Abu Dhabi National Oil Co.

ADNOC Technical Institute

أدنــوك
ADNOC
شركة بترول ابوظبي الوطنية

INSTRUMENTATION

INTRODUCTION TO PLC's

UNIT 1

PLC FUNDAMENTALS

UNITS IN THIS COURSE

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1.0 UNIT OBJECTIVES

The student will be able to:

- Explain the difference between PLC systems and the older relay systems.
- Explain the operation of a simple PLC ladder diagram.
- Explain the function of the Allen-Bradley PLC components.
- Explain using a block diagram the three basic PLC systems:
    1. Single μP PLC
    2. Dual redundant PLC
    3. Triple redundant PLC
- Give examples of where the different types of PLC would be used.

1.1 INTRODUCTION

The aim of this unit is to explain the fundamentals of a Programmable Logic Controller (PLC). It will also act as an introduction to the main part of the course; practical work on a PLC unit.

1.2 PLC SYSTEMS

There are various manufacturers of PLC equipment. They all use different methods for sending data and make their diagrams to different standards. This means that ADNOC and the operating companies do not mix the different types of PLC systems. You cannot mix PLC systems when controlling a process. Some of the PLC systems used in the field are:

ALLEN-BRADLEY MODICON	On most fields for ESD & Turbine, etc.
BAILEY	ADCO
ELLIOT	ADGAS
ECHARD	GASCO
AUGUST	UMM AL NAR (Refinery)
INTERNATIONAL CONTROL SYSTEMS (ICS)	ADGAS

The most common PLC systems are Allen-Bradley and Modicon which use the ladder diagram method for PLC logic. This system is explained here so that you can practice programming techniques on the Allen-Bradley training equipment available in the workshop.

1.3 LADDER DIAGRAMS

Ladder diagrams show the operating sequence for a PLC system. They indicate step by step what happens when the system is started, shut-down or operated under an emergency. You move down the ladder from top to bottom.

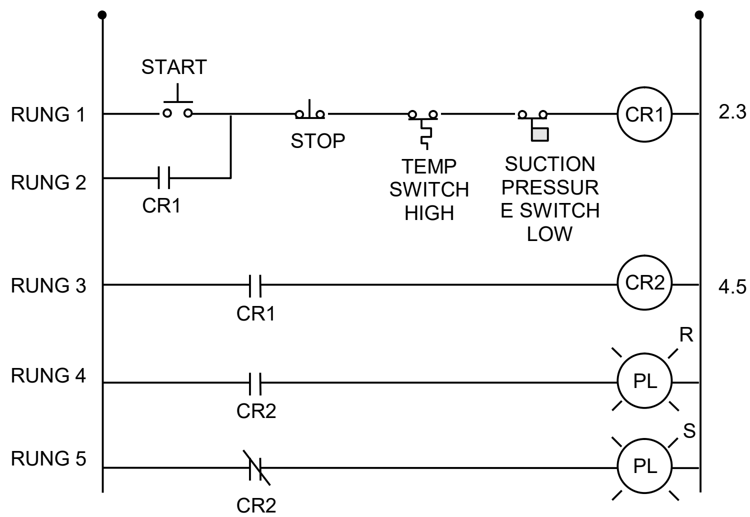


Figure 1-1 Simple Ladder Diagram for Pump Starting

Figure 1-1 shows a simple ladder diagram for starting/stopping a pump. The diagram will be explained as if the system were operated in relays. Remember the diagram is drawn with contacts in the de-energised position.

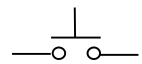
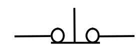
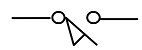
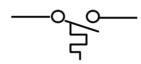
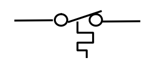
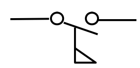
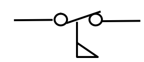
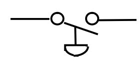
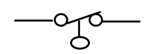
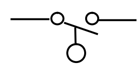
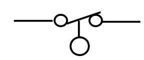
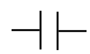
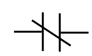
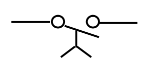
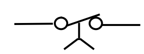
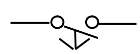
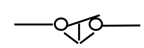
1. CR 1 is the coil of control relay one
2. The stop button, temperature switch and suction pressure switch are normally closed. When the start button is pressed CR 1 will energise.
3. The contacts of CR 1 (located on rungs 2 and 3) change over, from normally open (⊣⊢) to closed (⊬).

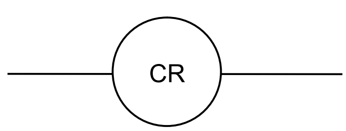
4. CR 1 contact on rung 2 is the hold "ON" contact. When this has closed the start button can be released.
5. When the CR 1 contact on rung 3 is closed it energises control relay CR 2
6. CR 1 is the operating relay for the pump. When CR 1 operates the supply is connected to the pump motor.
7. The CR 2 contacts on rungs 4 and 5 change over. The normally open contact on rung 4 closes to light the run light (PL-R). The normally closed contact on rung 5 opens and the stop light goes out (PL-S).
8. The stop button, temperature switch and pressure switch are connected as an AND circuit. If any one of them is operated then CR 1 is de-energised. The motor stops and the run-stop lights change over.

The operating supply for the relays on the ladder diagram can be 24V d.c. 110V a.c. or 220V a.c. depending on the system. The relays themselves are located in the electrical switch room. The stop/start buttons and lights are located in the control room. The temperature and pressure switches are located in the field and are hard-wired into the relay system.

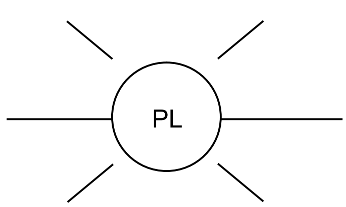
A PLC system provides the same sequence to start the pump but the relays are replaced by electronic switches. The contact switching sequence is set into the PLC by a hand held programmer (pocket programmer). Normally, the programmer uses the same type of ladder diagram as the relay system, with the same symbols. A ladder diagram of the required switching sequence must be drawn before the programme can be set into the PLC.

A table to show the common symbols is included as a reference to the Allen-Bradley PLC ladder diagram system.

DEVICE TYPE	CONTACT SYMBOL	
	NORMALLY OPEN	NORMALLY CLOSED
PUSH BUTTON		
LIMIT SWITCH		
TEMPERATURE SWITCH		
FLOW SWITCH		
PRESSURE SWITCH		
LEVEL SWITCH		
CONTROL RELAY (CR)		
TIME DELAY RELAY		
DELAY BEGINS WHEN COIL IS ENERGISED		
DELAY BEGINS WHEN COIL IS DE-ENERGISED		



CONTROL RELAY COIL



PANEL LIGHT
(OUTPUT CONDITION
INDICATOR)

1.4 RELAY SYSTEMS AND PLC COMPARISON

The ladder diagram used has been explained using relays. Figure 1-2 shows a block diagram of the overall system using relays. It is sometimes called a HARD-WIRED control system. When the control logic is installed it can only be changed manually.

Note: The relay system is still preferred in some safety systems as it is very difficult to check the software operation of a PLC for faults.

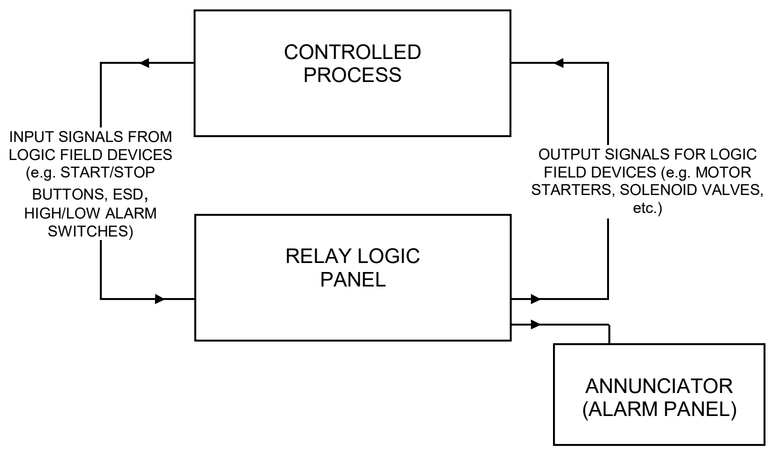


Figure 1-2 Block Diagram Relay Logic Control

A PLC collects inputs and distributes outputs in the same way as a relay logic circuit. However, the relays are replaced by a microprocessor which is programmed to provide the switching logic.

Figure 1-3 shows a typical PLC block diagram based on Allen-Bradley.

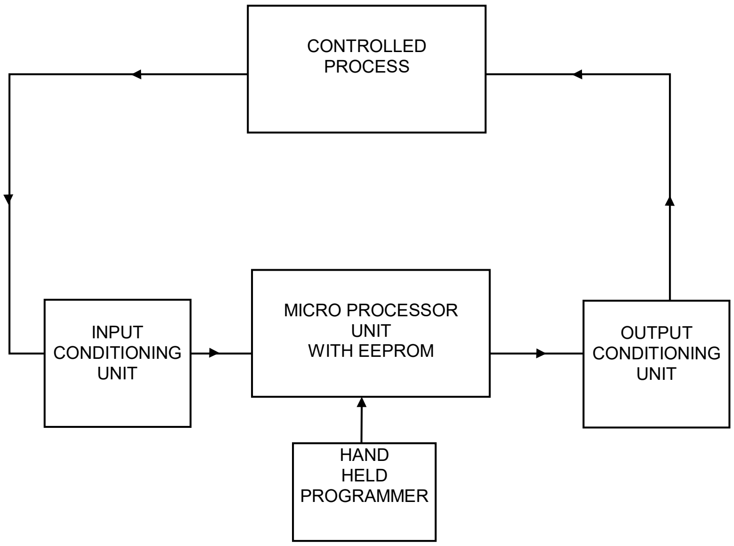
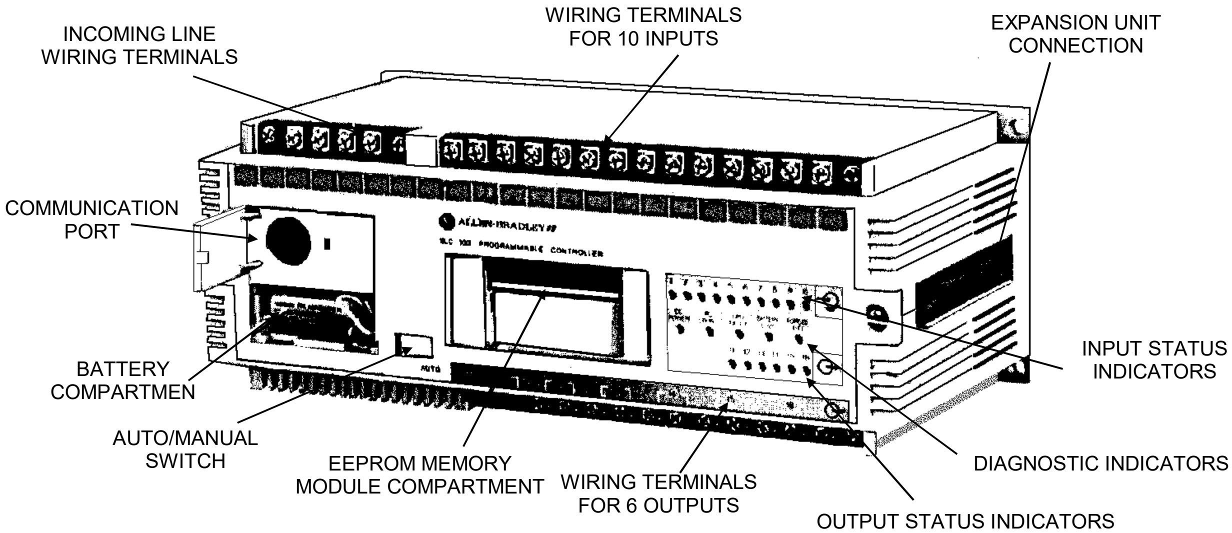


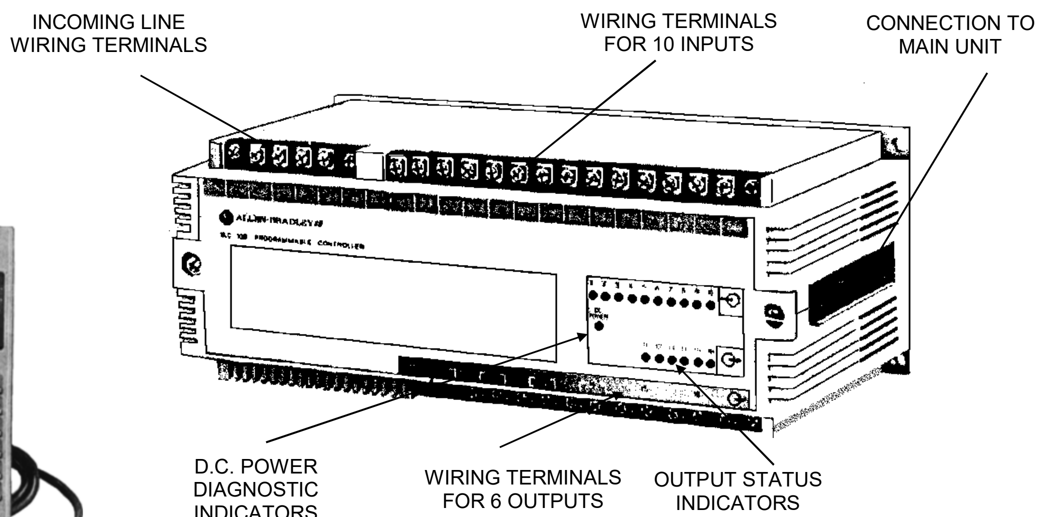
Figure 1-3 Block Diagram Programmable Logic Control

1.5 PLC SYSTEM EXAMPLES

1.5.1 The Allen-Bradley System



1) MAIN PROCESSOR UNIT



2) EXPANSION I/O UNIT

3) POCKET PROGRAMMER

Figure 1-4 Main Components of Allen-Bradley PLC

Figure 1-4 shows the major components of an Allen-Bradley PLC. It consists of the following units.

1) Main Processor Unit.

This units provides the following functions

- The system μP and RAM.
- EEPROM memory compartment. An EEPROM is normally added as a back-up to hold the RAM programme in case of system failure.
- Input conditioning for 10 inputs with status indicators.
- 6 separate outputs with status indicators.
- Battery compartment with lithium battery. This battery supplies D.C. power to hold the RAM data if the mains supply is lost.
- Communication port so that the processor RAM can be re-programmed.

The unit is powered by a standard single phase supply (UAE: 240V~50 Hz). This supply is connected to the incoming line terminals.

2) Expansion I/O unit.

This unit is connected to the main processor unit by a cable. It uses the connections shown to provide increased I/O's. This provides an extra 10 inputs and 6 outputs. There are status indicators for each I/O. This unit gets d.c. power from the main processor unit. A d.c. power indicator is provided to show that this unit is powered correctly.

Note: Allen-Bradley also supply a hard-wired relay expansion unit. This unit is used if higher current switching is required. Maximum 2.5A continuous when switching either 240V a.c. or 24V d.c.

3) Pocket Programmer.

This unit has a keyboard and display panel. It is used to programme (configure) the required logic operations. This will be used in the workshop when you try some simple programming techniques.

The Allen-Bradley system described is one of the simple single μP types. It is used for

a) Controlling a single process (e.g. pump starting, ship loading sequences etc.)

b) Larger processes which have no effect on plant safety. (Therefore they must be cheap, e.g. fire detector systems for accommodation units etc.)

c) As a back-up for a large safety system. (E.g. to operate a shut-down if the emergency shut-down button is pressed or a fire alarm if the "break glass" unit is operated).

1.5.2 The Dual Redundant Emergency Shut Down PLC System

The most important feature of an ESD system is that it must only operate when there is a failure in the plant. There are two main problems if the ESD equipment fails. The first problem is the high cost of lost production. The second problem is that if the ESD equipment keeps failing the operations staff by-pass the system in order to keep the plant running. The dual redundant PLC system reduces the chance of an ESD system shutting down the plant because of ESD equipment failure. However, it ensures the plant is shut-down when there is a failure in the plant. Figure 1-5 shows the basic block diagram of a fully redundant PLC system (e.g. the new Allen-Bradley PLC-5 series and ICS).

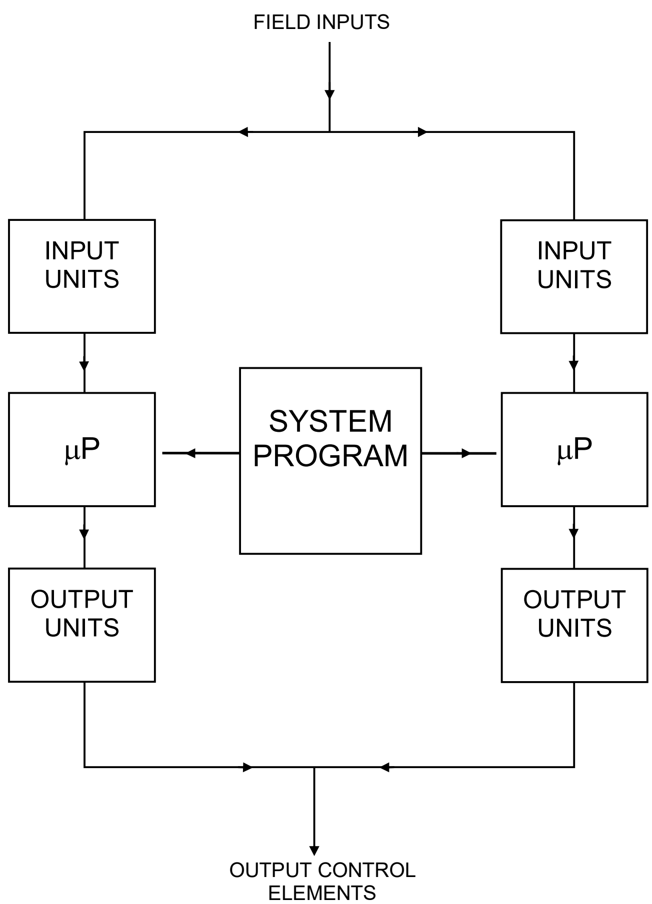


Figure 1-5 Dual Redundant PLC System

OPERATION

1) The field inputs are applied to two identical PLC systems in parallel.
2) The software program for the PLC is applied to both μPs.
3) If the field inputs are correct then the plant operates.
4) If a field input fails then both PLC systems will detect this. In this case both the output control elements will shut-down the plant.
5) Because there are two identical PLC systems the chances of a fault on both at the same time is very small. Therefore, a fault on one PLC system will not cause a shut-down because the good system will still hold the output control elements in the correct position.
6) A faulty unit in the PLC system will indicate it has a fault. Therefore, maintenance can be carried out while the system is still running under the control of the good PLC system.
7) This type of system uses automatic line checking to ensure the input/output wiring and devices are connected correctly. These systems will be learnt during advanced training at work.
8) Dual redundant systems are used to control a complete ESD system. They provide a good level of safety at a reasonable cost (e.g. for platform control, oil/gas production units, etc.)

1.5.3 Triple Redundant PLC Systems

This system is the latest type of safety system. It ensures the plant only shuts down because of a plant failure but not because of an equipment failure. These systems are expensive. They are only used when the highest safety and reliability is required; e.g. large installations such as refineries, LNG plants etc.

An example of the triple redundant PLC is the AUGUST C 300 system. This system is used in the refinery at Umm Al Nar. AUGUST control systems claim that their system is 99.999% guaranteed to shut down the plant ONLY if there is a plant failure.

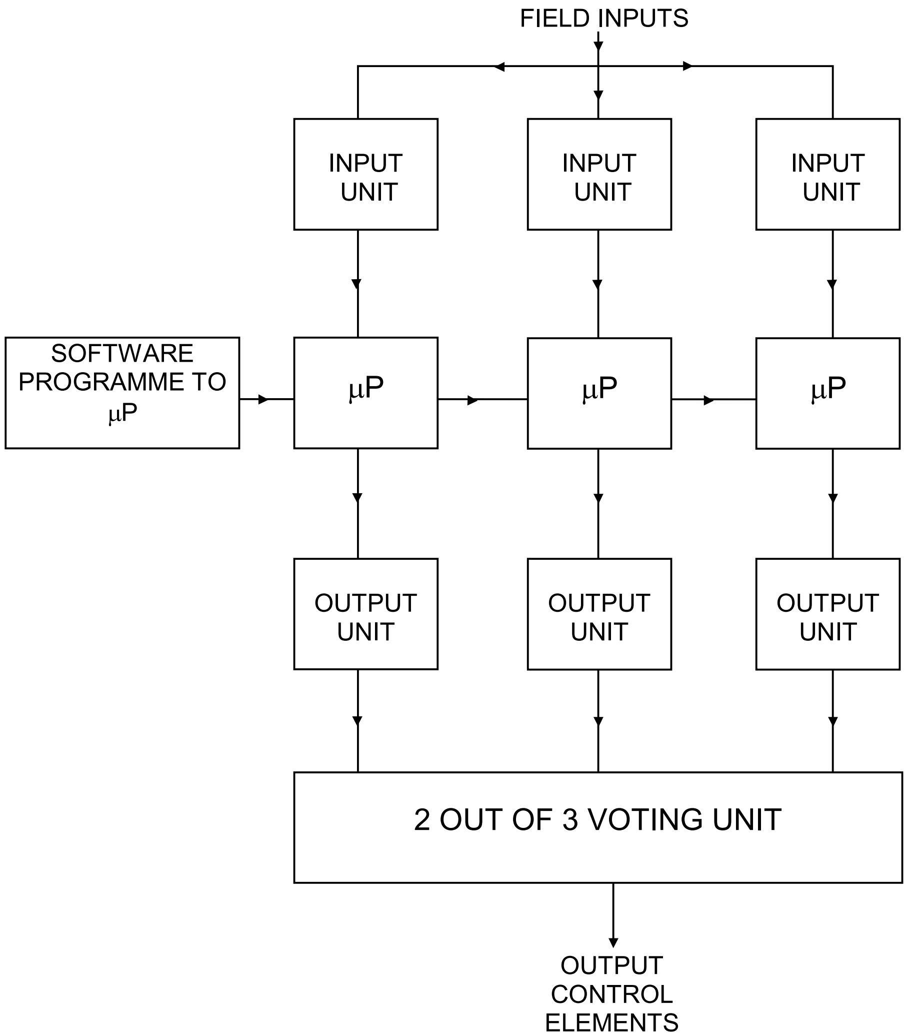


Figure 1-6 Triple Redundant PLC System

Figure 1-6 shows the basic principle of a triple redundant PLC system. This is sometimes called the 3.2.0 system. The voting unit will keep the plant running if 3 or 2 of the parallel systems are working correctly. It will shut the plant down if only 1 or none of the systems give the correct outputs. The software programme is fed into the three µPs. It uses a self checking system so a µP can detect faults in its own system. All the units have fault indicators so that they can be changed while the system continues to work using the good units.

All input/output wiring and devices are automatically checked to ensure that they are connected correctly.

These systems are very complicated and will be learnt on the job, as it depends on what system the plant uses.