Engg.
(Industrial
Control)
Ist & IInd

ELECTRICAL ENGINEERING

Industrial Control: Paper-1

Basic Electrical Engineering:

Ohm's Law,Kirchoff's laws – DC and AC Circuits; Mesh current and node voltage method analysis; Network reduction: voltage and current division, source transformation, star delta conversion. Thevenin's and Norton's Theorem, Superposition Theorem, Maximum power transfer theorem for D.C and A.C. circuits. RL, RC, RLC circuitsphasor diagram, power and power factor; RLC Series and parallel resonance – their frequency response, Quality factor and Bandwidth; Self and mutual inductance – Coefficient of coupling, Tuned circuits. Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and A.C. with sinusoidal input; Characterization of two port networks in terms of Z,Y and h- parameters. Three phase balanced / unbalanced voltage sources; analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced & unbalanced – phasor diagram of voltages and currents; power and power factor measurements in three phase circuits.

Electrical machines:

Electromagnetic energy conversion (EMEC)-Basic principles, conservation of energy.DC generators. construction, types, emf equation, various characteristics of shunt, series and compound generators, voltage build up process, losses and efficiency.DC motors: construction,operation, back-emf, torque of motor, types, characteristics of shunt, series and compound motors, speed control (field and armature control methods), basic idea of solid state devices in controlling of DC motors. Starting of DC motors, three point and four point starters, losses and efficiency, testing,electric braking of DC motors, applications. Transformers- Single phase: Construction, principal, types, emf equation, no load and short circuit test, equivalent circuits, phasor diagram, Voltage regulation. Efficiency, Condition for maximum efficiency, all day efficiency; Three phase transformers – connections, parallel operation,auto-transformer, basic idea of welding transformer.

Electrical Measurement and Instrumentation:

Construction and principle of operation of moving coil, moving iron meters, dynamometer, induction type and thermal type meter, rectifier type,voltmeters and ammeters; electrodynamometer type wattmeter, induction type energy meter; digital voltmeters and multimeters, frequency, period, time interval and pulse width measurement, cathode ray oscilloscope; dc potentiometer and ac potentiometer; C.T and P.T; Wheatstone bridge, Kelvin double bridge, high resistance measurement, earth resistance measurement, Megger; Measurement of inductance, capacitance –Hay's bridge, Maxwell bridge, Schering bridge , Anderson bridge, Wein's bridge; Q meters.

Analog electronics:

PN junction diode –structure, operation and V-I characteristics, Half Wave and Full Wave Rectifier, Display devices- LED, Laser diodes - Zener diode characteristics, Zener Reverse characteristics – Zener as regulator; Transistors: BJT, JFET, MOSFET, UJT- structure, operation, characteristics and Biasing, Thyristor and IGBT - Structure and characteristics. BJT small signal model – Analysis of CE, CB, CC amplifiers- Gain and frequency response – MOSFET small signal model– Analysis of CS and Source follower – Gain and frequency response, High frequency analysis. Multistage amplifiers and Differential amplifiers- cascade amplifier, Differential amplifier; FET input stages – Single tuned

amplifiers – Gain and frequency response, power amplifiers –Types. Feedback amplifiers and oscillators-Wien bridge, Hartley, Colpitts and Crystal oscillators. Op-amp characteristics – frequency response - summer, integrator, instrumentation amplifier, first and second order active fitters, V/I and I/V converters, comparators, waveform generators, precision rectifier, peak detector, S/H circuit, D/A converter ; A/D converter – dual slope, successive approximation and flash types – isolation amplifiers.

Power system:

Structure of Power System – Parameters of single and three phase transmission lines with single and double circuits -Resistance, inductance and capacitance of solid, stranded and bundled conductors, Symmetrical and unsymmetrical spacing and transposition ; skin and proximity effects -Typical configurations, conductor types and electrical parameters of EHV lines. Performance of Transmission lines – short line, medium line and long line – equivalent circuits, phasor diagram, attenuation constant, phase constant, surge impedance; transmission efficiency and voltage regulation; real and reactive power flow in lines, Power Circle diagrams; Formation of Corona, Critical Voltages, Effect on Line Performance. Mechanical design of OH lines, Line Supports, Types of towers, Stress and Sag Calculation, Effects of Wind and Ice loading. Insulators: Types, voltage distribution in insulator string, improvement of string efficiency, testing of insulators.Distribution Systems: General Aspects – Kelvin's Law, AC and DC distributions, Techniques of Voltage Control and Power factor improvement, Distribution Loss; Types of Substations -Methods of Grounding, Trends in Transmission and Distribution: EHVAC, HVDC and FACTS.

Microprocessors and Microcontrollers:

8085 Processor- Hardware Architecture, pin-outs – Functional Building Blocks of Processor, Memory organization, I/O ports and data transfer concepts,Timing Diagram, Interrupts. Programming of 8085 Processor – Instruction, format and addressing modes, Assembly language format, Data transfer, data manipulation& control instructions. Programming: Loop structure with counting & Indexing, Look up table, Subroutine instructions, stack. 8051 MicroController- Hardware Architecture, pintouts – Functional Building Blocks of Processor, Memory organization, I/O ports and data transfer concepts, Timing Diagram, Interrupts. Comparison to Programming concepts with 8085. Peripheral Interfacing – Study, Architecture, configuration and interfacing, with ICs: 8255 , 8259 , 8254,8237,8251, 8279;A/D and D/A converters &Interfacing with 8085& 8051; Micro Controller Programming and applications- Data Transfer, Manipulation, Control Algorithms& I/O instructions, Simple programming exercises, key board and display interface, Closed loop control of servo motor, stepper motor control.

ELECTRICAL ENGINEERING

Industrial Control: Paper-2

Control System and Process Applications:

Control System- Open and closed loop systems, transfer function, signal flow graphs. Time domain response-I and II order system response. Frequency response – Bode plot, polar plot - correlation between frequency domain and time domain specifications;Characteristic equation, location of roots in s plane for stability, Routh Hurwitz criterion, root locus construction, effect of pole, zero addition, gain margin and phase margin;Nyquist stability criterion; lag, lead and lag-lead networks, compensator design using Bode plots. State space analysis – controllability and observability.

Need for process control – Mathematical model of Flow, Level, Pressure and Thermal processes, Degrees of freedom; Continuous and batch processes, Self-regulation, Servo and regulatory operations, Heat- exchanger. Characteristic of on-off, proportional, integral and derivative controllers – PI, PD and PID control modes; Electronic PID controller; Auto/manual transfer, Reset windup. Control Elements - Pneumatic and electric actuators, Valve Positioner, Control Valves; Characteristic of ControlValves, Selection criteria. Controller Tuning Evaluation criteria – IAE, ISE, ITAE. Tuning - Process reaction curve method, Continuous cycling method and Damped oscillation method; Determination of optimum settings for mathematically described processes using time response and frequency response approaches, Auto tuning. Multi-loop Control, Feed-forward control, Ratio control, Cascade control,Inferential control, Split-range and introduction to multivariable control.

Electrical machines and Drives:

AC machines: types-Induction motor-3phase, construction-cage and slip ring motors-Slip-torque characteristics; no load and blocked rotor tests. Synchronous Machines-construction, operation and applications -Alternators and motors; Power semiconductor devices: Power diode and Power MOSEFET's- construction and working.Thyristors and IGBT's-construction, working and characteristics. Converters- Single phase half wave and full wave rectifiers with R and RL load.Single phase voltage source bridge inverter;AC voltage controllers and cyclo-converters.Chopper-step up-step down-quadrant chopper. DC drive: Speed control of dc motor, single phase converter fed dc drives and chopper fed dc drives (4 Quadrant operations). AC Drives-Induction motor speed control-stator voltage and frequency control- VSI fed induction motor drive. Special machines- DC servomotor, AC servomotor, Synchros, Stepper motor- construction and working

Switch Gear and Protection:

Introduction, requirement of a circuit breakers, difference between an isolator and circuit breaker, basic principle of operation of a circuit breaker, phenomena of arc,properties of arc, initiation and maintenance of arc, arc interruption theories, energy balance theory, Restriking voltage, recovery voltage, Rate of rise of Restriking voltage, DC circuit breaking, AC circuit breaking, current chopping, capacitance switching, resistance switching, Rating of Circuit breakers.Circuit Breakers: Air Circuit breakers, Air break and Air blast Circuit breakers, oil Circuit breakers, Single break, double break, minimum OCB, SF6 breaker, Vacuum circuit breakers - principle of operation and constructional details.Testing of Circuit breakers. Lightning Arresters -Causes of over voltages, internal and external, lightning, working principle of different types of lightning arresters.

Requirement of Protective Relaying, Zones of protection, primary and backup protection, Essential qualities of Protective Relaying, Classification of Protective Relays.Non-directional and directional over current relays, IDMT and Directional characteristics. Differential relay – Principle of operation, percentage differential relay, bias characteristics, distance relay – Three stepped distance protection, Impedance relay, Reactance relay, Mho relay, Buchholz relay, Negative Sequence relay, Microprocessor based over current relay – block diagram approach.Generator Protection - Merz price protection, prime mover faults, stator and rotor faults, protection against abnormal conditions. Transformer Protection - Differential protection, differential relay with harmonic restraint, Inter turn faults; Induction motor protection - protection against electrical faults such as phase fault, ground fault, and abnormal operating conditions such as single phasing, phase reversal, over load.

Transducers and Smart Sensors:

Units and standards, calibration methods, static calibration; classification of errors - error analysis.statistical methods – odds and uncertainty. Classification of transducers - selection of transducers.Characteristics of transducers – mathematical model of transducers. Variable resistance transducers,Variable inductance and Variable capacitance transducers, variable reluctance transducers. Principle of operation, construction details, characteristics and application of LVDT, capacitive transducer and Piezoelectric transducer- frequency response, Hall effect transducer, different types of photo detectors, digital transducers; Smart Transducers & Transmitters: basic characteristics of a Smart sensors – capabilities of Smart transduces – HART communication: introduction, performance features of HART protocol, fibre optic sensors.

Computer Control of Processes:

Programmable Logic Controller: PLC versus relay – characteristic functions of a PLC – PLC versus PC – PLC block diagram – I/O configuration: direct I/O, parallel I/O, serial I/O, – input and output module: discrete and analog – input and output devices – RS 232, 488 & 485 – memory unit: input image file, output image file – power supply – program loaders: hand held and computer based loaders – types of PLC software – programming languages: ladder programming – file organizing and addressing – instruction set: I/O and interrupt instructions, timers and counter. Distributed Control Systems: PLC versus DCS, DCS configuration, control room for DCS,the control console equipment, displays. Software configurations – relay rack mounted equipment – local control units – computer network: multi-mini computer architecture, peer-to-peer and server based network, network topology , DCS System Integration with PLC and Computers: man-machine interface – integration with PLC – integration with computers – integration with direct I/O – serial linkages – network linkages – links between networks. DCS Cost Estimating: the cost components – DCS definition – the hardware estimate – operator's console and related items. Introduction to SCADA System: Definition of SCADA – elements of SCADA system – communication in SCADA – applications. Introduction to Virtual Instrumentation. Buses and Networks: an introduction to networks in process automation: information flow requirements, hierarchical communication model, hierarchical levels, network requirements.

Engineering Material:

Importance of materials, Classification of electrical and electronic materials, Classification of solids on the basis of energy gap, Types of engineering materials, Levels of material structure. Conductors-Conductor materials, Factors affecting conductivity, Thermal conductivity, Heating effect of current, Thermoelectric effect, Seebeck effect, Thomson effect.Conductive Materials and Applications:

Mechanically processed forms of electrical materials, Types of conducting materials, Fusible materials, Filament materials, Carbon as filamentary and brush material, Material for conductors, cables, wires, solder, sheathing and sealing.Dielectrics- Introduction to dielectric materials, classification of dielectric materials, Dielectric constant, Dielectric strength and Dielectric loss. Insulating Materials- Insulating materials and applications – Ceramic, Mica, Porcelain, Glass, Micanite and Glass bonded mica. Polymeric materials – Bakelite, Polyethylene.Natural and synthetic rubber.Paper.Choice of solid insulating material for different applications, Liquid insulating materials – Requirements, Transformer oil.

Magnetic Materials- Origin of permanent magnetic dipole, Magnetic terminology, Relation between relative permeability and magnetic susceptibility.Classification of magnetic materials, Diamagnetic, Paramagnetism, Ferromagnetism, Magnetization curve, Initial and maximum permeability.Hysteresis loop and loss, Eddy current loss.