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Embedded System for Online Monitoring of Induction Motors

[1] Mohaseeena Shaikh, [2] Nadeem Shaikh

[1] E&TC Department, Pune University , SVIT
Nashik, Maharashtra , India

[2] Electrical Department, Pune University, SVIT
Nashik, Maharashtra, India

Abstract - Induction machines play a important role in industry and there is a demand for their reliable and safe operation. Different failures occurs in induction machines gives excessive down times and generate large losses in term, and this motivates the condition monitoring of induction motors. The condition monitoring includes taking measurements on three phase induction motor when it is operating in order to detect faults reducing both unexpected failures and maintenance costs. Condition monitoring of induction motors reduce the cost of maintenance and the risk of unexpected failures. In condition monitoring maintenance, one does not schedule maintenance or machine replacement based on previous records or statistical estimates of machine failure. The system for condition monitoring uses sensors for measurements of different parameter while a machine is in operating condition to determine if a fault exists. The project is to monitor the operating conditions of three-phase Induction motors. This system is based on a low-cost electronic device that can acquire and pre-process current, voltages and temperatures and speed transmit processed key-information related to the motor operation conditions using ZIGBEE wireless technology.

Keywords - *Embedded Systems, Induction Motors, ZigBee, Wireless Control.*

1. Introduction

In an industrial environment, mechanical systems driven by electric motors are used in most production processes, accounting for more than two-thirds of industry electricity consumption. Regarding the type of motors usually employed, about 90% are three-phase ac induction based, mainly due to its cost effectiveness and mechanical robustness time required for the operations can be improved. Industrial automation in coordination with the mechatronics gives more efficient performance. Mechatronics is the synergistic integration of Different signal conditioning, sensors, actuators, power electronics, Different decision and control algorithms, and computer hardware and software to manage complexity, uncertainty, and communication in systems. In an industrial environment, mechanical systems driven by electric motors are used in most production processes, and more electricity consumption in industry is due to three phase motors. Motor-driven systems use nearly 70 percentage of the total electric energy consumed by industry. On average, these motors operate at no more than 60% of their rated load because of oversized installations or under loaded conditions, and thus at reduced efficiency which results in wasted energy. About 90 % of the total motor electricity consumption is done with ac. three phase induction motors in the power range from 0.75 kW to 750 kW. A breakdown of the electricity consumption by end-use is given in Table 1. Induction machines are the majority of the industry prime movers and are the most popular for their reliability and simplicity of construction. Condition monitoring and diagnostics are very important issues in motor-driven and power electronics systems since they can greatly improve the reliability and maintenance of the system.

As said above Induction motor is used in majority of the industrial applications. The main reason for the usage of IM is its reliability and simplicity of operation. Most of electrical energy is utilized by induction motors. And thus it is essential to monitor the performance of the motor without changing its operation. Here the system is introducing a new technique in which embedded system is integrated into the wireless network during this technique, different sensors are connected with the motor and the values are extracted using an ARM7 (Advance RISC

Machine). It is then transmitted to the base station and at the base station a Graphical User Interface is given which give the user can interface with the system. The wireless protocol used is Zigbee.

Table 1: Electricity consumption

TYPES OF LOAD	INDUSTRIAL SECTOR	TERITORY SECTOR
Motors	69%	36%
Lighting	6%	30%
Other	25%	34%

2. Methodology Followed

The proposed system aims to monitoring the various parameters like current, voltage, temperature, speed, active, reactive & apparent power of induction motors in real time by using different sensors. An embedded system is used for acquiring electrical signals from the motor.The values are calculated by the embedded system are transmitted to a monitoring unit. The protocol used here for the wireless transmission is zigbee. ZigBee is a set of high level communication protocols designed to used in small, low power digital radios based on the IEEE 802.15.4 standard for wireless networking. The relationship Between IEEE 802.15.4 and ZigBee is equivalent to that existing between IEEE 802.11 and the Wi-Fi Alliance. It is expected that the standard eventually will be open (i.e., available free to the public for academic or other noncommercial use), while remaining proprietary (i.e., requiring membership in the ZigBee Alliance for commercial use).In the receiver side it is given to the personal computer. The GUI used is C sharp, which act as data manipulator. There it is again converted to the actual value.

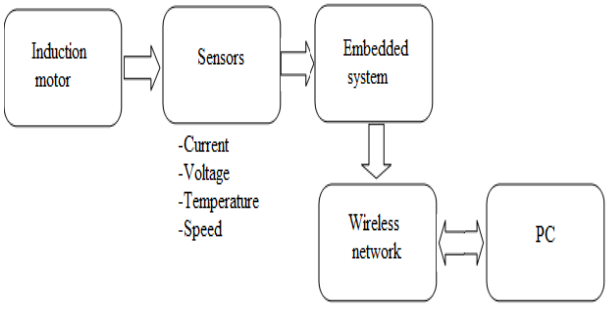

Fig. 1 Block Diagram of Proposed System

3. Need of Wireless Monitoring

A monitoring and wireless control system for an induction motor is realized using the Zigbee communication protocol for

- Safe and economic data communication in industrial fields.
- The wired communication is either more expensive or impossible due to physical conditions. The induction motor can be started and stopped wireless due to the computer interface developed with Zigbee. It is also possible to protect of the motor against some faults such as over current, higher/lower voltage, over temperature in windings, overloading of motor.
- Moreover, a database is built to execute online measurements and to save the motor parameters received by radio frequency (RF) data acquisition system. Therefore, monitoring, controlling, and protection of the system are realized in real time
- The wireless communication technology is used, controlling abilities of the system are increased and also hardware and the necessities of other similar equipment for data communication are minimized.
- Structured cabling and sensor deployment are usually more expensive than the cost of the sensors. Besides the high cost, the wired approach offers flexibility, making the network maintenance and deployment a complex process.

4. System Description

Monitoring of induction motor is essential for its better performance. For this purpose we have to acquire many parameters like voltage, current, speed, temperature & torque. All parameters must be acquired at fastest speed. For monitoring of all parameters sensors are used and sensors are connected to signal conditioning circuits to convert signals suitable form to be applied to embedded controller.

4.1. Induction Node

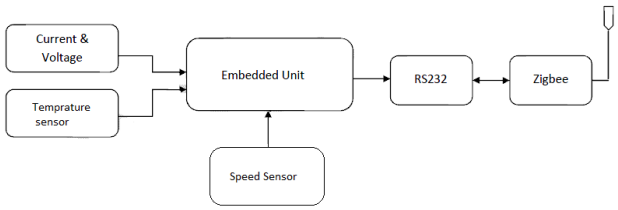

Fig.2 Block Diagram of System on Transmitter Side

4.2. Control Node

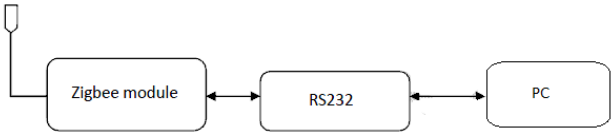

Fig.3. Block Diagram of System on Receiver Side

5. Hardware Design

The system consists of an embedded system and data transmitting unit which is mounted near the motor. In the receiver side value of different parameters are given to personal computer. On transmitter side hardware is connected with the motor. It mainly has different sensors, ARM processor,ADE 7758 and zigbee module for wireless transmission.

5.1. Voltage & Current Monitoring

Potential Transformer is used to sense voltage.To sense current, Three current transformers are used which ratio is 30/1. It will sense currents of three phases and sensing signal is given to controller. To sense the voltage of three phases the potential divider circuits are used, per phase voltage is 220 volts these voltages is given to signal conditional circuit that is positional divider circuit in this circuit five resistance of 20kilo ohm are connected in series to get 1mega ohm and one resistance connected across of value 1kilo ohm

5.2. Temperature Monitoring

For monitoring the temperature the LM 35 IC is used and the voltage at the output is given directly to the ADC channel. LM 35 is the temperature sensor which gives 10mv change in voltage per degree centigrade.The LM35 series are precision integrated-circuit temperature ssensors, whose output voltage is linearly proportional to the Celsius temperature. To interface LM 35 an analog input (LM35 – Temperature Sensor) with ARM7 LPC2148.ARM7 LPC2148 is having 2 Analog-to-Digital Converters as an inner peripheral LM35 can monitor temperature from -55 degrees to 150 degrees Celsius which can operate from 4V to 30V DC. It is a 3 pin sensor, out of which one will be Vcc, the second one will be GND and the third one will be O/P. This output pin will be given to analog pin of LPC 2148.

5.3. Speed Monitoring

A metallic disc is fitted on the output shaft.IR Sensors are used here. The disc on the shaft rotates in between the two IR sensors. Then the signals from the IR sensor are transferred to the embedded unit. The embedded unit processes the signals locally. The obtained speed and values are transmitted to the monitoring unit using ZigBee. Speed is detected using the IR transmitter and receiver pair, readings is displayed using a16x4 LCD display. It works on the principle that the number of times the IR receiver transmitter circuit is cut and re-established in a second gives the number of rotations per second.

5.4. Microcontroller Unit

ARM7 (LPC 2148) controller used to process received data from sensors. It has 64 pins. Sensors, RF module, LCD are connected to various pins of controller. Keil MDK ARM used to develop code for controller.The main unit of processing unit is ARM7 which is used for local processing.ARM7 is a member of the ARM family of general-purpose 32-bit microprocessors The ARM family offers high performance for very low power consumption, and small size. The ARM architecture is based on Reduced Instruction Set Computer. The ARM7 uses a pipeline to increase the speed of the flow of instructions to the processor. The ARM7 core has Von Neumann architecture, with a si 32-bit data bus carrying both instructions and data.

5.5. ADE7758

The ADE7758 is a high accuracy, 3-phase electrical energy measurement IC with a serial interface and two pulse outputs. The ADE7758 incorporates second-order Σ-Δ ADCs, a digital integrator, reference circuitry, a temperature sensor, and all the signal processing required to perform active, reactive, and apparent energy measurement and rms calculations. The ADE7758 is suitable to measure active, reactive, and apparent energy in various 3-phase configurations, such as WYE or

DELTA services, with both three and four wires. The ADE7758 provides system calibration features for each phase, that is, rms offset correction, phase calibration, and power calibration. The APCF logic output gives active power information, and the VARCF logic output provides instantaneous reactive or apparent power information.

5.6. Zigbee Transmitter Unit

The protocol used for wireless transmission is zigbee.zigbee modules are ideal for applications requiring low latency and predictable communication timing. Providing quick and robust communication in point-to-point, peer-to- peer, and multipoint configurations, ZigBee multipoint products enable robust end-point connectivity wit. Whether deployed as a pure cable replacement for simple serial communication, or as part of a more complex hub-and-spoke network of different sensors, ZigBee modules maximize wireless performance and ease of development.the data collected from motor is processed by ARM7 and then transmitted to the base station. At the receiver end data is collected by the receiver and given to the computer.

6. Results

This proposed system tested on three phase squirrel cage induction motor. Ratings of motor are 3hp, 415v, 5.5amp current, rated speed 1440 rpm. All the parameters of motor are monitor on normal condition.

Figure shows monitored parameters on LCD it is interface with ARM7 it shows temperature of motor body, speed of motor in rpm, phase voltage of R phase, phase voltage of B phase and Y phase and line current of R phase, Y phase and B phase

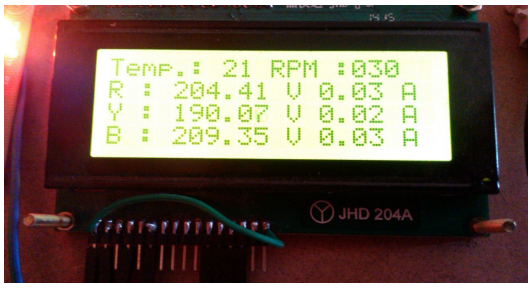

Fig.4. Results Displayed on LCD

Figure 5 shows results displayed on screen (A). In this screen the COM port of PC is selected where the zigbee receiver is connected. Baud rate is selected to 4800. In this screen start communication can be done. This screen shows the parameters of motor in serial communication.

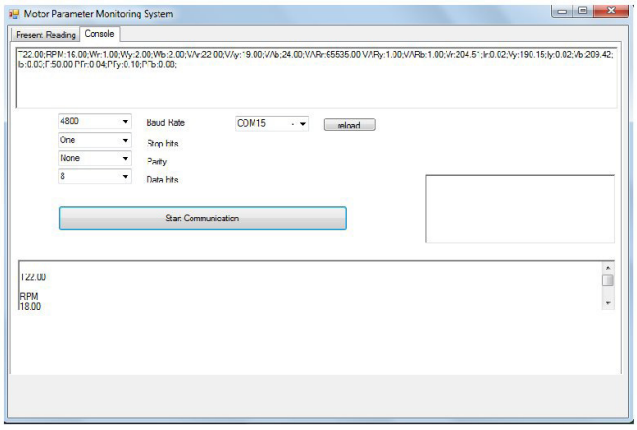

Fig.5. Result Displayed on Screen (A)

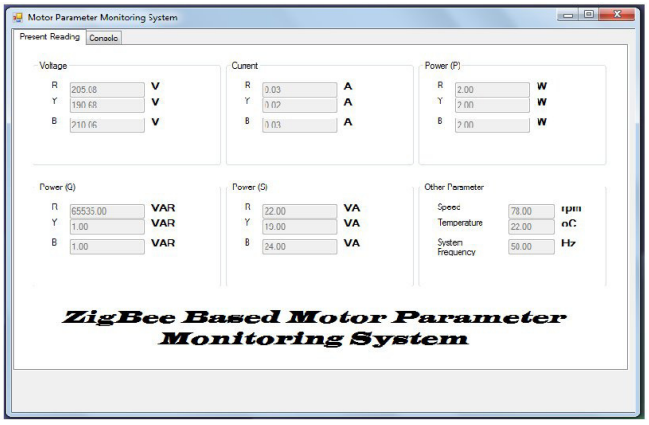

Fig.6.Result Displayed on Screen (B)

Figure 6 shows results displayed on screen (B). In this screen first block shows the measured value of phase voltages of R, Y & B phase. Second block shows the values of measured line current of R, Y & B phase. Third, forth, and fifth block shows the measured value of active power, reactive power and apparent power taken by motor. Six blocks shows the measured speed of motor, temperature of motor and supply frequency.

7. Conclusion

This system present an embedded system integrated into a WSN for online parameters such as power, speed, temperature, voltage and current monitoring in induction motors. We use different sensors for the purpose of sensing the parameters. The calculations for estimating the targeted values are done locally and then transmitted to a monitoring base unit through an IEEE 802.15.4

WSN. Results are displayed on LCD. The system is a combination of advanced techniques and plant management process, aiming for goal through technical means. Wireless sensor network is used to transmit data collected from the machine to the base station. The total system gives an efficient mechanism for the measurement & monitoring of the parameters of the induction motor without interrupting the actual working of the system. In this study, a parameter monitoring system for induction motors based on Zigbee protocol is achieved and tested successfully. The system developed is capable to perform such operations as running the motor though RF, measuring, monitoring and controlling the most parameters of the motor like phase currents, phase voltages, temperature, speed. The on line parameter monitoring system eliminates the costly installations of communication cables. The system developed can be used for not only industrial applications but also educational purposes.

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Author Profile:

Mohaseeena Shaikh: BE Electronics 2008**,** ME (VLSI) 2015, and Assistant Professor in E&TC Dept. SVIT Nashik, Pune University, and Published one paper in international journal.

Nadeem Shaikh: BE Electrical 2008, ME (Power System) 2014, Assistant Professor & Head in Electrical Engg Dept. in SVIT Nashik, Pune University, and published one paper in international journal & presented one paper in international conferences.