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Review on PLC Programming Languages with Bottle Filling Industrial Application

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Abstract:
PLC has evolved as an important controller in industries these days because of its simplicity and robustness. It is used for controlling many mechanical movements of the heavy machines or to control the voltage and frequency of the power supplies. In this paper, study of the PLC has been done with several industrial applications have been studied and realized through ladder diagrams. These ladder diagrams are simulated in either PLC trainer or PLC simulator software. MATLAB/Simulink is also used for realizing physical situations as in case of dc motor and power inverter. The applications on which we have stressed are the continuous bottle filling system, batch-mixing system, speed control of dc motor, 3 stage air conditioning system, control of planar machine and the automatic frequency control of the supply, during induction heating .

Keywords: PLC, ladder diagrams, DC Motor, air conditioning system, V/F control, Automatic mixing and filling.

I. INTRODUCTION

A programmable logic controller, commonly known as PLC, is a solid state, digital, industrial computer using integrated circuits instead of electromechanical devices to implement control functions. It was invented in order to replace the sequential circuits which were mainly used for machine control. They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation and communication, to control machines and processes. According to NEMA(National Electrical Manufacture's Association ,USA),the definition of PLC has been given as "Digital electronic devices that uses a programmable e-memory to store instructions and to implement specific functions such as logic , sequencing, timing, counting, and arithmetic to control machines and processes". PLC was invented to replace the sequential relay machine control.PLC works at its input and depending upon their state turning on off its output.PLC provides many other benefits including increases reliability and flexibility, lesser cost, capability of communication, quick response type is easier. Figure below illustrates conceptual diagram of PLC application

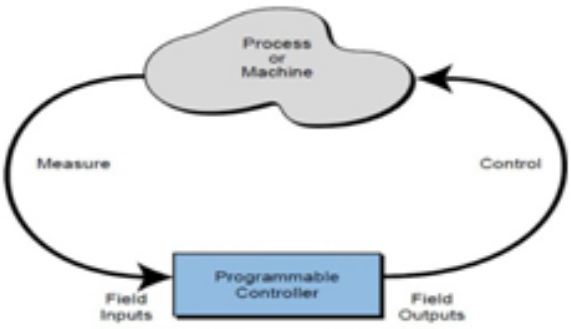

Figure.1. PLC conceptual application diagram

II. OBJECTIVE

1. To study basic parts of PLC and programming languages.
2. To understand industrial applications of PLC.

III.TOOLS

There are various tools used in our system.

3.1 Programmable Logic Controller (PLC)

A Programmable Logic Controller (PLC) is-

- A microprocessor based control system,
- Designed for using in an industrial environment,
- Programmed to sense, activate and control industrial equipment.

3.1.1 The conceptual design of PLC:

The first programmable controllers were more or less just relay replacers. Their primary function was to perform the sequential operations that were previously implemented with relays. These operations included ON/OFF control of machines and processes that required repetitive operations, such as transfer lines and grinding and boring machines. However, these programmable controllers were a vast improvement over relays. They were easily installed, used considerably less space and energy, had diagnostic indicators that aided troubleshooting, and unlike relays, were reusable if a project was scrapped. Although PLC functions, such as speed of operation, types of interfaces, and data-processing capabilities, have improved throughout the years, their specifications still hold to the designers' original intentions—they are simple to u se and maintain.

3.1.2 Today's Programmable Controllers:

Many technological advances in the programmable controller industry continue today. And these have led to many hardware (physical components) and software (control program) upgrades. The following list describes some recent hardware and software enhancements:-

- Faster scan times are being achieved using new, advanced microprocessor and electronic technology.
- Small, low-cost PLCs, which can replace four to ten relays, now have more power than their predecessor, the simple relay replacer.

- Mechanical design improvements have included rugged input/output enclosure and input/output systems that have made the terminal an integral unit.

Figure.3.1 Small PLC with built-in I/O and detachable - handled programming unit

- High-density input/output (I/O) systems (see Fi gure 1-3) provide space-efficient interfaces at low cost.
- Intelligent, microprocessor-based I/O interfaces have expanded distributed processing. Typical interfaces include PID (proportional - integral-derivative), network, CANbus, fieldbus,
- ASCII communication, positioning, host computer, and language modules (e.g., BASIC, Pascal).
- Special interfaces have allowed certain devices t o be connected directly to the controller.
- Typical interfaces include thermocouples, strain gauges, and fast-response inputs.
- Small PLCs have been provided with powerful instructions, which extend the area application for these small controllers.
- High-level languages, such as BASIC and C, have been implemented in some controllers' modules to provide greater programming flexibility when communicating with peripheral devices and manipulating data.

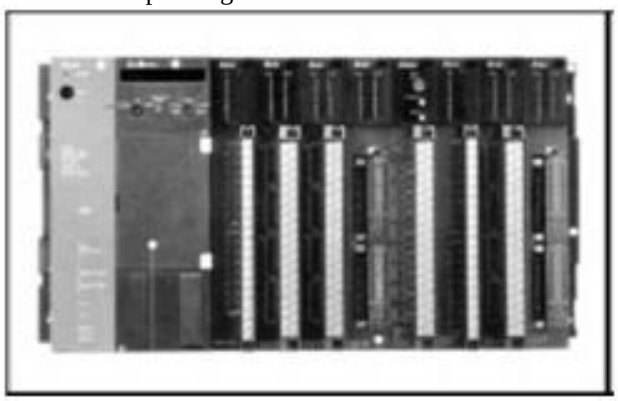

Figure.3.2 PLC system with high density I/O(64 point nodules)

- Advanced functional block instructions have been implemented for ladder diagram instruction sets to provide enhanced software capability using simple programming commands.
- Diagnostics and fault detection have been expanded from simple system diagnostics, which diagnose controller malfunctions, to include machine diagnostics, which diagnose failures or malfunctions of the controlled machine or process.
- Floating-point math has made it possible to perform complex calculations in control applications that require gauging, balancing, and statistical computation.

3.1.3 Basic parts of PLC:

All programmable controllers contain a CPU, memory, power supply, I/O modules, and programmable devices. Basic parts of the PLC are as follows:-

- Processor
- Memory
- Input/output devices
- Programming panel or unit
- Power supply

Processors module:

Processor module is the brain of the PLC. Intelligence of the PLC is derived from microprocessor being used which has the tremendous computing and controlling capability. Central processing –unit (CPU) performs the following tasks:-

- Scanning

Execution of program.

- Peripheral and external device communication
- Self- diagnose

Power of PLCs depends on the type of microprocessors being used. Small size PLCs use 8-bit microprocessors where as higher order controllers use bit-slice microprocessor in order to achieve faster instruction execute.

Input modules:

There are many types of input modules to choose from. The type of input module selection depends upon the process, some example of input modules are limit :-switches, proximity switches and push buttons etc. nature of input classification can be done in three ways, namely:-

- low/high frequency
- analog/digital (two-bit, multi-bit)
- maintained or momentary
- 5V/24V/110V/220V switched

Output modules:

Output modules can be used for devices such as solenoids, relays, contractors, pilot lamps and led readouts. Output cards usually have 6 to 32 output points on a single module. Output cards, like input cards , have electrically isolation between the load being connected and the PLC. Analog output cards are a special type of output modules that use digital to analog conversion. The analog output module can take a value stored in a 12 bit file and convert it to an analog signal. Normally, this signal is 0-10 volts dc or 4-20ma. This analog signal is often used in equipment, such as motor-operated valvesand pneumatic position control device. Each output point is identified with a unique address.

Addressing scheme:

Each i/o device has to be identified with a unique address for exchange of data. Different manufacturer apply different method to identify i/o devices. One of the addressing schemes may be "X1 X2 X3 X4 X5" where

- X1 = input or output designation fixed by hardware (i/p = 1, o/p = 0)
- X3 = modules slot number in i/o rack (fixed by hardware)
- X4 X5 = terminal number (fixed by hardware)

- X2 = i/o rack number in PLC (user designation)

Programming unit:
It is an external, electronic handheld device which can be connected to the processors of the PLC when programming changes are required. Once a program has been coded and is considered finished, It can be burned in to ROM. The contents of ROM cannot be altered, as it is not affected by power failure. Now a day's EPROM/EEPROM are provided in which program can be debugged at any stage. Once the program is debugged, programming unit is disconnected; and the PLC can operate process according to the ladder diagram or the statement list.

Operation of PLC:
During program execution, the processor reads all the inputs, and according to control application program, energizes and de-energizes the outputs. Once all the logic has been solved, the processors will update all the outputs. The process of reading the inputs, executing the control application program, and updating the output is known as scan. During the scan operation, the processor also performs housekeeping tasks. The inputs to the PLCs are sampled by processor and the contents are stored in memory. Control program is executed, the input value stored in memory are used in control logic calculations to determine the value of output. The outputs are then updated. The cycle consisting of reading of inputs, executing the control program, and actuating the output is known as "scan" and the time to finish this task is known as "scan time". The speed at which PLC scan depends upon the clock speed of CPU. The time to scan depends upon following parameter:-

- Scan rate
- Length of the program
- Types of functions used in the program

Faster scan time implies the inputs and outputs are updated frequently. Due to advance techniques of ASIC (application specific integrated circuit) within the microcomputer for specific functions, scan time of different PLCs have reduced greatly.

3.2 Programming Languages
The three types of programming languages used in PLCs are:-

- Ladder
- Boolean
- Grafcet

The ladder and Boolean languages essentially implement operations in the same way, but they differ in the way their instructions are represented and how they are entered into the PLC. The Grafcet language implements control instructions in a different manner, based on steps and actions in a graphic oriented program.

Ladder language:
For ease of programming the programmable controller was developed using existing relay ladder symbols and expressions to represent the program logic, needed to control the machine or process. The resulting programming language, which used these original basic relay ladder symbols, was given the name ladder language. Figure below illustrates a relay ladder logic circuit and the PLC ladder language representation of the same circuit. The control logic. That is, it uses the AND, OR, and NOT logic functions to implement the control circuits in the control program. Figure below shows a basic Boolean program.

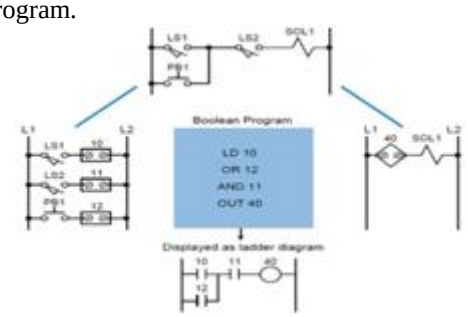

Figure. 3.2 Hardwired logic circuit and its Boolean expression
The Boolean language is just the another way of entering the control program in the PLC, rather than an actual instruction-oriented language. When displayed on the programming monitor, the Boolean language is usually viewed as a ladder circuit instead of as the Boolean commands that define the instruction.

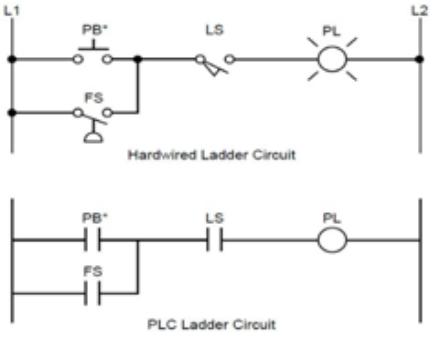

Figure 3.3 Hardwired logic circuit and its PLC ladder diagram representation
The evolution of the original ladder language has turned ladder programming into a more powerful instruction set. New functions have been added to the basic relay, timing, and counting operations. The term function is used to describe instructions that, as the name implies, perform a function on data i.e. handle and transfer data within the programmable controller. New additions to the basic ladder logic also include function blocks, which use a set of instructions to operate on a block of data. The use of function blocks increases the power of the basic ladder language, forming what is known as enhanced ladder language. The format representation of an enhanced ladder function depends on the programmable controller manufacturer; however, regardless of their format, all similar enhanced and basic ladder functions operate the same way.

Boolean language:
Some PLC manufacturers use Boolean language, also called Boolean mnemonics, to program a controller. The Boolean language uses Boolean algebra syntax to enter and explain

Grafcet:
Grafcet (Graphe Fonctionnel de Commande Étape Transition) is a symbolic, graphic language, which originated in France that represents the control program as steps or stages in the machine or process. In fact, the English translation of Grafcet means "step transition function charts." Grafcet is the foundation for the IEC 1131 standard's sequential function charts (SFCs), which allow several PLC languages to be used in one control program. Figure below illustrates a simple circuit represented in Grafcet. Note that Grafcet charts provide a flowchart-like representation of the events that take place in each stage of the control program. These charts use three components— steps, transitions, and actions—to represent

events. The IEC 1131 standard's SFCs also use these components; however, the instructions inside the actions can be programmed using one or more possible languages, including ladder diagrams.

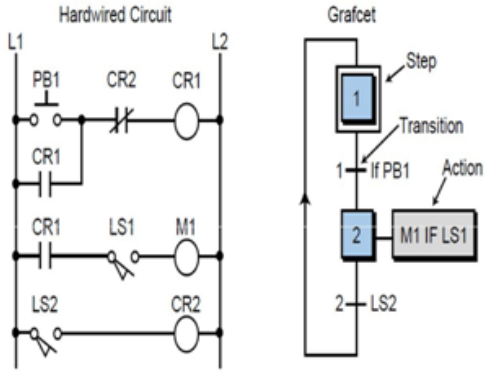

Figure.3.4 Hardwired logic circuit and its grafcet representation

Once programmed in the PC, the Grafcet instructions can be transferred to a PLC via a translator or driver that translates the Grafcet program into a ladder diagram or Boolean language program. Using this method, a Grafcet software manufacturer can provide different PLCs that use the same "language."

3.3 Industrial application:

Continuous bottle filling system:

This is one of the important application of PLC in the bottle filling industry where we want our bottles, which are moving on the conveyor belt, to be automatically detected at the appropriate position and get it filled by any desired liquid and also after getting filled the queued bottle gets chance to be filled. If this whole process is carried out manually it will really take a long time and also the quantities will be quite lesser. So PLC becomes requisite controller for these types of industry. Here also just a small demonstration of the process was performed with the help of PLC where a ladder diagram was created to control the process and the ladder diagram was run the PLC trainer kit to see its justification.

Objective:

We will implement a control program that detects the position of a bottle via a limit switch then waits for 0.5 secs, and then fills the bottle until a photo-detector detects the filled condition of the bottle. After the bottle is filled, the buzzer sounds and the control program will again wait for 0.7 secs. before moving to the next bottle .Until the limit switch signals ,the feed motor,M1 runs while there are fixed rollers which carries the filled bottles. Motor, M2 keeps running after the process has been started.

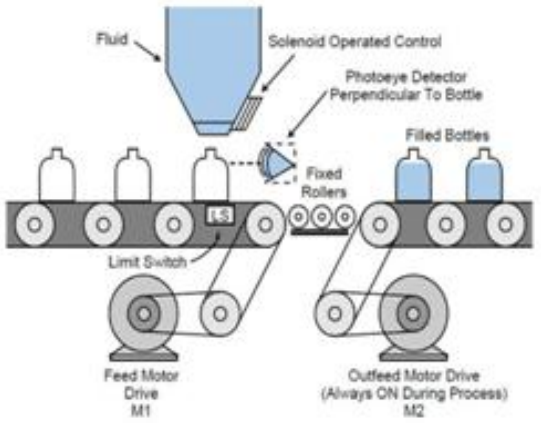

Figure 3.5 Bottle filling system

Table.1. Inputs and outputs employed

Inputs	address
Start	I0:15
Stop	I1:15
Limit switch(LS)	I2:15
Photo detector(PE)	I3:15

Outputs	address
Feed motor(M1)	O0:15
Outfeed motor(M2)	O1:15
Solenoid valve(S1)	O2:15
Light(L1)	O3:15
Buzzer(B1)	O4:15

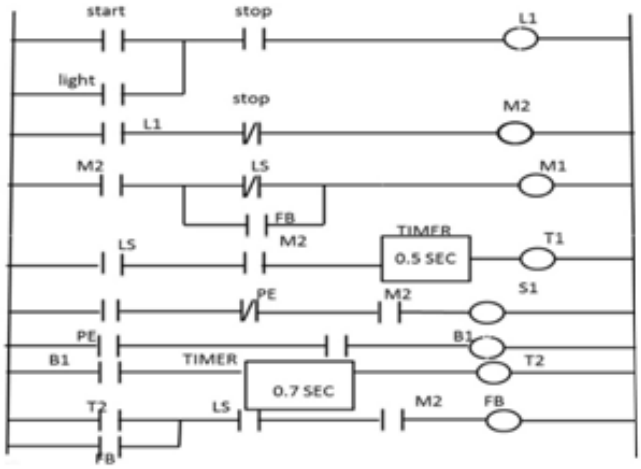

Figure 4.2 Ladder diagram for bottle filling system

IV. INTERFACING OF PLC WITH SCADA

(SCADA): Supervisory control and data acquisition is system for monitoring and control the process operating on the principle of unique coded signals over long communication channels using only one communication channel per remote station. When the control system is combined with a data acquisition system by using the coded signal over long communication channel. The main purpose of using SCADA is to get a graphical representation, monitoring and control. All the advanced control systems used today are coupled with HMI or SCADA. Here we have implemented RSView32 bit SCADA. Various protocols are used for the interfacing of the PLC and the server. There are many protocols used for serial communication. Here we have used serial protocol i.e. RS-232 for serial communication. Advantage of SCADA is that we can implement limited control options remotely. Figure -10 indicate block diagram of interfacing of PLC with SCADA. A PLC user program is also created using a personal or industrial to modify the user ladder program for which a PLC ladder development software package is used .When the entire user ladder program has been developed, entered and then verified for correctness. Transferring of PLC program from a personal computer's memory to PLC memory is termed as downloading the program. It must be in program mode before downloading a user program. When it is downloaded if all input and output signals are wired to the correct screw terminals, thereafter the processor can be put in run mode. The program will run continuously and solve the programmed instructions in run mode. Solving the programmed instructions is therefore called solving the logic. Hence this process of the program in a PLC is called scanning.

V.CONCLUSION

So the implementation of the PLC was carried out effectively for Bottle filling industrial application. It proves to be one of the important controller in industries for its simplicity and robustness and is used all over the world. For any control design approach understandings of the desired control system and how to use the ladder diagram to translate the machine sequence of operation are the most important parts, because it has direct effect on the system performance. PLC's are very good for controlling outputs based on the inputs. They are having very long period and are able to withstand all sorts of difficult conditions such as extreme temperature or dust in the air..They don't have contacts that wear out, like relays do. They also can switch fairly quick without much heating in direct contrast to relays. For any application we need not to change the whole structure only different program has to be embedded as like any other programmable devices. Compared to relays PLCs are almost always a better choice. In the bottle filling system, only one limit switch was used to detect the position of the bottle. This process has become quite obsolete, instead IR sensor can be used. It will be better if we add more sensors in this system like a flow sensor to detect water flow or use level sensor to detect water.

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