Programmable Logic Controller (PLC) and its Applications

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***Abstract*- As the need of automation increases significantly, a control system needs to be easily programmable, flexible, reliable and cost effective. In this paper a review on the application of Programmable Logic Controller (PLC) in our current market is discussed. Investigations on the applications of PLC's in energy research, engineering studies, industrial control applications and monitoring of plants are reviewed in this paper. PLC's do have its own limitations, but studies indicate that PLC's have more benefits than limitations. n this review paper we will see that PLC' scan be used for any application. PLC's can be for simple as well as complicated control system.**

In a traditional industrial control system, all the control devices in the field are wired directly to each other on how the whole system is to be operated. The main control is in the human hands which poses a lot of drawbacks such as more wired connections are required which may again lead to large number of mechanical faults and difficulties in troubleshooting the errors. Due to these drawbacks the PLC based automation systems were introduced which focused on controlling the various process control systems with the help of software and Hardware units.

INTRODUCTION

Programmable logic controllers [PLC] are computer-based, solid-state, single processor devices that emulate the behavior of an electric ladder diagram capable of controlling many types of industrial equipment and entire automated systems. PLCs are usually a main part of automatic systems in industry. They are very efficient and reliable in applications involving sequential control and the synchronization of processes and auxiliary elements in the manufacturing, chemical and process industries. Besides having technological advantages of using PLC, it also decreases the prices in the advanced level and complex control system. Nowadays, most of the control elements used to execute the logic of the system was substituted by the PLCs.

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In the mid-1960s, Hydramatic, a division of General Motors Corporation, envisioned that a computer could be used to perform the logic functions then performed by relays [2]. The engineering team wrote a list of features of the proposed computing device. GM initiated the development of the computing device by specifying certain design criteria, including:

- The device must be durable so that it can operate in the harsh environments (dirty air, humidity, vibration, electrical noise,etc.) encountered in a factory
- It must provide flexibility by implementing circuit modifications quickly and easily through software changes.
- It must be designed to use a programming language in ladder diagram form already familiar to technicians and electricians.
- It must allow field wiring to be terminated on input/output terminals of the controller.

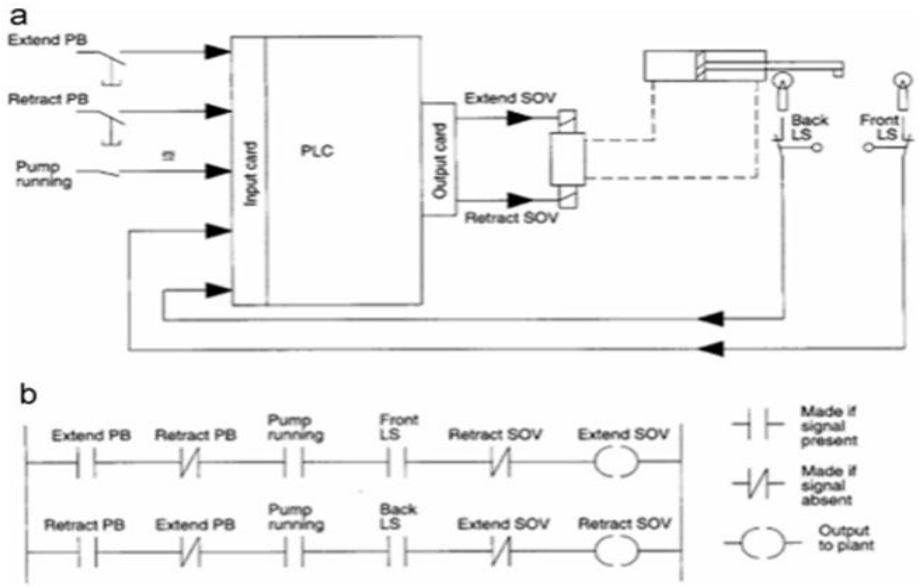


Fig. 1. A simple PLC application: (a) a hydraulic cylinder controlled by a PLC; (b) the 'Ladder Diagram' program used to control the cylinder [12]

DESCRIPTION

PLC Hardware The hardware components of a PLC system are CPU, Memory, Input/Output, Power supply unit, and programming device. Below is a diagram of the system overview of PLC.
CPU – The processor is the central processing unit (CPU) of the programmable controller. It executes the various logic and sequencing functions described in previous Sections by operating on the PLC INPUTS TO DETERMINE THE APPROPRIATE OUTPUT SIGNALS.

Memory – Tied to the CPU is the PLC memory, which contains the program of logic, sequencing, and other input/output operations. The memory for a programmable logic controller is specified in the same way as for a computer, and may range from 1k to over 48 k of storage capacity. A power supply of 115 V ac is specially used to drive the PLC even though the components of the industrial process that are regulated may have a higher voltage and power rating than the controller itself.

I/O section –Inputs come from sensors that translate physical phenomena into electrical signals. Typical examples of sensors are: o Proximity Switches—use inductance.

Capacitanceor light to detect an object logically. O Switches—mechanical mechanisms will open or close electrical contacts for a logical signal. O Potentiometer—measures angular positions continuously, using resistance. O LVDT (linear variable differential transformer)—measures linear displacement continuously using magnetic coupling.

O/P Section -- Outputs from PLC's are often relays, but they can also be solid state electronics such as transistors for DC out-puts or Triacs for AC outputs. Continuous outputs re-quire special output cards with digital to analog converters, or can be used another module for PLC analogue o/p.

The I/O ports are based on Reduced Instruction Set Computer (RISC).

Power supply – Certain PLCs have an isolated power supply. But, most of the PLCs work at 220VAC or 24VDC.Programming device – This device is used to feed the program into the memory of the processor. The program is first fed to the programming device and later it is transmitted to the PLC's memory.

System Buses – Buses are the paths through which the digital signal flows internally of the PLC. The four system buses are:

- Data bus is used by the CPU to transfer data among different elements.
- Control bus transfers signals related to the action that are controlled internally.
- Address bus sends the location's addresses to access the data.
- System bus helps the I/O port and I/O unit to communicate with each other.

INDUSTRIAL AUTOMATION SYSTEMS

Industrial automation is the use of computer and machinery aided systems to operate the various industrial operations in well controlled manner. Based on the operations involved, the industrial automation systems are majorly divided into two types: (a) Manufacturing automation and (b) Process plant automation systems.

1 Manufacturing Automation System:

The manufacturing industries make the product out of raw materials using robotics/machines. Some of these manufacturing industries include paper making, glass and ceramic, textile and clothing, food and beverages, etc. New trends in manufacturing systems have been using automation systems at every stage such as material handling, machining, assembling, inspection and packaging. With the computer aided control and industrial robotic systems, the manufacturing automation becomes very flexible and efficient.

2 Process Plant Automation

In process industries, the product results from many chemical processes based on some raw materials, some of the industries are cement industry, pharmaceutical, paper industry, petrochemical, etc. Thus the overall process plant is automated to produce the high quality, more productive, high reliable control of the physical process variables.

2.1 Plant:

This level consists of machines which are closest to processes. In this sensors and actuators are used to translate the signals from the machines and physical variables for the purpose of analysis and to produce the control signals.

2.2 Direct process control:

In this level, automatic controllers and monitoring systems acquire the process information from sensors and correspondingly drives the actuator systems.

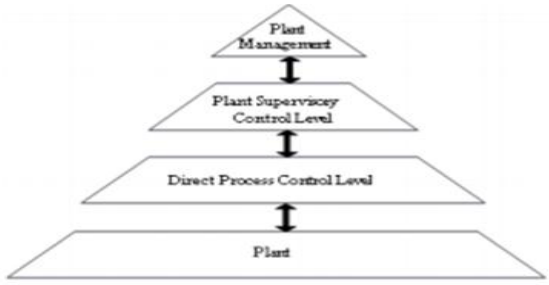


Fig. 1 Process automation system

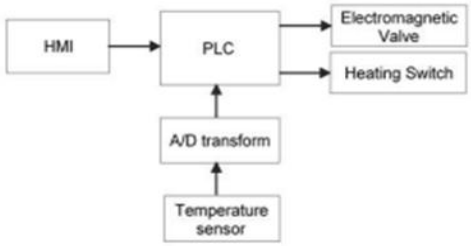
2.3 Plant supervisory control:

This level commands the automatic controllers by setting the targets or set points. It looks after the control equipment for an optimal process control.

3 Automated Dyeing Machine

In textile industry, dyeing machine is automated using PLC technology to automatically control the temperature and established the automatic temperature adjustment in the working process of dyeing machine. The control objective of dyeing machine and the structure of its temperature control system is shown in figure. The temperature of the system ranges from 20°C to 150°C, as water cannot attain the temperature of 150°C glycerin is used. Under normal pressure, glycerin can achieve 150°C.

According to the technical requirement, the temperature of glycerin in the dyeing trough must change. If the temperature of glycerin is lower than the predefined value the temperature control system should close the heat switch till the set value of temperature is reached. If the temperature is higher than set value then system should connect the cooling valve to drop the temperature. Thus dyeing technology of the textile needs strict requirement of the temperature control due to the difficulty in manual control.



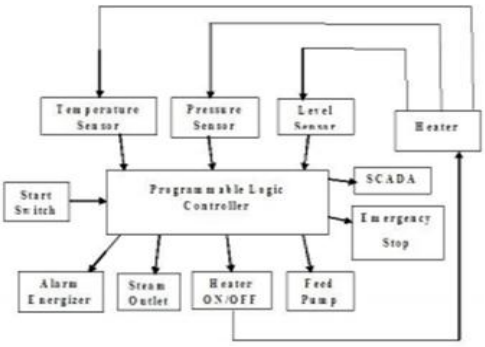
Structure of temprature conlrol system

4 Automated Boiler System for Thermal Power Plant

Boiler is one of the most important parts in any power plant. Which require continuous monitoring

and inspection at frequent interval. In Power plants it has number of boiling section. This boiling section produces the high temperature water of the steam. Boiler steam temperature in thermal power plant is very complex and hard to control, due to poorly understanding of the working principles; Boilers have many serious injuries and destruction of property. It is critical for the safe operation of the boiler and the steam turbine. Too low a level may overheat boiler tubes and damage them. Too high a level may interfere with separating moisture from steam and transfers moisture into the turbine, which reduces the boiler efficiency. Various controlling mechanism are used to control the boiler system so that it works properly, many control strategies have been applied to it. Block diagram of the automated boiler system for the thermal power plant is shown in figure. In order to automate a power plant and minimize human intervention, there is a need to develop a Boiler Automation system. It is achieved by using Programmable Logic Controller & Supervisory Control and Data Acquisition system that helps to reduce the errors caused by humans and avoids the catastrophic failure.

In boiler automation process using PLC and SCADA different sensors are used to measure the water level, temperature and pressure. PLC is used to control the process whereas SCADA monitors the various process parameters. If the pressure and temperature exceed the set value then the entire system shuts down and the valves automatically are opened to release the steam and pressure. Thus PLC can be programmed to function as an energy management system for boiler control for maximum efficiency and safety. In the burner management system it can be used to control the process of purging, pilot light off, flame safety checks, main burner light off and valve switching for changeover of fuels.



5. Induction Steel Heating Furnaces Using Plc

Induction heating is a thermal heating process, when a material is heated within an induction steel heating furnace (ISHF) its magnetic permeability and resistivity fluctuate, which proves detrimental to the control of power within the furnace. So to improve an power control within an ISHF programmable logic controller (PLC) is used. PLC not only helps in pressure, position and temperature control within ISHF but also provides over current and over voltage protection. PLC also allows heating to take place at constant power while maintaining a steady resonance frequency.

SALIENT FEATURES OF PLC

PLC control system is that it regards PLC as control key component, utilize special I/O module to form hardware of control system with a small amount of measurement and peripheral circuit, to realize control to the whole system through programming.

1. High Reliability:

Strong anti-interference quality and very high reliability are the most important features of PLC. In order to make PLC work stably in strong interferential circumstance. Many techniques are applied in PLC. Software control instead of relay control mode can decrease faults which are brought about by original electric contact spot outside working badly. Industrial grade components made by advance processing technology can resist interferences, and self-diagnosis measures of watchdog circuit for protecting memory can improve performance of PLC greatly.

2. Good Flexibility:

There are several programming languages for PLC including ladder diagram, SFC, STL, ST and so on. If operator can master only one of programming languages, he can operate PLC well. Every who want to use PLC has a good choice. Based on engineering practice, capacity and function can be expanded by expanding number of module, so PLC has a good flexibility.

3. Quality of Strong Easy-Operating:

It is very easy to edit and modify program for PLC by computer offline or online. It is very easy to find out where the fault lie by displaying the information of fault and function of Self Diagnosing Function, and all these make maintenance and repair for PLC

easier. It is very easy to configure PLC because of modularization, standardization, serialization of PLC

CONCLUSION

The automation of the design of industrial control processes has a history of strong innovations. In this paper the concept of Programmable logic controllers and its applications are discussed. PLC applications are typically highly customized systems so the cost of a packaged PLC is less compared to the cost of a specific custom-built controller design. Development of small modular structure in comparison with earlier structures have increased the flexibility of PLC configurations, PLC computing, scan time, data processing, network communication, graphics display, and other functions. The PLC programming tools are constantly developing, so it can be used more widely in the applications of numerical control technology, control of machining center which will be more flexible and reliable.

REFERENCES

[1] https://www.edgefx.in/industrial-applications-of-programmable-logic-controller/
[2] L.A Bryan. Programmable Controllers, Theory and Implementation.
[3] W. Bolton "Programmable Logic Controllers" ELSEVIER, Fourth Edition, 2006.
[4] Rehg, J.A., G.J. Satori, Programmable Logic Controllers. 2nd ed. 2009.
[5] SMC, Programmable Controller Technology International Training: SMC Pneumatics (SEA) Ptd Ltd
[6] S. Kalaivani, M. Jagadeeswari, "PLC and SCADA Based Effective Boiler Automation System for Thermal Power Plant", International journal of advanced research in computer engineering & technology.