B. Tech. in INSTRUMENTATION & CONTROL ENGINEERING / INSTRUMENTATION ENGINEERING

Syllabus of Paper – 1

CIRCUIT THEORY

Network Analysis Techniques: Reciprocity Theorem, Milliman's Theorem, Telegen's Theorem and Maximum Power Transfer Theorem – Applications of Network Theorems to network analysis both with dc and ac inputs. Magnetic coupling. Applications of Laplace Transform: Introduction, solutions of Linear Differential Equations for electric network-problems, The convolution Integral-evaluation. Application of Laplace Transform analysis of electrical circuits – Linear time invariant first and second order circuits. Zero input response, Zero state response and complete response. Impulse response of first and second order circuits, time varying circuits. Network Functions: Ports and terminal pairs, network functions, Poles and zeros, necessary conditions for driving point functions and transfer functions, Time domain behavior from pole-zero plot. Two Port Networks: Introduction, Characterization of linear time invariant two port networks, Z-,Y-, h- and transmission parameters, Interrelationship between these parameters, Interconnection of 2-port networks, Image parameters. Filters and Active Networks: Classifications of filters, Filter networks, pass band and stop band types, Constant k-low pass and high pass filters, Characteristics impedance and cut off frequency, m- derived filters. Introduction to Fourier Transform. Graph Theory and Network Equations: Introduction, graph of a network, trees, co-trees and loops, incidence matrix, Cut-set matrix, Tie-set matrix and loop currents, Analysis of networks using graph theory. Network Synthesis: Introduction, Hurwitz polynomials, positive real functions, driving point and transfer impedance function, LC-network, synthesis of dissipative network, Two-terminal R-L network, Two-terminal R-C networks, Synthesis of R-L and R-C networks by Cauer and Foster – methods.

ELECTRICAL MEASUREMENT AND MEASURING INSTRUMENTS

Measurement Systems: Measurement system architecture, errors in measurements. Standard used in measurement: Electrical standards, time and frequency standards, physical standards. AC/DC Bridge Measurements: Wheatstone bridge, Kelvin Bridge, Anderson Constant current loop; resistance ration bridge, Schering bridge, Parallel C bridge, De Sauty bridge, Wein bridge, Maxwell's bridge, hay bridge, Owen bridge, Anderson bridge, Heaviside Mutual inductance bridge. Measurement of high resistance including loss of charge method and Mega Ohm bridge method. Basic Electrical Measurements: DC voltage/current measurements, Static electric field and potential of charged surfaces measurement, Electromechanical and analog electronic AC voltmeters, AC current measurements, Phase measurements, frequency and time measurements, Q-meter for capacitance and inductance measurements. Magnetic Measurement: Working principle and theory of Ballistic galvanometer, Measurement of flux density, determination of B-H curve, Hysteresis loop, Ewing double bar permeameter, Hopkinson permeameter, separation of iron losses by wattmeter and Bridge methods. Instrument Transformers: Theory and construction of current and potential transformers, transformation ratio and phase angle errors and their minimization, effects of power factor, secondary burden and frequency. Steady-state performance of current transformers, Transient performance of current transformers, Special connections of current transformers, Voltage transformers, Coupling capacitor voltage transformers, Transient performance of CCVTs, Electronic voltage transformers . Cathode Ray Oscilloscope: Principle and working of CRO, Block diagram

presentation of CRO and brief description of various elements of CRO – CRT, horizontal Deflecting system, Vertical deflecting system, CRO screen, Measurement of voltage, frequency and phase angle using CRO, CRO probes; Oscilloscope specifications and performance; special purpose oscilloscopes

EMF THEORY

Electrostatics: Review of the fundamental postulates of Electrostatics in free space, Coulomb's Law, Gauss's Law and applications, Electric potential, Conductors and Dielectrics in static Electric Field, Electric flux density, boundary conditions for electrostatic fields, Capacitance and capacitors, Electrostatic energy and Forces, Poisson's and Laplace's Equations, Uniqueness of Electrostatic solutions, method of images. Magnetostatics: Review of the fundamental postulates of magnetostatics in free space, vector magnetic potential, Biot-Savart Law and applications, magnetic Dipole, Magnetic field intensity and relative permeability, boundary conditions for Magnetostatic fields, magnetic forces and torques. Time varying fields and Maxwell's Equations: Introduction, Faraday's law of Electromagnetic Induction, Maxwell's Equations. Plane Electromagnetic Waves: Introduction, Plane waves in lossless media, plane waves in lossy media, Group velocity, Flow of Electromagnetic Power and the poynting Vector, Normal Incidence at a plane conducting boundary, Normal incidence at a plane dielectric boundary. Transmission lines: Introduction, transmission line parameters, transmission line equations, input impedance, SWR, and Power, smith chart, microstrip transmission lines. Waveguides: Introduction, rectangular waveguides, TM and TE modes, wave propagation in the guide, power transmission and attenuation, waveguide current and mode excitation, wave guide resonators. Electromagnetic Interference and Compatibility: Introduction, source and characteristic of EMI, control techniques.

TRANSDUCERS AND SIGNAL CONDITIONING

Introduction: Measurement systems, Basic electronic measuring system, Transduction principles, Classification of transducers, General transducers characteristics, Criteria for transducer selection. Resistive Transducers: Principles of operation, construction, theory, advantages and disadvantages, applications of Potentiometers, strain gauges, (metallic and semi-conductor type), Resistance Thermometer, Thermistors. Inductive Transducers: Types of Inductive transducer, Principles of operation, construction, Advantages & disadvantages and applications. Various variable Inductive Transducers, LVDT (Linear variable differential transformer). Capacitive Transducers: Types of capacitive transducer, Principles of operation, construction, theory, advantages and disadvantages and applications, of capacitive transducers based upon familiar equation of capacitance. Elastic Transducers: Spring bellows, diaphragm, bourdon tube – their special features and application. Active Transducers: Principle of operation, construction, theory, advantages and disadvantages and applications of following transducers: Thermocouple, Piezo-electric transducer, Magneto-strictive transducer, Hall effect transducer, Photo-voltaic transducer and Electrochemical transducer. Other Transducers: Optical transducers: photo-emissive, photo-conductive and Photo-voltaic cells, Digital Transducers: Optical encoder, Shaft encoder. Feedback fundamentals, introduction to Inverse transducer. Signal Conditioning: Concept of signal conditioning, Introduction to AC/DC Bridges. Op-amp circuits used in instrumentation, Instrumentation amplifiers, analogue-digital sampling, introduction to A/D and D/A conversion, signal filtering, averaging, correlation, Interference, grounding , and shielding.

CONTROL SYSTEM ENGINEERING

Introductory Concepts: Plant, Systems, Servomechanism, regulating systems, disturbances, Open loop control system, closed loop control systems, linear and non-linear systems, time variant and invariant, continuous and sampled-data control systems, Block diagrams and some illustrative

examples. Modeling: Formulation of equation of linear electrical, mechanical, thermal, pneumatic and hydraulic system, electrical, mechanical analogies. Use of Laplace transforms, Transfer function, concepts of state variable modeling. Block diagram representation, signal flow graphs and associated algebra, characteristics equation. Time Domain Analysis: Typical test – input signals, Transient response of the first and second order systems. Time domain specifications, Dominant closed loop poles of higher order systems. Steady state error and coefficients, pole-zero location and stability, Routh-Hurwitz Criterion. Root Locus Technique :The extreme points of the root loci for positive gain. Asymptotes to the loci, Breakaway points, intersection with imaginary axis, location of roots with given gain and sketch of the root locus plot. Frequency Domain Analysis: Closed loop frequency response, Bode plots, stability and loop transfer function. Frequency response specifications ,Relative stability, Relation between time and frequency response for second order systems. Log. Magnitude versus Phase angle plot, Nyquist criterion for stability, polar plot. Compensation: Necessity of compensation, series and parallel compensation, compensating networks, applications of lag and lead-compensation. Control Components: Error detectors – Potentiometers and Synchros, ac and dc servo motors, tacho-generators.

DATA ACQUISITION AND TELEMETRY

Data Acquisition System: Definition and generalized block diagram of data acquisition system (DAQ), Classification of DAQ, working principle block diagram, construction and salient features of the following data acquisition systems: Analog data acquisition system using time division multiplexing, Analog data acquisition system using frequency division multiplexing, Digital data acquisition system with different configurations and Data logger. Analog Communication Techniques: Analog communication techniques: analog modulation of AC carrier; amplitude modulation of AM wave and frequency spectrum, frequency modulation and frequency spectrum of FM wave, Phase modulation and frequency spectrum of PM wave. Analog modulation of pulse carrier; basis of PAM, PFM. Digital Communication Techniques: Digital modulation of pulse carrier, basis of PCM, DCPM; Digital modulation of AC carrier, ASK, FSK, PSK, error detection and correction methods, error control techniques. Telemetry: Introduction, signal formation, conversion and transmission, general block diagram of telemetry system , classification of telemetry system, signal transmission media: Wires and cables, Power line carrier communication, terrestrial and satellite radio links, optical fiber communication, Multiplexing – TDM, FDM and WDM. Telemetry Systems: Direct voltage and current telemetry system, AM and FM telemetry system, Multi-channel PAM and PWM telemetry system, single and multi-channel digital telemetry system, modem based telemetry system, short range radio telemetry and satellite telemetry system, fibre optics telemetry system.

Syllabus of Paper - 2

ELECTRONIC DEVICES AND ANALOG INTEGRATED CIRCUITS

Introduction to Semiconductors Devices: Semiconductors, Conductor and Insulators, Intrinsic and extrinsic silicon, p-n junction, Current-Voltage characteristics of a p-n junction diode, Rectifiers-half wave and full wave, Special purpose diodes - Zener diode, Tunnel diode and Varactor diode, Photo diode, clippers-single and two level, clampers, their analysis with ideal and practical diodes. Bipolar Junction Transistor: Transistors-construction, operation, characteristics, parameters, Transistor as an amplifier at low frequency, Hybrid model and re model of BJT, Analysis of amplifier using Hybrid model and *re* model, Amplifier types-CE,CB,CC. DC operating point, Biasing circuits- fixed bias, emitter bias, voltage divider bias, bias stabilization. Field-Effect Transistor: The junction FET - construction, operation, characteristics, parameters, JFET as an amplifier, FET as a VVR and MOSFET- construction, operation, characteristics, parameters. Power and Multistage Amplifiers: Power Amplifiers, Types, analysis of Class A, B, C, AB; Multistage Amplifiers, Types of multistage couplings. Feedback Amplifier and Oscillators: Feedback concept, Analysis of various configurations of feedback in amplifiers, Criterion for oscillation and Oscillator based on RC and LC feedback circuits, crystal oscillator. Introduction to op-amps: Op-amp- analysis, Ideal op-amp building blocks, Open loop op-amp configurations, Practical op-amp- Offset voltage, Input bias and offset current, CMRR, Block diagram representations and analysis of configurations using negative feedback. Applications of op-amp. Specialized ICs: 555 Timer-Monostable multivibrator, astable multivibrator, PLL.

DIGITAL ELECTRONICS

Number Systems And Boolean Algebra: Subtraction using 1's & 2's complements and using 9's &10'scomplements, Binary codes, Error detecting and Correcting codes, Theorems of Boolean algebra, Canonical forms, Logic gates. Combinational Circuits: Representation of logic functions, Simplification using Karnaugh map, Tabulation method, Implementation of combinational logic using standard logic gates, Multiplexers and Demultiplexers, Encoders and Decoders, Code Converters, Adders, Subtractors, Parity Checker and Magnitude Comparator. Sequential Circuits: Flip flops - SR, JK, D and T flip flops - Level triggering and edge triggering, Excitation tables - Counters - Asynchronous and synchronous type Modulo counters, design with state equation state diagram, Shift registers, type of registers, circuit diagrams. Digital Logic Families: Introduction to bipolar Logic families: RTL, DCTL, DTL, TTL, ECL and MOS Logic families: NMOS, PMOS, CMOS, Details of TTL logic family - Totem pole, open collector outputs, TTL subfamilies, Comparison of different logic families. D/A And A/D Converters: Weighted resistor type D/A Converter, Binary ladder D/A converter, Steady state accuracy test, D/A accuracy and resolution, Parallel A/D Converter, counter type A/D converter, Successive approximation A/D converter, Single and Dual slope A/D converter, A/D accuracy and resolution. Semiconductor Memories: Memory organization, Classification, and characteristics of memories, Sequential memories, ROMs, R/W memories, Content Addressable memories, Charged-Coupled Device memory, PLA, PAL and Gate Array.

MICROPROCESSORS AND APPLICATIONS

Introduction to 8-Bit Microprocessor: General 8-bit Microprocessor and its architecture – Intel 8085 Microprocessor, Pin Configuration, CPU Architecture, Registers, ALU Control Unit, RISC and CISC processors, Stack. Microprocessor Instruction Set (INTEL 8085): Complete instruction set of

INTEL 8085, instruction format, types of instructions, various addressing modes, Timing diagrams – T-states, machine cycles, instruction cycle. Assembly Language Programming: Programming of Microprocessors using 8085 instructions, use of Arithmetic, logical, Data transfer, stack and I/O instructions in programming, Interrupts in 8085. Peripherals and Interfacing for 8085 Microprocessors: Memory interfacing, I/O interfacing – memory mapped and peripheral mapped I/O, Data transfer schemes – Programmed, Interrupt driven and Direct memory Access (DMA) data transfers, Block diagram representation, Control word formats, modes and Simple programming of 8255A PPI, 8254 Programmable Interval Timer, 8259A programmable Interrupt Controller, 8237 DMA Controller, Key board / display controller, Interfacing of Data converters (A/D & D/A), Serial I/O and data communication. Introduction to 8086 Microprocessors: Architecture of 8086, block diagram, register set, flags, Queuing, concept of segmentation, Pin description, operating modes, addressing modes and interrupts. Introduction to Pentium Microprocessors: Introduction, Real mode and protected mode operation, Software model of the Pentium, Functional description, Pentium processor registers, Pentium data organization, Instruction types, Addressing modes, Interrupts.

PROCESS DYNAMICS AND CONTROL

Basic Considerations: Introduction, Basic components, diagrammatic representation, symbol and Terminology, changes at arbitrary points in the loop, offset and its analysis. Process Characteristics: Process variables, mathematical modeling of liquid, gas, thermal, mechanical and chemical systems. Linearzing techniques, Liquid level control in a tank. Dynamics of manometer, response of non-interacting and interacting first-order elements in series, Mixing process, Heat transfer process, Distillation column. Controller Characteristics: Control modes, characteristics and comparison of ON/OFF, proportional, integral, derivative modes and their combinations (PI, PD and PID), Introduction to Digital controllers. Automatic Control: Single and combined modes in closed loop, static error, velocity error. Dynamic behavior of feedback control processes for different modes, IAE, ISE, IATE criteria, Tuning of controllers, process reaction curve. Controller Hardware: Electronic pneumatic and hydraulic controller's implementation, single and composite modes of controllers. Final Control Elements: Control valves-types, functions. Electrical, Pneumatic, hydraulic-actuators, Solenoid, E-P converters, stepper motors. Introduction to Computerized Process Controls: Control algorithm, PID Control action with Dead time.

SIGNAL PROCESSING

Introduction: Classification of systems: Continuous, discrete, linear, causal, stable, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect. Digital signal representation. Discrete Time System Analysis: Z-transform and its properties, inverse Z-transforms; difference equation – Solution by Z-transform, application to discrete systems - Stability analysis, frequency response – Convolution – Fourier transform of discrete sequence – Discrete Fourier series. Discrete Fourier Transform & Computation: DFT properties, magnitude and phase representation - Computation of DFT using FFT algorithm – DIT & DIF - FFT using radix 2 – Butterfly structure. Design of Digital Filters: FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. IIR design: Pole-zero placement, Impulse-invariant, matched z-transform and bilinear transformation methods. Digital Signal Processors: Introduction – Architecture – Features – Addressing Formats – Functional modes - Introduction to Commercial Processors.

BIOMEDICAL INSTRUMENTATION

Physiological Systems of the Body: Brief description of musculoskeletal, endocrine, gastrointestinal, nervous, circulatory and respiratory systems; the body as a control system; the nature of bioelectricity, action events of nerve; the origin of biopotentials. Biopotential Electrodes: Signal acquisition; electrodes for biophysical sensing; electrode-electrolyte interface; skin preparation, electrode-skin interface and motion artifact; surface electrodes; microelectrodes; Internal electrodes; electrode arrays; electrodes for electric stimulation of tissues; electrode polarization, electrical interference problems in biopotential measurement; electrical safety. Heart Physiology: The heart; electro conduction system of the heart; the ECG waveform; the standard lead system; the ECG preamplifier; ECG machines; Cardiac monitors; Transient protection; common-mode and other interference-reduction circuits. Cardiovascular Measurements: Physiological pressure; blood pressure measurements; sphygmanometer; oscillometric and ultrasonic methods; practical problems in pressure monitoring; cardiac output measurement; plethysmography; blood flow measurements; phonocardiography; vectorcardiography; defibrillators; pacemakers; heart lung machines. Respiratory System Measurements: Respiratory anatomy (lungs, conducting airways, alveoli, pulmonary circulation, respiratory muscles); lung volumes and gas exchange, mechanics of breathing; parameters of respiration; regulation of respiration; unbalanced and diseased states; environmental threats to the respiratory system; respiratory system measurements; respiratory transducers and instruments; spirometry, body plethysmography. Measurement of Electrical activity in Neuromuscular System and Brain: Neuron potential; muscle potential; electromyography (EMG); electroencephalography (EEG); EEG electrodes and the 10-20 electrode system; EEG amplitude and frequency bands; the EEG system – simplified block diagram; preamplifiers and EEG system specifications; EEG diagnostic uses and sleep patterns; visual and auditory evoked potential recordings; EEG system artifacts.

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