SYLLABUS FOR THE POST OF SENIOR INSTRUCTOR

Syllabus for Instrumentation Engg

1. Process Control:

1.1 **Control System**: Definition and Example of Control System, Manual and Automatic Control System, Close Loop and Open Loop Control System, Servo (or, Position) Control and Regulatory (or, Process) Control System; Process and Process Variables, Different Elements of Process Control Loop, Control system terminology.

1.2 **Laplace Transformation:** Laplace Transformation of Impulse, Step, Ramp, Parabolic, Exponential, Sinusoidal functions; Properties of Laplace Transforms, Laplace transformation of derivatives and integrals of a function, Initial and Final Value Theorem; Inverse Laplace Transform, Partial Fraction Expansion Method.

1.3 **Mathematical Modelling, Transfer function, Process Dynamics and Block diagram Algebra:** Modelling of Physical System, Linear and Non-linear System, Time Invariant and Time Variant System, General differential Equation of an n^{th} order Linear Time Invariant System; Transfer function of an LTI System, Order of a System, Poles and Zeros of a Transfer Function; Characteristic Polynomial, Characteristic Equation and Characteristic Roots of a System; General and Standard form of transfer function of a 1^{st} order and 2^{nd} order system/process; Steady state gain and time constant of a first order system/process; Steady state gain, damping ratio and natural frequency of a 2^{nd} order system/process; Impulse, Step and Ramp Response of a 1^{st} order system/process; Step response of Undamped, Under-damped, Critically Damped and Over Damped 2^{nd} order system/process; Specifications of Step response of under-damped 2^{nd} order System/process, Transfer function of simple electrical networks, mechanical translational and rotational system; Analogous system, Force (Torque)-Voltage analogy, Force (Torque)-Current Analogy; Sinusoidal Transfer function, Magnitude and Arguments of Sinusoidal transfer function; Mathematical model and transfer function of simple level system, Thermal system and Pressure System, Transfer function of two stage interacting and non-interacting level process, Block diagram Reduction Technique.

1.4 **Control action and types and Controllers:** Two-position (On-Off) action, Continuous Control action: Proportional, Integral and Derivative action, Composite (PD, PI and PID) control action, Performance comparison, advantages, drawbacks and applications. Pneumatic Controller: Principle, working and transfer function of pneumatic P, PD, PI and PID controller, electronic controllers using Op-amp. Hydraulic controllers.

1.5 **Control Elements:** Electromagnetic relay, Solenoid valve, nozzle flapper system, pneumatic relay, pneumatic control valve, lift-flow characteristics and types of valves, Synchro, Synchro as angular position transmitter, Synchro as error detector.

1.6 **Special Control Scheme:** Ratio control, Cascade Control, feed forward control, Computer control, Direct digital control, Programmable logic controller.

1.7 **Stability of control system:** conditions for stability, Open loop and close loop transfer function of feedback control system, Characteristic polynomial, characteristic equation and characteristic roots of a close loop system, Close loop poles, Necessary conditions of characteristic equation for stability of the system, Routh-Hurwitz Criterion of stability analysis, Routh Array, Special cases of Routh's test.

1.8 **Process Instrumentation:** Control centre, its lay out and basic requisites, P & I diagram, Graphic panelling, Types of scale and instruments used in process Instrumentation.

2. Analytical Instruments:

2.1 **Electrochemical Measurements:** P^H of aqueous solution, necessity and application of p^H measurement and control, Principle of p^H measurement, Hydrogen electrode, Buffer solution, Commercial scheme of p^H measurement, Reference electrode, measuring electrode; Electrolytic conductivity measurement, conductivity cell, Measuring circuit, Wheatstone bridge method.

2.2 **Measurement of humidity and moisture content:** Humidity, Absolute humidity, specific humidity, relative humidity and dew point temperature, Importance of humidity measurement, Measurement of humidity-Hair hygrometer, dry and wet bulb psychrometer; Moisture content, importance and application of moisture measurement and control, Laboratory method of moisture measurement, Principle of moisture measurement-electrical conductivity method, capacitive method.

2.3 **Analysis of Gaseous mixtures:** Analysis based on thermal conductivity of gaseous mixture, measurement of thermal conductivity of gas using hot wire cell, sensitivity of hot wire cell; Principle of analysis based on heat of reaction method-estimation of combustible gases in a mixture; Analysis based on magnetic susceptibility measurement-paramagnetic oxygen analyser; Analysis of flue gas (fuel gas)-Orsat's Apparatus.

2.4 **Spectroscopic method:** Electromagnetic spectrum, Interaction of radiation with matters-Absorption and emission of radiation by matters, Basic principle of spectroscopic analysis-advantages, Types of spectroscopic methods, Sources of radiation.

2.6 **Sampling and sampling system:** Sampling, types of sampling, Sampling system, Objectives and requirements of sampling, Rules to be followed during sampling a material/process fluid.

3. Automatic Control System:

3.1 **Control System:** Basic elements of control system, Control system terminology; Mathematical Model, Transfer function; Feedback control system, Open loop and close loop transfer function, Error transfer function, Poles and zeros of a transfer function, Order and type of a system, Characteristic equation, characteristic roots of a system, Close loop stability of a system; Block diagram and block diagram reduction technique; Signal Flow graph, Mason's Gain Formula.

3.2 **Analysis of Control System:** Standard Test signals, impulse response of a system, Step and ramp response of a first order system, step response of a 2^{nd} order system, Transient response specification of a second order system; Static Error analysis, Classification of close loop system based on type number, Steady state error, Static error coefficients-Position error constant, velocity error constant and acceleration error constant. Steady state error of type -0, type-1 and type-2 system with unit step, unit ramp and unit parabolic signal.

3.4 **Stability Theory:** Concept of stability, Effect of location of poles on stability, Necessary conditions of stability, Routh-Hurwitz criterion, Routh's test-difficulties and remedies.

3.4 **Root Locus Method:** Open loop and close loop pole of a system, Angle and magnitude condition of a transfer function, Properties of root locus, Rules for construction of root locus.

3.5 **Frequency Domain Analysis:** Sinusoidal transfer function, Magnitude and phase angle of sinusoidal transfer function, Frequency Response, Stability in frequency domain, Gain cross over

frequency, Phase cross over frequency, gain margin (GM), phase margin (PM); Bode Plot-Magnitude plot, phase plot, GM and PM from Bode plot; Steps to draw polar plot, Polar Plot of type-0, type-1, type-2 system; Nyquist Stability Criterion, Theory of mapping, encirclement and enclosement of a point by a close path, Principle of argument, Nyquist Path, Critical point, Nyquist Plot, Stability from Nyquist plot.

3.6 **State Space Model:** State, State Variable, State Vector, State Space, State Equation, Construction of State space model, Transfer function from state space model, Advantages of state space model.

4. Instrumentation System:

4.1 Functional Elements of an Instruments, General block diagram of measurement system, Classification of Instruments, Functions and application of measurements. Generalised performance characteristic of Instruments- Static and dynamic characteristic, Static calibration, Dynamic response of Instruments with standard inputs.

4,2 Different types of signals and their representation, Definition of transducer and classification, Diffeent types of transducers- Resistive transducer, Inductive transducer, Capacitive transducer and their basic principle and characteristic, analysis of linear potentiometer as resistive transducer under loaded condition, Strain gauge, LVDT, Piezo electric transducer.

4.3 Pneumatic Transducer, Standard Pneumatic signals, Flapper –Nozzle system. Need of signal conversion, P-I, I-P, V-I, I-V conversion

4.4 Temperature measurement: Modes of heat transfer, laws of conduction, convection and radiation, Temperature scales, classification of Temperature Sensors, Overview of Temperature Sensor Material, Thermometers: Classification of Thermometers, Construction and working of glass thermometers Liquid expansion thermometer, gas thermometer (filled system thermometer), bimetallic thermometer, solid state temperature sensor, Specifications of Thermometers, RTD Principle, types, Configurations, construction and working of RTD, Material for RTD, Signal Measurement techniques for RTD, Comparative Response curves for RTD, 2 wire,3wire and 4 wire RTD Element, Lead wire Compensation in RTD ,self heating effect, Specifications, advantages, disadvantages and applications of RTD, Thermistors: Principle, types (NTC and PTC), characteristics, Construction and working of Thermistor, Materials, specifications of Thermistor, applications, Thermocouples: Principle, thermoelectric effect, See beck effect, Peltier effect, laws of thermocouple, types of thermocouple with characteristic curve, thermocouple table, Sensitivity, constructional Features of Thermocouples, Electrical noise and noise reduction techniques, cold junction Compensation Method, thermopile, thermocouple emf measurement method, Thermowell, Material of construction and its specifications.

4.5 Pressure measurements: Pressure scales, units and relations, classification.me pressure sensors elastic elements like bourdon tube, diaphragm, bellows Properties and selection of elastic materials, Calibration using dead weight tester Differential pressure measurement ,Force balance, motion balance Semiconductor strain gauges Manometers : U-tube types, well type, inclined type, micro manometer, Vacuum Measurement Units and relations, McLeod gauge, Pirani gauge, thermocouple gauge, hot cathode ionization gauge, Knudsen gauge, calibration using dead weight tester etc

4.6 Level measurements: Need for Level Measurement, Classification of Level Measurement Techniques Direct and Indirect method, Construction and working of Dipstick, displacer, float system, bubbler, Capacitive devices for level measurement Ultrasonic level gauge, DP cell, load cell, , radioactive type level gauges, LASER type transducers Fibre optic level sensors, solid level detectors Intelligent level measuring instruments. Gamma ray absorption method. Air trap method.

4.7 Flow measurements: Bernoulli's equation, hydrostatic law, Pascal's law, Flow through pipes major and minor losses, flow measurement through open channel-weirs and notches Materials used for flow sensors, performance of materials, corrosion resistors, erosion, effect of vapour pressure, Head Type orifice, venturi, nozzle, pitot tube, characteristics of head type flow meters. Variable Area Type-Rotameter and its type, Other flow meters Turbine, electromagnetic, ultrasonic ,positive displacement, anemometers, mass flow meters, solid flow measurements.

4.8 Telemetering: Need of telemetering, Voltage telemetering, Current telemetering, Position telemetering, Impulse telemetering, Frequency telemetering.

5. Microprocessor

5.1 Definition of microprocessor, different generation of microprocessor. Computer languages- machine language, assembly language, high level language. Memory structure of microprocessor, memory map, decoder.

5.2 8085 microprocessor architecture and functional components, Registers and Flags of 8085, Timing diagram and machine cycles, Addressing modes of 8085. Classification of 8085 instructions, Programming of 8085 microprocessor- addition, subtraction, multiplication, block of data transfer. Logical programming, subroutine programming.

5.3 8086 microprocessor architecture and its difference with 8085 microprocessor. Registers and flags of 8086, memory segmentation of 8086. Instructions of 8086 microprocessor.

5.4 Interfacing and peripheral devices of 8085 microprocessor-DMA Controller 8257, Interrupt controller 8259, Programmable peripheral Interface 8255. Pin diagram of 8255,8257,8259.

6. Digital Electronics

6.1 Number system and codes- Binery, Octal, Decimal, Hexadecimal number system. Conversion from one number system to another. One's and two's complement number, subtraction using one's and two's complement method. ASCII code, EBCDIC code, BCD, Excess-3, Gray codes.

6.2 Logic gates- AND, OR, NOT, NAND, NOR, XOR, X-NOR gates. Symbol, Truth table and math expression. Universal gates, realisation of other gates using universal gates. Logic equation, De Morgans theorem, simplification of logic expression using Boolean Algebra and Karnaugh map. Combinational logic- Half adder, full adder, substractor, multiplexer circuit.

6.3 Sequencial logic circuits- S-R Flip Flops, D Flipflop, J-K Flipflop, J-K M/S Flipflop, T Flipflop. Race around condition of J-K flipflop. Registers and counters- Shift resisrers, synchronous and asynchronous counters, up down counters.

6.4 Logic families-RTL, DTL, TTL. Active pull-up TTL circuit. ADC and DAC circuit.

7. Industrial Electronic

7.1semiconductor switching devices- SCR, TRIAC,GTO, IGBT, SCR Characteristic, Triggering and commutation circuit. Turn-on and Turn-off Characteristic of SCR,

7.2 Controlled rectifier using SCR. Half control and Full control. Three Phase circuit- Three phase three pulse, three phase six pulse , three phase twelve pulse circuit. Inverter circuit- Basic principle, Series inverter, parallel inverter circuit using SCR. DC to DC conversion, Chopper circuit, Step up chopper. Ac to AC conversion, Cyclo-converter, single phase and three phase circuit.

7.3 AC and DC motor speed control. Basic principle of speed control, Various methods of speed control. Automatic speed control scheme. Electrical Heating- Power frequency and High frequency Heating. Induction heating, Dielectric Heating.

8. Bio Medical Instruments

8.1 Biometrics-introduction and components of man instrument system, transducers of biomedical applications, cardiovascular system, Respiratory system, nervous system, characteristic of living organism. resting and action potential, propagation of action potential, different types of bio electric potential—ECG, EEG EMG and others Electrode theory. Nernst equation, bio-potential electrodes—micro electrodes, skin surface electrodes and needle electrodes, the heart blood pressure and its measurements, Blood flow and its measurements,

8.2 Electrocardiography—electrodes and leads. X-ray system, properties of X-ray, X-ray machine, CT scan, MRI, Ultrasonography—properties of ultrasound, basic ultrasound system, ultrasonic Doppler, colour Doppler. Stethoscope, cardiac pacemakers, cardiac defibrillators, fibre optics endoscopy, artificial respiration.

9.Optical Fibre :

9.1 RI profile, modes of optical fibre. Ray theory of transmission, Total internal reflection, acceptance angle, NA, skew rays, Numerical problems, Fibre attenuation and losses, absorption, scattering, bend losses, dispersion, numerical problems. Different methods of fabrications- OVPO, MCVD, PCVD Rod and tube methods, double crucible method. Fibre alignments and joint loss, fibre splices—fusion splices, mechanical splices.

9.2 Fibre couplers, LED & LASER sources, PIN diodes, APD detectors, Attenuation, dispersion, RI profile, NA, scattering, OTDR, Introduction to fibre optic sensing advantages and disadvantages of FOS. Transduction technique based on intensity modulation, position sensors, Measurement of pressure, temperature, current, voltage liquid level and strain.