SYLLABUS FOR M.E.(POWER SYSTEMS & AUTOMATION)

SEMESTER – I

EPS 1.1: ADVANCED POWER SYSTEM OPERATION AND CONTROL

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Economic operation: Economic dispatch problem of thermal units without and with losses– Gradient method-Newton's method –Base point and participation factor method.

Unit Commitment Solution Methods: Introduction to unit commitment, methods of unit commitment**:** Priority-List Methods, Dynamic- Programming Solution, Forward DP Approach, Lagrange relaxation solution.

Hydro-thermal co-ordination: Hydroelectric plant models –short term hydrothermal scheduling problem -gradient approach.

Optimal Power Flow: Solution of OPF, gradient method, Newton's method, linear programming method with only real power variables, linear programming with AC power flow variables, security-constrained optimal power flow.

Power system security: Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow.

The control problem: The two-area system, Tie-line Bias control; steady state Instabilities: Torsional Oscillatory Modes-Damper windings and negative damping, effect of AVR loop: AGC Design using kalman method-state variable form of the dynamic model, Optimum control Index, state Trajectories, the RICCATTI equations, preventive and emergency control, computer control.

TEXT BOOKS

1. Allen J.Wood and Wollenberg B.F., 'Power Generation Operation and control', John Wiley & Sons, Second Edition,1996.
2. Electric Energy systems Theory - An Introduction' Olle I Elgard, TMH Second Edition

REFERENCES

1. Kirchmayer L.K., 'Economic Control of Interconnected Systems', John Wiley & Sons, 1959.
2. Nagrath, I.J. and Kothari D.P., 'Modern Power System Analysis', TMH, New Delhi, 2006.

EPC 1.2: OPTIMIZATION TECHNIQUES

(COMMON FOR POWER SYSTEMS AND AUTOMATION & CONTROL SYSTEM ENGINEERING)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Introduction to Optimization: Introduction, Historical Development, Engineering Applications of Optimization, Statement of Optimization Problem.

Classical Optimization Techniques: Introduction, Single variable optimization, Multivariable optimization with no constraints; Multivariable optimization with Equality constraints – Solution by Direct Substitution method, Method of constrained variation, Method of Lagrangian multipliers; Multivariable optimization with inequality constraints: Kuhn-Tucker conditions.

Linear Programming: Introduction, Applications of Linear Programming, Standard Form of a Linear Programming, Basic Terminology and Definitions, Exceptional cases, Simplex method, Big-M method, Two-phase method, Revised Simplex method, Duality, Decomposition Principle.

Non-Linear Programming-I: Unconstrained optimization-Univariate method, Pattern Directions, Hook and Jeeves Method, Powell's method, Gradient of a function, Steepest descent method, Conjugate Gradient Method, Newton's method, Marquardt Method, Quai-Newton Methods, Davidon-Fletcher-Powell Method, Broyden-Fletcher-Goldfarb-Shanno Method.

Non-Linear Programming-II: Constrained optimization- Characteristics of a Constrained Problem, Sequential linear programming, Basic approach in the methods of feasible directions, Zoutendijk's method of feasible directions, Sequential Quadratic Programming.

TEXT BOOK:

1. Engineering Optimization: Theory and Applications' By S.S.Rao, New Age International Publishers, Revised Third Edition,2005.

EPC 1.3 ADVANCED DRIVES & CONTROL

(COMMON FOR POWER SYSTEMS AND AUTOMATION & CONTROL SYSTEM ENGINEERING)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

DC drives: System model, motor rating, motor mechanism dynamics, drive transfer function, effect of armature current waveform, torque pulsations, adjustable speed drives, chopper fed and single-phase converter fed drives, effect of field weakening.

Induction Motor drives: Basic Principle of operation of 3 Phase motor, equivalent circuit, MMF space harmonics due to fundamental current, fundamental spatial MMF distributions due to time harmonics simulation, effect of time and space harmonics, speed control by varying stator frequency and voltage, impact of nonsinusoidal excitation on induction motors, variable square wave VSI drives, variable frequency CSI drives, line frequency variable voltage drives.

Induction Motor drives: Review of induction motor equivalent circuit, effect of voltage, frequency and stator current on performance of the machine, effect of harmonics, dynamic d.q model, small signal model, voltage and current fed scalar control, direct and indirect vector control, sensor less vector control, direct torque and flux control.

Synchronous motor drives: Review of synchronous motor fundamental, equivalent circuit, dynamic d-q model, synchronous reluctance, sinusoidal and trapezoidal back emf permanent magnet motors, sinusoidal SPM machine drives, trapezoidal SPM machines drives, wound field machine drives, switched reluctance motor drives.

Closed loop control: Motor transfer function-P, PI and PID controllers, current control-Design procedure, phase locked loop (PLL) control-microcomputer control.

Text Books:

1. B. K. Bose, "Modern Power Electronics and AC drives", Pearson Education, Asia, 2003.
2. M. H. Rashid, "Power Electronics", Third Edition, PHI
3. G. K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing house.

Reference Books:

1. V. Subrahmanyam, "Electric Drives-Concepts and Applications", TMH
2. G. K. Dubey, "Power Semiconductor controlled drives", PH 1989.
3. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", PH, 1998.
4. P. Vas, "Sensor less vector and direct torque control", Oxford Press, 1998.
5. W. Leonard, "Control of Electric Drives", Springer Verlag, 1985.

EPC 1.4: ADVANCED CONTROL SYSTEM DESIGN

(COMMON FOR POWER SYSTEMS AND AUTOMATION & CONTROL SYSTEM ENGINEERING)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Design of Linear Control Systems: Review of compensation techniques to obtain desired performance, Reshaping of Bode & Root locus plots to obtain desired response, Initial condition and forced response, a simple lag – lead design.

Integral-square error compensation: parameter optimization using Integral-square error criterion with and without constraints, principles of State variable Feedback compensation of continuous - time and discrete-time systems, simple problems to understand the concept.

MIMO Control design: Principles of Linear Quadratic Optimal Regulators, Discrete Time Optimal Regulators, Observer Design, Linear Optimal Filters, State Estimate Feedback, Transfer Function Interpretation, simple problems to understand the concept.

PID Controller: PID controller, Simulation of multi-loop control system using P, PI, PD, PID controller, Standard compensator structures (P, PD, PI and PID control).

Design of digital control system: Protocol of Digital controller design, Classical Compensation of Discrete-time control systems: Forward path continuous, Forward-path Digital Z-plane Synthesis approaches, Deadbeat performance.

Text Books:

1. G. C. Goodwin, S. F. Graebe, M. E. Salgado, "Control System Design", Prentice Hall of India
2. Gupta and Hasdorf, 'Fundamentals of Automatic control Willey Eastern, 1970.
3. B.C.Kuo, Automatic control systems' (5th Edition), Prentice Hall of India, 1988.

Reference Books:

1. M. Gopal, "Digital Control and State Variable Method", Tata McGraw Hill
2. Hadi Saadat, "Computational Aids in Control System Using MATLAB", McGraw Hill International
3. Ogata K., "Modern Control Engineering", 4th Edition, Prentice Hall
4. Norman S. Nise, "Control Systems Engineering", 3rd Edition, Wiley

EPS 1.5 (a) RENEWABLE ENERGY SYSTEMS
(ELECTIVE- I)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Energy and Electricity: The World Energy Scene, The Environmental Impact of Energy Use, Generating Electricity, The Electrical Power System

Features of Conventional and Renewable Generation: Introduction, Conventional Sources: Coal, Gas and Nuclear, Hydroelectric Power, Wind Power, PV and Solar Thermal Electricity, Tidal Power, Wave Power, Biomass, Summary of Power Generation Characteristics, Combining Sources.

Power Balance/ Frequency Control: Introduction, Electricity Demand, Power Governing, Dynamic Frequency Control of Large Systems, Impact of Renewable Generation on Frequency Control and Reliability, Frequency Response Services from Renewables, Frequency Control Modelling, Energy Storage.

Renewable Energy Generation in Power Systems: Distributed Generation, Voltage Effects, Thermal Limits, Other Embedded Generation Issues, Islanding, Fault Ride-through, Generator and Converter Characteristics.

Power System Economics and the Electricity Market: Introduction, The Costs of Electricity Generation, Economic Optimization in Power Systems., External Costs, Effects of Embedded Generation, Support Mechanisms for Renewable Energy, Electricity Trading.

The Future – Towards a Sustainable Electricity Supply System: Introduction, The Future of Wind Power, The Future of Solar Power, The Future of Biofuels, The Future of Hydro and Marine Power, Distributed Generation and the Shape of Future Networks.

Text Books:

1. Renewable Energy in Power Systems ,BY Leon Freris, David Infield, WILEY PUBLISHERS, July 2008

EPS 1.5(b) POWER SYSTEM MODELING
(ELECTIVE- I)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Modeling of Power System Components: The need for modeling of power system, Simplified models of non-electrical components like boiler, steam & hydro-turbine & governor system. Transformer modeling such as auto-transformer, tap-changing & phase-shifting transformer.

Reference Frame Theory : Static and rotating reference frames – transformation of variables – reference frames – transformation between reference frames – transformation of a balanced set – balanced steady state phasor and voltage equations – variables observed from several frames of reference.

Synchronous machine modeling: Voltage and Torque Equation – voltage Equation in arbitrary reference frame and rotor reference frame – Park equations - rotor angle and angle between rotor – steady state analysis – dynamic performances for torque variations- dynamic performance for three phase fault – transient stability limit – critical clearing time – computer simulation.

Transmission line, SVC and load modeling : Transmission line, d-q transformation using μ-b variables, static VAR compensators, load modeling.

Induction Machines : Voltage and toque equations – transformation for rotor circuits – voltage and toque equations in reference frame variables – analysis of steady state operation – free acceleration characteristics – dynamic performance for load and torque variations – dynamic performance for three phase fault – computer simulation in arbitrary reference frame.

Text Book:

1. Power Systems Dynamics – K.R.Padiyar, B.S. Publications
2. Power System Control and Stability – Vol. – I – Anderson & Foud, IEEE Press, New York.

Reference Books:

1. Power System Dynamics & Control – Kundur, IEEE Press , New York
2. Power System Operation & Control – P.S.R. Murthy
3. "Electrical Energy System Theory – an introduction" by Olle Elgerd. TMH Publishing Company 2nd Edition, New Delhi
4. "Power System Analysis" – John J. Granier and W.D. Stevenson Jr, 4th Edition, McGraw Hill International student edition.

EPS 1.5 (c): POWER SYSTEM PLANNING
(ELECTIVE- I)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Introduction: The electric utility industry, generation systems and transmission systems.

Load forecasting: Classification and characteristics of loads, approaches to load forecasting, load forecasting methodology, energy forecasting, peak demand forecasting, non-weather sensitive forecast(NWSF), weather sensitive forecast, total forecast.

Generation system reliability analysis: Probabilistic generating unit models, probabilistic load models, effective load, reliability analysis of an isolated system and interconnected systems.

Generation system cost analysis: Cost analysis, corporate models, production analysis, production costing, fuel inventories, energy transactions and off-peak loading, environmental cost.

Transmission system reliability analysis : Deterministic contingency analysis, probabilistic transmission system, reliability analysis, capacity state classification by subsets, subset decomposition for system LOLP and (DNS) calculations, single area and multi area reliability analysis.

Automated transmission system expansion planning: Basic concepts, automated network design, automated transmission planning, a DC method, automated transmission planning by interactive graphics.

TEXT BOOK:

1. Power system planning, R. Sullivan, McGraw International book Co., New York and New Delhi (chapters 1-4,6,7 of the text book)

SYLLABUS FOR M.E.(CONTROL SYSTEMS ENGINEERING)

SEMESTER – I

ECS 1.1: ADVANCED CONTROL SYSTEMS

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

State variable representation: Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity, state model-State Diagrams-Physical System.

Solution of state equation: Existence and uniqueness of solutions to Continuous-time state equations-Solution of Linear Time Varying State equations- Evaluation of matrix exponential- Role of Eigenvalues and Eigenvectors.

Controllability and Observability: Controllability and Observability-Tests for Continuous time Systems- Time varying and Time invariant case-Output Controllability-observability- System Realizations.

Stability: Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

Modal control: Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TEXT BOOKS:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.

REFERENCES:

1. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
2. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
3. Z. Bubnicki, "Modern Control Theory", Springer, 2005.

EPC 1.2: OPTIMIZATION TECHNIQUES

(COMMON FOR POWER SYSTEMS AND AUTOMATION & CONTROL SYSTEM ENGINEERING)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Introduction to Optimization: Introduction, Historical Development, Engineering Applications of Optimization, Statement of Optimization Problem.

Classical Optimization Techniques: Introduction, Single variable optimization, Multivariable optimization with no constraints; Multivariable optimization with Equality constraints – Solution by Direct Substitution method, Method of constrained variation, Method of Lagrangian multipliers; Multivariable optimization with inequality constraints: Kuhn-Tucker conditions.

Linear Programming: Introduction, Applications of Linear Programming, Standard Form of a Linear Programming, Basic Terminology and Definitions, Exceptional cases, Simplex method, Big-M method, Two-phase method, Revised Simplex method, Duality, Decomposition Principle.

Non-Linear Programming-I: Unconstrained optimization-Univariate method, Pattern Directions, Hook and Jeeves Method, Powell's method, Gradient of a function, Steepest descent method, Conjugate Gradient Method, Newton's method, Marquardt Method, Quai-Newton Methods, Davidon-Fletcher-Powell Method, Broyden-Fletcher-Goldfarb-Shanno Method.

Non-Linear Programming-II: Constrained optimization- Characteristics of a Constrained Problem, Sequential linear programming, Basic approach in the methods of feasible directions, Zoutendijk's method of feasible directions, Sequential Quadratic Programming.

TEXT BOOK:

1. **Engineering Optimization: Theory and Applications' By S.S.Rao, New Age International Publishers, Revised Third Edition,2005.**

EPC 1.3 ADVANCED DRIVES & CONTROL

(COMMON FOR POWER SYSTEMS AND AUTOMATION & CONTROL SYSTEM ENGINEERING)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

DC drives: System model, motor rating, motor mechanism dynamics, drive transfer function, effect of armature current waveform, torque pulsations, adjustable speed drives, chopper fed and single- phase converter fed drives, effect of field weakening.

Induction Motor drives: Basic Principle of operation of 3 Phase motor, equivalent circuit, MMF space harmonics due to fundamental current, fundamental spatial MMF distributions due to time harmonics simulation, effect of time and space harmonics, speed control by varying stator frequency and voltage, impact of nonsinusoidal excitation on induction motors, variable square wave VSI drives, variable frequency CSI drives, line frequency variable voltage drives.

Induction Motor drives: Review of induction motor equivalent circuit, effect of voltage, frequency and stator current on performance of the machine, effect of harmonics, dynamic d.q model, small signal model, voltage and current fed scalar control, direct and indirect vector control, sensor less vector control, direct torque and flux control.

Synchronous motor drives: Review of synchronous motor fundamental, equivalent circuit, dynamic d-q model, synchronous reluctance, sinusoidal and trapezoidal back emf permanent magnet motors, sinusoidal SPM machine drives, trapezoidal SPM machines drives, wound field machine drives, switched reluctance motor drives.

Closed loop control: Motor transfer function-P, PI and PID controllers, current control-Design procedure, phase locked loop (PLL) control-microcomputer control.

Text Books:

1. B. K. Bose, “Modern Power Electronics and AC drives”, Pearson Education, Asia, 2003.
2. M. H. Rashid, “Power Electronics”, Third Edition, PHI
3. G. K. Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing house.

Reference Books:

1. V. Subrahmanyam, “Electric Drives-Concepts and Applications”, TMH
2. G. K. Dubey, “Power Semiconductor controlled drives”, PH 1989.
3. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, PH, 1998.
4. P. Vas, “Sensor less vector and direct torque control”, Oxford Press, 1998.
5. W. Leonard, “Control of Electric Drives”, Springer Verlag, 1985.

EPC 1.4: ADVANCED CONTROL SYSTEM DESIGN

(COMMON FOR POWER SYSTEMS AND AUTOMATION & CONTROL SYSTEM ENGINEERING)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Design of Linear Control Systems: Review of compensation techniques to obtain desired performance, Reshaping of Bode & Root locus plots to obtain desired response, Initial condition and forced response, a simple lag – lead design.

Integral-square error compensation: parameter optimization using Integral-square error criterion with and without constraints, principles of State variable Feedback compensation of continuous - time and discrete-time systems, simple problems to understand the concept.

MIMO Control design: Principles of Linear Quadratic Optimal Regulators, Discrete Time Optimal Regulators, Observer Design, Linear Optimal Filters, State Estimate Feedback, Transfer Function Interpretation, simple problems to understand the concept.

PID Controller: PID controller, Simulation of multi-loop control system using P, PI, PD, PID controller, Standard compensator structures (P, PD, PI and PID control).

Design of digital control system: Protocol of Digital controller design, Classical Compensation of Discrete-time control systems: Forward path continuous, Forward-path Digital Z-plane Synthesis approaches, Deadbeat performance.

Text Books:

1. G. C. Goodwin, S. F. Graebe, M. E. Salgado, “Control System Design”, Prentice Hall of India
2. Gupta and Hasdorf, 'Fundamentals of Automatic control Willey Eastern, 1970.
3. B.C.Kuo, Automatic control systems' (5th Edition), Prentice Hall of India, 1988.

Reference Books:

1. M. Gopal, “Digital Control and State Variable Method”, Tata McGraw Hill
2. Hadi Saadat, “Computational Aids in Control System Using MATLAB”, McGraw Hill International
3. Ogata K., “Modern Control Engineering”, 4th Edition, Prentice Hall
4. Norman S. Nise, “Control Systems Engineering”, 3rd Edition, Wiley

ECS 1.5 (a): LARGE SCALE SYSTEMS
(ELECTIVE-I)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

L.S.S. Modelling : Time Domain: Introduction, Aggregation methods, exact and model aggregation by continued fraction, chained aggregation descriptive variables approach, descriptive variable systems, solvability and conditionality, time invariance, shuffle algorithm.

L.S.S. Modelling - Frequency Domain : Introduction, Moment matching, Pade approximation, Routh approximation, continued fraction method, error minimization methods, mixed methods and unstable systems, Pade model method, Pade-Routh method, multi input and multi output systems, reduction, matrix continued fraction method, Model continued fraction method, Pade model method, frequency comparison method.

Time Scales and Singular Perturbations: Introduction, problem statement and preliminaries, numerical algorithm, basic properties, relation to model aggregation, feedback control design, singularly perturbed linear systems, fast and slow sub systems, eigenvalue distribution, approximation to time scale approach, system properties, design of optimal controllers, fast and slow controllers, lower order controls.

TEXT BOOKS :

1. 'Large Scale Systems Modeling and Control', Mohammad Jamshidi,1989, North Hollard (Series in systems science and engineering, vol.9).
2. 'Large Scale Systems Modeling', Magdi S. Mohamoud and Madan G. Singh, Pergamon Press (International series on Systems and Control), 1981.

ECS 1.5 (b): DIGITAL CONTROL SYSTEMS
(ELECTIVE- I)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Discrete –Time Systems: The Structure of a Digital Control System ,Analog Systems with Piecewise Constant Inputs, Difference Equations, The Z-Transform, Z-Transform Solution of Difference Equation, The Time Response of a Discrete-Time System, Frequency Response of Discrete-Time Systems.

Modeling of Digital Control Systems: ADC Model, DAC Model, Transfer Function of the ZOH, Effect of Sampler on Transfer Function of a Cascade, Transfer Function for the DAC, Analog Subsystem, ADC Combination, Closed-Loop Transfer Function, Analog Disturbances in a Digital System, Steady-State Error and Error Constants.

Stability of Digital Control Systems: Definitions of Stability, Stable Z-Domain Pole Locations, Stability Conditions, Stability Determination, Jury Test.

State Space Representation: Discrete-Time State Space Equations, Solution of Discrete-Time State Space Equations, Z-Transfer from State Space Equations, Similarity Transformation, Stability of State Space Realizations, Controllability and Stabilizability, Observability and Detectability.

State Feedback Control: On State and Output Feedback, Pole Placement, Servo Problem, Principles of Observer, State Feedback and Pole Assignment Using Transfer Functions.

Text Books:

1. Digital control systems by B.C.Kuo, Oxford University Press

References:

1. Digital Control Engineering: Analysis and Design**,** By M. Sami Fadali, Antonio Visioli, Academic Press; 1 edition (February 16, 2009)
2. Digital control systems by K.Ogata

ECS 1.5 (c): ROBUST AND ADAPTIVE CONTROL
(ELECTIVE- I)

Credits	**: 4**
Lectures per week	: **4**
Theory, Univ. Exam. Marks	: **70**
Sessional Marks	: **30**
Total Marks	: **100**

Part I Robust Control

Introduction: Why Robust and Adaptive Control? Control-Oriented Models for Linear-Time-Invariant Systems, Norms of Vectors and Matrices in Euclidean Spaces.

State Feedback H_∞ Optimal Control: Introduction, Norms for Signals and Systems, Power signals, Norms for Systems, Computing Norms for Systems, Well-Posedness and Stability, Stability and Performance Specifications in the Frequency Domain, Loop Shaping Using Frequency –Dependent Weights, State Feedback H_∞ Optimal Control.

Output Feedback Control: Output Feedback Using Projective Controls, Linear Quadratic Gaussian with Loop Transfer Recovery, Summary, Loop Transfer Recovery Using the Lavretsky Method.

Part II Robust Adaptive Control

Model Reference Adaptive Control: Motivational Example, Introduction to Direct Model Reference Adaptive Control, Direct Model Reference Adaptive Control of Scalar Linear Systems with Parametric Uncertainties, Historical Roots and Foundations of Model Reference Adaptive Control.

State Feedback Direct Model Reference Adaptive Control: Introduction, Command Tracking, Direct MRAC Design for Scalar Systems, Dynamic Inversion MRAC Design for Scalar Systems, MRAC Design for Multi-Input Multi-Output Systems.

Model Reference Adaptive Control with Integral Feedback Connections: Introduction, Control Design, MRAC Augmentation of an Optimal Baseline Controller.

Robust Adaptive Control: MRAC Design in the Presence of Bounded Disturbances, MRAC Design Modifications for Robustness.

Text Books:

1. Robust and Adaptive Control: With Aerospace Applications, Advanced textbooks in control and signal processing, by Eugene Lavretsky, Kevin A. Wise, publisher Springer 2012