ECET 4530

Industrial Motor Control

Programmable Logic Controllers

Programmable Logic Controllers

Programmable Logic Controllers, or PLCs, are real-time, event-driven, process-control computers that are used to automate electro-mechanical processes.

Originally used by the automotive industry to replace hard-wired, relay-logic control systems, PLCs were designed to withstand the stresses that may be present in an industrial setting such as vibration, electrical noise, dust, high humidity, and extreme operating temperatures.

Programmable Logic Controllers

Fundamental components of a PLC:

- **Central Processing Unit (CPU)**
- **Power Supply**
- **Input Module(s)**
- **Output Module(s)**

Additionally, a PLC may contain communication ports (RS-232, RS-485, Ethernet, Profinet, etc.) and/or a variety of other components.

Programmable Logic Controllers

The different components may be manufactured individually and connected together as part of a modular system, or they may be contained in a preconfigured enclosure that is assembled in the factory.

Allen-Bradley Compact-Logix Modular PLC

Allen-Bradley SLC-500 Preconfigured PLC

Modular PLCs

Modular PLCs can be configured using a variety of individual modules, each of which perform a specific function, the selection of which depends upon the needs of the system that the PLC will be used to control.

Allen-Bradley Compact-Logix PLC

Modular PLCs can easily be expanded or reconfigured to accommodate any changes in the controlled system.

Modular PLCs

Shown above is a modular Allen Bradley CompactLogix PLC that contains: a CPU, a 12-port input module, a 16-port output module, a power supply, a 16-port input module, and another 16-port output module.

Preconfigured PLCs

Preconfigured PLCs are factory assembled with a predefined set of components.

Although not as flexible as modular PLCs, preconfigured PLCs are often relatively inexpensive and come in a variety of configurations that are well-suited for many different applications.

Allen Bradley SLC-500 PLC

Preconfigured PLCs

Shown above is a preconfigured Allen Bradley SLC-500 PLC that contains: a CPU, a power supply, 12 input ports, 8 output ports, and an RS-485 serial communication port.

PLC Components – CPU

The CPU typically contains a microprocessor, the system memory, communication ports, and any other peripheral components that are required for operation.

Allen-Bradley Compact-Logix PLC

The PLC's overall operation is determined by a program that is typically down-loaded into the CPU's memory from an external computer via a serial or network port.

PLC Components – Input / Output

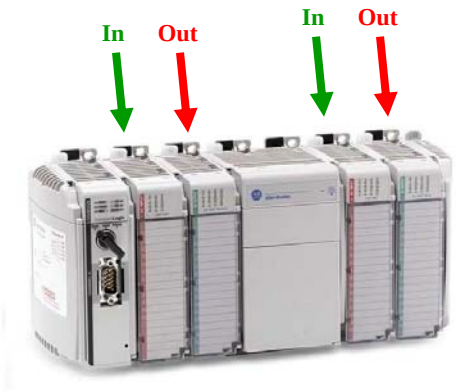
Traditionally, PLCs communicate with the various control system components by means of a set of input and output ports.

Newer PLCs often have communication or network ports that allow for communication with remote (I/O) system components via signals sent over a communication bus or via packets of data sent over a computer network.

Allen-Bradley Point I/O

PLC Components – I/O Modules

The <u>Input and Output Modules</u> contain ports that allow the PLC to interface with the other control system components.



Allen-Bradley Compact-Logix PLC

A <u>port</u> is an electrical interface that allows the PLC's CPU to either receive signals from external devices (such as push-buttons) or to send electrical signals to external devices (such as the field-coil of a contactor).

PLC Components – I/O Modules

The <u>input ports</u> provide the means for the CPU to receive control signals or other information from any switches, pushbuttons, sensors, detectors, or other pilot devices connected to the system.

The <u>outputs ports</u> provide the means for the CPU to control or send signals to any external system devices such as relays, contactors, actuators, valves, or indicator lamps.

PLC Components – Input / Output

During operation, the PLC continuously monitors its input ports and, based upon their state, adjusts the state of its output ports.

<u>For Example</u>: A "Start" button is pressed, temporarily supplying +24V_{DC} to one of the PLC's input ports.

The PLC detects the +24V_{DC} (high) voltage at its input port, and responds by activating one of its output ports.

The activated output port supplies 120V_{AC} to the field-coil of a contactor, causing the contactor to actuate its main contacts, in-turn supplying 208V to an induction motor.

PLC Components – Input Ports

A PLC's inputs ports are typically classified into two types:

<u>Discrete Inputs</u> and <u>Analog Inputs</u>.

PLC Components – Input Ports

A PLC's inputs ports are typically classified into two types:

Discrete Inputs and Analog Inputs**.**

Discrete Inputs are used to detect signals that can have two states that are often described as:

"True/False", "On/Off", "High/Low", "1/0"…

Many PLCs have discrete inputs that are rated for $24V_{DC}$. A $24V_{DC}$ input will register "True" if a $+24V_{DC}$ signal is applied to its terminal and it will register "False" if the $+24V_{DC}$ signal is removed from its terminal.

PLC Components – Input Ports

A PLC's inputs ports are typically classified into two types:

Discrete Inputs and **Analog Inputs.**

Analog Inputs are used to detect signals that can take-on a range of values, such as the variable-magnitude DC voltage that a temperature sensor outputs in order to indicate the sensed temperature.

Common analog input-signal ranges include:

0V to +10V, –10V to +10V, 0mA to 20mA, …

PLC Components – Output Ports

A PLC's outputs ports are typically classified into two types:

Discrete Outputs and Analog Outputs .

Discrete Outputs provide output signals that have two states; either "on" or "off"

Analog Outputs provide output signals that take on a range of values.

PLC Components – Output Ports

Discrete Outputs provide output signals that have two states; either "on" or "off".

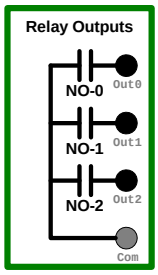
Discrete outputs can be further classified into two subcategories:

Relay Outputs and Electronic Outputs.

PLC Components – Output Ports

Relay Outputs are discrete outputs that utilize physical relay contacts to either make or break external circuits connected to their terminals.

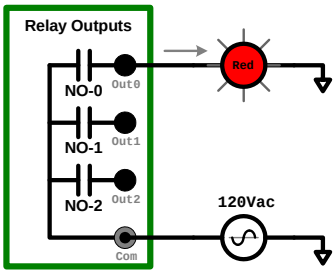
Relay outputs often have a common terminal that is connected to either the energized conductor of a voltage source or to ground depending on whether it is a sourcing or sinking output.



PLC Components – Output Ports

Relay Outputs are discrete outputs that utilize physical relay contacts to either make or break external circuits connected to their terminals.

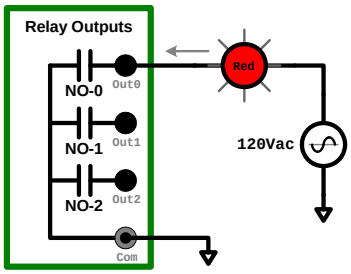
A sourcing output is an output that "sources" or pushes current through the load. For this type of output, a source is connected to the common terminal.



PLC Components – Output Ports

Relay Outputs are discrete outputs that utilize physical relay contacts to either make or break external circuits connected to their terminals.

A sinking output is an output that "sinks" or pulls current from the load. For this type of output, the common terminal is grounded.



PLC Components – Output Ports

Electronic Outputs are outputs that utilize transistors or other semiconductor devices to drive the field device (load).

Depending on the type of electronics used, they can either provide a discrete output signal or an analog output signal to the field device.

PLC Components – Output Ports

<u>Operational Note</u> – Although output ports can be used to energize field devices, the ports themselves typically have limited current capabilities and thus are restricted to supplying control-type devices such as indicator lamps or field-coils from a relay or contactor.

Thus, a large motor would <u>not</u> be supplied directly by these ports, instead requiring the use of a contactor to provide the high-power connection.

Simple PLC-based Motor Controller

<u>Example – PLC-based Motor Controller</u>

Design a Start/Stop motor controller that energizes the field-coil of a contactor when the "start" button is pressed and de-energizes the field-coil when a "stop" button is pressed.

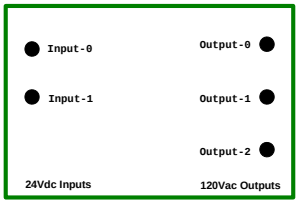
Include as part of the controller a red indicator that illuminates when the field-coil is energized (i.e. – the motor is running) and a green indicator that illuminates when the field-coil is de-energized (i.e. – the motor is stopped).

Simple PLC-based Motor Controller

PLC with 2 Discrete Inputs and 3 Relay Outputs

Input State: **True → +24V$_{dc}$ detected at terminal**
False → 0V$_{dc}$ detected at terminal

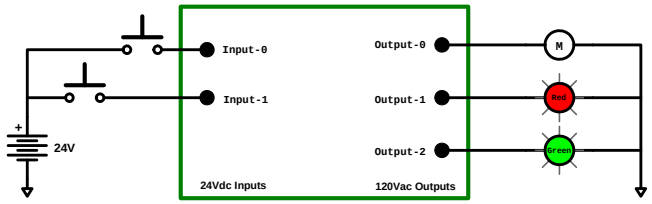
Output State: **True → 120V$_{ac}$ present at terminal**
False → 0V$_{ac}$ present at terminal



Simple PLC-based Motor Controller

PLC with 2 Discrete Inputs and 3 Relay Outputs

Logic: If Input-0 "True" → Set/Hold Output-0 "True"
Set/Hold Output-1 "True"
Set/Hold Output-2 "False"
If Input-0 "False" → No change.

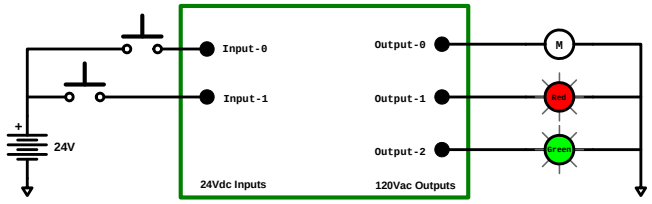


Simple PLC-based Motor Controller

PLC with 2 Discrete Inputs and 3 Relay Outputs

Logic: If Input-1 "True" → Set/Hold Output-0 "False"
Set/Hold Output-1 "False"
Set/Hold Output-2 "True"

If Input-1 "False" → No change.



Simple PLC-based Motor Controller

PLC with 2 Discrete Inputs and 3 Relay Outputs

Note that the program required to provide the operational logic will be discussed at a later time.