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PLC Based Starter & Protection of Induction Motor Against Abnormal Conditions

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ABSTRACT: Starting of an induction motor and protection of an inductions motor starting against possible problems such as over voltage, under voltage and temperatureoccurring in the course of its operation is very important, because it is used intensively in industry as an actuator. IMs can be started and protected using some components such as timers, contactors, voltage and current relays. this is known as classical method that is very basic and involves mechanical dynamic parts. In these studies, for IMs, a new protection method based on a progemmable logic controller (PLC) has been introduced. In this method all contactors, timers, relays and the conversion card are eliminated. Moreover the voltage, the temperature values of motor, and the problem occurred in the system are monitored on PLC. Experimental results show that the PLC baesd starting method and protection method developed costs less, provides higher accuracy as well as safe and visual environment compared with the classical, the computer, and the PIC based protection systems.

KEYWORDS: Induction Motor, Programmable logic Controller, Fault Detection

I. INTRODUCTION

AC INDUCTION MOTORS (IMs) are used as actuators in many industrial processes. Although IMs are reliable, they are subjected to some undesirable stresses, causing faults resulting in failure. Monitoring of an IM is a fast emerging technology for the detection of initial faults. It avoids unexpected failure of an industrial process. Monitoring techniques can be classified as the conventional and the digital techniques. Three phase induction motors are the heart of industries. The robustness and simple construction has led to vast industrial applications. every industrial process is associated with induction machines either directly ot indirectly. When we see importance of induction motors in industries the question of its protection and monitoring arises. industrial induction motors are used in different processes due to which they may exhibit abnormal conditions like over voltage, under voltage and over temperature many others. if THERE faults are not controlled in the defined time span, it can completely destroy the induction motor. The conventional methods of protection of induction motors uses mechanical relays and microcontroller and other discrete components that led to time delay and other processing problems which could result in damage to the costly industrial motors. Thus when it comes to huge industrial control units the modern method of protection plays an important role. 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 loadbearing capacity. Various starters and methods can be used to reduce currents and torque.

This paper discusses modern protection methodology where complete protection is done through the programmable logic controller (PLC). In this method of protection, the online monitoring of induction motor is done and all the necessary electrical parameters – voltage and temperature are monitored. If the parameters are bounded which mean all the parameters are within their normal operating range, the PLC will continuously be allowing the induction motor to be connected with the three phase supply. However, if there is any disturbance found, PLC will trip the induction motor by giving a tripping-signal to magnetic contactor and relay as per the programmed conditions. The uniqueness of this paper is that it proposes the protection scheme using solid state relays coupled with PLC and magnetic contactors.

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Various starters and methods can be used to reduce currents and torque. 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.

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. PROGRAMMABLE LOGIC CONTROLLER

A programmable logic controller (PLC) is a special form of micro-processor-based controller that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic in order to control machines and processes and are designed to be operated by engineers with perhaps a limited knowledge of computers and computing languages. They are not designed so that only computer programmers can set up or change the programs. Thus, the designers of the PLC have pre-programmed it so that the control program can be entered using a simple, rather intuitive, form of language. The term logic is used because programming is primarily concerned with implementing logic and switching operations. Input devices, e.g. sensors such as switches, and output devices in the system being controlled, e.g. motors, valves, etc., are connected to the PLC. The operator then enters a sequence of instructions, i.e. a program, into the memory of the PLC. The controller then monitors the inputs and outputs according to this program and carries out the control rules for which it has been programmed.

A programmable logic controller PLCs have the great advantage that the same basic controller can be used with a wide range of control systems. To modify a control system and the rules that are to be used, all that is necessary is for an operator to key in a different set of instructions. There is no need to rewire. The result is a flexible, cost effective, system which can be used with control systems which vary quite widely in their nature and complexity. PLCs are similar to computers but whereas computers are optimized for calculation and display tasks, PLCs are optimized for control tasks and the industrial environment. Thus PLCs are:

- Rugged and designed to withstand vibrations, temperature, humidity and noise.
- Have interfacing for inputs and outputs already inside the controller.
- Are easily programmed and have an easily understood programming language which is primarily concerned with logic and switching operations.

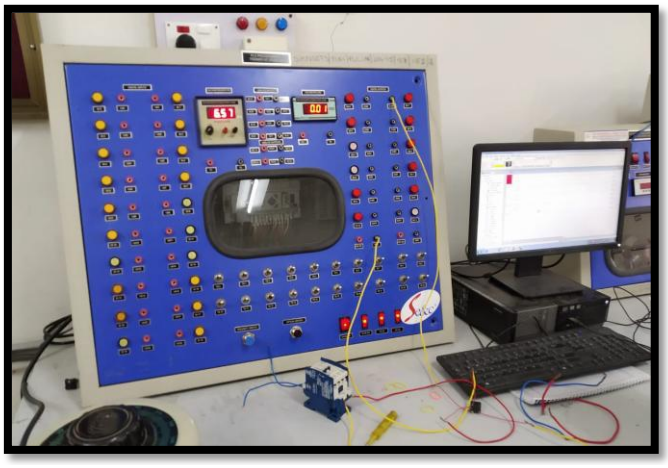

Fig.1.Programmable Logic Controller Kit

III. OVER VOLTAGE PROTECTION SCHEME

When the voltage in a circuit or part of it is raised above it's upper design limit , this is known as over voltage. The condition may be hazardous. Depending on it's duration, the over voltage even can be transient voltage. The overall result of an over voltage condition is decrease in load current and poor power factor. The protection system used in this study consists of a 0.75KW (1 HP)/1400rpm, three phase IM, three voltage transformer's with transformation ratio of

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230/12V , solid state relay of 24V , magnetic contactor of 440V (240V AC) and obviously Allen Bradley Micrologic 1400 PLC. From three phase source the three phase supply is given to the IM and inputs of three single phase transformers. The output of each voltage transformer is stepped-down from 240V to 12V. At the output of three voltage transformer a three rectifier circuit are connected. Where each single phase of three phase supply is rectified and then fed to input terminal of PLC. The 3 different rectifier circuits are used because of, if over voltage occurs in any one of the three phases the motor is disconnected from the supply. A rectified input is given to the analog input of PLC where it is monitored. At the output terminal of PLC, a solid state relay is connected to the digital output of plc and then relay is connected with three phase magnetic contactor, which triggers on/off the three phase supply of the motor. When a abnormal condition is occurred means a voltage is raise beyond the normal value which is 230V then the output of PLC is high which triggers relay and relay switches the contactor contacts are open and hence the three phase supply is cut off and motor is safely disconnected.

IV. UNDER VOLTAGE PROTECTION SCHEME

When the voltage in a circuit or part of it is fall below it's lower design limit , this is known as Under voltage. The condition may be hazardous. Depending on it's duration, the under voltage even can be transient (Sag) voltage. The overall result of an under voltage condition is increase in load current and poor power factor. The protection system used in this study consists of a 0.75KW (1 HP)/1400rpm, three phase IM, three voltage transformer's with transformation ratio of 230/12V , solid state relay of 24V , magnetic contactor of 440V (240V AC) and obviously Allen Bradley MicroLogix 1400 PLC. From three phase source the three phase supply is given to the IM and inputs of three single phase transformers. The output of each voltage transformer is stepped-down from 240V to 12V. At the output of three voltage transformer a three rectifier circuits are connected. Where each single phase of three phase supply is rectified and then fed to input terminal of PLC. The 3 different rectifier circuits are used because of, if under voltage occurs in any one of the three phases the motor is disconnected from the supply. A rectified input is given to the analog input of PLC where it is monitored. At the output terminal of PLC, a solid state relay is connected and then relay is connected with three phase magnetic contactor, which triggers on/off the three phase supply of the motor. When a abnormal condition is occurred means a voltage is fall below the normal value which is 230V then the output of PLC is high which triggers relay and relay switches the contactor contacts are open and hence the three phase supply is cut off and motor is safely disconnected.

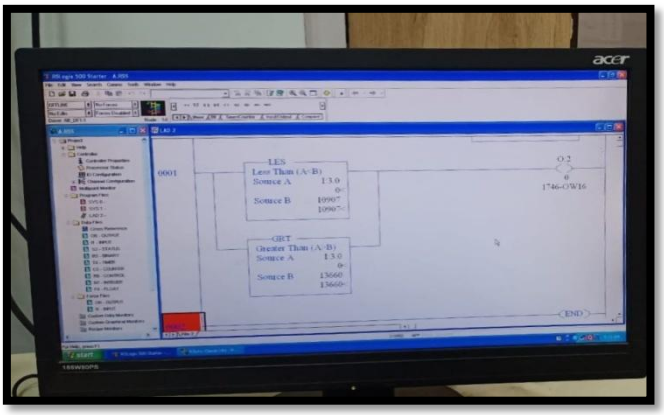

Fig.2.Ladder logic for over voltage & under voltage

V. OVER TEMPERATURE PROTECTION SCHEME

Whenever induction motor runs at full speed, Raised in temperature is observed than its steady state condition. Raised temperature in induction motor can be obtained from following

- % temperature raised = 2×(voltage unbalanced)^2

Over temperature damages insulation of motor winding and can cause major fault, And complete winding may also get burn. Bearing temperature at rated load should not increased then 45 degree centigrade according to IEEE 841 standard for Petroleum and chemical industry. If the voltage unbalance 3.5 % per phase then we can see raised in winding temperature. by 25% in the phase having the highest current. The previous temperature monitoring system like

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condition monitoring is more complex and costly, in our system we are using LM35 temperature sensor for its simplicity.

A. LM35 SENSOR

- This sensor gives output voltage linearly proportional to centigrade temperature.
- for obtaining convenient centigrade scaling large output voltage is not required, small change in temperature indicated by minute change in voltage
- external calibration is not required to get typical accuracies of +_-1/40C at room temperature and +- 8/40C over a full -55 to +1500C temperature range.
- LM35 temperature sensor has typically low impedance at output side also it has linear output, this makes interfacing of lm35 very convenient.

we are mounting this temperature sensor on the frame of induction motor which will keep sending voltage to analog input pins of PLC. We can obtain conversion from voltage to temperature by simple conversion which state that for 1°Cthen is 10 mV at output side of LM35. as temperature increases voltage at output side also increases linearly or correspondingly. The output LM35 is given to the PLC which will detect over temperature condition and if temperature goes beyond safe limit, the motor will be tripped

B. RESULT

- when over temperature occurred LM35 generate higher voltage ranges in mV that is given to analog input of the PLC
- As the voltage exceeds than a safe operating range the PLC output goes high and thus relay is operated, If the Motors temperature exceed than 45°C than high range of voltage produced by LM35 sensor goes to the analog input pin of the PLC

As the temperature exceed the safe operating range of motor the PLC activate relay which further send trip signal to magnetic contactor and thus motor is tripped.

VI. STAR-DELTA STARTER

Most induction motors are started directly on line, but when very large motors are started that way, they cause a disturbance of voltage on the supply lines due to large starting current surges.

To limit the starting current surge, large induction motors are started at reduced voltage and then have full supply voltage reconnected when they run up to near rotated speed we used star- detla starter
The star connection is mostly used to start larger motors and then switched to the delta configuration for normal running when the motor is up to speed.
When connected in Star there are now 2 windings in series between each line supply voltage. So the start connection draws less current that the delta connection, Hence, in Star Connections Line voltage is root 3 times of phase voltage. Relation Between Phase Current and Line Current in Star Connection. The same current flows through phase winding as well as in the line conductor as it is connected in series with the phase windings.

A. OPERATION

When the start push button is pressed the enable bit becomes high and the accumulator value starts increasing.
When the accumulated value reaches the present value that is 10sec in our system the Done bit gets activated.
When the start button is pushed induction motor runs on root 3 times of the voltage because of the star configuration.

As TT is connected to star connection of the star/delta starter, after 10 sec when done bit gets activated the motor is given its full rated voltage because of delta connection and motor runs at rated speed. As we connected Done Bit to delta connection of star/delta starter
In this system we have also used over current relay for protection of induction motor against over current fault.

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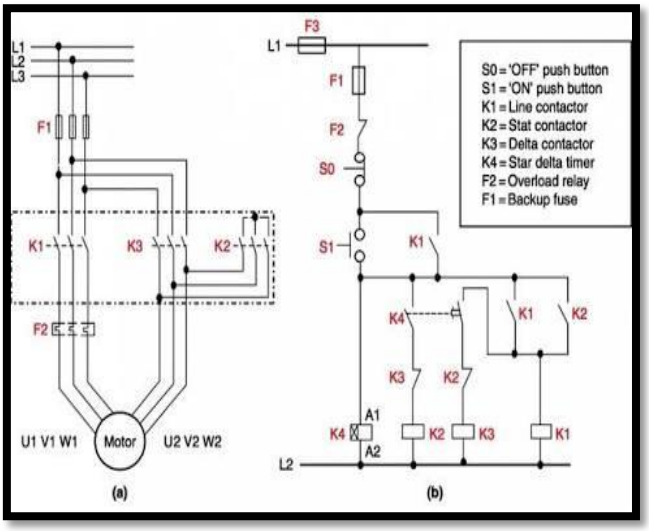

Fig.3.Star-Delta starter circuit diagram

VII.CIRCUIT DIAGRAM

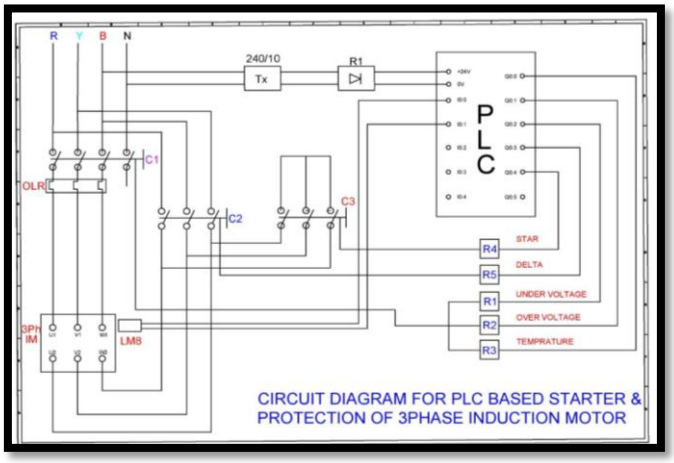

Fig.4.Circuit diagram

VIII. RESULT

Successful experiment result are obtained by hardware implementation starting, controlling and protection of three phase induction motor .The solution of various fault the phase current , phase voltage ,speed, winding temperature of an induction motor accruing in operation. system shows a good performance's in detecting the fault and in clearing them with the help of PLC and they monitored on PC. The efficient starting and over load protection is also occur.

IX. CONCLUSION

In This papers attempt to present cost effective and real time monitoring and protection scheme for industrial three phase induction motor against over- current , over- voltage & over- temperature conditions through programmable logic controller .The use of automate system with an induction motor .by automation we can improve the productivity in the industry . we can continuously monitor the state of input device and make the decision based upon custom project to control the state devices connected as output.

REFERENCES

[1]T.K.Chattetjee,D.K Mittra,'ANovelSolid-State Integrated Protection System for three phase Induction Motors', 2009 Third International Conference on Power Systems, Kharagpur,INDIADecember27-29.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

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[2]I.Colak, R.Bayindir,A.Bekta,I.Sefa,G.Bal,"Protection of Induction Motor using PLC.",Power eng IEEE, pp.96-102,2007.
[3]M.Peltola,"Slip of AC induction motors and how to minimize it", ABB Drives Press Releases Technical Paper,2003,pp.1-7,ABB,New Berlin.
[4]S.Sneha,S.Radhika,"Controlling and Protection of Three Phase Induction Motor Using PLC", IJRASET, Volume4 IssueXI,November2016,ISSN:*2321-9653*.
[5]A.Pawar,K.Pawar,P.Desai,"FaultDetectionofInduction MoorbyUsingPLC",IJTIR,Volume24,Issue2,April2017,e-ISSN:2321-1814.
[6] D.Kumar, A.Basit, A.Saleem, G.Abbas,"PLC Based Monitoring & Protection of 3-Phase Induction Motors against Various Abnormal Conditions", IEEE 2019 International Conference on Computing, Mathematics and Engineering Technologies – iCoMET 2019.
[7] M. G. Ioannides, "Design and implementation of PLC-based monitor-ing control system for induction motor," IEEE Trans. Energy Convers., vol. 19, no. 3, pp. 469–476, Sep. 2004.
[8] " Text Book of Electrical Technology in S.I units "by B.L.Theraja.
[9]P. M. Sarma, S. Swathi, A. Sathish Kumar, and P., Sridhar, "Simulation & Hardware Implementation of PLC Based Star- Delta Starter ",International Journal of Electronics, Electrical and Computational System IIJEECISSN 2348-117X,Volume 6, Issue 6June 2017.