Programmable Logic Controller (PLC) Based Fault Detection And Protection Of Induction Motor

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Abstract-The goal of this paper is to protect induction motors against possible failures by increasing the reliability, efficiency, and the performance. The proposed approach is a sensor based technique. For this purpose, current, voltages, speed and temperature values of the induction motor were measured with sensors. When any fault condition is detected during operation of the motor, PLC controlled on line operation system activates immediately. The performance of the protection system proposed is discussed by means of application results. The motor protection achieved in the study can be faster than the classical techniques and applied to larger motors easily after making small modifications on both software and hardware.

Keywords: Induction Motor, Protection, PLC

I. INTRODUCTION

Induction motors are used as actuators in many industrial processes. Although IMs are reliable, they are subject to some undesirable stresses, causing faults resulting in failure. Monitoring of an Induction Motor is a fast emerging technology for the detection of initial fault. It avoids unexpected failure of an industrial process. Monitoring techniques can be classified as the conventional and digital techniques. Classical monitoring techniques for three-phase IMs are generally provided by some combination of mechanical and electrical monitoring equipment. Mechanical forms of motor sensing are also limited in ability to detect electrical faults, such as stator insulation failures. In addition, the mechanical parts of the equipment can cause problems in the course of operation and can reduce the life and efficiency of a system. It is well known that Induction Motor monitoring has been studied by many Researchers and reviewed in a number of work.

Classical protection techniques for three phase Induction Motors are generally provided by some combination of mechanical and electrical equipments such as contactors, timers, electromagnetic switches, thermal relays, over current relays and over/lower voltage relays. These equipments have mechanical parts, and their responses are very slow compared with that of electronic equipment. The mechanical parts of the equipment can cause problems during their operations and reduce the life and efficiency of the system. In terms of economic consideration, the cost of the digital hardware has been decreased and the cost of classical relays has been increased recently .

A programmable integrated circuit (PIC) based protection system has been introduced in. The solutions of various faults of the phase currents, the phase voltages, the speed, and the winding temperatures of an induction motor occurring in operation have been achieved with the help of the microcontroller, but these electrical parameters have not been displayed on a screen. Nowadays, the most widely used area of programmable logic controller (PLC) is the control circuits of industrial automation systems. PLC systems are equipped with special I/O units appropriate for direct usage in industrial automation systems. The input components, such as the pressure, the level, and the temperature sensors, can be directly connected to the input. The driver components of the control circuit such as contactors and solenoid valves can directly be connected to the output. Many factories use PLC in automation processes to diminish production cost and to increase quality and reliability. There are a few papers published about the control of Induction Motors with PLC. One of them is power factor controller for a three-phase Induction Motor that utilizes a PLC to improve the power factor and to keep its voltage-to-frequency ratio constant over the entire control range.

II. MOTOR RELIABILITY AND PROTECTION

Industrial applications since several decades ago. These applications range from intensive care unit pumps, electric vehicle propulsion systems and computer-cooling fans, to electric pumps used in nuclear power plants. Safety, reliability, efficiency, and performance are some of the major concerns of motor applications. With issues such as aging motors, high reliability requirements such as for military applications, and cost competitiveness, the issues of preventive maintenance, on-line motor fault detection and diagnosis are of increasing importance.

Gabriel, included the data were reviewed to determine the percentage of failures associated in the following groups: electricity related, mechanically related, environmentally and maintenance related and other. In this study, the majority of motor failures were categorized. These are unbalanced voltage, single phasing effect, overloading effect, increasing of stator winding temperature. This study presents a combined protection approach for Induction Motors To achieve this, the current, the voltage, the speed and the temperature values of the Induction Motor were measured with sensors. The experimental results have shown that the Induction Motor was protected against the unbalanced voltage, the single phasing effect, the overloading effect, the increasing of stator winding temperature problems encountered in on-line operation. In addition, the protection system can easily be applied to larger motors after doing small modifications in the software developed.

III. EXPERIMENTAL STUDY

In this article, a new protection system was designed and implemented to achieve protection for the current, the voltage, the rotor the speed and the winding temperature of

Induction Motor. The schematic diagram of the experimental set-up is given in Figure. The implementation is based on hardware, instrumentation and software. These parts are explained in the following sections.

A. Convectional method

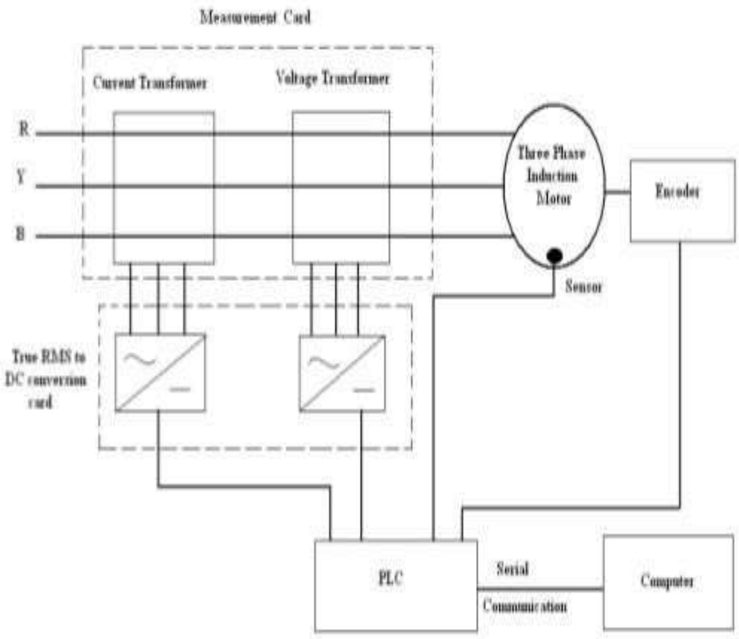
Classical monitoring techniques for three-phase IMs are generally provided by some combination of mechanical and electrical monitoring equipment. Mechanical forms of motor sensing are also limited in ability to detect electrical faults, such as stator insulation failures. In addition, the mechanical parts of the equipment can cause problems in the course of operation and can reduce the life and efficiency of a system. In computer based protection system, measurements of the voltages, currents, temperatures, and speed were achieved and transferred to the computer for final protection decision. Although all the variables of the motor were considered, usage of an analog-to-digital conversion (ADC) card increases the cost and the size of the system. A programmable integrated circuit (PIC) based protection system, solutions of various faults of the phase currents, the phase voltages, the speed, and the winding temperatures of an induction motor occurring in operation have been achieved with the help of the microcontroller, but these electrical parameters have not been displayed on a screen.

B. Research Methodology

In this proposed method for Induction Motors a new protection method based on a programmable logic controller (PLC) has been introduced. In this method, all contactors, timers and the conversion card are eliminated. Moreover, the voltages, the current, the speed, and the temperature values of the motor, and the problems occurred in the system, are monitored and warning messages are shown on the computer screen. This PLC-based protection method costs less, provides higher accuracy as well as safe and visual environment compared with the classical, and the PIC-based protection systems.

C. Block Diagram of Proposed method

This method explains a PLC-based protection and monitoring method for a three-phase induction motor. The new solutions for various faults of the phase currents, the phase voltages, the speed, and the winding temperatures of an IM occurring in operation have been achieved with the help of a PLC. If only a PLC is used as a protection relay for a system, it costs more. But the use of a PLC can be the right choice if it is considered in an automation system in order not to use extra microprocessor such as PIC.



IV. CONCLUSIONS

The solution of various faults of the phase currents, phase voltages, speed, winding temperatures of an Induction Motor occurring in operation have been achieved with the help of the PLC and they have been monitored on PC.

If any fault is observed during any action of the motor, a warning message appears on monitor and then motor is stopped. The test is successful and the protection system shows a good performance in detecting the faults and in clearing them.

If any fault is observed during online operation of the motor, a warning message appears on computer and then the motor is stopped.

It is expected that motor protection achieved in this study might be faster and more efficient than the classical techniques because of electronic equipment used in the experiments rather than mechanical equipment.

In addition, it does not require any conversion card, and therefore, costs less than a computer-based protection method. Moreover, it provides a visual environment, which makes the system more user-friendly than a PIC-based protection method.

- Low power consumption
- Maximum efficiency
- Less cost
- Easy implementation
- Reduces the man power
- Provides higher accuracy
- Provides safe and visual environment
- Faster operation
- More reliable

References

[1] 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.

[2] İ. Çolak, H. Çelik, İ. Sefa, Ş. Demirbaş, "On line protection system for induction motors", Energy Conversion and Management, vol.46(17), 2005, pp. 2773-2786.

[3] W.A. Farag, M.I. Kamel, "Microprocessor-based protection system for three-phase induction motors", Electric Machines and Power Systems, vol.27, 1999, pp. 453- 464.

[4] M. Çunkaş, R. Akkaya, A. Öztürk. "Protection of AC motors by means of microcontrollers", 10. Mediterranean Electrotechnical Conference, Melecon 2000, Nicosia, Cyprus, 3, pp. 1093-1096.

[5] A. Siddique, GS. Yadava, B. Singh, "A review of stator fault monitoring techniques of induction motors", IEEE Transactions on Energy Conversion, vol.20(1), 2005, pp. 106-114.

[6] Y. Zhongming, W. Bin, "A review on induction motor online fault diagnosis", The Third International Power Electronics and Motion Control Conference, PIEMC 2000, 3, 15-18 Aug. 2000, Beijing, pp. 1353–1358.

[7] MEH. Benbouzid, "Bibliography on induction motors faults detection and diagnosis", IEEE Transactions on Energy Conversion, vol.14(4), 1999, pp. 1065–1074.

[8] Tandon N., Yadava GS., Ramakrishna KM. A comparison of some condition monitoring techniques for the detection of defect in induction motor ball bearings, Mechanical Systems and Signal Processing.

[9] F. Filippetti, G. Franceschini, C. Tassoni, P. Vas, "AI techniques in induction machines diagnosis including the speed ripple effect", IEEE Trans. Ind. Application, vol.34(1), 1998, pp. 98–108.

[10] WT. Thomson, D. Rankin and DG. Dorrell, "On-line current monitoring to diagnose airgap eccentricity in large three-phase induction motors–Industrial case histories verify the predictions", IEEE Trans. Energy Conversion, vol. 14, December 1999. pp. 1372–1378.

[11] WT. Thomson and M. Fenger "Current signature analysis to detect induction motor faults", IEEE Ind. Applicat. Mag., vol. 7, July/Aug. 2001. pp. 26–34.

[12] M. Benbouzid, M. Vieira, C. Theys, "Induction motor's fault detection and localization using stator current advanced signal processing techniques", IEEE Trans. Power Electron., vol. 14, January 1999. pp. 14–22.

[13] M. Arkan, D. Kostic-Perovic, PJ. Unsworth, "Modelling and simulation of induction motors with inter-turn faults for diagnostics", Electric Power Systems Research, vol, 75 (1), July 2005, 57-66.

[14] Hodowanec MM., Finley WR., Kreitzer, SW. Motor field protection and recommended settings and monitoring. Industry Applications Society 49th Annual Petroleum and Chemical Industry Conference, New Orleans, Louisiana, 23-25 Sept. 2002, pp. 271–284.

[15] M.G. Ioannides, "Design and implementation of PLC-based monitoring control system for induction motor", IEEE Transactions on Energy Conversion, vol. 19 (3), Sept. 2004, pp. 469–476.

[16] B. Ayhan, MY. Chow, MH. Song, "Multiple signature processing-based fault detection schemes for broken rotor bar in induction motor", IEEE Transactions on Energy Conversion vol. 20(2), June 2005, pp. 336, 343.

[17] JP Gabriel and A. Rose, "Improving existing motor protection for medium voltage motors", IEEE Transactions on Industry Applications, vol. 25 (3), May/June 1989, pp. 456-464.

[18] Precision Centigrade Temperature Sensor (LM 35) Data Sheet National Semiconductor, November 2000. http://www.national.com

[19] Shaft type Rotary encoder Data sheet (ENB series), 2005, Korea. www.autonics.com

[20] Siemens, S7-200 Programmable controller system manuel 1999, Siemens AG, Nuemberg, Germany. P. 1.1-1.6.