15. INSTRUMENTATION, ELECTRONICS & CONTROL ENGINEERING

Electrical Circuits:

Voltage and current sources: independent, dependent, ideal and practical; source transformation; V-I relationships of resistor, inductor, and capacitor; energy stored in inductors and capacitors; transient analysis of RL, RC and RLC circuits with dc excitation.

Kirchhoff's laws, mesh and nodal analysis, superposition theorem, Thevenin and Norton theorems, maximum power transfer theorem; delta–star and star–delta transformations.

Peak, average and RMS values of AC quantities; phasor representation of sinusoidal signals; impedance and admittance; power factor, real, reactive and complex power in ac circuits; steady-state analysis of RL, RC and RLC circuits; series and parallel resonance and bandwidth.

Two-port networks and network parameters :,open-circuit and short-circuit parameters and h-parameters; Passive filters using R, L and C elements.

Signals and Systems:

Periodic, aperiodic and impulse signals; continuous-time and discrete-time signals; Laplace, Fourier and z-transforms; properties of linear time invariant (LTI) systems; transfer function, time response and frequency response of first and second order linear time invariant systems; convolution.

Discrete time system: impulse response, frequency response, pulse transfer function; sampling theorem and signal reconstruction; discrete Fourier transform (DFT) and Fast Fourier Transform (FFT); FIR and IIR filters.

Analog Electronics:

Characteristics and applications of diode, Zener diode, BJT and MOSFET; biasing of transistor circuits; small signal analysis of BJT and MOSFET amplifiers; multistage amplifiers; feedback amplifiers and stability.

Characteristics of operational amplifiers; applications of op-amps: difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, active filters and waveform generation circuits.

Oscillators and signal generators: RC and LC oscillators, voltage controlled oscillators and phase locked loop; basic voltage regulator circuits.

Digital Electronics:

Combinational logic circuits, minimization of Boolean functions; logic families: TTL and CMOS; arithmetic circuits, comparators, encoders and decoders, Schmitt trigger, multivibrators, sequential circuits, flip-flops, shift registers, timers and counters.

Sample-and-hold circuit, Multiplexer and demultiplexer, analog-to-digital converters (successive approximation, integrating and flash) and digital-to-analog converters (weighted R and R–2R ladder). Characteristics of ADC and DAC (resolution, quantization error, significant bits, conversion and settling time).

Microprocessors and microcontrollers: basic architecture and applications; memory organization and input-output interfacing; data acquisition systems.

Measurements:

SI units; standards and classification of measuring instruments; systematic and random errors in measurement, uncertainty and its propagation, accuracy and precision, PMMC, MI and electrodynamometer type instruments; measurement of resistance using Wheatstone bridge and Kelvin double bridge; measurement of inductance and capacitance using AC bridges.

Measurement of voltage, current, power in single and three phase circuits; instrument transformers; digital voltmeter and digital multimeter. Oscilloscope; Measurement of time, frequency and phase; grounding and shielding techniques.

Sensors and Industrial Instrumentation:

Resistive, capacitive, inductive, piezoelectric, Hall effect and Fibre optic sensors and associated signal conditioning circuits including amplification and filtering; static and dynamic characteristics of sensors.

Transducers and industrial instrumentation: displacement (linear and angular), velocity, acceleration, force and torque measurement; pressure measurement (including low pressure); flow measurement (differential pressure, variable area, electromagnetic and ultrasonic flow meters); temperature measurement (thermocouple, RTD and thermistor); liquid level measurement; basics of smart sensors.

Analytical Instrumentation:

Spectral methods of analysis: spectrophotometers, Mass spectrometer and NMR spectroscopy, sampling systems, radiation sources, detectors; Electrochemical methods: conductivity meters, pH meters and ion-selective electrodes; chromatography techniques

including gas and liquid chromatography.

Control System and Process Control:

Open loop and closed loop control systems; block diagram representation and signal flow graphs, mathematical modeling of physical systems, transfer function and state-space representation of systems; time-delay systems; design of lead, lag and lead-lag compensators,

Time and frequency response analysis of control systems: step response characteristics, steady state error and error coefficients; stability analysis.

Controllers and control actions: on–off control, proportional (P), integral (I), derivative (D) and PID controllers; tuning methods, cascade, feedforward and ratio control strategies.

Final control elements and industrial control systems: control valves; basics of distributed control systems (DCS) and programmable logic controllers (PLC).