RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS: M. TECH. (CONTROL & INSTRUMENTATION)

1MCI 1 MODERN CONTROL SYSTEM

State variable analysis and design: State space model for continuous time linear system and discrete time linear system. State space representation using phase variables and canonical variables, transfer function from state model, state model from transfer function, diagonalization Eigen values and eigen vector, solution of state equation. Controllability, observability and reproducibility, controllable companion transformation, interpretation of controllability, observability criteria, duality, output function controllability, input function observability. State feedback control. State feedback and output feed back, pole assignment using state feedback and output feedback, reconstructing the state from available outputs.
Analysis of state equations, Control law design for full state feedback, Selection of pole locations for good design, Estimator design, Combined control law and Estimator loop transfer recovery, Integral control and robust tracking, Design of systems with pure time delay.

1MCI 2 MODELLING OF DYNAMICAL SYSTEMS

Systems approach: Classification of inputs and models, Analytical and experimental methods of modelling: transform methods.
Energy approach of modelling: Co-ordinates and velocities, Generalized co-ordinates, Degrees of freedom, The Lagrangian, Rayleigh dissipation function. Application to a simple pendulum, simple circuit, elastic pendulum, capacitor microphone, spherical elastic pendulum.
Levy’s curve fitting technique: Methods based on decomposition, Levy’s basic theory, Levy’s special technique.
Least squares method: Regression function, least squares estimator, minimum variance estimator, sequential least-squares estimation, multi-dependent variable system, and recursive estimation for increasing parameter numbers.
Application of above techniques in modeling of thermal, chemical, electrical, medical-health, population, and agricultural systems etc.

1MCI 3 MEASUREMENT SYSTEMS & ERROR ANALYSIS

Fundamental methods of measurements, concept of a generalized measurement system, types of measurements, Experimental engineering analysis. Static performance characteristics-static sensitivity, Linearity, Threshold Resolution, Hysteresis and Dead span and readability of scale. Generalized static stiffness & input and output impedances. Dynamic performance characteristics, Generalized mathematical model of measurement system, operational transfer function. Input types, order of instruments. Response of zero, first and second order instruments to step, ramp and sinusoidal inputs. Transient and frequency response. Requirements of instrument transfer function for accurate measurement. Numerical correction of dynamic data. Experimental determination of measurement system parameters. Loading effect under dynamic conditions. Accuracy and precision, types of errors, statistical analysis of data, Systematic (non-random) errors, Determination and minimization of systematic errors, Probability concept and distribution law, Accidental (random) errors, calculation of mean value and standard deviation from the measurements, confidence limits, conversion tables, Testing a distribution for normalcy, Propagation of error, significance test & Chi-square test, Contingency table. Model of measurement systems, Models of resistive, capacitive piezo electric, optron, Seismic and Gyroscopic pickups. Dynamic studies of models.

2MCI 1 DIGITAL SIGNAL PROCESSING

DFT & its properties. Decimation in time and decimation in frequency FFT algorithms, discrete cosine transform.

IIR Filter design: Butterworth design, bilinear transformation. Low Pass, High Pass, Band Pass and Band Stop digital filters. Spectral transformation of IIR filters.

FIR filter design: Symmetric and antisymmetric linear phase. FIR filter by rectangular, triangular and Blackman window functions.

Finite word length effects in FIR and IIR digital filters: Quantization, round off errors and overflow errors.

Multi rate digital signal processing: Concepts, design of practical sampling rate converters, Decimators, interpolators. Polyphase decompositions.

2MCI 2 MULTI-VARIABLE CONTROL SYSTEM

State space descriptions: Some basic concepts, canonical realizations, parallel and cascade realizations, Nonuniqueness of state-space realizations, time variant parameters, nonlinear parameters.
The state observability problem, state controllability, Discrete time systems: Reachability and constructability, some examples to discuss the above fundamentals, representation of noncontrollable realizations, minimal realizations, The Popov-Belevitch-Hautus test for controllability and observability. Uncontrollable and controllable modes and eigen values.
Classification of linear controllable systems: Autonomous systems, discrete and periodic systems, stabilization controllability and observability of linear autonomous systems. Controllability and observability conditions of linear autonomous systems, observing the state of a linear system.

2MCI 3 OPTIMAL CONTROL SYSTEM

Introduction. static and dynamic optimization. Parameter optimization.
Caculus of Variations : problems of Lagrange,. Mayer and Bolza. Euler-Language equation and transversality conditions, Lagrange multipiliers.
Pontryagin’s maximum principle; theory; application to minimum time, energy and control effort problems, and terminal control problem.
Dynamic programming : Belaman’s principle of optimality, multistage decision processes. application to optimal control.
Linear regulator problem : matrix Riccati equation and its solution, tracking problem.
Computational methods in optimal control. application of mathematical programming. singular perturbations, practical examples.

3MCI 1 DIGITAL CONTROL SYSTEM

Basic system concepts and classification of digital control system, feedback systems and digital control, sampling and reconstruction of signals, computer interfacing, discrete time system response, convolution of sequences. Z-transform, pulse transfer function, pulse transfer function of the zero order hold, signal-flow graph method applied to digital systems. State variable technique. state equations and state transition equation of discrete-data system, state equation of digital system with sample and hold, state equation of digital transition equation of digital systems & for digital time invariant systems. Stability of digital control systems. Definitions of stability, stability tests of digital systems. Digital simulation-digital model with sample and hold. Comparison of time responses of continuous data and digital control system, correlation between time response and root locations in the s-plane and the z-plane, root loci for digital control system, steady-state error analysis of digital control system, frequency domain analysis, the Nyquist plot, bode diagram, gain margin, phase margin. Theorems on controllability and observability (time varying & time invariant systems) relationship between controllability, observability and transfer functions. Design of digital control system: Cascade & feedback compensation with continuous data controllers, digital controller, Design of digital control system with digital controller. The digital PID controller, controller through the bilinear transformation, design of digital control system with dead beat response. Introduction to PLC.

1MCI 4.1 REAL-TIME INSTRUMENTATION TECHNIQUES

Online & real time applications of Digital Instruments and Measurement Techniques, Digital voltmeters ramp type, Dual slope type, integrating type, Successive approximation type, Digital counters and timers, Basic elements of a Digital counter, Real time applications to the measurement of pulse counter, Frequency, Frequency ratio, time period, average time interval etc. Real time measurement techniques for measuring power at audio & radio frequencies, Measurement of power at audio & radio frequencies by Electronic wattmeter, three-ammeter, output meter, calorimetric and biometric methods. Real time measurement techniques for measuring the Audio & Radio frequencies and phase angle, Measurement of audio & radio frequencies by CRO method, Wein bridge, monostable multivibrator based direct reading frequency meter, heterodyne method, wave meters and digital frequency counter method, measurement of phase angle, at radio & audio frequencies by CRO method, direct reading phase angle meter and delay time method. Real time application in the Industries, Biomedical engineering etc.

1MCI 4.2 BIOMEDICAL ELECTRONICS

Brief introduction to human physiology. Biomedical transducers: displacement, velocity, force, acceleration, flow, temperature, potential, dissolved ions and gases.
Bio electrodes and bio potential amplifiers for ECG, EMG, EEG, etc. Measurement of blood temperature, pressure and flow. Impedance plethysmography. Ultrsonic and nuclear imaging.
Prostheses and aids: pacemakers, defibrilla-tors, heart-lung machine, artificial kidney, aids for the handicapped. Safety aspects.
Telemetry – Transmission of the original through wire & wireless.
Imaging techniques – Ultrasound, CAT, X-Rays, PET, NMR, Nuclear.
Physiological effect of electric current, safety.
Cardiological Signal Processing: Basic Electrocardiography, ECG data acquisition, ECG lead system, ECG parameters & their estimation, the use of multi scale analysis for parameters estimation of ECG waveforms, Arrhythmia analysis, monitoring, long form continuous ECG recording.
ECG data reduction technique, Direct data compression techniques, Direct ECG data compression techniques. Transformation compression techniques. Other data compression techniques. Data compression techniques, comparison.

1MCI 4.3 SIGNAL THEORY

Representation of deterministic signals: Orthogonal representation of signals. Dimensionality of signal spaces. Construction of orthogonal basis functions.
Random Processes: Definition and classification, stochastic integrals, Fourier transforms of random processes, stationary and non-stationary processes, correlation functions. Ergodicity, power spectral density, transformations of random processes by linear systems.
Representation of random processes (via sampling, K-L expansion and narrow band representations), special random processes :white Gaussian noise, Wiener-Levy process, Poisson process, shot-noise process, Markov process.
Optimum Filtering: Matched filters for deterministic signals in white and colored Gaussian noise. Wiener filters for random signals in white and colored Gaussian noise.

2MCI 4.1 ARTIFICIAL NEURAL NETWORKS

Introduction: Biological neurons and memory: Structure and function of a single neuron, artificial neural networks (ANN), typical applications of ANNs: classification, clustering, vector quantization, pattern recognition, function approximation, forecasting, control, optimization, basic approach of the working of ANN - training, learning and generalization.
Supervised Learning: single-layer networks, perceptron-linear separability, training algorithm, limitations; multi-layer networks-architecture, back propagation algorithm (BTA) and other training algorithms, applications. Adaptive multi-layer networks-architecture, training algorithms, recurrent networks, feed-forward networks, radial-basis-function (RBF) networks.
Unsupervised Learning: Winner-takes-all networks, hamming networks, maxnet, simple competitive learning, vector-quantization, counter propagation networks, adaptive resonance theory, Kohonen's Self-organizing Maps, principal component analysis.
Associated Models: Hopfield Networks, brain-in-a-box network, Boltzmann machine.
Optimization Methods: Hopfield Networks for-TSP, solution of simultaneous linear equations, Iterated gradient descent, simulated annealing, genetic algorithm.

2MCI 4.2 LARGE SCALE SYSTEM

Introduction to Large Scale Systems. Principal Component based model reduction methods. Modelling of Large scale systems Aggregation Eigen value Assignment State Space (Time domain) order reduction methods Transfer function (Frequency domain) model simplification, continued fraction expansion method, Time moment matching, Pade approximation stability based reduction methods, Error minimization methods order reduction of discrete time systems minimal realization Time scale analysis, Decoupling methods, fast-slow subsystem, state feedback design, Singular perturbations, controllers with accessible and in accessible states, design of optimal controllers, controller reduction.

2MCI 4.3 ADAPTIVE CONTROL SYSTEM

Introduction, linear feedback, effects of process variations, adaptive schemes, the adaptive control problem.
Real time parameter estimation, Least squares and regression models, simulation of recursive estimation, Deterministic self-tuning regulators, indirect self tuning regulators, direct self tuning regulators.
Stochastic and Predictive self tuning regulators, Minimum variance and moving average controllers, Stochastic self tuning controllers, Linear quadratic STR.
Model reference adaptive systems: Introduction, The MIT rule, MRAS using Lyapunov theory, bounded input, bounded output stability, applications to adaptive control.
Properties of adaptive systems: Nonlinear dynamics, adaptation of a feed forward gain, Stochastic adaptive control, multi step decision problem, auto tuning techniques, Gain scheduling, Design of Gain-Scheduling controllers, Nonlinear transformations, application of gain scheduling.

3MCI 2.1 POWER SYSTEM DYNAMICS AND CONTROL

Basic Concepts of dynamical systems and stability. Modelling of power system components for stability studies: generators, transmission lines, excitation and prime mover controllers, flexible AC transmission (FACTS) controllers.

Analysis of single machine and multi-machine systems. Small signal angle instability (low frequency oscillations): damping and synchronizing torque analysis, eigenvalue analysis.

Mitigation using power system stabilizers and supplementary modulation control of FACTS devices. Small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures. Transient Instability: Analysis using digital simulation and energy function method. Transient stability controllers. Introduction to voltage Instability. Analysis of voltage Instability.

3MCI 2.2 ROBOTICS AND AUTOMATION

Automation, Definition, Reasons for automating. Types of production, automation strategies, Detroit type automation-Automated flow lines, Method for work part transport. Transfer mechanism. Buffer storage, control functions, automation for machining operation, design and fabrication considerations. Automated inspection & testing, Inspection and testing, SQC, automated inspection principle and methods, sensor technologies for automated inspection, coordinate measuring machine, other contact inspection method, machine vision, optical inspection methods, non contact inspection methods.
Introduction to Robotics, Historical development, specification, Configuration Drive and precision of industrial Robots, Robot end-effecters. Robots Kinematics, Direct and Inverse, Robot trajectories, Control of Robots Manipulators. Sensing Range proximity, Touch, Force, Torque, Surface texture and vision, Robot programming: Robot languages, Robot teaching. Robot level languages, Task level languages and offline programming, concept of AI in Robotics. Robot application Planning, product design and production planning, principles of Robot's motion economy, design of robotic work stations, performance analysis, Justification of industrial robots. Industrial application of Robots, Selection and use of Robots for foundry and Casting, welding, material banding, machining, Inspection, assembly and painting.

3MCI 2.3 MICROPROCESSOR BASED CONTROL SYSTEM

Process Control Computer Systems : Minis, micros, classification by hardware features and software facilities, performance evaluation techniques.

Characteristics of Digital Processors : Organisation, instruction set,characteristics for process control, input/output arrangements, addressing techniques, memory systems.

Process Control System Software : Review of availability of process control languages, application packages, operating system for real-time process control.

System Selection Criteria : Specification,environment, hardware and softwarer equirements. Maintenance, procurement procedures, cost/performance/availability ratios.

Development Tools : Development systems for micros, software tools, logicanalyser, cross assemblers and compilers, simulators, emulators, in-house vs. turn-key trade off.

1MCI 5 CONTROL AND COMPUTATION LABORATORY

Programming and computation in MATLAB and SCILAB. Design of control systems and their simulation using software tools. Implementation of algorithms for multivariable systems for pole placement, observer design, stability computations, factorizations, solutions of Lyapunov and Ricatti equations, realizations, balancing. Use of algorithms for multivariable time series modelling.

2MCI 5 MODELLING AND SIMULATION LAB

Software required :- MATLAB

1. Design a lead compensator for a Temperature control system.
2. Design an estimator for a simple Pendulum and also design a reduced order estimator for the same.
3. Design a full order and reduced order compensator for satellite altitude control.
4. Design an integral control law for a motor speed system.
5. Design a system with pure time delay on heat exchanger model.
6. Design a full order observer for specified pole locations on a satellite model.
7. Design a tracking control to follow a sinusoid for a disk drive servomechanism using matlab and simulink.
8. Design a fuzzy logic controller for liquid level system.
9. Realization of z transforms and its properties for given systems.

3MCI 3 PROJECT (Stage I)

3MCI 4 SEMINAR

4MCI 1 PROJECT (Stage II)

MCI 401 DISSERTATION