# NIELIT Courses

Level Code: Vertical Name:

L5

Industrial Automation

Course Code: Course Name:

3.3.3 Automation Technology – Intermediate Level –L5

Objective of the Course:

To get an overview of automation technology. With hands on and theoretical knowledge on basics of Hydraulics, Pneumatics, Sensors and PLC

The students are also equipped with good Communicative English Skills, soft Skills and Basic IT skills required for good performance in any job in the modern world .

Learning Outcomes:

At the end of the level one the student will be able to identify basic components of automation technology, gets an idea on the overall working of the system and shall be able to troubleshoot on an intermediate level.

Have Good Communicative English skills, Soft skills & Basic IT Skills

Expected Job Roles:

Aassistants in regular production areas, quality, logistics and maintenance areas

Duration of the Course (in hours)

Technical Students –350 Hrs

Non-Technical Students –450 Hrs

Minimum Eligibility Criteria

and pre-requisites, if any Diploma in /Electronics/Instrumentation/ Mechanical/Electrical – for Technical students.

Non Technical Students: Students with 12+ with science background and affinity towards technical studies.

Professional Knowledge:

To be competent, the user/ individual must be able to:

PK1. Understand the overview of automation PK2 Different devices used in Automation,

PK3. interact with the technical lead engineer in order to understand the work schedules,

PK4. understand the roles and responsibilities of the work

PK5. understand broad level activities involved in the Industrial automation PK6. list the various department to interact with for completing the work PK7. interact with higher officials to understand the specifics of work

PK8. understand the different Communication Protocols/Field Buses PK9. establish module requirement and constraints

PK10. understand Network Settings/Communication Settings PK11. understand the PLC Software

PK12. understand the basics of electro hydraulics PK13. define the design flow for the specific system

PK14. use agreed language and application as per standards

PK15. define the requirement specification of the electro pneumatics

PK16. get approval from superior and relevant department on the electro pneumatics PK17. Understand different types of pumps

PK18. Understand different types of valves

PK19. understand the functionality of the electro pneumatics PK20. assist in system testing, product verification and validation PK 21. understand the functionality of the electro hydraulics PK22. understand the functionality of the HMI

Professional Skill:

PS 1: Overview of Automation System PS 2: Overview of Switchgears.

PS 3: Different Communication Protocols/Field Buses PS 4: Introduction to PLC

PS 5: Network Settings/Communication Settings PS 6: Digital Signals/IO’s, Relay Logic PS 7: Timer/Counters/Triggers/FlipFlops,

PS 8: Trouble Shooting the PLC programming errors PS 9: Basic and electrohydraulics

PS 10: Force pressure and weight PS 11: Laminar and turbulent flow PS 12: Selection of Hydraulic fluid PS 13: Hydraulic Pumps

PS 14: External and internal gear pumps PS 15: Pressure Control Valves

PS 16: Types of directional control valves, Spool design, Poppet design PS 17: Directional control valves

PS 18: Basic & Electro Pneumatics PS 19: Pneumatics Vs Hydraulics PS 20: Air compressors

PS 21: Pneumatic Valves and Control Circuits PS 22: Pressure Control Valves PS 23: HMI

PS 24: Programming of HMI

PS 25: Downloading and Uploading the program to or from the HMI

PS 26: Hydraulic Accumulator and its Applications

PS 27: Classifications of filters

PS 28: Principles of Electro-Hydraulics, Basics PS 29: Electro-hydraulic valves

PS 30: Design of Pneumatics systems PS 31: Maintenance Activities

PS 32: System Malfunctions

Core Skill:

The individual on the job needs to know and understand:

CS1. specifications and use of automation system used by the organisation CS2. licensed software and application tools used for design, their performance CS3. PLC Programming using Ladder Logic

CS4. Efficient in working with any kind of Hydraulics & Pneumatic Systems

*Interpersonal skills*

CS5. how to interact with higher officials to understand the work requirement CS6. how to interact with co employees in order to co-ordinate work processes *Reflective thinking*

CS7. to improve work processes CS8. to reduce repetition of errors

Detailed Syllabus of Course Module 1 PLC

*Overview of Automation System*: What is Automation? Different devices used in Automation, Role of PLC in automation system., Scope of Automation field in present and future, Comparison between Automated and Manual Operated Systems.

Overview of Switchgears: What is a Relay and its applications? Introduction to Switching devices like Contactors, Solenoids, MCB’s etc., Symbolic representation of different electrical & electronic components in wiring diagram.

Introduction to Different Communication Protocols/Field Buses: Ethernet, RS232, Profibus DP, Canopen, Devicenet, Sercos II & III, Modbus, Profinet, Ethercat, Different types of Signals, Digital Signal, Analog Signal, Overview of Limit Switches, Proximity Switches & Reed switches, Introduction to PLC, Comparison of PLC & PC, What is a PLC?, How does a PLC work? Applications of PLC, Block Diagram of PLC, Processing cycle of PLC, Different types of PLC’s available in the market, Programmable Logic Controller, Specifications of PLC, Onboard/Inline/Remote IO’s, Memory Allocation in PLC, What is Scan time of PLC? IO handling capacity of different PLC, Remote connectivity in PLC, Internal Structure of PLC, Hardware Details of the PLC, Wiring and

Connection Techniques, Safety Measures for handling the PLC, Diagnosis of PLC Status and other hardware connected to PLC.

Network Settings/Communication Settings: Introduction to PLC Software, Overview of Software/Software at a glance, Hardware Configuration Communication Settings for PLC, PLC Programming, Building simple logic in PLC (AND/OR/NOT), Online & Offline Change, Overview of different types of Data types in PLC programming, Standard format for addressing the variables, Standard Time formats, Rules for Declaration of Variable names, Working with Digital Signals/IO’s, Relay Logic, Difference between Function & Function Blocks, Introduction to Timer/Counters/Triggers/FlipFlops, Exercises based on Timers, Counters, Flip Flops & Triggers, Usage of Mathematical Operators, Comparators, Conversion Operators, Multiplexers & Logical Gates in the PLC Program, Exercises based on the above operators, Compilation & Downloading the program to PLC, Trouble Shooting the PLC programming errors, Local & Global Variables, Working with Analog Signals/IO’s, Developing a program for process control, Declaration in Tabular Format, Display of Address and Comments in Logic, Jump & Return Command, Commands like Run, Stop, Reset, Reset Original, Breakpoint etc, Developing User Defined Function Blocks & Functions in the PLC program, Conditional & Unconditional Calling in PLC Program, Task, Configuration, Visualization, Developing user defined Data Types in PLC program, Password Management, Different Methods to take the PLC Program Backup (Source Code Download/Upload, Archive/Restore & Export/Import), Library Management, Target Settings, Running the PLC program in Simulation Mode, Master/Slave Configuration, Data Exchange between the Master & Slave PLC.

HMI : Introduction, Applications, Role of HMI in Automation, Interfacing HMI with different devices, Hardware Details of HMI, Technical Specifications of HMI, Wiring and Connection Techniques, Various models of HMI available in market, Editing various display options using the keys, Programming of HMI, Overview of HMI software, Hardware Configuration, Network Settings or Communication Settings, Developing Different Screens on HMI, Writing Plain Text on the screen, Developing Headers & Footers for the Screen, Configuring the function keys of HMI for screen change or for giving inputs, Linking the variables directly on the screen, Password Management (for screen change & for editing the values), Developing user defined text list, Screen Change using PLC variables, Displaying Alarm Messages on the Screen during fault, Configuring Help Screen for Troubleshooting the errors or faults, Downloading and Uploading the program to or from the HMI respectively using bus interface or USB drive.

*PROJECT*: Tank Filling Device Simulator, Supervise Equipment, Pump Control 1, Selective Band Switch, Gate Control System, Star Delta Starting Up, Starter Control, Dahlander Pole Changing, Furnace Door Control, Reaction Vessel, Pump Control 2, Roadworks Traffic Lights, Cleaning System, Buffer Store Simulation, Automatic Tablet Filler, Changing Floor, Embossing Machine, Bending Tool, Drilling Tool, Pipe Bending Machine, Two Door Access Control System, Mix Equipment, Level Control, Compressed Air Network, Water Level Controlling, A Low-Cost PLC Based Automatic Liquid Filling and Sorting System, Modular Automated Testing Unit Sequencing and Controlling, Low Cost PLC Based Automated Sorting And Pressing By Servo- Pneumatic Pressure Control, Automated Multistorey Car Parking System

There are 3 mixing devices on a processing line A,B,C. After the process begin mixer-A is to start after 7 seconds elapse, next mixer-B is to start 3.6 second after A. Mixer-C is to start 5 seconds after B. All then remain ON until a master enable switch is turned off. Write PLC ladder diagram, timing diagram and realize the same

An indicating light is to go ON when a count reaches 23.The light is then go off when a count of 31 is reached. Design, construct, and test PLC circuits for this process

In certain process control application when the count reaches 25, a paint spray is to run for 40 seconds. Design, construct and test PLC circuits for this process

Three conveyors feed a main conveyor. The count from each feeder conveyor is fed into an input register in the PLC. Construct a PLC program to obtain the total count of parts on the main conveyor. Use a time to update the total every 15 seconds. Design, construct, and test PLC circuits for this process

In certain process control application o/p is ON if the count is less than 34 or more than 41. Implement the same using PLC ladder diagram

A conveyor is supposed to have exactly 45 parts on it. You have three indicating lights to indicate the conveyor count status: less than 45, yellow: exactly 45, green: and more than 45, red. The count of parts on the conveyor is set at 45 each morning by an actual count of parts. There are two sensors on the conveyor, one is actuated by parts entering the conveyor, and the other is actuated by parts leaving. Design a PLC program to carry out this process.

Theory / Lecture Hours: 60 Practical / Tutorial Hours: 90

Module II

*Basic and electrohydraulics*

What is Fluid power: Advantages of Fluid power, What is Hydraulics? Definition of industrial Hydraulics, Hydrostatics and Hydrodynamics, Applications of Hydrostatics and Hydrodynamics, Characteristics of Industrial Hydraulics like advantages and its limitations, Comparisons of Drives (Hydraulics Vs Pneumatics, Electrical/Electronics & Mechanical, Applications of Hydraulics.

Force pressure and weight, Pascal’s Law, Calculations : Pascal’s Law, Application of Pascal’s Law, Force Multiplication, Pressure Multiplication, Displacement transmission, Calculations, Units of pressure., What does 1bar mean? Absolute and relative pressure, What is flow rate? Flow law, Calculation, Open, Types of flow : Laminar and turbulent flow, Reynolds’s number, Throttling, Graphical Symbols and Circuit Diagrams ISO 1219, Purpose of graphical symbols, Function of symbols, Basic elements, Circuit diagram Commonly used symbols, Circuit symbols., Symbols for energy supply and processing unit ( Power Pack ), Symbols for Hydraulics energy control units (Pressure, Flow and Direction ), Symbols for Energy conversion units (Actuators), Symbols for accessories, Demonstration of Hydraulics circuits, Hydraulic circuit with manual DCV and a cylinder, Hydraulic circuit with manual DCV and a Hydraulic motor, Hydraulic circuit with solenoid DCV and cylinder and a motor, Demonstration of speed and direction changes in Hydraulic circuit, Hydraulic Fluids, Main functions of Hydraulic fluids, Functions, Capacity and Constructions of Tanks, Calculation, Requirements of Hydraulic fluids, Types of Hydraulic Fluids, Viscosity of Hydraulic fluid, Relation between temperature and viscosity, Selection of Hydraulic fluid for an applications, Compressibility of Hydraulic fluids, Thermal expansion of Hydraulic fluids, Fluid Analysis, Hydraulic Pumps, Functions and Operating principle Hydraulic pumps, Differentiate b/w positive and non – positive displacement pumps, Characteristics of standard Hydraulic pumps, Construction and Operating principle following pumps, i. External and internal gear pumps, ii. Vane pumps, iii. Axial piston pumps, iv. Radial piston pumps, Selection criteria of pumps, Flow rate and pump power, Efficiency, Hydraulic Cylinder, Operating Principle, Components of a Hydraulic cylinder, Functions of Hydraulic cylinder, Design and operation, Types of cylinder, Types of design, i. Tie rod cylinders, ii. Mill type cylinders, Technical specification, End positioning cushioning, Cylinder mounting, Hydraulic Motors, Functions of Hydraulic Motors, Characteristics of standard Hydraulic Motors, Selection of Hydraulic motors, Calculations, Efficiency, Pressure Control Valves, Introduction, Function and operating principle of pressure relief valve, direct operated, Pressure relief valve in series and parallel, Pressure relief valve, pilot operated, Function and

operating principle of pressure reducing valve, Pressure sequence valve, direct operated, Directional Control Valve, Operation and Function, Special characteristics, Types of directional control valves, Spool design, Poppet design, Types of actuation of spools with symbols, Directional spool valves, direct operated, Directional spool valves, pilot operated, Designation of Directional control valves, Operation of solenoid, Solenoid operated valves and its symbols, Standard spool valve : G spool, E spool, J spool and H spool, Comparison of spool Vs poppet valves, Flow Control Valves, Functions, Throttle valves, Viscosity dependent throttle valves, Types of mounting, Throttle valve independent of viscosity, Flow control valves, 2-way flow control valves, Upstream pressure compensator, Downstream pressure compensator, Applications of 2-way flow control valve, Meter-in flow control, Meter-out flow control, Check Valves, Operation and function of a simple check valve, Check valve, pilot operated, Double pilot operated check valve, Applications of check valves,

Hydraulic Accumulator and its Applications, Functions, Energy storage, Types of Accumulator, Safety regulations, Application of accumulators, Filtration and Filtration Technology, Causes of contamination, Classifications of filters, Suction filter, Pressure line filter, Return line filter, Bypass filter, Filter with clogging indicator, Basic Principles of Electro-Hydraulics, Basics : Electric current, voltage, resistance and power, Basic electric circuits : series and parallel, Measurement of current and voltage, Electro-hydraulic valves, Solenoids, Classifications of solenoids, Function and operating principle of a relay, Relay as a logical switch, Relay Logic Diagram : control and main circuit, Symbols of most important switching elements (NO an NC), Signal storage concept, Electrical interlocking concept, Momentary-contact limit switches, Categories of limit switches, Pressure switches, Graphical symbols to DIN electrical engineering and electronics.

*Project*: Hydraulic pump, characteristic Curve, Single-rod cylinder, pressure intensification, Single-rod cylinder, flow, Hydraulic motor, 4/3 directional valve, Check valve, Check valve, pilot operated, Throttle valve, adjustable, Throttle check valve, Flow control valve, Pressure relief valve, direct operated, controls, Pressure reducing valve, Pressure switch, hydraulic accumulator, Regenerative circuit, Rapid speed/creep speed control, Extending a cylinder by operating a push button, Signal storage by electrical self-locking, setting and resetting using a momentary-contact switch, Mechanical locking by means of momentary-contact switch contacts, Electrical locking by means of contactor contacts, Signal storage by means of contactor contacts, Rapid advance circuit, Pressure-dependent reversing, Pressure switches and proximity switches, Advance control with time-dependent intermediate stop, Pressure-dependent sequence control, Sequencing Hydraulic actuators

Theory / Lecture Hours: 60 Practical / Tutorial Hours: 90

Module III

*Basic & Electro Pneumatics*

Fluid power, Advantages, Pneumatics, Definition, Characteristics of Industrial Pneumatics, advantages and its limitations, Comparisons of Drives - Pneumatics Vs Hydraulics, Electrical/Electronics & Mechanical, Applications of Pneumatics, Compressed Air Generation and Contamination Control, Compressed Air for transmitting power, Composition of Atmospheric Air, force, weight, pressure, Pascal’s Law, Application of Pascal’s Law, Force Multiplication, Pressure Multiplication, Displacement transmission, Calculations, Gas Laws, Air compression process, Absolute and relative pressure. Flow rate, Characteristics of compressed air, Graphical Symbols and Circuit Diagrams ISO 1219, Purpose of graphical symbols, Function of symbols, Basic elements, Circuit diagram, Commonly used symbols, Circuit symbols., Symbols for Maintenance unit, Symbols for Pneumatic energy control units (Pressure, Flow and Direction ), Symbols for Energy conversion units

(Actuators), Symbols for accessories, Demonstration of Pneumatic circuits, Pneumatic circuit with manual DCV and a cylinder, Pneumatic circuit with solenoid DCV and cylinder and a motor, Demonstration of speed and direction changes in Pneumatic circuit, Compressed Air Generation and Contamination Control, A typical Pneumatic system, Air compressors, Classification of Compressors, Terms and Definition : Delivery volume, Pressure, Drive , Cooling and Regulation, Piston Compressor, Screw Compressor, Vane Compressor, Compressor unit, Preparation of compressed Air, Stages of Preparation, Drying of Compressed Air, Distribution of Compressed Air, Pneumatic Actuators, Introduction, Basic Actuator Functioning, Thrust, Cylinder Air Consumption, Cylinder speed and its relation to flow rate, Stroke Length, Piston –rod buckling, Classification of Pneumatic Actuators, Linear Actuators, Single-Acting cylinder, Double-Acting cylinder, Cylinder cushioning, Classification of cylinders According to Duty, Cylinder with Magnetic Piston, Cylinder with Non-Rotational Guiding, Rodless Cylinder, Tandem Cylinder, Rotary Actuator, Semi-Rotary Actuators, Pneumatic Valves and Control Circuits, Introduction, Classification of valves, Functional Classification of Valves, i. Directional control valves, ii. Pressure control valves, iii. Flow control valves, iv. Non return valves, Graphical Representation, Port Markings, Ports and Positions, Graphical symbols for DC valves, Methods of DC Valve Actuations, 3/2- Directional Control valve, i. NC-type 3/2-DC valves, ii. NO-type 3/2-DC valves, Non-Return Valves, Flow control valves, Throttle valve and Throttle check valves, Pneumatically Actuated 3/2-DC valve, Manually actuated 5/2- DC valve, Pneumatically actuated 5/2-DC valve, Speed control of Double-Acting Cylinder, 5/2-DC Double-Pilot valve, Login Controls, Pneumatic, i. Shuttle valve, ii. Twin pressure valve, iii. Applications of Logic valves, Structure of Pneumatic Circuits, Automatic Control, Roller valve, Quick-Exhaust vavle, Time-Delay valves, Pressure Control Valves, Introduction, Function and operating principle of pressure relief valve, direct operated Pressure regulator.

Multiple-Actuator Circuits, Introduction, Representation of a Control Task, i. Text form, ii. Positional Layout, iii. Notational form, iv. Displacement –step diagram, v. Displacement-time diagram, Sequence Control, Circuit design for the sequence of two cylinder and three cylinders, Elimination of signal overlaps, Electro-Pneumatics, Introduction, Integration of Technologies, Solenoid valves, DC solenoids Vs AC Solenoids, 3/2-Way single solenoid valve, Spring return, 5/2-Way single solenoid valve, Spring return, 5/2-Way double solenoid valve, Control devices, Switch and Push button, Terminal Markings, Relay, Logic Controls, Electric, Memory function, Operation of the ‘Dominant OFF’ Circuit, Operation of the ‘Dominant ON’ Circuit, Electronic sensors, Limit switch, Reed switch, Proximity Sensors, Time-Delay Relays, Two-hand safety operation, Pressure switch, Electro-Pneumatic Multiple-Actuator Circuits, Pneumatic Application Concepts, Introduction, Selection and Optimization Criteria, i. Type of motion, ii. Stroke and stroke control, iii. Force, iv. Speed and speed control,

Design of Pneumatics systems, Selection of Pneumatic Actuators, Selection of Pneumatic Valves, Maintenance, Troubleshooting, and Safety, Introduction, Requirements of Preventive Maintenance, Definitions of Maintenance Activities, Preventive Maintenance of Pneumatic Systems (General Procedure), System Malfunctions, i. Malfunctions due to contaminants, ii. Malfunctions due to improper mountings, iii. Malfunctions due to inadequate air supply, iv. Malfunctions due to under-lubrication/over lubrication, Maintenance Tips, i. Maintenance of compressor, ii. Maintenance of air receivers, iii. Maintenance of air- mains, iv. Maintenance of air service units (FRL), v. Maintenance of Pneumatic cylinder, vi. Maintenance of Pneumatic valves, Troubleshooting, i. General troubleshooting procedure, ii. Faults in Pneumatic systems, General Malfunctions, i. Malfunction in pneumatic cylinder, ii. Malfunction in Pneumatic valves, iii. Malfunctions in limit switches and reed switches, Safety in Pneumatic Systems, i. Safety hazards, ii. General safety measures.

*Project:* Direct control of a single-acting cylinder, extending, Direct control of a single-acting cylinder, retracting, Indirect control of a single-acting cylinder, Regulating the speed of a single-acting cylinder, Slow- speed extension, rapid retraction of a single-acting cylinder, Direct control of a double-acting cylinder with push-button, Indirect control of a double-acting cylinder, Speed regulation of a double-acting cylinder,

Controlling a double-acting cylinder, impulse valve, 2 push-buttons, Displacement-dependent control of a double-acting cylinder, impulse, Controlling a double-acting cylinder, impulse valve, 2 reflex nozzles, Stop control, double-acting cylinder, 5/3 directional control valve, tensile load, Pressure-dependent control of 1 double-acting cylinder, Time-dependent control of 1 double-acting cylinder, Logical control with shuttle and twin-pressure valves, Sequential control 2 double-acting cylinders w/o overlapping signals, Seq. control 2 double-act. cylinders, signal overlapping, idle return rollers, Pilot control of a single-acting cylinder with spring return valve, Pilot control of a double-acting cylinder with spring return valve, Holding-element control of a double-acting cylinder with impulse valve, directly controlled, Holding-element control of a double-acting cylinder with impulse valve, relay, Basic circuit with AND Function, Basic circuit with OR Function. Basic circuit with electric latching circuits, Displacement-dependent control of a double-acting cylinder with 1 electric limit switch, Displacement-dependent control of a double acting cylinder, impulse valve, cylinder switch, Displacement-dependent control of a double-acting cylinder with spring return valve, cylinder switch, Stop control of a double-acting cylinder with a 5/3 directional control valve in closed mid-position, Time-dependent control of a double-acting cylinder with switch-on time delay, Time-dependent control of a double-acting cylinder with switch-off time delay, Pressure-dependent control of a double-acting cylinder, Two-hand safety control, electric, Sequential control of 2 double-acting cylinders with impulse valve, Sequential control of 2 double-acting cylinders with impulse valves and signal overlapping, Sequential control of 2 double-acting cylinders with spring return valves and step sequence, Sequential control of 3 double-acting cylinders with impulse valves and step sequence, Sequential control of 3 double-acting cylinders with spring return valves and step sequence, Multiple actuator sequence, Two cylinder sequence, Three cylinder sequence.

Theory / Lecture Hours: 60 Practical / Tutorial Hours: 90

Total Course Theory / Lecture Hours: 180 Total course Practical / Tutorial Hours: 270 Total course Hours: 450

Recommended Hardware:

State of the art Training system for Hydraulics, Pneumatics, Sensoric and PLC

Recommended Software:

Automation studio, web trainers, Indraworks and indralogic

Text Books:

* Hydraulics. Basic Principles and Components (Bosch Rexroth AG) Volume 1
* The Pneumatic Trainer – Basic Pneumatics Volume 1 (Bosch Rexroth AG)
* The Pneumatic Trainer – Volume 2 (Bosch Rexroth AG)
* Sensors in Theory and Practice – Textbook (Bosch Rexroth AG)
* Basics of Indraworks and Indralogic (Bosch Rexroth AG)

Reference Books:

* Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
* Dudbey.A.Peace, Basic Fluid Power, Prentice Hall Inc, 1967
* R.Srinivasan Hydraulic and Pneumatic Control published by Vijay Nicole Imprints Private Ltd.
* Programmable Logic Controllers by W.Bolton
* Dudbey.A.Peace, Basic Fluid Power, Prentice Hall Inc, 1967
* Introduction to Programmable Logic Controllers by Garry Dunning, 2nd edition, Thomson, ISBN:981-240-625-5
* Programmable Logic Controllers by Hugh Jack

Evaluation criteria:

The training is conducted with the industrial support of Bosch Rexroth,Germany. MOU

Signed with them .

Bosch has supplied all equipments and set up the state of the art lab facilities in two engineering colleges in the state.. They have trained our faculty.

Evaluation & Certification by Bosch Rexroth.

ESSCI has also agreed to do Assessment and Certification.