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## Course Outline – PLC (Programmable Logic Controller)

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**Course Topic:** PLC (Programmable Logic Controller)

**Recommended Contact Hours:** 90 hours

### Course Description:

This class will introduce the fundamentals of Programmable Logic Controller (PLC) operations, including symbology and programming techniques. PLC hardware and data structures will be presented. Methods of using the programming interface to troubleshoot applications will be emphasized. The student will write, enter, and execute application programs using the programmable controllers and Human Machine Interface (HMI). The use of the Robotics Lab equipment will give the student practical programming and troubleshooting skills used in the maintenance of automated systems.

### Course Outcomes and Objectives

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#### PLC-1 Describe and list the consideration for PLC and electrical safety

1. List the considerations associated with PLC safety
2. Describe the size designations used by PLC manufacturers
3. Explain electrical shock. (OCC)
4. List the electrical properties associated with PLCs. (OCC)
5. Describe the grounding of PLCs and PLC systems
6. Explain static electrical discharges. (OCC)
7. Describe the personal protective equipment (PPE) used by technicians when working on electrical systems. (OCC)
8. Explain the lockout/tagout process and the need to inspect a PLC system
9. Given an I/O chassis, Input module, Output module, sensor & actuator, wire the proper I/O field wiring and create a ControlLogix routine necessary to exercise the I/O devices
10. Given an I/O chassis, Input module, Output module, sensor & actuator, wire the proper I/O field wiring and create Networks necessary to exercise the I/O devices

#### PLC-2 Describe and list the electrical principles and PLCs

1. Describe the electrical circuits that connect input devices to the input sections of PLCs and output devices to the output sections of PLCs
2. Explain why polarity is important when connecting input devices and output devices to some PLCs
3. Identify the ratings used for the power supply, input sections, and output
4. sections of PLCs
5. Describe current sinking and current sourcing as they pertain to PLC input
6. sections





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7. Explain the use of Ohm's law in series and parallel circuits and calculate the voltage drops across each type of circuit

### PLC-3 Identify and list the electrical circuits and their use in PLCs

Identify the use of symbols in electrical and PLC circuits.

1. Identify typical logic gate symbols
2. Explain normally open (NO) and normally closed (NC) for manual and
3. automatic switches
4. Identify the use of symbols in software programming diagrams
5. Define pictorial drawings, wiring diagrams, ladder diagrams, and programming diagrams
6. Explain and list the common logic functions
7. Describe direct hardwiring, hardwiring using terminal strips, and PLC wiring

### PLC-4 Explain the types and functions of generic PLC hardware.

1. Explain the functions and different variations of the five sections of a PLC:
2. input section, output section, power supply, CPU, and programming device
3. List the typical number of I/Os for the various size classifications of PLCs
4. Explain the different types of PLC memory
5. Describe the operating cycle of a PLC and how it relates to a PLC's memory
6. Match the description of the CPU's operating modes to a given list.
  - STOP, the CPU does not execute the program, and you can load a project
  - STARTUP, the CPU performs internal diagnostic checks associated with a startup
  - RUN, the program is executed cyclically
7. Change the processor's mode of operation

### PLC-5 Describe the PLC and system interfacing to the field devices

1. Describe the primary systems used to transmit and control energy
2. Explain what an interface device is and when these devices are required in an electrical circuit
3. Describe a PLC-wired electrical circuit from a hardwired electrical circuit that includes a contactor or motor starter
4. Identify the differences between electromechanical relays and solid-state relays and why they are used with input and output devices
5. Define the terms "poles," "throws," and "breaks" as they pertain to electrical contacts
6. Describe how contactors and motor starters are used as interface devices and how they are properly connected to the output sections of PLCs





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7. Perform the replacement procedure of the following modules:
  - Processor module
  - Ethernet Communications module
  - Input module
  - Output module

### PLC-6 List the procedures and considerations for PLC installations and startup

1. List the proper procedures for receiving a PLC and related components
2. Identify the installation considerations for PLC enclosures and power supplies
3. Identify the installation considerations regarding electrical noise and PLCs
4. Describe the PLC wiring methods, wiring termination methods, and I/O wiring related to PLC installations.
5. Explain the checks involved in a PLC startup and the safety considerations
6. involved in each of the checks
7. Create a new ControlLogix project by configuring all module properties including requested packet interval, and electronic keying
8. Change the processor's mode of operation
9. Install and configure a ProfiBus Communications Module. Interpret diagnostic indicators status related to the modules functionality
10. Match the description of the installation and configuration steps with a list of the specific steps required to install and configure a new system incorporating a S7-1200 controller.
  - Installation
    - a. Install CPU on the DIN Rail
    - b. Install Signal Modules (SM) on the DIN Rail
    - c. Slide Buss Connection Switches to the left on all Signal Modules to make both a mechanical and electrical connection between the modules on the DIN Rail
    - d. Install the SIM Card
  - Wiring
    - a. Land wires from input devices to the corresponding removable terminal blocks on the Signal Modules
    - b. Land wires going to the output devices to the corresponding removable terminal blocks on the Signal Modules
  - Commissioning
    - a. Verify each hardware device is receiving power and functioning properly.
    - b. Download the configuration to the CPU
    - c. Establish and set-up communications (Profibus / ProfiNet
11. Match the description of the CPU's operating modes to a given list.
  - STOP, the CPU does not execute the program, and you can load a





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- project
  - STARTUP, the CPU performs internal diagnostic checks associated with a
  - startup
  - RUN, the program is executed cyclically
12. Using TIA Portal software, establish communications between a PC and CPU
  13. Create a new Step 7 Project and use the “Detect” option to automatically populate the associated hardware properties
  14. Display specific module properties using the TIA Portal software
  15. Perform the replacement procedure of the following modules:
    - Processor module
    - Signal Board
    - ProfiBus Communications module
    - ProfiNet Communications module
    - Signal module - Input
    - Signal module – Output

### **PLC-7 Explain and list the visual inspection and use documentation for PLC and system maintenance**

1. Explain how a PLC and PLC system is maintained
2. List the steps involved in safely performing a visual inspection of a PLC as part of hardware maintenance
3. List the steps involved in safely performing energized maintenance of a PLC as part of hardware maintenance
4. List the steps involved in safely performing battery maintenance of a PLC as a part of hardware maintenance
5. Explain the process of equipment and documentation verification as part of PLC software maintenance.(e.g. Tags, labels, etc.)
6. Explain the process of software and program verification as part of PLC
7. software maintenance
8. Add instruction and rung comments to a ladder diagram

### **PLC-8 Describe the Troubleshooting Principles and Test Instruments used for PLC and system maintenance**

1. Explain what each status light on a PLC or CPU module indicates
2. Describe the advantages of using PLC error codes and how they are displayed on a PLC
3. Identify the use of symbols and abbreviations on test instruments and their meanings
4. Explain the meaning of each CAT rating on a test instrument
5. Describe how to set a test instrument to measure voltage and properly connect the test instrument to take voltage measurements on a PLC system





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6. Explain how to set a test instrument to measure resistance and properly connect the test instrument to take resistance measurements on a PLC system
7. Describe how to set a test instrument to measure current and properly connect the test instrument to take current measurements on a PLC system

### PLC-9 Describe the procedures for the troubleshooting PLC hardware

1. Identify the differences between sag, swell, undervoltages, overvoltages, and transients.
2. Describe how to set a test instrument for testing control transformers and how to connect the instrument to determine if the transformer is good or bad
3. Describe how to set a test instrument for testing input sections or modules and output sections or modules and how to connect the instrument to determine if the sections or modules are good or bad
4. Troubleshoot faulty machine operation on training simulator with instructor induced faults
5. Using the S7-1200 reference material, identify all indicators on a CPU module, determine whether the indicator represents normal or a faulted condition and identify the recommended recovery action for each possible condition
6. Using the Tia Portal reference material, identify all indicators on Signal modules, determine whether the indicator represents normal or a faulted condition and identify the recommended recovery action for each possible condition
7. Given the TIA Portal ladder logic display, input and output module indicator conditions, and the associated voltage measurements that would be measured in the control panel, determine whether a failed input or output condition is due to a processor error “or” the input/output interfaces “or” a real world device/wiring issue
8. Using the ControlLogix reference material, identify all indicators on a ControlLogix Processor module, determine whether the indicator represents normal or a faulted condition and identify the recommended recovery action for each possible condition
9. Using the ControlLogix reference material, identify all indicators on I/O modules, determine whether the indicator represents normal or a faulted condition and identify the recommended recovery action for each possible condition

### PLC-10 Explain and identify the analog principles of devices used with PLCs

1. Explain the difference between digital and analog electrical circuits
2. Describe how PLCs and variable frequency drives operate in analog circuits
3. Identify the types of signals used by analog input devices
4. Identify the types of signals used by analog output components
  - Provided a screen shot from the Device Configuration Properties Dialog Box, Match the Module Properties for an Analog Module to a given list
  - Output Type (Voltage / Current)





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- Output Range
  - Smoothing (weak, medium, strong)
  - Substitute value for channel on a change from Run to Stop (output)
5. Demonstrate the following in a lab exercise:
- Create a PLC Tag for an analog input
  - Create a PLC Tag for an analog output
  - Create a program that displays the voltage of an analog input on an analog output device (display)

### **PLC-11 Describe the device installation of analog devices to PLCs**

1. Describe the applications and installation considerations of analog input devices (sensors)
2. Describe the applications and installation considerations of analog output components (actuators)
3. List the troubleshooting procedures required for PLC analog input devices, PLC and sensor wiring, and PLC input terminals
4. List the troubleshooting procedures required for PLC analog output
5. components, PLC and actuator wiring, and PLC output terminals

### **PLC-12 Demonstrate the startup and use the editor functions for PLCs**

1. Demonstrate the start-up and opening of application files
2. Demonstrate how to use Windows features to view a PLC program
3. Demonstrate how to use programming software features to view a PLC program
4. Demonstrate how to safely and systematically debug a PLC program, the Cross Reference function, the Find function, and the Data files functions
5. Explain how to safely use the Force function when troubleshooting
6. Explain the possible consequences of forcing an input or forcing an output
7. Describe how to use the Help features of the programming software
8. Demonstrate the modes of operation
9. Demonstrate downloading and uploading a PLC program
10. Perform Search cross-references
11. Add and delete Networks (rungs) within an existing Organization Block
12. Add Instructions to an existing Network
13. Download and Upload programs to/from a CPU
14. Perform minor edits on-line to the ladder logic to include relay, timer, and counter instructions
15. Demonstrate the use of the Cross-Reference tab from within the Info tab to trace a specific bit through a program
16. Demonstrate searching a ladder diagram by Tag or Address using Find (Find/Replace)
17. Change the processor's mode of operation
18. Perform Find and Cross-references exercises







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19. Given a ladder listing and input conditions, predict the output status. This ladder listing will include basic relay-type instructions as well as timers and counters
20. Using the Tia Portal software, review an example plant standard Project. Evaluate the logic and create Comments that would describe the action of the rung
21. Using the RSLogix5000 software Communications menu, “Who Active”, select a processor and initiate online communications
22. Using RSLinx software, setup the proper driver necessary to allow the PC to communicate the ControlLogix system
23. Using the RSLogix5000 software, use the I/O Configuration folder in the Controller Organizer to display specific module properties
24. Apply and enable forces, find, remove, and disable forces.
25. Search a ladder diagram by tag address and instruction type. (Using “Search Next”, “Search Previous”, and “Find All”)
26. Using the RSLogix5000 software, create a trend chart
27. Switch between Project and Portal Views within the TIA Portal software
28. Using TIA Portal software, assign an IP Address to a new CPU’s MAC Address or change an existing IP Address on the CPU
29. Monitor I/O or using a Watch Table
30. Control I/O using a Force Table, including Start and Stop of the Forces

### **PLC-13 Demonstrate and use of the structure and organization of PLC program files for PLCs**

1. Explain how a PLC scans a program and how the scan relates to input and output data table files
2. Demonstrate the uses the ‘Main’ program file to enter logic instructions
3. Explain the memory structures of the controllers (e.g Tasks, Programs, Routines, Organization Blocks, Functions, and Function Blocks.)
4. Download and Upload programs to/from a CPU
5. Using the RSLogix5000 software, review plant standard tasks, programs, routines, instructions, I/O configuration, and User-defined Data Types. Evaluate the logic and create Rung comments that would describe the action of the rung
6. Create a new Step 7 Project and configure all module properties using the “Hardware Catalog”
7. Match the description of specific types of Blocks a Step 7 Project to a given list:
  - Organization Block (OB): called by the operating system and are the interface between the user program and the CPU’s operating system. These blocks act as a scheduling mechanism of the program segments





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- Function (FC) : contain sections of the program that pertain to a particular function within the manufacturing process. These blocks are called by OB's or other blocks. They do not have an assigned memory area to hold data - local data is lost after the block is processed
- Function Block (FB): contains sections of the program that pertain to a particular function within the manufacturing process and are called by other blocks. These blocks included an assigned area of memory (a Data Block, for example) that can be accessed using variables
- Data Block (DB): provides memory for data variables
- Two types of data blocks:
  - Global DBs - where all OBs, FBs and FCs can read the stored data
  - Instance DBs - assigned to a certain FB

### PLC-14 Demonstrate the use of the data structures for PLCs

1. Define the data table files and structure, organization, and physical addressing for inputs and outputs
2. Access/ assign the data files or types for the systems to create addresses or tags names for the physical and inputs and outputs
3. Access and assign data types and structures for application elements
4. Access the Tag database viewer and interpret the information in the following areas – Input & output image tables, Timer and Counter areas (including modifications of the preset values)
5. Switch the displayed “Style” (radix) while viewing data tags
6. Assign Global PLC Tags to I/O Addresses using the TIA Portal software. Demonstrate using both keyboard entry and “Drag & Drop”
7. Create a new Step 7 Project and use the “Detect” option to automatically populate the associated hardware properties
8. Demonstrate the following in a lab exercise:
  - Create a PLC Tag for an analog input
  - Create a PLC Tag for an analog output
  - Create a program that displays the voltage of an analog input on an analog output device (display).

### PLC-15 Demonstrate and use the basic relay instructions files for PLCs

1. Use the XIC or NO instruction where appropriate for the signal logic applications
2. Explain the difference in the selection of the input relay instruction based on the signal and dependency for the application
3. Use the basic relay instruction to create interlocks
4. Use the basic relay instructions to create seal-in or holding circuits or set/reset logic circuit
5. Use internal bit in the sequencing of logic structures.







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6. Use the application's dependencies to construct implicit and implied logic structures
7. Perform minor edits on-line to the ladder logic to include relay, timer, and counter instructions
8. Add storage bits to a ladder routine, cross-reference their location throughout the program, toggle output bits on & off. Add software jumpers & rung output blocker bits
9. Add storage bits to Network, cross-reference their location throughout the Project. Add software jumpers & rung output blocker bits
10. Create and save simple PLC programs (Simple Start (N.O.-PB) - stop circuit (N/C-PB) using storage bit tags and one output lamp

### PLC-16 Demonstrate and use of timers and counters instructions files for PLCs

1. Describe the data structure of timer and counter instructions
2. Demonstrate the use Delay Timer On, Delay Timer Off, and Retentive timer instructions
3. Demonstrate how free running timers and cascaded timers are used in
4. applications
5. Demonstrate the use up and down counter instructions
6. Explain the use and application of the reset instruction
7. Construct a simple clamp and drill circuit, program and debug. This will be completed on pneumatic actuated lab stations. (Note the program will be given to the students with one logic error in the program. The students are to debug the program. The circuit will demonstrate anti-tie down and pinch point control)
8. Construct a simple clamp and drill circuit, program and debug. This will be completed on pneumatic actuated lab stations. (Note the program will be given to the students with one logic error in the program. The students are to debug the program. The circuit will demonstrate anti-tie down and pinch point control)

### PLC-17 Demonstrate the construction of Human Machine Interface (HMI) with a PLC application program

1. Demonstrate creating a new HMI application
2. Establish the link to the Tags used in the PLC application program
3. Demonstrate the transferring of an HMI application for execution
4. Create a HMI with Boolean Tags pushbuttons and indicator
5. Create a HMI using Timer tags and animation
6. Create a HMI to annunciate process status
7. Create a HMI using multiple screens
8. Construct an alarm screen to list process errors





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### **PLC-18 Analyze a problem with a systematic approach to troubleshoot an automated system**

1. Demonstrate a systematic approach using observations, test instruments, and software to determine the source of the problem
2. Identify using a systematic approach specific to mechanical troubleshooting as to the cause and resolution of the problem
3. Identify using a systematic approach specific to fluidic troubleshooting as to the cause and resolution of the problem
4. Identify using a systematic approach specific to electrical troubleshooting as to the cause and resolution of the problem
5. Identify using a systematic approach the cause and resolution of a control problem
6. Using the ControlLogix reference material, identify all indicators on a ControlLogix Processor module, determine whether the indicator represents normal or a faulted condition and identify the recommended recovery action for each possible condition
7. Identify what appears to be program anomalies when the program is running with Program Control Instructions (i.e. MCR, JMP, and LBL)
8. While viewing the Networks of an operating program, search for the output that the simulated machine is waiting for and identify the inhibitors to machine operation. Trace these inhibitors back to real world inputs
9. Troubleshoot faulty machine operation on training simulator with instructor induced faults
10. While viewing the ladder listing of an operating program, search for the output that the simulated machine is waiting for and identify the inhibitors to machine operation. Trace these inhibitors back to real world inputs
11. Given the RXlogix5000 ladder logic display, input and output module indicator conditions, and the associated voltage measurements that would be measured in the control panel, determine whether a failed input or output condition is due to a processor error “or” the input/output interfaces “or” a real world device/wiring issue
12. Using the RSLogix5000 software, reset electronic fuses on the 1756-OAD module
13. Construct a simple clamp and drill circuit, program and debug. This will be completed on pneumatic actuated lab stations. (Note the program will be given to the students with one logic error in the program. The students are to debug the program. The circuit will demonstrate anti-tie down and pinch point control)





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