3.1 CONTROL SYSTEMS

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RATIONALE

It is pre-requisite for the students to know the various total plant controls in the process industry. An automatic control system saves manpower, reduces cost of production, increases the accuracy of the finished product and helps in mass production so that the knowledge of this subject is required to have deeper grasp of the control environment/techniques as need to be studied in the subjects e.g. process control, process instrumentation.

DETAILED CONTENTS

1. Introduction (20 hrs)

   Basic elements of control system, open loop control system, closed loop control system, control system terminology, manually controlled closed loop systems, automatic controlled closed loop systems, basic elements of a servo mechanism, Examples of automatic control systems, use of equivalent systems for system analysis, linear systems, non-linear systems, control system examples from chemical systems, mechanical systems, electrical systems, introduction to laplace transform.

2. Transfer function analysis of ac and dc servomotors synchros, steppermotor, amplyedyne. ac position control system, magnetic amplifier. (14 hrs)

3. Control system representation (16 hrs)

   Transfer function, block diagram, reduction of block diagram, problems on block diagram, Mason's formula signal flow graph

4. Time Response Analysis (16 hrs)

   Standard test signals, time response of first and second-order system, time constant, time response of second order system, time response specifications, steady-state errors and error constants, problems in first and second order system.

5. Stability (14 hrs)

   Routh Hurwitz Criterion, Root Locus, Bode Plotting using semi log graph paper

LIST OF PRACTICALS

1. Study of characteristic of servomotor
2. Characteristics and speed control of a steppermotor
3. To demonstrate the synchro characteristic and use a synchro pair as error detector
4. Characteristics of a potentio meter
5. Study of speed control of motor with tachometeric feed back.
6. Design of a DC speed control system
7. Simulation of a position control system with PC
8. Study of ON-OFF controller

RECOMMENDED BOOKS

1. Control Systems by Nagrath and Gopal
2. Control Systems by KUO
3. Control Systems by Ogata

3.2 ELECTRONIC COMPONENTS AND MATERIALS (ECM)

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RATIONALE

Study of Electronic components and Materials is important from point of view of manufacturing, testing and maintenance of electronic devices and systems. Students should understand the procedure of identification, characteristics, specifications, merits, limitations, and applications of electronic components and materials.

DETAILED CONTENTS

1. **Materials** **(32 hrs)**

1.1 Classification of materials (4 hrs)
Conducting, semi-conducting and insulating materials through a brief reference to their atomic structure.

1.2 Conducting Materials (10 hrs)
Resistors and factors affecting resistivity such as temperature, alloying and mechanical stressing. Classification of conducting materials into low resistivity and high resistivity materials.

1.3 Insulating Materials (10 hrs)
Important relevant characteristics (electrical, mechanical and thermal) and applications of the following material:

Mica, Glass, Copper, Sliver, PVC, Silicon, Rubber, Bakelite, Cotton, Ceramic, Polyester, Polythene and Varnish.

1.4 Magnetic Materials (8 hrs)
Different Magnetic materials; (Dia, Para, Ferro) and their properties. Ferro magnetism, Domains, permeability, Hysteresis loop. Soft and hard magnetic materials, their examples and typical applications.

2. Components **(32 hrs)**

2.1 Capacitors (8 hrs)

a) Concept of capacitance and capacitors, units of capacitance, types of capacitors, constructional details and testing specifications
b) Capacity of parallel plate capacitors, spherical capacitors, cylindrical capacitor.
c) Energy stored in a capacitor.

d) Concept of di-electric and its effects on capacitance, di-electric constant, break down voltage.
e) Series and parallel combination of capacitor. Simple numerical problems of capacitor.
f) Charging and discharging of capacitor with different resistances in circuit, concept of current growth and decay, time constant in R-C circuits, simple problems.

2.2 Resistors: Carbon film, metal film, carbon composition, wound and variable types (presets and potentio-meters) (3 hrs)

2.3 Transformer, inductors and RF coils: (4 hrs)
Methods of manufacture, testing, Need of shielding, application and trouble shooting

2,4 Surface Mounted Devices (SMDs): (4 hrs)
Constructional detail and specifications.

2.5 Connectors, Relays, switches and cables: (5 hrs)
Different types of connectors, relays, switches and cables, their symbols, construction and characteristics.

2.7 Semi Conductors and Integrated Circuits (8 hrs)

- Basic characteristics of Semiconductor materials, testing of diodes, transistors, FETs and SCRs.
- Various processes in IC manufacturing. Hybrid IC technology.
- Superconductivity and piezoelectric ceramic transducer elements

RECOMMENDED BOOKS

1. Electronic components and Materials by Grover and Jamwal; Dhanpat Rai and Sons, New Delhi
2. Basic Electronics and Linear Circuits by NN Bhargava and Kulshreshta; Tata McGraw Hill, New Delhi
3. Electronic components and Materials by SM Dhir, Tata McGraw Hill, New Delhi
4. Electrical and Electronic Engineering Materials by SK Bhattacharya, Khanna Publishers, New Delhi
5. Electronic Engineering Materials by ML Gupta, Dhanpat Rai and Sons; New Delhi.

3.3 TEST AND MEASURING INSTRUMENTS

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RATIONALE

Instrumentation and control engineering diploma holders are normally placed in process and manufacturing industries and service sector. They are required to operate and maintain various electrical and electronic systems. This course provides a starting background to the students of diploma programme in Instrumentation and Control acquainting him/her with various electrical and electronic instruments for their principle, operation, testing, calibration and applications. The detailed content of this course has been tailored as per industrial needs. Proper understanding of the measuring techniques, construction and working principles of various instruments will help the students in proper handling, operation and maintenance of industrial plants, control circuits and panels etc. This course will help the diploma students to pursue higher studies as well.

DETAILED CONTENTS

1. Introduction to Testing and Measurements (6 hrs)

   Classification, Absolute and secondary instruments, Indicating recording and integrating instruments

   1.1 Review of units, dimensions and standards
   1.2 Symbolic representation of circuits

2 Measurement of Resistance, Inductance and Capacitance (12 hrs)

   2.1 Measurement of resistance: Ohmmeters, Meggers, Wheatstone Bridge, Kelvin Bridge, Potentiometer method, Impedance Measurement:
   2.2 Measurement of inductance and capacitance: AC bridge method, Wagner earth devices, Detectors – classification and types, Vibration galvanometers

3 Ammeter, Voltmeter and Multimeter (16 hrs)

   Zero error Moving Iron, Permanent Magnet Moving Coil Meters, Range Extension, Thermal type, electrostatic inductor, rectifier instruments, Electronic voltmeter, Digital Voltmeter (DVM)- ramp type and integrating type digital voltmeters, transistor tester, D' Arsonoval Galvanometer, dynamo galvanometer equation of motion, damped, under damped and critical damped

   Multimeter: Principle of measurement, Measurement of d.c voltage and a.c voltage, a.c and d.c sensitivity, Shunt and multiplier for range extension, Insulation Tester, Earth Tester

4. Power and Energy Measurements (6 hrs)

   Wattmeters – types, definition, classification, 2 Wattmeter and 3 Wattmeter methods, Energy Measurement, Energy meters – types, definition, principle, Maximum demand indicators

5. Frequency and Phase difference Measurement (4 hrs)

   Stroboscopes, synchro-scopes, Phase meters, power factor meters, Digital frequency meters, phase sequence indicators

6. Illumination Instrument (6 hrs)

   Definition, Flicker, Photometer, Illumination photo meter, Physical photometry

7. Cathode ray Oscilloscope (6 hrs)

   Block diagram, Construction of Circuit, Deflection sensitivity, Various controls, X – Y Section, delay line, Horizontal sweep section, synchronization of sweep and triggered sweep, Measurement of voltage, current, phase angle, frequency, CRO probes, dual trace beam, high frequency beam

8. Construction, principle and operation of the following Meters and Instruments (6 hrs)

   Q- meter, transistor tester, analog IC tester, LCR Bridge, output power meter (AP), function generator, Digital Storage Oscilloscope (DSO), VTVM, Tong tester, flux meter, wave form and spectrum analyzer

INSTRUCTIONAL STRATEGIES

While teaching this course the teacher should give demonstration in working and calibration of the instruments pertaining to relevant topics in the class. A trip to power plant or industry can also be organized in order to reinforce the classroom teaching and substantiating the course fundamentals

RECOMMENDED BOOKS

1. A Course in Electrical Measurement and Measuring Instruments by AK Sawhney; Dhanpat Rai and Sons, New Delhi
2. Electrical Measurements and Measuring Instruments by Golding and Widdis; Wheeler Publishing, New Delhi
3. Electrical Measurements by MU Reissland; Wiley Eastern Ltd., New Delhi
4. Electronic Measurement by Ternam Pettat
5. Electronic, Instrumentation Fundamentals by Malvino
6. Modern Electronic Instrumentation and Measurement Techniques by Cooper

3.4 PRINCIPLES OF INSTRUMENTATION

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RATIONALE

The syllabus has been designed to integrate the basic knowledge to make the base of understanding instrument technology. The basic principles involves in instrumentation system, displays etc. are included in the syllabus. This concept will help the students to pick up the higher knowledge which is to be imparted in the following years. The faculty may give some assignments and arrange for Industrial trips.

DETAILED CONTENTS

1. Basic building blocks of any instrumentation systems (6 hrs)
   - Scope and necessity of instrumentation
   - Name of important process variables, their units
   - Building blocks of instrumentation system
   - Various testing signals

2. Performance characteristics of Oscillator Instruments (20 hrs)
   - Static and dynamic characteristics of instruments
   - Concept of time constant, response time, natural frequency, damping co-efficient
   - Order or instruments (1^{st} and 2^{nd} order) with Industrial applications
   - Ramp, sinusoidal, step response of different orders of instruments systems
   - Analytical execution

3. Display and recording devices (18 hrs)
   - Operating mechanism in indicators and recording devices
   - Various indicating, integrating and recording methods and their combination
   - Merits and demerits of circular chart and strip chart recorder
   - Basics of printing devices
   - Scanning, data logging and field buses
   - Bar graph LCD, Seven segment display, X-Y recorder, scanners
   - Design experiments for display system

4. Instrument selection (8 hrs)

   - Factors affecting instrument selection, accuracy, precision, linearity, resolution, sensitivity, hysteresis, reliability, serviceability, loading effect, range advantage and limitation, cost effectiveness and availability
   - Static and dynamic response
   - Environmental effects
   - Calibration tools

5. Errors
   - Sources and classification of errors, the remedial action
   - Grounding, earthing, guarding and shielding
   - Precautions
   - Analytical execution

LIST OF PRACTICALS

1. To find the constant of 1st order instrument
2. To find the constant of 2nd order instrument
3. To find the response of 1st order instrument with step, sinusoidal and ramp input
4. To find the response of 2nd order instrument with step, sinusoidal and ramp input
5. To assemble seven segment display using LEDs
6. To make fourteen segments display using LCD and verify it
7. To make the DOT Matrix display and its verification
8. Make any word using LCD and LED
9. To study circular and strip chart recorder

RECOMMENDED BOOKS

1. Mechanical and Industrial Measurement of by RK Jain, Khanna Publishers, New Delhi
2. Industrial Instrumentation by Donald P Eickrman
3. Electrical and Electronics Measurement of by AK Shawney, Dhanpat Rai and Company, New Delhi
4. Advanced Instrumentation and Control by MF Kureshi

3.5 ELECTRICAL MACHINES

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RATIONALE

Electrical machines is a subject where a student will deal with various types of electrical machines which are employed in industries, power stations, domestic and commercial appliances etc. After studying this subject, diploma holder in Instrumentation and Control must be competent to repair and maintain these machines and give suggestions to improve their performance. Practical aspects of the subject will make the students capable of performing various tests on the machines as per latest BIS specifications

DETAILED CONTENTS

1. Three Phase Supply (4 hrs)
   - Advantage of three-phase system over single-phase system.
   - Star Delta connections
   - Relation between phase and line voltage and current in a three phase system
   - Power and power factor in three-phase system and their measurements.

2. Transformers (7 hrs)

   Principle of operation and constructional details of single phase and three-phase transformer, core type and shell type transformers, difference between single phase and three phase transformers, advantages and disadvantages.
   - Voltage Regulation of a transformer
   - Losses in a transformer
   - Efficiency, condition for maximum efficiency and all day efficiency
   - Auto transformers and instrument transformer
   - CTs and PTs (Current transformer and potential transformer)

3. Introduction to Rotating Electrical Machines (6 hrs)
   - E.M.F induced in a coil rotating in a magnetic field.
   - Definition of motor and generator

- Basic principle of a generator and a motor
- Torque due to alignment of two magnetic fields and the concept of Torque angle
- Basic Electromagnetic laws
- Common features of rotating electrical machines.

4. DC Machines (10 hrs)

- Principle of working of d.c motors and d.c generator, their constructional details
- Function of the commutator for motoring and generating action
- Armature winding
- Factors determining induced e.m.f.
- Factors determining Electromagnetic torque
- Armature reaction and its compensation
- Action and relationship between terminal voltage and induced e.m.f
- Factors determining the speed of a DC motor
- Different types of excitation
- Performance and characteristics of different types of DC machines
- Starting of DC machines, motors and starters
- Application of DC machines

5. A.C. Motors (8 hrs)

- Brief introduction about three phase induction motors, its principle of operation
- Types of induction motors and constructional features of squirrel cage and slip-ring motors
- Starting and speed control: Star Delta and DOL (Direct-on-line) starters.
- Reversal of direction of rotation of 3-phase induction motors
- Applications of induction motors

6. **Synchronous Machines** (7 hrs)

- Synchronous generators
- Synchronous motors and their applications

7. Single Phase and Fractional Kilowatt Motors (6 hrs)

- Introduction
- Principle of operation of single phase motors
- Types of single phase induction motors and their constructional details (i.e. split phase, capacitor start, capacitor start and run, shaded pole and reluctance start)
- Single phase synchronous motors – reluctance motor (hysteresis motor)
- Commutator type single-phase motors – Repulsion Induction motor, shaded pole motors, AC series motor and universal motors
- Introduction to servo- motors and stepper motors

LIST OF PRACTICALS

1. To measure power factors in 3 Phase system with
   a) Balance Load
   a) Unbalanced load by the two wattmeter method and any other methods

2. To draw the equivalent circuit of a transformer and to determine efficiency and regulation by performing:
   a) Open circuit test
   b) Short circuit test

3. To measure the Induced e.m.f. of a separately excited d.c generator as a function of field current.

4. To measure the terminal voltage of a separately excited d.c generator as a function of load current.

5. To measure the terminal voltage of a d.c shunt generator as a function of load current.

6. To measure the speed of a separately excited d.c motor as a function of load torque at rated armature voltage.

6. To measure the speed of a separately excited d.c motor as a function of load torque at rated armature voltage.

8. To measure the speed of a d.c series motor as a function of load torque at rated armature voltage.

9. To determine the efficiency of a d.c shunt motor by the measurement of losses (Sunburn's method)

10. To observe the difference in the effect of switching on a single-phase capacitor start induction motor with.

    a) the capacitor disconnected and

    b) the capacitor connected

    Also to determine how to reverse the direction of rotation

11. Measurement of power and power factor in a 3 phase circuit by two wattmeter method.

INSTRUCTIONAL STRATEGY

A visit to a small factory (Preferably Transformer Factory) must be organised to give live exposure to students. For this the teacher should visit first to understand the assembly line-up which could be followed by a visit of the students in groups of 10-20 (depending upon the size of the factory), where the instructor can give an idea of the working of the factory with minimum possible assistance of the factory staff.

RECOMMENDED BOOKS

1) Electrical Machine by SK Bhattacharya, Tata McGraw Hills, New Delhi

2) Electrical Machines by Nagrath and Kothari, Tata McGraw Hills, New Delhi

3) Experiments in Basic Electrical Engineering: by S.K. Bhattacharya, KM Rastogi: New Age International (P) Ltd. Publishers, New Delhi

4) Electrical Machines by SK Sahdev, Unique International Publications, Jalandhar

5) Electrical Technology Vol. - I and II B.L. Thareja, S Chand and Co. New Delhi

3.6 FUNDAMENTALS OF DIGITAL ELECTRONICS

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RATIONALE

The contents in the syllabus are basically drawn to provide basic and working knowledge to the students in digital electronics, which will cover number system, gates, codes, arithmetic logic circuits, flip-flops, shift resistors and counters. The students need to go into details of the above subject in greater length and to build up reasonable awareness about digital electronics. The course curriculum follows an experiments for which the experiment should be taken on the training board.

DETAILED CONTENTS

1. Introduction (2 hrs)
   - Digital signal and its representation
   - Difference between analog and digital signal
   - Advantages of digital signals

2. Number Systems (10 hrs)
   - Decimal, binary and hexadecimal number system
   - Conversion from decimal and hexadecimal to binary and vice-versa
   - Binary addition, subtraction, multiplication and division including binary points
   - BCD representation, BCD addition
   - 1'^{s} and 2'^{s} compliment method of addition/subtraction

3. Logic Gates (12 hrs)
   - Concept of positive and negative logic
   - Symbol and truth table of NOT, AND, OR, NAND, NOR and Exercises-OR gates with 2 and 3 inputs
   - NAND and NOR gate as universal gates
   - Introduction to logic families and classification of digital ICs

4. Logic Simplification and K-Map (10 hrs)
   - Postulates of Boolean algebra
   - De Morgan's Theorem
   - Boolean identities and specifications of Boolean expressions

- SOP and POS representation of Boolean expressions
- Karnaught map up to four variables and important logic circuits

5. Codes and Parity (2 hrs)
   - Concept of codes, weighted and non-weighted codes examples of 8421, BCD
   - Concept of parity, single and double parity and error detection
   - Use of ASCII and EBCDIC codes

6. Arithmetic Circuits (8 hrs)
   - Definition of combinational circuits. Half adder and full adder circuits and its Implementation
   - Half subtract or and full sub-stractor circuit and its Implementation
   - Multiplexer, demultiplexer, implement 4:1 mux and 1:4 demux.
   - Encoder: Decimal to BCD and BCD to decimal

     Encoder: BCD to Decimal

7. Sequential Circuits (6 hrs)
   - Difference between combinational and segmental circuits
   - Symbol, logic circuit and truth table of R-S, J-K, J-K Master slave D&T flip-flop
   - Introduction to edge and level triggering

8. Shift Registers (4 hrs)
   - Introduction to basic concept of left, right serial in parallel out, parallel in parallel out serial in serial out, parallel in serial out. Shift register
   - Basis of universal shift register

9. Counters (8 hrs)
   - Introduction and concept of binary counters, dimode by N ripper counter, decade counter, programmable counter, up/down counter
   - Introduction to synchronous counter, difference between asynchronous and synchronous counters, concept of ring counter

10. Introduction to A to D and D to A converter (2 hrs)

RECOMMENDED BOOKS

1. Verify the truth table of NOT, AND, OR, NAND, NOR Ex-OR gates
2. Verify NAND and NOR gate and universal gates
3. Verify a half adder and half subtractor with its truth table
4. Verify a full adder and full subtractor with its truth table
5. Verification of K-map using 2 and 4 variables with suitable examples
6. To study two line to four line decoder
7. To study shift right and shift left register
8. To study universal shift register
9. Verify ring counter
10. Use of digital IC tester for testing of different ICs

Note: The students should be exposed to different digital ICs numbers related to the experiments and data book.