M.TECH. IN ELECTRICAL AND ELECTRONICS ENGINEERING (ELECTRICAL DRIVES AND CONTROL)

CURRICULUM AND SYLLABUS

(Effect from the Academic Year 2007 – 08)

PONDICHERRY UNIVERSITY

PUDUCHERRY – 605014.

M.TECH. IN ELECTRICAL AND ELECTRONICS ENGINEERING (ELECTRICAL DRIVES AND CONTROL)

COURSE CURRICULUM AND SCHEME OF EXAMINATION

(Minimum Credit Requirement for the completion of the Programme: 72)

ELIGIBILITY:

M.Tech. in Electrical and Electronics Engineering (Electrical Drives and Control) : Candidates for admission to the first semester of four semester M.Tech. Course in Electrical and Electronics Engineering with specialization in Electrical Drives and Control should have passed B.E./B.Tech. in Electrical and Electronics Engineering (or) an examination of any University or Authority accepted by the Pondicherry University as equivalent thereto, with at least 55% marks in the degree examination or equivalent CGPA.

SEMESTER – I

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	MA 901	Mathematics	3	1	0	4	40	60	100
2.	EE 901	Analysis of Power Electronics Circuits	3	1	0	4	40	60	100
3.	EE 902	Modern Control Theory	3	1	0	4	40	60	100
4.	EE 903	Special Machines	3	1	0	4	40	60	100
5.		Elective – I	3	0	0	3	40	60	100
6.	EE 907	Power Electronics & Control Simulation Lab	1	0	3	2	50	50	100
						20	250	350	600

SEMESTER – II

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	EE 904	AC Drives	3	1	0	4	40	60	100
2.	EE 905	DC Drives	3	1	0	4	40	60	100
3.		Elective – II	3	1	0	3	40	60	100
4.		Elective – III	3	0	0	3	40	60	100
5.		Elective –IV	3	0	0	3	40	60	100
6.		Elective – V	3	0	0	3	40	60	100
7.	EE 908	Seminar	0	0	3	2	100	-	100
						23	340	360	700

SEMESTER – III

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.		Elective – VI	3	0	0	3	40	60	100
2.		Elective – VII	3	0	0	3	40	60	100
3.	EE 961	Directed Study	0	0	6	3	100	---	100
4.	EE 909	Dissertation Project (Phase I)	0	0	24	8	200	100	400
						17	380	220	600

SEMESTER – IV

Sl. No.	Code	Subject	Hours / Week			Credits	Evaluation (marks)		
			L	T	P		Internal	External	Total
1.	EE 910	Dissertation Project(Phase II)	0	0	36	12	250	150	400
						12	250	150	400

List of Elective

Sl.No.	Code	Subject
1	EE921	Adaptive control Theory
2	EE922	Advance Control Theory
3	EE923	Advanced Power Electronic Converters
4	EE924	Control System Design
5	EE925	Controller design techniques
6	EE926	Digital Control System
7	EE927	Digital Signal Processing
8	EE928	Embedded Systems
9	EE929	FACTS Controller
10	EE930	Fuzzy Control
11	EE931	Micro Controller
12	EE932	Neural Networks
13	EE933	Optimal Control Theory
14	EE934	Power Electronics in Power system
15	EE935	Wind Energy Conversion System

MA 901 MATHEMATICS

UNIT-I *VECTOR SPACES*

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

UNIT-II *LINEAR TRANSFORMATIONS*

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

UNIT-III *LINEAR PROGRAMMING*

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

UNIT-IV *DYNAMIC AND QUADRATIC PROGRAMMING*

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

UNIT-V *RANDOM PROCESS*

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

REFERENCES:

1. V. Krishnamurthy, V.P. Maiwa and J.L.Arora, An introduction to linear Algebra, Affiliated East West Press Pvt. Ltd., New Delhi-Madras.
2. Taha. H.A., operations research – An introduction, Mac Millian publishing Co., (1982).
3. Pant J.C. optimization and operations research, Jain Publishers, New Delhi.
4. Kishore S Trivedi, Probability and Statstics with Reliability, Queueing and Computer Science Applications, John Wiley & Sons (2002).

EE 901 ANALYSIS OF POWER ELECTRONIC CIRCIUTS

UNIT-I *RECTIFIER*

Single phase and three phase bridge rectifier-Half controlled and fully controlled converter with RL, RLE loads-free wheeling diodes-Dual converters-Sequence control of converter-Inverter operation –Input harmonics and output –ripple –smoothing inductance-Power factor –effect of source impedance overlap-inverter limit.

UNIT-II *CHOPPER AND CYCLOCONVERTER*

Principle of operation of DC choppers-choice of commutation circuit element-step down and steppers choppers-classification-voltage and current commutated choppers.

Principle of operation of single phase-Three phase to single phase-three phase to three phase cycloconverter-Input and output performances-Harmonics-output voltage and frequency range-control circuit of cycloconverter.

UNIT III *VOLTAGE SOURCE INVERTERS*

Single-phase inverters: Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques, Mc Murry and MC Murry Bed ford inverters-Analysis with R and RL loads

Three-phase inverters: 180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters

UNIT-IV *SERIES, PARALLEL AND RESONANT INVERTER*

Principle of forced commutation-configuration and analysis of series inverter and parallel inverter-push pull driven inverters half bridge and full bridge inverters-series resonant inverter parallel resonant inverter.

UNIT-V *CURRENT SOURCE INVETRTER AND MULTILEVEL INVERTER*

Analysis of single phase and three-phase auto sequential current source inverter-current source bridge inverter-third harmonic auxiliary commutated inverter.

Multilevel concept – diode clamped, flying capacitor , cascade type multilevel inverters-comparison of multilevel inverters-applications.

TEXT BOOKS

1 Power Electronics, D.Singh, K.B.Khan chandani
2. Power Electronics Circuits, Devices and Applications, Rashid M.H, Prentice Hall India, Third Edition, New Delhi, 2004.

REFERENCES

1. Power Electronics, Cyril Lander McGraw Hill, Int.Edit, 1993
2. Power Electronics, Vedam Subramanium, New Age Int.1996
3. Power Electronics, Mohan/Underland/Robbins, John Wiley &Sons, 1995
4. Power Electronics Systems .Jai P.Agrawal, Pearson Education, Second Edition, 2002.
5. Modern Power Electronics, P.C Sen., Wheeler publishing Co, First Edition, New Delhi-1998.
6. Power Electronics P.S.Bimbra, Khanna Publishers, Eleventh Edition, 2003.

EE902 MODERN CONTROL THEORY

UNIT I: *INTRODUCTION TO STATE SPACE APPROACH*

Modeling of physical systems using state space approach – advantages of state space approach over transfer function model.

State diagram, state space and state trajectory – state space realization – controllable, observable, diagonal and Jordan canonical forms - Similarity transformation – Transformation into various canonical realizations.

Solution of Linear Time Invariant (LTI) state equation – state transition matrix and its properties – computational techniques.

UNIT II: *STATE SPACE ANALYSIS*

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

UNIT III: *STATE FEEDBACK CONTROLLER DESIGN*

Controller design by state feedback –Necessary and Sufficient condition for arbitrary pole placement- state regulator problem.

Reference tracking (Servo) problem – State feedback with integral control. Eigen structure assignment.

Observer Design – Full order/reduced order observer design – observer based state feedback control – separation principle.

UNIT IV: *STABILITY ANALYSIS*

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

UNIT V *OPTIMAL CONTROL*

Linear quadratic optimal regulator (LQR) problem formulation – optimal regulator design by parameter adjustment (Lyapunov method) – optimal regulator design by Continuous - time Algebraic Riccatti Equation (CARE) – Hamiltonian matrix and its significance.

Introduction to Kalman filter – optimal controller design using LQG framework.

BOOKS:

1. Katsuhiko Ogata, 'Modern control engineering', Prentice hall of India pvt. Ltd., New Delhi -110001, 1989.
2. Katsuhiko Ogata, State space analysis of control systems', Prentice hall Inc., New Jersey, 1967.

REFERENCE:

1. Biswa Nath Datta," Numerical methods for linear control systems', Elsevier, 2005.
2. Gene.F.Franklin, J.David Powell and Abbas Emami-Naeini,'Feedback Control of dynamic systems',Pearson Edu. Asia, 2002.
3. Chi-Tsong chen,' Linear System theory and design', 3rd edition, oxford press, 1999.
4. John.S.Bay, 'Fundamentals of linear state space systems', WCB/McGraw Hill, 1999.
5. Aashish Tiwari,'Modern control design with MATLAB and SIMULINK', John Wiley and sons Ltd., 2002.
6. Kailath. T, Linear systems, Englewood cliffs, New Jersey, Prentice Hall, 1990.
7. Anderson B.D.O and Moore JB,' Optimal control- Linear Quadratic methods', Englewood cliffs, New Jersey, Prentice Hall, 1990.

EE903 SPECIAL MACHINES

UNIT I *SINGLE PHASE MACHINES*

Principles and construction of split phase motors – Shaded pole motor – Repulsion motor - Universal motor – Unexcited synchronous single phase motor – Reluctance and Hystersis motor – Schrage motor - Applications.

UNIT II *STEPPER MOTORS*

Constructional features - Principle of operation - Modes of excitation – Types of motors – Drive systems and circuit for control of Stepper motor – Applications Dynamic characterstics.

UNIT III *SWITCHED RELUCTANCE MOTORS*

Constructional features - Principle of operation - Torque prediction - Power controllers - Characteristics and control - Applications.

UNIT IV *PERMANENT MAGNET BRUSHLESS DC MOTORS*

Commutation in DC motors - Difference between mechanical and electronic commutators - permanent magnet brushless motor drives - Torque and Emf equation; Torque-Speed characteristics; Sensors - Controllers; Applications.

UNIT V *PERMANENT MAGNET SYNCHRONOUS MOTORS*

Principle of operation - Constructional features - EMF, Power input and torque expressions - Phasor diagram - Power controllers - Torque-Speed characteristics - Vector control - Applications.

REFERENCES:

1. T.J.E. Miller, "Brushless Permanent Magnet and Reluctance Motors Drives", Clarendon Press, Oxford, 1989.
2. T. Kenjo and S.Negamori, "Permanent Magnet Brushless DC Motors" Clarendon Press, Oxford, 1989.
3. P.P. Acarnley, "Stepping Motors, A Guide to Modern Theory and Practice", Peter Peregrinus, London, 1990.
4. A. Hughes, "Electric Motors and Drives", Affiliated East-west Pvt., Ltd., Madras, 1990.
5. Kenjo, "Stepping Motors and their Microprocessor Control" Clarendon Press, Oxford, 1989.
6. I.J.Nagrath & D.P.Kothari, "Electrical Machines", Tata McGraw Hill,1999.
7. B.L.Theraja, A.K.Theraja, "Electrical Technology, vol-II, Ac & Dc Machines", S.Chand & Company Ltd., 2005.

EE 904 AC DRIVES

UNIT I: *STATOR VOLTAGE CONTROL OF INDUCTION MOTOR*

Torque, Slip characteristics, operation with different types of loads, Performance, Comparison of different ac power controllers, Speed reversal, closed loop control.

UNIT II: *STATOR FREQUENCY CONTROL*

Operation of induction motor with non-sinusoidal supply waveforms, variable frequency operation of 3-phase induction motors, constant flux operation, current fed operation, Dynamic and Regenerative Braking of CSI and VSI fed Drives, Principle of vector control.

UNIT III: *ROTOR RESISTENCE CONTROL*

Torque; slip characteristics, types of rotor choppers, Torque Equations, Constant torque operation TRC strategy, combined stator voltage control and rotor resistance. control.

UNIT IV: *SLIP POWER RECOVERY SCHEME*

Torque equation, torque – slip characteristics, - Power factor consideration sub-synchronous operation and closed loop speed control.

UNIT V: *SYNCRONOUS MOTOR DRIVES*

Need for leading PF correction – open loop VSI fed Drive and its characteristics – self control – Torque angle control – Power factor control – brushless excitation system – Starting methods – Principles of vector control.

TEXT BOOK

1. Murphy. J.M.D, Turnbull. F.G. "Thyristor control of AC motors", Pergamon Press, Oxford, 1988.
2. Shepard. W and Hulley. L.N and PTW Liang "Power Electronics and motor control", Cambridge University Press, Cambridge,1998.

REFERNCES

1. Dubey. G. K., "power Semiconductor controlled drives". Prentice Hall Internattional, New Jersey, 1989.
2. dewan. S.B.,Slemon, G.R. Straugnen.A.,"Power Semiconductor Drives",john Wiley and Sons, New York, 1984.
3. B.W.Williams "Power Electronics", ELBS, 1992.

EE905 DC DRIVES

UNIT I: *DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS*

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Water Leonard control – Constant torque and constant horse power operations.

Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

UNIT II: *CONVERTER CONTROL*

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters, performance characteristics.

Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with free wheeling diode; Implementation of braking schemes; Drive employing dual converter.

UNIT III: *CHOPPER CONTROL*

Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control - Chopper based implementation of braking schemes; Multi-phase chopper; Related problems.

UNIT IV: *CLOSED LOOP CONTROL*

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Simulation of converter and chopper fed d.c drive.

UNIT V: *DIGITAL CONTROL OF DC DRIVE*

Phase Locked Loop and micro-computer control of DC drives – Program flow chart for constant horse power and load disturbed operations; Speed detection and gate firing.

TEXT BOOKS

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Jersey, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

EE 934 POWER ELECTRONICS IN POWER SYSTEMS

UNIT: I *STATIC COMPENSATOR CONTROL*

Theory of load compensation – voltage regulation and power factor correction – phase balance and PF correction of unsymmetrical loads – Property of static compensator – Thyristor controlled rectifier (TCR) – Thyristor Controlled Capacitor (TSC) – Saturable core reactor – Control Strategies.

UNIT: II *HARMONIC CONTROL AND POWER FACTOR IMPROVEMENT*

Input power factor for different types of converters – power factor improvement using Load and forced commutated converters.

UNIT: III *VOLTAGE CONTROL USING STATIC TAP-CHANGERS*

Conventional tap changing methods, static tap changers using Thyristor, different schemes – comparison.

UNIT: IV *STATIC EXCITATION CONTROL*

Solid state excitation of synchronous generators – Different schemes - Generrex excitation systems.

UNIT: V *UNINTERRUPTABLE POWER SUPPLY SYSTEM*

Parallel, Redundant and non- redundant UPS – Ups using resonant power converters – Switch mode power supplies.

TEXT BOOK

1. Miller. T.J.E, “Reactive power control in Electric systems”. Wiley interscience, New York, 1982.

REFRENCES

1. “Static Compensator for AC power systems”, Proc. IEE vol.128 Nov. 1981. pp 362-406.
2. “A Static alternative to the transformer on load tap changing”, IEEE Trans. On Pas, Vol.PAS-99, Jan. /Feb. 1980, pp86-89.
3. “Improvements in Thyristor controlled static on- load tap controllers for transformers”, IEEE Trans. on PAS, Vol.PAS-101, Sept.1982, pp3091-3095.
4. “Shunt Thyristor rectifiers for the Generrex Excitation systems”, IEEE Trans. On PAS. Vol.PAS -96, July/August, 1977, pp1219-1225.

EE932 NEURAL NETWORKS

Unit – I

Introduction – Biological neural network – Artificial Neural network – comparison, motivation and Development.

Neuron model – single / multiple inputs, transfer functions.

Network architecture – single / multiple layer – Recurrent networks

Perceptron network – architecture, learning rule, linear seperability limitation.

Unit – II

Learning mechanism – supervised learning – multiplayer perceptrons for pattern classification and function approximation.

The back propagation algorithm – numerical examples. Drawbacks in Back propagation – Momentum method, variable learning rate, Levenburg Marguardt Algorithm.

Other supervised learning methods – supervised Hebbs rule, Widrow Hoff learning rule – Adaline network.

Unit – III

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

Unit – IV

Competitive networks – Fixed weight competitive network – Kohonen Self organizing maps – architecture, algorithm – Learning vector quantisation – architecture, algorithm. Counter propagation networks – Full / Forward types.

Unit – V

Adaptive resonance theory – ART1, ART2 networks – architecture, algorithm. Networks for constrained optimization – Boltzman machine, Cauchy machine.

Hardware realization of neural networks. Existing and previous chip Design, Array approaches. VLSI and ULSI approaches.

Reference Books

1. Neural Network Design – Martin T. Hagam, Howard B.Demuth and Mark Beale, Thomson learning 2002.
2. Fundamentals of Neural Networks-architecture, algorithm and application – Laurene Faseff, Pearson Education 2004.
3. Neural Networks-algorithms, applicaitions and programming techniques – James A.Freemen and David M.Skapura, Addison Wesley Publishing House 1992
4. Artificial Neural Network – Robert J.Schalfoll, Tata McGraw Hill Co, 1997.
5. Neural Network – Sathis kumar, Tata McGraw Hill 2004

EE930 FUZZY CONTROL

UNIT I *INTRODUCTION TO FUZZY SETS*

Crisp sets- Fuzzy sets- Operation and properties- Fuzzy relation- properties - Fuzzy tolerance and equivalence relations – value assignments.

UNIT II *FUZZY-CRISP CONVERSIONS*

Features of membership function- Standard forms and boundaries- Fuzzification- Membership value assignments – Intuition – Inference – Rank ordering - Fuzzy to crisp conversions- Lamda- cuts for Fuzzy sets- Lamda cuts for Fuzzy relations- Defuzzification methods.

UNIT III *OPERATIONS ON FUZZY SETS AND FUZZY LOGIC*

Fuzzy Arithmetic, numbers, vectors and the extension principle – Fuzzy numbers – Internal arithmetic - Fuzzy logic- Approximate reasoning- Fuzzy tautologies, contradictions, equivalence and logical proofs- Forms of implication operator- Max-Min Composition – Max Product Composition - other Composition operation.

UNIT IV *FUZZY RULE BASED SYSTEM*

Natural language- Linguistic hedges- Rule based systems- Canonical rule forms- Decomposition of compound rules- Likelihood and truth qualification- Aggregation of Fuzzy rules- Graphical techniques of inference- Fuzzy relational equations- Partitioning- Fuzzy association memories(FAM).

UNIT V *FUZZY CONTROL SYSTEM*

Simple Fuzzy logic controller- General Fuzzy logic controller- Examples of Fuzzy control system design.

Classical Fuzzy control problem- Inverted pendulum – Fuzzy Logic with Motor control – Example of Fuzzy Logic in Motor drives – Non-Linear fuzzy control – Application of Fuzzy Logic in Industry.

Reference Books

1. Timothy J. Ross 'Fuzzy logic with Engineering Applications' McGraw Hill.
2. Li-Xin Wang, 'A Course in Fuzzy Systems and Control', Prentice Hall PTR, 1997.
3. R.K. Yager, D.P.Filev, 'Essentials of Fuzzy Modeling and Control', John Wiley & Sons Inc, New York, 1994.
4. Klir G.J. and B.O.Yuan, 'Fuzzy sets and Fuzzy Logic: Theory and Applications', PHI, India, 1997.
5. Dimiter Driakov etal,' An Introduction to Fuzzy Control', Narosa Publication House, 1993.

EE926 DIGITAL CONTROL SYSTEM

UNIT-I *INTRODUCTION*

Introduction to discrete time control system - Sampling and holding - sample and hold device - D/A, A/D conversion – sampling theorem – data interpolation
Z transform –properties - inverse Z transform - Pulse transfer function

UNIT-II *STATE VARIABLE TECHNIQUE*

State equations of discrete time systems – solution of state equation - state transition matrix, its properties – state space realization and state diagram – pulse transfer function from state equation - characteristic equation - Eigen values - Eigen vectors.
Similarity transformation – transformation into various canonical forms.

UNIT-III *CONTROLLABILITY, OBSERVABILITY AND STABILITY*

Controllability and observability of Llinear Time Invariant (LTI) discrete data systems – tests for controllability and observability - relationship between controllability, observability and pulse transfer functions
Stability of LTI discrete time systems - Jury's stability tests – Schur - Cohn stability test - Bilinear transformation method - Lyapunov stability analysis.

UNIT-IV *CONTROLLER DESIGN – I*

Classical approach:

Correlation between root locations in Z-plane and time response - direct digital design in Z and W plane (under bilinear transform)

State space approach:

State feedback - Design via pole placement – observer based state feedback - Introduction to digital redesign.

UNIT-V *CONTROLLER DESIGN – II*

Kalman filter – optimal state estimation – optimal controllers – LQR, LQG frameworks – Extended Kalman filter.
PID controller – Digital PID controller design.

TEXT BOOKS:

1. K.Ogata, "Discrete time control systems", 2nd edition, Pearson Edu., 2003
2. Franklin, Powell, workman, "Digital control of Dynamic systems", 3rd edition, Pearson Edu., 2002.

REFERENCE:

1. M.Gopal, "Digital Control and state variable methods", Tata McGraw hill, New Delhi, 2003.
2. Aashish Tiwari, "Modern control design with MATLAB and SIMULINK", John Wiley and sons Ltd., 2002
3. Benjin.Kuo, 'Digital Control systems', 2nd Edition, Oxford University, 1992.

EE933 OPTIMAL CONTROL THEORY

UNIT: I *PERFORMANCE MEASURE*

Problem formulation - state variable representation of systems - performance measures for optimal control problems - selecting a performance measure.

UNIT: II *DYNAMIC PROGRAMMING*

Optimal control law – principle of optimality – Application of Principle of optimality to decision making – Recurrence relation of Dynamic Programming – Imbedding Principle – computational procedure to solve optimal control problems – Discrete Linear regulator Problems – Hamilton – Jacobi Belman Equation – Continous linear regulator problems

UNIT: III *CALCULUS OF VARIATIONS:*

Fundamental concepts – Functional of a single function – functionals involving several independent functions – piece wise smooth extremals – constrained extrema.

UNIT: IV *VARIATIONAL APPROACH TO OPTIMAL CONTROL PROBLEM*

Necessary condition for optimal control – Linear regulator problems – Pontryagin's Minimum Principle and state inequality constraints – Minimum time Problems – Minimum Control – Effort problems – Singular intervals in optimal control Problem.

UNIT: V *NUMERICAL DETERMINATION OF OPTIMAL CONTROL*

Simplex Method – golden section Method – Hill climbing – Gradient – Penalty functions methods.

REFERENCES:

1. Optimal Control theory, An Introduction, Donald.E.Kirk, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1962.
2. Optimum system control, Sage A.P., Prentice Hall N.H. 1968
3. Rao S.S. Optimization theory And Application, Wiley Eastern, New Delhi, 1992.

EE 924 CONTROL SYSTEM DESIGN

UNIT: I *INTRODUCTION TO DESIGN*

System Performance specifications – design of Lead, Lag, Lead-Lag compensators, Using Root Locus & Bode plot.

UNIT: II *CLASSICAL CONTROLLER DESIGN*

Basic control action – P+I, P+D, PID controllers – characteristics – Design – Tuning – optimal controllers setting – evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Zeigler Nichols method – damped oscillator method – Process reaction curve method.

UNIT: III *MULTILOOP CONTROL SYSTEM DESIGN*

Feed forward control – ratio control – cascade control – inferential control – spilit range control – Introduction to multivariable control.

UNIT: IV *STAET VARIABLE DESIGN*

Design by state feedback – output feedback – Pole assignment technique – design of state and output regulators – Design of reduced and full order observers – introduction to robust control – H Control – Parameter optimization.

UNIT: V *CASE STUDIES*

Radar tracking – Control of Robot arm – Satellite Altitude Control – Temperature Control.

REFERENCE

1. S.Thompson, Control systems Engineering and Design, Longman group, UK. Ltd., 1989.
2. E.O. Doebelin, Control systems Principles and Design, John Wiley, 1990.
3. I.J. Nagrath and M.Gopal, Control systems Engineering, Wiley Eastern Ltd., 1982.
4. M.Gopal, Modern control systems Engineering, Wiley Eastern Ltd., 1993.
5. Stephampoulis. A, Chemical process control, prentice hall of India, New Delhi, 1990.
6. Eckman D.P., Automatic process control, Wiley Eastern Ltd., New Delhi, 1993.

EE922 ADAPTIVE CONTROL THEORY

UNIT: I *MODELING AND SIMULATION*

Linear Feed back – Effect of process variations – Classifications of Adaptive control - Modeling – Frequency – Impulse – Step Response methods – Simulations of 1st and 2nd order systems.

UNIT:II *IDENTIFICATION TECHNIQUE*

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

UNIT: III *MRAS & STC*

Introduction – the gradient approach – MIT rule Liapunov Functions – Control policies – Pole placement control – minimum variance control – Predictive control.

UNIT: IV *AUTO-TUNING AND GAIN SCHEDULING*

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

UNIT: V *APPLICATIONS AND EXPERT CONTROL*

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

REFERENCES

1. Adaptive Control, Karl.J.Astrom, Bjorn Witten mark, Pearson Education, pvt. Ltd 1995.
2. Adaptive Filtering, Prediction and control, Goodwin G.C Sin KS New Jersey, Prentice Hall inc. 1984.
3. Self tuning and Adaptive control, Harris C.J. Billings. S.A. Peter pereginius Ltd., 1984.
4. Isermann R, Digital Control System vol. I & II Narosa Publishing House, Reprint 1993.
5. Mendal JM, Discrete Technique of Parameter Estimate Marcel dekkas, New York, 1973.

EE927 DIGITAL SIGNAL PROCESSING

UNIT I

Introduction to Discrete time signals – Linear shift invariant system – Stability – Properties systems – Sampling – Frequency domain representative of Discrete time signals and systems – Discrete time random signals.

UNIT II

The Z-transform – Properties of ROC to the Z-transforms – Properties – The Inverse Z-transform and its properties – Discrete Fourier Transforms (DFT) – Properties – FFT – Decimation in time and decimation in frequency algorithm.

UNIT III

Design of IIR filters from continuous time filter – Implementation – Basic structure of IIR and – Cascade – Parallel structure design of biquads – Design examples.

UNIT IV

Design of FIR filters – Basic structure of FIR filters – Windowing – Frequency domain design – Design examples.

UNIT V

Effects of finite register length realization of IIR and FIR filters – Sensitivity calculation – Quantization – Number representation – Introduction to signal processing system design.

TEXT BOOK:

1. Sanjit K. Mitra, 'Digital Signal Processing'. Tata McGraw Hill, 1998.

REFERENCE BOOKS:

1. Alan V. Oppenhain and Ronal W. Schafer, 'Discrete-Time Signal Processing'. Prentice Hall of India Pvt. Ltd., New Delhi, 1992.
2. Simon Haykin and Barry Van Veen, 'Signals and Systems', John Wiley a$ Sons Inc. 1998.

EE928 EMBEDDED SYSTEM

UNIT I:

Introduction to embedded system – Processor with system – Hardware units – Embedded processors – Microcontroller 68H05 – 68H11 – Data processing.

UNIT II:

Memory Interface – Basic peripherals – parallel ports – timer/counter – Real time clocks – Serial ports – Interfacing – analog world – power control - Interrupts.

UNIT III:

Real time operating system – Scheduler algorithm – Priority inversion – Tasks, threads and processes.

UNIT IV:

Writing software for embedded system – The compilation process – Native in cross-compilation – Run-time libraries – writing a library – alternative libraries.

UNIT V:

Design examples – Burglar alarm – Real time without RTOS – Application.

REFERENCE:

1. Steve Heath, 'Embedded systems design', Newnes, 2003.
2. Raj Kamal,' Embedded System', Tata McGraw Hill, 2003.
3. Daniel. W. Lewis,' Fundamentals of Embedded software when C and assembly met', Pearson Education, 2004.

EE 935 WIND ENERGY CONVERSION SYSTEM

UNIT I: *INTRODUCTION:*

History of wind electric generation – Darrieus wind – Horizontal and vertical axis – Wind turbine – other modern developments – Future possibilities.

UNIT II *WIND RESOURCE AND ITS POTENTIAL FOR ELECVTRIC POWER GENERATION:*

Power Extracted By A Wind Driven Machine – Nature and occurrence of wind characteristics and power production – variation of mean wind speed with time.

UNIT III *WIND POWER SITES AND WIND MEASUREMENTS:*

Average wind speed and other factors affecting choice of the site – Effect of wind direction – Measurement of wind velocity – Personal estimation without instruments – anemometers – Measurement of wind direction.

UNIT IV *WIND TURBINES WITH ASYNCHRONOUS GENERATORS AND CONTROL ASPECTS:*

Asynchronous systems – Ac Generators – Self excitation of Induction Generator – Single Phase operation of Induction Generator – Permanenet magnet Generators – Basic control aspects – fixed speed ratio control scheme – fixed vs variable sped operation of WECS.

UNIT V *GENERATION OF ELECTRICITY '*

Active and reactive power – P and Q transfer in power systems – Power converters – Characteristics of Generators – Variable Speed options – Economics.

REFERENCES:

1. N.G.Calvert, 'Wind Power Principles: Their Application on small scale', Charles Friffin& co. Ltd, London, 1979.
2. Gerald W.Koeppel, "Pirnam's and Power from the wind", Van Nastran Reinhold Co., London, 1979.
3. Gary L. Johnson, "Wind Energy System", Prentice hall Inc., Englewood Cliffs, New Jersey, 1985.
4. Wind energy conversion system by L. Lfreris, Prentice hall (U.K) Ltd., 1990.

EE929 FACTS CONTROLLERS

UNIT-I

Introduction to FACTS controllers – Reactive power control: Reactive power, uncompensated transmission line, reactive power compensation – Principles of conventional reactive power compensators: Synchronous condensers, saturated reactor, phase angle regulator, and other controllers.

UNIT-II *Thyristor Controlled Shunt Compensator: SVC*

Objective of shunt compensation – Principle and operating characteristics of Thyristor Controlled Reactor – Thyristor Switched Capacitor – TSC-TCR static Var Compensators – SVC control system – SVC voltage regulator model – Transfer function and dynamic performance of SVC – Transient stability enhancement and power oscillation damping, mitigation of subsynchronous resonance.

UNIT-III *Thyristor Controlled Series Compensator: TCSC*

Series compensation – Principles of operation of TCSC – Capability characteristics of TCSC – Modeling of TCSC – TCSC control system – enhancement of system damping – mitigation of subsynchronous resonance.

UNIT-IV *Voltage Source Converter based Shunt and Series Compensator*

STATCOM: (Static Synchronous Compensator)

Principle of operation, VI Characteristics, Harmonic performance – Steady state model – SSR mitigation.

SSSC: (Static Synchronous Series Compensator)

Principle of operation and characteristics of SSSC – control range and VA rating – capability to provide real power compensation – Immunity to subsynchronous resonance – control scheme for SSSC.

UNIT-V *Unified Power Flow Controller*

Basic operating principles – conventional transmission control capability of UPFC – Independent real and reactive power flow control – control scheme for UPFC – Basic control system for P and Q control – dynamic performance.

Text Book

1. Narani.G.Hingorani and Laszlo Gyugyi, "Understanding FACTS", First Indian Edition, 2001, IEEE Power Engineering society sponsor, IEEE Press.

References:

1. Narani.G.Hingorani, "Flexible AC Transmission", IEEE Spectrum, April 1993, pp. 40-45.
2. Narani.G.Hingorani, "High Power Electronics and Flexible AC Transmission Systems", IEEE High Power Engineering Review, 1998.
3. Narani.G.Hingorani, "Power Electronics in Electric Utitlities: Role of Power Electronics in future Power Systems", Proceedings of IEEE, Vol. 76, no. 4, April 1998.
4. Einar V.Larsen, Jaun J. Sanchez-Gasca, Joe H.Chow, "Concepts for design of FACTS Controllers to damp power swings", IEEE Transaction on Power Systems, Vol. 10, no. 2, May 1995.
5. Gyugyi.L, "Unified Power flow control concept for flexible AC Transmission", IEEE Proceedings, Vol. 139, no.4, July 1992.
6. R. Mohan and R.K.Varma, "Thyristor-Based FACTS Controllers for Electrical Transmission Systems", IEEE Press – A John Wiley and Sons, Inc. Publications.

EE921 ADVANCE CONTROL THEORY

UNIT I: *STATE SPACE ANALYSIS*

Review of state model for system – state transition matrix and its properties – free and forced system responses controllability and observability – kalman decomposition

UNIT II: *STATE FEED BACK*

Stability improvement – pole placement technique – state regulator design - state observers – full order and reduced observers – compensator design by separation principle – state feedback with Integral control.

UNIT III: *NONLINEAR SYSTEMS*

Distinguishing features of linear and non-linear systems – common physical nonlinearities – phase plane analysis – singular points – limit cycles – equivalent linearisition.

UNIT IV: *DESCRIBING FUNCTION ANALYSIS:*

Derivation of describing function of common non-Linearities – condition for stability – Stability of Oscillations – Accuracy of DF Method - Stability of System with Multiple Non-Linearities – Dual Input Describing Function.

UNIT V: *STABILITY ANALYSIS:*

Stability Definitions Krasovskii Method - Lyapunov Function for Linear and Non-Linear Functions – Lyapunov Direct Method - Lure's Transformation – Popov's Criterion – Circle Criterion.

REFERENCES:

1. M.Gopal, 'Modern Control Theory', New age Int. 1993.
2. M.Gopal, 'Digital Control and State variable methods', Tata McGraw Hill, 1997.
3. K.Ogata, 'Modern Control Engineering' PHI, 1997.
4. William.S.Levine, The control handbook, IEEE and CRC press VAS 2000.
5. Jean Jacques E.Slotliz Applied non linear System, PA, 1991.
6. Petes cook. A, 'Non Linear Dynamical System' – PA 1 1986
7. D.J.Bell, 'Mathematics of Linear and Non – linear system clarendar press oxford, 1990.

EE 925 CONTROLLER DESIGN TECHNIQUES

UNIT: I *INTRODUCTION TO DESIGN*

System Performance indices – controller specifications in time and frequency domain, relationship between time and frequency domain specifications – Noise , uncertainty issues – performance criterions like IAE, ISE, ITAE, ITSE etc.

Compensators – methodologies and assessment.

UNIT: II *CONTROLLER DESIGN: CLASSICAL APPROACH -I*

Three term control – P, I, and D action – design of PI, PD, PID controllers – characteristics –Tuning by manual automatic techniques – PID controller design for specified phase margin and gain margin.

UNIT: III *CONTROLLER DESIGN: CLASSICAL APPROACH -II*

Design of lead, lag, and lag-lead compensators – root locus and frequency response based approaches.

UNIT: IV *CONTROLLER DESIGN: STATE SPACE APPROACH -I*

Controller design by state feedback – necessary and sufficient condition for arbitrary pole placement, regulation and servo problems –output feedback control.

Full order and reduced order observer based controller design – Introduction to Kalman filter.

UNIT: IV *CONTROLLER DESIGN: STATE SPACE APPROACH -II*

Optimal controllers – problem formulation – LQR problem – optimal controller design via parameter adjustment (Lyapunov method) and Ricatti equation (Hamiltonian matrix). LQG controller framework – Loop transfer recovery.

Introduction to robust controllers.

TEXT BOOKS:

1. Stefani, Shahian, Savant, Hostetter, "Design of Feedback control systems", Oxford University Press, 2004.
2. Katsuhiko Ogata, "Modern control engineering", Prentice hall of India pvt. Ltd., New Delhi -110001, 1989'.
3. D.Azzo and Constantine.H.Houpis, "Linear control system analysis and design", McGraw Hill, 1995.

REFERENCE:

1. Biswa Nath Datta, "Numerical methods for linear control systems', Elsevier, 2005.
2. Gene.F.Franklin, J.David Powell and Abbas Emami-Naeini, 'Feedback Control of dynamic systems',Pearson Edu. Asia, 2002.
3. Chi-Tsong chen, 'Linear System theory and design', 3rd edition, oxford press, 1999.
4. Goodwin, Grabe and salgado,' Control system design', Prentice Hall of India pvt limited.
5. Anderson B.D.O and Moore J.B, 'Optimal control- linear quadratic methods', Englewood cliffs, New Jersey, Prentice Hall, 1990.
6. Jacqueline Wilkie, Micheal Johnson, Reza Katebi,' Control Engineering', Palgrave, 2003.

EE 931 MICRO CONTROLLER

<u>UNIT – I *INTRODUCTION TO MICRO CONTROLLER*</u>

Microprocessor and Micro Controllers –Micro Controller survey-role of Micro Controller- Micro Controller resources.

UNIT – II *8051 ARCHITECTURE AND PROGRAMMES*

8051 Architecture-8051 Micro Controller hardware- Input/Output ports and circuits-External Memory-Counter and Timers- Serial data Input/Output- Interrupts.

Basic Assembly language programming concepts- Data transfer operations-Addressing Modes-Arithmetic and logic operations- jump and call instructions-simple program.

<u>UNIT – III *8051 MICRO CONTROLLER DESIGN*</u>

Micro controller specification-Micro controller design- Testing the design-Timing subroutines- Lookup tables for 8051- Serial Data transmission **.**

UNIT – IV *16 BIT MICRO CONTROLLER*

16 Bit Micro controller – Intel 8096- Architecture – Modes of operation-Addressing modes-interrupts- timers and high speed I/O- Pulse width modulated output-Instruction set.

<u>UNIT – I *APPLICATIONS OF 8051*</u>

Keyboards-Displays-Pulse measurement-D/A and A/D conversion- PID control algorithm- DC motor Position/speed control- Stepper motor control- Data Transfer between two micro controllers.

Reference books:

1: John B. Peatman, ‘Design with Micro controller’ Mc Graw Hill,1998.
2: Kenneth J. Ayala ‘The 8051 Micro controller Architecture, Programming and Aplications’, Penram Int. Pub, 1996.
3: 16-Bit Embedded Controller hand Book, Intel Corporation, New York, 1990.
4: Kenneth Hintz and Daniel Tabak, ‘Micro controller Architecture, implemention and programming’, Mc Graw Hill Int, New York, 1992.

EE 923 ADVANCED POWER ELECTRONIC CONVERTERS

Unit – I *AC-DC Converters*

Vienor rectifier – control strategies – applications.

Unit – II *DC-DC Converters*

Synchronous and bidirectional converters – control principles and applications – Lue converters.

Unit – III *DC-AC Converters*

Three phase VSI and RSPWM methods – DPWM – SVPWM.
Multilevel inversion – SHPWM and variations.
Active filters – VAR compensators

Unit – IV *AC-AC Converters*

Matrix converters – control principles and typical applications.

Unit – V *Power conversion using Resonant Converters*

Introduction – classification – soft-switching and EMI suppression – Soft switching DC-AC power Inverters.

Reference Books

1. M.H.Rashid, Power Electronics Handbook, Academic press,2000,Newyork
2. Mohan/Underland/Robbin, Power Electronics, Second Edition, 2002