Syllabus for the Post of Junior Engineering Assistant (Instrumentation) –Level F1

Essential Qualification: 3 years Diploma in Instrumentation Engineering

Part (A): General Mental Ability and Aptitude	20% (20 questions carrying 1 mark each)

General Mental Ability and Aptitude to test the following:

- Interpersonal Skills
- Logical reasoning/Analytical/Comprehension ability
- Basic Numeracy and Data Interpretation Skills
- General Awareness

Part (B): Subject/Domain Related	80 % (80 questions carrying 1 mark each)

ELECTRONIC DEVICES & CIRCUITS

Unit 1: Semiconductor and Diodes:

Semiconductor – Definition, Classification, Intrinsic and Extrinsic N type & P type -Drift current & Diffusion current, Diodes-PN junction diode-Forward and Reverse bias characteristics-Specification-Zener diode-Construction & working 1 principle-Characteristics- Zener break down-Avalanche break down-Zener diode as a voltage regulator - Applications-Specifications

Rectifier-Introduction-Classification of Rectifiers-Half wave rectifier- Fullwaverectifier (Center tapped, Bridge) – (no mathematical equations) – comparison - Applications – Filters – C, LC, and PI Filters

Unit 2 : Bipolar Junction Transistor:

Transistor – NPN and PNP transistor – operation- Transistor as an amplifier – Transistor as a switch - Transistor biasing – Fixed bias, Collector base bias, Self bias – CB, CE, CC Configurations – Characteristics – Comparison between three configurations in terms of input impedance, 2 Output impedance, Current gain, Voltage gain – Classification of amplifiers -

RC coupled amplifier– Emitter follower and its application - Negative feedback – Basic concept, effect of negative feedback -Types of Negative feedback connections

Unit 3 : Transistor Oscillators and FET and UJT:

Transistor oscillator – Classifications – Condition for oscillations (Barkhausen criterion) General form of LC oscillator – Hartley Oscillator – Colpitts Oscillator – RC Phase shift oscillator- Crystal oscillator.

Field Effect Transistor – Construction – Working principle of FET – Difference

between FET and BJT – Classification of FET - Characteristics of FET – Applications – FET amplifier(Common source amplifier).

Uni Junction Transistor – Construction – Equivalent circuit – Operation – 5 Characteristics – UJT as a relaxation oscillator

Unit 4 : SCR, DIAC, TRIAC & MOSFET:

SCR – Introduction – Working – Comparison between SCR and Transistor – VI Characteristics – SCR as a switch , Controlled rectifier - TRIAC- working principle Characteristics - DIAC – characteristics – DIAC as bi-directional switch.

MOSFET – Types & characteristics of both N, P channel MOSFET. Characteristics of Enhancement and Depletion Mode MOSFETs.- MOSFET as a switch. Applications of SCR, TRIAC, DIAC and MOSFET

Unit 5 : Opto Electronics Devices and wave shaping circuits:

Classification of opto electronic devices – symbols, Characteristics, working of LDR , LED, 7 segment LED and LCD– optocoupler - Photo transistor. Clipper, Clamper Circuits and waveforms only – Solar Cell Principles – Applications ,Astable, Monostable and Multivibrators using Transistors -Schmitt Trigger using Transistors.

ELECTRICAL CIRCUITS AND MACHINES

Unit 1 : DC Circuits and DC Network Theorems Concept of electrical quantities – Voltage – current – resistance – power – energy – ohm's law – Resistances in series – Resistances in parallel – series parallel circuits – Kirchhoff's laws Super position, Thevenin's, Norton's and maximum power transfer theorems – Statement and explanations – Simple problems.

Unit 2 : AC Circuits AC fundamentals – AC waveform – sinusoidal and non-sinusoidal – period – frequency – cycle – amplitude – phase – peak value – average value – RMS value (effective value) – form factor – crest factor

AC Through pure resistor, inductor and Capacitor – Concept of impedance – vector diagram. Capacitors in series and parallel – energy stored in a capacitor– derivation – simple problems. Power in AC circuits – power factor– RL, RC and RLC series and parallel circuits – simple problems. Introduction of Harmonics - Effects of Harmonics

Unit 3: Resonance and 3 Φ AC circuits

Resonance – condition for resonance – series and parallel resonance – resonance curve – effect of resistance on resonance curve – selectivity – Q factor and bandwidth – applications of resonance – simple problems in resonance. Concept of 3 supply – line and phase voltage and current in star and delta connected circuits – three phase power – Measurement of three phase power by two watt meter method – simple problems – advantages of three phase over single phase system.

Unit 4 : D.C Machines and A.C Machines

DC machines – Types – constructional details of DC machines – DC generators – principle – types – emf equation – characteristics of shunt, series and compound generators DC motor – types – motor action – back emf – torque speed characteristics – starting of motors using 3 and 4 point starters – speed control of DC motor-applications. AC machines – 3 alternator – construction and working – relation between speed and frequency. 3 Induction motor – construction – types – principle of operation – methods of starting of 3 induction motor – slip. Single phase induction motor – principle of operation – capacitor start - motors – Applications – principle of operation -Stepper motor .

Unit 5 : Transformers

Transformer – Ideal transformer – principle of working – constructional details – emf equation – turns ratio – core loss – copper loss – efficiency – regulation – SC and OC tests – simple problems. Transformer on No load – Transformer on load – condition for maximum efficiency – All-day efficiency(simple problems). Auto transformer – construction and working – applications.

BASICS OF INSTRUMENTATION

FUNDAMENTALS OF INSTRUMENTATION

Definition – Measurement, Instrument, Instrumentation system. Generalized Functional block diagram of an Instrumentation system – Examples – Bourdon tube pressure gauge, Pressure Thermometer. Definition – Standards, Primary, Secondary and Working Standards –Definition – Error, True value, Correction, Calibration, Zero error, Backlash error-Classification of errors – Gross error, Systematic error, Random error. Statistical analysis of test data – Arithmetic mean, Deviation, Standard Deviation, Variance, Simple problems.

PERFORMANCE CHARACTERISTICS OF INSTRUMENTS

Static characteristics – Range, Span, Accuracy, Precision, Significant of figure, Range of doubt, Dead time, Dead zone, Hysteresis, Threshold, Resolution, Sensitivity, Linearity, Reproducibility, Stability, Loading effect, Input impedance and Output impedance. Dynamic characteristics – Speed of response, Measuring lag, Fidelity and Dynamic error. Standard Test input signals - Dynamic response – Steady state and Transient response.

TRANSDUCERS AND SENSORS

Transducer – Definition, classification – Primary and Secondary transducer, Active and Passive transducer, Analog and Digital transducer, Transducer and Inverse Transducer (with one example for each classification). Characteristics of transducer – Input characteristics, Output characteristics and transducer Response. Factors to be considered in the selecting of Transducers. Electrical Transducer- Advantages of electrical Transducer over Mechanical Transducer. Sensors – Pressure Sensor, Proximity and Displacement sensor, Magnetic sensor, Bio sensor, Hall-effect sensor, Optical sensor.

MECHANICAL TRANSDUCER

Definition- Mechanical pressure transducer - Elastic element – Bourdon tube, Bellows, Diaphragms. Manometers – U Tube manometer, Well type manometer, Barometer, Inclined tube manometer, Ring balance manometer, Micro manometer, manometric fluids- Construction, Principle, Working and Applications only –Thermal detectors – Liquid in glass thermometer, Filled system thermometer, Bi-metallic thermometer- Construction, Principle, Working and Applications only. Hydro-pneumatic elements – Venturi and Orifice - Construction, Principle, Working and Applications only.

ELECTRICAL TRANSDUCER

Definition- Resistive Transducer-Potentiometer–types, PiezoResistive effect- Strain gauge – types – bonded, unbonded and semiconductor. Resistance Temperature Detector - Thermo-couple, Thermistor, Thermo-diodes and transistors – Construction, Principle, Working and Applications only. Variable Inductance

Transducer - LVDT, Variable capacitance transducer - Construction, Principle, Working and Applications only. Piezo-electric Transducer – Piezo electric effect, materials, Modes of oCourseName : DIPLOMA IN INSTRUMENTATION AND CONTROL ENGINEERING

ANALOG AND DIGITAL ELECTRONICS

Linear ICs: Op-amps, Timers and their applications Operational amplifier – Ideal Op.Amp – Block diagram and characteristics –Op-amp parameters – CMRR – Slew rate – Virtual ground – Applications of op-amp – Inverting amplifier – Summing amplifier – Non inverting amplifier – Voltage follower – Comparator – Zero crossing detector – Integrator – Differentiator – Op- Amp Specifications. 555 Timer – Functional Block diagram – Astable, Monostable and Schmitt Trigger – Sequence timer,555 timer can be used as PWM.

Boolean Algebra Number systems – Decimal – Binary – Octal – Hexadecimal – BCD – Conversion from one number system to other – Boolean Algebra – Basic laws and Demorgan's Theorems – Logic gates – OR – AND – NOT – NOR – NAND – EX-OR Symbols, Truth table and Boolean expression – Realization of gates using universal gates NAND, and NOR – Problems using 2, 3, and 4 variables – Boolean expression for outputs – Simplification of Boolean expression using Karnaugh map (up to 4 variable)- Constructing logic circuits for the Boolean expressions.

Combinational Logic Arithmetic circuits – Binary addition – Binary Subtraction – 1's complement and 2's complement – Signed binary numbers – Half adder – Full adder – Half subtractor – Full subtractor – Parity Generator and checker – Digital comparator – Arithmetic Logic Unit – Decoder – 3 to 8 decoder – BCD to seven segment decoder – Encoder – Multiplexer – Demultiplexer – Digital Logic families – TTL – CMOS – LS series – Fan in – Fan out – Propagation delay – Noise immunity for the above families.

Sequential Logic Flip-flops – RS – D – T – JK – Master Slave Flip Flops – Edge triggered FF – Asynchronous Binary Counter – Decade counter – Mod n counter – Up Down Counter –

Preset table counter – Ring counter – Johnson counter – Synchronous counter – State diagram – Shift register – 4 bit shift register – Serial in Serial out – Serial in Parallel out – Parallel in serial out.

D/A, A/D and Memory D/A Converter – Basic concepts – Weighted Resistor D/A converter – R-2R Ladder D/A converter – Specification of DAC IC. Sampling and quantization – Analog to digital conversion using Ramp method – Successive approximation method – Dual slope method, simultaneous method voltage to frequency converter – Frequency to voltage converter specification of A/D converter. Memory – Static Memory – Dynamic Memory – Static Memory organization in terms of address lines, control lines and data lines –– SDRAM – DDR RAM

MESUREMENTS AND INSTRUMENTS

MEASURING INSTRUMENTS

Basic forces for indicating instruments – constructional features of permanent magnet and moving coil instrument – moving iron instrument – attraction and repulsion types – rectifier type ac volt meter – ohm meter – series and shunt type – extension of range using shunt and multipliers – analogMultimeter circuits – dynamo meter type wattmeter - 1ϕ & 3ϕ induction type energy meter, Multifunctional Meters.

BRIDGES AND OSCILLOSCOPE

Construction, working, balance equation (derivation not required) and application of measurement of resistance by Wheatstone bridge – measurement of capacitance by Scheringbridge – measurement of inductance by Maxwell's bridge –measurement of frequency using Wien bridge - RLC meter. Block diagram of oscilloscope – construction and working of CRT – horizontal deflection and vertical deflection – time base generator – CRO probes –voltage – current – active – passive probes -applications of CRO.

TEST INSTRUMENTS

Block diagram, working and applications of DC power supply –fixed and variable – Audio signal generator – Function generator – Megger – working and applications. Instrument transformer – CT and PT – block diagram, working ofrecorders – XY recorder – strip chart recorder.

DIGITAL INSTRUMENTS

Digital vs Analog instruments – Digital volt meter-Integrated type, Ramp type and successive approximation – Digital Multimeter– auto ranging – auto zeroing – auto polarity – Digital Frequency Meter –Block diagram- circuit diagram – Digital tachometer – digital panel meter using LCD – Digital storage oscilloscope, mixed storage oscilloscope.

OP - AMP APPLICATIONS

Circuit diagram and working of ramp, triangular, square wave generators using operational amplifier – Differential amplifier – Instrumentation amplifier – Charge amp with zero electric crystal –low pass and high pass filters using op. amps –PWM - PLL –Functional block diagram Capture range – Lock range - applications.

MEASUREMENT OF PROCESS VARIABLES

MEASUREMENT OF TEMPERATURE

Mechanical methods – pressure spring – liquid – gas – Vapour in glass – liquid in steel – thermometers,Bimetallic thermometer - Construction,working, range,advantages, disadvantages and applications of above. Electrical methods – Thermo couples – Cold junction compensation – Lead wire compensation – Thermoelectric laws – series and parallel combination – thermopile – Bolo meter – Measurement of output of thermocouples using potentiometer and millivoltmeter – RTD – 3 wire and 4 wire - Thermistors. Construction,working, range,advantages, disadvantages and applications of above. High temperature measurement – Non contact methods – Total Radiation Pyrometers – Selective radiation pyrometer - Photo electric pyrometers – Optical pyrometers – Temperature transmitters.

MEASUREMENT OF PRESSURE

Types and units of pressure - mechanical methods – Manometers (all types) – Elastic elements – Bellows – Diaphragms–Bourdon Tube. Electrical methods – Pressure measurements using strain gauge, capacitive transducer, LVDT and Piezo-electric transducer. Construction, working, range, advantages, disadvantages and applications of above. Pressure calibration – Dead weight tester. Transmitters – Differential pressure transmitters. Data transmission theory and Telemetry system-General telemetry system-Radio frequency telemetry system-Brief theory about modulation and demodulation.

MEASUREMENT OF FLOW (MECHANICAL)

Bernoulli’s theorem – Continuity equation – Reynolds’s number – Types of flow – Inferential flow meters – Differential pressure type meters – Orifice plates – Venturi tube – Flow Nozzle – Dall tube - Pitot tube (No derivation) – Positive displacement type meters – Nutating type meter – Oscillation piston type – Construction,principle, working,advantages and disadvantages of above.

MEASUREMENT OF FLOW (ELECTRICAL)

Electromagnetic flow meter – Ultrasonic flow meter – Doppler and Transit time method – Swirl meter – Vortex shedding meter - Cross correlation meter – Thermal mass flow meter – solid flow measurement using conveyor belt method – Turbine flow – Target flow meter – Hot wire anemometer- Construction, principle, working, advantages and disadvantages of the above.

MEASUREMENT OF LEVEL ,HUMIDITY AND MOISTURE

Level – Measurement of differential pressure to indicate level, Measuring by the movement of float. Electrical methods – change in conductance – change in capacitance - Radiation method – sight glass – solid level – bin type and diaphragm type – level in open and closed vessel. Moisture – Moisture in granular materials, solid penetrable material in paper and textiles. Humidity – Measurement of humidity – Absolute humidity – Relative humidity – Psychrometer – Hair Hygrometer. Density and specific gravity – Definition – Measurement using weighing tube type. Construction, principle, working, advantages and disadvantages of the above.

INDUSTRIAL INSTRUMENTATION

COMPARATORS

Introduction -Types - Mechanical Comparators - Dial Gauge - Reed type comparator - Optical comparators - Optical lever - Cooke Optical Comparator - Zeiss ultra optimeter - Electrical Comparator - Electronic comparator - Pneumatic Comparators - Solex Pneumatic Comparator - Principle of operation, construction, advantages and disadvantages of the above comparators.

MEASUREMENT OF VELOCITY &ACCELERATION

Linear Velocity Measurement - Doppler effect method - Linear encoder - Angular velocity measurement – Tachometer - Eddy current or Drug cup rotor A.C tachogenerator - Angular encoder - Accelerometer-Seismic Accelerometer – Piezoelectric Accelerometer – Strain gauge Accelerometer - Principle of operation, construction, advantages and disadvantages of the above.

MEASUREMENT OF FORCE, TORQUE AND SHAFT POWER

Force Measurement: Definition- Principle of operation and construction - Equal and Unequal arm balance – Pendulum scale – Elastic element spring – Proving Ring - Load cell - Hydraulic load cell – Pneumatic load cell – Strain gauge load cell.

Torque measurement: Definition - Principle of operation and construction of - Gravity balance method – Optical torsion meter – Electrical torsion meter – Strain gauge torsion meter.

Shaft Power Measurement: Definition- Principle of operation and construction of - Prony brake Dynamometer – Rope Brake Dynamometer – Fluid Friction (Hydraulic) Dynamometer – Eddy current Dynamometer – D.C Dynamometer.

MEASUREMENT OF pH & GAS ANALYSIS

pH: Definition - Electrodes - Principle of operation and construction - Hydrogen electrode - Calomel electrode - Quinhydrone electrode - Antimony electrode - Glass electrode.

Gas Analyzer: Principle of operation and construction - Oxygen analyzer – Paramagnetic oxygen analyzer – CO analyzer – SO_2 analyzer.

CHROMATOGRAPHY AND SPECTRAL METHOD OF ANALYSIS

Chromatography: Definition - Classification - Principle of operation and construction – Gas Chromatography – Liquid chromatography – Retention time - Dead time - Chromatogram - Significance and advantages of chromatography.

Detectors: Principle of operation and Construction of TCD, FID, FPD, ECD.

Spectral Analysis: EMR Spectrum - Beer's law - IR/UV spectro photometry - General description - range of IR/UV radiation - measurement of IR/UV radiation - Instrumentation - IR/UV radiation sources -monochromator

Process Control Instrumentation

SIMPLE PROCESS CONTROL SYSTEMS AND TERMINOLOGY

Process – Continuous and Batch process – process variables Functional block diagram of an automatic process control system – set point – measured value – error - simple liquid level control system – flow control system – temperature control system with transportation lag – self regulation – Introduction to Piping and Instrumentation diagram- symbols for equipments, piping, instrumentation and control, P&ID diagram for simple liquid level control system 14Hrs

CONTROL PRINCIPLES

Controller – reverse and direct action, controller modes – discontinuous – ON-OFF Control with differential gap, without differential gap – continuous – proportional controller – proportional band (PB) – effect of PB on a controller output – offset – integral control – Derivative control - PI – PD-PID definition, salient features, applications and limitations of above controllers – selection of control action – electronic controllers – error detector – two position controller – P,I,D, PI, PD, PID controllers – pneumatic controllers for PID action – flapper nozzle mechanism, pneumatic relay

TUNING OF CONTROLLERS

Concept of tuning – criteria for controller tuning – quarter Decay ratio, IAE, ISE, ITAE – methods of tuning – open loop response method – process reaction curve – closed loop response method – ultimate cycle method - damped oscillation method.

FINAL CONTROL ELEMENTS

Signal converters – P to I converter, I to P converter – actuator – electrical, pneumatic, hydraulic–control valve – characteristics - quick opening, linear, equal percentage-pneumatic valve – solenoid valve –split range control valve – single seat and double seat plug – electric motor actuated control valve – control valve sizing – CV rating – selection of a control valve – effect of cavitation and flashing on control valve performance

COMPLEX CONTROL SYSTEMS

Feed forward control system, Feed forward control of heat exchanger. comparison of feedback control system and feed forward control system. Ratio control – examples - Cascade control – cascade control of heat exchanger –cascade control of distillation column. Direct digital control(DDC) of single loop, Direct digital control with multiple control loops.

MICROCONTROLLER

Unit 1 : ARCHITECTURE & INSTRUCTIONS SET OF 8051

ARCHITECTURE OF 8051

Comparison of Microprocessor and Microcontroller - Block diagram of Microcontroller – Functions of each block - Pin details of 8051 – ALU – ROM – RAM – Memory Organization of 8051 - Special function registers –Program Counter – PSW register –Stack - I/O Ports – Timer – Interrupt –Serial Port – Oscillator and Clock - Clock Cycle – State - Machine Cycle – Instruction cycle – Reset – Power on Reset – Overview of 8051 family

INSTRUCTION SET OF 8051

Instruction set of 8051 – Classification of 8051 Instructions – Datatransfer Instructions – Arithmetic Instructions – Logical instructions –Branching instructions – Bit Manipulation Instructions

Unit 2 : PROGRAMMING EXAMPLES

ASSEMBLER AND ADDRESSING MODES

Assembling and running an 8051 program –Structure of Assembly Language –Assembler directives - Different addressing modes of 8051

PROGRAMMES

Multibyte Addition – 8 Bit Multiplication and Division – Biggest Number / Smallest Number – Ascending order / Descending order BCD to ASCII Conversion – ASCII to Binary Conversion – Odd Parity Generator – Even Parity Generator -Time delay routines

UNIT 3 : I/O AND TIMER

I/O : Bit addresses for I/O and RAM – I/O programming – I/O bit manipulation programming.

TIMER

Programming 8051 Timers – Timer 0 and Timer 1 registers – Different modes of Timer – Mode 0 Programming – Mode 1 Programming - Mode 2 Programming - Counter programming – Different modes of Counter – Mode 0 Programming – Mode 1 Programming -Mode 2 Programming (simple programs)

UNIT 4 : INTERRUPT AND SERIAL COMMUNICATION

SERIAL COMMUNICATION

Basics of Serial programming – RS 232 Standards - 8051 connection to RS 232 – 8051 Serial Communication Programming – Programming 8051to transmit data serially - Programming 8051 to Receive data serially.

INTERRUPT

8051 Interrupt s – Programming Timer Interrupts – Programming external hardware interrupts – Programming the serial communication interrupt –Interrupt priority in 8051 (simple programs).

UNIT 5 : INTERFACING TECHNIQUES

IC 8255

IC 8255 – Block Diagram – Modes of 8255.

INTERFACING TECHNIQUES

Interfacing external memory to 8051– 8051 interfacing with the 8255 – ASM Programming – Relays – Sensor interfacing – ADC interfacing – DAC interfacing - Keyboard interfacing – Seven segment LED Display Interfacing - Stepper Motor interfacing – DC motor interfacing using PWM

CONTROL ENGINEERING

BASICS OF CONTROL SYSTEMS, LAPLACE TRANSFORM AND TRANSFER FUNCTION

System – Linear & Non Linear, Continuous & Discrete - Control system - open loop & closed loop –Examples – basics of Laplace transform – Inverse Laplace transform – Transfer function –order and type of a transfer function – pole/ zero plot - Transfer function of Translational Mechanical system (simple second order system with one mass) – Transfer function of Electrical systems using R,L,C

BLOCK DIAGRAM AND SIGNAL FLOW GRAPH REPRESENTATION

Block diagram: Introduction – advantages – rules for block diagram reduction – simple problems.

Signal flow graph: Rules for reduction – Mason's gain formula – applications of Mason's formula – simple problems – comparison of block diagram reduction and signal flow graph methods.

TIME RESPONSE

Standard test signals (step, ramp, sine and Parabolic) – order and Type of system - I order, II order system – derivation – step response of I order, II order system – time domain specifications (definition & formulas only) – steady state error, static error constants – problems.

FREQUENCY RESPONSE

Frequency response of linear system –Advantages – Frequency domain specifications (definitions only) – bode plot – gain margin – phase margin – problems – polar plot – problems.

STABILITY

Definition –Location of the roots on the s-plane for stability absolute stability – relative stability– characteristic equation – Routh's stability criterion technique – construction of root locus – problems.

INSTRUMENTATION SYSTEM DESIGN

DESIGN OF TRANSDUCERS AND SIGNAL CONDITIONING CIRCUITS

Design of Thermocouple Circuit with Cold Junction Compensation, Linearization, Amplification and Conversion of its output to 4 to 20 mA current – Design of RTD bridge circuit with lead wire compensation and conversion of its output to 4 to 20 mA current – Design of Flow measurement devices – Orifice Plate, Venturi meter- Design of Charge amplifier – Instrumentation amplifier

DESIGN OF TRANSMITTERS AND CONTROLLERS

Design of two and four wire transmitters with 4-20 mA output – Smart Transmitters –Design of On-Off Controller – Design of Pneumatic and Electronic PID Controller – Design of annunciators –Low Level and High Level annunciators

CONTROL VALVE SELECTION

Function in the system –Pressure drop requirements for good control – Capacity requirements –Valve Rangeability– Choosing the Flow Characteristic – Choosing the Body Design – Body materials – End Connections – Choice of Single Seat Versus Double Seat design – Selection of Actuators – Split ranging Control Valves – Control Valve Sizing Equations – Constant Pressure System –Variable Pressure system –Valve selection guidelines.

ENGINEERING DESIGN CRITERIA

Pneumatics Versus Electronics – Control Center design– Specifications for various Measurement and Control Systems – Flow measurement, Pressure measurement, Level measurement, Temperature measurement, Control Valves, Control Panels – Pneumatic and Electronic Transmission systems –Process Connections – Location of taps, Sealing instruments from the Process – Mounting instruments – Selections of Units, Charts and Ranges – Instrument Identification– Construction material

SAFETY IN INSTRUMENTATION AND CONTROL SYSTEMS

Area and Material Classification – International Electro technical Commission (IEC)– Classifying a Hazardous Location – Techniques used to reduce Explosion Hazards – Explosion proof Housings – Sealing – Pressurization Systems – Intrinsic Safety – Definition – Design of Intrinsically Safe Systems – Basic techniques in the design of intrinsically safe apparatus –

Mechanical and Electrical Isolation – Current and Voltage Limiting – Shunt Elements – System design using Commercially available Intrinsically safe and associated apparatus

PROGRAMMABLE LOGIC CONTROLLERS

ARCHITECTURE AND OPERATION OF PLC

Evolution of PLCs - Hard-wired control systems. PLC – definition, features, Advantages, Relays .PLC parts and architecture – CPU – I/O section – Programming device - Memory - input field devices – output field devices - input module wiring connections, output module wiring connections- Power Supply -PLC versus computer - Types of PLC – single ended – multitask – control management- unitary - modular- small – medium – large. Developing circuits from Boolean expression – Hardwired logic to programmed logic – programming word level logic instruction – processor memory organization program files – data files – program scan.

PROGRAMMING OF PLC

PLC Programming languages -Standard languages- Ladder diagram (LD) - Function block diagram (FBD) Sequential function chart(SFC)- Statement List(STL) (each one example program)Symbols of a PLC Input and output contact graphical languages(IES)– program format – Typical Numbering mode – Equivalent ladder diagram of AND, OR, NOT, XOR, NAND AND NOR gate equivalent ladder diagram to demonstrates De Morgan's theorem, Ladder design switches- Develop elementary program design of a 4:1 Multiplexer using ladder logic programming wired level logic instructions input, output, flag, timer, counter, latch.

PLC TIMERS AND COUNTERS

Definition and Classification of a timer. Characteristics of a PLC timer – functions in a timer – resetting –retentive functions and function block format- non-retentive – classification – Timer ONdelay- Timer-OFF delay- Simple problems using timer PLC counter – Operation of a PLC counter – Counter parameters – Format of counter instruction and counter data file - count up (CTU)- count down(CTD) simple problems using counter.

ADVANCED INSTRUCTION

Introduction - comparison instructions- Addressing format for micro logic system - Different addressing types - Data movement instructions - Mathematical instructions- Program flow control instructions - PID instructions. Program development and execution using Allen bradly PLC. Simplified start up process of a coal feeding to a boiler plant - elevator for 3 floor building - Traffic light control -conveyor belt Selection of PLC - Safety considerations built in the PLC's.

I/O Module Communication and networking

Introduction – classification of I/O Module Input – Output system – Direct I/O, parallel I/O – Sourcing and sinking of serial I/O system. PLC interfacing-Discrete Input module –DC - AC –

Discrete output module – Analog input module single ended and output module - RTD input modules- Thermocouple- High speed Encoder-Stepper motor- RS-232 interface module- Differential input module. Types of Communication Interface. Parallel – serial – Parallel – IEEE 488 BUS- Serial _ balanced – unbalanced- communication mode- simplex – Half duplex – full duplex features of good interface. Serial interface RS 232c. DB-9 connection of Rs232C Network Topology, Bus Ring, Star, Tree.

INDUSTRIAL POWER ELECTRONICS

POWER DEVICES AND TRIGGER CIRCUITS

Thyristor family –Working principle ,VI characteristics, Applications of SCR – Definitions for holding current, latching current, dv/dt rating, di/dt rating– Symbol, principle of working ,VI characteristics ,applications of Insulated gate bipolar transistor (IGBT), MOSFET and GTO. Triggering of SCR - Gate triggering –Types – Concepts of DC triggering, AC triggering, Pulse gate triggering – Pulse transformer in trigger circuit – Electrical isolation by opto isolator - Resistance firing circuit and waveform – Resistance capacitor firing circuit and waveform, Synchronized UJT triggering (ramp triggering) and waveform – Ramp and pedestal trigger circuit for ac load.

CONVERTERS (QUALITATIVE TREATMENT ONLY)

Converters – Definition – Single phase Half controlled bridge converter with resistive load and resistive inductive load- importance of flywheel diode – Single phase fully controlled bridge converter with resistive load – voltage and current waveforms – Single phase fully controlled bridge converter with RL load —voltage and current waveforms. Commutation- Natural commutation – Forced commutation – Types of forced commutation (mention the types only) 3 phase half controlled bridge converter with resistive load - current and voltage waveform -3 phase fully controlled bridge with resistive load – current and voltage waveforms. Dual converter – modes of Dual converter

CHOPPERS

Introduction – applications -principle of chopper-control strategies (time ratio and current limit control)-types of choppertype A, B, C, D, and E - step up chopper –Jones chopper – Morgan chopper-chopper using MOSFET – PWM control circuit for driving MOSFET in chopper. DC Transmission- principle – advantages – drawbacks.

INVERTERS & APPLICATIONS

Inverter Definition Requirement of an inverter –Single phase inverter with resistive load – Single phase inverter with RL load –Methods to obtain sine wave output from an inverter- output voltage control in inverters - McMurray inverter – advantages- Basic 3 phase bridge inverter with 120 conduction mode – circuit, trigger sequence, waveform – Through pass inverter – Parallel inverter using IGBT. UPS – Need for UPS –ON Line UPS -OFF Line UPS - Comparison of ON line and OFF line UPS

NUMERICALLY CONTROLLED SYSTEMS

Basic concepts of numerical control- Block diagram of numerical control system– Advantages, disadvantages , applications of numerical control system – Driving devices – Hydraulic system , Stepper motor - Programming systems (mention the names only) – Data processing unit – Data reading – Part programming – steps - Post processor Introduction to CNC / DNC – Basic concepts of CNC , DNC and AC system - Types of AC system - -Block diagram of ACO , ACC – Comparison between NC & CNC – Typical CNC system – Block diagram - Advantages of CNC system .

TEST ENGINEERING

INTRODUCTION TO TEST ENGINEERING

Need and Importance of Test Engineering – Principles of Fundamental Testing Methods – Basic Principles of Memory Testing – PCB Track Short Testing Methods –Concepts of Trouble Shooting PCBs - Manual and Automated PCB Trouble Shooting Techniques.

AUTOMATED TESTING METHODS AND TECHNOLOGY

Introduction to Automated Test Techniques – Fundamental of Digital Logic Families - Concepts of Back-Driving / Node Forcing Technique and its International Defense Standard - Concepts of Digital Guarding - Auto Compensation - Clock Termination – Functional Test Methods - Functional Testing of Digital, Analog and Mixed Integrated Circuit – Different types of Memory Module Functional Test.

V-I(SIGNATURE) TESTING METHODS AND TECHNOLOGY

Fundamentals of Electrical Characteristics - Effects of Curve Trace, Characteristics of Passive and Active Components - Understanding Composite VI-Curve and it deviations – Component Identification of Ageing Effects with VI Curve Trace, Input and Output Characteristics of Digital Integrated Circuits - Good Versus

BOUNDARY SCAN TESTING METHODS AND TECHNOLOGY

Introduction to Boundary Scan – Need of Boundary Scan Test Technique - Principle of Boundary Scan Test - Boundary Scan Architecture - Application of Boundary Scan Test- Boundary Scan Standards - Boundary Scan Description Language (BSDL) – Interconnect test – Serial Vector Format (SVF) Test - Basic of JTAG Port - Digital Integrated Circuit Test using Boundary Scan Techniques.

ATE TEST PROGRAM & SEMICONDUCTOR TESTING

ATE in PCB Test – Test Fixtures - Basics of Automatic Test Program Generation - Standard Test Data Format STDF – Basic of Digital Simulator - Introduction to Semiconductor Test, Use of Load Boards.

INDUSTRIAL AUTOMATION AND DRIVES

INDUSTRIAL DRIVES

Electric drive - Definition - Parts - Types - Individual - Group - Multi motor. Stepper motor - Definition - Step angle - Slewing rate Types -Variable reluctance -Hybrid - Closed loop control of stepper motor - Drive system(any one) - logic sequencer - Optical encoder. Servo motor - Definition - Types - DC servo motor - Permanent magnet DC motors - Brushless motor - AC servo motor - Working of an AC servo motor in control system - Induction motors - Eddy current drive for speed control of induction motors.

PNEUMATIC AND HYDRAULIC SYSTEMS

Hydraulic system - Elements of Hydraulic system - Hydraulic power supply and accumulator. Pneumatic system-Introduction - Elements of Pneumatic power supply - Filter - Regulator-lubricator(FRL) - Pressure control valves - Pressure relief valve - Pressure reducing valve - Directional control valve(DCV) - Poppet and spool valve - 3/2 DCV - 4/3 DCV - 5/2 DCV - Valve symbols - Pneumatic circuits - Control of a single acting cylinder and double acting cylinder - Comparison between hydraulics and Pneumatics.

PROGRAMMABLE LOGIC CONTROLLER(PLC)

Definition –Conventional Hard wired logicRelays- Features of PLC- Advantages of PLC over relay logic - Block diagram of PLC - Programming basics of PLC - Ladder logic - Symbols used in ladder logic - Logic functions - Timers - Counters - PLC networking - Steps involved in the development of Ladder logic program - Program execution and run operation by PLC - Ladder logic diagram for liquid level operation. List of various PLCs and their manufactures.

DISTRIBUTED CONTROL SYSTEM (DCS)

Evolution of distributed control system - Definition of DCS - Functional elements of DCS - Elements of local control unit -Operator interfaces-Engineering interfaces -Types of information displays - Architecture of anyone commercial DCS - Advantages of DCS - Selection of DCS - List of various DCS and their manufactures.

ROBOTICS

Definition - Robot anatomy - Classification of robots -sensors - Contact and non-contact Touch, tactile, range and proximity sensor - End effectors -Types of end effectors - Robot programming languages - Robot drives - Applications of robots - One specific application of industrial robot - Material handling - Automated guided vehicle system.

BIO MEDICAL INSTRUMENTATION

Unit 1 : BIO-ELECTRIC SIGNALS AND ELECTRODES

Elementary ideas of cell structure, Bio – potential and their generation – resting and action potential – propagation of action potential.

Electrodes – Micro – Skin surface – needle electrodes.

CLINICAL MEASUREMENT: Measurement of Blood pressure (direct, indirect) – blood flow meter (Electro magnetic& ultrasonic blood flow meter) – blood pH measurement - Measurement of Respiration rate – measurement of lung volume – heart rate measurement – Measurement of body and skin temperature - Chromatography, Photometry, Flurometry.

Unit 2: BIO - MEDICAL RECORDERS:

Electro cardiograph (ECG) – Lead system – ECG electrodes – ECG amplifiers – ECG recording units – analysis of ECG curves. Nervous system – EEG recorder – 10-20 lead system – recording techniques – EEG wave types – Clinical use of EEG – brain tumour Electro – myograph (EMG) – EMG waves – measurement of conduction velocity – EMG recording techniques – Electro – retinograph (ERG) Audiometer – principle – types – Basics audiometer working

Unit 3 : III THERAPEUTIC INSTRUMENTS:

Cardiac pacemaker – classification – External pace makers – implantable pacemaker – pacing techniques – programmable pacemaker – Cardiac defibrillators – types – AC and DC defibrillators - Heart lung machine with Block diagram. Dialysis – Hemo dialysis – peritoneal dialysis. Endoscopes Endoscopic laser coagulator and applications – physiotherapy equipment – short wave diathermy – micro wave diathermy – ultrasonic therapy unit (block / circuit) – Ventilators – types – modern ventilator block diagram.

Unit 4: BIOTELEMETRY AND PATIENT SAFETY:

Introduction to biotelemetry – physiological – adaptable to biotelemetry – components of a biotelemetry system – application of telemetry – elements of biotelemetry; AM, FM transmitter and receiver – requirements for biotelemetry system – radio telemetry with sub carrier – single channel and multi channel telemetry – Telemedicine; introduction, working, applications. Patient safety: Physiological effects of electric current – Micro and macro shock – leakage current – shock hazards from electrical equipment. Methods of Accident Prevention – Grounding – Double Insulation – Protection by low voltage – Ground fault circuit interrupter – Isolation of patient connected parts – Isolated power distribution system. Safety aspects in electro surgical units – burns, high frequency current hazards, Explosion hazards.

Unit 5 : MODERN IMAGING TECHNIQUES:

LASER beam properties – block diagram – operation of CO2 and NDYag LASER – applications of LASER in medicine. X ray apparatus – block diagram – operation – special techniques in X-ray imaging – 12

Tomogram – computerized Axial tomography – Ultrasonic imaging techniques – Echo cardiography – Angiography – CT scanner - Magnetic resonance imaging techniques.

ROBOTICS

Basic Configuration of Robotics and its Working

Introduction – definition – basic configuration of robotics and its working –robot components – manipulator, end effectors, drive system, controller, sensors –mechanical arm – degrees of freedom – links and joints – construction of links, types of joint – classification of robots – Cartesian, cylindrical, spherical, horizontal articulated (SCARA), vertical articulated – structural characteristics of robots –work envelope and work volume - robot work volumes and comparison – wrist rotations – mechanical transmission, pulleys, belts, gears, harmonic drive – conversion between linear and rotary motion and its devices.

Robot Controller, Servo Systems

Robot controller – level of controller – open loop and closed loop controller –servo systems –– robot path control – point to point – continuous path control – sensor based path control – controller programming – actuators – dc servo motors – stepper motors – hydraulic and pneumatic drives - feedback devices – potentiometers – optical encoders – dc tachometers.

Robot Motion Analysis and Vision System

Robot motion analysis – robot kinematics – robot dynamics - end effectors –grippers and tools - gripper design – mechanical gripper – vacuum gripper –magnetic grippers – sensors – transducers – tactile sensors – proximity sensors and range sensors – force and moment sensors and its applications and problems photoelectric sensors – vision system – image processing and analysis – robotic applications – robot operation aids – teach pendent – MDI and computer control

Robot Programming

Robot programming – lead through methods and textual robot languages – motion specification - motion interpolation - basic robot languages – generating of robot programming languages – On-Line & Off-Line programming - robot language structure – basic commands – artificial intelligence and robotics.

Robot Application in Manufacturing

Robot application in manufacturing – material handling –assembly finishing –adopting robots to work station - requisite and non – requisite robot characteristics –stages in selecting robot for individual application – precaution for robot –future of robotics. Economics analysis for robotics – cost data required for the analysis – methods of economic analysis – pay back method – equivalent uniform annual cost method – return on investment method.

EMBEDDED SYSTEMS

Unit 1 : ARM PROCESSOR ARCHITECTURE

The RISC,CISC and ARM design - Philosophy, Embedded System Hardware - ARM Development tools

ARM PROCESSOR FUNDAMENTALS: Data Flow model, Registers, modes of operation-Current Program Status Register, Pipeline -Exceptions, Interrupts, and the Vector Table. ARM nomenclature and families - Big Endian and Little Endian - ARM development tools.

Unit 2 : ARM INSTRUCTIONS SETS AND INTERRUPTS

ARM and Thumb Instruction Sets, Data Processing Instructions- Branch Instructions, Load-Store Instructions -Software Interrupt Instruction, Program Status Register -Instructions, Conditional Execution, Stack Instructions.

ARM PROCESSOR EXCEPTIONS AND MODES Vector table, Priorities, link Register offsets - Interrupts, and IRQ / FIQ exceptions interrupt-Stack design and implementation.

SIMPLE PROGRAM: Addition, Subtraction, Multiplication in assembly language

Unit 3 : CACHE MECHANISM AND MEMORY

Introduction to cache memory- memory hierarchy and Cache memory - Cache architecture and cache policies

CONCEPT OF FLUSHING AND CLEANING CACHE :Flushing and Cleaning ARM cache core.

CONCEPT OF CACHE LOCKDOWN : Locking Code and Data in Cache - Cache and write buffer - Stack and stack pointer - Comparison of cache and stack

MEMORY PROTECTION AND MANAGEMENT UNIT: Introduction to Protection unit, Protected Regions - Demonstration of an MPU system - Components of MPU - Importance of MPU - Memory management unit block diagram - Main components of MMU - Definition of Virtual Memory - Virtual Memory - working principle - Memory size & speed - Importance of MMU

UNIT 4 : LPC 2148 ARM CPU

INTRODUCTION Architectural overview – Memory mapping – block diagram

SYSTEM CONTROL BLOCK FUNCTIONS PLL – Power control – Reset – VPB divider – Wakeup Timer - Memory Acceleration module – Timer 0 and Timer 1 - PWM – RTC – On chip ADC – On chip DAC- Interrupts – Vector interrupt controller – General Purpose Input/Output(GPIO) – Universal Asynchronous Receiver/Transmitter - I2C Interface

Unit 5 : EMBEDDED OS AND RTOS

Fundamentals components to Embedded OS - Simple Little Operating System: Initialization - Memory model, interrupts and exceptions handling - Scheduler, and context switch

INTRODUCTION TO RTOS Real-time systems concepts, foreground/background systems - Critical sections, resources, multitasking - Context switching, scheduling, re-entrancy - Task priorities, mutual exclusion

SYNCHRONIZATION AND IPC Introduction to Semaphores and types - Inter process communication: pipes and message box.

Note: The above syllabus is indicative and the questions in the test may include similar other topics pertaining to the level and content of essential qualification.