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Implementation of PLC Based Starting and Direction Control with DC Dynamic Injection Braking for Three Phase Induction Motor

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Abstract: ***The implementation of forward and reverse direction control system with DC Injection braking for three phase induction motor based on programmable logic controller (PLC) technology is described. The implementation of the hardware with results obtained from tests on induction motor performance is also provided. Experimental results show that the PLC-based control method developed costs less, provides higher accuracy as well as safe and visual environment compared with the classical, the computer systems.***

Keywords: Programmable logic controller (PLC), three phase induction motor, contactor

1. Introduction

Since technology for motion control of electric drives became available, the use of programmable logic controllers (PLCs) in electric machines applications has been introduced in the manufacturing automation. In many industrial applications the use of three phase induction motor is extensively increasing because of their high robustness, reliability, low cost, high efficiency and good self starting capability. So for the use of industrial applications one of the most important control parameter in the motor drive system is braking. There is a need to bring a drive system quickly to rest to hold a drive at standstill after some operation has been completed, or under the condition of faulty operation to save the machinery parts or operating personal. An industrial PLC was used for controlling motors in direction and reducing the number of circuit components, lowering the cost, and enhancing reliability.

2. Description of PLC

Programmable logic controllers are solid-state members of the computer family, using integrated circuits instead of electromechanical devices to implement control functions. It uses programmable memory for the internal storage of user orientated instructions for implementing specific functions such as counting, logic, sequencing, and timing. Input and output devices of the process are connected to the PLC and the control program is entered into the PLC memory (Fig1).Details of the PLC configuration are shown in Tables I.

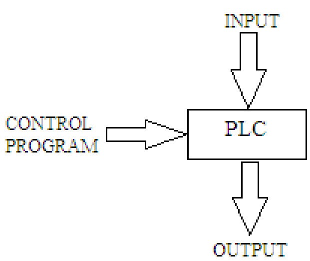


Figure 1: Control action of a PLC

Table 1: PLC configuration

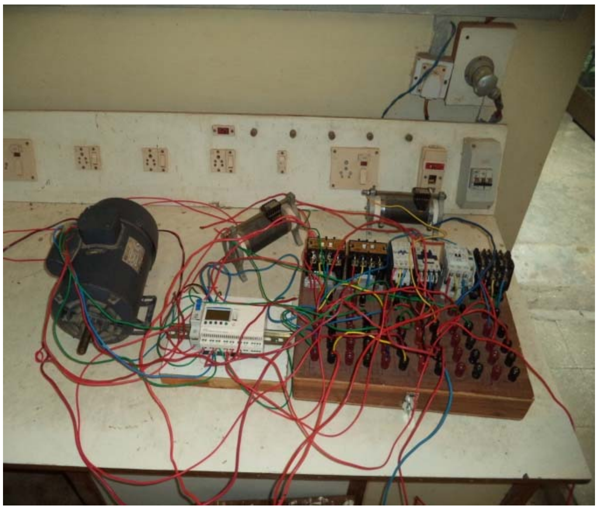
Module type	SR3B261FU	
Power supply	100-240VAC	
Discreet Inputs(I)	Available	Used
	16	1
Output Relays(O)	10	3
No. of program lines	120	20

3. Software Description

PLC's programming is based on the logic demands of devices and the programs implemented are predominantly logical rather than numerical computational algorithms. The programming method used is the ladder diagram method. The PLC system provides a design environment in the form of software tools which allows ladder diagrams to be developed, verified, tested, and diagnosed. First, the high-level program is written in ladder diagrams. Then, the ladder diagram is converted into binary instruction codes so that they can be stored in the memory. Each successive instruction is decoded and executed by the Processor. The function of the processor is to control the operation of memory and I/O devices and to process data according to the program. Each input and output connection point on a PLC has an address used to identify the I/O bit. The PLC program uses a cyclic scan in the main program loop such as periodic checks are made to the input variables. The program loop starts by scanning the inputs to the system and storing their states in fixed memory locations. The ladder diagram program is then executed rung by-rung. Scanning the program and solving the logic of the various functions rungs determine the output states. The updated output states are stored in fixed memory locations. The output values held in memory are used to set/reset the physical outputs of the PLC.

4. Control System of Induction motor

In Fig.4, the control circuit diagram of the experimental system is illustrated. This automation operation is controlled through to contactors which in turn controlled through PLC. Therefore there are three contactors are used. Each contactor has technical specification as: four poles, 16amp. and 230 V. In which contactor one and three are used for movement of three phase induction motor and contactor two used for DC Injection braking. The direction control system is implemented and tested for three phase induction motor, having the technical specifications given in table II.



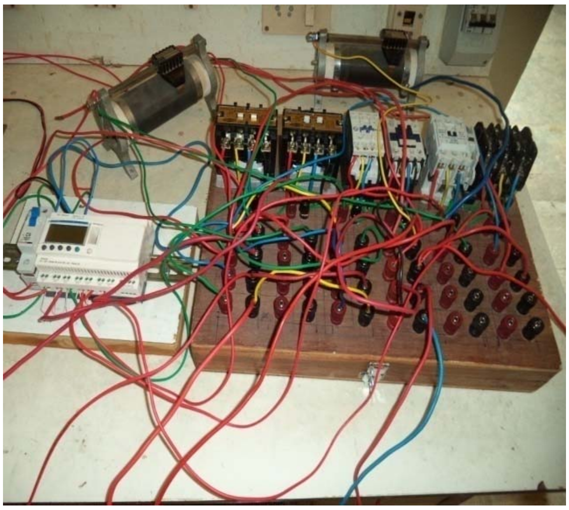


Figure 2: General View of the proposed system Fig.3 Connection of PLC with contactors

R, Y, B Phase terminal of AC supply, (+) – Positive terminal of DC supply, (-) – Negative terminal of DC supply, I.M.- three phase induction motor, Q1, Q2, Q3 – Contactor coil.

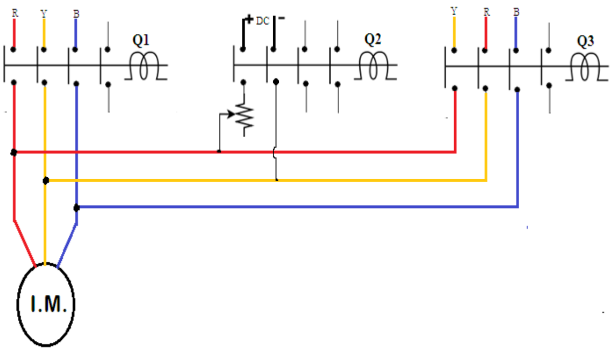


Figure 4: control circuit

When the input signal applied contactor Q1 energized thus the three phase induction motor gets supply and motor run in

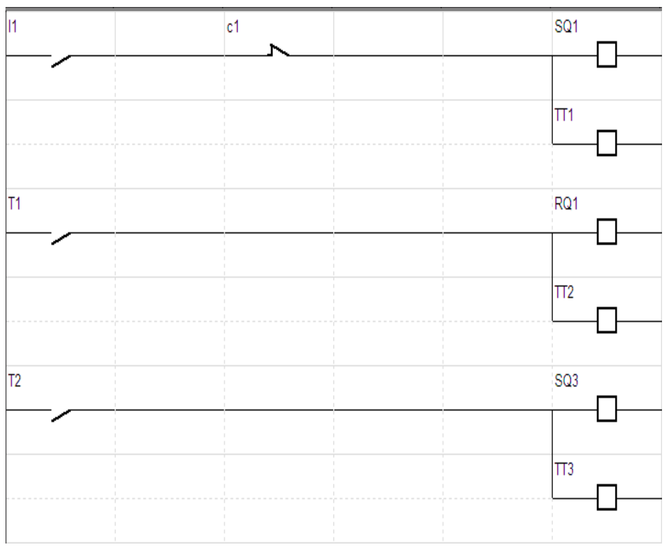
Table2: Three phase Induction motor technical specifications.

Input Voltage	415 V
Input Current	1.5 A
Input Frequency	50 Hz
Rated Power	0.55/0.75 kW
Rated Speed	1400 rpm

forward direction for predefined time duration. After predefined time contactor Q1 de-energised and contactor Q2 energised. By this the dc voltage is applied to the stator winding of induction motor across two of the three stator leads the induction motor becomes an inverted synchronous generator, which result braking is acquired. After some time contactor Q2 de-energised. And then contactor Q3 energised thus three phase induction motor getting supply through these contactors and run in reverse direction. At predefined time contactor Q3 de-energised and again contactor Q2 energised. The actual logic of the control system is established inside the PLC by means of a ladder program. This program dictates which output gets energized under which input conditions. Figure 2 and figure 3 shows the photographic views of the proposed system.

5. PLC Ladder Program

In the ladder program input applied through I1 to PLC which update output status of Q1, Q2, and Q3. This output energised their respective contactors. In this we create two loops, which operate simultaneously. The first loop is responsible for three phase induction motor for moving in forward and reverse direction. The second loop is responsible for DC Injection braking of motor. Motor runs in forward and reverse direction when the output Q1 and Q3 are set in program line one and five respectively. For DC Injection braking of three phase induction motor line 14 is used to set output Q2. The rest of the program lines are used to reset the output according to their timer position. This cycle continues to operate till the number of cycle specified in the counter completed. As the number of cycle completed the NC contact of counter which is provided in every loops, breaks the operation and the cycle stops. Forward and reverse operation cycle can be run three times. We can increase it five times or even more times as per the required. The program written on the PLC is as shown in Fig 5.



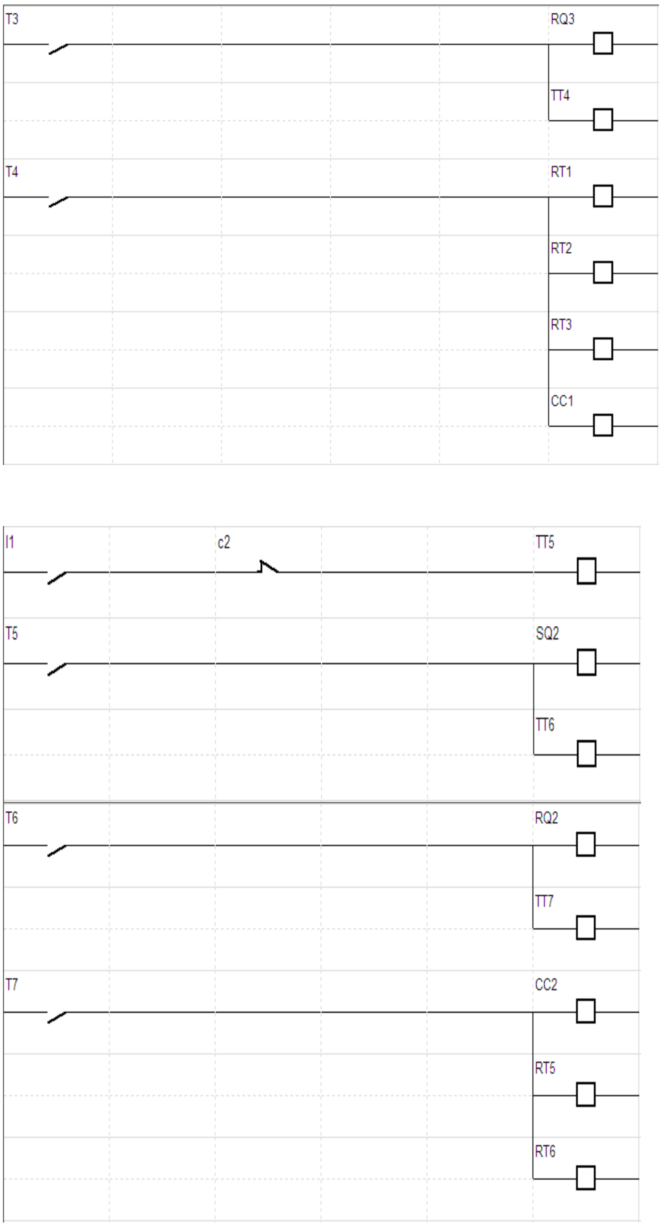


Figure 5: PLC ladder program

6. Result

The system was tested during operation on three phase induction motor. The PLC controls forward and reverse direction and braking operation according to the ladder program. Braking system has been performed during the study of the above mention. The experimental results are shown in the tables III for braking.

Table 3: DC Injection to stop at 0.5 seconds

Sl. No.	Starting Speed (rpm)	DC Voltage (Volts)	Max. Current Drawn		Duration of Stopping (Seconds)
			During Brake (Amperes)	At Standstill (Amperes)	
01	1000	80	4.1	5.3	0.5
02	900	70	3.5	4.6	0.5
03	800	60	3.0	4.0	0.5
04	700	50	2.5	3.4	0.5
05	600	40	2.0	2.7	0.5
06	500	30	1.8	2.0	0.5
07	400	20	1.3	1.4	0.5
08	300	15	1.0	1.0	0.5

Table III shows that at low speed a low voltage is required to bring the motor to standstill at a particular duration of braking period and vice versa. And the motor direction control achieved in this study might be faster and more efficient than the classical techniques because of the PLC relay used in the experiments rather than mechanical equipment.

7. Conclusion

Successful experimental results were obtained from the previously described scheme indicating that the PLC can be used in automated systems with three phase induction motor. Braking system achieved safely without any over voltage, over current and overheating in the motor windings. The proposed system can be used in many industrial applications such as Milling operation, Capsule Filling Machine, Material conveying, Steel industry, Printing industry, Snack foods industry, mainly in case of emergency stop to protect costly machinery equipments and operating personals. The use of PLC smart relay with ladder logic functions is more economical less complex and has so many features which justify their use in the industries to make the operation smooth, safe and complexity of the system is reduced.

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