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Simulation & Hardware Implementation of PLC Based Star-Delta Starter

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Abstract-*Monitoring and inspection of several processes is becoming dominant part of the automation technique in any industry. So the automation is basically the delegation of human control function to technical equipments for increasing productivity and quality, reducing costs, increasing safety in working conditions.*

This paper mainly deals with the basic concepts of Programmable logic controller (PLC) and its applications which is a recent trend in automation of industrial range machines and also various techniques. Here, we have considered the case study for which we design a star delta starter and we try to completely automate the designing by simulation and then applying it to the hardware considered using the three phase induction motor to reduce the starting current and voltage drops at the time of starting motor.

The simplest case is a switch to connect a motor to a power source, such as in small appliances or power tools. The switch may be manually operated or may be a relay or contactor connected to some form of sensor to automatically start and stop the motor. Overload and over current protection may be omitted in very small motor controllers, which rely on the supplying circuit to have over current and short circuit protection. Small motors may have built-in overload devices to automatically open the circuit on overload. Larger motors have a protective overload relay or temperature sensing relay included in the controller and fuses or circuit breakers for over current protection. An automatic motor controller may also include limit switches or other devices to protect the driven machinery. This automation here is done by using PLCs. Motor controllers can be manually, remotely or automatically operated. They may include only the means for starting and stopping the motor or they may include other functions. .

PLC programming is implemented in this paper to achieve the desired output as any sort of changes can be done through only changing the prescribed commands in the ladder diagram.

Keywords- Starters of Induction Motor, PLC, SMPS, Ladder Logic, PLC Wiring, WPL Software, Timers.

I. INTRODUCTION

A PROGRAMMABLE LOGICAL CONTROLLER (PLC)[1] is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. Almost any production line, machine function, or process can be greatly enhanced using this type of control system. However, the biggest benefit in using a PLC is the ability to change and replicate the operation or process while collecting and communicating vital information. Another advantage of a PLC system is that it is modular. That is, you can mix and match the types of Input and Output devices to best suit your application.

A Programmable Logic Controller, or PLC, is more or less a small computer with a built-in operating system (OS). This OS is highly specialized and optimized to handle incoming events in real time, i.e., at the time of their occurrence. The PLC has input lines, to which *sensors* are connected to notify of events (such as temperature above/below a certain level, liquid level reached, etc.), and output lines, to which *actuators* are connected to effect or signal reactions to the incoming events (such as start an engine, open/close a valve, and so on). The system is user programmable [4]. It uses a

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language called "Relay Ladder" or RLL (Relay Ladder Logic)[5]. The name of this language implies that the control logic of the earlier days, which was built from relays, is being simulated.

A PLC is primarily used to control machinery. A program written for a PLC consists basically of instructions to turn on and off outputs based on input conditions and the internal program. In this respect, it is similar to how a standard computer application is used. Once a PLC program is activated, however, it will typically run continuously as a loop for an indefinite period. PLC-based systems[3] are frequently used not only to control simple devices such as a garage door opener, but also for solving complex application scenarios, such as controlling a whole house, including switching lights on or off at certain times, monitoring custom built security system, and so on.

Most commonly, a PLC is found inside of a machine in an industrial environment. A PLC can run an automatic machine for years with little human intervention. They are designed to withstand most harsh environments.

In this paper, PLC's based technique is used to solve one of the most common problems involved in industries that are to limit the starting current of motors by designing Star-Delta starters which can be automated using the PLC to obtain the desired output to control the motors.

Due to their simplicity, robustness and cost-effectiveness, squirrel-cage motors are the preferred choice of industry. During start-up, they develop currents of up to approximately eight times the rated current and the high starting torque linked to this. The high starting currents often lead to unwelcome voltage drops in the supply network and the high starting torque put the mechanical elements under considerable strain. Therefore, the electricity companies determine limiting values for the motor starting currents in relation to the rated operational currents. The permissible values vary from network to network and depend on its load-bearing capacity. Various starters and methods can be used to reduce currents and torque:

• Star-Delta-Starting

• Auto-transformer-Starting

• Starting via chokes or resistors

• Multi-stage starting

• Starting using electronic soft starters

• Starting using frequency inverters

Star delta starter is preferred with induction motor due to following reasons:

• Starting current is reduced 3-4 times of the direct current due to which voltage drops are less and hence it causes less losses.

• Star delta starter circuit comes in circuit first during starting of motor, which reduces voltage √3 times, that is why current also reduces up to √3 times and hence less motor burning is caused.

PLCs[9] are becoming more and more intelligent. In recent years PLCs have been integrated into electrical communications such as Computer network(s) i.e., all the PLCs in an industrial environment have been plugged into a network which is usually hierarchically organized. The PLCs are then supervised by a control centre. There exist many proprietary types of networks.

So in this paper, simulation and hardware setup of PLC[6]is done to completely automate the process of starters taking Star-Delta in consideration to eliminate the manual starting of motors and then following up with the simulation and output for the same.

II. PLC

Over time control system engineering has evolved greatly. In the past manual control was the only the form of control. More recently electrical control based on relays were used .These relays allow switching of power without a mechanical switch.PLC or a programmable logic controller [7] is used to check and control a system using digital inputs which can be programmed for automation .The growth of PLC started in 1970s.The PLCs [2] have become a major component of factory mainly because of the advantages they offer like

- Cost effective control for complete system
- Flexible and reusable

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- Computational abilities
- Analytical power and decision making

PLCs are available in different designsor formats [8] which vary in the type of their inputs and outputs and the software used for programming.

Figure 2.1: Process Block Diagram

FEATURES

The 2nd generation DVP-SS2 series [2][8] slim type PLC keeps the basic sequential control functions from the DVP-SS series PLC but with faster execution speed and enhanced real-time monitoring capability.

The structure of a PLC which is shown in figure 2.2 can be divided into four parts. They are:-

1. Input/output modules,
2. Central processing unit (CPU),
3. Memory and
4. Programming terminal.

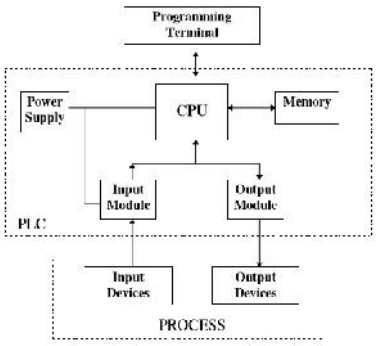

Figure2.2 PLC structure

A programmable controller operates by examining the input signals from a process and carrying out logic instructions (which have been programmed into its memory) on these input signals, producing output signals to drive process equipment or machinery. Standard interfaces built-in to PLC allow them to be directly connected to process actuators and transducers without the need for intermediate circuitry or relays.The figure 2.3 shows DVP PLC module.

Figure2.3DVP PLC

Specifications:

- MPU points: 14 (8DI + 6DO)
- Max. I/O points: 494 (14 + 480)
- Program capacity: 8k steps
- COM port: Built-in RS-232 & RS-485 ports, compatible with Modbus ASCII/RTU protocol. Can be master or slave.
- High-Speed Pulse Output：Supports 4 points (Y0 ~ Y3) of independent high-speed (max. 10kHz) pulse output.
- Supports PID Auto-tuning：DVP-SS2 saves parameters automatically after the PID auto temperature tuning is completed .Built-in High-Speed Counters.

POWER SUPPLY

DVP series & CliQ series power supplies are the latest offering from Delta Electronics. The product offers a nominal output voltage of 24V, a wide temperature range from -20°C to +75°C and a minimum holdup time of 20ms. The state-of-the-art design is made to withstand harsh industrial environments. The rigged, ultra-compact case material is shock and vibration resistant according to IEC 60068-2. The power supply provides overvoltage, overload and thermal protection. The wide input voltage ranges from 85 to 264VAC (1 phase) and 320 ~ 575VAC (3 phase), and the multiple

terminals are for fast wiring and easy installation.

Figure 2.4 Power Supply

• Power Input: 100 ~ 240VAC-15% ~ +10P/60Hz
• Power Output: 24VDC±3%
• Maximum Output Current: 1A / 2A / 5A
• DVP-PS01/02: 0°C ~ 55°C, 50 ~ 95%RH, Pollution degree 2
• DVP-PS05: -20°C ~ 55°C50 ~ 95%RH, Pollution degree 2
• Overvoltage / Over current / Over Temperature Protections
• Certification: CE, UL

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Power Output: 24VDC±3%
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Overvoltage / Over current / Over Temperature Protections
Certification: CE, UL

III. WPL SOFTWARE

The figures 3.1 to 3.6represents the Simulation output at differnt timings. At any instant of time no two green lights are on in two directions.

Figure 3.1: Simulation Output 1

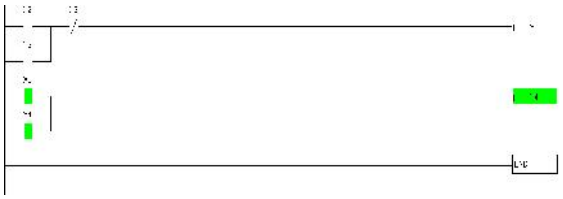

Figure 3.2: Simulation Output 2

Figure 3.3: Simulation Output 3

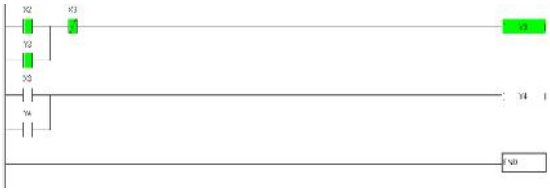

Figure 3.4: Simulation Output 4

Figure 3.5Simulation Output 5

IV HARDWARE IMPLEMENTATION

The hardware prototype is designed in two ways The figure 4.1&4.2 shows the hardware outputs with lamps showing that the voltage in the delta circuit is more than in case of star as hardware visualization and same principle is implemented with induction motor as shown in figure 4.3 & 4.4. The specifications of motor used for implementation as follows

Type : Induction Motor

Output Power (hp) :0.5 HP

Output Power (kW) :0.37 kW

Pole :4.0

Phase : 3 Phase

Speed : 1500 RPM

Casing : Squirrel Cage

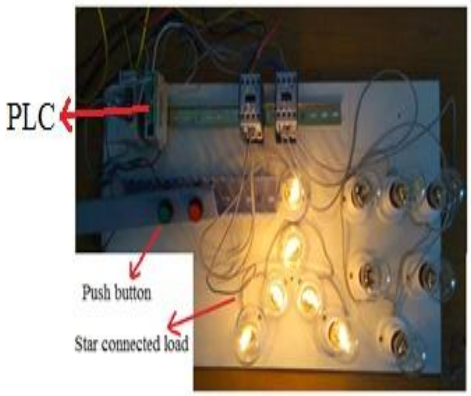

Figure 4.1Star Connections

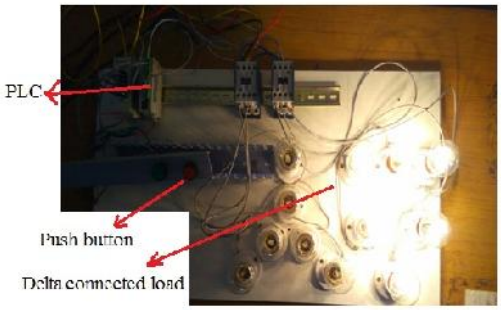

Figure 4.1Delta Connections

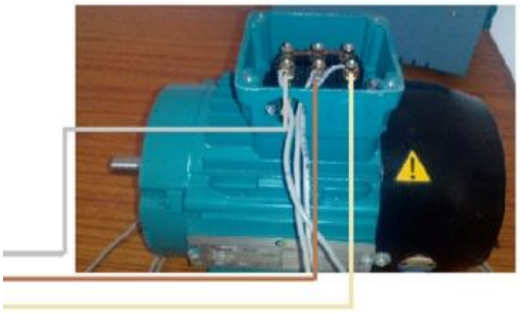

Figure 4.3Winding Connections

Figure 4.4Star Delta Connections Output

V CONCLUSION

Nowadays, most of the control system operation in industries used PLC as a controller to control the process. It contain in the process control, transportation, domestic appliances, production lines and so on.

The star-delta method is usually only applied to low to medium voltage and light starting Torque motors. The received starting current is about 30 % of the starting current during direct on line start and the starting torque is reduced to about 25 % of the torque available at a D.O.L start. This starting method only works when the application is light loaded during the start. If the motor is too heavily loaded, there will not be enough torque to accelerate the motor up to speed before switching over to the delta position.

In this paper, we have mainly studied the concepts of various automation techniques and then we have considered PLC technique for our paper. The various concepts of PLCs and the components involved with it

are studied and then based on how PLC operates, we have undertook the concept of star delta starters but the theme here involved is that we are focussing on obtaining star load and delta load separately for their applications respectively instead of using both as seen in conventional methods.

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