History Of PLC

Early Control Systems

Even though the electro-mechanical relay(control relay) has served well for many generations, often under adverse conditions, the ever increasing sophistication and complexity of modern processing equipment requires faster acting and more reliable control than electro-mechanical relays and/or timing devices can offer. Relays have to be hard wired to perform a specific function, and when the system requirements change, the relay wiring has to be modified. In extreme cases, such as in the auto industry, complete control panels have to be replaced since it is not economical to rewire the old panels with each model changeover.

It was, in fact the requirement of the auto industry and other highly specialized, high speed manufacturing processes that created a demand for smaller, faster acting, and more reliable control devices. The electrical/electronics industry responded with modular designed soil-state electronics devices.

These early devices, while they offered solid-state reliability, lower power consumption, expandability, and elimination of much of the "hard-wiring" also brought with them a new language. The language consisted of AND gates, NOR gates, J-K flip flop and so on.

The reluctance of the end user to learn a new language and the advent of the microprocessor gave the industry what is known as the "***Programmable logic controller (PLC)***.

The history of the programmable controller is not extensive. In fact it goes back only as far as late 1960s and early 1970s. These first PLCs were mostly installed in automotive plants. Traditionally, the auto plants had to be shut down for up to a month at model changeover time. The early PLCs were used along with other new automation techniques to shorten the changeover time. One of the time-consuming changeover procedures has been the wiring new or revised relay and control panels. The PLCs keyboard reprogramming procedure replaced the rewiring of the panel full of wires, relays, timers and other components. The new PLCs helped reduce reprogramming time to a matter of a few days. [Ref. 31,(5 - pp. 1-2), (4 - pp. 13), (3 - pp. 1-6), (2 - pp. 2-4)].

Rise Of The PLC Systems

The first programmable controllers were quite primitive when evaluated by today standards. Evolution of PLCs can be understood when you examine the growth the major manufactures have experienced in the past years.

Modicon P.Cs :

The earliest fully programmable P.C was developed in 1969 by a consulting engineering firm called *Bedford associated*, which changed their name to *Modicon*. It was dedicated computer control system built specifically for the General Motor Hydramatics Division.

In June 1969, they delivered a P.C system called the 084 (Hard Hat) to General Motors' Hydramatics division. With modifications 184 model was developed in 1970 and 384 in 1972.

During this same era Modicon also produced two other models 284 and 1084, which had controllers with 80 inputs and 40 outputs, and 5120 inputs and 5120 outputs respectively.

In 1977, Modicon was purchased by Gould Inc. From 1978 to 1980 they developed Modbus which was a compact, low cost, powerful P.C system. In 1984, models were designed to handle PID control applications.

Modicon's future plans include continued updating of their system with more flexible memory and emphasis on program scan and communication capability [Ref. 4 pp. 13].

Allen-Bradley

Modicon was not alone in the P.C industry. In 1969, when the General Motors hydramatics division put out call for a P.C type system, Allen-Bradley also responded with P.C system. This system was called PLC. Allen-Bradley has been working on a solid-state control system for some time. Their first solid-state control system, the PDQ was designed in 1959. It was not reprogrammed, but it filled a much needed demand as a relay replacement. In 1970, Allen-Bradley designed the PMC programmable controller system, which was joined by PLC-2 in 1975. This provided mini computer capabilities, networking data transfer and program documentation.

In 1979, the PLC 2/20 was introduced which was followed by PLC 2/30. PLC-3 introduced in 1980 had the capability of off-line and online programming.

In 1982 Allen-Bradley introduced the PLC-4 which provided 20 inputs and 12 outputs in a small PLC system. By 1984 Allen Bradley had provided a PLC for the largest and the smallest user.

Future trends for Allen Bradley PLC call for more intelligent type modules, the rest as Modicon P.C's future tends [Ref. (4 - pp. 13), (5 - pp. 149,179)].

Texas Instrument P.Cs

In 1973, Texas Instruments designed their first P.C called the STI, which was sold from mid 1970 through present day. In 1987, the 570 system met the need for a larger P.C system. In 1982, 520 & 530 P.Cs were introduced with enhanced functions.

In late 1984 they produced the latest P.C system 560/565. Their new units have allowed TI to be able to stay at the top with Allen Bradley & Modicon in P.C market. [Ref. (4 - pp. 14-15)].

Square D P.Cs

Square D company has manufactured all types of traditional motor controls and solid state controls. In 1959, they produced a control product called the class 8852 NORPAK solid state control logic.

Their first true P.C was produced in 1973, named as the class 881. In 1975, they implemented a ladder diagram processor (LDP) using PROM memory. Later in 1977, the EAROM & RAM memory base system was introduced. The latest Square D Controller was in 1982 which had feature like ASCII keyboard and RS232C serial communications.

These were the four major manufacturers which contributed in the development of the programmable logic controllers. [Ref. (4 - pp. 13), (5 - pp. 149,179), (8 - handbook)]. Although, the history of PLC is based on the control system, there is a lacks of efficient and user-friendly interfaces for programming PLCs. This thesis designs and implements software for graphical manipulation of PLC ladder diagrams.

IEC

Fortunately the international industrial community has recognized that a new standard for PLC is required. A working group within IEC (International Electro-technical commission) was set up in 1979 look at the complete design of PLCs controllers, including the hardware, design, installation, testing, documentation, programming & communication. [Ref. 31 - Catalog]

The PLC ladder diagram software developed as a part of this thesis abides by the recommendations of IEC standards.

Introduction to Control Systems

Automation & Control

Many factories and plants place the workers in control of machines and equipment instead of requiring them to physically carry out the task. This control requires the worker to know how a particular process operates, and what inputs are necessary to achieve and maintain the desired output.

To achieve process automation, the operator must be replaced by some form of automatic system that is able to control the process with little or no human intervention.

A system that possesses the ability to start, regulate and stop a process in order to obtain the desired output is called a ***Control System.***

Elements of a Control System

A control system consist of three basic units, the input section which is usually a transducer, the processing section which can be implemented in the two different ways, using either hardwired or programmable controls, and the output unit.[Ref. 1 pp.1-4]

It is possible to achieve a high proportion of the potential benefits by using a microprocessor based programmable controller as mentioned in [Ref. 9 cp. 11 pp. 424].

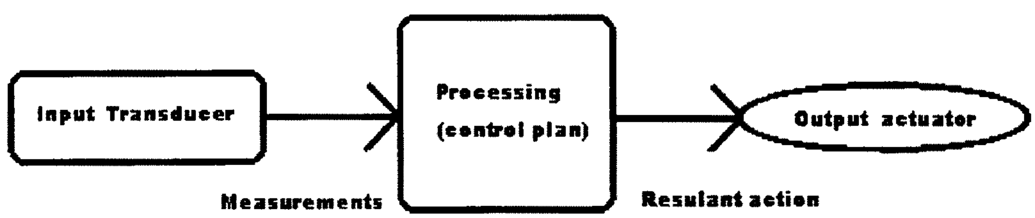

Figure 1 Elements of a control system

Table 1 and Table 2 list the different types of input, output and control systems. The following references discuss how they can be implemented in a programmable controller [Ref. (10 - pp.

57-71), (11 - pp. 181-154), (12 - pp. 123-142), (15 - pp. 105-121), (17 - handbook), (18 - vol. 2 no.4 pp.90-105, no.3 pp.142-149), (24 - cp. 5).

Table 1 Types of input transducers

Transducer	Measured quantity	Output quantity
Switch	Movement /position	Binary voltage (on/off)
Thermostat	Temperature	Binary voltage
Thermocouple	Temperature	Varying voltage
Thermistor	Temperature	Varying resistance
Strain gage	Pressure/movement	Varying resistance
Photocell	Light	Varying voltage
Proximity	Presence of objects	Varying resistance

Table 2 Types of Output devices.

Output device quantity	Quantity produced	Input
Stepper Motor	Rotation motion	Electrical
Pump	Rotation motion plus displacement of product	Electrical
Piston	Linear motion/pressure	Hydraulic/pneumatic
Solenoid	Linear motion/pressure	Electrical
Heater	Heat	Electrical
Relay	Electrical switching/Limited physical	Electrical

Comparison Of PLCs With Other Control Systems

The PLC versus a Relay control system

The relay is an important part of many control systems, being an electrical switch with a high current capacity that is indirectly operated by a relatively low control current. The relay control system is made up of several hundreds or thousands of relays that are energized by the opening and closing of input contacts. The overall control function is determined by the particular way the input and output contacts are connected during the design and assembly of the relay system. [Ref. (cp. 2), (5 pp. 1-27)]

A PLC is a computer, but a different type from the one you are probably used to seeing and working with. Most people are familiar with data-processing computers. But there is another type of computer know as a process-control computer. Although it of course processes data, its main function is to control manufacturing and industrial processes (machinery, robots, assembly lines etc.). PLCs are a type of process-control computers.[Ref. (3 - pp. 26-27), (15 - handbook)]

PLCs compared to Minicomputers and Microcomputers

In recent years, the uses of microprocessors have increased the capabilities of PLCs and have tended to reduce the differences between programmable controllers and microcomputers/minicomputers. The main differences between PLCs and microcomputer are:

- A microcomputer can be programmed to perform most of the functions of PLCs. However, general-purpose microcomputers are not built to operate reliably under industrial conditions, where they can be exposed to heat, humidity, corrosive atmosphere, mechanical shock and vibrations, electromagnetic noise, unreliable power with dropping voltages, voltage spikes etc. PLCs, by comparison are especially designed for industrial environment.
- While microcomputers can be interfaced with external equipment, they require special circuit cards. PLCs by comparison come with input or output (I/O) modules available for different equipment. PLCs are easily interfaced with hundreds of input and output lines, which is difficult to do with most microcomputers.

- PLCs usually contain various diagnostic features which facilitate troubleshooting. They are built for easy maintenance. Defective modules are simple exchanged, rather than replacing components.
- PLCs are usually programmed using relay type ladder diagram although programming languages similar to BASIC are becoming more common. This is so because many potential users are familiar with relay circuit ladder diagrams.
- Although many PLCs are able to accept analog data and to perform simple arithmetical operations, they really cannot compete with microcomputers when it come to complicated mathematical routines.
- PLCs are usually much slower than microcomputers. This is because the PLC scans the program line by line and only comes back to a given line after one complete scanning operation depending on PLC design and memory size. While this scanning speed is generally sufficient for most industrial system, it might be a limitation with fast feedback loops under PID control.

Throughout the present work PLCs have been compared to computer and this is investigated further in the references 26 and 27.

PLCs Versus Microcontrollers

Although PLCs and Microcontrollers have similar characteristics and functions they slightly differ in the hardware and software structures. The differences are given as follows:

- The central control unit of microcontroller is the Arithmetic and Logic Unit (ALU). The ALU is connected to three different blocks, the Input/Output block, the Program memory and the Data memory. A microcontroller follows the Harvard architecture or the Von Neumann memory architecture, but most PLCs follow the Harvard architecture.

- The I/O capability of a microcontroller is limited by the hardware design, it depends on the chip used in the microcontroller. Whereas in the PLCs you can increase the I/O capability by using expanded I/O slots.
- The interrupt handing capability of microcontrollers differs from that of PLCs.
- Microcontrollers have both synchronous & asynchronous communication devices, A/D & D/A converter and timers on the single chip. The PLC central processing unit (CPU) relies on the external hardware to do this.
- Microcontrollers are available with relay logic instruction. While designing PLCs, relay logic instructions need to be constructed. [Ref. 18 pp. 31]