
04 EE 6003	**OPTIMIZATION TECHNIQUES**		**2-1-0:3**
MODULES		**Contact hours**	**Sem. Exam Marks;%**
MODULE : 1 Statement and Classification of Optimization Problems , Overview of Optimization Techniques, Standard Form of Linear Programming Problems-Definitions and Theorems		5	15
MODULE : 2 Simplex Method-Revised Simplex Method-Duality and Dual Simplex Method-Sensitivity Analysis		8	15
FIRST INTERNAL TEST			
MODULE 3 Necessary and Sufficient Conditions-Search Methods(Unrestricted Fibonacci and Golden)-Interpolation Methods(Quadratic, Cubic and Direct Root Method)		6	15
MODULE 4 Direct Search Methods-Random Search-Pattern Search and Rosen Brock's Hill Climbing Method Descent Methods-Steepest Descent, Conjugate Gradient, Quasi Newton and DFE Method		7	15
SECOND INTERNAL TEST			
MODULE 5 Necessary and Sufficient Conditions-Equality and Inequality Constraints-Kuhn-Tucker Conditions. Gradient Projection Method-Cutting Plane Method-Penalty Function Method (Interior and Exterior). Principle of Optimality-Recurrence Relation-Computation Procedure-Continuous Dynamic Programming		9	20
MODULE 6 Rosenbrocks Rotating Coordinate Method-Tabu Search-Simulated Annealing. -- Genetic Algorithm-Particle Swarm Optimization –Ant Colony Optimization-Bees Algorithm		7	20

COURSE NO.	COURSE TITLE	L-T-P: C	YEAR
04 EE 6103	SYSTEM THEORY	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

To give students

- A foundation in state space representation of systems.
- An ability to design observers.
- The ability to analyse the stability of linear and non linear systems.
- An introduction to the basic concepts of optimal control;

Syllabus

State space analysis and design of linear systems, Design of observers, Stability analysis using lyapnov stability criterion, Introduction to Optimal Control and dynamic programming

Course Outcome:

At the end of the course students will be able to

1. Use state space method to represent and analyse a system
2. Analyse the stability of a nonlinear system.
3. Describe the basic concepts of optimal control.

References:

1. Benjamin C. Kuo, Control Systems, Tata McGraw-Hill, 2002.
2. M. Gopal, Modern Control System Theory, Tata McGraw-Hill.
3. Thomas Kailath, Linear System, Prentice Hall Inc., Eaglewood Clis, NJ, 1998
4. D. E. Kirk, Optimal Control Theory, Prentice-Hall. 1970

COURSE PLAN

COURSE NO.	COURSE TITLE	Credits	
04 EE 6103	SYSTEM THEORY	3-0-0: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 State Space Analysis and Design -Analysis of stabilization by pole cancellation - reachability and constructability - stabilizability - controllability - observability -grammians. - Linear state variable feedback for SISO systems, Analysis of stabilization by output feedback-modal controllability-formulae for feedback gain		6	15
MODULE: 2 Significance of controllable Canonical form-Ackermann's formula -feedback gains in terms of Eigen values - Mayne-Murdoch formula state feedback and zeros of the transfer function - non controllable realizations and stabilizability -controllable and uncontrollable modes.		7	15
FIRST INTERNAL TEST			
MODULE: 3 Observers -Asymptotic observers for state measurement-open loop observer-closed loop observer formulae for observer gain - implementation of the observer - full order and reduced order observers - separation principle - combined observer -controller optimality criterion for choosing observer poles.		7	15
MODULE: 4 Observer Design -Direct transfer function design procedures-Design using polynomial equations - Direct analysis of the Diophantine equation.		6	15
SECOND INTERNAL TEST			
MODULE: 5 Lyapunov Stability - definition of stability, asymptotic stability and instability - Lyapunov's second method. Lyapunov's stability		8	20

analysis of LTI continuous time and discrete time systems , stability analysis of non linear system – Krasovski’s theorem - variable gradient method.		
MODULE: 6 Introduction to Optimal Control- Pontryagin’s maximum principle-theory-application to minimum time, energy and control effort problems, terminal control problem. Dynamic programming-Bellman’s principle of optimality, multistage decision processes. Linear regulator problem: matrix Riccati equation and its solution.	8	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6305	DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS	3-0-0-3	2015

Pre-requisites:

Course Objectives:

To enable the students:

- To develop simulation models of power electronic systems and carry out simulations using appropriate techniques and algorithms.
- To model and simulate power electronic converters accurately.
- To troubleshoot common issues in dynamic system simulations.

Syllabus

Types of simulations - Formulation of System Equations - Nonlinear circuits – Convergence issues - Transient-analysis-accuracy and stability- explicit and implicit schemes. Numerical methods for solving ODE. Stability of numerical methods - Adaptive step size - Assessment of accuracy – singular matrix problems - Steady state analysis - AC modelling of converters - Small-signal analysis - State Space averaging - Circuit averaging - Averaged switch modelling

Course Outcome:

Students will be able to develop simulation models of power electronic systems and circuits with thorough understanding about the accuracy and stability of the simulation algorithms used.

Text Books:

1. M. B. Patil, V. Ramanarayanan, V. T. Ranganathan, “Simulation of Power Electronic Circuits”, Narosa Publishers
2. Robert W. Erickson and Dragan Maksimovich, “Fundamentals of Power Electronics”, 2nd Ed., Springer (India) Pvt. Ltd.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 6305	DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 Introduction to Simulation: Different types of simulations - DC Analysis - AC Sweep Analysis, Transient Simulation, Digital/Logic Simulation. Simulation Tools: Equation Solvers Vs Circuit Simulators. Formulation of System Equations - Modified Nodal Analysis- Sparse Tableau Approach – Application to nonlinear circuits – Newton-Raphson Method- Formulation of equations- Computation Time -Convergence issues - Nonlinear circuit equations – Jacobian - Practical limits		10	15
MODULE :2 Introduction to transient simulation: Discretization of time- transient-analysis-accuracy and stability- explicit and implicit schemes. Methods of transient simulation - Numerical methods for solving ODE – Taylor series, Runge-Kutta, multistep, predictor-corrector methods.		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 Stability of numerical methods – stability of small h-stability for large h- stiff equations – Adaptive step size – LTE based adjustment of step size – convergence based adjustment of step size.		6	15
MODULE 4: Transient analysis in circuit simulation – equivalent circuit approach – RC circuit – Buck converter. Some practical aspects: Undamped oscillations and Ringing introduced by Integration algorithms – Global error in switching circuits –round off error – assessment of accuracy – singular matrix problems Steady state analysis: Direct method for SSW computation – Computational efficiency		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 **AC equivalent circuit modelling:** Basic AC modelling approach-State space averaging-circuit Averaging and averaged switch modelling- Modelling examples of basic switched mode converters – Modelling of losses in Switches and Circuit elements - Modelling the PWM		6	20

MODULE: 6 Circuit Averaging Concepts -Obtaining a time-invariant circuit - Circuit averaging - Perturbation and linearization - Development of circuit averaged models of buck, boost converters - Averaged switch modelling. DCM averaged switch model - Small-signal ac modelling of the DCM switch network - Developing Canonical model Generalized switch averaging -DCM modelling of basic switch-mode converters - Modelling Inverters - Models of inverters using ideal switches	8	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 6407	POWER QUALITY	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

- To familiarise the various power quality characterizations, sources of power quality issues and recommend standards related to power quality
- To understand the effects of various power quality phenomena in various equipments.
- To understand and to provide solutions for power factor correction through various power factor correction techniques.
- To gain knowledge on active harmonic filtering and to provide solutions to grounding and wiring problems

Syllabus

Introduction; power quality; voltage quality; classification of power quality issues; power acceptability curves; Harmonics; effect of power system harmonics on power system equipment and loads; Modelling of networks and components under non-sinusoidal conditions; Power factor improvement; Active Harmonic Filtering; Dynamic Voltage Restorers; Grounding and wiring; NEC grounding requirements

Course Outcome:

Upon completion of course on Power quality the students

- Will be able to identify and classify power quality disturbances.
- Will be able to analyse the causes of power quality issues caused by components in the system.
- Will be able to provide feasible solutions for power factor correction.
- Will be able to develop the harmonic mitigation methods.

Text Books:

1. Heydt G T, “Electric power quality”.
2. Math H. Bollen, “Understanding Power Quality Problems”.

References:

1. Arrillaga J, “Power System Quality Assessment”, John wiley, 2000.
2. Arrillaga J, Smith B C, Watson N R & Wood A R, “Power System Harmonic Analysis”, Wiley, 1997.
3. Ashok S, “Selected Topics in Power Quality and Custom Power”, Course book for STTP, 2004,
4. Surya Santoso, Wayne Beaty H, Roger C. Dugan, Mark F. McGranaghan, “Electrical Power System Quality “, MC Graw Hill, 2002.

COURSE PLAN

COURSE NO:	COURSE TITLE	CREDITS	
04 EE 6407	POWER QUALITY	3-0-0-3	
MODULES		Contact hours	Sem. Exam Marks; %
MODULE : 1 Introduction-power quality-voltage quality-overview of power quality phenomena-classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C-message weights- flicker factor-transient phenomena-occurrence of power quality problems.		7	15
MODULE : 2 Power acceptability curves-IEEE guides, standards and recommended practices.		5	15
FIRST INTERNAL TEST			
MODULE : 3 Harmonics-individual and total harmonic distortion-RMS value of a harmonic waveform-triplex harmonics-important harmonic introducing devices-SMPS-Three phase power converters-arcing devices - saturable devices-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.		8	15
MODULE : 4 Modelling of networks and components under non-sinusoidal conditions-transmission and distribution systems-shunt capacitors-transformers-electric machines-ground systems-loads that cause power quality problems-power quality problems created by drives and its impact on drives.		8	15
SECOND INTERNAL TEST			
MODULE : 5 Power factor improvement- Passive Compensation. Passive Filtering. Harmonic Resonance. Impedance Scan Analysis. Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC		6	20

Based on Bilateral Single Phase and Three Phase Converter. static var compensators-SVC and STATCOM.		
MODULE : 6 Active Harmonic Filtering-Shunt Injection Filter for single phase , three-phase three-wire and three-phase four-wire systems . d-q domain control of three phase shunt active filters uninterruptible power supplies-constant voltage transformers- series active power filtering techniques for harmonic cancellation and isolation .Dynamic Voltage Restorers for sag, swell and flicker problems. Grounding and wiring-introduction-NEC grounding requirements-reasons for grounding-typical grounding and wiring problems-solutions to grounding and wiring problems.	8	20
END SEMESTER EXAMINATION		

COURSE CODE	COURSE NAME	L-T-P-C	YEAR
04 GN 6001	RESEARCH METHODOLOGY	0-2-0:2	2015

Pre-requisites:

Course Objectives:

To enable the students:

- To get introduced to research philosophy and processes in general.
- To formulate the research problem and prepare research plan
- To apply various numerical /quantitative techniques for data analysis
- To communicate the research findings effectively

Syllabus

Introduction to the Concepts of Research Methodology, Research Proposals, Research Design, Data Collection and Analysis, Quantitative Techniques and Mathematical Modeling, Report Writing.

Course Outcome:

Students who successfully complete this course would learn the fundamental concepts of Research Methodology, apply the basic aspects of the Research methodology to formulate a research problem and its plan. They would also be able to deploy numerical/quantitative techniques for data analysis. They would be equipped with good technical writing and presentation skills.

Text Books:

1. Research Methodology: Methods and Techniques', by Dr. C. R. Kothari, New Age International Publisher, 2004
2. Research Methodology: A Step by Step Guide for Beginners' by Ranjit Kumar, SAGE Publications Ltd; Third Edition

References:

1. Research Methodology: An Introduction for Science & Engineering Students', by Stuart Melville and Wayne Goddard, Juta and Company Ltd, 2004
2. Research Methodology: An Introduction' by Wayne Goddard and Stuart Melville, Juta and Company Ltd, 2004
3. Research Methodology, G.C. Ramamurthy, Dream Tech Press, New Delhi
4. Management Research Methodology' by K. N. Krishnaswamy et al, Pearson Education

COURSE CODE:	COURSE TITLE	CREDITS	
04 GN 6001	**RESEARCH METHODOLOGY**	**0-2-0: 2**	
MODULES		**Contact Hours**	
MODULE : 1 Introduction to Research Methodology: Concepts of Research, Meaning and 2 Objectives of Research, Research Process, Types of Research, Type of research: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, and Conceptual vs. Empirical		5	
MODULE :2 Criteria of Good Research, Research Problem, Selection of a problem, Techniques involved in definition of a problem, Research Proposals – Types, contents, Ethical aspects, IPR issues like patenting, copyrights.		4	
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 **Research Design :** Meaning, Need and Types of research design, Literature Survey and Review, Identifying gap areas from literature review, Research Design Process, Sampling fundamentals, Measurement and scaling techniques, Data Collection – concept, types and methods, Design of Experiments.		5	
MODULE 4: **Quantitative Techniques:** Probability distributions, Fundamentals of Statistical analysis, Data Analysis with Statistical Packages, Multivariate methods, Concepts of correlation and regression - Fundamentals of time series analysis and spectral analysis.		5	
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 **Report Writing:** Principles of Thesis Writing, Guidelines for writing reports & papers, Methods of giving references and appendices, Reproduction of published material, Plagiarism, Citation and acknowledgement.		5	
MODULE: 6 Documentation and presentation tools – LaTeX, Office software with basic presentations skills, Use of Internet and advanced search techniques.		4	

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6390	POWER ELECTRONICS LAB	0-0-2-1	2015

Pre-requisites:

Course Objectives:

To enable the students:

1. To design, develop and troubleshoot Power Electronic Circuits.
2. To develop experimental skills for independent research.

Syllabus/List of experiments:

1. Firing schemes for converters.
2. Single Phase Semi-converter with R-L and R-L-E loads for continuous and discontinuous conduction modes.
3. Single phase full- converter with R-L and R-L-E loads for continuous and discontinuous conduction modes.
4. Three phase full-converter with R-L-E load.
5. Controlled and Uncontrolled rectifier with different types of filters-continuous and discontinuous modes of operation.
6. Transformer and Inductor design.
7. Voltage and current commutated choppers.
8. MOSFET, IGBT based Choppers.
9. IGBT and MOSFET based inverters.
10. Current source inverter.
11. Single phase AC voltage controller.
12. Transfer function of a DC Motor.
13. Resonant Inverters.
14. Microcontroller/DSP/FPGA based control of dc-dc converters.
15. Study of harmonic pollution by power electronics loads.

Simulation Experiments:

1. Simulation of single-phase Semi-converter and Fully controlled converters with R, RL and RLE Load.
2. Simulation of Three-phase semi converter.
3. Simulation of Three-phase fully controlled converter.
4. Simulation of Single-phase full bridge inverter.

5. Simulation of Three-phase full bridge inverter.
6. Simulation of PWM inverters.
7. Simulation of single phase and three phase AC voltage Controller.
8. Simulation of class A, B, C, D and E choppers.
9. Simulation of buck, boost and buck-boost converters.
10. Simulation of single phase and three phase cycloconverter.
11. Measurement of THD of current & voltage waveforms of controlled & uncontrolled 3-phase rectifiers.

(At least 15 experiments in the list are to be conducted in the laboratory. Additional experiments and simulation assignments may also be developed by the department. Suitable simulation tools may be used for simulation studies. Use of open source tools such as Python, SciLab, Octave, gEDA etc are encouraged).

Course Outcome:

After completing this course the students will be able to develop control algorithms in digital control platforms such as DSP/FPGA/Microcontrollers.

The students will be able to develop electrical drive systems from fundamental principles.

The students will acquire sufficient experimental skills to carry out independent experimental research.

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6302	SWITCHED MODE POWER CONVERTERS	4-0-0: 4	2015

Pre-requisites: [04 EE 6303] Power Electronics Devices and Circuits

Course Objectives:

To give the Student:-

- A comprehensive study of various topologies of switched mode power converters;
- Ability to design and develop power electronic system control.

Syllabus

DC-DC non-isolated switched mode converters; Buck, Boost, Buck-Boost converters, CUK and SEPIC; State space modelling; Switched Mode Power Converters, Fly back, Forward Converter, Push-Pull, Half and Full Bridge Converters; Voltage and Current control methods for converters; Resonant Converters, ZVS and ZCS; Switched Mode inverters, PWM techniques, Space Vector Modulation; Introduction to Multilevel inverters.

Course Outcome:

Students who successfully complete this course will have an ability to understand various topologies of switched mode power converters; Design and develop power electronic system control.

Text Books:

1. Mohan, Undeland, Robbins, Power Electronics; Converters, Applications and Design. -3rd edition, John Wiley and Sons, 2003
2. Abraham I Pressman, Switching Power Supply Design. McGrawHill

References:

1. Daniel M Mitchell, DC-DC Switching Regulator Analysis. McGraHill
2. Daniel W. Hart, Power Electronics, Tata McGraw-Hill, 2011
3. William Shepherd, Li Zhang, Power Converter Circuits, Marcel Decker, 2004.
4. Prof. V. Ramanarayanan, Course Material on Switch Mode Power Conversion, Electrical Department, IISc, Bangalore, 2006.
5. B K Bose, Modern Power Electronics and AC Drives, Pearson Education, 2002.
6. B W Williams, Power Electronics; Principles and Elements, University of Strathclyde Glasgow, 2006.
7. D Grahame Holmes, Thomas A Lipo, Pulse Width Modulation for Power Converters:
8. M H Rashid (Ed), Power Electronics Handbook: Devices, Circuits and Applications, Academic Press 2010.

COURSE PLAN

COURSE NO:	Course Title:	CREDITS	
04 EE 6302	**SWITCHED MODE POWER CONVERTERS**	**3-1-0: 4**	
MODULES		**Contact hours**	**Sem. Exam Marks; %**
MODULE : 1 DC-DC switched mode converters, DC steady state principles, Buck, Boost, Buck-Boost converters, CUK- Basic Operation with Waveforms (Continuous and discontinuous operation)- Voltage and current relationship switching stresses - switching and conduction losses - optimum switching frequency – Output voltage ripple; State space modelling		12	15
MODULE : 2 Push-Pull and Forward Converter Topologies - Basic Operation. Waveforms - Flux Imbalance Problem and Solutions - Transformer Design -Output Filter Design -Switching Stresses and Losses -Forward Converter Magnetics --Voltage Mode Control		8	15
FIRST INTERNAL TEST			
MODULE : 3 Half and Full Bridge Converters; Basic Operation and Waveforms-Magnetics, Output Filter, Flux Imbalance, Switching Stresses and Losses, Power Limits, Voltage Mode Control, Flyback Converter; discontinuous mode operation, waveforms, Control, Magnetics - Switching Stresses and Losses, Disadvantages - Continuous Mode Operation, Waveforms, Control, Design Relations.		8	15
MODULE : 4 Study - Voltage and current Mode Control of SMPS, Current Mode Control Advantages, Current Mode vs. Voltage Mode, Tolerance Band control, Fixed and variable Frequency control		8	15
SECOND INTERNAL TEST			
MODULE : 5 Resonant Converters- Classification, Basic Resonant Circuit Concepts, Load Resonant Converter, Resonant Switch Converter, Zero Voltage		10	20

Switching - Zero current switching, ZVS Clamped Voltage Topologies, Resonant dc-link inverters.		
MODULE : 6 Switched Mode Inverters; PWM Techniques – Natural Sampled PWM (Sinusoidal PWM) – Regular Sampled PWM, Space Vector Modulation; Multilevel inverters – Concepts, Types; Diode clamped, Flying capacitor, Cascaded – Principle of operation, comparison, PWM techniques.	10	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6202	ADVANCED CONTROL OF AC DRIVES	3-0-0-3	2015

Pre-requisites:

1. 04 EE 6201 Dynamics of Electrical Machines
2. 04 EE 6203 Fundamentals of Electric Drives
3. 04 EE 6303 Power Electronic Devices and Circuits

Course Objectives:

To enable the students:

- To analyse and design vector controlled AC drives

Syllabus

Dynamic modelling of induction machines - Generalized model in arbitrary reference frame - Stator reference frame model, Rotor reference frame model, Synchronously rotating reference frame model – Vector Control - Vector controlled induction motor drive – Stator flux oriented vector control - Indirect rotor flux oriented vector control scheme - Flux weakening operation - Speed controller design.
Parameter sensitivity and compensation of vector controlled induction motors - Sensorless methods for vector control-Observer based techniques- Direct torque control of induction motor.
Permanent magnet synchronous motor drives - Vector control strategies

Course Outcome:

Students will be able to develop Simulation models of AC Motors and drive systems.
Student will be able to develop basic designs of control loops in vector control drives.

Text Books:

1. R. Krishnan, “Electric Motor Drives,” PHI.
2. W. Leonhard, Control of Electric Drives, Springer

References:

1. D. W. Novotny and T. A. Lipo, Vector Control and Dynamics of AC Drives, Oxford University Press, 1996.
2. B. .K Bose, Modern Power Electronics and AC Drives, Pearson-2002.Leonhard, Control of Electric Drives, Springer-2001.
3. John Chiasson, Modelling and High Performance Control of Electric Machines, Wiley- IEEE Press, 2005.
4. I. Boldea, S A Nasar, Electric Drives, 2ndedition, CRC Press, 2006.
5. K. Rajashekara, Sensorless Control of AC motors, IEEE Press, 1996.
6. I. Boldea, S. A. Nasar, Vector Control of AC Drives, CRC Press, 1992.
7. J. Holtz, Sensorless Control of Induction Motor Drives, Proceedings of the IEEE, August 2002, PP 1359-1394

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 6202	ADVANCED CONTROL OF AC DRIVES	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 Modelling - Dynamic modelling of induction machines – 3-phase to 2-phase transformation –power equivalence – generalized model in arbitrary reference frame – electromagnetic torque – derivation of stator reference frame model, rotor reference frame model, synchronously rotating reference frame model – equations in flux linkages- Simulation of starting characteristics of induction motor using MATLAB/SIMULINK (Assignment/Project).		8	15
MODULE :2 Vector Control - Vector controlled induction motor drive – Principle of vector or field oriented control – direct rotor flux oriented vector control – estimation of rotor flux and torque– implementation with current source and voltage source inverters - Stator flux oriented vector control - Indirect rotor flux oriented vector control scheme - Dynamic simulation - Selection of Flux level - Flux weakening operation - Speed controller design – simulation of vector control of induction motor using MATLAB/SIMULINK (Assignment/Project).		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 Parameter sensitivity and compensation of vector controlled induction motors - Sensor less methods for vector control- Introduction to observer based techniques.		6	15
MODULE 4: Direct torque control of induction motor – principle – control strategy — reduction of torque and flux ripple – Comparison of DTC and FOC – Simulation of DTC of induction motor using MATLAB/SIMULINK (Assignment/Project)		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 **Permanent Magnet Synchronous Motor (PMSM) drives:** Types of permanent magnet synchronous machines – Model of PMSM – Vector control strategies		6	20
MODULE: 6 **PMSM Drives:** Constant torque-angle control, unity power factor control, constant mutual flux-linkages control, optimum torque per ampere control- field weakening operation		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6204	SPECIAL ELECTRICAL MACHINES AND DRIVES	3-0-0-3	2015

Pre-requisites:

Course Objectives:

To enable the students:

- To select, evaluate and design suitable special electrical machine drives for various applications.

Syllabus

Stepper Motors - Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor.

Switched Reluctance Motors - Characteristics and control. Synchronous Reluctance Motors -

Permanent Magnet Brushless DC Motors - Torque-speed characteristics, Controllers-Microprocessor based controller. Sensor less control.

Permanent Magnet Synchronous Motors - Self control, Vector control, Current control schemes. Sensorless control.

Course Outcome:

- Students will be able to evaluate and select a special electric machine drive for particular applications
- Students will be able to do the basic design of special electrical machine drive systems.

References:

1. Kenjo T, Sugawara A, Stepping Motors and Their Microprocessor Control, Clarendon Press, Oxford, 1994
2. Miller T J E,Switched Reluctance Motor and Their Control, Clarendon Press, Oxford, 1993.
3. Miller T J E, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford, 1989.
4. B K Bose, Modern Power Electronics & AC drives, Pearson, 2002.
5. Kenjo T, Power Electronics for the Microprocessor Age, Oxford University Press, 1990.
6. Ali Emadi (Ed), Handbook of Automotive Power Electronics and Motor Drives, CRC Press, 2005.
7. R Krishnan, Electric Motor Drives – Modeling, Analysis and Control, PHI, 2003.
8. H A Toliyat, S Campbell, DSP Based Electromechanical Motion Control, CRC Press, 2004.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 6204	SPECIAL ELECTRICAL MACHINES AND DRIVES	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 Stepper Motors - Constructional features, principle of operation, modes of excitation, single phase stepping motors, torque production in variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, microprocessor based controller.		10	15
MODULE :2 Switched Reluctance Motors - Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control. Microprocessor based controller, Sensorless control.		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 Synchronous Reluctance Motors-Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – Phasor diagram, motor characteristics.		6	15
MODULE 4: Permanent Magnet Brushless DC Motors - Commutation in DC motors, Difference between mechanical and electronic commutator, Hall sensors, Optical sensors, Multiphase Brushless motor		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller. Sensor less control.		6	20
MODULE: 6 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.		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6104	DIGITAL CONTROL SYSTEMS	3-0-0:3	2015

Pre-requisites:

Course Objectives:

To give students

- an introduction digital control system and its analysis
- a foundation for the classical and advanced design of digital control system.

Syllabus

Introduction to Digital Control systems, Analysis of Digital Control Systems, Classical Design of Digital Control Systems, Advanced Design of Digital Control Systems

Course Outcome:

At the end of the course students will be able to design and analyse a digital control systems

REFERENCE

1. B. C. Kuo , Digital Control Systems (second Edition),Oxford University Press, Inc., New York, 1992.
2. G. F. Franklin, J.D. Powell, and M.L. Workman, Digital control of Dynamic Systems, Addison-Wesley Longman, Inc., Menlo Park, CA , 1998.
3. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publishing Company, Third Edition,2009.
4. John F. Walkerly, Microcomputer architecture and Programs, John Wiley and Sons Inc., New York, 1981.
5. K. Ogata, Discrete Time Control Systems, Addison-Wesley Longman Pte. Ltd., Indian Branch, Delhi, 1995.
6. C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw Hill Book Company, 1985.
7. C. L. Philips and H.T. Nagle, Jr., Digital Control System Analysis and Design, Prentice Hall, Inc., Englewood Cliffs,N.J.,1984

COURSE PLAN

COURSE NO:	COURSE TITLE		CREDITS
04 EE 6104	**DIGITAL CONTROL SYSTEMS**		**3-0-0: 3**
MODULES		**Contact hours**	**Sem. Exam Marks;%**
MODULE : 1 Data conversion and quantisation- Sampling process- Mathematical modelling- Data reconstruction and filtering of sampled signals- Hold devices, Z transform and inverse Z transform - Relationship between S- plane and Z- plane		6	15
MODULE : 2 Difference equation-Solution by recursion and z-transform- Discretisation Methods, Digital control systems- Pulse transfer function - z transform analysis of closed loop and open loop systems		8	15
FIRST INTERNAL TEST			
MODULE : 3 Modified z- transfer function- Multirate z-transform - Stability of linear digital control systems- Stability tests, Steady state error analysis- Root loci - Frequency domain analysis- Bode plots- Nyquist plots- Gain margin and phase margin.		8	15
MODULE : 4 Cascade and feedback compensation by continuous data controllers- Digital controllers-Design using bilinear transformation- Root locus based design, Digital PID controllers- Dead beat control design- Case study examples using MATLAB		8	15
SECOND INTERNAL TEST			

MODULE : 5 State variable models- Interrelations between z- transform models and state variable models- Controllability and Observability - Response between sampling instants using state variable approach-Pole placement using state feedback	5	20
MODULE : 6 Servo Design- State feedback with Integral Control-Deadbeat Control by state feedback and deadbeat observers Dynamic output feedback- Effects of finite word length on controllability and closed loop pole placement- Case study examples using MATLAB	7	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6106	STOCHASTIC MODELLING AND APPLICATIONS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

- To imbibe the essentials of probability models leading up to stochastic processes;
- Acquire the necessary skills in building stochastic models using Markov chains;
- To develop an understanding of queuing systems under different configurations;
- Acquire problem solving skills in applying ingrained subject skills to real world problems.

Syllabus

Discrete probability distributions, Continuous probability densities, Distribution functions, Expectations, moments, Characteristic functions, Moment generating functions, Random variables, Convergence concepts, Law of large numbers, Central limit theorem – Bernoulli trials, Discrete and continuous independent trials, Stochastic processes-Markov chains, Computation of equilibrium probabilities, Stationary distribution and Transient distribution of Markov chains, Poisson processes – Exponential distribution and applications, Birth-death processes and applications.

Course Outcome:

- Have an appreciation of the power of stochastic processes and its range of applications;
- Master essential stochastic modelling tools including Markov chains and queuing theory; Ability to formulate and solve problems which involve setting up stochastic models.

Text Books:

1. Hole, P.G., Port, S.C., and Stone C.J.,' Introduction to Probability Theory', Indian Edition Universal Book Stall, New Delhi, 1998.
2. Hole P.G., Port, S.C., and Stone C.J.,' Introduction to Stochastic Process', Indian Edition Universal Book Stall, New Delhi, 1981

References:

1. Alberto Leon-Garcia; Probability, Statistics and Random process for Electrical Engineering, Pearson Third Edition,2008.
2. Miller and Freund, "Probability", PHI India, 2005.

COURSE PLAN

Course No:	Course Title	CREDITS	
04 EE 6106	Stochastic Modelling and Applications	3-0-0: 3	
MODULES		Contact hours	Sem. Exam Marks;%
MODULE : 1 Probability Spaces- Discrete probability distributions, Continuous probability densities, Conditional probability		8	15
MODULE : 2 Probability distributions and densities, Distribution functions, Multiple random variables and joint distributions		7	15
FIRST INTERNAL TEST			
MODULE : 3 Expectations, Moments, Characteristic functions, Moment generating functions, Sequence of random variables, Convergence Concepts		6	15
MODULE : 4 Law of large numbers, Discrete and continuous random variables, Central limit theorem, Bernoulli trials, Discrete and continuous independent trials		7	15
SECOND INTERNAL TEST			
MODULE : 5 Stochastic processes-Markov chains – Transient analysis, Computation of equilibrium probabilities, Stationary distribution and Transient distribution of Markov chains		8	20
MODULE : 6 Poisson processes, Exponential distribution and applications, Birth-death processes and applications		6	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6208	COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES	3-0-0-3	2015

Pre-requisites:

Course Objectives:

To enable the students:

- To develop computer aided design of electrical machines

Syllabus

Analysis and synthesis methods - Limitations - Need for field analysis based design - **Mathematical Formulation of Field Problems.** Mathematical Models - Differential/Integral equations - Finite Difference method – Finite Element Method - Energy minimization - Variational method - 2D Field problems - Discretisation- Shape functions - Stiffness matrix - Solution techniques. Elements of a CAD System - Preprocessing - Modeling - Meshing -Material properties -Boundary Conditions - Setting up solution - Post processing. Design Applications-CAD Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines

Course Outcome:

Students will be able to design electrical machines using CAD packages.

Text Books:

References:

1. S J Salon, *Finite Element Analysis of Electrical Machines*, Kluwer Academic Publishers,London, 1995.
2. Chee-Mun Ong, *Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK,*Prentice Hall, 1998.
3. Vlado Ostovic, *Computer Aided Analysis of Electric Machines*, Prentice Hall International (UK)Ltd, 1994.
4. Silvester and Ferrari*, Finite Elements for Electrical Engineer,* Cambridge University Press,1983.
5. S R H Hoole, *Computer-Aided, Analysis and Design of Electromagnetic Devices*, Elsevier, New York, Amsterdam, London, 1989.
6. D A Lowther, P P Silvester, *Computer Aided Design in Magnetics*, Springer Verlag, New York.
7. M Ramamoorthy, Computer Aided Design of Electrical Equipments, Affiliated East West Press.
8. C W Trowbridge, *An Introduction to Computer Aided Electromagnetic Analysis*, Vector Field Ltd.
9. User Manuals of Software Packages like MAGNET, ANSOFT& ANSYS.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 6208	COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 **Introduction** Computer aided design of electrical machines - Conventional design procedures - Analysis and synthesis methods - Limitations - Need for field analysis based design		10	15
MODULE :2 **Mathematical Formulation of Field Problems** Development of torque/force - Electromagnetic Field Equations - Magnetic Vector/Scalar potential - Electrical Vector/Scalar potential - Stored energy in field problems – Inductances -		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 Laplace and Poisson's Equations - Energy functional - Principle of energy conversion		6	15
MODULE 4: **Philosophy of FEM** Mathematical Models - Differential/Integral equations - Finite Difference method – Finite Element Method - Energy minimization - Variational method - 2D Field problems - Discretisation- Shape functions - Stiffness matrix - Solution techniques		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 **CAD Packages** Elements of a CAD System - Preprocessing - Modeling - Meshing -Material properties -Boundary Conditions - Setting up solution - Post processing.		6	20
MODULE: 6 Design Applications-CAD Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6300	ADVANCED POWER SEMICONDUCTOR DEVICES	3-0-0: 3	2015

Pre-requisites: NIL

Course Objectives:

To give the Student:-

- The fundamentals of static and dynamic characteristics of current controlled & voltage controlled power semiconductor devices
- Ability to realize appropriate solid state device for various power electronic applications

Syllabus

Power switching devices overview; Attributes of an ideal switch; Power handling capability, Construction, Device Physics, static and dynamic characteristics of Power diodes, BJT, Thyristors, Power MOSFETs and IGBTs; Basics of GTO, MCT, FCT, RCT and IGCT; Isolation, snubber circuits, Gate drives circuitry for power devices; Thermal Protection.

Course Outcome:

Students who successfully complete this course will have an ability to understand various power electronics devices such as SCR, TRIAC, DIAC, IGBT, GTO etc. Also able to realize appropriate Power Electronics devices in Choppers, Inverters, Converters to create an optimum design.

Text Books:

1. Mohan, Undeland, Robbins, Power Electronics; Converters, Applications and Design. -3rd edition, John Wiley and Sons, 2003
2. Power Electronics ,P. C. Sen

References:

1. Kassakian J G et al, “Principles of Power Electronics”, Addison Wesley, 1991.
2. B W Williams, Principles and Elements of Power Electronics, University of Strathclyde,Glasgow, 2006.
3. M D Singh, K B Khanchandani, “Power Electronics”, Tata McGraw Hill, 2001.
4. Daniel W. Hart, Power Electronics, Tata McGraw-Hill, 2011
5. M H Rashid (Ed), Power Electronics Handbook: Devices, Circuits and Applications, Academic Press 2010.

COURSE PLAN

COURSE NO.	COURSE TITLE	CREDITS	
04 EE 6300	ADVANCED POWER SEMICONDUCTOR DEVICES	3-0-0:3	
MODULES		Contact hours	Sem. Exam Marks; %
MODULE : 1 Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching		7	15
MODULE : 2 Power diodes - Types, forward and reverse characteristics, switching characteristics – rating. Shottky Diode BJT's – Construction, Device Physics, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown, steady state and dynamic models of BJT, Power Darlington		7	15
FIRST INTERNAL TEST			
MODULE : 3 Thyristors – Physical and electrical principle underlying operation, Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; Comparison of BJT and Thyristor – steady state and dynamic models of Thyristor		8	15
MODULE : 4 Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, Device physics, Static and Switching Characteristics, Steady state and dynamic models of MOSFET and IGBTs, Basics of GTO, MCT, FCT, RCT and IGCT		7	15
SECOND INTERNAL TEST			
MODULE : 5 Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. Over voltage,		7	20

over current and gate protections; Design of snubbers.		
MODULE : 6 Thermal Protection**:** Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types	6	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6002	SOFT COMPUTING TECHNIQUES	3-0-0: 3	2015

Pre-requisites: Nil

Course Objectives:

To enable the student to apply neural and fuzzy logic based analysis tools in optimization of power systems and power electronic problems.

Syllabus

Neural Network- Different architectures-supervised learning-perceptron- Adaline-Back Propagation-Caushy's and Boltsman's training methods-Simulated annealing-Unsupervised learning-Competitive learning-Kohenon self organizing network-Hebbian learning-Hopfield network- ART network-NNW applications in control.

Fuzzy Logic- Basic concepts-set theoretic operations-membership function fuzzy rules-fuzzy reasoning fuzzy inference systems Mamdani and Sugeno type-defuzzification- fuzzy controllers applications in electric drives and power system. **Neuro Fuzzy-** Modelling - Neuro fuzzy inference system-controllers-Back propagation through recurrent learning- Reinforced learning.

Genetic Algorithms-Basic concepts-design issues - modelling hybrid models.

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to apply soft computing techniques in engineering applications.

Text Books:

1. Leandro Nunes de Castro," Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications".
2. "Philip D Wasserman, "Neural Computing"Van Nostrand Reinhold, 1993
3. Chapman & Hall/CRC, 2006.1. S Rajasekharan, VijayaLakhmi Pai, Neural Network, Fuzzy logic and Genetic Algorithm, PHI, 2002

References:

1. Melanie Mitchell, " An Introduction to Genetic Algorithms", MIT Press- 1996.

2. Mohamed E. El-Hawary, "Modern Heuristic Optimisation technique –Theory and application to power system," IEEE Press.
4. J S R Lang, C T Sun, Mizutani, Neuro Fuzzy and Soft Computing.
5. David E Goldberg, Genetic Algorithms
6. G. Rozenberg, T. Bäck, J. N. Kok ,"Handbook of Natural Computing", Springer Verlag- 2010.
7. Xin-She Yang, "Nature-Inspired Metaheuristic Algorithms", Luniver Press 2010
8. J. R. Koza: "Genetic Programming: On the programming of computers by means of natural selection", MIT Press- 1992 .

COURSE PLAN

COURSE NO:	Course Title		CREDITS
04 EE 6004	Soft Computing Techniques		3-0-0:3
MODULES		Contact hours	Sem. Exam Marks;%
MODULE : 1 **Neural Network-** Different architectures-supervised learning-perceptron-Adaline-Back Propagation-Caushy's and Boltsman's training methods-Simulated annealing.		10	15
MODULE : 2 Unsupervised learning-Competitive learning-Kohenon self organizing network-Hebbian learning-Hopfield network- ART network-NNW applications in control.		8	15
FIRST INTERNAL TEST			
MODULE : 3 **Fuzzy Logic-** Basic concepts-set theoretic operations-membership function fuzzy rules-fuzzy reasoning fuzzy inference systems Mamdani and Sugeno type-defuzzification- fuzzy controllers applications in electric drives and power system.		6	15
MODULE : 4 **Neuro Fuzzy-** Modelling - Neuro fuzzy inference system-controllers-Back propagation through recurrent learning- Reinforced learning.		8	15
SECOND INTERNAL TEST			
MODULE : 5 **Genetic Algorithm Application :** Modern Heuristic Search Techniques Genetic Algorithm-Introduction- -Encoding-Fitness Function, Premature Convergence, Slow Finishing,Basic Operators, Selection-Tournament Selection, Truncation Selection, Linear Ranking Selection, Exponential Ranking Selection, Elitist Selection, Proportional Selection-Crossover,		5	20
MODULE : 6 Mutation, Control Parameters Estimation, Niching Methods, Parallel		5	20

Genetic Algorithms-Application in Drives.- Tuning of membership function using genetic algorithm. Application of GA to neural network.- Tuning of controllers.		
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6118	ADVANCED DIGITAL SIGNAL PROCESSING	3-0-0: 3	2015

Pre-requisites:

Course Objectives:

- To introduce basic concept behind digital signal processing;
- To study the design and realization of IIR and FIR filters;
- To study the different methods for power spectrum estimation;
- To study multirate signal processing fundamentals

Syllabus

Discrete time signals and systems: Basic principles of signal processing, sampling process, Properties of systems, Discrete time Fourier transform, Z transform; Frequency domain representations: Discrete Fourier transform and its properties, linear and circular convolution, radix 2 DIT FFT, Radix2 DIF FFT; IIR filter design: Analog butter worth functions for various filters, analog to digital transformation, Structures for realizing digital IIR filters; Design of FIR filters: Design of FIR filters using Fourier series method, Design of FIR filters using windows, Design using frequency sampling, realization of FIR filters; Spectral estimation: Estimation of spectra from finite duration signals, Nonparametric methods, Parametric methods; Multirate digital signal processing: Interpolation and Decimation, Sampling rate conversion by a rational factor, Polyphase filter structures, Multistage implementation of multirate system

Course Outcome:

The students will be able to

- Understand the basics of digital signal processing and various frequency domains
- Understand the design and implementation of IIR and FIR filters.
- Understand the various methods for spectral estimation.
- Understand the concept behind multirate signal processing.

Text Books:

1. John G. Proakis, Dimitris G. Manolakis, *Digital Signal Processing*, PHI, New Delhi,1997.
2. Mitra, *Digital Signal Processing*, 3e, Tata McGraw –Hill Education New Delhi,2007

References:

1. Alan V. Oppenheim, Ronald W. Schafer, Discrete time Signal Processing , PHI, New Delhi,1997.
2. Monson H. Hayes, *Statistical Digital Signal Processing and Modelling*, Wiley, 2002.
3. ES Gopi, *Algorithm collections for Digital Signal Processing Applications using Matlab*, Springer, 2007.
4. Roberto Cristi, *Modern Digital Signal Processing*, Thomson Brooks/Cole (2004)

COURSE PLAN

Course No:	COURSE TITLE	CREDITS	
04 EE 6118	ADVANCED DIGITAL SIGNAL PROCESSING	3-0-0: 3	
MODULES		Contact hours	Sem. Exam Marks;%
MODULE : 1 Discrete time signals and systems: Basic principles of signal processing-Building blocks of digital signal processing. Review of sampling process and sampling theorem. Properties of systems-linearity, causality, time variance, convolution and stability Frequency domain representation – Discrete time Fourier transform and its properties- Z transform and inverse Z transform		8	15
MODULE : 2 Discrete Fourier transform-inverse discrete Fourier transform-properties of DFT-linear and circular convolution-overlap and add method-overlap and save method FFT - radix 2 DIT FFT-Radix2 DIF FFT		6	15
FIRST INTERNAL TEST			
MODULE : 3 Digital filter design: Design of IIR filters from analog filter - analog butter worth functions for various filters - analog to digital transformation-backward difference and forward difference approximations-impulse invariant transformation. Structures for realizing digital IIR filters-Direct form 1-direct form II-parallel and cascade structure, lattice structure.		6	15
MODULE : 4 Design of FIR filters-Design of FIR filters using Fourier series method-Design of FIR filters without using windows- Design of FIR filters using windows-Design using frequency sampling- realization of FIR filters.		6	15
SECOND INTERNAL TEST			

MODULE : 5 Spectral estimation-Estimation of spectra from finite duration signals, Nonparametric methods-Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods. Parametric methods – ARMA model based spectral estimation, Yule-Walker equation and solution, Solution using Levinson-Durbin algorithm.	9	20
MODULE : 6 Multirate digital signal processing- Mathematical description of change of sampling rate – Interpolation and Decimation, Decimation by an integer factor, Interpolation by an integer factor, Sampling rate conversion by a rational factor, Polyphase filter structures, Multistage implementation of multirate system	7	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	CREDITS	YEAR
04 EE 6308	ANALYSIS, DESIGN AND GRID INTEGRATION OF PHOTOVOLTAIC SYSTEMS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

- To familiarize Solar PV System
- To analyze grid integrated PV System
- To learn about PV system over current protection of solar system
- To understand various faults of solar power system

Syllabus

Fundamental concepts and overview of Solar Cells ; MPPT Algorithm; Study of solar panel; Analysis of Grid Connected solar PV systems; Protection of solar PV system

Course Outcome:

Students who successfully complete this course will able to analyze and design the grid integration of photovoltaic systems

Text Books:

1. A K Mukerjee, Niveditha Thakur : *Photovoltaic Systems Analysis and Design*, PHI
2. Chetan Singh Solanki: *Solar Photovoltaics Fundametals, Technologies and Applications*, PHI
3. Amir Naser Yazdani and Reza Iravani: *Voltage - Sourced Converters in Power Systems modeling, control and Applications*, WILEY, IEEE Press
4. Photovoltaic System Over current Protection by cooper bussmann

References:

1. A. Goetzberger V.U. Hoffmann : *Photovoltaic Solar Energy Generation* Springer Series in optical sciences
2. Antonio Luque and Steven Hegedus : *Handbook of Photovoltaic Science and Engineering*, WILEY

COURSE PLAN

Course No:	Course Title		CREDITS
04 EE 6308	**Analysis, Design and Grid Integration of Photovoltaic Systems**		**3-0-0: 3**
MODULES		**Contact hours**	**Sem. Exam Marks;%**
MODULE : 1 - Solar Cells: Generation of Photo Voltage – Light Generated Current – I V Equation of Solar Cells- Solar Cell Characteristics. **Design of Solar Cells:** Upper Limit of Cell Parameters- Losses in Solar Cells - Diode Equivalent Model		6	15
MODULE: 2 – Solar Cell Energy Conversion Efficiency Effect of Variation of Solar Insolation and Temperature on Efficiency. Solar PV Modules from Solar Cells - Series and Parallel Connection of Cells – Design and Structure of PV Module – Number of Solar Cells in a Module – Wattage of Modules- PV Module Power Output - I- V Equation of PV Module - Ratings of PV Module – I-V Curve and P-V Curve of Module		7	15
FIRST INTERNAL TEST			
MODULE: 3 Mismatch Losses of PV Modules Effect of Variation of Solar Insolation and Temperature – Partial Shading of a Solar Cell and a Module. **Batteries for PV systems** – Factors affecting battery performance **MPPT Algorithms**: Perturb and Observe- Incremental Conductance, Mechanical Tracking - Single Axis Tracking – Dual Axis Tracking.		7	15
MODULE: 4 Standalone P V System Configurations Design PV powered DC fan and pump without battery- Design of Standalone System with Battery and AC or DC Load. A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter – Protection Against Islanding and Reverse Power Flow – AC Modules- Design of EMI Filters.		8	15
SECOND INTERNAL TEST			

MODULE : 5 - Grid Imposed Frequency VSC system : Control in αβ Frame - Structure of Grid Imposed Frequency VSC system – Real-/ Reactive Power Controllers - Current Mode Versus Voltage Mode Control - Dynamic Model of Real-/ Reactive Power Controllers - Current Mode Control of Real/ Reactive Power	8	20
MODULE : 6 - **PV power protection systems** Over current protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications.	6	20
END SEMESTER EXAM		

COURSE CODE	COURSE NAME	L-T-P-C	YEAR
04 EE 6604	DIGITAL CONTROLLERS FOR POWER APPLICATIONS	3-0-0-3	2015

Pre-requisites: [04 EE 6303] POWER ELECTRONIC DEVICES AND CIRCUITS

Course Objectives:

To give students:

- A foundation in the fundamentals of PIC 18F4580 controller based system design;
- An ability to design and develop various power converter circuits using embedded system;
- An introduction to TMS320F2407 DSP controller for developing embedded controllers for power electronic applications.

Syllabus

PIC 18F4580 - Architecture, Programming, fundamental of embedded system design; Typical functions of PIC18F4580 microcontrollers in power electronic systems; Use of microcontroller in power converters, control; Introduction to TMS 320LF2407, Architecture details, basic programming

Course Outcome:

The students who successfully complete this course will have an ability develop embedded controllers for power electronic based system.

Text Books:

1. Muhammad Ali Mazidi, Rolind D. Mckinlay, Danny Causey. " PIC microcontroller and Embedded Systems – using assembly and C for PIC18" 13th impression, Pearson, 2013
2. Han Way Huang, "PIC Microcontroller, An introduction to software and hardware interfacing", Delmar, 2007
3. George Terzakis, Introduction to C Programming With the TMS320LF2407A DSP Controller, Create Space Independent Publishing Platform, February 2011

References:

1. Richard H. Barnett, Larry O'Cull, Sarah Alison Cox, Embedded C Programming and the Microchip PIC, Volume 1, Thomson Delmar Leaning
2. Kenjo.T, "Power electronics for microprocessor Age", Clarendon press, Oxford, 1999
3. GourabSen Gupta, Subhas Chandra Mukhopadhyay, "Embedded Microcontroller Interfacing, Designing Integrated Projects", Springer, 2010
4. Harprit Singh Sandhu, Making PIC Microcontroller Instruments and Controllers, McGraw-Hill Professional , 2009
5. Harprit Singh Sandh, Running Small Motors with PIC Microcontrollers, McGraw-Hill Professional, 2009
6. Sen M. Kuo, Woon-Seng S. Gan, Digital Signal Processors: Architectures, Implementations, And Applications, Pearson Education , 2009

7. Phil Lapsley, Jeff Bier, Amit Shoham, Edward A. Lee, DSP Processor fundamentals: Architectures and Features , IEEE Press -1997 , Wiley India Pvt Ltd
8. H.A. Toliyat, S.Campbell, DSP based Electro Mechanical Motion Control, CRC Press-2004
9. Avtar Singh and S. Srinivasan, Digital Signal Processing, Thomson/Brooks/Cole, 2004
10. PIC18F4580 Data Sheet – DS39637D, Microchip Technology Inc., 2009
11. TMS320LF2407 Data Sheet , Texas Instrument, September 2003

COURSE PLAN

COURSE CODE:	COURSE TITLE	CREDITS	
04 EE 6604	DIGITAL CONTROLLERS FOR POWER APPLICATIONS	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE : 1 - Microchip PIC 18F4580: Architecture of PIC 18F4580 microcontroller, PIC memory organization, Interrupt structure, Timers / Counters, Capture / Compare / PWM modules, Master Synchronous Serial Port (MSSP) module, USART A / D Converter module, Comparator module.		10	15
MODULE : 2 – PIC 18F Programming: Different addressing modes. Instruction set, General Programming – .LST and .HEX files generation for applications using MPLab IDE		6	15
FIRST INTERNAL TEST			
MODULE: 3 Typical functions of PIC18F4580 microcontrollers in power electronic systems: Measurement of voltage, current, speed, power and power factor, Frequency measurement, PWM implementation; Interfacing LCD Display, Keyboard Interfacing		6	15
MODULE: 4 Use of PIC18F4580 microcontroller in power converters: Overview of Zero Crossing Detectors, Generation of gating signals for Converters, Inverters and chopper circuit, Control of AC/DC electric drives.		6	15
SECOND INTERNAL TEST			
MODULE: 5 PIC18F4580 based system control: Implementation of PI, PID controller, Power quality/power factor correction, Solar Power Conditioning (MPPT) - Miscellaneous examples		6	20
MODULE: 6 Introduction to TMS 320LF2407: Introduction to DSP architecture- computational building blocks - Address generation unit, Program control and sequencing- Parallelism, Pipelining Architecture of TMS320LF2407 - Addressing modes- I/O functionality, Interrupt. ADC, PWM, Event managers- Elementary Assembly Language Programming		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 6292	ELECTRICAL DRIVES LAB	0-0-2-1	2015

Pre-requisites: 04 EE 6201 Dynamics of Electrical Machines

04 EE 6203 Fundamentals of Electric Drives

04 EE 6303 Power Electronic Devices and Circuits

Course Objectives:

To enable the students:

1. To design, develop and troubleshoot Electrical Drive Systems by providing experimental insights into the operation and control of Electric Drives.
2. To develop control algorithms of Electrical Drives and Power Converters on digital control platforms (DSP/FPGA/Microcontrollers).

Syllabus/List of experiments:

1. Closed loop control of converter fed DC motor Drives.
2. Closed loop control of chopper fed DC motor drives.
3. VSI fed three phase induction motor drive.
4. Three phase synchronous motor and drive.
5. PC based control of power electronic devices.
6. Closed loop control of high frequency of DC – DC converters
7. Closed loop control of BLDC motors.
8. Closed loop control of Switched reluctance motors.
9. Vector control of three phase induction motors.
10. Vector control of three phase synchronous motors.
11. Closed loop control of PMSM.
12. Sensor less control of motors.
13. Use of Microcontrollers, DSP and FPGA for the control motors.

Simulation Experiments:

1. Simulation of sine PWM & space vector PWM
2. Simulation of 3-phase induction motor drive using V/f control
3. Simulation of Vector control of 3-phase induction motor
4. Simulation of Direct Torque Control of 3-phase induction motor
5. Simulation of Brushless DC Motor drive
6. Simulation of STATCOM & DSTATCOM

(At least 10 experiments in the list are to be conducted in the laboratory. Additional experiments and simulation assignments may also be developed by the department. Suitable simulation tools may be used for simulation studies. Use of open source tools such as Python, SciLab, Octave, gEDA etc are encouraged).

Course Outcome:

After completing this course the students will be able to develop control algorithms in digital control platforms such as DSP/FPGA/Microcontrollers.

The students will be able to develop advanced drive systems from fundamental principles.

The students will acquire sufficient experimental skills to carry out independent experimental research.

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7101	ESTIMATION THEORY	3-0-0-3	2015

Pre-requisites: [04 MA 6301] ADVANCED MATHEMATICS

Course Objectives:

To introduce the students to the fundamentals of estimation and Kalman filters.

Syllabus

Elements of Probability Theory - Optimal Estimation of Discrete-Time Systems – Optimal Filtering – Kalman Filter – Extended Kalman Filter – Optimal Smoothing - Optimal Fixed-point smoothing – Stability – Performance evaluation.

Course Outcome:

Students will be able to design and implement Kalman filters based estimators in Dynamic System Control Systems.

Text Books:

1. James S Meditch, Stochastic Optimal Linear Estimation and Control, McGraw-Hill, New York, 1969.

References:

1. Jerry M Mendel ‘Lessons in Estimation Theory for Signal processing, Communication, and Control, Prentice-Hall Inc, New Delhi, 1995.
2. Mohinder S. Grewal, Angus P Andrews, Kalman Filtering; Theory and Practice,Prentice-Hall Inc, Englewood Cliffs, 1993.
3. Grimble M. J., M. A. Johnson, Optimal Control and Stochastic Estimation; Theory and Applications, Wiley, New York, 1988.
4. Peter S. Meybeck, Stochastic Models, Estimation, and Control, Volume 1 & 2, Academic Press, New York, 1982.
5. Papoulis Athanasios, Probability, Random Variables, and Stochastic Process, 2^{nd} Edition, McGraw-Hill, New York, 1984.
6. Frank L. Lewis, Optimal Estimation, Wiley, New York, 1986.
7. Mcgarty J. P., Stochastic Systems and State Estimation, John Wiley, New York, 1974.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 7101	ESTIMATION THEORY	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE : 1 **Elements of Probability Theory** Random variables-Gaussian distribution-stochastic processes-characterizations and properties- Gauss-Markov processes-Brownian motion process-Gauss-Markov models		10	15
MODULE :2 **Optimal Estimation for Discrete-time Systems** Fundamental theorem of estimation-optimal prediction		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 **Optimal Filtering** Weiner approach-continuous time Kalman Filter-properties and implementation-steady-state Kalman Filter		6	15
MODULE 4: Discrete-time Kalman Filter-implementation-sub-optimal steady-state Kalman Filter-Extended Kalman Filter-practical applications		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 **Optimal Smoothing** Optimal fixed-interval smoothing - optimal fixed-point smoothing		6	20
MODULE: 6 **Optimal Smoothing** Optimal fixed-lag smoothing stability- performance evaluation		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7103	OPTIMAL CONTROL THEORY	3-0-0-3	2015

Pre-requisites: [04 MA 6301] ADVANCED MATHEMATICS

Course Objectives:

To enable the students:

1. To apply the principles of optimal control to control problems
2. To develop computational solutions to Control Problems

Syllabus

Optimality Problems in Control Theory - Mathematical models-selection of performance measures-constraints-classification of problem constraints-problem formulation-Dynamic Programming - Calculus of Variations - Basic Concepts-variation of functional – extremals-fundamental theorem in calculus of variation-Euler Equation-Piecewise Smooth extremals-constrained extrema- Hamiltonian-necessary condition for optimal control - **Pontryagin's Minimum Principle** - Minimum Time problem-Minimum Fuel problem-Minimum Energy problem. Case Studies

Course Outcome:

Students will be able to develop computational solutions to Control Problems.

Students will be able to develop Optimal Controllers for Linear Regulator Problems.

Text Books:

Donald E. Kirk, "Optimal Control Theory", Dover Publications, Inc, New York.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 7103	OPTIMAL CONTROL THEORY	3-0-0:3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE 1: Optimality Problems in Control Theory - Mathematical models - Performance measures for optimal control problems - selection of performance measures Constraints-classification of problem constraints-problem formulation-		6	15
MODULE 2: Dynamic Programming - The Optimal Control Law - Principle of OPtimality - Application of Principle of Optimality to Decision-Making Dynamic Programming Applied to a Routing Problem- Interpolation - A recurrence relation for Dynamic Programming -		8	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: Computational Procedure for Solving Control Problems - Characteristics of Dynamic Programming Solution - Analytical Results - Discrete Linear Regulator Problems -		8	15
MODULE 4: The Hamilton - Jacobi-Bellman Equation - Continuous Linear Regulator Problems Hamiltonian-necessary conditions for optimal control - Linear Regulator Problems		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: Calculus of Variations - Basic Concepts-Functionals of a single functions - variation of functional - functionals of several independent functions - Extremals-fundamental theorem in calculus of variation- Euler Equation-Piecewise Smooth extremals-constrained extrema		8	20
MODULE 6: **Pontryagin's Minimum Principle** - Minimum Time problem-Minimum Fuel problem-Minimum Energy problem. Case Studies		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 7105	ROBOTICS AND AUTOMATION	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

- To learn the specifications necessary to model Industrial Robots.
- To apply prior knowledge of coordinate systems to specific transformation matrices relevant to robotics.
- To learn the complexities of linear and revolute motions in the course of system planning.
- Ability to use the Lagrange-Euler method as an alternative to determine kinematic solutions.

Syllabus

Geometric configuration of robots, Manipulators, Drive systems, Sensors, End effectors, Control systems, Programming languages, Robotic vision, Direct and inverse kinematics, Rotation matrices, Euler angle-representation, Homogenous transformation, Denavit Hartenberg representation, Lagrange – Euler formulation, Kinetic energy, Potential energy, Equations of motion, Generalized D'Alembert equations of motion, 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.

Course Outcome:

- To be familiar with general robot specifications.
- Will be able to conceptualize the different frames of reference used in robots.
- Calculate the composite transformation matrices involved when the manipulator progresses through different dimension modes.
- Assess the detailed forward and reverse kinematics for a 2-link assembly.
- Be able to formulate the kinetic energy and potential energy calculations while applying Lagrange–Euler method to solve the 2-DOF, 2-link kinematics problem.
- Versed in the application of higher order polynomials in trajectory planning.

Text Books:

1. Fu K S, Gonazlez R C and Lee C S G, 'Robotics Control, Sensing, Vision and Intelligence',McGraw-Hill, 1987.
2. Saeed B Niku, 'Introduction to Robotics, Analysis, Systems and Applications', PearsonEducation, 2002.

References:

1. Wesley, E Sryda, 'Industrial Robots: Computer Interfacing and Control', PHI, 1985.
2. Asada and Slotine, 'Robot Analysis and Control', John Wiley and Sons, 1986.
3. Groover M P, Mitchell Weiss, 'Industrial Robotics Technology Programming and Applications', Tata McGraw-Hill, 1986.

COURSE PLAN

Course No:	Course Title:		CREDITS:
04 EE 7105	**Robotics and Automation**		**3-0-0:3**
MODULES		**Contact hours**	**Sem. Exam Marks;%**
MODULE : 1 Introduction to Robotics, Geometric configuration of robots, Manipulators, Robot programming languages and applications, Introduction to robotic vision, Drive systems, Internal and external sensors, End effectors, Control systems.		10	15
MODULE : 2 Robot Arm Kinematics, Direct and inverse kinematics, Rotation matrices, Composite rotation matrices.		6	15
FIRST INTERNAL TEST			
MODULE : 3 Euler angle representation, Homogenous transformation, Denavit-Hartenberg representation, Various arm configurations.		8	15
MODULE : 4 Lagrange–Euler formulation, Joint velocities, Kinetic energy, Potential energy, Motion equations, Generalized D'Alembert equations of motion		6	15
SECOND INTERNAL TEST			
MODULE : 5 Trajectory planning, Joint interpolation, Cartesian path trajectories		6	20
MODULE : 6 Control of Robot Manipulators, PID control, Computed Torque control, Near-minimum time control, Variable structure control, Non-linear decoupled feedback control, Resolved motion control and adaptive control.		6	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7305	POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS	3-0-0-3	2015

Pre-requisites:

Course Objectives:

To enable the students:

- To analyse Static shunt, series and UPFC compensators used in power systems.
- To carry out basic design and development of static compensators.

Syllabus

Concept and General System Considerations. Power Flow in AC System. Types of FACTS Controllers. Converters for Static Compensation.

Multi-Pulse Converters and Interface Magnetics. Transformer Connections for 12, 24 and 48 pulse operation. Multi-Level Inverters

SVC and STATCOM, Operation and Control of TSC and TCR, direct and indirect control of STATCOM.

Static Series Compensators: TSSC, TCSC and SSSC, Operation and Control, External System Control for Series Compensators, SSR and its damping - Static Voltage and Phase Angle Regulators, TCVR and TCPAR, Operation and Control.
Custom Power Devices - DSTATCOM, DVR, UPQC, Custom Power Park.
Distributed generation and grid interconnection – standards -Power quality issues
- islanding issues.
Excitation Systems: Need for AVR-brushless alternator - static excitation – Modeling – Stability - Applications of
power electronics in modern excitation systems.

Course Outcome:

Students will be able to carry out analysis and basic design of Power Electronic Compensators used in Power Systems.

Text Books:

- G Hingorani and L Gyugi*, Understanding FACTS*, IEEE Press, 2000

References:

1. Song, Y.H and Allan. T. Johns, ‘Flexible Ac Transmission Systems (FACTS); Institution Of Electrical Engineers Press, London, 1999
2. Hingorani, L Gyugyi “Concepts and Technology Of Flexible Ac Transmission System’, IEEE Press New Yourk, 2000 Isbn- 078033 4588.
3. IEE Tutorials on ‘Flexible Ac Transmission Systems’ Published in Power Engineering Journal, IEE Press, 1995.
4. Miller , T J E “Reactive Power Control in Power Systems” John Wiley, 1982.
5. Padiyar K.R. “FACTS Controllers In Power Transmission and Distribution”, New Age International Publishers, June 2007

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 7305	**POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS**	**3-0-0:3**	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE : 1 Concept and General System Considerations. Power Flow in AC System. Definitions on FACTS . Basic Types of FACTS Controllers. Converters for Static Compensation. Multi-Pulse Converters and Interface Magnetics. Transformer Connections for 12, 24 and 48 pulse operation. Multi-Level Inverters - Diode Clamped Type, Flying Capacitor and cascade multilevel inverters.		10	15
MODULE :2 SVC and STATCOM, Operation and Control of TSC and TCR, direct and indirect control of STATCOM. Decoupled control strategy - Compensators- Comparison between SVC and STATCOM - transient and dynamic stability enhancement using STATCOM**.**		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE: 3 **Static Series Compensators** TSSC, TCSC and SSSC, Operation and Control, External System Control for Series Compensators, SSR and its damping - Static Voltage and Phase Angle Regulators, TCVR and TCPAR, Operation and Control.		6	15
MODULE 4: The Unified Power Flow Controller. Operation, Comparison with other FACTS devices, control of P and Q, Dynamic Performance.		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE: 5 **Custom Power Devices** Introduction - DSTATCOM, DVR, UPQC, Custom Power Park. Load compensation using DSTATCOM - Distributed generation and grid interconnection – standards - Power quality issues - Islanding issues.		6	20
MODULE: 6 **Excitation Systems** Need for AVR-brushless alternator - static excitation – Modeling – Stability - Applications of power electronics in modern excitation systems.		8	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 7001	BIO-INSPIRED ALGORITHMS	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

To enable the student to apply fuzzy logic based analysis tools in optimization of power systems and power electronic problems.

Syllabus

Fuzzy Logic-concepts-set theory -operations-membership function-fuzzy rules-fuzzy reasoning-fuzzy inference systemsMamdani and Sugeno type-defuzzification- fuzzy controllers-applications in electric drives, power system **Genetic Algorithm Application :** Modern Heuristic Search Techniques Genetic Algorithm-Introduction- -Encoding-Fitness Function, Premature Convergence, Slow Finishing,Basic Operators, Selection-Tournament Selection, Truncation Selection, Linear Ranking Selection, Exponential Ranking Selection, Elitist Selection, Proportional Selection-Crossover, Mutation, Control Parameters Estimation, Niching Methods, Parallel Genetic Algorithms-Application in Drives.- Tunning of membership function using genetic algorithm. Application of GA to neural network.- Tunning of controllers.

Swarm Intelligence: Ant Colony Optimization

Swarm intelligence general characteristics, Ant Colony Optimization: Basic Concepts- The Ant Colony System- Ants' Foraging Behaviour and Optimization,- The Max-Min Ant System Minimum Cost Paths, Combinatorial Optimization, Major Characteristics of Ant Colony Search Algorithms- Positive Feedback-Rapid Discovery of Good Solution - Use of Greedy Search and Constructive Heuristic Information- Ant Colony Optimization Algorithms Applications.

Particle swarm optimization and Firefly Algorithm

Particle swarm optimization: Application and Implementation. **Fire Fly Algorithm** – Basic Concepts- Application in optimization, power electronics and power system problems.

Course Outcome:

Students who successfully complete this course will have demonstrated an ability to apply optimization techniques in engineering applications.

Text Books:

1. Leandro Nunes de Castro," Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications". Chapman & Hall/CRC, 2006.

2. G. Rozenberg, T. Bäck, J. N. Kok ,"Handbook of Natural Computing", Springer Verlag- 2010.

References:

1. Melanie Mitchell, " An Introduction to Genetic Algorithms", MIT Press- 1996.
2. Mohamed E. El-Hawary, "Modern Heuristic Optimisation technique –Theory and application to power system",IEEE Press.
3. Xin-She Yang, "Nature-Inspired Metaheuristic Algorithms", Luniver Press 2010.
4. J. R. Koza: " Genetic Programming: On the programming of computers by means of natural selection", MIT Press- 1992 .

COURSE PLAN

COURSE NO:	Course Title		CREDITS
04 EE 7001	BIO INSPIRED ALGORITHMS		3-0-0:3
MODULES		Contact hours	Sem. Exam Marks;%
MODULE : 1 Fuzzy Logic-concepts-set theory -operations-membership function-fuzzy rules-fuzzy reasoning-fuzzy inference systemsMamdani and Sugeno type-defuzzification- fuzzy controllers-applications in electric drives, power system.		10	15
MODULE : 2 **Genetic Algorithm Application :** Modern Heuristic Search Techniques Genetic Algorithm-Introduction- -Encoding-Fitness Function, Premature Convergence, Slow Finishing, Basic Operators, Selection-Tournament Selection, Truncation Selection, Linear Ranking Selection, Exponential Ranking Selection, Elitist Selection, Proportional Selection-Crossover, Mutation, Control Parameters Estimation, Niching Methods, Parallel Genetic Algorithms-Application in Drives.- Tuning of membership function using genetic algorithm. Application of GA to neural network.- Tuning of controllers.		8	15
FIRST INTERNAL TEST			
MODULE : 3 **Swarm Intelligence: Ant Colony Optimization** Swarm intelligence general characteristics, Ant Colony Optimization: Basic Concepts- The Ant Colony System- Ants' Foraging Behavior and Optimization,- The Max-Min Ant System Minimum Cost Paths, Combinatorial Optimization.		6	15
MODULE : 4 Major Characteristics of Ant Colony Search Algorithms- Positive Feedback-		8	15

Rapid Discovery of Good Solution - Use of Greedy Search and Constructive Heuristic Information- Ant Colony Optimization Algorithms Applications.		
SECOND INTERNAL TEST		
MODULE : 5 Particle swarm optimization: -Fundamentals- Concepts of PSO-Comparison with Genetic Algorithm-Application and Implementation.	5	20
MODULE : 6 **Firefly Algorithm** –Basic Concepts-Application in optimization, power electronics and power system problems.	5	20
END SEMESTER EXAMINATION		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7107	ADAPTIVE CONTROL	3-0-0-3	2015

Pre-requisites: [04 MA 6301] ADVANCED MATHEMATICS

Course Objectives:

To enable the students:

- To learn the concepts of Adaptive Control, Model Reference Systems
- To Design MRAS systems.

Syllabus

Adaptive Control-effects of process variation-Adaptive schemes-Adaptive Control problem-Applications Real-Time Parameter Estimation-Introduction. Least Squares and Regression Models. Estimating-Parameters in Dynamical Systems.

Model-Reference Adaptive Systems, **Self-Tuning Regulators,** Pole Placement Design-Indirect Self-tuning Regulators-Continuous Time Self-tuners. Direct Self-tuning Regulators-Disturbances with Known Characteristics-Relations between Model Reference Adaptive Systems and Self Tuning Regulators.

Gain Scheduling

Introduction-Principle and Design of Gain Scheduling controllers-Nonlinear Transformations applications of Gain Scheduling. Practical Issues and Implementation-Controller and estimator implementation-operational issues. Case Studies

Course Outcome:

The students will be able to formulate and design Model Reference Adaptive Systems.

Text Books:

1. Karl Jhon Astrom & Bjom Wittenmark, Adaptive Control, Addison Wesley, 1994.
2. Shankar Sastry, Adaptive Control, PHI (Eastern Economy Edition), 1989.

References:

1. Karl Jhon Astrom, Adaptive Control, Pearson Education, 2001.
2. Petros A. Ioannou, Jing, Robust Adaptive Control, Prentice-Hall, 1995.
3. Eykhoff P., System Identification: Parameter and State Estimation, 1974.
4. Ljung, System Identification Theory for the User, Prentice-Hall, 1987.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 7107	ADAPTIVE CONTROL	3-0-0:3	
MODULES		**Contact Hours**	**Sem. Exam Marks (%)**
MODULE 1: **Introduction** Adaptive Control-effects of process variation-Adaptive schemes-Adaptive Control problem-ApplicationsReal-Time Parameter Estimation-Introduction-Least Squares and Regression Models-Estimating-Parameters in Dynamical Systems.		10	15
MODULE 2: **Model-Reference Adaptive Systems** Introduction-The MIT Rule-Determination of the Adaptation Gain-Lyapunov Theory-Design of MRAS Using Lyapunov Theory-Bounded-Input-Bounded-Output Stability-Applications to Adaptive control.		6	15
INTERNAL TEST 1 (MODULE 1 & 2)			
MODULE 3: **Self-Tuning Regulators** Introduction-Pole Placement Design-Indirect Self-tuning Regulators-Continuous Time Self-tuners.		6	15
MODULE 4: Direct Self-tuning Regulators-Disturbances with Known Characteristics-Relations between Model Reference Adaptive Systems and Self Tuning Regulators.		6	15
INTERNAL TEST 2 (MODULE 3 & 4)			
MODULE 5: **Gain Scheduling** Introduction-Principle and Design of Gain Scheduling controllers-Nonlinear Transformations applications of Gain Scheduling.		8	20
MODULE 6: Practical Issues and Implementation-Controller and estimator implementation-operational issues. **Case Studies**		6	20
END SEMESTER EXAM			

COURSE NO.	COURSE TITLE	L-T-P:C	YEAR
04 EE 7109	ROBUST CONTROL DESIGN	3-0-0:3	2015

Pre-requisites:

1. [04 EE 6101] DYNAMIC SYSTEM THEORY OR [04 EE 6103] SYSTEM THEORY

Course Objectives:

To give the students

- Introduction to Robust controllers and robust design specifications
- The knowledge of design and analysis of robust control system

Syllabus

Basics of robust control, Modelling of uncertain systems, Robust design specifications, Loop shaping design procedures, m- Analysis and Synthesis, Lower order controller, Linear Matrix Inequalities

Course Outcome:

Students will be able to design and develop a robust controller for a system

REFERENCE

1. D. W. Gu, P.Hr.Petkov and M.M.Konstantinov, Robust Control Design with MATLAB, Springer, 2005.

2. Alok Sinha, Linear Systems- Optimal and Robust Controls, CRC Press, 2007.

3. S. Skogestad and Ian Postlethwaite, Multivariable feedback control,John Wiley & Sons, Ltd, 2005.
4. G. E. Dullerud, F. Paganini, A course in Robust control theory- A convex approach, Springer, 2000.

5. Kemin Zhou with J.C. Doyle and K. Glover, Robust and Optimal control, Prentice Hall,1996.

6. G Balsa, R.Y. Chiang, A.K.Packard and M.G.Safonov, Robust Control Toolbox (Ver. 3.0) User's Guide. Natick,MA: The Mathworks,2005. [http://www.mathworks.com/access/helpdesk/hellp/toolbox/robust]

7. Kemin Zhou, John Comstock Doyle, Keith Glover, Robust and optimal control, Prentice Hall, 1996.

8. Kemin Zhou, John Comstock Doyle, Essentials of robust control, Prentice Hall, 1998.

9. Stephen Boyd, Laurent El Ghaoul, Eric Feron, Linear Matrix Inequalities in System and Control Theory, SIAM, 1994

COURSE PLAN

COURSE NO:	COURSE TITLE		CREDITS
04 EE 7109	ROBUST CONTROL DESIGN		3-0-0:3
MODULES		Contact hours	Sem. Exam Marks (%)
MODULE : 1 Introduction to robust control: Control system representations, System stabilities, Co-prime factorization and stabilizing controllers, Signals and system norms, Modelling of uncertain systems: Unstructured Uncertainties, Parametric uncertainty, Linear fractional transformation, Structured uncertainties		6	15
MODULE : 2 Robust design specifications: Small gain theorem and robust stabilization, Performance considerations, Structured singular values. H-∞ Design: Mixed sensitivity optimization, 2-Degree of freedom design, Sub-optimal solutions, Formulae for discrete time cases.		8	15
FIRST INTERNAL TEST			
MODULE : 3 H-∞ Loop shaping design procedures: Robust stabilization against Normalized co prime factor perturbation, Loop shaping design procedures, Formulae for discrete time cases.		6	15
MODULE : 4 μ-Analysis and Synthesis: Consideration of robust performance. μ-synthesis: D-K iteration method, μ-synthesis: μ -K iteration method.		6	15
SECOND INTERNAL TEST			

MODULE : 5 Lower order controllers: Absolute error approximation methods like Balanced truncation, Singular perturbation approximation and Hankel-norm approximation, Reduction via fractional factors, Relative error approximation and frequency weighted approximation methods.	6	20
MODULE : 6 Design case studies using H-∞ Design and μ-synthesis: Robust Control of a mass damper spring system, A triple inverted pendulum control system.	10	20
END SEMESTER EXAM		

COURSE NO.	COURSE TITLE	L-T-P-C	YEAR
04 EE 7115	DATA ACQUISITION AND SIGNAL CONDITIONING	3-0-0:3	2015

Pre-requisites: Nil

Course Objectives:

- To understand the concepts of data acquisition and signal conditioning for real-time applications

Syllabus

Classification of Signals & Signal Encoding Techniques - Fundamentals of data acquisition, Transducers and sensors-Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware, Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion, Conversion Processes, Speed, Quantization Errors. Successive Approximation ADC . Dual Slope ADC. Flash ADC, Introduction to Sensor-Based Measurement Systems: Features & characteristics, Micro sensor Technology, Signal Conditioning - Introduction- Types of signal conditioning, Classes of signal conditioning

Field wiring and signal measurement- Noise and interference, Minimizing noise, Digital-to-Analog Conversion (DAC), Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs, Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware, Shielded and twisted-pair cable - Resistive Sensors & Signal Conditioning for Resistive Sensors, Reactance Variation and Electromagnetic Sensors Signal Conditioning for Reactance Variation, Sensors - Self-Generating Sensors, Communication Systems for Sensors: Current telemetry: 4 to 20 mA loop, Simultaneous analogue and digital communication, Serial data communications, Error detection, DAS Boards-Introduction . Study of a representative DAS Board-Interfacing Issues with DAS Boards, Virtual Instrumentation: Introduction to LABVIEW, Creating Virtual Instruments, Making decisions in a Virtual Instrument, Plotting data in VI, Data Acquisition Using NI DAQ & LAB View

Course Outcome:

- The student will be able to implement data acquisition system

Text Books:

1. Ramon Pallas-Areny, John G. Webster, Sensors & Signal Conditioning, John Wiley & Sons, Inc, 2001.
2. John Park & Steve Mackay, Practical Data Acquisition for Instrumentation & Control Systems, Elsevier, 2003

References:

1. LABVIEW Data Acquisition Manual, National Instruments, 2000
2. LABVIEW Graphical Programming Course, National Instruments, 2007
3. S. Sumathi and P. Surekha , LABVIEW based Advanced Instrumentation Systems, SPRINGER, 2007.
4. Gary Johnson, LabVIEW Graphical Programming(2e), McGraw Hill, New York, 1997.

COURSE PLAN

COURSE NO.:	COURSE TITLE	CREDITS	
04 EE 7115	DATA ACQUISITION AND SIGNAL CONDITIONING	3-0-0: 3	
MODULES		Contact Hours	Sem. Exam Marks (%)
MODULE: 1 Classification of Signals & Signal Encoding Techniques - Fundamentals of data acquisition, Transducers and sensors-Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware Field wiring and communications cabling,-Signal conditioning, Data acquisition hardware		7	15
MODULE: 2 Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion Conversion Processes , Speed, Quantization Errors . Successive Approximation ADC. Dual Slope ADC. Flash ADC Digital-to-Analog Conversion (DAC) . Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs		8	15
FIRST INTERNAL TEST			
MODULE: 3 Introduction to Sensor-Based Measurement Systems: Features & characteristics, Micro sensor Technology Signal conditioning: Introduction- Types of signal conditioning, Classes of signal conditioning Field wiring and signal measurement- Noise and interference, Minimizing noise		8	15
MODULE: 4 Shielded and twisted-pair cable - Resistive Sensors & Signal Conditioning for Resistive Sensors Reactance Variation and Electromagnetic Sensors Signal Conditioning for Reactance Variation Sensors - Self-Generating Sensors, Communication Systems for Sensors: Current telemetry: 4 to 20 mA loop		7	15
SECOND INTERNAL TEST			
MODULE: 5 Simultaneous analog and digital communication, Serial data		6	20

communications, Error detection DAS Boards-Introduction . Study of a representative DAS Board-Interfacing Issues with DAS Boards		
MODULE: 6 Virtual Instrumentation: Introduction to LABVIEW Creating Virtual Instruments, Making decisions in a Virtual Instrument, Plotting data in VI Data Acquisition Using NI DAQ & LAB View	7	20
END SEMESTER EXAMINATION		

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 EE 6291/7291	**SEMINAR-I & II**	**0-0-2: 2**	**2015**

Course Objectives:

1. Improve the technical presentation skills of the students.
2. To train the students to do literature review.
3. To impart critical thinking abilities.

Methodology

Individual students are required to choose a topic of their interest from related topics to the stream of specialization, preferably from outside the M. Tech syllabus. The students are required to do a moderate literature review on the topic and give seminar. A committee consisting of at least three faculty members (preferably specialized in the respective stream) shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of his seminar topic. The seminar report shall not have any plagiarised content (all sources shall be properly cited or acknowledged). One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other shall be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation. It is encouraged to do simulations related to the chosen topic and present the results at the end of the semester.

COURSE CODE	COURSE NAME	L-T-P:C	YEAR
04 EE 7293	PROJECT PHASE - I	0-0-12: 6	2015

Course Objectives:

The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real-life problems related to industry and current research.

The project work can be a design project/experimental project and/or computer simulation project on any of the topics related to the stream of specialisation. The project work is chosen/allotted individually on different topics. Work of each student shall be supervised by one or more faculty members of the department. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to carry out their main project outside the parent institute, subject to the conditions specified in the M. Tech regulations of the APJ Abdul Kalam Technological University. Students are encouraged to take up industry problems in consultation with the respective supervisors.

The student is required to undertake the main project phase-1 during the third semester and the same is continued in the 4th semester (Phase 2). Phase-1 consist of preliminary work, two reviews of the work and the submission of a preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

COURSE CODE	COURSE NAME	L-T-P: C	YEAR
04 EE 7294	PROJECT PHASE - II	0-0-21: 12	2015

Main project phase II is a continuation of project phase-I started in the third semester. There would be two reviews in the fourth semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work, presentation and discussion. Second review would be a pre -submission presentation before the evaluation committee to assess the quality and quantum of the work done. It is encouraged to prepare at least one technical paper for possible publication in journals or conferences. The project report (and the technical paper(s)) shall be prepared without any plagiarised content and with adequate citations, in the standard format specified by the Department /University.