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# PLC AND ITS APPLICATION TO CONTROL SINGLE PHASE INDUCTION MOTOR

**Nidhi Phadnis*, Shruti Kharait, Devesh Tamrakar and Sudhir Pulambrikar**
Electrical Department SATI, Vidisa, (MP) - India

## ABSTRACT

This paper is discussed about important concepts of Programmable logic controller (PLC) and its industrial applications. PLC technology have been increasing rapidly and proving its role in automation beneficially. There are many applications which use PLC technology for automation now a days, PLC has replaced relay logics. Here we are demonstrating one of the applications of PLC in detail, i.e. duty cycle control of single phase induction motor with braking.

**Key words:** PLC (Programmable Logic Controllers), Ladder Logic, Single Phase Induction Motor

## INTRODUCTION

A Programmable Logic controller is a solid state user programmable control system which is used for simplification of Engineering aspects and skillful control in automation, which results in effective cost reduction. According to NEMA (National Electrical Manufacturers Association), PLC is defined as "A digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions for implementing specific functions such as logic sequencing, timing, counting and arithmetic to control through digital or analog input/output modules, various types of machines or processes."

Before PLC, the electrical control, sequencing and safety interlocking was done through electromechanical relays, cam timers and controllers. But such equipments have some shortcomings. In case the system requires any change or modification, the control function in the panel has to be changed, which is extremely difficult task as it involves the complete rewiring of the system, this forms laborious and increases cost.

The first PLC was designed in 1970's. Bedford Associates started a new company dedicated to developing, manufacturing, seling and servicing the new product: Modicon, which stood for modular digital controller .One of the people who worked on the project was Dick Morley, who is considered to be the "father" of PLC. The first PLC designated the 084 because it was Bedford Associates eighty-fourth project.

***Corresponding Author**

Single phase induction motors are popular since early 1930's. These machines are known for its high starting and running torques. It is also widely used in industrial application due to its special features, such as size, cost, weight, reliability and ease of maintenance. They are extensively use in agricultural machinery and home appliances. In domestic application it is used in dishwashers, clothes washers, clothes dryers, compressors, fans, pumps, mixer grinders, air conditioners etc.

An induction motor is an AC electric motor in which the electric current in the rotor needed to produce torque is induced by electromagnetic induction from the magnetic field of the stator winding. When an ac supply is connected to the stator winding, a pulsating
flux density will be produced, which will link the rotor circuits.

The voltage induced in the rotor circuits will cause a current to flow, producing a flux density to oppose change in the stator flux linking the circuit.

**DESCRIPTION OF PLC:** A Programmable controller is an aggregate and accurate control mechanism. It consists of multiple electronic relays, counters and timers and number of special functions that provide execution of internal logic wiring of plc by programming panel. Programmable logic controllers are purposely built special computers. It consists of four separate yet interlinked parts. They are:

- Input /Output section:-The input/output section provides terminals to get connected to the other equipments.
- Central Processing Unit:-It is the brain of the plc and microprocessor based.
- Programming Device:-It provides connectivity between user and plc and make it user friendly.
- Power supply:-It provides input power to sensors and output power to further connected machinery.

When a plc operates or executes any program to control other system then the series of operations are automatically performed. These automatic operations are known as PLC's internal organization program.

**ADVANTAGES OF PLC:**

After we discuss about knowledge of the PLC (Programmable Logic Controller), now we will discuss about some advantages of it.

- PLCs are very flexible. In the early days each system requires separate controls. For example, 5 machines require 5 controllers for its operation. But now each machine is controlled by its own respective program by using only one PLC.
- PLCs are low in cost compared to other control systems. The timers, counters and analog inputs are inbuilt so it reduces the overall cost of control system.
- More contacts are available on PLC. The panel that connects the relay has five contacts, if the design changes and if we require the more contacts then we have to connect an additional relay again.
- The visual observations are available on PLC. Logic paths which are getting operated will light up on the screen so that, if any errors occurs, can be easily detected and repaired.
- The operating speed of plc is better as compared to relays and any other control equipments. It can be varied from microseconds to hours.
- PLC provides two simple methods of programming i.e. Boolean or Ladder logic method. Ladder logic methods are frequently used because they are near to practical circuitry and easy to understand.
- PLCs are more reliable as compared to mechanical relays or timers. They can work in several environmental conditions.
- PLCs are more secure. No one can change programs as it can add passwords.
- PLC facilitates changes by reprogramming.
- PLCs provide good time efficiencies.

**SOFTWARE DESCRIPTION**

PLC programming emphasis on the logical demands and the program methodology is purely logical and is not based on computational algorithm methodology. The software used in our work is 'ZelioSoft 2'. It consist of different modules, the module we preferred is SR3B261FU. The programming can be done in two different ways:

- FBD (Functional Block Diagram) Mode
- LD (Ladder Diagram) Mode

**Ladder Network Description**

A ladder network is made up of a collection of graphic elements set out over a grid with:

- A maximum 120 program lines,
- Each line comprising a maximum of 5 contacts and a coil.

It is divided into two zones:

- The test zone, in which the conditions necessary for triggering an action (contacts) are displayed,
- The action zone, which applies the result following a logical test combination (coils).

**Contacts**

Graphic elements of the contacts are programmed in the test zone and take up one cell (one row high by one column wide).

| Name | Electrical symbol | Functions |
|---|---|---|
| Normally open contact |  | Conducting contact when its controlling input (switch, sensor, etc.) is active. |
| Normally closed contact |  | Conducting contact when its controlling input is inactive. |

**Linking Elements**

Linking graphic elements are used to connect test and action graphic elements.

| Name | Graphic representation | Functions |
|---|---|---|
| Horizontal connection |  | Used to link test and action graphic elements together between the two potential bars. |
| Vertical connection |  | Used to link test and action graphicelemes in parallel. |

A horizontal connection represents a logical AND; it sends the state of the contact located immediately to its left to the contact located immediately to its right.
A vertical connection represents the logical OR of the active states of the horizontal connections located to its left, i.e.:

- Inactive if the states of all the horizontal contacts located to the left are inactive,
- Active if at least one of the horizontal contacts located to the left is active.

**Coils**

The graphic elements of the coils are programmed in the action zone and take up one cell (one row high by one column wide).

| Name | Electrical symbol | Functions |
|---|---|---|
| Direct coil |  | The coil is energized if the contacts to which it is connected are conducting (contact mode). |
| Impulse coil |  | The coil is energized if the contacts to which it is connected change state (impulse relay mode). |
| Set or latch coil |  | The coil is energized once the contacts to which it is connected are conducting, then stays triggered even if later the contacts are no longer conducting (SET mode). |
| Reset or unlatch coil |  | The coil is deactivated when the contacts to which it is connected are conducting. It remains inactive even if later the contacts are no longer conducting (RESET mode). |

**HARDWARE DESCRIPTION**

It consists of the following parts:-

- Contactors - Contactors are advanced form of switches which are easy to use and logically operated with the help of plc. It consists of two parts- stationary and movable. Whole circuit is connected to the stationary part and provided with a coil having a moving part. When the coil is energized the movable contacts are closed against the stationary contacts, and the circuit gets completed.
- Single Phase Induction Motor - We are using a single phase induction motor of rating 750 W, 220/230 V, 7.6 A,
  1.0 HP.

The Photograph of proposed system is demonstrated in fig. 1 and fig. 2.

## I. HARDWARE CIRCUITRY

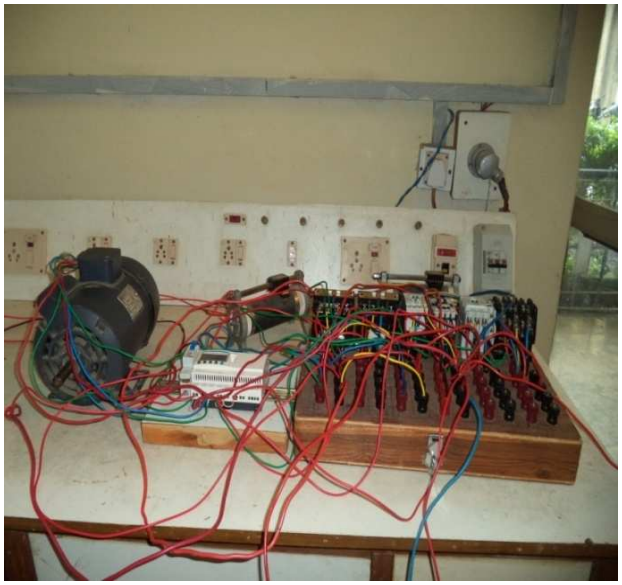


Fig.1. General view of the proposed system.

Fig.2. Connection of PLC with induction motor

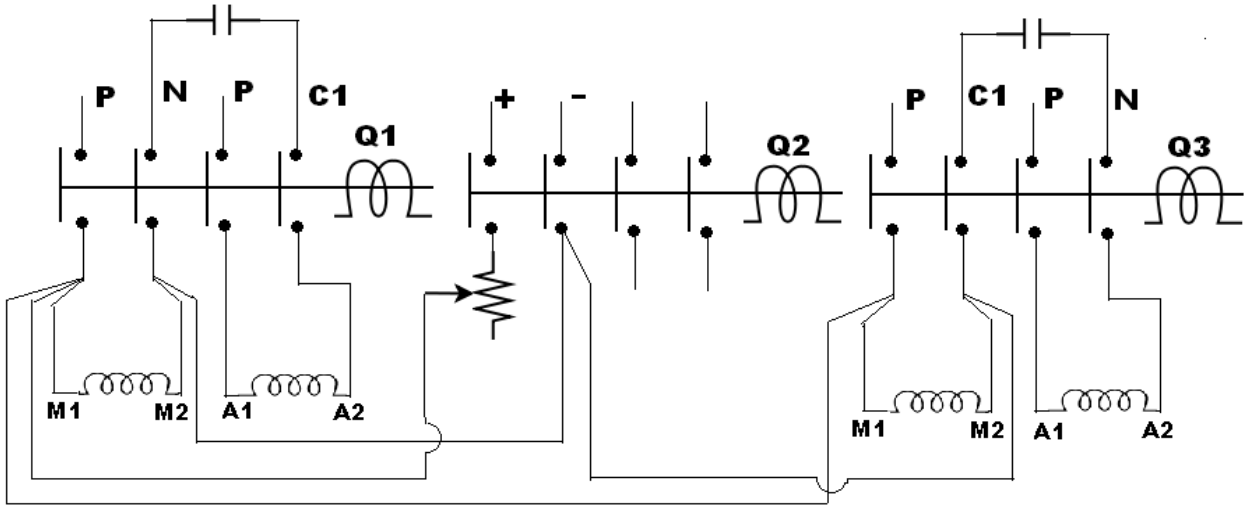
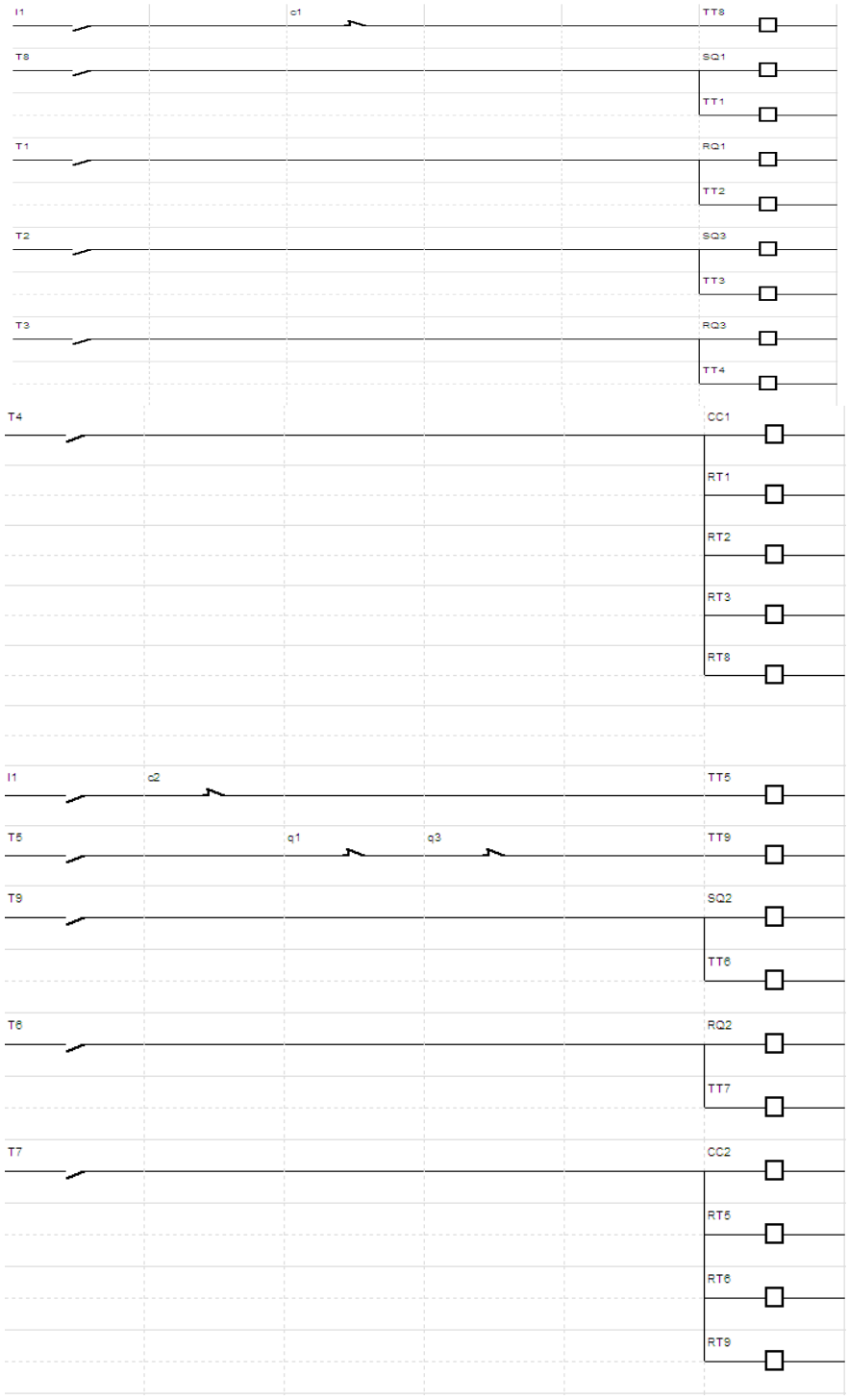



Fig.3. Direction control and braking arrangement circuit

P – Phase terminal of AC supply, N- Neutral terminal of AC supply
(+) – Positive terminal of DC supply, (-) – Negative terminal of DC supply
M1, M2 - Terminals of main winding, A1, A2 – Terminals of auxiliary winding
C1 – Terminal of capacitor, Q1, Q2, Q3 – Contactor coil.

**PLC PROGRAM**


I1
c1
TT8
T8
SQ1
TT1
T1
RQ1
TT2
T2
SQ3
TT3
T3
RQ3
TT4
T4
CC1
RT1
RT2
RT3
RT8
I1
c2
TT5
T5
q1
q3
TT9
T9
SQ2
TT6
T6
RQ2
TT7
T7
CC2
RT5
RT6
RT9

**APPLICATIONS**

The applications of plc begins with the conversion of information into convenient parameters to save money, time and efforts, and hence easy operations in plants, factories and laboratories is achieved. Some of the applications of plc in industries are shown below:

- **Snacks Food Industry:** PLC control system have been designed for monitoring and controlling the gas fired ovens, temperature control, pressure control, slurry mixing, material handling, cutting and distribution systems.
- **Glass Manufacturing:** PLCs are used in the control systems for the production of plate glass from the introduction of raw ingredients into the furnace to the float pans and curing of the glass to the cutting out of impurities from the glass sheet.
- **Material Conveying:** Industries are facing various challenges regarding the conveyance of different materials. PLC systems are designed for handling and conveying of material, be it the raw ingredients or the finished products.
- **Packing and Labeling:** PLC design provides the logic that controlled the labeling and packaging of products for the bottling, pharmaceutical, food and vitamin packaging industries.
- **Steel Industry:** PLC systems provide controls for the annealing, stress relief, quenching and material conveying and storage of metal pipe for the steel industry.

**Milling Operation:** Milling operates on the principle of rotary motion. The Basic tool of milling machine is cutter. The cutter has shaped bar that has saw teeth. Milling cutter's saw ending can be spaced, size and oriented in many ways.

Milling processes are designed such that the cutter makes many individual cuts on the material in a single run; this may be accomplished by using a cutter with many teeth, spinning the cutter at high speed, or advancing the material through the cutter slowly. The controlling of the cutter can be accomplished by PLC. The set up designed for the implemention of direction control of single phase induction motor with braking can be used for the above.

## CONCLUSION

Successful experimental results were obtained from the above described system indicating that the PLC can be used in automatic systems with an induction motor. The setup of the single phase induction motor for forward and reverse rotation with braking has been implemented and achieved The motor is rotating for prescribed time set in the timers for forward direction and revrese direction. The motion can also be controlled by controlling the time of the timers as per requirement. This feature makes the system more efficient for flexible implementation. Thus, the PLC proves itself to be a versatile control tool in industrial electric drive systems.

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