Electronics & Instrumentation (59)

UNIT I: ENGINEERING MATHEMATICS

Arithmetic and linear algebra, elements of differential and integral calculus, partial differential equations, theory of complex variables, probability theory

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and Eigenvectors, rank, solution of linear equations – existence and uniqueness.
Calculus: Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.
Differential Equations: First order equations (linear and nonlinear), higher-order linear differential equations, Cauchy's and Euler's equations, methods of solution using a variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.
Vector Analysis: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stoke's theorems.
Complex Analysis: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula; Taylor's and Laurent's series, residue theorem.
Probability and Statistics: Mean, median, mode and standard deviation; combinatorial probability, probability distribution functions - binomial, Poisson, exponential and normal; Joint and conditional probability; Correlation and regression analysis.

UNIT II: BASIC ELECTRONICS

Semiconductor properties, band structure of semiconductors, semiconductor materials, P–N Junction, voltage-current characteristics of diodes, formation of a transistor, current gain, D. C. characteristics, low frequency characteristics, base resistance, power gain, high frequency properties of transistors, Field effect transistors, JFET, MOSFET, Power MOS, SCR, DIAC, TRIAC, Tunnel diode. Rectifier, Clipper and Clamper; Analysis of full-wave rectifiers; Filters: C and LC. Classification of amplifiers, Basic transistor amplifier circuits. RC-coupled amplifier. Concept of controlled current source and power gain, Amplifier topologies; Analysis of CE amplifier using simplified hybrid model. JFET amplifiers, biasing techniques, source follower and common source amplifiers. Transistor and FET differential amplifiers. Regulated power supplies, Oscillators circuit and their characteristics. Operational Amplifier, Op-Amp Characteristics. Linear Op-Amp Circuits, Current amplifier, Difference amplifier, Instrumentation amplifier, Schmitt trigger and applications, Precision rectifiers, D.C. errors, Slew rate, Frequency response, Noise effect, Frequency compensation., Active filters, Multivibrators: Astable, Monostable. Signal Generators: Wien bridge oscillator, Sawtooth wave generator. Integrated Circuit Timer 555 and its applications, Analogue to Digital Converters, Digital to Analog Converters. IC Voltage regulators.

UNIT III: DIGITAL ELECTRONICS

Number systems - Positional number system, Radix conversion, Different types of codes: BCD, ASCII, EBCDIC, Gray. Binary Arithmetic – R's and (R-1)'s complement representation, Fundamental logic operators, Boolean Algebra. Combinational Logic Design – Definition, Truth Table, SOP and POS realization form, truth table, Logic minimization using K-map, Minimization with don't care terms, Quine-McClusky's tabular method of logic minimization,

combinational logic design: Adder/Subtractor circuits; 2's complement ripple carry adder/subtractor circuit, Parity generator/checker circuit, Circuit for Binary to Gray and Gray to Binary conversion. Encoder, Decoder, Demultiplexer and Multiplexer, Sequential machine design - Concept of Moore and Mealy machine, State transition diagram and State transition table, Various memory elements, NAND-latch and its use, Clocked flip-flops, SR, JK, D, T. Timing constraints on edge triggered flip-flops; Changing one type of Flip-flop to another type, Design of sequence detector. Asynchronous and synchronous counter design. Different types of registers. Programmable Logic Devices – PROM, PLA, PAL, FPGA. Integrated Circuit Logic Families - TTL, PMOS, NMOS, CMOS. Semiconductor memories: ROM, RAM.

UNIT IV: SIGNAL PROCESSING AND COMMUNICATIONS

Signals: Representation of signals; Generalized periodic waveforms, trigonometric and exponential Fourier series, Fourier transform, Convolution, Correlation, antenna fundamentals, Modulation: Amplitude modulation, Frequency and phase modulation, AM and FM transmitters and Receivers, Digital Modulation Schemes: BPSK, QPSK, QAM, FSK; Noise in Communication Receivers.

Discrete-time description of signals: Discrete-time sequences, their frequency domain behaviour, comparison with analog signals, convolution of two sequences, sampling a continuous function to generate a sequence, reconstruction of continuous-time signals from discrete-time sequences. Discrete-time Fourier transform: Definition of Discrete-time Fourier transform, properties of DTFT for real-valued sequences, the inverse DTFT. Discrete Fourier Transform: The definition of the Discrete Fourier Transform (DFT), important properties of the DFT, properties of DFT for real-valued sequences, use of DFT in signal processing, programming the DFT, increasing the computational speed of the DFT.

FFT and its properties. Z-transform, the system function of a digital filter, the inverse z-transform. Definition and anatomy of a digital filter, frequency domain description of signals and systems, Applications of digital filters, filter categories: IIR and FIR, recursive and non-recursive. Digital Filter Structures: The direct form I and II structures, Cascade combination of second order sections, parallel combination of second-order sections, Linear-phase FIR filter structures, Frequency-sampling structure for the FIR filter.

UNIT V: ELECTRONIC INSTRUMENTATION

Functional elements of instruments. Active and passive transducers, Analog and digital modes, Null and deflection methods. Performance characteristics of instruments including static and dynamic characteristics. Building blocks of Electronic Instruments: Voltage controlled oscillators, Phase Locked Loop, Charge Amplifier, Programmable Gain Amplifier, Voltage to frequency and frequency to voltage converters. Analog Electronic Instruments: Basic Emitter Follower Voltmeter, Voltmeters with IC Operational Amplifiers, True R.M.S Voltmeter, Peak Response Voltmeter. Current measurement with Analogue Electronic Instruments – Current-to-voltage converter type Electronic Ammeters, Chopper stabilized amplifiers for measurement of very low voltages and currents. Electronic Measurement of Power. Deflection Amplifiers, Oscilloscope Time Base, Dual-Trace Oscilloscopes, Oscilloscope Controls, Digital Storage Oscilloscope. Digital instruments: Basic Digital Displays – LEDs and LCD panels. Display, Design and Implementation of a simple Digital Frequency Meter, Errors in frequency measurement, Digital Voltmeters. Microprocessors (8085), Microprocessor Based Instrumentation, Spectrum Analyzer.

Gas Analysis: Thermal Conductivity Type, Heat of Reaction Method, for oxygen analyzers, Spectroscopic Techniques, IR Radiation Absorption Type, IR Sources, IR Detectors, FT-IR Spectrometer based on Michelson Interferometer.

Liquid Analysis: Different Electrodes: Ion-selective and Molecular- selective types, their variations and application prospects, Dissolved Oxygen Analysis Cells, pH electrodes, circuits and applications, Conductivity Cells, Standards, Effect of frequency variation, circuits, Cells for different applications, Polarography: Determination of concentrations of constituents. Apparatus, Circuits; Pulse polarography, Spectroscopic Techniques: Absorption in Visible and UV-range, monochromators and detectors, Atomic Spectral Methods: Emission and Absorption: Visible, UV and X-rays; sources, principles, detectors and sample preparation.
Measuring instruments for calorific value of solid, liquid, and gaseous fuels. Measurement of gas composition using GLC. Chromatography, GC, GLC, LC, HPLC, Columns, Detectors; X-ray methods of analysis; Humidity and Moisture; Viscosity and Consistency; Density and Specific Gravity; NMR and ESR.

UNIT VI: PROCESS CONTROL

Control systems, Physical elements of a control system, Abstract elements of a control system, the design process. Mathematical Model of Physical Systems: Differential equation representation of physical systems, Transfer function concepts, Signal flow graphs, Concepts of state, state variables and state model, State models of linear continuous-time systems, The basic process control loop- different blocks in the loop. Process modeling principles and techniques, degree of freedom analysis. Dynamic behavior of processes: Transfer function (TF) and state space (SS) models; steady state models and deviation variable models.
First and second order processes - Effect of disturbances and set-point variations in the loop transfer functions, Review of system response with standard inputs, offset. Development of empirical models from process data: Process Reaction Curves, Regression – linear and nonlinear, step tests, neural network models.
Control System Instrumentation: Transducers, transmitters, Final control elements, The pneumatic actuator and control valves, Sizing and selection of control valves, Dynamic behavior and stability of closed loop control systems: Block diagram, review of stability, root-locus diagrams, frequency response analysis, Bode diagram and stability, Nyquist stability; robustness analysis Schemes and analysis of typical process control strategies: On-off control, PID control – design and tuning, Feedforward control, Ratio control, Cascade control, Split-Range control, Dead time compensation – Smith predictor. Sampled-data control system: Digital Computer as a controller in process control loop, discrete time signal, sampling of continuous signal, signal reconstruction, Digital implementation of PID controller, Digital control algorithms - controller design by transformation from s-domain to z-domain. AC & DC drives and motors.
Programmable Logic Controller (PLC): Architecture, Programming, Distributed Control System: Architecture and loop elements, networks, gateways and connectivity, proprietary software protocol, redundancy, interfacing units, operating stations, Multivariable control system: Loop interaction, Pairing controlled and manipulated variables, Adaptive and Self-tuning control: Need for adaptive control, adaptive control by pattern recognition, adaptive control by discrete parameter estimation.

UNIT VII: SENSOR TECHNOLOGY

Sensing principles, sensor types and classification - mechanical, acoustic, magnetic, thermal, chemical, radiation; micro sensors; sensors based on surface-acoustic wave devices. Micro machining techniques- bulk, surface and other micro machining methods; microelectronics compatible sensors technology; principles of design, fabrication and characterization of miniature sensors. MEMS for automotive, communication and signal processing applications; modeling and simulation of micro sensors and actuators; micro electro-mechanical / electro-optical sensors and systems.

Film sensors- thick film and thin film types. Electro analytic sensors – Electrochemical cell, Polarization types, membrane electrode types, electro ceramic type and chem FET. Biosensors. Smart/Intelligent sensors, sensor arrays and networks. Nano-sensors, adaptation of scanning tunnelling microscopy and atomic force microscopy for realization. Nano-tube sensors, molecular and quantum sensors.

Strain and stress measurements, strain relationship, strain gauges. Mechanical, optical, electrical and pneumatic etc. and their use. Various methods of determining strain/stresses experimentally. Measuring devices/sensors for displacement (linear and rotational), velocity, force, torque and shaft power. Strain gauges: types and their application in two and three dimensional force measurement. Design and analysis of strain gauges. Sensors for measurement of temperature, relative humidity, pressure, sound, vibration and flow.

UNIT VIII: TELEMETRY, MEASURING AND ADVANCED INSTRUMENTATION DEVICES

Telemetry- its purpose and application potential, basic schemes- pneumatic, current, voltage, frequency over short distances. Line length limitations; Wired and wireless types. Signals and Transforms: Signals and their representation and transformation; Frequency spectra of pulses and pulse waveforms; continuous and discrete transforms; Noise- its distribution; Probability function.

Codes and Coding: Concepts of information transfer, bits and symbols; coding source, line and channel; biasing. BCD, ASCII, EBCDIC, BAUDOT; AMI, CMI, Manchester (phase), HDBn, Codes: PAM, PFM, PTM (PPM, PWM), PCM. Bit error rate, Parity checking, Effect of time delays and noise in bit information and Noise induced bit errors

FDM and TDM Systems, IRIG Wave Propagation: Aspects of wave propagation; Space and Surface waves, Propagation in ionosphere.

Satellite Telemetry: Basics, TT&C Services and subsystems, the Subsystems, The earth station. Fiber Optic Telemetry: Optic fiber as a transmission medium; Interconnections; Repeaters; Remote Control: Concept, IoT and its application in agriculture.

Biological Intelligence - Neural Network Systems. Building Intelligent Agents. AI Application– Vision. Knowledge Representation- Semantic Networks. Knowledge Representation II – Frames. AI Application– Robotics. Conflict Resolution. Expert Systems, Fuzzy Systems - Fuzzy sets, Membership function, Fuzzy relation, Fuzzy operators, Fuzzy reasoning: fuzzification, inferencing, Fuzzy logic controller (FLC). Automated Knowledge Acquisition.

Data acquisition system- micro computers for measurement and data acquisition. Data storage and their application. Data-loggers.