**What are PLC’S**

 The first PLC's were designed for complex processes and introduced into most large industrial companies in the late 1960's. Further developments in electronics led to the production of smaller PLC's able to replace smaller relay control systems. This market was mainly developed by the Japanese. Current PLC units can cost effectively replace a relay control system made up of about ten relays.

**Relay Logic Systems**

1. Electro-mechanical relays convert a single input into a coil, to multiple outputs, by means of a moveable armature, which open and close contacts. Relays may either be of an open or enclosed type. The electrical circuit of a relay is divided into two parts; the control section, "the coil" and the power section, "the contacts".

2. Small relays are used for control systems, while larger relays - commonly called contactors - are used to switch the heavy power loads such as electric motors.

3. Control relays, combined with electro-mechanical timers, counters and stepping relays constitute the control or decision making component of a control system. Bringing together these control functions into a decision making process requires a high degree of skill in circuit design.

**Static Logic Control Systems**

1. With the introduction of transistors, it wasn't long before control system engineers began to see major advantages in using the "new" technology for control systems. Transistors and other electronic devices which have been developed are ideal for switching operation, because of their high speed and low power consumption.

2. Early control systems of this type were large, constructed from discrete electronic devices and easily damaged in service. They were called "Static" devices as they had no moving parts.

3. With the advent of the "microchip" technology, these transistors and other discrete components were miniaturised even further, to a point where a large number of individual devices could be produced on a single small chip of silicon.

4. These "Logic Gates" were used in all types of electronic control, such as electronic timing circuits, counters and a range of other devices. Many of these devices had multiple "gates" on each chip, allowing a high packaging density and small physical size.

5. Logic gates, unlike relays, have one or more control inputs, but generally only one output, for each gate. Most gates are interconnected to produce a control system.

6. Static logic circuits are constructed on printed circuit boards, where the integrated circuit chips are fixed into the circuit by soldering. Copper tracks on the surface of an insulated substrate material are used for interconnections.

7. Static logic devices typically operate on low levels of DC voltages. This low voltage requirement places some constraint on the use of these devices where when used to control high voltage AC loads. This problem may be overcome by using an interface device - such as a relay - to control the load.

**Programmable Control Systems**

1. A programmable controller is a solid state device which is microprocessor based. It performs the control logic functions which were previously controlled by electro-mechanical relays, drum controllers, timers, counters, and static logic devices.

2. Programmable controllers are used for the control and operation of manufacturing equipment and machinery. The basic design is similar to that of a computer, but they can operate both input and output field devices in "real time".

3. The programmable controller can be divided into three main parts as shown below in block diagram form. These component parts are the Central Processing Unit, (CPU), the programming device and the input and output section.

**From Field Inputs**

Sensors, Limit Switches, Push Buttons etc

**To Field Outputs**

Relays, contactors, lights etc

Output Modules

Central Processing Unit

Input Modules

Programming device

 4. The CPU, is the "brains" of the system. Internally it contains various logic gate circuits that replace relays, timers, counters, etc. It is designed so that the user can program the desired circuit in any one of several formats.

5. The CPU accepts (reads) input data from various input field devices, executes the user's stored program and operates various field output devices.

6. The input/output (I/O) section consists of input and output modules. These modules form the interface between the field devices and the CPU. The purpose of this interface is condition the various signals that are to be received from or sent to the field devices. This conditioning is required so that the higher voltages on the field devices are separated from the low voltages on which the CPU operates.

7. Input devices consist of such devices as:

a) Push buttons.

b) Limit switches.

c) Sensors.

d) Thumbwheel selectors.

These devices are hard wired to terminals on the input module.

8. Output devices consist of such devices as:

a) Motor contactors.

b) Solenoids.

c) Indicator lamps.

d) Alarm devices.

 These devices are hard wired to terminals on the output module.

9. These devices mentioned in 7 & 8 are termed field devices, to identify them as actual external devices that exist and have to be physically connected to the terminals of the I/O modules. This is distinct from the internal user program which duplicates the functions of relays, timers and counters.

**Programmable Control Systems (cont.)**

10. A Programming Device or Terminal is used to enter the desired program into the CPU's memory. It is this program with the information supplied by the input module that decides the sequence of operation of the equipment connected to the output module. Normally the programmer is only connected to the CPU when a program is being entered, modified or monitored.

14. Advantages of Programmable Control Systems:-

a) Complex control circuits are easily entered and modified.

b) Operates at high speed. Typically less than 100 ms for the entire program.

c) Very easy to fault find. The working area is small when compared to relay systems.

d) Basic instructions are easily understood by the tradesperson.

e) The ladder format is compatible with ladder diagrams used for electrical circuits.

f) Unlimited number of operations of the internal circuitry.

g) Costs are low when compared to relay or static logic equivalents.

h) The program can be easily and quickly changed when required. This allows a quick changeover in production lines.

**Common Terms Used with PLC's**

Address - A code that indicates the location of data to be used by a program.

Ambient Temp - The naturally occurring temperature within a room or an enclosure.

AND - A logic operation between two or more bits whereby bits are series with each other.

Bit - The bit is the smallest unit of information in the binary number system. It represents a decision between one of two possible states. It is often used to represent an Off or On state.

CPU - The part of computer based system which contains memory, arithmetic and logic unit and other special purpose electronic circuitry. The CPU is responsible for the interpretation and execution of user instructions.

Clock - An electronic circuit which generates extremely accurate electric pulses used to achieve synchronisation in a digital computer system.

Data - Information encoded in a digital form, which is stored in an assigned address of data memory for later use.

Digital - The representation of numerical quantities by means of discrete numbers. Either 1 or 0.

Element - An individual program instruction.

End of Scan - A PLC instruction which instructs the processor not to continue scanning the memory and return to the beginning of the user memory.

Examine Off - A term used by some PLC manufacturers to refer to a normally closed contact instruction in a relay ladder program.

Examine On - A term used by some PLC manufacturers to refer to a normally open contact instruction in a relay ladder program.

Executive - A machine language program for interpreting user program instructions and executing them.

Flag - see internal coil.

Hard Wired - Physically wired devices. The physical interconnection of electrical and electronic components with wire.

Input Device - Hardware devices used to provide data to a computer or PLC system. They can be discrete or analogue in their nature.

Interface - The connection between components, circuits or systems which allows the transmission of data.

Internal Coil - A relay instruction used for internal storage. A flag instruction differs from an output coil instruction in that the status of the internal coil is not passed to the I/O hardware control of a field device.

I/O - An abbreviation for Input/Output.

I/O Module - An electronic assembly containing the interface and isolation electronics for interfacing user field devices to the processor.

LED Display - A display device incorporating light emitting diodes.

LCD - A display device using reflected light liquid crystals to form a display.

Logic - A mathematical approach using functions such as NAND, OR, NOT, etc, which are formed in Boolean statements for simplification.

Memory - A grouping of circuit elements which has data storage and retrieval capacity.

Output - A signal provided by the PLC to the real world. They can be either discrete or numerical.

PLC - An abbreviation for programmable controller.

Program - A sequence of instructions to be executed by the CPU.

PROM - Programmable Read Only Memory. A type of ROM which can be programmed once then only read from there after. This type of memory is non-volatile.

RAM - Random Access Memory. A type of memory which data can be read from and written to. It a volatile memory type

ROM - Read Only Memory. A ROM is a solid state digital storage memory whose contents cannot be altered by the user. This type of memory is non-volatile.

Scan - The scanning operation is performed by the processor. The sequential examination of the ladder logic instructions stored in the memory and the status of inputs, outputs and registers to determine whether or not to energise each output.

Software - The user program which controls the operation of the PLC.

Solid State - Circuits designed using only integrated circuits, without any electro-mechanical devices.

Truth Table - A matrix which describes a logic function by listing all possible combinations of inputs and indicating the outputs for each combination.