Study of WSN based Torque and Efficiency monitoring and Noise fault analysis in Induction Motor

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Abstract—In this paper used the real time based wireless sensor network (WSN) based method for torque and efficiency monitoring. An embedded system is implemented to collect the information in the form of electrical signal and this data is converted by the embedded system and transmitted through wireless network by using RF module. The wireless technology is very advance technology and having low cost.

The noise of the motor is monitor by frequency analysis method and from that the difference between healthy motor and faulty motor is observed .From the electric motor noise monitoring it is very easy to detect the motor fault.

Keywords-*Efficiency and Torque measurement, embedded systems, induction motors, WSN, RF module, Noise analysis.*

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I. INTRODUCTION

The induction machines are widely used because of its simplicity, robustness and their low cost.

Induction motors are the main loads in the electrical power systems. The efficient operation of the motors can bring direct and significant savings in consumed energy levels and indirectly reduce requirements for the installation of new power plants, transmission lines, and distribution systems.

It is estimated that over two-thirds of the total electric energy generated is consumed by motor driven systems. On average, the motors in industrial plants operate at 60% of their rated load because of oversized installations or under loaded conditions and, as a result, have fairly low efficiencies..

Regarding the type of motors usually employed, about 90% are three-phase ac induction based,[2] mainly due to its cost effectiveness and mechanical robustness[3]. Torque is one of the main parameters for production machines. In several industry sectors, torque measurements are specially used to identify equipment failure, which makes their monitoring essential to avoid disasters in critical production processes. Torque is one of the main parameters for production machines. There are basically two torque measurement methods:

Direct torque measurement on the shaft, and estimated torque measurement from motor electrical signal. Mostly, the methods for direct torque measurement on the shafts are the more accurate.

There are some simple methods for efficiency estimation, like the slip method, the current method, and nameplate method. These methods have main limiting factor the low accuracy, estimative based on nominal motor data and the need of typical efficiency-versus-load curves

Furthermore, these machines can be subjected to different operating conditions that can produce electrical or mechanical damages on the stator and/or the rotor and bearings too. It is well known that the bearing faults constitute a significant part of the faults of the induction motors. This is why research on the faults of these electrical machines has developed many techniques based on the signals analysis applied to measure parameters such as vibrations, noise the magnetic flux, power, voltage or stator current. In this paper, we use vibration and noise analysis method to detect the bearing faults [1]. This technique is based on the frequency analysis of noise signals.

II. LITERATURE REVIEW

An embedded system is designed for acquiring electrical signals from the motor in a non-invasive manner, and then performing local processing for torque and efficiency estimation. The values calculated by the embedded system are transmitted to a monitoring unit through an IEEE 802.15.4-based WSN. At the base unit, various motors can Be monitored in real time.

The work presented in [1] aims at monitoring the torque and efficiency in induction motors in real time by employing wireless sensor networks (WSNs). In an industrial environment, mechanical systems driven by electric motors are used in most production processes, calculating for more than two-thirds of industry electricity consumption. Torque is one of the main parameters for production machines. In distinct industry sectors, torque measurements can identify equipment failure, which makes their monitoring essential in order to avoid disasters in critical production processes (e.g., oil and gas, mining, and sugar and alcohol industries).

Hsu and Scoggins presented the air-gap torque [2] (AGT) for energy efficiency estimation. In, the AGT is also used to measure ability in a much less invasive manner. The AGT [2] method can be occupied without interrupting the motor operation and it is not based on the motor nameplate. This method generally is more accurate than the other methods Hsu and Scoggins further presented the air-gap torque (AGT) for energy efficiency estimation. The AGT is also used to measure efficiency in a much less invasive manner. The AGT method can be occupied without interrupting the motor operation and it is not based on the motor nameplate. This method broadly is more accurate than the other methods described earlier. In this study, the AGT method was used for the evaluation of the motor shaft torque and efficiency, because it is the non-invasive method for determining torque and efficiency that has less uncertainty [3]. Traditionally, energy monitoring and fault detection in industrial systems are executed in an offline manner or through wired networks [1].

The installation of cables and sensors usually has a higher cost than the cost of the sensors themselves. Besides the high cost, the wired access offers little flexibility, making the network deployment and maintenance a harder process. In this context, wireless networks present a number of benefits compared to wired networks as, for example, the ease and speed of deployment and maintenance, and low cost. In addition to that, wireless sensor networks (WSNs) provide self-organization and local processing efficiency. Therefore, these networks appear as a flexible and inexpensive solution for building industrial monitoring and control systems. Never the less, the use of WSNs [1], when developing automation systems for industrial environments, presents a number of challenges that should be faced. Wireless networks have inaccurate communication links, what can be grated with noise and interfered in the communication spectrum range [1]

Studies on the application of WSNs in industrial environments, aiming at replacing wired systems, have been largely analyzed in recent years. This paper presents an embedded system for determining torque and efficiency in industrial electric motors by applying WSNs technology. For set of electric motors, current and voltage measures are combined for later processing into an embedded system.

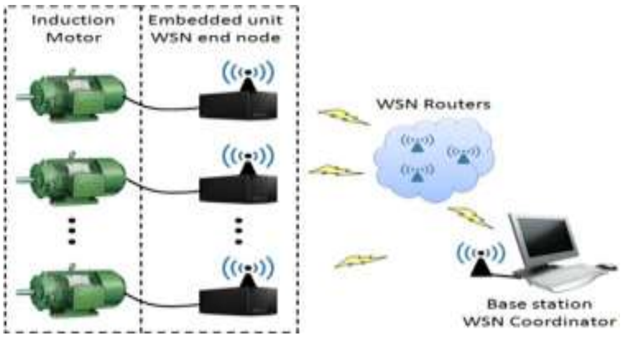

Fig 1: Embedded system integrated into the WSN

In general, fault diagnosis of induction motors has fixed on sensing failures in one of three major components, the stator, the rotor, and the bearings. Even though mechanical sensing techniques based on thermal and vibration monitoring have been applied widely, most of the recent research has been directed toward electrical sensing with emphasis on analysing the motor stator current [10].

III. INDUCTION MOTOR FAULT

The major faults of induction motors can broadly be classified as the following:

- Bearing wear and failure. As a result of bearing wear, air gap eccentricity can increase**,** and this can generate serious stator core damage and even destroy the winding of the stator.
- Stator faults resulting in the opening or shorting of one or more of a stator phase windings.
- Abnormal connection of the stator windings,
- Static and/or dynamic air-gap irregularities.
- High mechanical unbalance in the rotor increases centrifugal forces on the rotor;
- Broken rotor bar or cracked rotor end rings.
- Looseness or decreased stiffness in the bearing pedestals can increase the forces on the rotor;
- Bent shaft which can result in a rub between the rotor and stator, causing serious damage to stator core and windings [10]

The three phase induction motor noises are measured to detect bearing faults. In the single phase motor case the fault detects is a broken bars rotor.

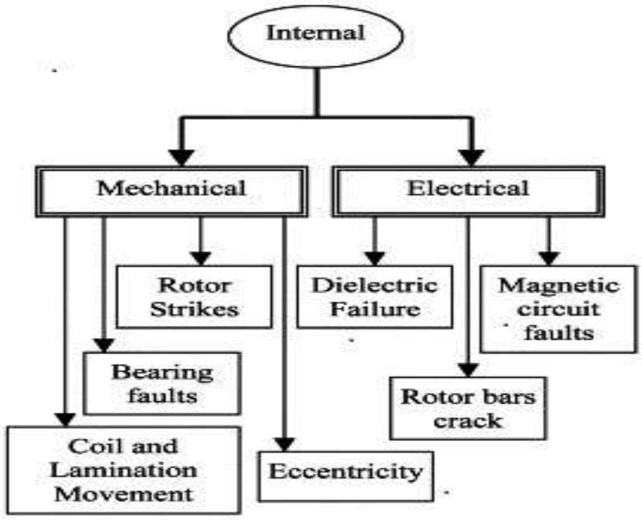

Fig 2: Types of Internal faults.

IV. NOISE ANALYSIS

For the noise diagnostics the sound quality and the noise source are analyzed. The noise is measured using a microphone. The noise signals are converted in electric signals. It is necessary to analyze this signal without losing the diagnostic information. There are very strict requirements for the analyzing instruments. The operations that the noise analyzing instruments must perform are the following:

- Measurement of overall noise level in a standard frequency range and using the units required by these standards[11].

V. METHOD AND MATERIAL.

The WSN proposed in this paper. End nodes are composed by the embedded systems located close to the electric motors. The values of motor voltage and current are obtained from the sensors, and the embedded system performs the processing for determining the values of torque, speed, and efficiency. Information obtained after the processing are transmitted to the base station through the WSN. Depending on the distance between end nodes and the coordinator, it may not be possible to achieve direct communication, due to the radio's limited range and the interference present on the environment, among other factors. Therefore, the communication among nodes and coordinator can be done with assistance of router[1]. For current measurement, CT coil are employed due to their robustness and non-invasiveness. Transformers with grain-oriented core are used to measure the voltage between phases, which provide the voltages in the secondary and primary without delay. The acquisition and data processing unit (ADPU) is responsible for data acquisition and conversion, besides the data processing. The printed boards power supply supplies the current and voltage for the sensors, the RF2.4 GHz transceiver, and the ADPU. The main element of the ADPU is a PIC16F877A, which is a digital signal controller designed for applications that require high processing capacity. It has two integrated ADC, which perform simultaneous acquisition of the voltage and current sensors. The input/output channels can be used for user interface, and possible connections to auxiliary sensors and actuators. The values of torque and motor efficiency are transmitted using the RF 2.4 GHz Transceiver.The MAX232 is an integrated circuit that convert signal from serial port to compatible digital logic circuit. The MAX232 is dual transmitter/ dual receiver that typically is used to convert the RX, TX, CTS and RTS signals

The paper has target to single induction motor diagnosis, more precisely rotor fault using noise measurement. Initially the measurements were realized by using electric motor with "healthy" rotor. Then we made the measurement successive by the same motor with a broken rotor bar[10].

VI. PROPOSED BLOCK DIAGRAM

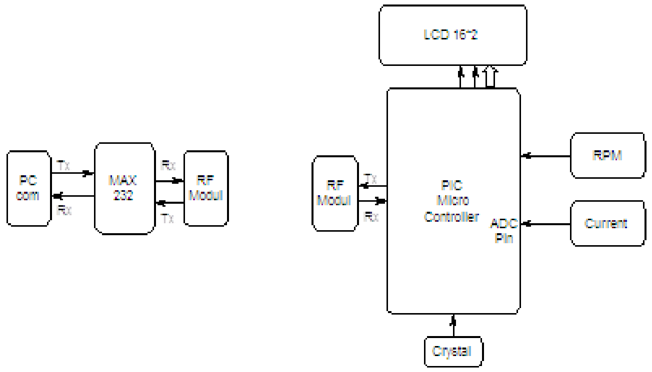

Fig 3: Proposed block diagram for torque and efficiency monitoring

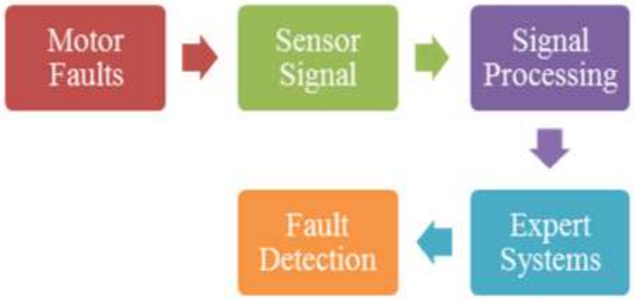

Fig 4: Proposed block diagram for noise fault analysis

VII. SYSTEM ANALYSIS

The system used in the latest existing system is embedded system integrated with wireless sensor network. A WSN is used here for making the calculations more reliable and non-invasive.

At first the parameters are calculated using the embedded system circuit. Here used only two sensors, Hall Effect voltage sensor and current sensor. The current and voltage values are obtained from the sensors. Here Air Gap Torque method is used for the calculation of efficiency. That is first using the voltage and current values the Air Gap Torque is calculated. And this torque is recorded. From this the losses are subtracted from the air gap torque and the shaft torque is calculated. Then efficiency is calculated by comparing output to the input. From the torque and efficiency parameter the health of the induction motor is to be determined [1].

After that by measuring frequency of healthy motor it is consider as a reference frequency, then by using microphone the noise of the faulty motor is recorded and then by converting it in to electrical signal the frequency of that signal is recorded, by comparing this two frequency the noise fault of the electric motor can be easily detected [10].

VIII. PROBLEM STATEMENT

The IEEE 802.15.4 standard is best for WSN applications. It provides wireless communication with low power consumption and low cost, for monitoring and control applications that do not require high data transmission rate.
There are some protocols that use the network layer over the IEEE 802.15.4 standard, such as Zigbee and WiFi .The standard defines three frequency bands: 868 MHz, 915 MHz, and 2.4 GHz [11]. In this study, we have considered only the 2.4-GHz band.

Nowadays, many communication devices operate in the 2.4-GHz band, which is an unlicensed band within th Industrial, Scientific, and Medical radio bands (ISM), including radios that use the Bluetooth technology, WiFi, and other devices such as cordless phones and microwave ovens. The ISM band was initially allocated for non-commercial use, and it was later modified to allow more services, which led to the emergence of a large number of applications.

The only restriction is on the strength of the signal power, for ensuring decrease interference among concurrent systems. Since there is no protection against interference Of concurrent users, it is necessary to establish efficient coexistence technologies, providing a good operation of unlicensed band systems. Therefore, it is necessary to achieve a new approach for wireless communication systems design, which should include spectrum measurements, modeling of interference and coexistence, and performance evaluations. The operation of WSNs in harsh industrial environments has been continuously evaluated.

IX. CONCLUSION

This paper presented an embedded system integrated into WSN for online dynamic torque and efficiency monitoring in induction motors. Here the AGT method is used to estimate shaft torque and motor efficiency. The calculations for estimating the targeted values are done locally and then transmitted to a monitoring base unit through an CC2500 RF modem WSN.

Wireless sensor network is used to transmit data's collected from the machine to the base station. Visual basic is used for the graphical user interface. In the visual basics we calculate the efficiency of the system torque and other parameters measured. The total system gives an efficient mechanism for the measurement of the parameters of the induction motor and calculating its efficiency without interrupting the actual working of the system.

In this case electric motor noise motoring is very useful to detect electric motor fault. It is proposed that the method of noise monitoring is efficient to make electrical motor diagnosis.

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