S.R.T. Marathwada University, Nanded

PROPOSED SYLLABUS FOR Ph.D. ENTRANCE

INSTRUMENTATION ENGINEERING

***Section B*:**

Basics of Circuits and Measurement Systems: Kirchoff's laws, mesh and nodal Analysis. Circuit theorems. One port and two-port Network Functions. Static and dynamic characteristics of Measurement Systems. Error and uncertainty analysis. Statistical analysis of data and curve fitting.

Transducers, Mechanical Measurement and Industrial Instrumentation: Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration and shock. Measurement of pressure, flow, temperature and liquid level. Measurement of pH, conductivity, viscosity and humidity.

Analog Electronics: Characteristics of diode, BJT, JFET and MOSFET. Diode circuits. Transistors at low and high frequencies, Amplifiers, single and multi-stage. Feedback amplifiers. Operational amplifiers, characteristics and circuit configurations. Instrumentation amplifier. Precision rectifier. V-to-I and I-to-V converter. Op-Amp based active filters. Oscillators and signal generators.

Digital Electronics: Combinational logic circuits, minimization of Boolean functions. IC families, TTL, MOS and CMOS. Arithmetic circuits. Comparators, Schmitt trigger, timers and mono-stable multi-vibrator. Sequential circuits, flip-flops, counters, shift registers. Multiplexer, S/H circuit. Analog-to-Digital and Digital-to-Analog converters. Basics of number system. Microprocessor applications, memory and input-output interfacing. Microcontrollers.

Signals, Systems and Communications: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first- and second order systems. Convolution, correlation and characteristics of linear time invariant systems. Discrete time system, impulse and frequency response. Pulse transfer function. IIR and FIR filters. Amplitude and frequency modulation and demodulation. Sampling theorem, pulse code modulation. Frequency and time division multiplexing. Amplitude shift keying, frequency shift keying and pulse shift keying
for digital modulation.

Electrical and Electronic Measurements: Bridges and potentiometers, measurement of R,L and C. Measurements of voltage, current, power, power factor and energy. A.C & D.C current probes. Extension of instrument ranges. Qmeter and waveform analyzer. Digital voltmeter and multi-meter. Time, phase and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and grounding.

Control Systems and Process Control: Feedback principles. Signal flow graphs. Transient Response, steadystate- errors. Routh and Nyquist criteria. Bode plot, root loci. Time delay systems. Phase and gain margin. State space representation of systems. Mechanical, hydraulic and pneumatic system components. Synchro pair, servo and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and derivative controller, Fuzzy controllers.

Analytical, Optical and Biomedical Instrumentation: Mass spectrometry. UV, visible and IR spectrometry. X-ray and nuclear radiation measurements. Optical sources and detectors, LED, laser, Photo-diode, photo-resistor and their characteristics. Interferometers, applications in metrology. Basics of fiber optics. Biomedical instruments, EEG, ECG and EMG. Clinical measurements. Ultrasonic transducers and Ultrasonography. Principles of Computer Assisted Tomography.

Paper-1:

Group-I: Process Instrumentation

1. Overview of process control system design: introduction, degree of freedom for process control, selection of controlled, manipulated and measured variable, process safety and process control
2. Control system instrumentation, introduction, basic control modes, on-off controller, features of PID controller, PID controller design, tuning and trouble shootings, digital version of PID controller, electronic/pneumatic/hydraulic controller, optimum control settings, transducers, transmitters, transmission lines, final control elements and their calculations and selection
3. Feed forward and ratio control, cascade control: introduction to Feed forward and ratio control, cascade control and their design consideration, tuning, Servo motors - symmetrical components applied to two - phase servo motors - equivalent circuit and performance based on symmetrical components - servo motor torque - speed curves
4. Programmable Logic Controllers (PLC): Introduction. Architecture, discrete I/O systems, Analog I/O systems, definition of discrete state process control, discrete state variables, event sequence description Ladder diagram: Background, ladder diagram elements, ladder diagram symbols, development of ladder diagrams, Programming, advanced features and study of at least one industrial PLC.
5. Introduction to Supervisory control and data acquisition (SCADA).
6. Distributed Control System: Introduction and overview, History, System architecture, System elements, Data communication links.
   Difference between centralized and distributed control system, Overall tasks of digital control systems, Detailed task listing.
   Displays: Group display, Overview display, Detail display etc, Local control units, Mean time between failures.
   Data Highways, Field buses, Multiplexers and Remote Sensing Terminal units,

Reference Books

1. Process dynamics and control by Dale E. Seborg, Thoman F. Edgar, Dyncan A. Mellichamp, IInd Edition , Wiley publication, 2006
2. Instrument Engineers Handbook by B. G. Liptak Vol. I and II, Third Edition, Chilton and Book Company, 1990.
3. Process control by Peter Harriot Tata McGraw Hill, New Delhi
4. Automatic process control by D. Ekman,Wiley Eastern Ltd, New Delhi
5. Process control system Application,Design and tunning by F.G. Shinsky McGraw hill
6. D. Popovic and Vijay Bhatkar: Distributed Computer Control for Industrial Automation, Marcel Dekker Inc., 1990.
7. B. G. Liptak, Instrument Engineer's Handbook, Process Control, Third Edition, Chilton Book Company, 1996.
8. C. D. Johnson, Process Control Instrumentation technology, Prentice- Hall of India, 1993.
9. C. L. Alberts and D. A. Coggan, Editors: Fundamentals of Industrial Control, ISA Publication, 1992.
10. Hughes: Programmable Controllers, ISA Publications, 1989.
11. Parr, Programmable Controllers: An Engineers Guide, Butterworh-Heinmen Limited, 1993.
12. Garry Dunning, Introduction to Programmable controllers, 2nd Edition, Thomson Asia, Pte, Ltd, Singapore, 2002.

Group-II: Advanced Control Theory

1. State Space Description for multivariable Control Systems: The concept of state and state models, State equations for dynamic systems, State equations using phase, physical and canonical variables, Plant models of some illustrative control systems, State space representation and realization of transfer matrices, Minimal realization, Solution of state equation.
2. Multivariable Control Systems Analysis: Concept of Controllability and Reachability, Observability and Constructibility, Controllable and Uncontrollable subspace, Observable and unobservable subspace, Controllability and Observability tests: Kalman's test matrix, Gilbert's test, Popov-Belevitch-Hautus test, Controllability and observability canonical forms, Stability and stabilizability theory.
3. Multivariable Control Systems Design: Linear state variable feedback: The effect of state feedback on controllability and observability, Necessary and Sufficient condition for arbitrary pole placement, Ackermann's formula for pole placement, State observers: Full-order state observers and minimum order observers, Study of some physical plant like inverted pendulum for analysis and design.
4. Linear Quadratic Control: The Linear Quadratic Regulator (LQR) problem: LQR solution using the minimum principle, Generalization of LQR; LQR properties with classical interpretations; Optimal observer design- Kalman-Bucy filter: Problem formulation and Solution, The Linear Quadratic Gaussian (LQG) problem: Introduction, LQG problem formulation and solution, Performance and Robustness of optimal state feedback, Loop Transfer Recovery (LTR).

5. Introduction: Introduction to nonlinearities and non linear phenomenon, Nonlinear system behavior , Why nonlinear control?, Examples.
6. Fundamentals of Lyapunov Theory: Introduction, Nonlinear Systems and Equilibrium Points. Autonomous and Non-autonomous systems, Concept of Stability, Asymptotic stability and exponential stability, Local and global stability, Linearization and Local stability, Lyapunov's linearization method, Lyapunov's direct method, Positive definite functions, and Lyapunov's functions, Equilibrium Point theorems; Lyapunov theorem for local and global stability, Invariant set theorems, System Analysis based on Lyapunov Direct method. Lyapunov analysis of linear time-invariant systems, Generation of Lyapnov functions. Krasovski's Method, The variable gradient method Physically motivated Lypunov functions, control design based on Lyapunov's direct method.

Reference Books

1. C. T. Chen, Linear System Theory and Design, Holt, Rinehart and Winston, New York, 1984.
2. T. Kailath, Linear Systems, Prentice-Hall, Englewood Cliff's, NJ, 1980.
3. M. Gopal, Modern Control System Theory, Second Edition, New Age International (P) Limited, New Delhi, 1996.
4. W. A. Wolovich, Linear Multivariable Systems, Springer-Verlag, and Berlin, 1974.
5. P. J. Antsaklis and A. N. Michel, Linear Systems, McGraw-Hill International Editions, 1998.
6. K. Ogata, Modern Control Engineering, Third Edition, Prentice-Hall of India, New Delhi, 1997.
7. J. M. Maciejowski, Multivariable Feedback Design, Addison-Wesley Publishing Company, 1989.
8. H. Kwakernaak and R. Sivan, Linear Optimal Control Systems, Wiley-Interscience, 1972.
9. B. D. O. Anderson and J. B. Moore, Linear Optimal Control, Prentice-Hall, 1990.
10. S. P. Bhattacharya, H. Chapellat and L. H. Keel, Robust Control: The Parametric Approach, Prentice-Hall, PTR, NJ07458, 1995.
11. K. Zhou, J. C. Doyle and K. Glover, Robust and Optimal Control, Prentice-Hall, NJ07458, 1996.
12. J. E. Slotine and w. Li, Applied Nonlinear Control., Prentice Hall Inc. Englewood cliffs, New Jersey 1995.

Group-III: Neural Network and Fuzzy Logic based Control Systems

1. Artificial Neural Systems: Preliminaries, fundamentals concepts and models of artificial neural system, neural network learning rules, Hebbian, Perceptron, delta Windrow-Hoff learning rules.
2. Single layer Perceptron Classification: Classification model, features and decision regions, training and classification using discrete perception, algorithm and example, single layer continuous Perceptron networks for linear separable classification

3. Multilayer Feed forward Networks: Generalized delta learning rule, feed forward recall and error back propagation training, learning factors
4. Single layer feedback networks: Basic concepts of dynamical systems mathematical foundation of discrete time and gradient type Hopfield networks, transient response of continuous time networks solution optimization problem

5. Neural network in control system: Neuro control approaches, training algorithms, evaluation of training algorithms, through simulation, self running neuro-control scheme, self tuning PID neuro controller, neuro control scheme feed water bath temperature control system
6. Introduction of fuzzy control: Introduction fuzzy control from an industrial perspective, mathematical of fuzzy control fuzzy sets, fuzzy relation, approximate reasoning representing a set of rules
7. Fuzzy knowledge based controllers FKBS design parameters: Structure of FKBC fuzzification and defuzzification module, rule base choice of variable and contents of rules, derivation of rules, data base choice of membership function and scaling factors, choice of fuzzification, defuzzification procedure

Reference Books:

1. M. T. Hagan, H. B. Demuth and M. Beale, "Neural Network Design" Thomson Learning, Vikas Publishing House, New Delhi, 2002.
2. J. M. Zurada, "Introduction to Artificial Neural Systems", Jaico Publication House 1997.
3. S. Haykin, "Neural Networks: A Comprehensive Foundation", Pearson Education, New Delhi, 2002.
4. John Yen and Reza Langari, "Fuzzy Logic: Intelligence, Control and Information", Pearson Education New Delhi, 2003.
5. S. Rajsekaran, G. A. Vijayalaxmi Pai, "Neural Networks, Fuzzy Logic, and Genetic Algorithms, Synthsis and Applications", Prentice Hall of India, 2003.
6. S. Omatu, M. Khalid and R Yusof, "Neuro Control and its Applications", Springer – Verlag, London Limited 1996.
7. D. Driankov H. Hellendoorn and M. Reinfrank, "An Introduction to Fuzzy Control", Narosa Publication House, Second Reprint, New Delhi, 1997.

Group-IV: Digital Signal and Image Processing

1. Fundamentals of DSP background and review discrete time random signals.
2. Quatisation effects: - Effect of round of noise in digital filter, zero input limit cycles in fixed point realization of IIR digital filters. Effects of finite register length in DFT computations.
3. Multirate digital signal processing: Fundamentals of Multirate systems, Basic multirate operations, Decimation, interpolation, filter design and implementation of sampling rate conversion, polyphase filter structures, time variant filter, structures, multistage implementation of sampling rate conversion of BP signals, sampling rate conversion by an arbitrary factor, interconnection of building blocks, polyphase representation, multistage implementations.
4. Wavelet Transform: Introduction to wavelets, wavelets and wavelet expansion systems, discrete wavelet transform, multiresolution formulation of wavelet

systems, Haar Wavelet and other wavelet representations, scaling function, wavelet functions, Parseval's theorem,

5. Multirate filter banks: Maximally decimated filter banks, errors created in QMF banks, simple alias free QMF system, power symmetric filter banks, M channel filter banks, polyphase representation, PR systems, alias free filter banks, Linear phase PR QMF banks, cosine modulated filter banks, Wavelet transform and its relation to multirate filter banks, paraunitary PR filter banks, Applications of multirate signals processing narroband LPF, suband coding of speech.
6. Linear Prediction: Innovations representation of a stationary random process, forward and backward linear prediction, solutions of the normal equations (Levinson-Durbin algorithm and Schur algorithm)
7. Power Spectrum Estimation: Parametric and non-parametric methods for power spectrum estimation.
8. Introduction: Digital image representation, fundamental steps in image processing, elements of digital image processing systems, hardware for image processing system - Frame Graber, Characteristics of image digitizer, Types of digitizer, Image digitizing components, Electronic image tube cameras, solid state cameras, scanners.
9. Digital image fundamentals: Elements of visual perception, a simple image model sampling and quantization some basic relationship between pixels, image geometry,
   Basic transformations, Perspective transformation, Camera model and calibration, stereo imaging
10. Image transforms: 2-D Fourier transform, Fast Fourier transform, Other separable transforms, Walsh Transform, Hadamard Transform, Discrete Cosine Transform, wavelet Transform- Haar function, Gabor Transform, Hotelling transforms.
11. Image enhancement: - Enhancement by point processing, spatial filtering, enhancement in the frequency domain, Color image processing.
12. Image restoration: Degradation model, diagonalization of circulate and block-circulate matrices, algebraic approach to restoration, inverse filtering, least mean square (wiener) filter, constrained least squared restoration, invractive restoration.
13. Image compression: - Redundancies, image compression models, elements of information theory, error-free compression- variable length coding, bit plane coding, lossless predictive coding, lossy compression – predictive coding, transform coding, video compression, image compression standards- JPEG, MPEG.
14. Image Analysis: Segmentation - detection of discontinuities, edge linking and boundary detection, thresholding, region -oriented segmentation, Representation and description: Representation schemes, descriptors, regional descriptors, pattern and pattern classes, Classifiers.

Reference Books

1. Multirate filters and Filter banks: P. P. Vaidyanathan, PH International, Englewood Cliffs
2. Multirate signal Processing: Rabiner and Schafer, PH Inernational, Englewood Cliffs
3. Introduction to Wavelets and Wavelet Transform: C. S. Burrus, Ramesh and A. Gopinath, Prentice Hall Inc.

4. Digital Signal Processing: Principles, Algorithms, and Applications: J. G. Proakis and D. G. Manolakis; Prentice Hall of India Ltd, 1995.
5. Discrete-Time Signal Processing; A. V. Oppenheim and R. W. Schafer; ; Prentice Hall of India Ltd, 1997.
6. R. C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson Education Asia, 2002.
7. A. K. Jain, Fundamentals of Digital Image Processing, Prentice Hall of India Pvt Ltd, New Delhi, India, 1989.
8. K. R. Castleman, Digital Image Processing, Prentice-Hall International, 1996.

Group-V: Biomedical Instrumentation

1. Introduction to instrumentation, Biomedical Instrumentation, classification of Biomedical Instruments, Justification of biomedical instrumentation, Scope for Biomedical Engineers.
   Introduction to Human Body, Anatomy, Physiology, Electrophysiology, Electrode system, Electronics.
2. Basic Principal, Construction Classification, operation, testing, design, problems analysis, research, manufacturers, safety, application, artifacts costing, electronics, software, hardware etc. of:
   i. BP Apparatus ii. Audiometers iii. EEG iv. X-ray v. Dialyser vi. Pacemaker vii. Difibrillator viii. Phonocardiograph ix. Spirometer x. Blood Analysis Instruments.
3. Electrical properties of tissues, Shock Analysis, Shock Prevention, Instrument Safety Design, cases, electric systems design, safety standards
4. Design of biomedical instrumentation for utility, safety ergonomics, cost, space, ventilation, operation, maintenance, installation requirement. Documents, testing, design problem and solutions.
5. Biomedical signal processing: ECG signal analysis, ECG QRS detection EEG signal analysis for Epilipsy, $\propto\beta\theta\delta$ activity, artifact detection and elimination, intelligent testing.

Reference Books:

1. J. G. Webster, Biomedical Instrumentation, John Wiley and Sons, Hoboken, NJ, 2004.
2. J. Carr and J. Brown, Introduction to Biomedical Equipment Technology, Pearson Education, 2000.
3. R. S. Khandpur, Hand book of Biomedical Instrumentation, Prentice Hall of India Pvt Ltd, New Delhi, India, 1996.
4. W.J. Tomplans, Biomedical digital signal processing PH publication, New Dehli 2004