A Review on Induction Motor Parameter Monitoring System using ZigBee Protocol & MATLAB GUI

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Abstract— In this review paper, the basic idea behind using the Zig bee protocol system used by various researchers is described. The availability of ZigBee communication protocol for safe and economic data communication where the wired communication is either more expensive or impossible due to physical conditions is explained in this paper. ZigBee sensor network formed for data acquisition and monitoring. The three-phase induction motor can be started and stopped using a computer interface developed with ZigBee. A remote device is built of a commercially available ZigBee module and a sensor. A ZigBee module is connected via a USB interface to a PC, which works as a base station in the sensor network. Data collected from remote devices are sent to the base station PC which is represented in graphical form with user interface developed on MATLAB. By considering all factors, a low-cost system for measuring the parameters of induction motor such as phase voltages, phase currents, power, power factor, and motor temperature with Zigbee protocol connectivity can be developed for different applications.

Keywords: Three-phase induction motor, MATLAB, motor parameters, Zigbee

I. INTRODUCTION

Induction motors are the most important workhorse of the electrical power industry. They are low-cost, highly efficient, robust, and reliable. The power range of induction motors is from a few hundred watts to megawatts, which satisfies the requirement of most industrial processes. Induction motors have been utilized in not only general purpose applications, including machine tools, elevators, pumps, centrifugal machines, conveyors, and presses, but also hazardous locations and severe environments, such as grain elevators, shredders and equipment for coal, petrochemical and natural gas plants.

Environmental stress, heavy-duty cycles, load conditions, installation, and manufacture imperfections can reduce the efficiency or cause a malfunction of induction motors, leading to repair expenses and financial loss due to unexpected downtime. Reducing the operation and maintenance cost is one of the critical requirements in manufacturing industries. If the faults are not prognosticated beforehand, they may result in large revenue loss as well as pose a threat to reliability and safety of operation. Condition monitoring is an effective method that can capture the initiation and growth of faults at an early stage. Therefore, reliable condition monitoring and fault diagnosis are necessary to lower maintenance costs and increase the productivity of the plant.

Development of the motor condition monitoring and fault diagnosis techniques resulted in an increased demand for induction motor drives. At the early stage of the application, only simply motor protections were applied, such as over-current, over-voltage, and earth-faults to ensure safe and reliable operation. With the increasing demand for uninterrupted operation and system availability, enormous research efforts have been devoted to improving motor condition monitoring and fault diagnosis techniques.

Induction motor parameters, provided by manufacturers, are usually obtained under starting or full-load condition, instead of the normal operating conditions. In reality, the motor parameter values might change under different circumstances. For example, the temperature has a great impact on rotor resistance, magnetic saturation, mutual inductance, and stator resistance. Furthermore, fabrication tolerances could lead to variations in the motor parameters even in the same batch. Therefore, accurate motor parameters identification has been a fundamental research field for motor control.

Condition monitoring and fault diagnosis of induction motors has been a challenging task for engineers and researchers in many industries. Condition monitoring is defined as the continuous evaluation of the equipment's life throughout its service life. It is important to able to detect faults when they are developing and these are called incipient failures. This system allows the machine operators to have necessary spare parts before the machine is stripped down thereby reducing outage times. Current monitoring techniques are usually applied to detect various induction motor faults such as stator winding faults, bearing faults, etc. This is because the basic electrical quantities associated with electromechanical parts such as current and voltage are readily measured by tapping into the existing system of voltage and current transformers that is always installed as a part of the protection system.

In such cases, remote control and monitoring techniques become a considerable solution to eliminate these hazards. Hence, wireless data communication is used in various industries. Wireless communication called Wi-Fi is capable of high data rate transmission, Bluetooth, and 3G in industrial companies. These devices use system resources a lot and are proportional to transmission speed. The Institute of Electrical and Electronics Engineers (IEEE) developed 802.15.4 standards and helped the production of Zigbee protocol and devices that support this protocol.

As a result, Zigbee supported devices have low-cost, intelligent network topologies and are energy-saving features. So, they have their place in daily life and industrial companies in various ways. A lot of devices and machines can be controlled, and data can be received and sent at the same time by Zigbee wireless technology. So, system running can be achieved without any trouble. In the literature, several methods have been presented for running, monitoring, and detecting mechanical and electrical defects in three-phase induction motors. Traditional protection practices for detecting motor defects and protecting motors use various types of protection relays such as overcurrent relays, temperature relays, low and high current protection relays, electromagnetic switches, contactors, and time relays. If the traditional protection methods are compared

with the computer-based ones, traditional methods considerably reduce the efficiency and sensitivity of the system because of many mechanical parts including in the whole system increase the time for detecting defects. Another disadvantage of the traditional protection methods is their cost; namely, it is clear that traditional methods increase the cost of systems while digital systems reduce it. There are many publications on the detection of the mechanical defects of induction motors. In some studies, motor parameters have been used to display the electrical and mechanical performance of the motor through a PC.

A real-time monitoring system has been developed against the failure of the induction motor. All measurements related to the induction motor were done and protection against the failure of the induction motor has been achieved. However, it was realized that the cost is increased due to the use of sensors to collect the current and the voltage information from the network and transfer them to the computer by an analog/digital converter card.

Especially, a powerful remote control has been achieved successfully to monitor the basic size for those places where the motor is difficult to reach.

II. Literature Review

A. Present Theories and Practices

In recent years there are many technologies among remote control that have been achieved successfully to monitor Induction Motor Parameter. And many control technologies have been investigated. Following are the main researchers who contributed to this topic and had given thoughts:

Nadh et al. [1] explained various strategies that can be followed to assess operating conditions of induction motors, condition monitoring based on non-invasive detection of signals is the emergent one. Regular inspection and processing of input voltages and currents allow one to predict possible deterioration and to schedule the motor shut down if a prefixed rate is exceeded. Based on the above, current transformers (CTs) and potential transformers (PTs) are utilized to measure the currents and voltages from the motor terminals and are used for on-line monitoring, fault detection, and protection purposes

Various modeling methods of the induction motor and the fault conditions are described by Kumar et al. [2]. In this paper, simulation of electrical fault analysis is done using the basic components of MATLAB Simulink toolbox.

The PIC series had the advantage of the C compiler that was reasonable in price, free updates of the complier, a free development environment, and a single supplier of software and hardware. Although embedded C programming has the disadvantage of not knowing the real-time nature of the code it is producing, it was implemented and proved to be effective and efficient [3]. In this paper, the PIC16F877 microcontroller is used to implement the integrated motor protection scheme considering the above advantages.

Chengbo et al. [5] have proposed a wireless control and monitoring system for a D.C motor realized using the ZigBee communication protocol for safe and economic data communication in industrial fields where the wired communication is either more expensive or impossible due to physical conditions. The motor can be started and stopped using a computer interface developed with ZigBee. It is also possible to create a database to execute online measurements and to save the motor parameters received by the radio frequency (RF) data acquisition system. Therefore, controlling, monitoring, and protection of the system are realized in real-time. Since the wireless communication technology was used in this study, controlling abilities of the system are increased and also hardware and necessities of other similar equipment for data communication are minimized. The system is fully controlled by the Personal Computer through Visual Basics GUI (Graphical User Interface).

Visan et al. [6] has proposed a ZigBee sensor network for data acquisition and monitoring. Each remote device is built of a commercially available ZigBee module product and a sensor. A ZigBee module is connected via a USB interface to a PC, which works as a base station in the sensor network. Data collected from remote devices are sent to the base station PC, which is set as a data sink.

Peng et al. [7] have proposed an automatic fire rescuing system for trains using the ZigBee sensor network. ZigBee and sensor network both are cost-effective monitoring system which helps the railway industry for both signaling and communication purpose. The system has 16f877a microcontroller of PIC as hardware platform, and combine with ZigBee and wireless sensor network as a communication platform, which can transmit, receive and display warnings and emergency signals and for sensing the temperature in trains.

Bayindir et al. [8,9] have proposed a wireless control and monitoring system for an induction motor using the ZigBee communication protocol for safe and economic data communication in industrial fields where the wired communication is either more expensive or impossible due to physical conditions. Controlling, monitoring and protection of the system are realized in real-time. Since wireless communication technology is used in this work, the controlling abilities of the system are greatly increased. The hardware and the necessities of other similar equipment for data communication are minimized.

Siddiqui et al. [10] has proposed a new design technique for wireless industrial automation. All the processor and controllers are interconnected to personal computer through ZigBee. The personal computer based wireless network for industrial application using ZigBee can be adopted at micro and macro Industries. It has various types of Processors and Microcontrollers. The Personal Computer will continuously monitor all the Data from remote processing unit and compare it with the value preloaded process structure. If any error is found the personal computer takes necessary action.

All measurements related to the induction motor were done by Bektas et al. [11] and protection against the failure of induction motor has been achieved by developing a real time monitoring system against the failure of induction motor. But cost of system is increased due to input traducers like temperature sensors or other sensors use to collect the voltageand current information from the motor network andtransfer to the PC.

Dobai et al. [12], described a simple condition monitoring algorithm, which can be used in advanced

condition monitoring systems in industrial environment. It can be used in both off-line and on-line monitoring systems.

Gupta et al [13] reports the design and development of a smart wireless sensor network (WSN) for an agricultural environment. The sensor data is transmitted to network coordinator which is heart of the wireless personal area network.ZigBee is newly developed technology that works on IEEE standard 802.15.4, which can be used in the wireless sensor network (WSN). The low data rates, low power consumption, low cost are main features of ZigBee. WSN is composed of ZigBee coordinator (network coordinator), ZigBee router and ZigBee end device. The sensor nodes information in the network will be sent to the coordinator, the coordinator collects sensor data, stores the data in memory, process the data, and route the data to appropriate node.

B. Need for Monitoring

Monitoring of ac motor is necessary for operating efficiently. There are many undesirable things that happen to electric motors and other electrical equipment as a result of operating a power system in an over voltage manner. Operating a motor beyond its nominal range of its voltage requirements will reduce its efficiency and cause premature failure. The economic loss from premature motor failure can be devastating. In most cases, the price of the motor itself is trivial compared to the cost of unscheduled shutdowns of the process. Both high and low voltages can cause premature motor failure, as well as voltage imbalance. So the best life and most efficient operation occur when motors are operated at voltages close to the nameplate ratings. Monitoring of ac motor provides not only reducing the cost of the electricity bill, but also extending the life of the electrical motors while preventing unexpected failure.

III. CONCLUSIONS

By studying various literature related to Zig bee protocol and MATLAB GUI, it can be concluded that the system can be useful to carry out wireless monitoring of induction motors in small and medium scale industries which will reduce cost of wiring. The performance of the induction motor can be recorded and in case of fault condition the protection is also provided. The system can be cost-effective as compared to conventional systems. The system can be modified to vibration, chemical monitoring by adding some sensors to system. So more study is required to effective use of this study in this regard.

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