FACULTY OF ENGINEERING

Syllabus for the

T.E (Instrumentation & Control)

(w. e. f. 2010 - 2011)

UNIVERSITY OF PUNE

Note:- **This syllabus is subject to change without prior notice by the concerned BOS**

Faculty of Engineering

T.E. (Instrumentation and Control)

Term I

Subject Code No.	Subject	Teaching Scheme Hrs./week			Examination Scheme				
		Lecture	Tutorial	Practical	Paper	Term work	Practical	Oral	Total
306261	Instrumentation for Chemical Analysis	04	-	02	100	-	-	50	150
306262	Embedded System Design	04	-	02	100	-	50	-	150
306263	Control System Components	04	-	02	100	50	-	-	150
306264	Electronic Instrumentation	04	-	02	100	-	50	-	150
306265	Industrial Management	04	-	-	100	-	-	-	100
306266	Application Programming			02		50			50
	Total	20		10	500	100	100	50	750

Term II

Subject Code No.	Subject	Teaching Scheme Hrs./week			Examination Scheme				
		Lecture	Tutorial	Practical	Paper	Term work	Practical	Oral	Total
306267	Digital Signal Processing Fundamentals	04	-	02	100	50	-	-	150
306268	Power Plant Instrumentation	04	-	-	100	-	-	-	100
306269	Process Loop Components	04	-	02	100	-	50	-	150
306270	Instrumentation System Design	04	-	02	100	-	-	50	150
306271	Control System Design	04	-	02	100	50	-	-	150
306272	Seminar	-	-	02	-	50	-	-	50
	Total	20		10	500	150	50	50	750

306261: Instrumentation for Chemical Analysis

Teaching Scheme:
Lectures: 4hrs/week
Practicals: 2hrs/week

Examination Scheme:
Theory-100-Marks
Oral: 50 Marks

Unit I:

A- Introduction to.Chemical Instrumental Analysis, advantages over classical methods, classification, various units used in chemical analysis.

B- B. Introduction to Electro analytical methods, potentiornetry, voltametry, coulonietry

Unit II:
Spectrometric Methods-I

A -Laws of Photometry, UV-visible instrument component, photocolorimeters, single and double beam' instruments, various types of UV-visible spectrophotometers.
B. Atomic absorption spectrophotometer: Principle, working, hollow cathode lamp, atomizer, back-ground correction.

Unit III:
Spectrometric Methods-ll.

a. IR spectroscopy: Principle, IR sources, IR detectors, dispersive and Fourier Transform IR spectroscopy.
b. Atomic Emission Spectroscopy: Principle, types, Flame photometer, DC arc and AC arc excitation, plasma excitation.

Unit IV:
Spectrometric Methods-III and Miscellaneous Instruments

a. Fluorimeters and Phosphorimeters: Principle, spectrofluorimeters, spectrophosporimeter, Raman effect, Raman spactorometer
b. Nuclear Magnetic Resonance (NMR) spectometry. Chemical shift principle, working of NMR, FR-NMR
c. Gas analysers: CO, C02, Hydrocarbons, 02, NOx

Unit V:
Separative Methods

a. Mass Spectrometer(MS): Principle, ionisation methods, mass analyzer types - magnetic deflection type time of flight, quadrupole, double focusing, detectors for MS.
b. Chromatography: Classification, Gas chromatography: principle, constructional details, GC detectors, High Predominance Liquid Chromatography (HPLC): principle, constructional details, HPLC detectors

Unit VI:

Radioactive instrumentation

a. X-ray spectrometry: Instrumentation for X-ray spectrometry, X-ray diffractometer: Bragg's law, Auger emission spectroscopy, Electron spectroscopy for chemical analysis(ESCA)
b. Radiation detectors: Ionisation chamber, Geiger-Muller counter, proportional counter, scintillation counters,

List of Experiments

Students are expected to perform Minimum 8 Experiments.

1. Study of filter photometer.
2. Study of flame photometer.
3. Study of optical densitometer.
4. Study of UV-visible spectrophotometer.
5. Study of Mass spectrometer.
6. Study of Gas Chromatograph.
7. Study of HPLC.
8. Study of Atomic Absorption Spectrophotometer.
9. Study of NMR.
10. Study of ESR.

Text Books:

1. Instrumental Methods of Analysis, Willard, Merritt, Dean, Settle, CBS Publishers & Distributors, New Delhi, Seventh edition.
2. Instrumental Methods of Chemical Analysis, Galen W. Ewing, McGraw-Hill Book Company, Fifth edition

Reference Books:

1. Introduction to Instrumental Analysis, Robert D. Braun, McGraw-Hill Book Company.
2. Principles of Instrumental Analysis, Skoog, Holler, Nieman, Saunders College Publishing, 1998.

306262: Embedded System Design

Lectures: 4 hours per week
Practicals: 2 hours per week

Theory: 100 marks
Practical: 50 marks

Prerequisites: Students should be familiar with Digital Electronics, Digital Logic Designs.

Unit I:

Introduction to Microcontrollers & Embedded processors

Overview & Features, The MCS-51 Microcontroller : 8051 Pin Description, Connections, I/O Ports, Memory Organization, Timers/Counters, Interrupts, etc
Atmel 89C51 & 89C2051 Flash Microcontrollers, Assembly Language Programming Tools

Unit II:

Instruction Set & Programming

Addressing Modes, Instruction Set, Assembler Directives, Programming examples, Programming in C, Programming for Timers/Counters, Serial Communications, Interrupts, etc

Unit III:

Interfacings to outside world

Interfacing of Displays (LED/LCD) & Keyboards, Interfacing DAC & ADC,
Interfacing of Sensors, Interfacing of Stepper motor, Relays, etc
Buses & Protocols –RS 232, RS 485, I2C, SPI

Unit IV:

The AVR Microcontroller

Introduction to AVR family, The AVR AT Tiny2313, AT Mega8535, Microcontroller, Architecture, Register File, Memory organization, Stack operation
Timer, UART, Watchdog timer, Interrupt structure.

Unit V:

The AVR Instruction set & programming

AVR hardware design issues
AVR System Development tools, Addressing Modes, Instruction set,
Programming examples, Communication links

Unit VI:

System Design with the AVR

Interfacings of DAC, ADC, Keyboard, Display, stepper motor.
Interfacing of serial EEPROM, RTC.
System design case studies: Dual channel voltmeter, Data acquisition system design, etc

List of Experiments

Students are expected to perform Minimum 8 Experiments (5 + 3)

8051/89c51

1. Basic Programs: Arithmetic logical operations, Code Conversions.
2. Basic Programs: Counting/Looping, Stack operations
3. Program for configuration of Timers as timers and counter for:
   a. Pulse width measurement
   b. Frequency measurement
   c. Square wave generation
4. Interfacing of Digital to Analog Converter or Analog to Digital Converter
5. Interfacing of Displays (LED/LCD)
6. Interfacing of Keyboard
7. Development of an Embedded System.

AVR AT Tiny2313/AT Mega8535

8. Basic Programs: Arithmetic logical operations, Code Conversions.
9. Basic Programs: Counting/Looping, Stack operations
10. Interfacing of Analog to Digital Converter
11. Development of Embedded System.

Suggested Books

1. **The 8051 Microcontroller & Embedded Systems** by M. A. Mazidi & J. G. Mazidi and Mckinlay, Pearson Prentice Hall.

2. **Microcontrollers: Theory & Applications** by Dr. A. V. Deshmukh, Tata McGraw Hill Publications

3. **Programming and Customizing the AVR Microcontroller** by Dhananjay V. Gadre, Tata McGraw-Hill Publishing Company Limited, 2003.

4. **Internet resources for AVR**

   Atmel AVR Page: http://www.atmel.com/atmel/products/prod23.htm
   Atmel AVR Page: http://www.atmel.com/atmel/products/prod200.htm

306263: Control System Components

Lectures: 4 hours per week
Practicals: 2 hours per week

Theory: 100 marks
Termwork: 50 marks

Prerequisites: DC/AC Motors, Flapper Nozzle Transducer.

Unit I:

Industrial Control Devices
Switches:
Construction, symbolic representation, working, application of Toggle switch, Slide switch, DIP switch, Rotary switch, Thumbwheel switch, Selector switch, Push button, Drum switch, Limit switch, Temperature switch, Pressure switch, Level switch, Flow switch.

Relays:
Construction, working, specifications/selection criteria and applications of electromechanical relay, Reed relay, hermetically sealed relay, Solid state relays.

Contactors:
Construction, working, specifications and applications of contactors.
Comparison between relay & contactor

Unit II:

Sequencing & Interlocking for Motors
Standard symbols used for Electrical Wiring Diagram, Electrical Wiring Diagram in relation to motors

- Concept of sequencing & Interlocking
- Starting, Stopping, Emergency shutdown, (Direct on line, star delta)
- Protection of motors: Short circuit protection, Over load Protection, Low/Under Voltage Protection, Phase reversal Protection, Over temperature Protection
- Reversing direction of rotation
- Braking
- Starting with variable speeds
- Jogging/Inching

Motor Control Center: Concept and wiring diagrams

Unit III:

Introduction to Pneumatic, Hydraulic & Electrical systems & their Comparison

Pneumatics

Pneumatic components

- Pneumatic Power Supply and its components
- Pneumatic relay (Bleed & Non bleed, Reverse & direct)
- Single acting & Double acting cylinder
- Special cylinders: Cushion, Double rod, Tandem, Multiple position, Rotary
- Filter Regulator Lubricator (FRL)
- Pneumatic valves (direction controlled valves, flow control etc)
- Special types of valves like relief valve, pressure reducing etc.
- Time delay valve
- Air motors

Pneumatic Circuits

- Standard Symbols used for developing pneumatic circuits
- Sequence diagram (step-displacement) for implementing pneumatic circuits
- Different Pneumatic Circuits: Reciprocating, Sequencing, Anti-cycle repetition, Block transfer, Speed regulation etc

Unit IV:

Hydraulics

Hydraulic components:

- Hydraulic supply
- Hydraulic pumps
- Actuator (cylinder & motor)
- Hydraulic valves

Hydraulic Circuits

- Standard Symbols for developing hydraulic circuits
- Different Hydraulic Circuits: Meter in, Meter out, Reciprocating, speed control, Sequencing of cylinders, Direction control etc

Unit V:

Auxiliary components

Construction, working & applications of: Synchros, Feeders, Dampers, Alarm annunciator, High/low selectors, Flow totalizer, Computing relays, Seals, Snubber.

Circuit Breaker: Need of Circuit Breaker, Operating Principle, and Types. **Fuses:** Desirable characteristics, Materials according to rating, Terminology (Fusing Current, Current rating of fuse element, fusing factor) & Types of fuses. **Fluidic Control Devices**: -Characteristics, Principle of Operation, Bistable & Proportional Amplifier & applications.

Unit VI:

Instrument connections:

Pipe and pipe fittings, Flanged pipe fittings, Tapered thread pipe fittings, Parallel thread pipe fittings, Sanitary pipe fittings, Tube and tube fittings, Compression tube fittings, Common tube fitting types and Bending instrument tubing.

Safety in Instrumentation & Control Systems:

Hazardous Area & Material classification as per NEC Standards, Explosion Proof Housing, Encapsulation, Sealing, & Immersion, Purging systems.

Intrinsic Safety: -Definition, Designing for intrinsic Safety, Isolation or Encapsulation (Series & Shunt Protective elements, & Zener barrier)

List of Experiments:

Students are expected to perform Minimum 8 Experiments

1. Implementation of Logic Gates using relays.
2. Study of various pneumatic and hydraulic components and power supplies.
3. Implementation and testing of Pneumatic circuits.
4. Implementation and testing of Hydraulic circuits.
5. Study of Synchro transmitter and receiver system
6. Study of Pressure/temperature/level/flow Switches (any two).
7. Study of Motor control Center based on industrial visit.
8. Demonstration & study of auxiliary components like, flow totalizer, Alarm annunciator, computing relay (any two)
9. Designing intrinsic safety circuits (Zener barriers)

Text Books:

1. Industrial Electronics, Petruzella, McGraw-Hill
2. Pneumatic Instrumentation, Majumdhar, TMH
3. Industrial Hydraulics, Pipenger

Reference Books:

1. Pneumatics, Festo Didactic
2. Hydraulics, Festo Didactic
3. Process control and Instrument technology, C.D.Johnson, TMH.
4. Process Control, Instrument Engineering Hand book, B.G. Liptak, Butterworth-Heinemann Ltd
5. Process Instruments and Controls Handbook, Douglas M. Considine, McGraw-Hill.
6. Power Systems by V.K.Mehata, S.chand Publication.

306264: Electronic Instrumentation

Lectures: 4 hours per week
Practicals: 2 hours per week

Theory: 100 marks
Practical: 50 marks

Unit I:
Measuring Instruments: True RMS measurement and DMM, R, L, C, Q measurement technique, active passive component testing, Automatic Test Equipment.

Unit II:
Function generator, Sine, square, triangular, ramp Wave generator, pulse generator, sine wave synthesis, arbitrary waveform generator.

Unit III:
Oscilloscope: Dual Trace Oscilloscope, sweep modes, active, passive probes, delay line, Digital Storage Oscilloscope and its features like roll, refresh, sampling rate, application of the same in instrumentation and measurement, sampling oscilloscope.

Unit IV:
ADC and DAC techniques, types, and their specifications, V to F converter, Sample and hold, analog multiplexer, data loggers.

Unit V:
Digital Instrumentation: Universal counter and its mode – totalizing frequency, period, time interval, ratio, measurement errors, application of counters for, frequency meter, capacitance meter and timers, automation digital instruments.

Unit VI:
Virtual Instrumentation and its applications, Wave analyzer , Distortion analyzer, spectrum analyzers.

List of Experiments:

Students are expected to perform Minimum 8 Experiments

1. Measurement of bandwidth of X and Y amplifier of CRO -using source and rise time method
2. Study and application of Universal counters
3. Study of DSO - measurement of response time. of relay using DSO
4. Study of DMM and RMS meter,
5. Study and application of ADC 0809
6. Study and application of DAC 0808
7. Study of Arbitrary waveform generator
8. System building and simulation on Virtual Instrumentation
9. Study of R, L, C, Q meter

10. Study of Distortionmeter -measurement distortion in mains signal

List of Equipments:
1 .CRO, DSO,
2. Universal counter,
3. True RMS meter,
4. Arbitrary waveform generator,
5. Virtual instrumentation Package (Labview or equivalent),
6. ADC 0809, DAC 0808,
7. R, L, C, Q meter.

Text Books:

1. Electronic Instrumentation and Measurement Techniques, Cooper, PHl
2. Digital Instrumentation, A. J. Bowen
3. Digital Instrumentation, Kalsi

Reference books,

1. Electronic Instrumentation Handbook, Coombs.
2. Electronic Instrumentation. Oliver Cage, McGraw Hill.
3. Digital Instrumentation, J. J. Carr.

306265: Industrial Management

Lectures: 4 hours per week Theory: 100 marks

Unit I: Strategic Industrial Management
Introduction to Management, definition, functions, and principles. Strategic planning, types of business strategy, Business environment, SWOT analysis, Developing competitive advantage profile and Environmental, Threat and opportunity Profile. BCG Matrix porter's 5 forces of competition Management techniques for developing strategy
Viz., Balanced score card, opportunity Identification, Area Vs product Matrix, Mind Mapping etc, performance Management and analysis techniques viz, Ishikawa/Reverse Ishikawa diagrams, Business process Re-engineering.

Unit II : Quality, Health and Environment Management and Enterprise Excellence
Quality Circles/Forums, Quality Objectives, use of Statistical Process control, Introduction to ISO 9000 and Role of R & D, Innovation, Industry Institute Interaction, Long Term Economic Stability Business expansion, diversion, Mergers and Takeovers, Global Market, Exports orientation, Effect of GAT/WTO agreement, Introduction to Intellectual property Right, patent and copy right.

Unit III: Production Planning, Inventory Control and Supply Chain Management
Manufacturing Excellence, Outsourcing, Production planning techniques, Purchase and Inventory Management, Inventory control using Economic Order Quantity, Minimum Order Quality, Ordering Level, store keeping, Finished goods, semi finished goods, raw material handling and storage, Value Addition, Supply Chain concepts and management for leveraging profit.

Unit IV: Human Resources Management
Manpower planning, Human Resources: exploiting true potential, Staff training and development, Motivation, Selection and training of manpower, Appraisal and increments management, Leadership skills, Delegation and development for growth, objectives and job Description/Role summary.

Unit V: Financial & Project Management
Capital Structure, Fixed & working capital, sources of finance. Introduction to capital budgeting, Methods of capital budgeting. Break even analysis, assumptions, importance, CVP graph, Role of Securities and Exchange Board of India (SEBI) , function of money market and capital Market, Project Management, Project network analysis, CPM, PERT and Project crashing and resource Leveling.

Unit VI : Disaster Management

Introduction to Disaster Management. Man-made and Natural disaster – causes and effects, Disaster mitigation mechanism. Safety and Environmental norms (ISO 14000) Global Warming.

Text Books:

(1) Management in Engineering – Gail Freeman-Bell and James Balkwill (PHI).
(2) Industrial organization and Engineering Economic- T.R.Bange and S.C. Sharma.
(3) Engineering Economics C.D. Stervens
(4) Elementary Economic Theory – Dr. R.D. Gupta.
(5) Business Organization and Management- M.C. Shukla.

Ref.Books :

(1) Business Poly – Azar Kazmi
(2) Resisting Intellectual property – Halbert, Taylor & Francis – 2007 – PHI

www.ndma.nic.in
(National Disaster Management Authority, Bhopal)

306266: Application Programming

Practicals: 2 hours per week Term work: 50 marks

It is desirable to know Graphical User Interface (GUI) development for Instrumentation Engineers.
The students are expected to develop GUI in any of the following programming tools and perform minimum 8 experiments:
Visual Basic, Python (Freely available on Internet), PERL or JAVA.

306267: Digital Signal Processing Fundamentals

Lectures: 4 hours per week
Practicals: 2 hours per week

Theory: 100 marks
Term work: 50 marks

Pre- requisite:

- Laplace transform and its properties.
- Inverse Laplace transforms.
- Z- Transform and its properties.
- Inverse Z- transforms.
- Basics of C- language and MATLAB / OCTAVE Programming

Unit I:

- **Introduction to Signals & Systems:** Classification of signals and systems. Properties of discrete time systems. Representation of discrete time signals in terms of weighted impulses. Convolution sum. Methods for finding convolution. Correlation: Cross Correlation and Auto Correlation.
- **Difference equations and differential equations:** Solution by classical method, natural response, forced response. Finding solution of difference equation by z- transform method

Unit II:

- **Frequency Response Characteristics of LTI systems:**

  Frequency response of LTI systems, ideal frequency selective filters, magnitude and phase response, group delay, system functions of LTI systems: stability and causality, inverse systems, significance of poles and zeros.
- **Structure of FIR and IIR filters:**

  Structures for discrete time systems, block diagram representation of linear constant coefficient difference equations, Direct form I, II. Signal flow graph representation of LCCDE, basic structure for IIR systems, direct forms, cascade, parallel forms, lattice,, transposed forms. Basic structure for FIR systems, direct form, cascade form.

Unit III:

Introduction to Fourier Transform and its significance**.** Representation of periodic and non-periodic sequences. The Discrete Time Fourier Transform (DTFT), the discrete Fourier series, properties of DFS, Fourier Transform of Periodic signals, sampling of Fourier Transform, Fourier representation of finite duration sequences, the discrete Fourier transform, properties of DFT, symmetry properties, circular convolution, linear convolution using DFT, implementation linear time invariant systems using DFT.

Unit IV:

Effective computation of DFT. Goertzel algorithm, Radix-2 Decimation in time FFT algorithm, Radix-2 Decimation in frequency algorithm . In place computation, bit reverse, alternative forms. IFFT by using DIT and DIF algorithm

Unit V:

FIR Filters

Introduction to FIR filters, linear phase filters, symmetric and anti symmetric filters, FIR design by Fourier approximation, Window method, frequency sampling method, optimal equi ripple FIR design. Design of FIR filters using Kaiser Window.

Unit VI:

IIR Filters

Introduction to IIR filters, Butterworth approximation, Chebyshev approximation. Design of IIR filter: impulse invariance method, bilinear transformation, approximation derivative method, least square method, Pade approximation. Frequency transformations: low pass to high pass, band pass, band reject. Comparison between FIR and IIR filters

List of Experiments:

Students are expected to perform Minimum 8 Experiments

(Any 5 from 1-8 and any 3 from 9-12)

1. Response of the system for standard input signals.
2. Convolution sum and verifying properties of Convolution.
3. Correlation.
4. Magnitude and Phase response for the given system.
5. Discrete Fourier Transform and Inverse DFT.
6. Circular Convolution.
7. Linear convolution using DFT.
8. FFT using DIT and DIF algorithm.
9. Design & Implement of FIR filter using windowing method.
10. Design & Implement of IIR filter using butter worth approximation.
11. Design & Implement of IIR filter using Chebyshev approximation
12. IIR filter design using least square method

Text Books:

1) Proakis J. G and D. G. Manolakis, *"Digital Signal processing, Principles, Algorithms and Applications"*, PHI.
2) Oppenheim A. V and R. W. Schafer, *"Discrete Time Signal Processing"*, Person Education, India.
3) P. Ramesh Babu, *"Digital Signal Processing"*, Sci- Tech Publications.

References:

1) S. K. Mitra, *"Digital Signal Processing: A Computer based Approach"*, TMH, 2001.
2) Johnson J. R, *"Introduction to Digital Signal Processing"*, PHI.
3) Schaum's Outlines: *"Digital Signal Processing"*, TMH.
4) Rabnier, Gold, *"Theory and Applications of Digital Signal Processing"*, TMH.

306268: Process Plant Instrumentation

Teaching Scheme:
Lectures: 4 Hrs./ Week

Examination Scheme:
Paper: 100 Marks

Unit I
Unit Operations
Basic concepts and principals of commonly used unit operations with processes and their study related to different process industries like distillation, extraction, drying, humidification / dehumidification, filtration, absorption etc Basic concepts behind pumps, compressors, fans, blowers etc. (7 Hours)

Unit II
Heat and Mass Transfer
Heat Transfer: Energy Balance, heat transfer coefficients, double pipe, shell & tube heat exchangers, boilers, condensers, evaporators, cooling towers, water & waste water treatment, refrigeration plants. Process & mechanical design considerations in brief.
Mass Transfer: Material balance with or without chemical reactions mass transfer coefficients. Process & mechanical design considerations for equipment for unit operations of Unit **1** in brief.
(7 Hours)

Unit III

A. Overview of Power Generation

Brief survey of methods of power generation-hydro, thermal, nuclear, solar and wind power – importance of instrumentation in power generation – Thermal power plants – building blocks – details of boiler processes P & I diagram of boiler –cogeneration.
B. Measurements in Power Plants
Electrical measurements – current, voltage, power, frequency, power-factor etc., non-electrical parameters – flow of feed water, fuel, air and steam with correction factor for temperature – steam pressure and steam temperature-drum level measurement – radiation detector – smoke density measurement – dust monitor. (7 Hours)

Unit IV
Boiler Instrumentation

Boiler Instrumentation: Types of Boilers like FBC, CFBC, DIPC, Fluidized Bed etc Control and optimization, Combustion control, air to fuel ratio control, 3-element drum level control, steam temperature and pressure control, oxygen/CO2 in flue gases, furnace draft, boiler interlocks, sequence event recorder, supervisor control, data acquisition controls, burner management systems and controllers. Start-up and shut-down procedures, Boiler safety standard, Boiler inspection procedures, Boiler load calculation, boiler efficiency calculation.
(7 Hours)

Unit V

A. Turbine Instrumentation

Turbine instrumentation and control, start-up and shut-down , thermal stress control, condition monitoring & power distribution instrumentation. Synchronous, Induction generators Speed, Vibration, shell temperature monitoring and control-steam pressure control – lubricant oil temperature control – cooling system.

B. Analyzers in Power Plants

Flue gas oxygen analyser – analysis of impurities in feed water and steam – dissolved oxygen analyser – chromatography – PH meter-fuel analyser – pollution monitoring instruments.

(7 Hours)

Unit VI

Power Generation using non-conventional energy sources viz. Wind Power, solar Power, Tidal Power, Plant safety & redundancies. Nuclear Power Generation & control Station. Diesel Generator Controls (5 hours)

Text Books:

1. Unit operations in Chemical Engg. McCabe Smith 4/e McGraw Hill.
2. Outline chemical technology. M gopal Rao & M. Sitting 3/E East West 1973.
3. Energy Technology Handbook ,Considine D.M.,MGH
4. Process Control, B.G. Liptak

Reference Books:

1. Chemical Engineering Hand Book, Peiry, Mc-Graw Hill.
2. Chemical reaction Engineering O Leven spiel J. Wiley & Sons.
3. Boiler Control Systems, David Lindsley, Mc-Graw Hill
4. Computer Based Industrial control by Krishna Kant.

306269: Process Loop Components

Lectures: 4 hours per week
Practicals: 2 hours per week

Theory: 100 marks
Practical: 50 marks

Unit I:

a. Fundamentals of process control:

Elements of process control loop, Concept of Process variables, set point, controlled variable, manipulated variable, load variable. Representation of Process loop components using standard symbols (basics with reference to control loop), and Examples of process loops like temperature, flow, level, pressure etc.

b. Transmitters:

Need of transmitter (concept of field area & control room area), Need for standardization of signals, Current, voltage, and pneumatic signal standards, Concept of live & dead zero.

Types of transmitters:

Two and four wire transmitters, Electronic and Pneumatic transmitters

Electronic Differential Pressure Transmitter: Types, Mounting (Installation), Manifold, Calibration setup, Application of DPT for Level measurement, Zero elevation, suppression, Square root extractor.

Signal conditioning (analog & digital) for RTD & T/C, span & zero adjustment.

SMART: Comparison with conventional transmitter, Block schematic, Wireless transmitters

Unit II:

Controller Basics

Process Characteristics

- Process load, Process lag, Self Regulation, Distance/velocity lag (dead time), Capacity.

Control System Parameters

- Error, Variable Range, Control Lag, Cycling, Direct/Reverse Action.

Control Actions

Discontinuous: ON/OFF, Multiposition Control, Floating Control.

Continuous: Proportional (offset), Integral (Reset windup), Derivative, Proportional-Integral, Proportional- Derivative, Proportional- Integral-derivative, Antireset windup, Rate before Reset, Concept of Bump less transfers in PID controller, Effect of process characteristics on PID combination, Selection & application of controller actions.

Unit III:

Tuning of controller: Different Criteria like Quarter Amplitude Decay Ratio, Loop disturbance, Optimum Control, Measure of Quality, Stability Criteria.
Tuning Methods: Process Reaction Curve (open loop), Ziegler Nichols (closed loop), & Frequency Response Method.
Digital PID controllers: Velocity & Position algorithm, Block Schematic,
Faceplate of Digital controller, Direct Digital Control.
Current to pneumatic converter & Pressure to Current converter.
Continuous versus Discrete Process Control, Relay based ladder diagram using standard symbols, Limitations of relay based system.

Unit IV:

Programmable Logic Controller (PLC)

Architecture of PLC, Types of Input & Output modules (AI, DI, DO, AO), Wiring diagram, Interfacing pneumatic & Hydraulic systems to PLC, Fixed & Modular PLC (Rack, slot, grouping), PLC specifications, PLC manufacturers,
PLC Basic instructions, Timers & Counters, PLC ladder diagram, PLC programming for process applications, Introduction to analog programming.

Unit V:

Control valve

Necessity, comparison with other final control elements,
Control valve Characteristics: (Inherent & Installed)
Control valve terminology: Rangeability, Turndown, valve capacity, viscosity index, AO, AC (Fail Safe Action) etc.
Classification of control valve based on: valve body. Construction, type of actuation, application etc. Construction, Advantages, Disadvantages & applications of Globe: Single, double, 3way, angle, Gate, Needle, Diaphragm, Rotary valves, Ball, Butterfly.
Types of actuators: Construction, Advantages, Disadvantages & applications: Spring Diaphragm & Smart actuators.
Control valve accessories:
Positioners: Applications/Need, Types, Effect on performance of Control valves. Volume boosters, Pressure boosters, Reversing relay, Solenoid valves, Air lock, Position indicating switches, Electro pneumatic converter, Hand wheel.

Unit VI:

Control Valve Sizing

C_v sizing concept & basic equations
Designing control valve for gas, vapor and liquid services: Valve sizing by ANSI/ISA 75.01 STD, Valve capacity testing by ANSI/ISA 75.02
Effect and remedies of cavitations and flashing.
Control valve noise generation and remedies
High temperature and High-pressure service valves
Control valve dynamic performance.
Control valve application & selection

List of Experiments:

Students are expected to perform Minimum 8 Experiments
(Experiment No. 6 & 10 are compulsory)

1. Design of signal conditioning for a K-type/J-type thermocouple.
2. Study of Temperature transmitter.
3. Study of D.P. Transmitter and its application for flow or level.
4. Study of Square Root Extractor.
5. Study and Calibration of I/P & P/I converter
6. Study & verification of different control actions (P, I, D, PI, PD, PID) for step Input.
7. Tuning of PID controller
8. Study of Control valve & plot the characteristics of Control valve
9. Control valve design using any software package.
10. Study of PLC and PLC Programming
11. Interfacing PLC to hydraulic & pneumatic circuits

Text Books

1. Process control and Instrument technology, C.D.Johnson, TMH
2. Instrumentation for Process measurement and control, N.A. Anderson, CRC Press
3. Introduction to Programmable Logic Controller, Gary Dunning, DELMAR Cengage Learning.
4. Programmable Logic Controller, Webb, PHI

Reference Books

1. Tuning of Industrial control systems, ISA
2. Control valve Handbook, ISA
3. Process Instruments and Controls Handbook, Douglas M. Considine, McGraw-Hill.
4. Process Control, Instrument Engineering Hand book, B.G. Liptak, Butterworth-Heinemann Ltd
5. Programmable Logic Controller, NIIT
6. Fundamentals of Process Control Theory, Paul Murrill, ISA
7. Lessons In Industrial Instrumentation, By Tony R. Kuphaldt, Version 0.4 – Released January 11, 2009.

306270: Instrumentation System Design

Lectures: 4 hours per week
Practicals: 2 hours per week

Theory: 100 marks
Oral: 50 marks

Unit I:
Basic concepts of instrument design: Functional requirements and specifications, Operational environment NEMA, BIS, DIN and ANSI standards with special reference to packaging standards - IP34, 54,57

Unit II:
Guidelines for enclosure, components and accessories': Grounding and shielding techniques noise in electronic circuits, EMI/ EMC protection against EMI, ESD selection of cables, connectors, types of knobs,; mechanical fixture PCB holders, clamps, control panel layout engonomics, types of' gear boxes and drives.

Unit III:
Analog system design guidelines and application: single chip devices instrumentation amplifiers AD524 or equivalent log, antilog amplifiers AD538 or equivalent linear optoisolator HCNR201 or equivalent, V to I converters XTR110 or equivalent, signal conditioners AD594, 595 or equivalent.

Unit IV:
Digital system design guideline and application: single chip devices, Phase Locked Loop CD4046 or equivalent, programmable counters ICM 7217 or equivalent multidigit counters with display drivers 74C926 or equivalent, digital Panel meters 7107 or equivalent, optoisolator MCT2 E equivalent, power drivers ULN2803 or equivalent, microcontroller MCS-51 or equivalent-

Unit V:
Printed circuit board design guidelines: general components loyout scheme, PCB size mechanical stress, design rules for analog and digital circuit PCB, single, multi layer and SMD boards,Artwork CAD packages, soldering techniques

Unit VI:
System performance and documentation:
System simulation using virtual instrumentation, troubleshooting and documentation. Reliability and testing, Calibration methods and tractability standards.

List of Experiments:
Students are expected to perform Minimum 8 Experiments

1. Power supply for loop powered transmitters,
2. Study and application of linear optoisolator HCNR201,
3. Study and application of instrumentation amplifiers AD524,

4. Study and application of signal conditioners AD594,
5. frequency multiplier using PLL CD4046,
6. Study and application of 74C926,
7. Study and application of ULN2803,
8. Study and application of aptoisolator MCT2E,
9. Designing of PCB on above any one application.

List of Equipment:
1 .Lab Power supply,
2. CRO,
3. Multimeter,
4. Semiconductors or their equivalents - HCNR201, AD524, AD594, CD4046, 74CO26, ULN2803, MCT2E
5. Bread boards, other components for above applications,
6. CAD package for PCB designing,

Text and Reference Books:

1. Electrostatic Discharge and Electronic Equipment, Warren Boxleitner IEEE press.
2. Printed Circuit Boards, Walter C. Bosshart, CEDT series, TMH.
3. Reliability Engineedng,.E. Baiguruswamy.
4. Noise Reduction Techniques, Ott.
5. Process Control, B. G. Liptak.
6. Machine Design, V. B. Bhandari, Tata McGraw Hill.
7. Machine design Pandya Shah
8. 8. Data manual for analog and digital lCs by - National semiconductors, Analog Devices, SGS Thompson, Texas, Motorola.

306271: Control System Design

Lectures: 4 hours per week
Practicals: 2 hours per week

Theory: 100 marks
Termwork: 50 marks

Unit I:
Compensators and compensator design using root locus approach
Need of compensators, types of compensators (series, feedback and feedforward – introduction only), root locus approach: addition of zero, addition of pole. Types of series compensators (lead, lag, lag-lead) and their transfer functions, Electrical lead, lag and lag- lead compensating networks, lead, lag and lag-lead compensator design using root locus approach.

Unit II:
Compensator design using Bode plot approach
Lead, lag and lag-lead compensator design using Bode plot approach.

Unit III:
Control actions and Controller tuning
Control actions (ON-OFF, proportional, integral, derivative, proportional plus integral, proportional plus derivative, proportional plus integral plus derivative, Controller tuning by Ziegler-Nichols methods (step response reaction curve method and frequency response method), Cohen Coon tuning method, Obtaining controller settings (k_p,T_i,T_d) through Ziegler-Nichols frequency response method using Routh array and Bode plot approaches.

Unit IV:
Controller Design
Design of PI/PD/PID controller for getting required performance specifications (damping factor, natural frequency, steady state error, phase margin, static error constants) using root locus and Bode plot approaches, Direct synthesis of controller, controller design for systems with and without dead time through controller synthesis formula.

Unit V:
Analysis of control system in state space
State transition matrix: Definition, derivation and properties, computation by Laplace transform method, infinite series, Cayley Hamilton method, Similarity transformation method, solution of state equation, diagonalisation of plant matrix through similarity transformations, concept of controllability: definition, derivation for the necessary and sufficiency condition for complete state controllability, controllability matrix, concept of observability: definition, derivation for the necessary and sufficiency condition for complete state observability, observability matrix, stability analysis in state space: Lyapunov stability test.

Unit VI:
Design concepts in state space
State variable feedback, control system design via pole placement: necessary and sufficiency condition, derivation for state feedback gain matrix K through sufficiency condition, Ackermann

formula, coefficient comparision method. State observer: necessity, types, theory, design of full order state observer, principle of duality between state feedback gain matrix K and observer gain matrix K_e, quadratic optimal control systems: concept of performance index, ISE, IAE, ITAE, ITSE, design of optimal state regulator using reduced matrix Riccati equation.

List of Experiments:

Students are expected to perform Minimum 8 Experiments

1. Study of magnitude and phase characteristics of lead, lag and lag-lead compensator (Use MATLAB).
2. Design a lead / lag compensator for getting desired specifications by root locus approach.
3. Design a lead / lag compensator for getting desired specifications by Bode plot approach.
4. For a given third or higher order system transfer function, obtain controller settings of P,PI,PID controllers (k_p,T_i,T_d) through Ziegler-Nichols frequency response method using Bode plot approach (Use MATLAB).
5. Design of PI/PD/PID controller for getting required performance specifications (damping factor, natural frequency, steady state error, phase margin, static error constants) using root locus and Bode plot approaches.
6. Design a controller using direct controller synthesis for getting specified closed loop response (Use MATLAB).
7. Check for complete state controllability and complete state observability of a given system (Use MATLAB).
8. Design a state feedback controller through pole placement (Use MATLAB).
9. Design full order state observer using principle of duality between state feedback gain matrix K and observer gain matrix K_e (Use MATLAB).
10. Design optimal state regulator for minimizing given performance index using reduced matrix Riccati equation (Use MATLAB).

List of text books:

1. B. S. Manke, “Control System Design”, 1st ed., Khanna Publishers, New Delhi, 2007.
2. I. J. Nagrath, M. Gopal, “Control System Engineering”, 3rd ed., New Age International Publishers, 1999.

List of reference books:

1. K. Ogata, “Modern Control Engineering”, 2nd ed., PHI, New Delhi, 1994.
2. Norman S. Nise, “Control System Engineering”, 4th ed., John Wiley and Sons, 2003.
3. B. C. Kuo, “Automatic Control Systems”, 3rd ed., PHI New Delhi, 1979.
4. Graham C. Goodwin, Stefan F. Graebe and M. E. Salgado, “Control system Design”, PHI, New Delhi, 2002.

306271: Seminar

Practical: 2 Hrs./week Term work: 50 Marks

The term work will consist of a report prepared by every student on the seminar topic allotted to them and oral presentation. The student is expected to submit the seminar report in standard format approved by the University. The topic for the seminar should necessarily be out of syllabus and relevant to the latest trends in Instrumentation and Control.