Ethiopian TVET-System

Electro Mechanical Equipment Operation and Maintenance

Level –III

Based on March, 2017G.C. Occupational Standard

Module Title: - Operating and Installing Programmable Logic Controller System

TTLM Code: EIS EME3 TTLM 09 20-V1

September, 2020

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This module includes the following Learning Guides

LG59: Plan and prepare for installation

LG Code: - EIS EME3 M11LO1-LG-59

LG 60: Write and test basic programs using a hand program loader

LG Code: - EIS EME3 M11LO2-LG-60

LG61: Edit and monitor basic programs using a hand program loader

LG Code: - EIS EME3 M11LO3-LG-61

Instruction Sheet-1	Learning Guide 40: Plan and prepare for installation

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- Observing OHS policies and procedures
- Reading and Interpreter Work instructions
- Selecting Tools and testing devices
- Obtaining Materials and components

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Observe OHS policies and procedures.
- Read and interpreter Work instructions.
- Select Tools and testing devices to carry out the installation work.
- Obtain Materials and components in accordance with job requirements.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 5”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4 ,” in each information sheets on pages 3,6,9and 23.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2 and 3 on pages 28,29 and 30.and do the LAP Test on page 31”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Observing OHS policies and procedures

OH&S Policies and Procedures are a major part of protecting the safety, health and welfare of people engaged in work or employment. Having a clear set of OHS Policies and Procedures will make it clear to all concerned where the guidelines and boundaries are in relation to the operation of the organization. As an employer you are required by law to provide a "safe system of work". What that means is the employer needs a method of communicating, duplicating and implementing safe work environment. This begins with OHS Policy. Most OHS Policies and Procedures follow a similar format.

AIM: The main goal that the policy intends to achieve.

POLICY: This would be the actual working document. This is the specifics of what needs to be done and how the company will achieve its goal.

PROCEDURES: This would explain a step by step process on how a task should be done safely.

Having the correct OHS Policies and procedures will help the organization make sure they are following correct legislation in order to keep their staff during work condition

Some common OHS Policy templates are:

- Chemical Emergency Management Policy and Procedure Module
- Incident & Hazard Report Policy and Procedure Module
- Manual Handling Policy and Procedure Module
- Personal Protective Equipment (PPE) Policy and Procedure Module
- Workplace Policy and Procedure Module

This is just a small sample of OHS Policy templates that an organization should have as part of their Occupational Health and Safety strategy.

Electrical Safety Policy

Electric shock can be received by either direct or indirect contact with an energized item, tracking through or across a medium (such as water), or by arching. Electrical burning and arching from equipment can also release toxic gases and air contaminants.

Organizations under the WHS Regulations are obligated to protect workers and others from the risk of injury from the use of electricity, and from working in the vicinity of electricity. The Electrical Safety Module is a document that provides guidance on the management strategies and mechanisms organization can implement to eliminate, or reduce and control risks arising from electricity.

The policy includes:

- Electrical Safety Policy
- Electrical Safety Procedure

- Electrical Equipment Register
- Electrical Safety Checklist

Functional safety - Safety instrumented systems for the process industry sector, is the benchmark standard for the management of functional safety in the process industries. It defines the safety lifecycle and describes how functional safety should be managed throughout that lifecycle. It sets out many engineering and management requirements, however, the key principles of the safety lifecycle are:

- To use hazard and risk assessment to identify requirements for risk reduction
- To allocate risk reduction to safety instrumented systems (SIS) or to other risk

Occupational safety and health is an extensive multidisciplinary field, invariably touching on issues related to scientific areas such as medicine – including physiology and toxicology – ergonomics, physics and chemistry, as well as technology, economics, law and other areas specific to various industries and activities. Despite this variety of concerns and interests, certain basic principles can be identified, including the following:

All workers have rights: - Workers, as well as employers and governments, must ensure that these rights are protected and must strive to establish and maintain decent working conditions and a decent working environment. More specifically:

- work should take place in a safe and healthy working environment;
- conditions of work should be consistent with workers' well-being and human dignity;
- work should offer real possibilities for personal achievement, self-fulfillment and service to society.

For more information refer LG-12 information sheet -3

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: and each contains 2pts

1. What is OHS Policy &Procedure? 5pts
2. what is OHS and its importance in our work activities? (3pts)
3. write the materials used in personal protective equipment's? (2pts)

Note: **Satisfactory rating –6 points** **Unsatisfactory - below 6 points**

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Answer sheet

1._____

_____

2._____

_____

3._____

_____

Information Sheet-2	Work instructions

Work instruction: -is the processes of performing activities in sequential order to control the element to be operated

There are many different types of instructions in programming logic control to perform different electromechanical jobs.

1. Standard Instructions

Standard instructions consist of instructions that are found in most programs. Standard instructions include; timer, counter, math, logical, increment/decrement/invert, move, and block instructions.

2. Special Instructions

Special instructions are used to manipulate data. Special instructions include shift, table, find, conversion, for/next, and real-time instructions**.**

3. High-Speed Instructions

High-speed instructions allow for events and interrupts to occur independent of the PLC scan time. These include high-speed counters, interrupts, output, and transmit instructions.

It is not the purpose of this text to explain all of the instructions and capabilities. A few of the more common instructions necessary for a basic understanding of PLC operation will be discussed. PLC operation is limited only by the hardware capabilities and the ingenuity of the person programming it. Refer to the SIMATIC S7-200 Programmable Controller System Manual for detailed information concerning these instruction

4. Program instruction:

The programming software can be run Off-line or On-line. Offline programming allows the user to edit the ladder diagram and perform a number of maintenance tasks. The PLC does not need to be connected to the programming device in this mode. On-line programming requires the PLC to be connected to the programming device. In this mode program changes are downloaded to the PLC. In addition, status of the input/output elements can be monitored. The CPU can be started, stopped, or reset.

In order to understand the instructions a PLC is to carry out, an understanding of the language is necessary. The language of PLC ladder logic consists of a commonly used set of symbols that represent control components and instructions. One of the most confusing aspects of PLC programming for first-time users is the relationship between the device that controls a

status bit and the programming function that uses a status bit. Two of the most common programming functions are the normally open (NO) contact and the normally closed (NC) contact. Symbolically, power flows through these contacts when they are closed. The normally open contact (NO) is true (closed) when the input or output status bit controlling the contact is 1. The normally closed contact (NC) is true (closed) when the input or output status bit controlling the contact is 0.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is instruction?
2. Why instruction needed in our work activities?
3. Counter, timer increment and block instruction in what types of instruction is categorized?

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------

Information Sheet-3	Tools and testing devices

Tools and Equipment

1. Multi meter or a multi tester, also known as a volt/ohm meter or VOM, is an electronic measuring instrument that combines several functions in one unit. A standard multi meter may include features such as the ability to measure voltage, current and resistance. There are two categories of multi meters, analog multi meters (or analogue multi meters in British English) and digital multi meters (often abbreviated DMM or DVOM.)

A digital multi meter

an ohmmeter

Analog multi meter

2. Pliers are hand tools, designed primarily for gripping objects by using leverage. Pliers are designed for numerous purposes and sometimes require different jaw configurations to grip, turn, pull, or crimp a variety of things.

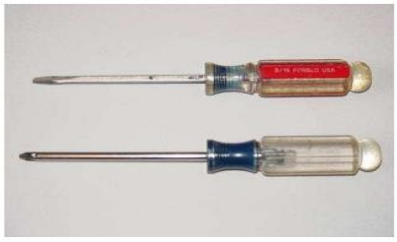
Needle-nose pliers

Combination pliers

3. Screwdriver is a device specifically designed to insert and tighten, or to loosen and remove, screws. The screwdriver comprises a head or tip which engages with a screw, a mechanism to apply torque by rotating the tip, and some way to position and support the screwdriver.

Jeweler's screwdriver set

flat screwdriver



flat & Phillips screwdrivers

2. Signal Generator

Electronic Signal Generators is electronic device usedto produce a variety of waveforms at a wide range of frequencies –An oscillator in the signal generator produces the repetitive wave – it is possible to set the frequency and amplitude of the signal from the signal generator

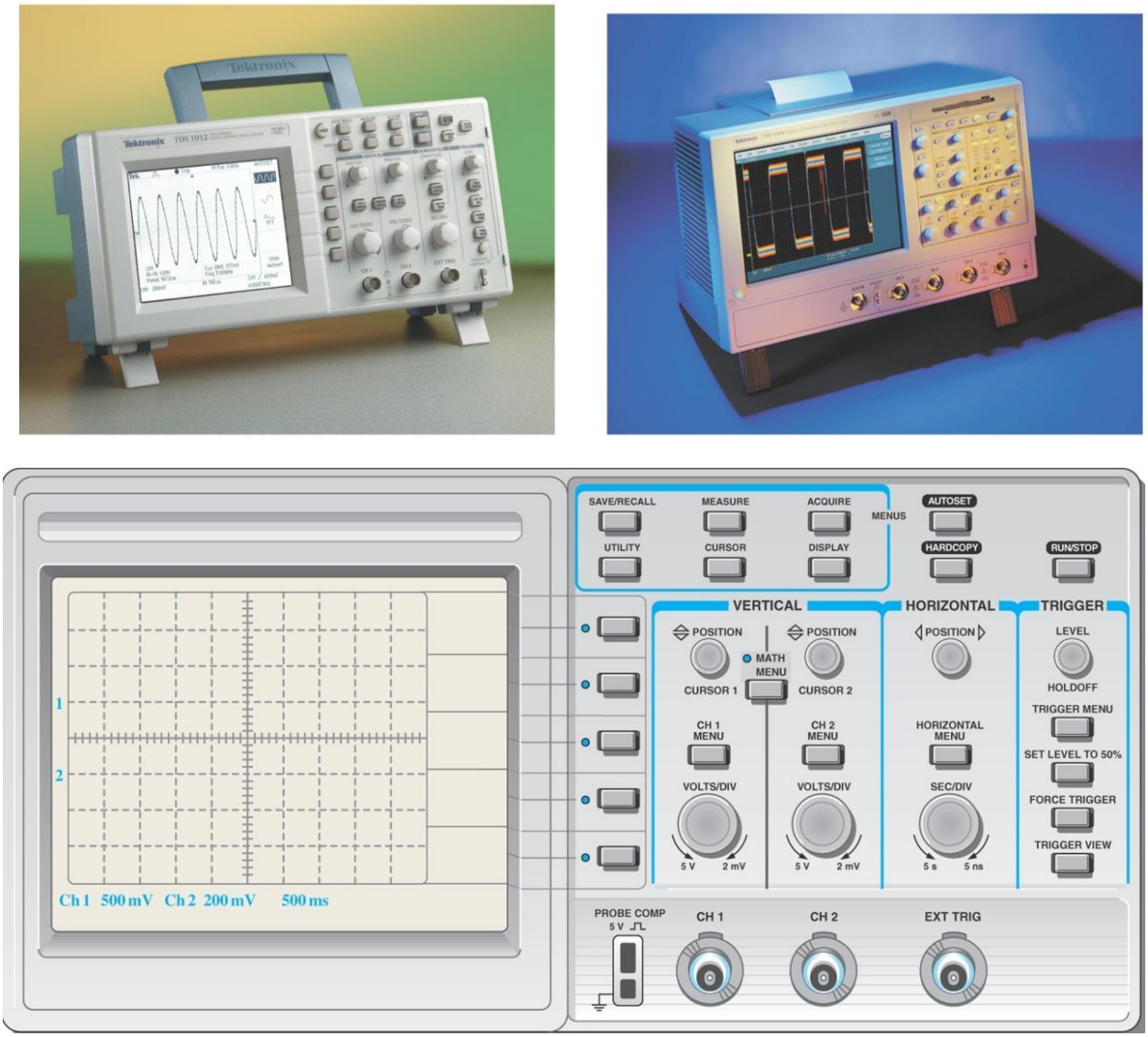


Figure 1.1. Different types of signal generators

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. list at least three example electrical testing device
2. write the difference between electrical hand tools and testing device
3. write the importance of signal generator
4. write the importance of multimeter in electromechanical work.

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------
4. ----------

Information Sheet-4	Materials and components

1. Wire and cable

Basically, there is no difference between a cable and a wire. It is the relative term. The term 'Cable' is used for all heavy section insulate' conductors whereas a 'wire' means a thin (ie., smaller) section insulated conductor used for carrying current from one point to another point. There are four best conductors which cab be used for conducting electrical energy. They are: Silver, Copper, Aluminums, Iron, its Alloys.

Silver: Not in use due to its heavy cost.

Copper: Less in use now-a-days due to high cost.

Aluminum: The electrical conductivity of it is approximately 60% that of copper. It is mostly used for all purposes like over-head lines, underground

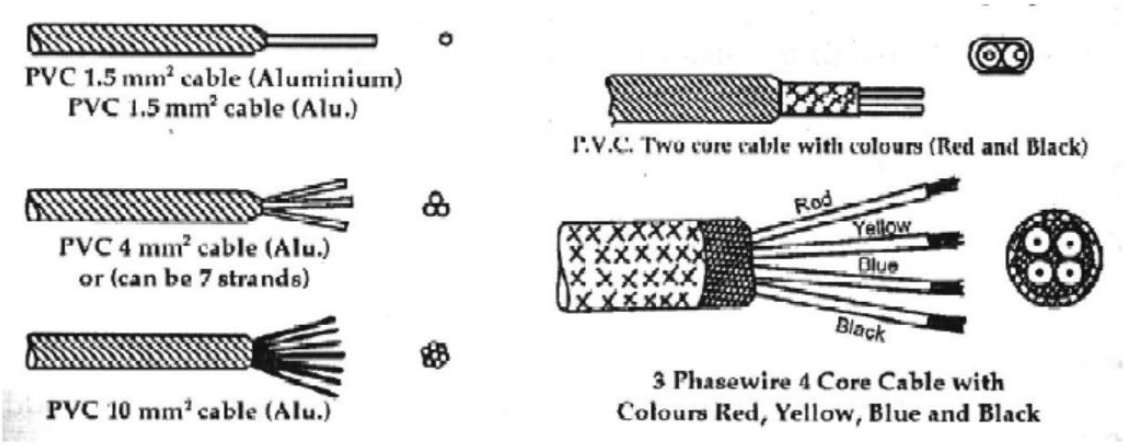


Figure 1.2 different stranded cable and wire

1.1. Grades of Cables According to Voltage.

The Cables are graded according to their working voltages as follows.

1. Up to 1000 volts-Low voltage grade.
2. Up to 11000 volts-High voltage grade.
3. From 33 to 66 KV-Extra high voltage grade.
4. From 66 to 132 KV-Oil or gas pressured cables.

1.2. Types Cables

There are following types of cables.

1. Vulcanized India-rubber insulated cables and PVC cables-These are

weather proof cables and these are used in domestic service lines and open air lines in building etc.
2. Impregnated paper insulated cables.
3. Impregnated jute insulated cables.
4. Lead covered vanished cambric cables.
5. Mineral insulated copper sheathed cables.

Wire gauge: A wire gauge is used for the measurement of the diameter of a wire. In India, Standard Wire Gauge (S.W.G.) and Metric Wire Gauges are used. A wire gauge has a different slot for each diameter. A metric wire gauge measures the diameter of the wire directly in millimeters; e,g 0.70mm, 1.20 mm etc

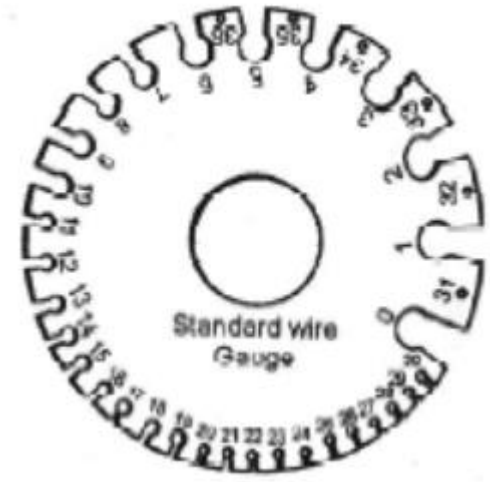


Figure 1.3 wire gauge

1.3. Types of Wires

The types of wires used in electrical wiring are as follows:

(a) According to Core

i. Single Core Wire. It has a single conductor and is generally used in domestic wiring.

Figure 1.4 single core wire

ii. Two Core Wire. It has two separately insulated cores within one insulation cover. One core is used for phase-line and the other other for neutral line.

Figure 1.5 two core wire

iii. Three Core Wire. It has three separately insulated cores within one insulation cover. One core is used for phase-line, second neutral-line and third for earth-line. It may be used for 3 phase wiring along with a separate neutral line.

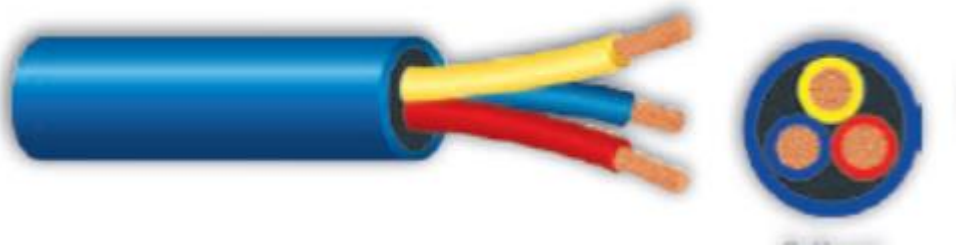


Figure 1.6 Three core cable/wire

iv. Four Core Wire. It has four separately insulated cores within one insulation cover. Three cores are used for 3 phases and the fourth core for theneutral line.

Figure 1.7 Four core cable /wire

(b) According to Insulation

1. V.I.R Wires. (Vulcanized India Rubber wires) These wires can be usedfor general electrical wiring in casing capping and conduit wiring. These wiresabsorb moisture quickly. These are absolute now.

1.4. Types of Flexible Wires

1. P.V.C. Flexible wire twin twisted.
2. P.V.C. Flexible wire two core.
3. P.V.C. Flexible wire three core.
4. Cotton covered flexible wire twin twisted.
5. Silk covered flexible wire twin twisted.

6. Cotton covered flexible wire 2core/3core.
7. T.R.S. or P.V.C. Flexible wire 3core/4core.

2. Terminal Lugs

A terminal may be attached to a wire by a number of methods including screw-on, press-on or crimp-on. Selection is based on two main criteria ; the wire size the barrel is designed to accept and the tongue with will fit a particular stud size. The barrel may be insulated or non-insulated. Normally both insulated or non-insulated should have the wire crimped on, but in some cases the non-insulated lugs may be soldered. There are a number of styles including three and four way. The eyelet may be Ring, Block Spade, Spring Spade, Flanged Spade, or Hook. Some terminal lugs also have two eyelets.

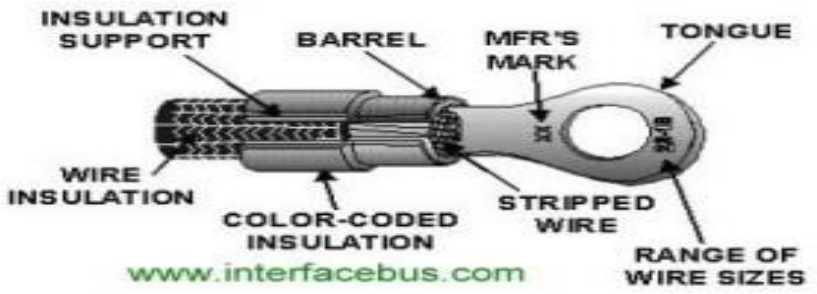


Figure 1.8 (a)pre-insulated Terminal Lug

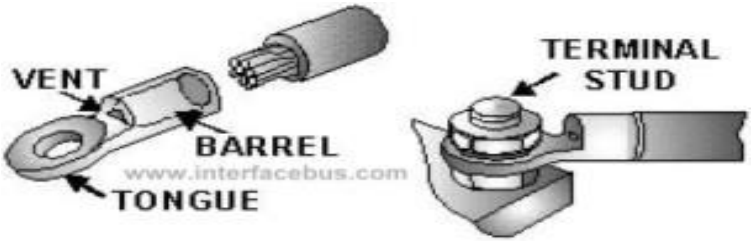


Figure 1.9 (b)Terminal Lug attached to a Terminal Stud

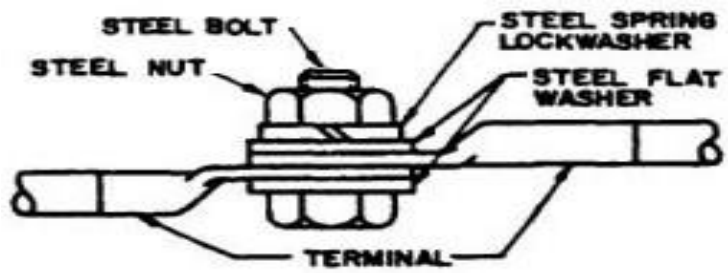


Figure 1.10 (c) Terminal Lug Assembly

There are four main types of terminal lugs;

- Basic Terminal with insulated nylon support sleeve.
- Basic terminal with permanently attached insulating sleeve.
- Basic terminal bonded with silver brazing alloy.
- Basic terminal with butted seam

2.1.1. Terminal blocks

A **terminal block** (also called as **connection terminal or terminal connector**) is a modular block with an insulated frame that secures two or more wires together. It consists of a clamping component and a conducting strip. A typical simplest terminal block is as shown in the image below.

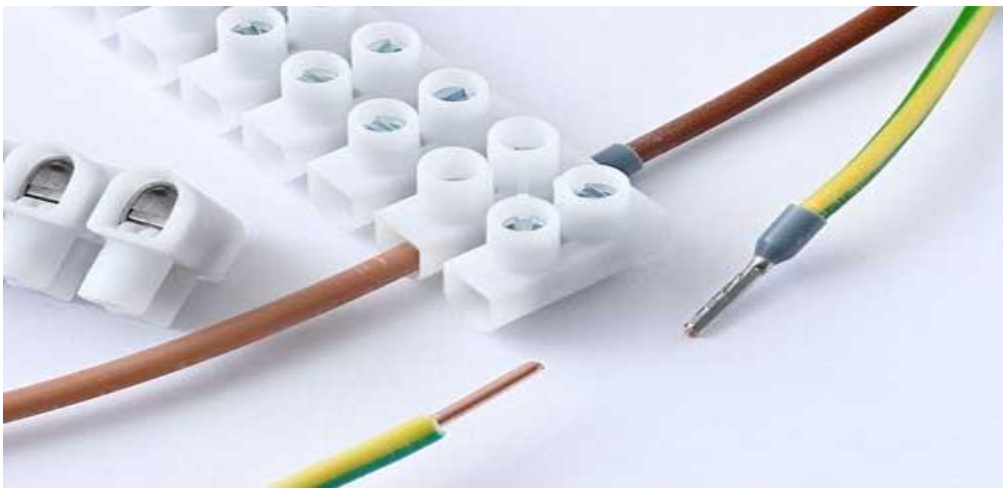


Figure 1.11 Terminal block

The insulating body of a terminal block houses a current carrying element (a metal strip or terminal bar). It also provides a base for clamping element. The body has a mounting arrangement so that the block can be easily mounted on or unmounted from a PCB or a mounting rail. Terminal blocks keep connections much more secure and wires well organized.

2.1.2. Types of Terminal Blocks

Electrical terminal blocks can be classified on the basis of structure, device type, termination options etc.

2.1.2.1. Structure type

Single level pass-through terminal blocks These are simply used to connect two wires together, i.e. wire-to-wire connection. These are also called as **single feed terminal**

blocks. Single level terminal blocks are of the most simple type having one input contact and one output contact.

- **Dual level terminal blocks** These blocks have another level of connection terminal stacked on the first one. This arrangement is generally used to save space.
- **Three level terminal blocks** Just like dual level blocks, these have an extra level at the top. An advantage of using multilevel blocks is that multiple connections can be made in the same block.

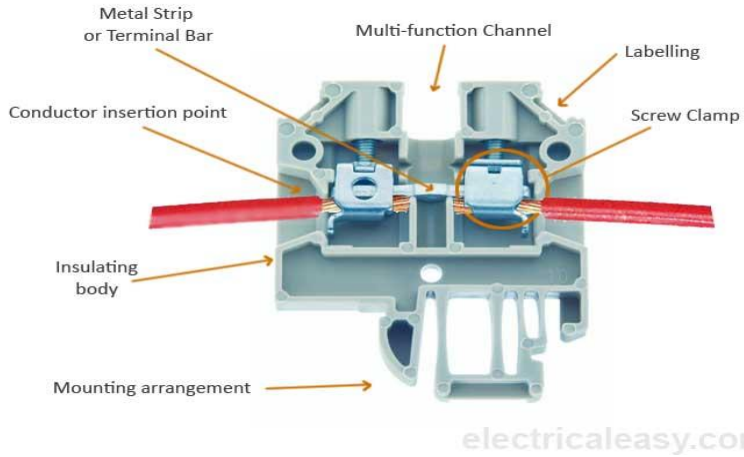


Figure 1.12 (a)Single level pass through terminal block

Dual level terminal block

Figure 1.13 (b) dual terminal block

Three level terminal block

Figure 1.14 (c) three level terminal block

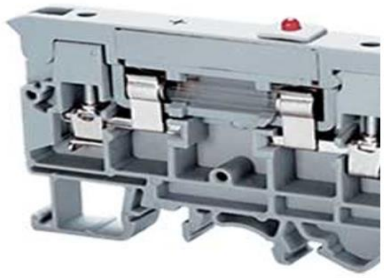
2.1.2.2. Device Type

- **Ground Terminal Blocks**

These blocks often look like a single level feed through terminals. The exception is that these blocks and the metal connection where the wire is terminated are grounded to the panel or DIN rail on which the block is mounted.

(a)

Figure 1.15 (a) ground terminal block block



(b)

Figure 1.16 (b) Fuse connection terminal

3. Selector Switch

Selector switches are actuated with a rotary knob or level of some sort to select one of two or more positions like the toggle switch, selector switches can either rest in any of their positions or contain spring- return mechanisms for momentary operation.

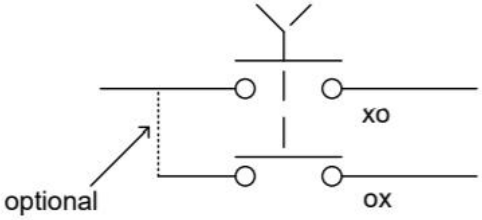


Figure 1.17 sector switch

4. Relay

Relay: is an electrotechnical device used to open, close and protect electrical circuit during normal or abnormal condition.

There is different type of electromagnetic relays

Time delay relay, phase sequence relay, motor protection relay, float less relay, phase sequence phase failure protection relay etc .

4.1. Time delay relay

Time delay is defined as the controlled period between the functioning of two events. ATime delay relay is a combination of an electromechanical output relay and a control circuit. The control circuit is comprised of solid-state components and timing circuits that control operation of the relay and timing range. Typical time delay functions include on-delay, repeat cycle (starting off), interval, off-delay, retrigger able one shot, repeat cycle (starting on), pulse generator, one shot, on / off delay, and memory latch. Time delay relays have a broad choice of timing ranges from less than one second to many days. There are many choices of timing adjustments from calibrated external knobs, DIP switches, thumbwheel switches, or recessed potentiometer. The output contacts on the
electromechanical output relay are direct wired to the output terminals. The contact load ratings are specified for each specific type of time delay relay.

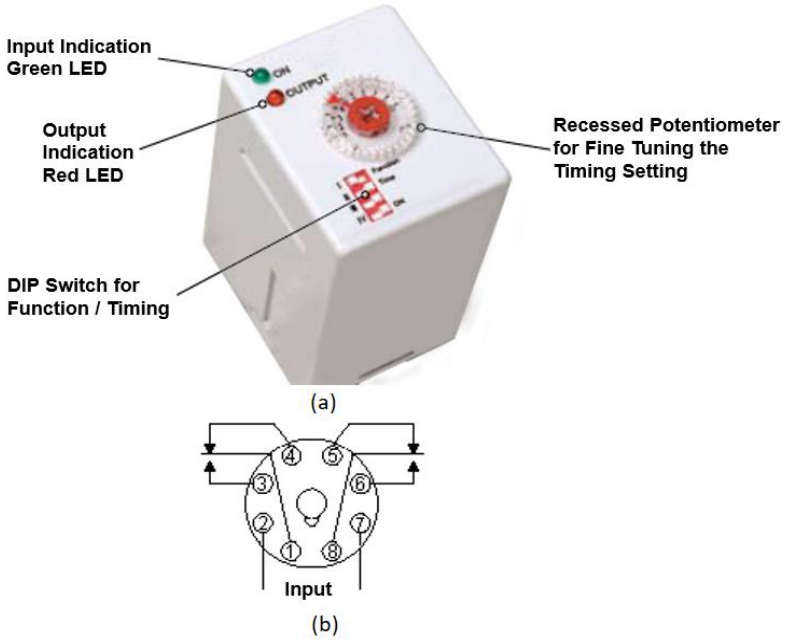


Figure 1.18 (a)- time delay relay device (b)- base of timer relay

4.2. Phase Sequence Phase Failures Relay

Phase Sequence Phase Failures Relay:-is used us phase sequence and phase failures protection device in control circuits with an Ac voltage of 200v-500v and frequency of 50Hz to make and break the circuit it can't monitor the phase failures of motor load .

Figure 1.19 phase sequence phase failures relay

4.3. **Three phase unbalance , phase sequence , phase failure protection :-**this type of relay is applied in 380v-480v control circuit at frequency of 50/60HZ as protection element of phase sequence, phase failures, and phase un balance making or breaking circuits relay

Figure 1.20 Three phases unbalance, failure, sequence relay device

4.4. Motor protection relay

Motor protection relay referred to protector as simply applicable for overload, locked rotor , phase failure, three phase current un balance , earthing and PTC(positive temperature control) protection of Ac motor at 50HZ/60Hz

Figure 1.21 Motor protection relay

4.5. Floatless Relay

Floatless relay is applicable for water level automatic control in industrial facilities and water work construction for water schemes, civil water tower, groundwater pump etc . the control of automatic water supply for different sectors without modifying the user connection condition

Figure 1.22 Float less relay

Relay Contact Symbols

Device Type	Contact Symbology	
	Normally Open	Normally Closed
Push Button (PB)		
Limit Switch (LS)		
Temperature Switch (TAS)		
Flow Switch (FLS)		
Level Switch (FS)		
Control Relay (CR)		
Latching Relay (CRL)		
Counter (CTR)		
Time Delay Relay (TR) Delay Begins When Coil is Energized		
Delay Begins When Coil is De-Energized		

Figure 1.23 Relay Contact Symbols

4.6. Limit switches

Limit switches is a presence Sensing is the act of detecting the presence or absence of an object with a contact or non-contact sensing device. The sensors then produce an electrical output signal that can be used to control equipment or processes. Mechanical limit switches are contact sensing devices widely used for detecting the presence or position of objects in industrial applications. The term limit switch is derived from the operation of the device it-self. As an object (or target) makes contact with the operator of the switch, it eventually moves the actuator to the "limit" where the electrical contacts change state. Through this mechanical action, electrical contacts are either opened (in a normally closed circuit) or closed (in a normally open circuit).

A limit switch could be used to stop the motor or prevent the motor from being started. An access door to the motor, or its associated equipment, is one example of a limit switch's use. If the access door is open, the normally open contacts of LS1 connected to input I0.3 are open and the motor will not start.

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: each contains 2pts

1. Write at least two types of relays and their uses
2. What makes limit switches from selector switches?
3. Write the difference between wire and cable
4. Write the symbol of NC and NO pushbutton
5. Write different types of terminal lugs

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

4. ----------
5. ----------
6. ----------

Instruction Sheet	Learning guide 60: write and test basic programs using a hand program loader

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- PLC
- PLC programming
- Appropriate language of plc
- Loading programs into PLC
- Testing the operation of the program
- Verifying Programs
- External documentation and back-up of programs

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Write Programs in accordance with programming rules
- Use Appropriate language according to applications
- Load Programs into a PLC.
- Teste the operation of programs.
- Review test processes to ensure defect-free PLC program

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- 6”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2,3,4 ,” in each information sheets on pages 4,11,14,19,23 and 26.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2 and 3 on pages 28,29 and 30.and do the LAP Test on page 31”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Programable logic controller (PLC)

1. Terms and definitions

Address The numerical location of a particular status bit in the permanent memory of a PLC processor

Examine OFF A basic statement in PLC logic that directs a status bit to look for a condition where power in a circuit is OFF

Examine ON A basic statement in PLC logic that directs a status bit to look for a condition where power in a circuit is ON

NC (Normally Closed) A switch or contact which is closed and passing power when it is inactive, and open and not passing power when it is active

NO (Normally Open) A switch or contact which is open and not passing power when it is inactive, and closed and passing power when it is active

PLC (Programmable Logic Controller) A microprocessor-based control system designed to respond to user input in executing a control objective

User program A set of instructions which can be entered into processor memory at a local time and place by a programmer

Hard-wired An electrical control design built around relays where components have to be physically wired to one another to complete electrical continuity

Grafcet A graphical method of programming PLCs in steps and transitions that speed up

A **programmable logic controller (PLC)**, also referred to as a **programmable controller**, is the name given to a type of computer commonly used in commercial and Industrial control applications. PLCs differ from office computers in the type's tasks that they of perform and the hardware and software they require to perform these tasks. While the specific applications vary widely all PLCs monitor inputs and other variable values make decisions based on a stored program and control outputs to automate a process or machine. This course is meant to supply you with basic information on the functions and configurations of PLCs with emphasis on the **S7-200 PLC** family.

The basic elements of a PLC include input modules or points, a central processing unit (CPU), output module. or points and a programming device.

The type of input modules or points used by a PLC depends upon the types of input devices used. Some input modules or points respond to digital inputs, also called discrete inputs which are either on or off. Other modules or inputs respond to analog signals. These analog signals represent signals represent machine or process conditions as a range of voltage or current values The primary function of a PLC's input circuitry is to convert the signals provided by

these various switches and sensors into logic signals that can be used by the CPU.
Programmable logic controllers are so named because they use logic to control input/output devices, and they can be programmed by a user. In a hard-wired relay panel, circuits or loads can be energized only with closed contacts, and a switch can be used only with the load to which it is directly connected. To change the operating objectives of a hard-wired relay panel requires physically redesigning and changing the wiring.

2. Basic components of PLC and their function

i. **Programmer:** A device where a set of instructions stored in memory can be used to tell a controller how to manage a specific operation
ii. **Input module** A component that gathers signals from a process and sends information about the process on to a controller
iii. **Controller** The brains of a PLC where logic solving and decision making are performed and appropriate signals sent to an output module
iv. **Output module A** component that receives controller output and forwards signals on to real-world devices such as motors and relays to accomplish a control objective

Advantage of PLC

- Flexible
- Faster response time
- Less and simpler wiring
- Solid-state - no moving parts
- Modular design - easy to repair and expand •Handles much more complicated systems
- Sophisticated instruction sets available
- Allows for diagnostics “easy to troubleshoot”
- Less expensive
- Eliminates much of the hard wiring that was associated with conventional relay control circuits.

3. Basic PLC operation

PLCs consist of input modules or points, a Central Processing Unit (CPU), and output modules or points. An input accepts a variety of digital or analog signals from various field devices (sensors) and converts them into a logic signal that can be used by the CPU. The CPU makes decisions and executes control instructions based on program instructions in memory. Output modules convert control instructions from the CPU into a digital or analog signal that can be used to control various field devices (actuators). A programming device is used to input the desired instructions. These instructions determine what the PLC will do for a specific input. An operator interface device allows process information to be displayed and new control parameters to be entered.

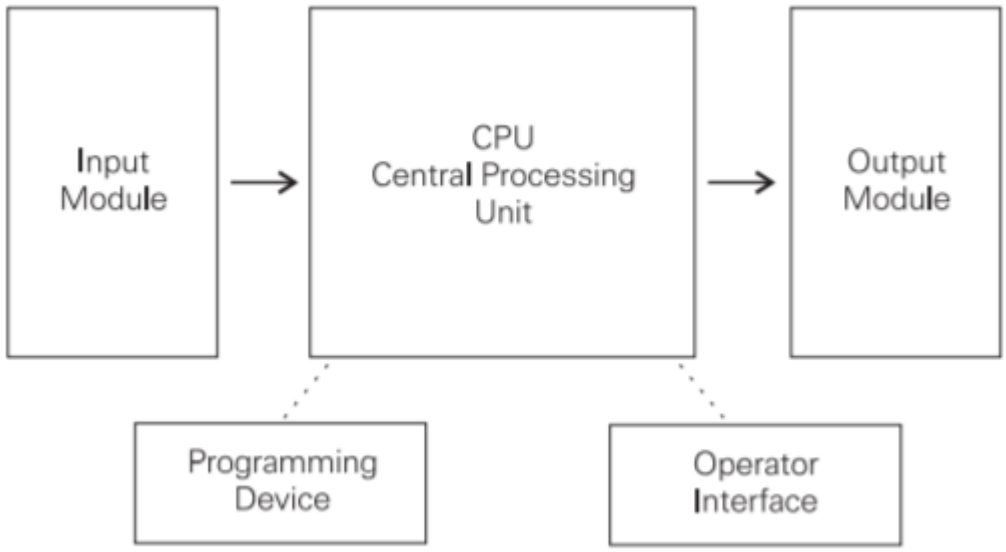
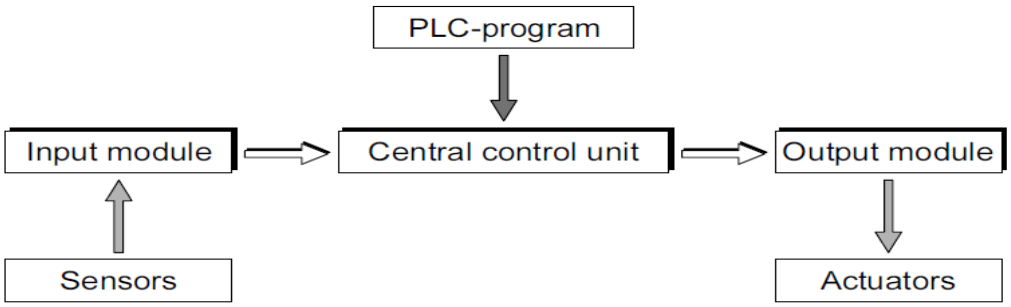
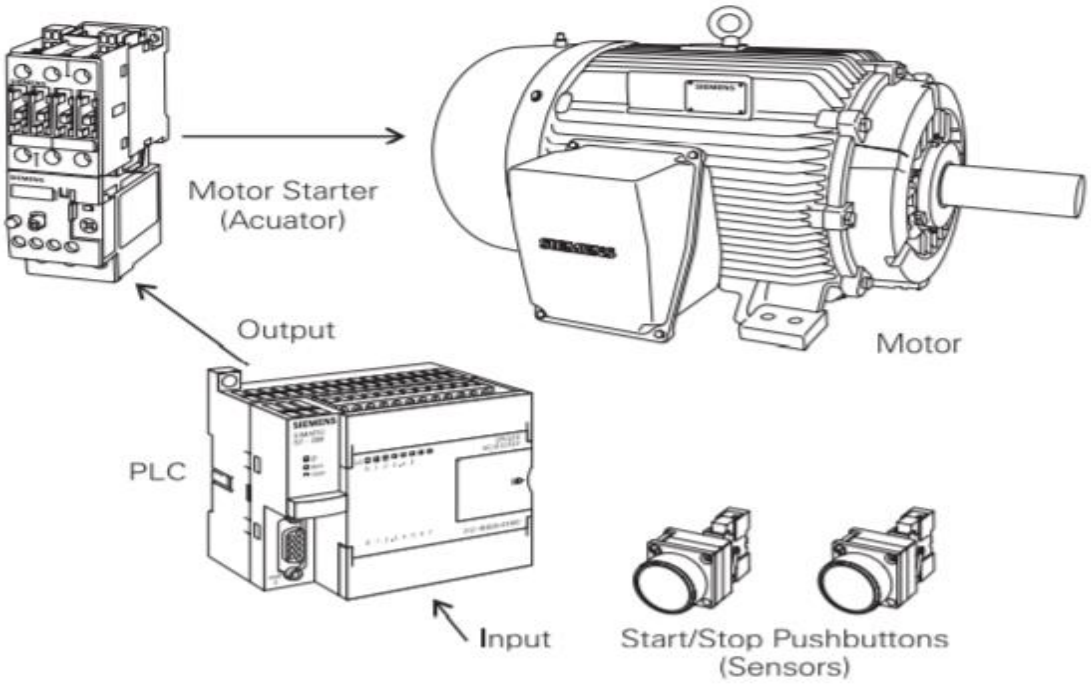


Figure 2.1 PLC block diagram



Pushbuttons (sensors), in this simple example, connected to PLC inputs, can be used to start and stop a motor connected to a PLC through a motor starter (actuator).



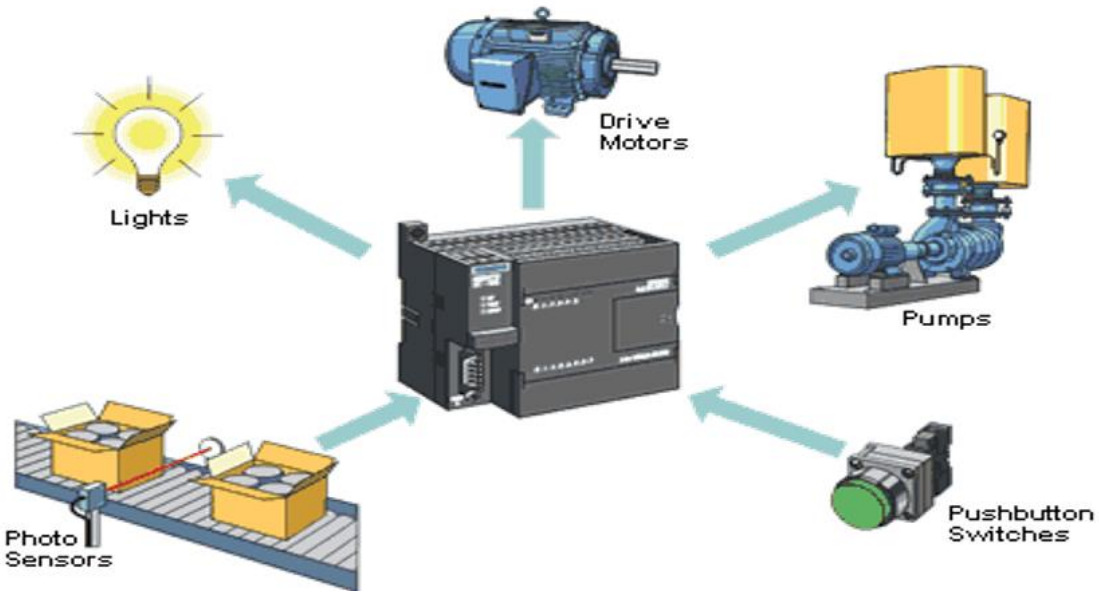


Figure 2.2 input and out put for PLC motor controlling

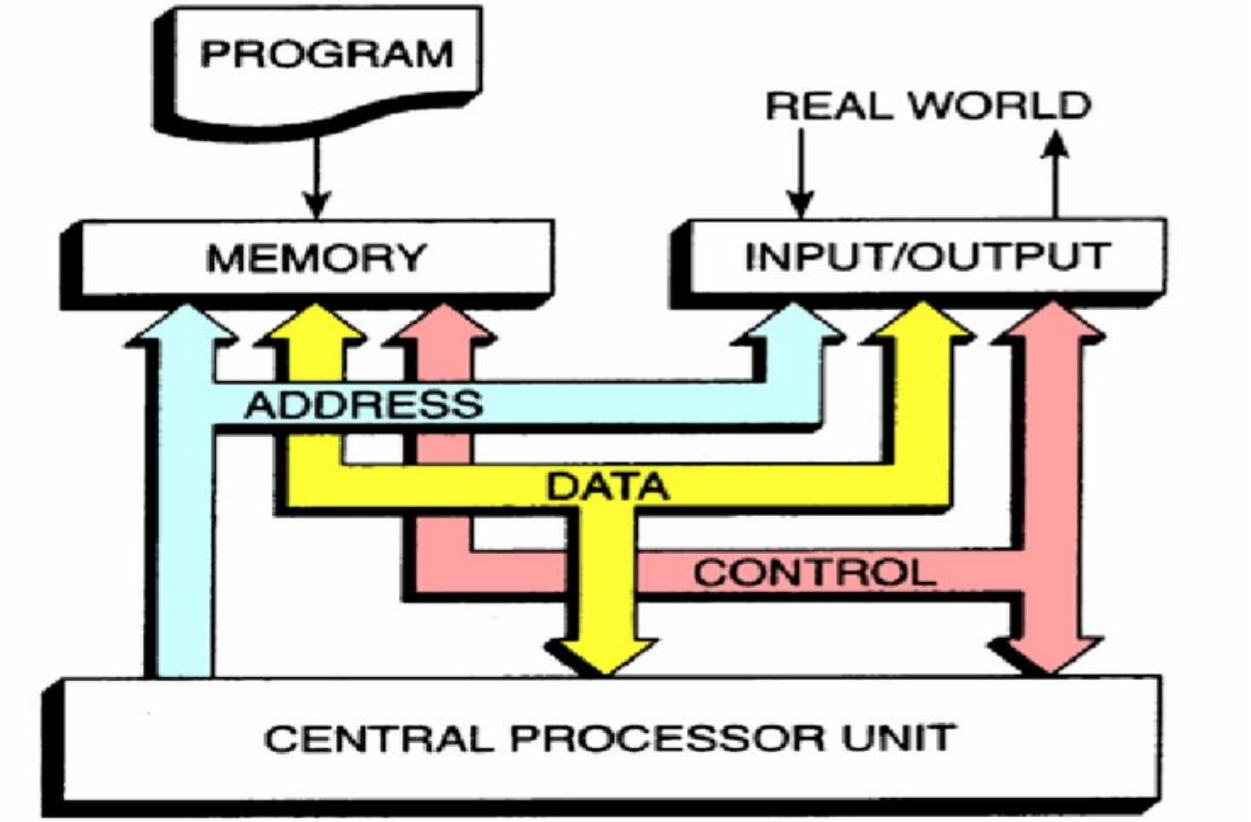


Figure 2.3 PLC Architecture

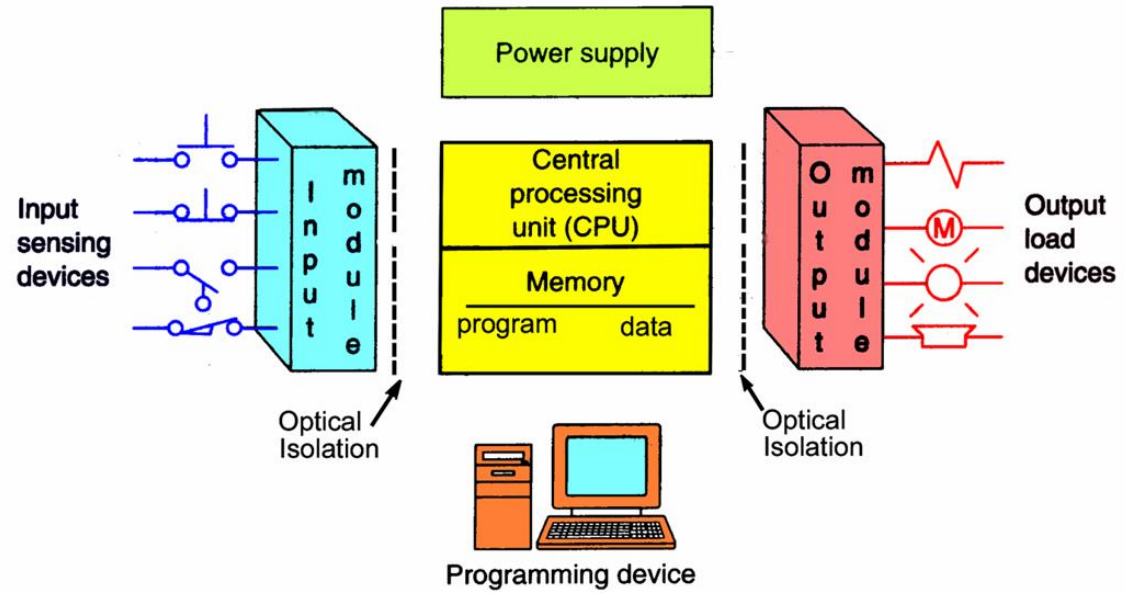


Figure 2.4 PLC system block diagram

Principles of Operation

A programmable controller consists of two basic sections:

- The central processing unit
- The input/output interface system

The central processing unit (CPU) governs all PLC activities. The following three components form the CPU:

- The processor
- The memory system
- The system power supply

The operation of a programmable controller is relatively simple. The input/ output (I/O) system is physically connected to the field devices that are encountered in the machine or that are used in the control of a process. These field devices may be discrete or analog input/output devices, such as limit switches, pressure transducers, push buttons, motor starters, solenoids, etc.

The I/O interfaces provide the connection between the CPU and the information providers (inputs) and controllable devices (outputs).

The input/output system forms the interface by which field devices are connected to the controller. The main purpose of the interface is to condition the various signals received from or sent to external field devices. Incoming signals from sensors (e.g., push buttons, limit switches, analog sensors, selector switches, and thumbwheel switches) are wired to terminals on the input interfaces. Devices that will be controlled, like motor starters, solenoid valves, pilot lights, and position valves, are connected to the terminals of the output interfaces. The system power supply provides all the voltages required for the proper operation of the various central processing unit sections.

During its operation, the CPU completes three processes: (1) it **reads**, or accepts, the input data from the field devices via the input interfaces, (2) it **executes**, or performs, the control program stored in the memory system, and (3) it **writes**, or updates, the output devices via the output interfaces. This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as **scanning.**

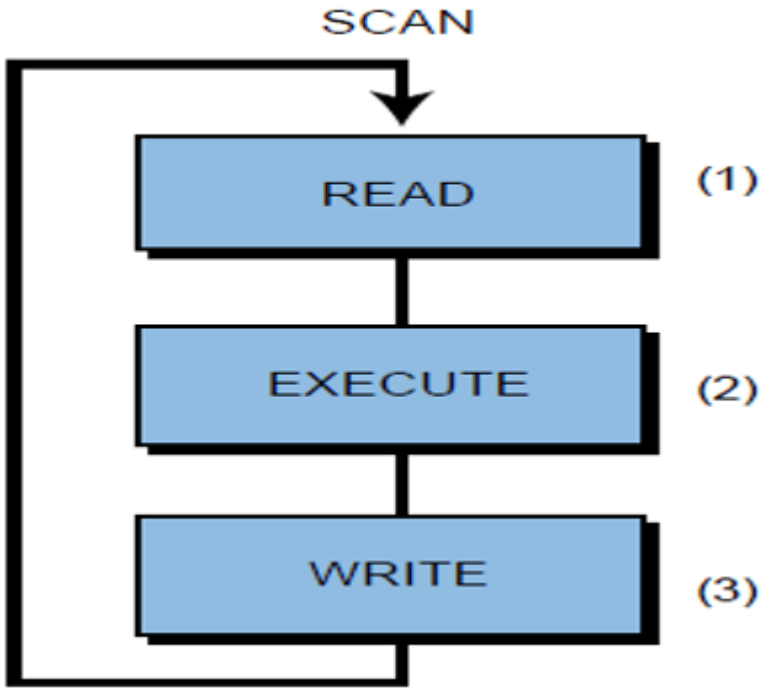


Figure 2.5 Illustration of scan

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

4. What is PLC and its function (2pts)
5. Write the difference between computer and PLC (2pts)
6. Write the advantage of PLC (6pts)
7. Write the basic components of PLC and their function 2pts

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Answer sheet

7. ----------
8. ----------
9. ----------

Programming PLCs

properly connecting inputs and outputs to a PLC begins with an activity called programming. Programming means using an operator terminal with a keyboard to enter commands that will tell the PLC controller what action is desired at an output in response to a certain input.

A program consists of one or more instructions that accomplish a task. Programming a PLC is simply constructing a set of instructions. There are several ways to look at a program such as ladder logic, statement lists, or function block diagrams

Example: If a temperature sensor sends an input which indicates a drying oven has reached 350°F, a properly programmed controller would activate a solenoid which would open the oven door so the product could be moved out. Because of electrical circuits are frequently complex, programming PLCs is accomplished with a format based on ladder logic diagrams which are similar to ladder relay diagrams.

(NOTE: Not all PLCs are programmed with ladder logic diagrams, and other forms of programming will be discussed in a later unit of instruction.). Ladder relay diagrams indicate electrical continuity, but ladder logic diagrams indicate logical continuity

PLC consists of a number of instructions that must be arranged in a logical order to obtain the desired PLC operation. These instructions are divided into three groups: standard instructions, special instructions, and high-speed instructions

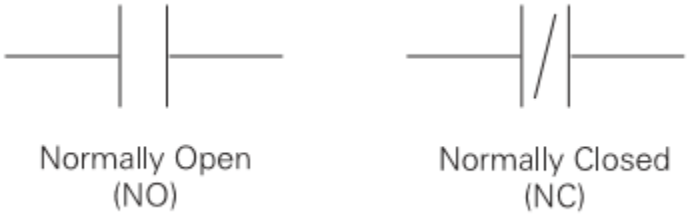
Standard Instructions-: Standard instructions consists of instructions that are found in most programs. Standard instructions include; timer, counter, math, logical, increment/decrement/invert, move, and block instructions.

Special Instructions: -Special instructions are used to manipulate data. Special instructions include shift, table, find, conversion, for/next, and real-time instructions.

High-Speed Instructions: - High-speed instructions allow for events and interrupts to occur independent of the PLC scan time. These include high-speed counters, interrupts, output, and transmit instructions.

Fundamentals of PLC programming

When learning PLC programming, one of the most difficult concepts to grasp is the difference between physical components and program components. We will be connecting physical components (switches, lights, relays, etc.) to the external terminals on a PLC. Then when we program the PLC, any physical components connected to the PLC will be represented in the program as program components. Two of the most common programming functions are the normally open (NO) contact and the normally closed (NC) contact. Symbolically, power flows through these contacts when they are closed. The normally open contact (NO) is true (closed) when the input or output status bit controlling the contact is 1. The normally closed contact (NC) is true (closed) when the input or output status bit controlling the contact is 0.



PLC programming process is to plan activities such as design and write a program to perform the required tasks

Table 1. The part that should be there in PLC program

Start	Starting operation
Operating mode	Degerming the origin of the device input /out put also the starting point
The rest	Controlling the operation of start / stop it manually or automatically in the program
Operation and ordering process	Program design as required by the task
Signal out put	Trigger output devices.
Status out put	Display indicator light or alarm.
End	Stop the process./operation

Programming unit. The programming unit allows the engineer or technician to enter and edit the program to be executed. In it's simplest form it can be a hand held device with a keypad for program entry and a display device (LED or LCD) for viewing program steps or functions, as shown in Figure 2-1 below More advanced systems employ a separate personal computer which allows the programmer to write, view, edit and download the program to the PLC. This is accomplished with proprietary software available from the PLC manufacturer. This software also allows the programmer or engineer to monitor the PLC as it is running the program. With this monitoring system, such things as internal coils, registers, timers and other items not visible externally can be monitored to determine proper operation. Also, internal register data can be altered if required to fine tune program operation. This can be advantageous when debugging the program. Communication with the programmable controller with this system is via a cable connected to a special programming port on the controller. Connection to the personal computer can be through a serial port or from a dedicated card installed in the computer.

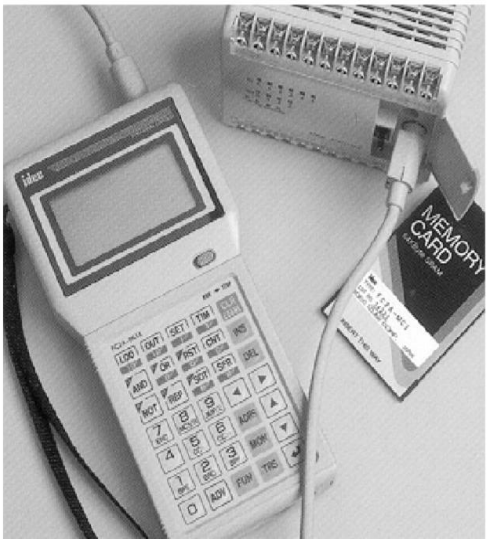


Figure 2.6 PLC programming units (device)

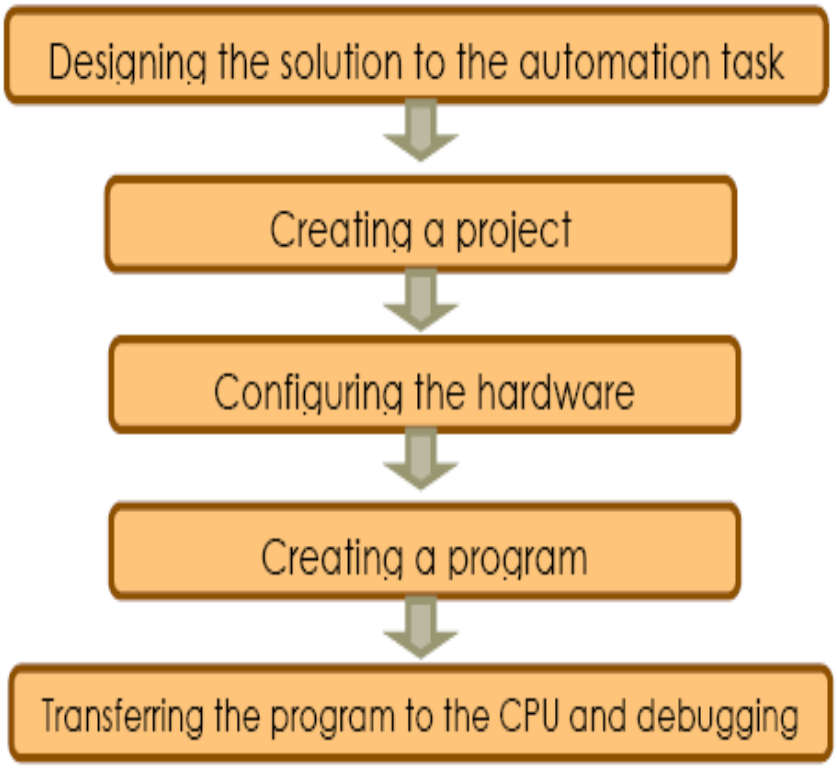


Figure 2.7 Basic procedure for programing

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: each contains 2pts

1. What is PLC programing
2. Write example of input/output device for PLC programming
3. What program included in PLC list them
4. Write Basic procedure for programing

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------
4. _____

Information Sheet-3	Appropriate language of plc

programming languages.

The following is a list of programming languages specified by this standard:

i. Ladder Diagram (LD)
ii. Mnemonic Programming Code
iii. Instruction List (IL)
iv. Function Block Diagram (FBD)

One of the primary benefits of the standard is that it allows multiple languages to be used within the same programmable controller. This allows the program developer to select the language best suited to each particular task.

i. **Ladder Diagram** Ladder Diagram is kind of graphical programming language that changed the relay control wiring circuit diagram. Ladder Diagram contains tracks from left to right contact diagram (see Figure below). This platform is connected to contact elements available normally open - NO or available Normally closed - NC through the current path and loop elements. Ladder diagram also shows the control circuit and the display function and a combination of the sequence of operations for each branch of the horizontal lines separately. Ladder logic is the primary programming language of programmable logic controllers. Since the PLC was developed to replace relay logic control systems, it was only natural that the initial language closely resembles the diagrams used to document the relay logic.

Ladder logic (LAD) is one programming language used with PLCs. Ladder logic uses components that resemble elements used in a line diagram format to describe hard-wired control.

Ladder Logic Diagram. The left vertical line of a ladder logic diagram represents the power or energized conductor. The output element or instruction represents the neutral or return path of the circuit. The right vertical line, which represents the return path on a hard-wired control line diagram, is omitted. Ladder logic diagrams are read from left-to-right, top-to-bottom. Rungs are sometimes referred to as networks. A network may have several control elements, but only one output coil

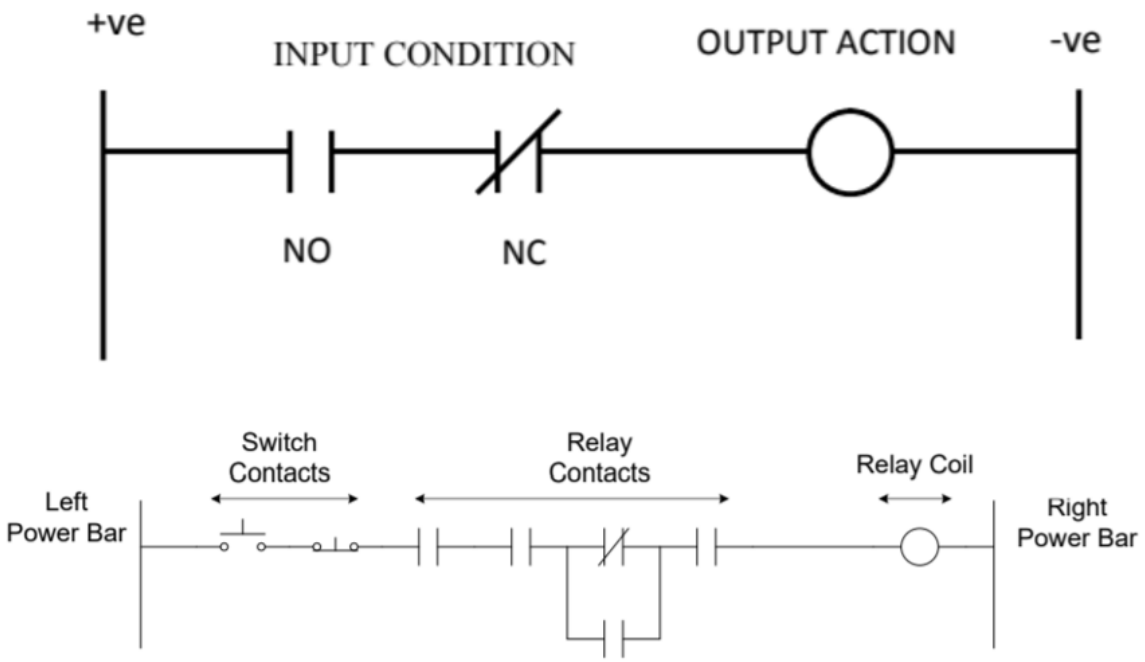


Figure 2.8 Sample Ladder Diagram – Single Rung

Relay symbol

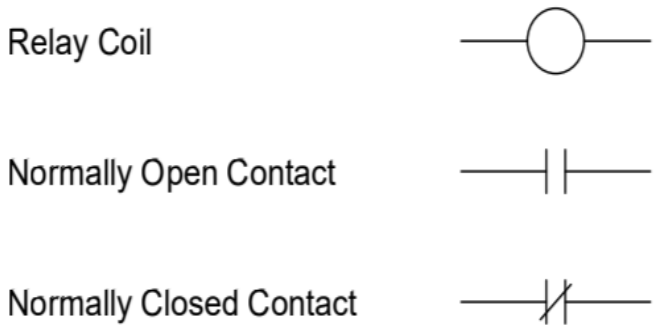


Figure 2.9 symbol for components of relay

Example 1. **OR Circuit.** Two switches labeled A and B are wired in parallel controlling a lamp as shown in Figure 3.3.a. Implement this function as PLC ladder logic where the two switches are separate inputs.

Solution. The switch circuit action is described as, “The lamp is on when switch A is on (closed) or switch B is on (closed).” All possible combinations of the two switches and the consequent lamp action is shown as a truth table in Figure 3.3b

. To implement this function using relays, the switches A and B are not connected to the lamp directly, but are connected to relay coils labeled AR and BR whose normally-open (NO) contacts control a relay coil, LR, whose contacts control the lamp, Figure 2.3a. The switches, A and B, are the inputs to the circuit. When either switch A or B is closed, the corresponding relay coil AR or BR is energized, closing a contact and supplying power to the LR relay coil. The LR coil is energized, closing its contact and supplying power to the lamp.

(a)

Or (O) Function

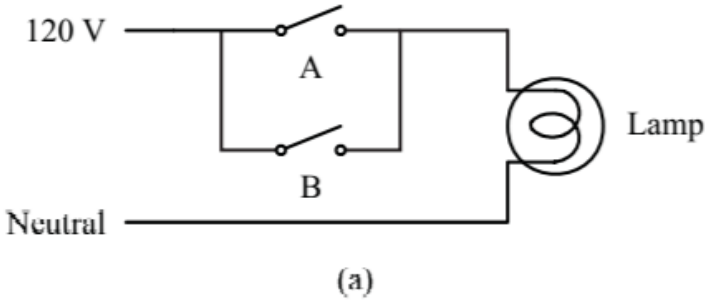
Input 3	Input 4	Output 2
0	0	0
0	1	1
1	0	1
1	1	1

Or (O) Function

I0.4	I0.5	Q0.1
0	0	0
0	1	1
1	0	1
1	1	1

(b)

Figure 2.10 (a) OR ladder diagram representation (b) truth table



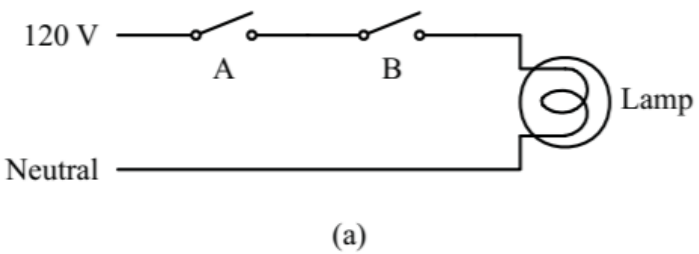
A	B	Lamp
off	off	off
off	on	on
on	off	on
on	on	on

(b)

Figure 2.11 Parallel switch circuit: (a) switch circuit; (b) truth table.

Where OFF=0, ON =1

Example 1 AND Circuit. Two switches labeled A and B are wired in series controlling a lamp as shown in Figure 3.5a. Implement this function as PLC ladder logic where the two switches are separate inputs.



A	B	Lamp
off	off	off
off	on	off
on	off	off
on	on	on

(b)

Figure 2.12 Series switch circuit: (a) switch circuit; (b) truth table.

And (A) Function

Input 1
Input 2
Output 1

Input 1	Input 2	Output 1
0	0	0
0	1	0
1	0	0
1	1	1

And (A) Function

I0.0
I0.1
Q0.0

I0.0	I0.1	Q0.0
0	0	0
0	1	0
1	0	0
1	1	1

(b)

Figure 2.13 (a) represents AND ladder diagram (b) truth table

Solution. The switch circuit action is described as, “The lamp is on when switch A is on (closed) and switch B is on (closed).” All possible combinations of the two switches and the consequent lamp action is shown as a truth table in Figure 3.5b. To implement this function using relays, the only change from Example 1 is to wire the normally-open contacts of control relays AR and BR in series to control the light, “When input (switch) A is on AND input (switch) B is on then the lamp is on The lamp is on when switch A is on and switch B is on. translates into a relay circuit described as A series connection of normally-open contact

ii. Mnemonic Programming Code

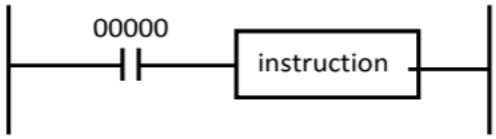
There are other methods to program PLCs. One of the earliest techniques involved mnemonic instructions. These instructions can be derived directly from the ladder logic diagrams and entered into the PLC through a simple programming terminal. All discussions in previous sections have considered only the ladder diagram in all program example development. The next thing to be considered is how to get the ladder diagram into the programmable controller. In higher order controllers, this can be accomplished through the use of dedicated personal computer software that allows the programmer to enter the ladder diagram as drawn. The software then takes care of translating the ladder diagram into the code required by the controller. In the lower order, more basic controllers, this has to be performed by the programmer and entered by hand into the controller. It is this type of language and the procedure for translating the ladder diagram into the required code that will be discussed in this chapter. This will be accomplished by retracing the examples and ladder diagrams developed in earlier chapters and translating them into the mnemonic code required to program a general controller. This controller will be programmed in a somewhat generic type of code. As the code is learned, comparisons will be presented with similar types of statements found in controller use. The student will have only to adapt to the statements required by the type of controller being used to develop a program for that control.

Mnemonic Instruction

a. LOAD- instruction

These instructions are use to start a line of the program. It is used in the first contacts in the normally open condition (NO).

Ladder Diagram



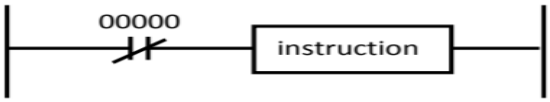
Mnemonic Code

Address	Instruction	Operand/Data
00000	LD	00000
00001	instruction	

b. LD NOT - LOAD NOT Instruction These instructions are use to start a line of the program. It is used in the first contacts in the normally closed condition (NC).

The Execution Conditions of the instruction on the right will be ON when IR 00000 is OFF

Ladder Diagram



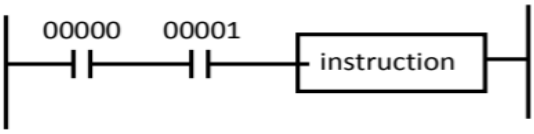
Mnemonic Code

Address	Instruction	Operand/Data
00000	LD NOT	00000
00001	instruction	

c. AND - AND Instruction These instructions are used in the second contact in a normally open (NO) and a series with previous contacts

d. Explanation The Execution Conditions of the instruction on the right will be ON when IR 00000 and IR 00001 are ON

Ladder Diagram



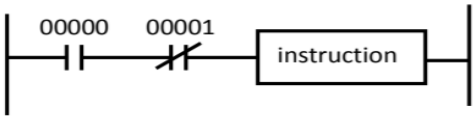
Mnemonic Code

Address	Instruction	Operand/Data
00000	LD	00000
00001	AND	00001
00002	instruction	

e. AND -AND NOT Instruction

These instructions are used in the second contact in a normally closed (NC) and in series with previous contacts

Ladder Diagram



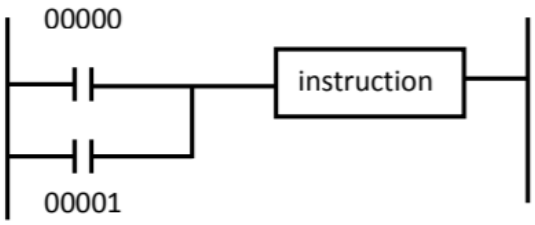
Mnemonic Code

Address	Instruction	Operand/ Data
00000	LD	00000
00001	AND NOT	00001
00002	instruction	

Explanation: The Execution Conditions of the instruction on the right will be ON when IR 00000 ON and IR 00001 are OFF.

f. OR - OR Instruction These instructions are used in the second contact in a normally open (NO) and in line (parallel) with previous contacts.

Ladder Diagram



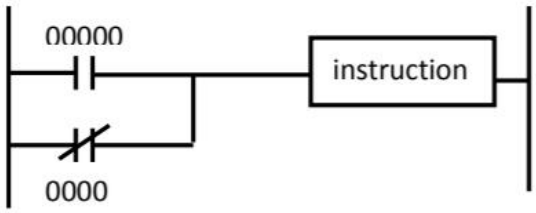
Mnemonic Code

Address	Instruction	Operand/Data
00000	LD	00000
00001	OR	00001
00002	instruction	

Explanation the Execution Conditions of the instruction on the right will be ON when either IR 00000 or IR 00001 are ON.

g. OR NOT - OR NOT Instruction These instructions are used in the second contact in a normally closed (NC) and in line (parallel) with previous contacts

Ladder Diagram



Mnemonic Code

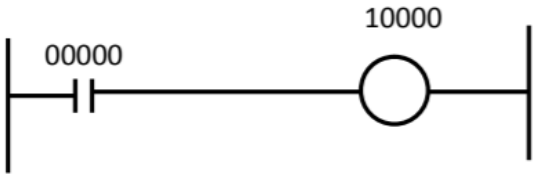
Address	Instruction	Operand/Data
00000	LD	00000
00001	OR NOT	00001
00002	instruction	

Explanation:
The Execution Conditions of the instruction on the right will be ON when either IR 00000 is ON or IR 00001 is OFF or IR 00000 ON, IR 00001 OFF simultaneously

h. OUT - OUTPUT Instruction

These instructions are used for the **coil output**

Ladder Diagram



Mnemonic Code

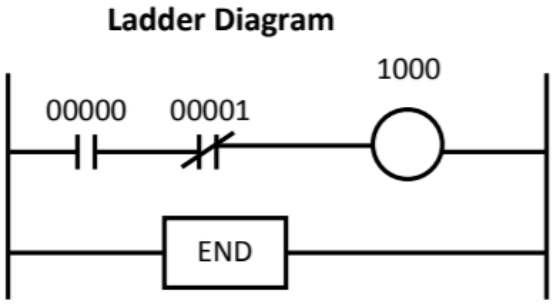
Address	Instruction	Operand/ Data
00000	LD	00000
00001	OUT	10000

IR 10000 will ON when IR 00000 is ON .

i. END -END instruction has no physical contact device

It is the last instruction required for completion of a program.

If no END instruction, the program cannot be implemented



Mnemonic Code

Address	Instruction	Operand/ Data
00000	LD	00000
00001	AND NOT	00001
00002	OUT	10000
00003	FUN 01	

III. A statement list (STL) provides another view of a set of instructions.

The operation, what is to be done, is shown on the left. The operand, the item to be operated on by the operation, is shown on the right. A comparison between the statement list shown below, and the ladder logic shown on the previous page, reveals a similar structure. The set of instructions in this statement list perform the same task as the ladder diagram

In the example program shown example I0.0, I0.1 and Q0.0 represent the first instruction combination. If inputs I0.0 and I0.1 are energized, output relay Q0.0 energizes. The inputs could be switches, pushbuttons, or contact closures. I0.4, I0.5, and Q0.1 represent the second instruction combination. If either input I0.4 or I0.5 are energized, output relay Q0.1 energizes.

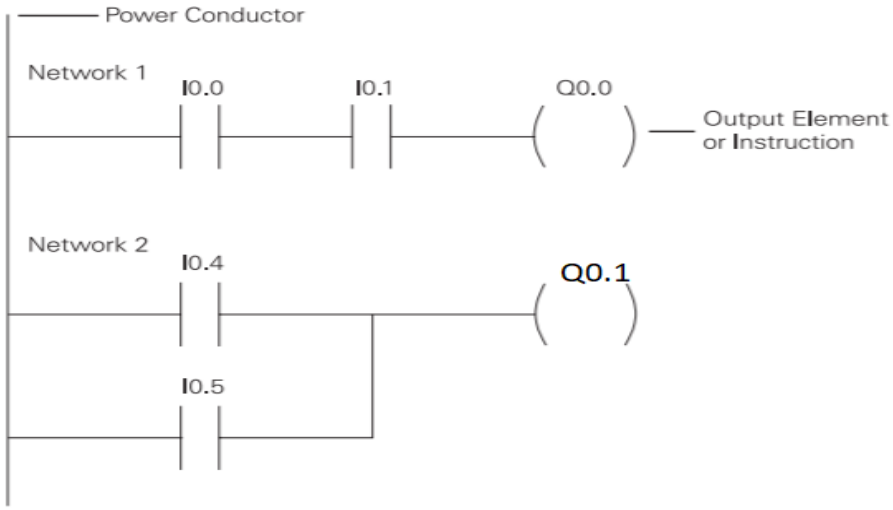


Figure 2.13 ladder logic diagram

The statement list instruction

Network 1 Network 2

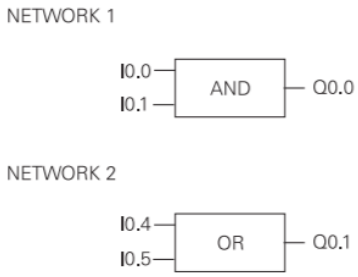
LD =10.0 LD=10.4

A=10.1 O=10.5

=Q0.0 =Q0.1

N.B Where A represents AND gates logic gates and series connection and O represents OR logic gates and represents parallel connection Q represents out put

IV. Function Block Diagrams (FBD) provide another view of a set of instructions. Each function has a name to designate its specific task. Functions are indicated by a rectangle. Inputs are shown on the left-hand side of the rectangle and outputs are shown on the right-hand side. The function block diagram shown below performs the same function as shown by the ladder diagram and statement list.



Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Write different of PLC language (2pts)
2. Develop the ladder diagram of DOL and its mnemonic code (2pts)
3. Write the symbol of relay coil, normally open and closed switch (2pts)
4. Write the function block diagram of AND and OR 4 points

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------
4. ----------

Operation Sheet 1	preparing DOL PLC control

Techniques for preparing power and control circuit of DOL

Step 1- wear PPE.
Step 2- Select the necessary tools and materials required for construction of Dol.
Step3- Develop its ladder diagram
Step 4- Develop its mnemonic code
Step5- Connect the input and output wiring diagram to PLC
Step 6- Test the motor

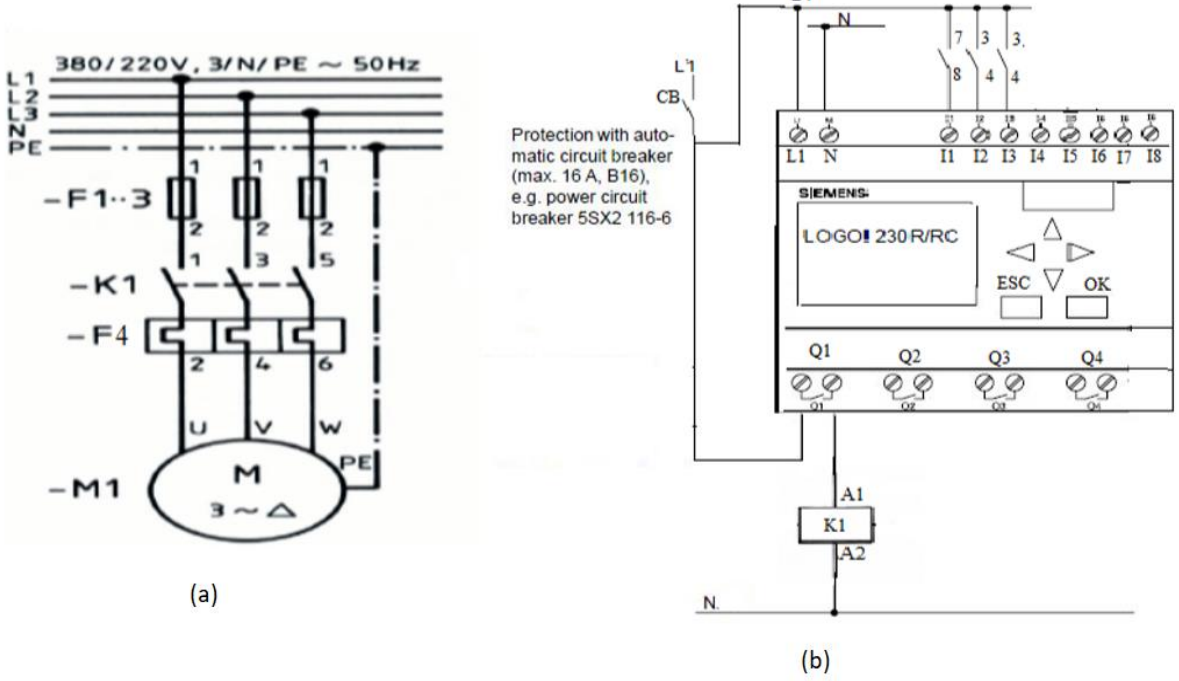


Figure 2.14 (a) DOL power circuit (b) Dol wiring diagram

Operation Sheet 2	Star- delta PLC control

Techniques for preparing power and control circuit of DOL

Step 1- wear PPE.
Step 2- Select the necessary tools and materials required for construction of star-delta
Step3- Develop its ladder diagram
Step 4- Develop its mnemonic code
Step5- Connect the input and output wiring diagram to PLC
Step 6- Test the motor

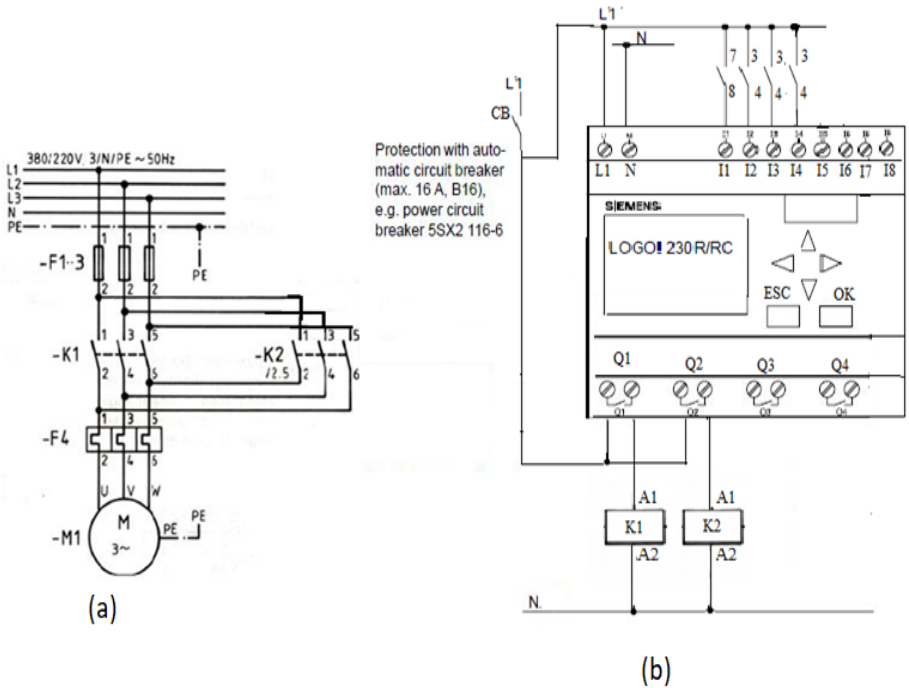


Figure 2.14 (a) star-delta power circuit (b) star-delta wiring diagram

Information Sheet-4	Creating and loading programs in to PLC

Each horizontal rung on the ladder represents an instruction in the program to be used by the PLC. The entire ladder gives the complete program. There are several methods that can be used for keying in the program into a programming terminal. Whatever method is used to enter the program into a programming terminal or computer, the output to the memory of the PLC has to be in a form that can be handled by the This is termed machine language and is just binary code, e.g., 0010100001110001

A program consists of instructions that accomplish specific tasks. The degree of complexity of a PLC program depends upon the complexity of the application, the number and type of input and output devices, and the types of instructions used.

Ladder logic (LAD) is one programming language used with PLCs. Ladder logic incorporates programming functions that are graphically displayed to resemble symbols used in hard-wired control diagrams. The left vertical line of a ladder logic diagram represents the power or energized conductor. The output coil instruction represents the neutral or return path of the circuit. The right vertical line, which represents the return path on a hard-wired control line diagram, is omitted. Ladder logic diagrams are read from left-to-right and top-to-bottom. **Rungs are sometimes referred to as networks**. A network may have several control elements, but only one output coil.

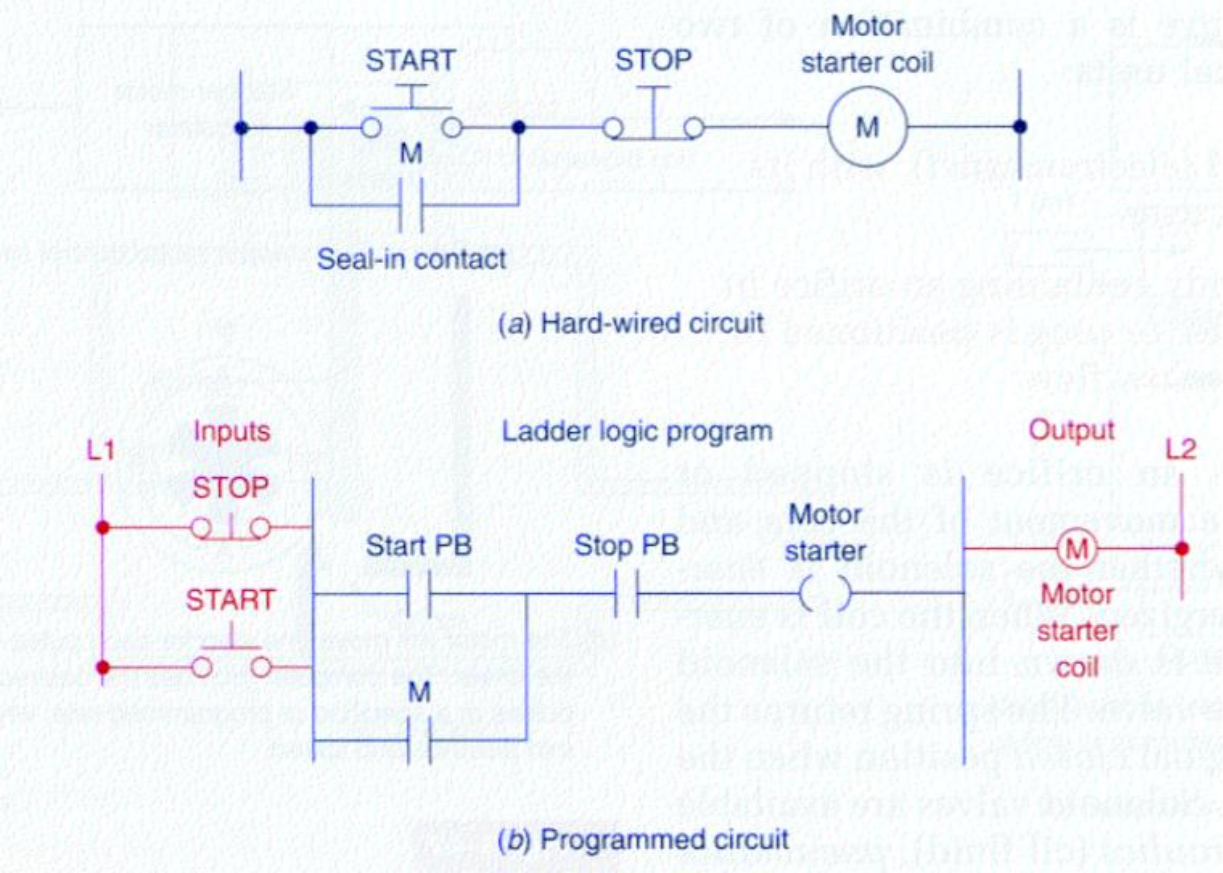
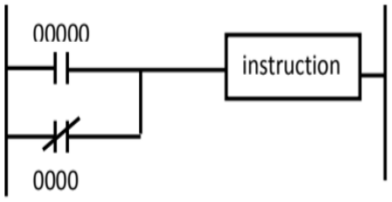


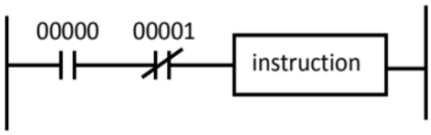
Figure 2.25 Control Elements Network

N.B For more detail refer information sheet -3 of LO-41 about this circuit of mnemonic instruction coding program (refere AND -and- OR logic gate)

Self-Check -4	Written Test

Directions: create and load the following ladder diagram mnemonic code : each contains 5 pts

1. 

2. 

Note: **Satisfactory rating –above 5** **Unsatisfactory - below 5points**

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Answer sheet

1. _____-
2. _____

Information Sheet-5	Testing and verify the operation of the gram

Testing Inputs and Outputs

Input devices, such as switches, can be manipulated to give the open and closed contact conditions and the corresponding LED on the input module observed. It should be illuminated when the input is closed and not illuminated when it is open. Failure of an LED to illuminate could be because the input device is not correctly operating, there are incorrect wiring connections to the input module, the input device is not correctly powered, or the LED or input module is defective. For output devices that can be safely started, push buttons might have been installed so that each output could be tested.

Another method that can be used to test inputs and outputs is forcing. This involves software, rather than mechanical switching on or off, being used with instructions from the programming panel to turn off or on inputs/outputs. To do this, a PLC has to be switched into the forcing or monitor mode by perhaps pressing a key marked FORCE or selecting that mode on a screen display.

Testing Software

Most PLCs contain some software-checking program. These checks through the installed Program for incorrect device addresses and provides a list on a screen or as a printout of all the input/output points used, counter and timer settings, and so on, with any errors detected.

For example, there might be a message that an output address is being used more than once in a program, a timer or counter is being used without a preset value, a counter is being used without a reset, or the like. can be checked. To carry out this type of operation, the terminal has to be placed in the correct mode.

Simulation

Many PLCs are fitted with a simulation unit that reads and writes information directly into the input/output memory and so simulates the actions of the inputs and outputs. The installed program can thus be run and inputs and outputs simulated so that they, and all preset values, can be checked. To carry out this type of operation, the terminal has to be placed in the correct mode.

Fault Finding

With any PLC-controlled plant, by far the greater percentage of faults is likely to be with sensors, actuators, and wiring rather than within the PLC itself. Of the faults within the PLC, most are likely to be in the input/output channels or power supply rather than in the CPU.

Procedure for testing

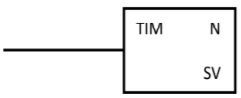
1. Power supply application
   a. Check the PLC power supply voltage and terminal connection
   b. Check I/O device power supply voltage and terminal connection
   c. Turn on the power supply and check that the power indicator lit up(illuminates)
   d. Use peripheral device to program mode
2. I/O wiring checks
   a. Within the program mode Check the out put wiring by turning on the bits with the force set and force reset operation
   b. Check the input wiring with the plc input indicator or peripheral device monitor operation
3. Test run
   a. Use peripheral device to set the PLC to RUN or MONITOR mode and check that the "RUN" indicator lights up
   b. Check the sequence of operation with force set/reset operation, etc
4. Debugging
   a. Correct any programming errors that are detected.
5. Saving the program

Timer and counter

i. **TIMER (TIM**) and COUNTER (CNT) is the instructions that require numbers TIM / CNT (N) and the set value(SV). The range of numbers TIM / CNT is from 000 to 511, while the range of set values for the TIM / CNT is 0000 to 9999 The numbers TIM / CNT can not be used twice. When a number has been used as definer, such as number 000 for instructions on TIM / CNT, the number cannot be used again. When a number is defined as the number of TIM / CNT, it can be used as often as required as an operator operand in other instructions from the command TIMER or COUNTER

TIMER =TIM

Symbol



- Timer numbers (N) is between 000 and 015.
- The set value (SV) is between 0000 to 9999.
- All numbers TIM / CNT can be used as definer in only one TIMER or COUNTER instruction.

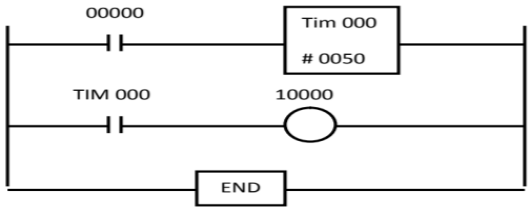
A timer is a special counter ladder function which allows the PLC to perform timing operations based on a precise internal clock, generally 0.1 or 0.01 seconds per clock pulse.

Timers usually fall into two different categories depending on the PLC manufacturer. These are retentive and non-retentive timers. A non-retentive timer is one which has one control line, that is, the timer is either timing or it is reset. When this type of timer is stopped, it is automatically reset. This will become clearer as discussion of timers continues. The retentive timer has two control lines, count and reset. This type of timer may be started, stopped then restarted without resetting. This means that it may be used as a totalizing timer by simply controlling the count line. Independent resetting occurs by activating the reset control line. At the beginning of this section, it was stated that a timer is a special counter. The timing function is performed by allowing the counter to increment or decrement at a rate controlled by the internal system clock. Timers typically increment or decrement at 0.1 second or 0.01 second rates depending upon the PLC manufacturer.

Example

TIMER is enabled/activated when the execution condition is ON and will be reset to set value (SV) when the execution condition is OFF.

The set value (SV) of TIMER is the binary code (BCD) between # 0000 to # 9999. For example, if TIMER be set to 5 seconds, then the set value (SV) is # 0050.



Timer ladder diagram

Mnemonic Code

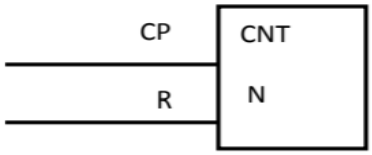
Address	Instruction	Operand/Data
00000	LD	00000
00001	TIM	000 # 0050
00002	LD	TIM 000
00003	OUT	10000
00004	FUN 01	

Operating Condition: When the input (LD 00000) is ON, the timer contact will be activated after 5 seconds. Next the output (OUT 10000) will be ON

ii. **A counter** is a special function included in the PLC program language that allows the PLC to increment or decrement a number each time the control logic for the rung switches from false to true. This special function generally has two control logic lines, one which causes

the counter to count each time the control becomes true and one which causes the counter to reset when the control line is true.

Symbol



- Number TIM / CNT can be used as definer for either timer or counter.
- Counter numbers are range from 000 to 015.
- Counters are used to calculate the count down from the set value (SV) on the execution condition on the counting pulse (CP) when it is changed from OFF to ON.
- The set value (SV) is range 0000 to 9999.
- Counters will reset to the reset (R).

Notice that this special function has two control lines one containing a normally open contact IN1 and one containing normally open contact IN2. The counter itself has a coil associated with it that is numbered CTR1. Notice too, that inside the function block are two labels, ACTUAL and PRESET. These ACTUAL and PRESET items contain numbers. The PRESET value is the maximum count allowed for the counter. This number may be held as a constant value in permanent memory or as a variable in a Holding Register. A holding register is a memory location in RAM which may be altered as required. The programmer would use a holding register for the PRESET value of the counter if the maximum count value needed to change depending upon program operation such as in a program that needed to count items to be placed in a box.

Example Counter set to count 10. When the input (LD 00,000) is the pulse of ten, a counter will be activated and thus the output (OUT 10000) will be ON. When reset (LD 00,001) ON, a counter will be in original condition

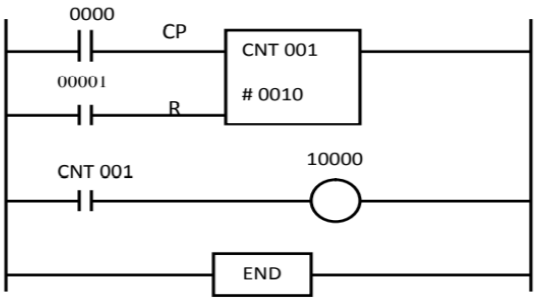


Figure Counter ladder diagram of counter

Mnemonic code

Address	Instruction	Operand/Data
00000	LD	00000
00001	LD	00001
00002	CNT	000
		#0010
00003	LD	CNT 001
00004	OUT	10000
00005	FUN 01	

Self-Check -5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: each contains 2pts

1. What is going to be tested in PLC programing list them (2pts)
2. List most likely faults in PLC controlled plant
3. How to test software in PLc?
4. Write the difference between timer and counter

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------
4. ----------

Information Sheet-6	Create/prepare external documentation and back-up programs

Documentation is an orderly collection of recorded information about both the operation of a machine or process and the hardware and software components of its control system. These records are a valuable reference during system design, installation, start-up, debugging, and maintenance.

To the system designer, documentation should be a working tool that is used throughout the design phase. If the various documentation components are created and kept current during system design, they will provide the following benefits:

- They will provide an easy way to communicate accurate information to all those involved with the system.
- They will serve as a reference to the designer during and after the design phase.
- They will help the designer, or someone else, answer questions, diagnose possible problems, and modify the program if requirements change.
- They will serve as training material both for the operators who will interface with the system and for the maintenance personnel who will maintain it.
- They will allow the system to be reproduced or altered to serve other purposes.

Proper documentation comes from the compilation of hardware, as well as software, information. The engineering or electrical group that designs the system usually provides this information to the end user. Although documentation is often thought of as extraneous, it is actually a vital system component and a good engineering practice

System Documentation

The documentation is the main guide used by everyday users, including for troubleshooting and fault finding with PLCs. It thus needs to be complete and in a form that is easy to follow.

The documentation for a PLC installation should include the following:

- A description of the plant
- Specification of the control requirements
- Details of the programmable logic controller
- Electrical installation diagrams
- Lists of all input and output connections
- Application program with full commentary on what it is achieving
- Software backups
- Operating manual, including details of all start up and shut down procedures and alarms

Self-Check -6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: each contains 2pts

1. What is documentation? PLC
2. Write the importance of documentation
3. Write at least three example of documentation included in PLC . ?

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------

Instruction Sheet-3	Learning Guide 61: Edit and monitor basic programs using a hand program loader

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- Checking the current values of timers and counters.
- Editing features to make minor program changes

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- verify the monitoring function is circuit conditions and check the current values of timers and counters.
- Edit minor program changes

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the “Information Sheets 1- ”. Try to understand what are being discussed.
4. Accomplish the “Self-checks 1,2, ,” in each information sheets on pages 4,11,14,19,23 and 26.
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “Operation sheets 1, 2 and 3 on pages 28,29 and 30.and do the LAP Test on page 31”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity.
7. After You accomplish Operation sheets and LAP Tests, ensure you have a formative assessment and get a satisfactory result; then proceed to the next LG.

Information Sheet-1	Checking the current values of timers and counters.

TIMERS There are four fundamental types of timers shown in Figure 3.1 An on-delay timer will wait for a set time after a line of ladder logic has been true before turning on, but it will turn off immediately. An off-delay timer will turn on immediately when a line of ladder logic is true, but it will delay before turning off. Consider the example of an old car. If you turn the key in the ignition and the car does not start immediately, that is an on-delay. If you turn the key to stop the engine but the engine doesn't stop for a few seconds, that is an off delay. An on-delay timer can be used to allow an oven to reach temperature before starting production. An off-delay timer can keep cooling fans on for a set time after the oven has been turned off

	on-delay	off-delay
retentive	RTO	RTF
nonretentive	TON	TOF

Figure 3.1 four basic type of timer

TON - Timer ON

TOF - Timer Off

RTO - Retentive Timer On

RTF - Retentive Timer OFF

COUNTERS :-There are two basic counter types: count-up and count-down. When the input to a count-up counter goes true the accumulator value will increase by 1 (no matter how long the input is true.) If the accumulator value reaches the preset value the counter DN bit will be set. A count-down counter will decrease the accumulator value until the preset value is reached

Example of a timer on-delay that sets an output after a count-down

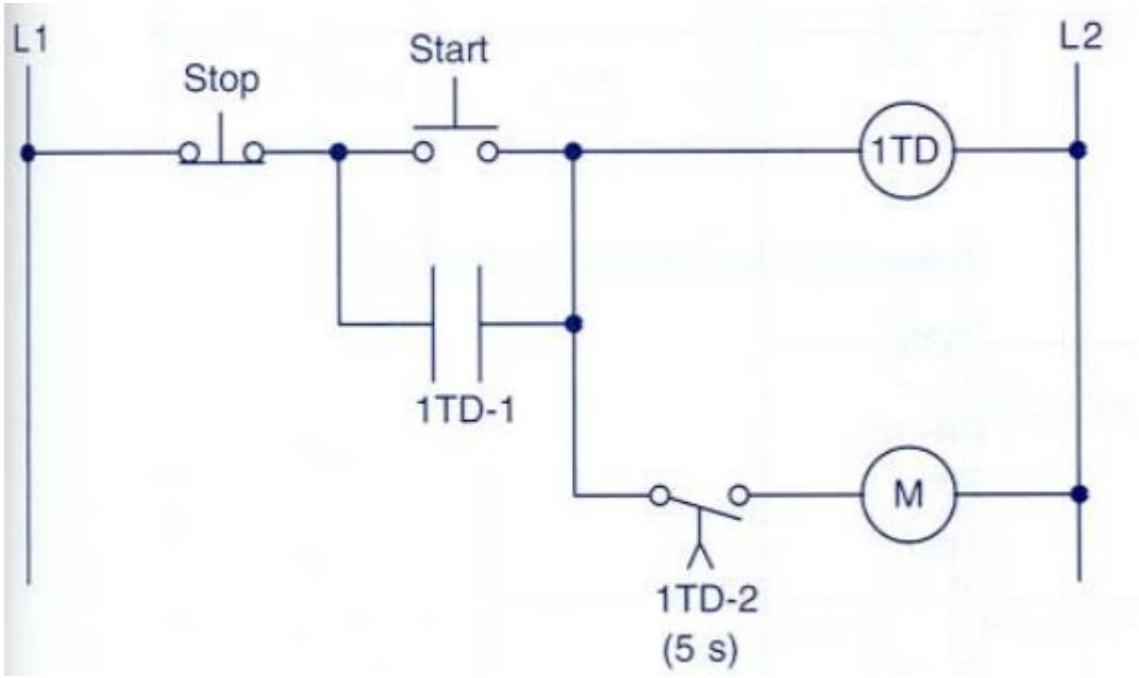


Figure 3.2 relay ladder schematic diagram

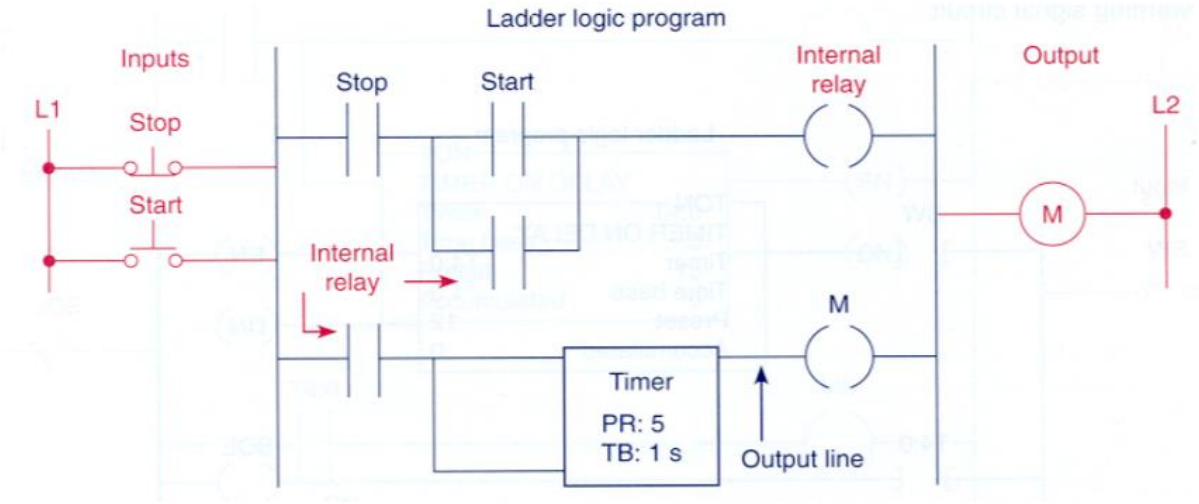


Figure 3.3 ladder diagram

For mort information refer LO-02 -41 of information -3 for information 2 of this LO-3-41

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page: each contains 5pts

1. Write the four type of timer
2. Write the two type of counter

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------

LAP Test#1	Operating direct on line induction motor with PLC

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, workshop, tools and materials you are required to perform the following tasks within 1 hours.

Job Title	Programming direct on line induction motor control
OBJECTIVE	To develop skills for operating motor with PLC
Condition for the operation	You will finish with in 1 hour
Equipment and tools	PLC Computer
ACTIVITY PROCEDUR	Must follow OH&S procedure, write program with ladder diagram, simulate the program.
EVALUTION CRITERIA	• Interpreted work instructions according to job requirements • Selected appropriate basic PLC programming language

LAP Test#2	Operating forward reverse induction motor with PLC

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, workshop, tools and materials you are required to perform the following tasks within 01:30 hours.

Job Title	Programming forward reverses induction motor control.
OBJECTIVE	To develop skills for operating motor with PLC
Condition for the operation	You will finish with in 01:30 hour
Equipment and tools	PLC Computer
ACTIVITY PROCEDUR	Must follow OH&S procedure, write program with ladder diagram, and simulate the program.
EVALUTION CRITERIA	• Interpreted work instructions according to job requirements • Selected appropriate basic PLC programming language

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