Recognition of fault and security of three phase induction motor by means of programmable logic controller

M.Pradeep¹, S.Sathishkumar², C.John de britto³, A.T.Sankara Subramanian⁴

¹Assistant Professor, Rajalakshmi Engineering College, Chennai, Tamilnadu, India.
²Assistant Professor, Rajalakshmi Institute of Technology, Chennai, Tamilnadu, India.
³Assistant Professor, Jeppiaar Engineering College, Chennai, Tamilnadu, India.
⁴Assistant Professor, K.Ramakrishnan College of Technology, Trichy, Tamilnadu, India.

Corresponding Email Id: pradeep7raj@gmail.com

Abstract. This paper presents a fault protection of three phase induction motor. Induction motor is common in many industries. Fault can be occurred due to over speed, over load, high temperature, vibration, over current and over voltage. Complete monitoring is necessary to prevent the motor from the damage. Various protection schemes are implemented to protect the motor from the fault. Here we come with the PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition) for the detection and protection of three phase induction motor from the fault. PLC is used to control the system and the SCADA is used to control and monitor the motor. Motor status can be viewed and controlled in remote location by using the SCADA software. If any fault occurs, motor automatically turns off and gives the warning to the person working in the vicinity. Hereby we can avoid unexpected failure of the motor and prevent the whole industrial process from shutting down all of a sudden which can be dangerous to the people working in the industry. This possesses high efficiency, low cost and more safety benefits than relay based system.

Keywords – Protection, Induction Motor, PLC, SCADA

1. Introduction

The three phase induction motor is necessary for manufacturing. It is preferred because it can also be operated in hazardous conditions. The advantage of alternating current three phase induction motor is that it offers rugged construction, cost effective pricing and easy maintenance. These factors have result in the development of the manufacturing infrastructure which has led to a vast installed base of motors. AC induction motor is used in worldwide industries. Unexpected fault occurrence can damage the motor and it cause industrial issue. So continuous monitoring of induction motor has received considerable attention in recent years.

Various types of faults occurring in three phase induction motor are over current, over voltage, under current, under voltage, temperature and bearing fault. These faults can be controlled and monitored by Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA). Programmable Logic Controller (PLC) has achieved recent development in industrial applications. Control circuit of industrial automation system is the most widely used area of programmable logic controller.

PLC offers high reliability control, ease of programming and process fault diagnosis. Input devices state is continuously monitored for an industrial application using PLC. It controls the entire system.
Supervisory Control and Data Acquisition (SCADA) is used to monitor and control the system simultaneously. While many types of motor fault detection and protection methods have been proposed, practical detection techniques for three phase induction motors are generally provided by some combination of mechanical and electrical monitoring techniques. Digitally conditioned monitoring of electrical machines has received considerable attention in recent years. In this paper various types of fault in three phase induction motor occurring in operation have been achieved with the help of PLC and SCADA. In this study, the method applied is PLC and SCADA based protection system of three phase induction motor.

2. Programmable Logic Controllers
A PLC (Programmable Logic Controllers) is used to run more complex processes. It is possible to connect more PLC to a central computer. Induction motors are used worldwide in industrial applications. These motors not only used for general purposes, but also in severe environments and hazardous locations. These motor is reliable but they are prone to some undesirable stresses which causes faults and failure of induction motor. A motor failure that is not identified in an initial stage may become severe and the induction motor may suffer severe damage like, production shutdowns. Such shutdowns are costly in terms of production time, maintenance costs, and wasted raw materials. In order to protect the induction motor recent technology is introduced in our model. Due to recent development in Programmable logic control (PLC) it can be used efficiently for fault diagnosis of induction motor. The earlier models include Fault diagnosis of induction motor using PLC in 2013 [1] which involves Single phase Induction Motor connected to the protection system through the measuring components. The proposed PLC-controlled protective relays deals with the failures such as the over current, over voltage, overload, under voltage, under current, temperature, over speed and vibration. In the year 2014, Fault identification and protection of induction motor using PLC and SCADA [2] was developed which involves Advanced Signal Processing techniques and Stator current spectral signature analysis.

In 2015, Harmonic tracking analysis: a novel method for fault diagnosis in induction machine [3] was developed which involves usage of Fourier transform which relies on tracking the frequency signature of each type of fault in current’s spectrum. In 2015, Microcontroller Based Protection and Control of Three-Phase Induction Motor [4] was developed in which implemented protection system can be programmed to suit wide range of induction motor sizes. In 2016, automated SCADA based system for identification of induction motor bearing fault [5] used in process control operation was developed. It includes analyzing of vibration amplitude using standard deviation faulty bearing. Faulty bearing can be identified from the vibration signal.

In 2017, A review and comparison of fault detection and diagnosis for squirrel cage induction motors [6] was developed. In this model, the effect of simultaneous or cascaded faults with respect to different combinations of fault severity on each individual is desired to explore.

We have proposed a system which includes the following features:

Fault detection and protection of three phase Induction Motor using PLC and SCADA. Incremental encoder is used to converts linear or rotary displacement into digital or pulse signal. Vibration sensor used to rectify the bearing fault. Temperature sensor with contact type is used, which is in physical contact with the object being sensed and use conduction to monitor change in temperature.

3. Block Diagram:
In this article, we have designed the protection system for three phase induction motor. The three phase induction motor will have the rating as 415V, 3.50A and 50 Hz. The protection is done by means PLC and SCADA. The PLC used is OMRON PLC which can be utilized by CX-Programmer for CP1E. It allows faster programming by using the easy input editor software.

Quicker symbol creation because of management and memory allocation is automatic. Wonder ware In touch SCADA software is used to control and manage the process of remote area from the control room. It is the most sophisticated graphical tool which can be monitor more than 1,00,000 plants and factories. Thermal overload relay is used to control the over current, over voltage from the power supply. A contactor with 24V is used to control the 240V motor switch.

The motor is connected with the sensors like temperature sensor, vibration sensor and encoder. The temperature sensor is to control the temperature in the induction motor which has the limit of 50 ambient. The vibration sensor is used to protect the motor from the bearing fault. Encoder gets the speed of the motor which is very much essential to run the motor without stopping it.

Temperature sensor, vibration sensor, encoder is fixed with PLC to operate without making issues in changing of values beyond the range. The SCADA and PLC is interfaced to control and manage the fault detection and protection of three phase induction motor without causing major damage to the motor. The solution of various faults of the phase currents, phase voltages, winding temperature and vibration of the induction motor occurring can be achieved with the help of PLC and can be monitored on PC. If any fault is observed during operation of the motor then the warning message will be displayed and then the motor will be automatically stopped.
4. Methodology:

**Step 1:** SCADA frameworks are significant for modern associations since they help to look after productivity, process information for more astute choices, and impart framework issues to help moderate personal time.

**Step 2:** The fundamental SCADA design starts with programmable rationale controllers (PLCs) or remote terminal units (RTUs).

**Step 3:** PLCs and RTUs are microcomputers that speak with a variety of items, for example, plant machines, HMIs, sensors, and end gadgets, and afterward course the data from those articles to PCs with SCADA programming.

**Step 4:** The SCADA programming forms, appropriates, and shows the information, helping administrators and different workers break down the information and settle on significant choices. For instance, the SCADA framework rapidly tells an administrator that a cluster of item is demonstrating a high rate of mistakes.

**Step 5:** The administrator delays the task and perspectives the SCADA framework information through a HMI to decide the reason for the issue. The administrator audits the information and finds that Machine 4 was breaking down.
Step 6: The SCADA framework's capacity to tell the administrator of an issue encourages him to determine it and counteract further loss of item.

1. Software Tools:

The snapshot shows the SCADA design for the fault detection and protection of three phase induction motor. Here comes the thermal overload relay, main contactor, delta and star contactor, encoder, vibration sensor and temperature sensor. When the power supply is given to the motor, initially the motor runs in star connection then it runs in delta connection because of the use of star delta starter. Starter is always essential in a motor.

\[ I_a = \frac{V - E_b}{R_a} \]

(I = V/R, Ohm Law) Suppose

A 5 HP motor with 415V having the armature resistance as 0.25ohms and normal full load current is 50 amperes.

Direct connection to the motor without a starter the result will be

\[ I_a = \frac{415 - 0}{0.25} \]

\[ = 1660 \text{ A} \]
This high current will destroy the winding because it is 33.2 times high with normal full load current. So this is the reason to install a starter with a motor.

Figure 2: Pen Trend Control

Figure 3: Fault condition of the Motor

Figure 4.2 show the time period to control and monitor the process. As mentioned by date and time it will show the graph in the name of trend and the process update. Figure 4.3 is the fault condition of the motor and during this condition the motor will stop and the alarm is heard and the detail of alarm is shown in figure4.4

Figure 4: Alarm status of the each stepping process
This shows the simple PLC ladder diagram for the fault detection process.

5. Conclusion:
The solution of various faults of the phase currents, phase voltages, winding temperature and vibration of the induction motor occurring can be achieved with the help of PLC and can be monitored on PC. If any fault is observed during operation of the motor then the warning message will be displayed and then the motor will be automatically stopped.

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