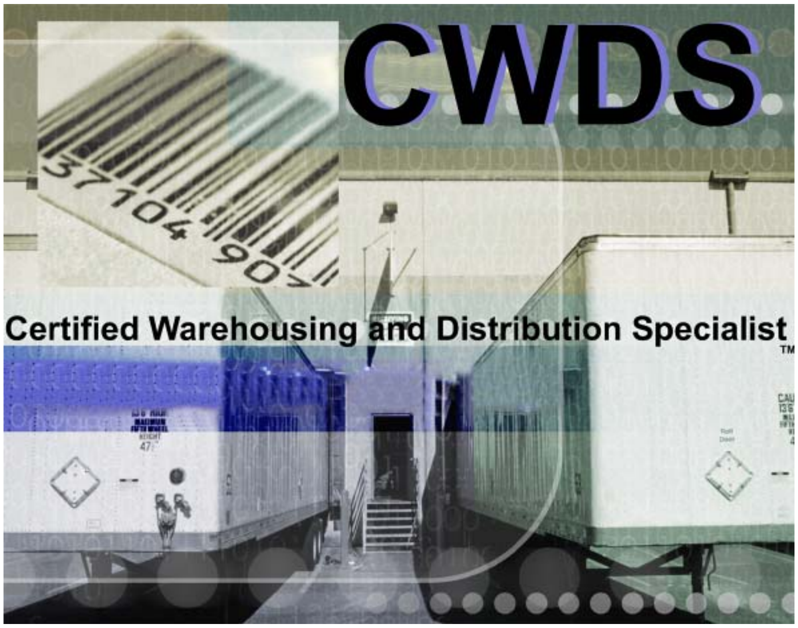


Instructor Guide

Introduction to Industrial Controls

QUICKSTART®
TECHNICAL COLLEGE SYSTEM OF GEORGIA

Published August 2002
(G081502)

Table of Contents

Unit Description

Overview

Industrial control circuits assist in performing very simple to sometimes very complex tasks that might otherwise have to be performed manually. Some control circuits may perform simple functions such as signaling when an operation is complete. Others may be highly developed programmable control circuits used to monitor, make decisions and control operations throughout the complete manufacturing process.

In a simple home heating system a control circuit is used to monitor room temperature and signal the heating unit to operate when the temperature falls below a certain level. In industry they may be used to monitor quality, send instructions to automatic equipment or control the flow of a product in a production line.

Industrial control circuits respond as designed without changes or surprises. Many control circuits are designed to be very adaptable to changing conditions or manufacturing processes.

A basic understanding of industrial control circuits is helpful for those working in manufacturing environments and will aid in the overall understanding of manufacturing processes.

Objectives

The information, activities, and practice provided during this unit will enable participants to:

1. Identify the basic purpose and the three sections of a control circuit.
2. Name three common switches used to control industrial components.
3. State three purposes of a relay.
4. Identify the different types of logic used in control circuits.
5. State the purpose and function of a Programmable Logic Controller.

Materials

1. Participant Guides
2. Projection System

PowerPoint Slides

1. Introduction to Industrial Controls
2. Objectives
3. Basic Control Circuit
4. Open Contacts
5. Basic Concept of Industrial Control Circuits
6. Contact Blocks
7. Manual Pushbutton Switch
8. Plunger Type Limit Switch
9. Pressure Switch
10. Basic Relay

11. AND Logic
12. OR Logic
13. NOT Logic
14. NOR Logic
15. NAND Logic
16. MEMORY Logic
17. Parts of a Programmable Logic Controller

Agenda

Introduction	5 minutes
Control Circuits	15 minutes
Programmable Logic Controllers	15 minutes
Summary	5 minutes
Industrial Controls Unit Assessment	20 minutes
Performance Exercises	60 minutes
Total	**2 hours**

Introduction

Overview

DISPLAY the slide titled "Introduction to Industrial Controls."

DIRECT the participants to the "Introduction" in the Participant Guide.

EXPLAIN that industrial control circuits assist in performing very simple to sometimes very complex tasks that might otherwise have to be performed manually. Some control circuits may perform simple functions such as signaling when an operation is complete. Others may be highly developed programmable control circuits used to monitor, make decisions and control operations throughout the complete manufacturing process.

STATE that in a simple home heating system a control circuit is used to monitor room temperature and signal the heating unit to operate when the temperature falls below a certain level. In industry they may be used to monitor quality, send instructions to automatic equipment or control the flow of a product in a production line.

CONTINUE by stating that industrial control circuits respond as designed without changes or surprises. Many control circuits are designed to be very adaptable to changing conditions or manufacturing processes.

SAY: "A basic understanding of industrial control circuits is helpful for those working in manufacturing environments and will aid in the overall understanding of manufacturing processes."

Objectives

DISPLAY the slide titled "Objectives."

REVIEW the unit objectives with the participants.

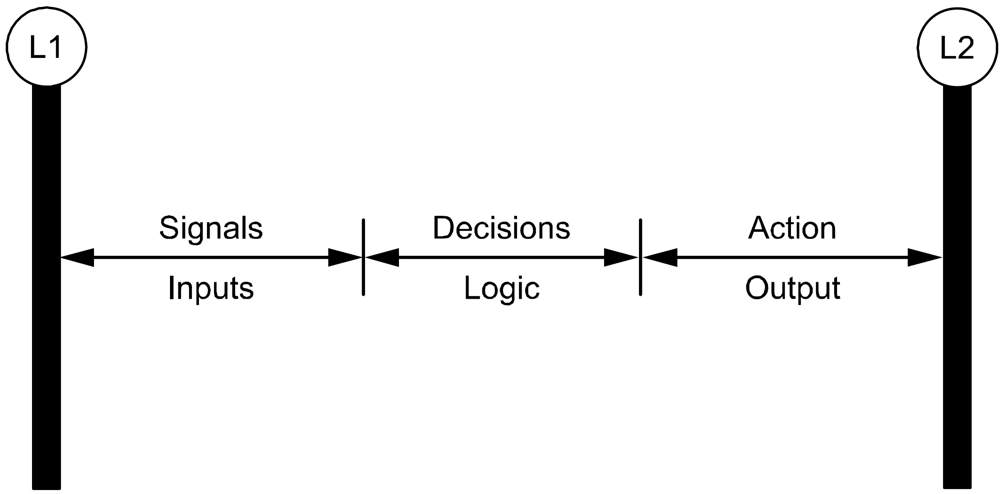
STATE that the information, activities, and practice provided during this unit will enable participants to:

1. Identify the basic purpose and the three sections of a control circuit.
2. Name three common switches used to control industrial components.
3. State three purposes of a relay.
4. Identify the different types of logic used in control circuits.
5. State the purpose and function of a Programmable Logic Controller.

Control Circuits

DIRECT the participant to the section titled "Control Circuits" in the Participant Guide.

DISPLAY the slide titled "Basic Control Circuit."



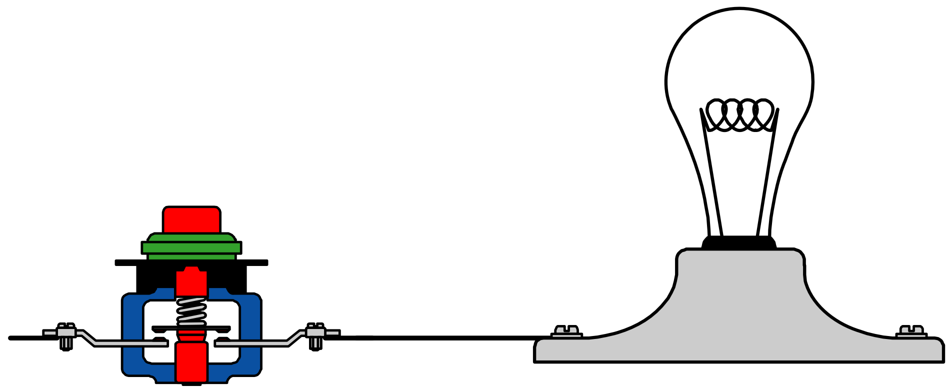
Basic Control Circuit

EXPLAIN that the concept of industrial control circuits is to accomplish specific work in a predetermined manner. In other words, the industrial control circuit must respond as designed, without any changes. To accomplish consistency, all industrial control circuits are composed of the signal, or input, the decision, or logic, and the action, or output.

CONTINUE by stating that a complete comprehension of industrial control circuit concepts paves the way for knowledge of any of the existing industrial control circuits, past, present, or future.

Signals – Inputs

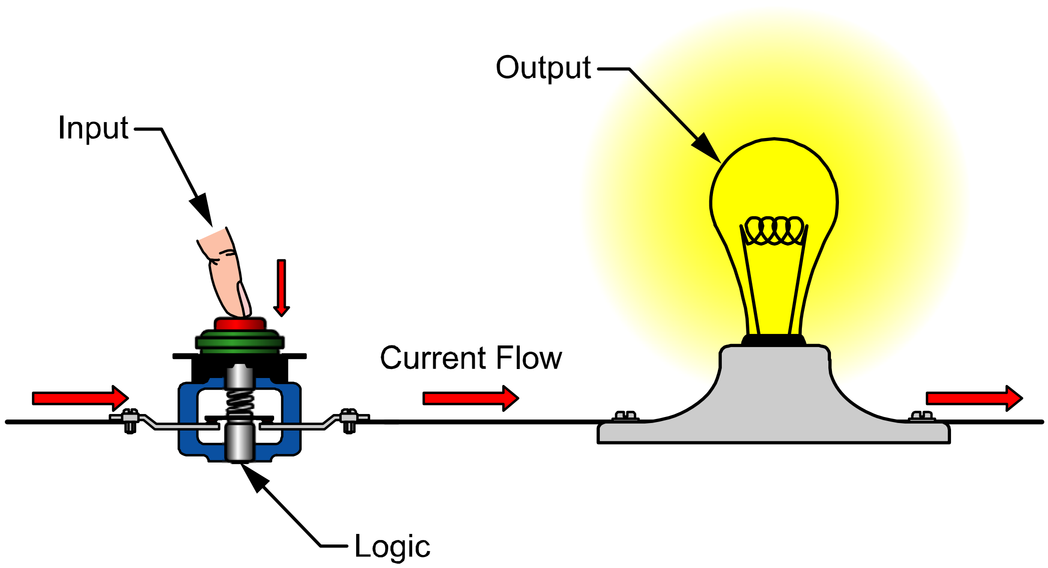
DISPLAY the slide titled “Open Contacts.”



Open Contacts

EXPLAIN that a signal starts or stops the flow of current by closing or opening a control device’s contacts. If the contacts are closed, current is allowed to flow through the control device. If the contacts are opened, current is not allowed to flow through the control device.

DISPLAY the slide titled “Basic Concept of Industrial Control Circuits.”

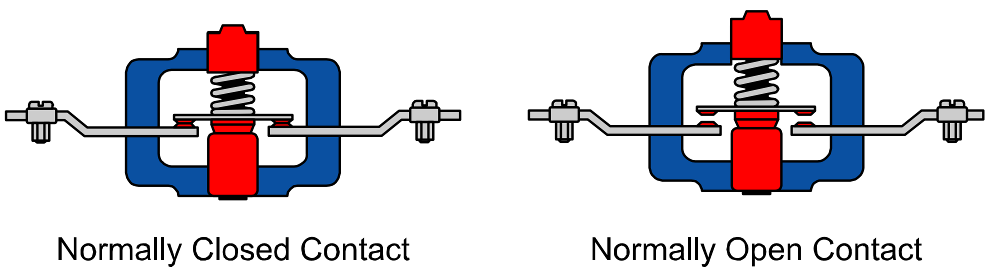


Basic Concept of Industrial Control Circuits

EXPLAIN that the entire concept of industrial control circuits starts with the signal or input, logic or a decision occurs, and output or action is the result.

CONTINUE by explaining that some of the common input devices used to control industrial components are pushbutton switches, limit switches, foot switches, temperature, pressure, and proximity switches.

DISPLAY the slide titled “Contact Blocks.”

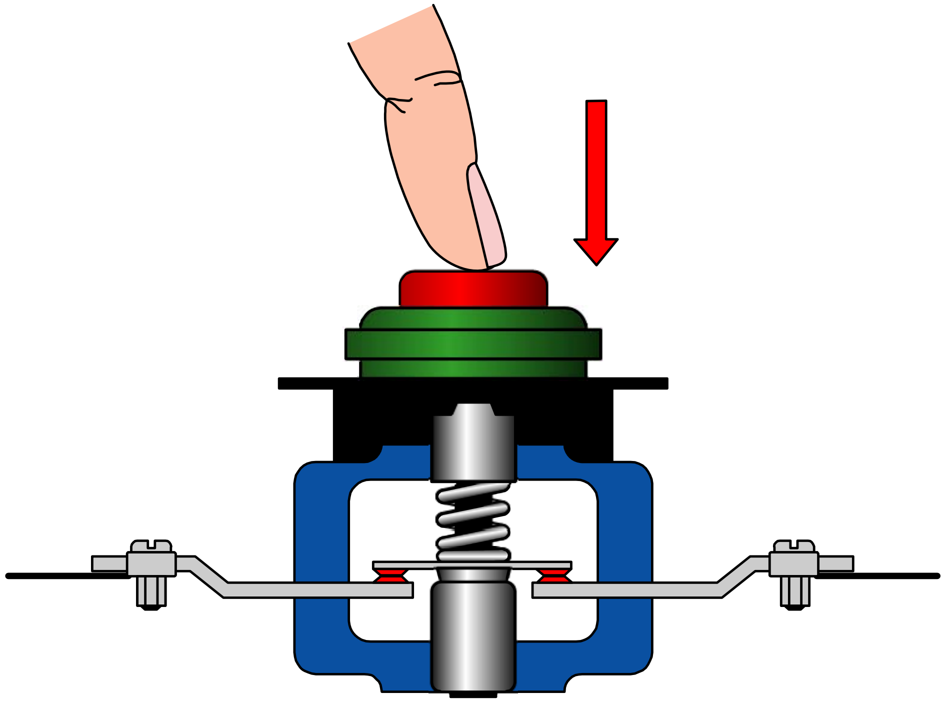


Contact Blocks

EXPLAIN that the purpose of a switch is to establish (close contacts) or interrupt (open contacts) a path for current flow. Contacts are designated by normal position, either normally open or normally closed.

FURTHER explain that all signals are dependent upon some condition that must take place. The condition can be manual, mechanical, or automatic.

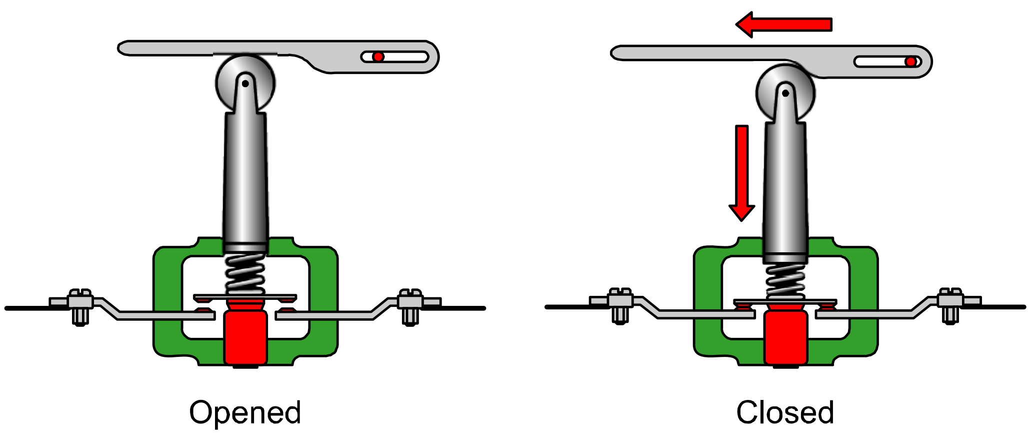
DISPLAY the slide titled "Manual Pushbutton Switch."



Manual Pushbutton Switch

EXPLAIN that a manual condition is any input into the circuit by a person. A pushbutton switch is a device that responds to a manual condition.

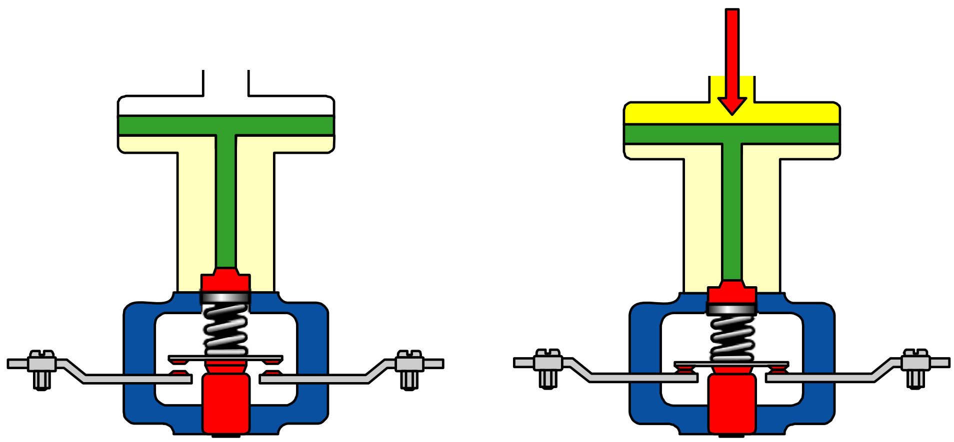
DISPLAY the slide titled "Plunger Type Limit Switch."



Plunger Type Limit Switch

EXPLAIN that a mechanical condition is any input into the circuit by a mechanically activated device. A limit switch is a good example of a control device that would respond to a mechanical input. When a moving object, such as a box, hits a limit switch, the limit switch usually has a lever, roller, ball, or plunger type actuator to cause a set of contacts to open or close without further assistance.

DISPLAY the slide titled "Pressure Switch."

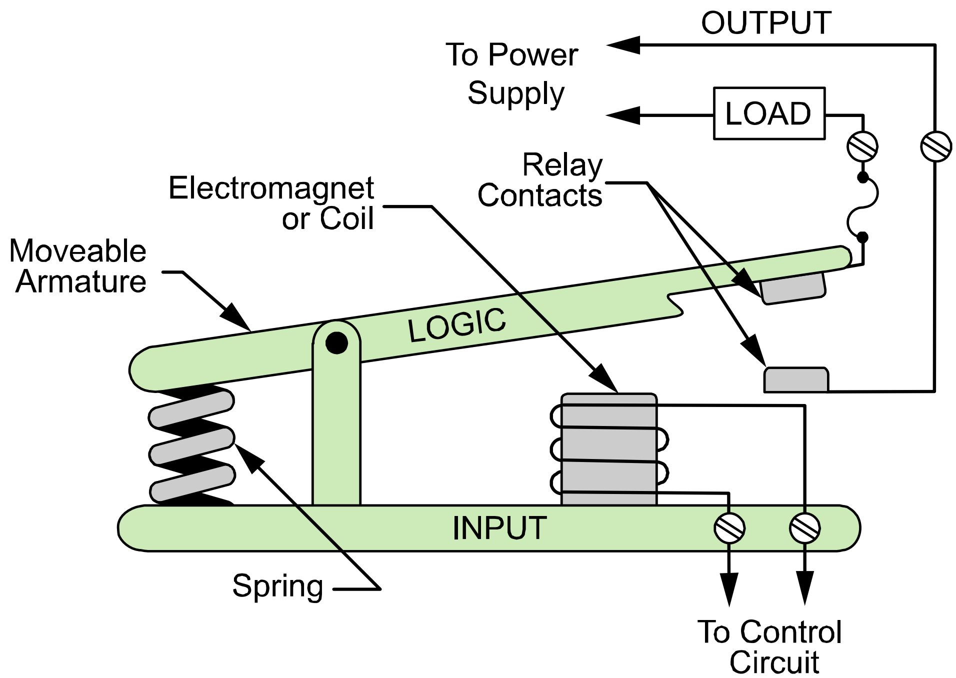


Pressure Switch

EXPLAIN that an automatic condition is a condition which responds to changes in a system. Flow, temperature, and pressure switches are good examples of automatic conditions controls. When a change in the flow of a liquid is created, a change in temperature is sensed, or a pressure variance is detected, automatic controls can open and close sets of contacts.

Relay

DISPLAY the slide titled "Basic Relay."



Basic Relay

EXPLAIN that a relay is a special type of switch or industrial control device that is operated by a magnetic coil. When the coil is energized, the resulting magnetism moves an armature which opens and closes sets of contacts. The magnetic coil is controlled by a separate switch.

CONCLUDE the discussion of relays by stating that relays can be used to control equipment from remote locations, control multiple devices from one switch location, and control high voltage equipment from a low voltage switch.

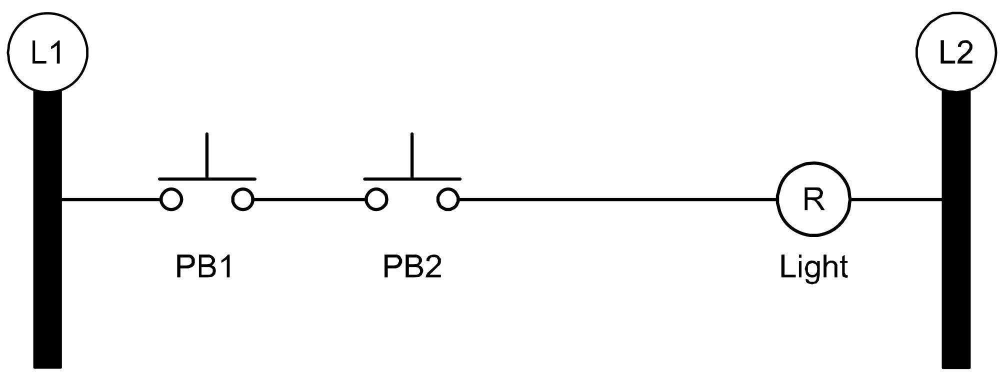
Basic Decision – Logic

DIRECT the participant to the section titled "Basic Decision – Logic" in the Participant Guide.

EXPLAIN that the decision part of the circuit determines what work is to be done, and in what order. The decision part of the circuit is the part that adds, subtracts, sorts out, selects, and redirects the signals from the industrial control device to the output. In order for the decision part of the circuit to perform a definite sequence of outputs, the decisions must be made in a logical manner. The way the industrial control devices are connected into the circuit gives the circuit some "logic" function. Six "logic" functions are AND, OR, NOT, NOR, NAND, and MEMORY.

AND Logic

DISPLAY the slide titled "AND Logic."

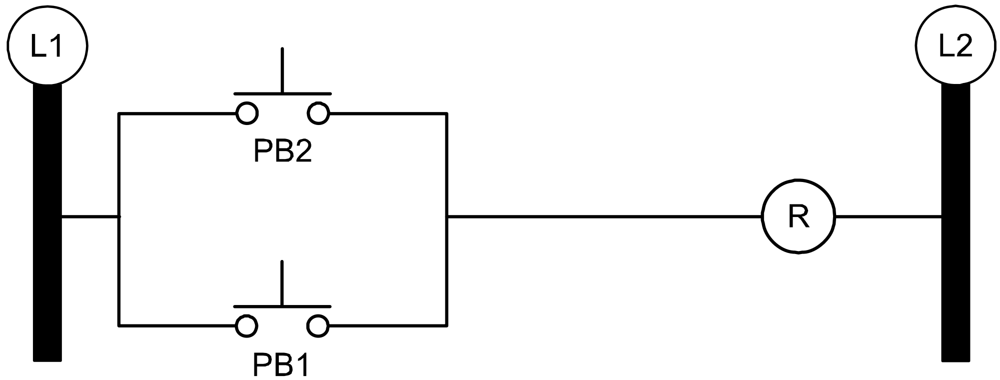


AND Logic

EXPLAIN that AND logic is the condition in which two or more inputs (signals) are used in such a way that all inputs (signals) are required for the circuit to provide an output (action). In other words, "this input (signal) AND that input (signal)" must be received. A simple example is turning on a light. Pushbutton one (PB1) and pushbutton two (PB2) must be activated for the light to be energized.

OR Logic

DISPLAY the slide titled "OR Logic."

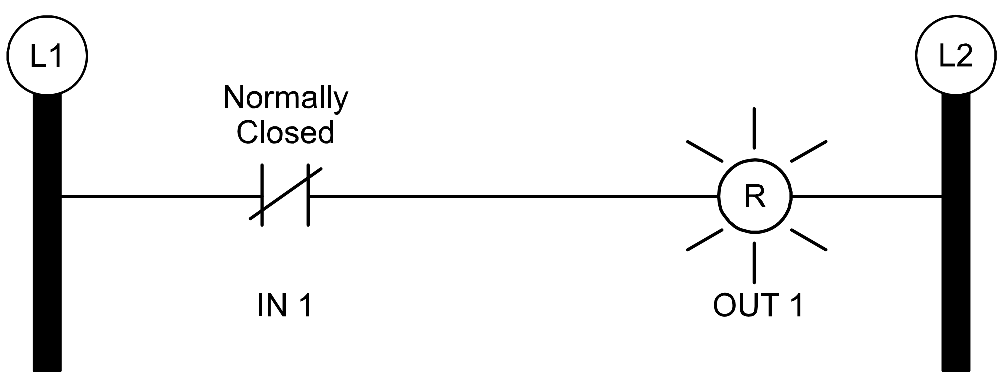


OR Logic

EXPLAIN that OR logic is the condition in which two or more inputs (signals) are used in such a way that any one input (signal) provides an output (action). In other words, "this input (signal) OR that input (signal)" must be received. An example of OR logic is in a home that has two doorbell buttons controlling one bell. The bell may be energized by pressing the front doorbell button OR the back doorbell button.

NOT Logic

DISPLAY the slide titled "NOT Logic."

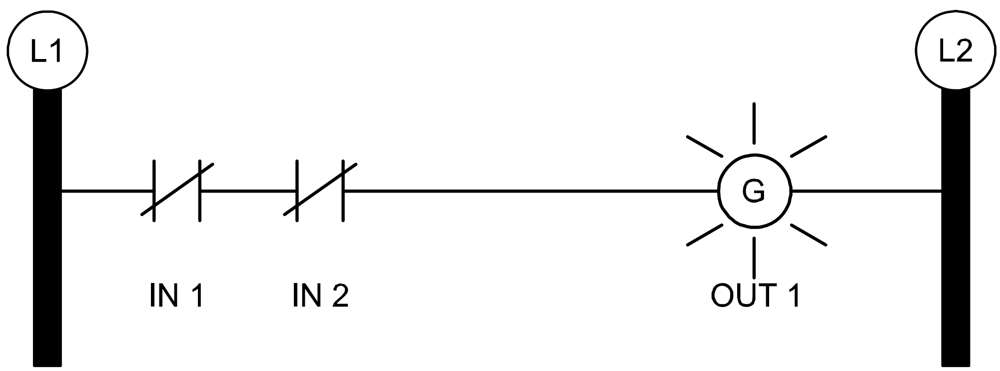


NOT Logic

EXPLAIN that AND and OR logic both use control devices that have normally open contacts. Normally open contacts indicate that when there in no input (signal) to the control device, the contacts remain open in the circuit. If normally closed contacts are used instead of normally open contacts, the logic function changes. An example of NOT logic is a simple light switch. If the switch is normally closed (the light is ON) at night, the light is energized only if the switch is NOT opened. To open the switch turns the light OFF.

NOR Logic

DISPLAY the slide titled "NOR Logic."

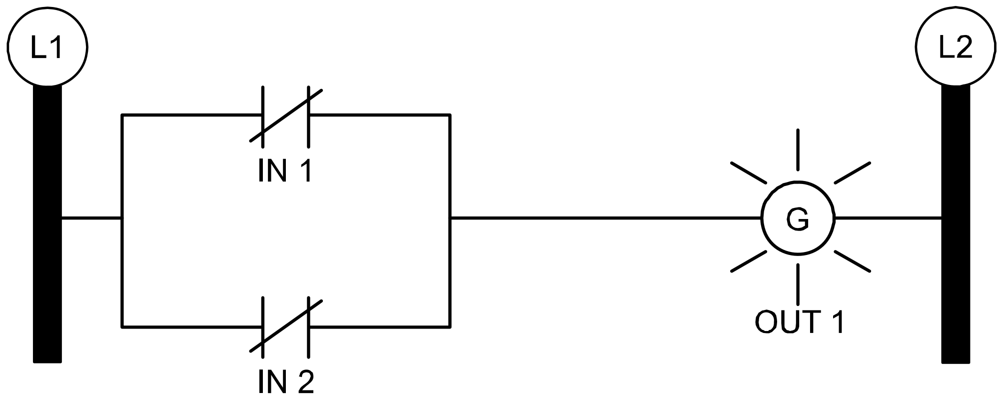


NOR Logic

EXPLAIN that NOR logic is an extension of NOT logic in that two or more normally closed contacts in series are used to control an output (action). A good example of NOR logic in industry is a safety circuit that uses two or more emergency STOP buttons to provide a means for stopping a machine in an emergency. Pressing one safety STOP button de-energizes the machine. In order for the machine to keep operating, the STOP button on one control panel must not be pushed NOR must the STOP button on any other control panel be pushed.

NAND Logic

DISPLAY the slide titled "NAND Logic."

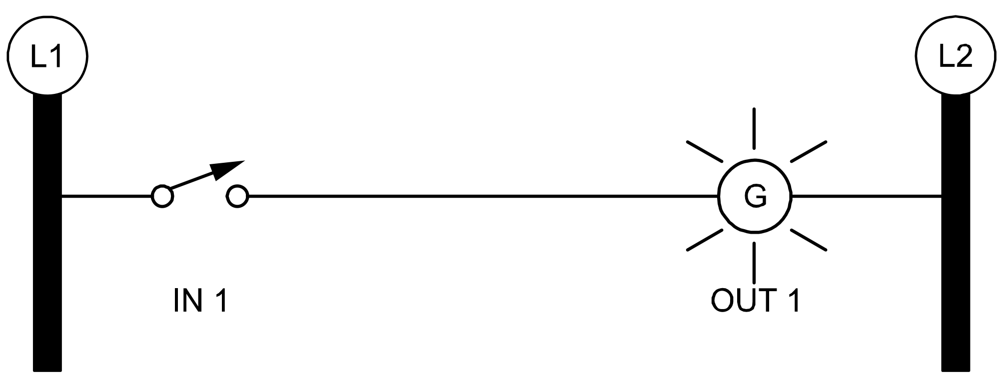


NAND Logic

EXPLAIN that NAND logic is also an extension of AND and NOT logic. An example would be two switches controlling the same light in a room. In order for the light to stay on, there must not be an input (signal) at one switch AND there must not be an input (signal) at the other switch.

MEMORY Logic

DISPLAY the slide titled "MEMORY Logic."



MEMORY Logic

EXPLAIN that some electrical control circuits need to be able to store, remember, or maintain the logic attained from an input (signal) after the input (signal) has been removed. A simple example of a circuit that uses MEMORY logic is a switch that controls a light from only one location. After the switch is operated, the light remains ON or OFF until further operation. In other words, when the switch is ON, the light remains on until the light is turned OFF and remains off until the light is turned ON. The switch performs MEMORY logic because the output (action) corresponds to the last input (signal).

Action – Output

DIRECT the participants to the section titled "Action – Output" in the Participant Guide.

EXPLAIN that, once a signal (input) is generated, and the decision (logic) within a circuit has been made to open or close, some type of action (output) results. In most cases, the results (output) is energizing the operating coil in the circuit, which is responsible for initiating action (output). The action (output) is indirect when the coil in solenoids, magnetic starters, and relays are energized. Action (output) is indirect because the coil energized by the signal (input) and the decision (logic) may in turn energize a magnetic motor starter, which actually starts the motor. Regardless of how action takes place, the signal (input) causes some action (output) which is direct or indirect in the circuit, and the signal (input) is called the action (output) part of the circuit.

Programmable Logic Controllers

DIRECT the participants to the section titled "Programmable Logic Controllers" in the Participant Guide.

EXPLAIN that programmable logic controllers are electrical devices designed to control machines and industrial processes automatically. Programmable logic controllers are capable of many industrial function and applications, and are now widely used in automated industrial application. Programmable logic controllers have become popular because the way a machine or process is supposed to operate can be programmed and, as processes and manufacturing needs change, the controllers can be altered with a few strokes on a keyboard. Programmable logic controllers have enabled industry to make changes without going through costly retooling or designing new components

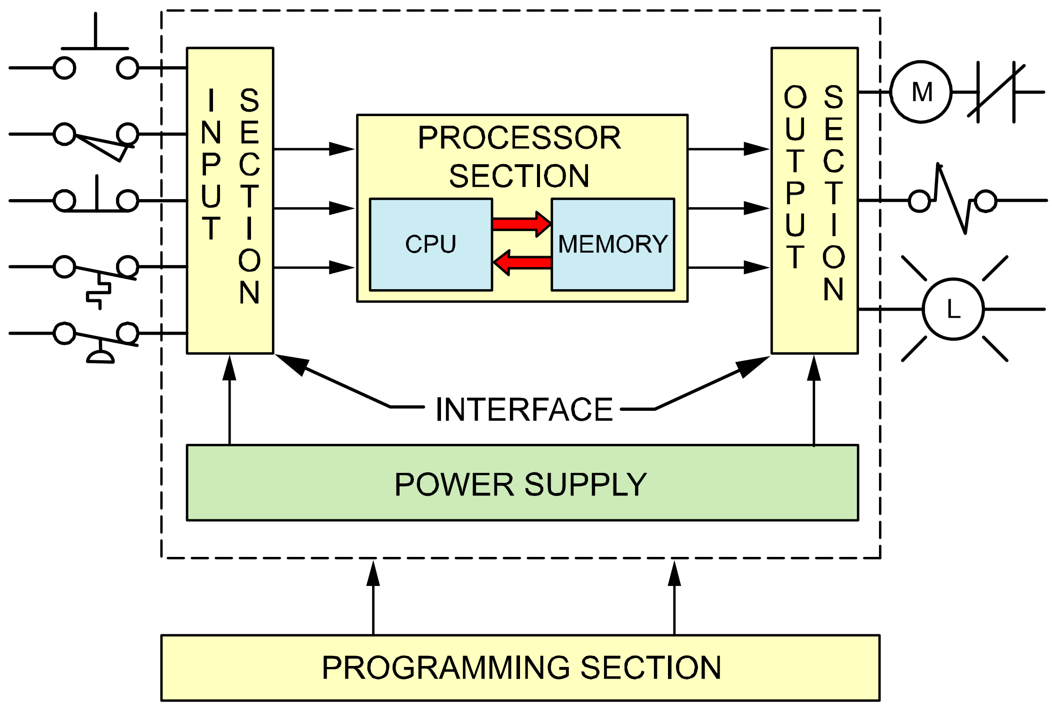
CONTINUE by listing the additionally advantages of programmable logic controllers to include:

1. A reduction in hard wiring and wiring costs.
2. Reduced space requirements due to a much smaller size as compared to using other control components.
3. Flexible control because all operations are programmable.
4. Microprocessor-based memory allows storage of large programs and data.
5. Improved on-line monitoring and troubleshooting by monitoring and diagnosing the programmable logic controllers' failures as well as the machines and processes the programmable logic controller controls.
6. Eliminates the need to stop a controlled process to change operations.
7. Modular design allows components to be added, substituted, and rearranged as requirements change.

Parts of a Programmable Logic Controller

DIRECT the participants to the section titled "Parts of a Programmable Logic Controller" in the Participant Guide.

DISPLAY the slide titled "Parts of a Programmable Logic Controller."



Parts of a Programmable Logic Controller

EXPLAIN that all programmable logic controllers have the same basic parts and characteristics. The four basic parts of the programmable logic controller are the power supply, input/output interface sections, processor section, and the programming section.

Power Supply

DIRECT the participants to the section titled "Power Supply" in the Participant Guide.

EXPLAIN that the power supply provides all the necessary voltage levels required for the programmable logic controller's internal operations. The power supply also charges an internal battery in the programmable logic controller to prevents loss of memory should the external power supply be removed.

Input/output Interface Section

DIRECT the participants to the section titled "Input/output Interface Section" in the Participant Guide.

EXPLAIN that the input/output interface section functions as the clearing house for the signals (input) received by the programmable logic controller. The input (signal) section is designed to receive information from push-buttons, temperature switches, and other sensors. The output (action) section is designed to deliver the output (action) signal required to control alarms, lights, solenoids, starters, and other supports.

CONTINUE by stating that the input (signal) section receives incoming signals and decodes the signals and sends the signals to the digital processor section. The output (action) section receives digital signals from the processor, decodes the signals, and sends the power to drive industrial equipment that can light, move, grip, rotate, extend, release, heat, and perform other work.

Discrete I/O

EXPLAIN that the most common type of input (signal) and output (action) is the discrete type. Discrete I/O is a signal (input) that is separate and distinct, such as ON/OFF, open/closed, and STOP/START. Examples of discrete inputs (signals) are push-buttons, selector switches, joy sticks, relay contacts, and limit switches. Discrete outputs (action) include lights, relays, solenoids, starters, alarms valves, heating elements, and motors.

Data I/O

EXPLAIN that, in many applications, more complex information is required than the simple discrete I/O is capable of handling. Processes require more than a simple “yes” or “no” answer. In some instances, a measurement is required, or a temperature must be maintained. In other words, specific data must be transferred, and the data of inputs (signal) and outputs (action) are called data I/O.

Processor Section

PARTICIPANT GUIDE

DIRECT the participants to the section titled “Processor Section” in the Participant Guide.

EXPLAIN that the processor section is the brain of the programmable logic controller. The processor section evaluates all input (signal) from the input interface section. The data is compared to the memory in the programmable logic controller which contains the logic of how the inputs (signal) are interconnected in the circuit. Based on the input (signal) conditions and the memory of what task is to be accomplished, the processor section then controls the outputs (action).

Programming Section

PARTICIPANT GUIDE

DIRECT the participants to the section titled “Programming Interface Section” in the Participant Guide.

EXPLAIN that the programming section of the programmable logic controller allows instructions to be sent to the programmable logic controller through a keyboard. Even though the programmable logic controller has a brain (the processor section), the programmable logic controller must be told what to do. The processor section must be given exact, step-by-step directions which include communicating to the processor section such things as load, set, reset, clear, enter in, move, and start timing. All the instructions are given to the programming section, and the programmable logic controller does the rest.

Summary

DIRECT the participants to the "Summary" in the Participant Guide.

DISCUSS the Summary.

The concept of industrial controls is to accomplish specific work in a predetermined manner. All industrial control circuits are composed of the signal, or input, the decision, or logic, and the action, or output.

The entire concept of industrial control circuits starts with the signal (input), then logic (decision) occurs, and output (action) is the result.

All signals (inputs) are dependent on some condition that must be present, such as a manual condition, mechanical condition, or an automatic condition. A manual condition is any input into the circuit by a person, a mechanical condition is any input into the circuit by a mechanically activated device, and an automatic condition is a condition which responds to changes in a circuit controlled system.

A relay is a special type of switch or industrial control device that is operated by a magnetic coil.

The decision or logic part of the circuit determines what work is to be done, and in what order. Six "logic" functions are AND, OR, NOT, NOR, NAND, and MEMORY. AND logic determines that "this input (signal) AND that input (signal)" must be received. OR logic determines that "this input (signal) OR that input (signal)" must be received. NOT logic determines that, if a switch is normally closed and the light is on at night, the stays lit only if the switch is NOT opened. NOR logic dictates that, in order for a machine to keep operating the STOP button on one control panel must not be pushed NOR must the stop button on any other control panel be pushed. NAND logic dictates that, in order for a light to stay on, there must Not be input (signal) at one switch AND there must not be input (signal) at another switch.

MEMORY logic dictates that the switch performs MEMORY logic because the output (action) corresponds to the last input (signal received).

Once a signal (input) is generated, and the decision (logic) within a circuit has been made to open or close, some type of action (output) results.

Programmable logic controllers are electrical devices designed to control machines and industrial processes automatically. The four basic parts of the programmable logic controller are the power supply, input/output interface sections, processor section, and the programming section.

The power supply provides all the necessary voltage levels required for the programmable logic controller's internal operations. The input/output interface section functions as the clearing house for the signals (input) received by the programmable logic controller. Sort of the mail sorter of the programmable logic controller.

Discrete I/O is a signal (input) that is separate and distinct, such as ON/OFF, open/close, and STOP/START. Data I/O is input (signal) that requires more information than a simple "yes or no." Some measurement or data must be transferred.

The processor section is the brain of the programmable logic controller and sorts through all the input (signal), contains the logic (decision), and determines what action (output) to take.

The programming section of the programmable logic controller allows instructions to be sent to the programmable logic controller through a computer keyboard, in order to make changes and adjust to system alterations.

HAND OUT the Industrial Controls Assessment after discussing the Summary.

COLLECT and review answers to the assessment when the class has finished.

Glossary

Action	Output or results which occur when a circuit is opened or closed.
AND Logic	Logic involving a circuit with two or more inputs (signal) and a single output (action).
Automatic Condition	Circumstance that causes an industrial control to open or close sets of contacts without input from any other source.
Input	Signal which starts or stops the flow of current by closing or opening a control device's contacts.
Memory	Information storage facility of a programmable controller.
Manual Condition	Any input (signal) in a circuit by a person.
Mechanical Condition	Any input (signal) in a circuit by a mechanically moving component.
MEMORY Logic	Ability of a circuit to store the last input (signal) to maintain the current output (action).
NAND Logic	Circuit with two or more inputs (signal), all of which must not have input (signal) in order to continue the output (action).
NOR Logic	Circuit with two or more inputs (signal), all of which must not be activated in order to continue the output (action).

NOT Logic	Circuit with one circuit which, in order to remain as is, there must NOT be a condition or input (signal) to the circuit.
OR Logic	Circuit with two or more inputs (signal), one of which must be activated in order to produce a single output (action).
Output	The result of any action by any condition that causes action.
Programmable Logic Controller	Electrical device designed to control machines and industrial processes automatically.
Relay	Industrial control device that responds to current or voltage changes by activating switches or other devices in a circuit.
Switch	Device that is used to open and close an electrical circuit, or to divert current from one conductor to another.

Appendix

Practice Exercises

Materials Needed

1. Contact block
2. Push-button switch
3. Plunger type limit switch
4. Pressure Switch
5. Relay
6. Programmable Logic Controller (PLC)

Exercise Sets

Exercise Set 1

1. Discuss the concepts discussed in the unit with regard to the input, logic, and output using the contact blocks.
2. Discuss the three conditions for signals – manual, mechanical, and automatic conditions – using the various switches.

Exercise Set 2

1. Exhibit and discuss a basic PLC, including discrete and data input/output, the various logic employed, and how each part of a PLC interacts with the other parts.
2. Allow the participants to experiment with the PLC and perform some programming functions using the mobile laboratory.