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PLC and SCADA based Fault Diagnosis of Induction Motor

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Abstract - **Induction motors are widely used in many operating areas and industrial applications as they are simple, robust, reliable and have low production costs. The use of Induction motors have increased nowadays due to their versatility, good self-starting capability and these motors also offer simple, rugged construction, , low cost, reliability and easy maintenance. The reliability of an induction motor is of great Importance in applications such as commercial, aerospace and military and many industrial applications. In this paper different problems of IM are dealt with as over current, overvoltage, over temperature, over speed, inrush current, vibration monitoring during it's time of operation. There are various proposed methods for fault diagnosis and protection of IM. Some of them are Stator fault monitoring techniques, protection system using Microcontrollers, On-line fault detection, Programmable Integrated Circuit (PIC) based protection system and Programmable Logic Controller (PLC) based protection system. In this study, the method which is applied is PLC based protection system of an IM.**

Keywords - **Reliability, PLC, PIC, Fault diagnosis**

I. INTRODUCTION

Induction motors are one of the reliable electrical machines but sometimes they undergo undesirable stress, causing faults in induction motor and its failure [1]. The introduction of redundant element provides safety by detecting the failure and lead to the appropriate solution. Due to the recent advances in Programmable Logic Controller (PLC) technology, it is used in many industrial applications. One possible application of PLC, is to use it for fault detection of IM. There exists a variety of machine failures including mechanical and insulation faults. There are also different types of insulation system faults and mechanical faults.

The solution to the different faults of the induction motor including phase currents, the phase voltages, the speed, and the winding temperatures have been achieved with the using a microcontroller ,but representation of these electrical parameters have not been displayed on a screen.

The PLC systems are comprised of special I/O units applicable for direct usage in industrial automation systems [2].The input components, such as temperature sensors, the level, and the pressure can be directly connected to the input. The driver components such as contactors and solenoid valves of the control circuit can be directly connected to the output. Many industries use PLC in automation processes to reduce the production cost and to increase quality and reliability [2].

This paper explains a detailed view of PLC-based protection and monitoring method for a single-phase induction motor. The new solutions to the different faults of voltage, the speed, the current, and the winding temperatures of an IM have been achieved with the use of a PLC. If a PLC is used alone as a protection relay for a particular system, it costs more .But the use of a PLC with a view that it does not require an extra microprocessor such as a PIC, it can be the right choice in an automation system. This paper is organized as given next. Section II introduces and describes the PLCs. Section III presents real-time implementation details of measurements of the

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system and its hardware, software. Section IV represents the experimental studies of motor fault detection and its protection. The research is finally brought to a conclusion in Section V.

II. PROGRAMMABLE LOGIC CONTROLLER

A PLC or a programmable controller is a small computer used for control of machinery on factory assembly lines and automation of real-world processes. A PLC can also be programmed to sense, control and activate industrial equipment. Thus, a PLC includes a number of I/O points, which allow interfacing of electrical signals. First the input and output components of the processes are connected to the PLC; and then the control program is loaded onto the PLC memory. The basic structure of the PLC is shown in Fig. 1. In this study, the PLC measures the voltage, the temperature, current and the speed of an induction motor through analog inputs. It also continuously monitors the various inputs and activates the outputs according to the requirements of the program.

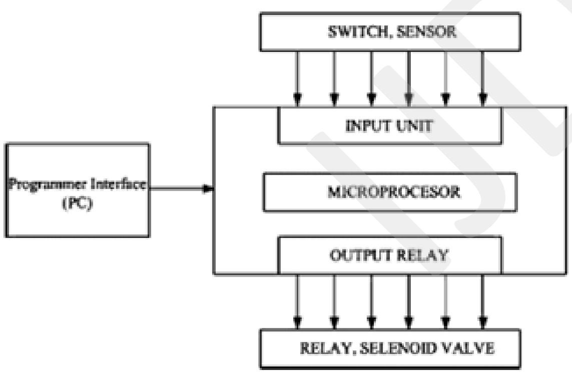

Fig 1.General structure of PLC

An analog module is essentially required for processing the analog signals. Analog modules work in accordance with 8 or 12 bit systems. One or more analog sensors of different types can be connected to the analog module according to their use. In Fig. 2, analog and digital module is shown containing circuit elements of PLC.

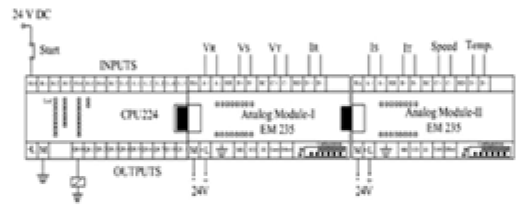

Fig 2.Analog and digital module

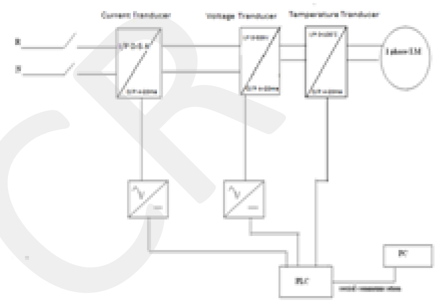

Fig 3.Block diagram of Protection System

III.CONTROL SYSTEM OF IM

A block diagram of the protection system for IM is shown in fig.3.It consists of several measuring instruments for measuring the current, the voltage, the winding temperature and the rotor speed. The proposed protection system can better be demonstrated under the three categories as the hardware, software and instrumentation. The functions of these three categories are explained in the following sections.

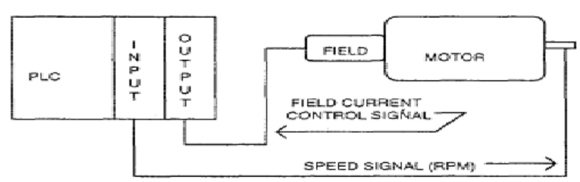

Fig 4.Control System for PLC and Motor

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A. Hardware

The protection system used in this case of protection of IM consists of a single phase IM of 0.25HP,having specifications of initial current 1.4A, voltage 230V,speed 1600 rpm, three transducers as voltage transducer ,current transducer and temperature transducer to make the specified values of IM compatible with PLC, an auto transformer, a Siemens CPU, and a PLC(Schneider).A snapshot of the proposed system is demonstrated in Fig. 5.PLC is connected to the computer with a software through an interface called OPC Server.

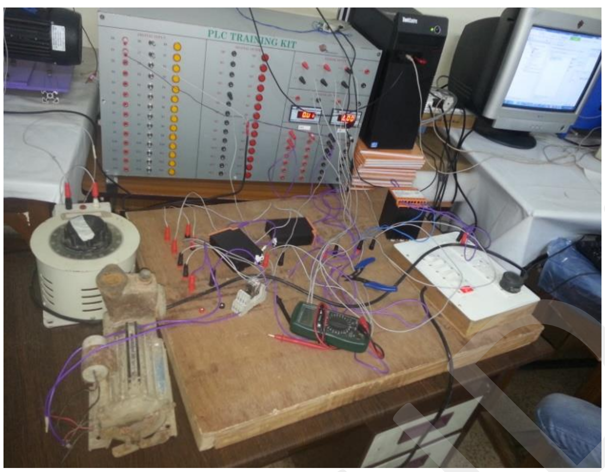

Fig 5.Basic view of the proposed system implemented

B. Instrumentation

The current transducer and voltage transducer are used measure currents and the voltages of the induction motor in the proposed protection system. The analog module of PLC is used as current voltage, and time are real time parameters. The three transducers are used to step down the values of current and voltage as 4-20 mA current and 0-10V voltage since PLC cannot accept such high values of current, temperature and voltage. These converted values of current and voltage are then transferred to the PLC analog module. The temperature signal is also modified and then transferred to analog module of PLC. Now the values are checked by using the software available in PC and if all the conditions are true it energizes the coil in relay and the IM is ON.PLC. One of the outputs of PLC is connected to a relay which is normally in NC condition. If anytime the conditions are not true this relay will then come in NO condition and the motor will stop.

C. Developed Software

A PLC program was developed in order to achieve the protection of IM easily, The PLC system provides a favourable environment for design in the form of software tools which are running on a host computer terminal which allows LADs to be developed, verified, tested and diagnosed. First, the high-level program is fed to the LADs. The LAD is converted into binary instruction codes, so that they can be easily stored in RAM or Erasable Programmable Read-Only Memory (EPROM).Each successive instruction is decoded by the CPU and then executed. The CPU controls the operation of memory and I/O components and process the data according to the program. Each input and output connection point of a PLC is assigned an address which is used to identify the I/O bit. Flowchart of the proposed program is described in Fig.6.

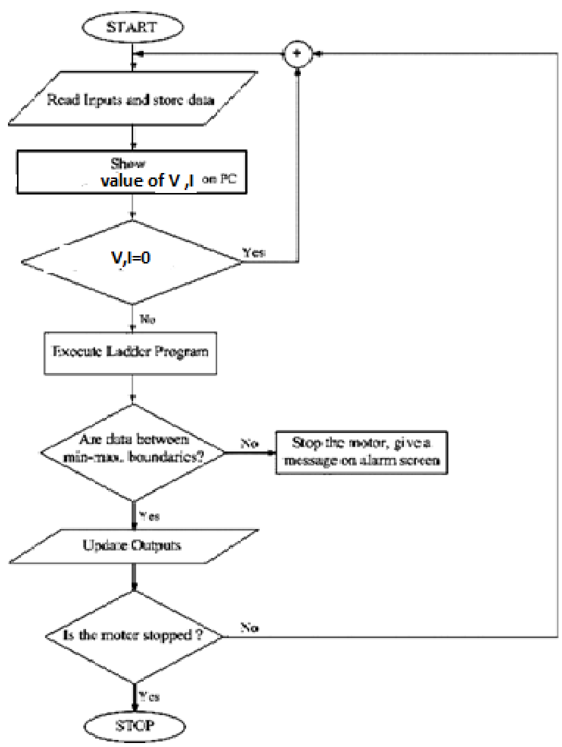

Fig 6.Flow Chart of the Program of Software developed

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Table 1. Motor electrical variables obtained on computer

Variables	Symbol	Inputs	Unit
Phase Voltage	V	Analog Module	volt
Phase Current	I	Analog Module	Amp
Temperature	T	Analog Module	Deg

The SCADA software used to compare the values of voltage, current and temperature with the set minimum and maximum values is "SOMACHINE".

IV. EXPERIMENTAL RESULTS OF MOTOR FAULT DETECTION AND PROTECTION

The computer interface program has been written and the SCADA software used for SCHNEIDER PLC is SOMACHINE. The communication can be achieved by two methods either through a "Modbus" protocol or an OPC Server between the PLC and a computer. In this case OPC Server is used as interface between software and the existing PLC.

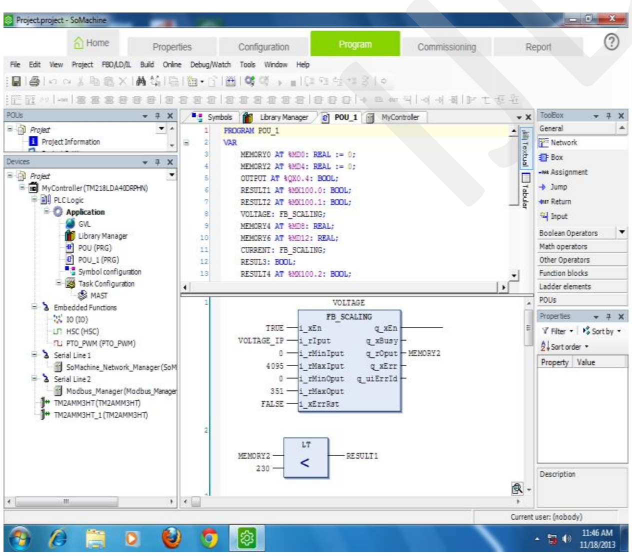

Fig7.Snapshot of Programming in software used showing Voltage parameter

A view of the programming software (SOMACHINE) describing voltage parameter is shown in Fig 7.Similarly the parameters such as current and temperature can also be described in a same manner. All the instructions for operation come from the programmable logic controller for either switching ON/OFF any component of the subsystem depending on its particular state or the state of another component [3].

Result of the operation can now be compared with the fixed maximum and minimum values of current, voltage and temperature as illustrated in Fig 8.The output of the AND gate will be true if all the values are within the set limits. The most prominent faults occurring in an induction motors, has been diagnosed using PLC [4].

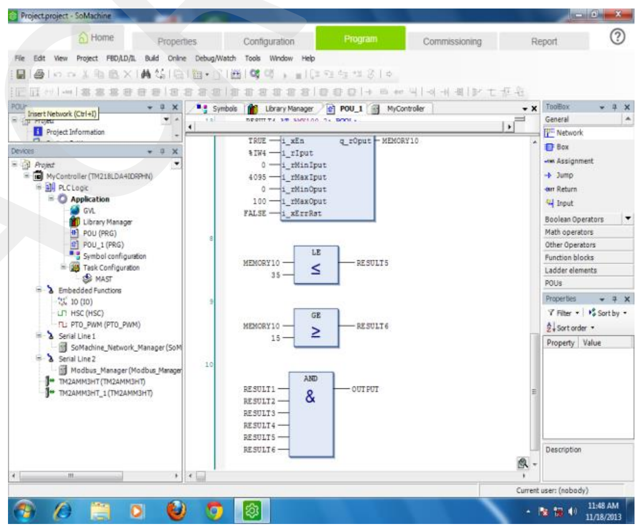

Fig 8. Snapshot of the Programming in software used

To detect the faults of motor and to diagnose it, the software which was developed is used throughout experiments. The menu of the program comprises of six buttons as start, stop, groups, time axis, alarm and reset and aspect.

1) Start button is used to start the motor.

2) Stop button is used to stop the motor.

3) Alarm and reset is used to stop the motor if any failure occurs. Even if the failure condition changes to normal, the motor will not be automatically start again. To again start the motor, reset icon is clicked first and then the start icon

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must be clicked on. Group is used to form individual graphical group.

4) Time axis adjusts the time division.

5) Aspect sets the line thickness.

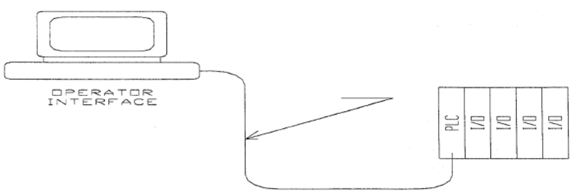

Fig 9.General PLC system layout

A typical existing PLC system layout is shown in Fig 9. This system has two main components, the PLC unit and the Man- Machine Interface. The PLC unit consists of several parts. At the base the hardware parts of the PLC system are placed which has a chassis of the PLC system. This chassis gives the physical support by which all other parts of the PLC system communicate with each other. The most important part of the PLC system is the CPU which is known as the actual PLC. The Ladder Logic program which is used resides in this unit. The CPU available also contains the communication hardware. The CPU receives process status and sends commands through various n0 (input output) cards with the help of the chassis.

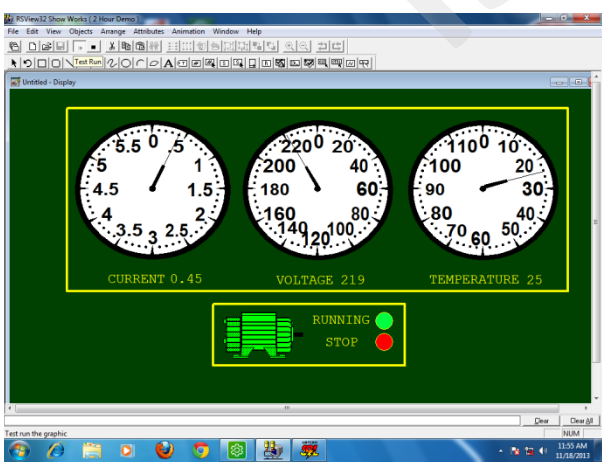

Fig 10.Snapshot of parameters showing fixed values at a particular time interval

The different values of voltage, current and temperature can be observed at different time intervals similarly as shown in Fig 10.Graphic forms of the parameters such as voltages and the currents are also described in this menu. Motor variables such as voltage, current, and the temperature are also shown on this screen. If the induction motor is to be run, the minimum and maximum values of the current, the voltage, the temperature, and the speed have to be first entered using a keyboard. After all the values are entered, the motor is now ready for starting. The waveforms of the currents and the voltages can also be seen using an oscilloscope. These data which are obtained are then analyzed using the software developed on the computer. The computer screen is refreshed within a duration of 200ms**.**

V.CONCLUSION

A single-phase IM of specifications as 0.25 HP, 1.4A current, 230V, 1600 rpm has been connected to the protection system with the help of various measuring components. The PLC-controlled protective system deals with the most important types of failures of an IM, some of them are phase lost, the unbalance of supply voltages, the over or undercurrent, the over or under voltage, the overload, the unbalance of phase currents and the ground fault.

If any fault occurs during the operation of the motor, a warning message appears on the computer and the motor is stops. The most common causes of motor troubles which are responsible for the majority of problems and faults are highlighted [5].When any undefined fault occurs in the motor, it stops without giving any information. In this case, the fault can be detected by the operator. The test has been found successful in diagnosing the faults of an IM and in recovering them.

The various parameters such as current, voltage and winding temperature are then directly being displayed on the screen of the computer using the software developed. After getting all these data they are controlled considering their acceptable tolerance values. The system generally continues to run under normal condition but in case of any occurrence of fault on the system that means if the value of

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phase voltage, rotor speed, phase current or winding temperature increases beyond its prescribed values then the PLC will immediately informs the control circuit of the motor and hence the motor stops.

The results shows that a reliable PLC-based protection system of an IM have been developed. With the advances in PLC, it has greatly reduced the cost of implementing new control circuits on the plant floor and has reduced the time required to make various changes in the relay circuit as demanded by a given process and SCADA is used to make the system more accurate.

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