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Full Length Research Paper

Embedded System Integrated into a Communication System for the Monitoring of Induction Motor Parameters

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This paper is for monitoring different parameters of induction motors in domestic and industrial environments. Various sensors are used here. Parameters of induction motor are obtained with the help of these sensors. Sensors used are IR sensor, MEMS sensor and Vibration sensor. An embedded system is employed for acquiring electrical signals from these sensors in a noninvasive manner. The obtained signals are locally processed and the values calculated by the embedded system are sending to the mobile phones as SMS using GSM modem. The real time monitoring of various motors can be done at a time.

Keywords : Infrared Sensor (IR), Microelectromechanical Systems (MEMS), Wireless Sensor Network (WSN), Peripheral Interface Controller (PIC), Pulse Width Modulation (PWM), Static Random Access Memory (SRAM), Electrically Erasable Programmable Read-Only Memory (EEPROM).

INTRODUCTION

This paper is for monitoring the different parameters of induction motors in real time by using GSM modem. Electrical signals from the motor are acquired in a noninvasive manner. An embedded system performs local processing for speed and torque estimation. The values calculated by the embedded system are sending to the mobile phones as SMS using GSM modem.Local processing capability is used for this type of application.

Electric motors are mainly used in production processes. An electrical motor converts electrical energy into mechanical energy. In case of three phase AC operation, most widely used motor isthree phaseinduction motor. An induction motor (Lee et al., 1994) is an inherently self-starting AC motor in which energy is transferred by electromagnetic induction from a
Primary winding to a secondary winding, the two windings being separated by an air gap and such transfer usually being from the stator to either a wound rotor or a short-circuited squirrel cage rotor. It does not require any starting device and are self-starting. An induction motor (Hsu Jet al., 1998) is an AC motor in which current is induced in the rotor winding by electromagnetic induction. Therefore they do not require the sliding electric contacts, such as a commutator or slip rings.

Three-phase squirrel-cage induction motors

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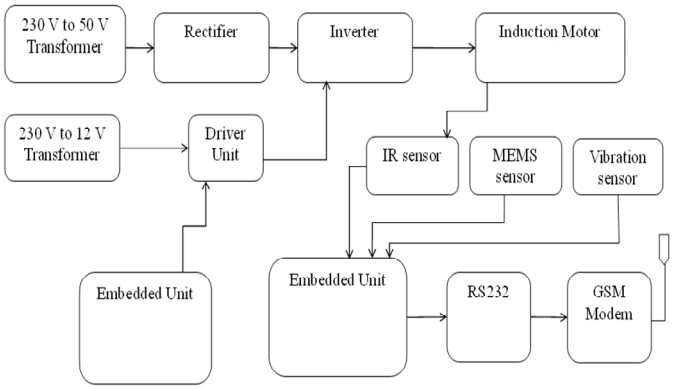

Figure 1. Transmitter side

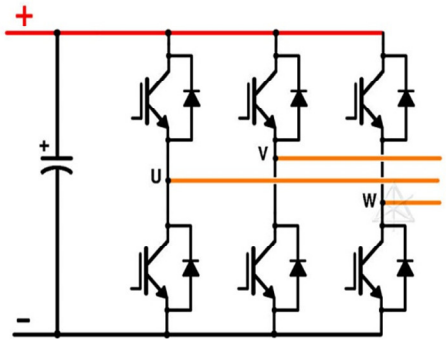

Figure. 2. Three Phase inverter

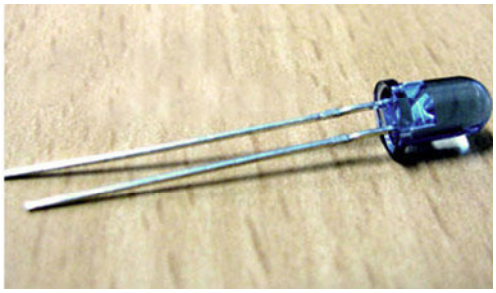

Figure 3. IR Sensor

(Washington State University-Energy Program, 1999) are widely used in industrial drives because they are rugged, reliable and economical. Normally the simple induction motor (Bharadwaj and Parlos, 2004), (Lu et al., 2006) is a fixed-speed device, but they are used along with variable-frequency drive systems, which allow the speed to be varied. Normally monitoring of motors in domestic and industrial systems is performed in an offline manner or through wirednetworks.The installation of cables usually has ahigher cost and compared to it, costs of wireless networks (Cao et al., 2008), (ZigBee Networks," in Proc. ACMConf. EmbeddedNetw), (Gungor and Hancke, 2009) are less. Besides the high cost, the wired approach offers little flexibility, takes longer installation time and making the network deployment and maintenance a harder process. The wireless (Willig et al., 2005), (Anis et al., 2009), (Salvadori et al., 2009) networkspresent a number ofadvantages compared to wired networks. They are speed of deployment, low cost and easy maintenance.

In several industry sectors, torque (Gulez et al., 2007) measurements can identify equipment failure, which makes their monitoring essential in order to avoid disasters in critical production processes (e.g., oil, gas and mining). There are basically two lines of study: direct torque measurement on the shaft and estimated torque measurement from motor electrical signals. The methods for direct torque measurement on the shafts are the more accurate. However, they are highly invasive. So estimated torque measurement from motor electrical signals is preferred.

Embedded system is used for determining speed, torque, rotor angle and vibration in industrial electric motors by employing (Fette et al., 2007), (Yick et al., 2008) wireless network technology. For a set of electric

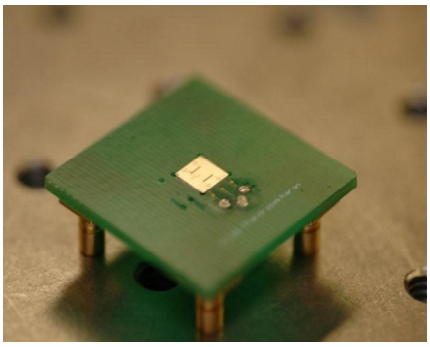

Figure 4. Microelectromechanical systems chip

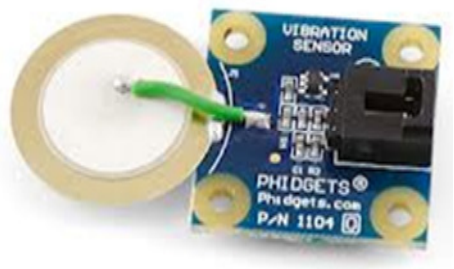

Figure 5. Vibration sensor

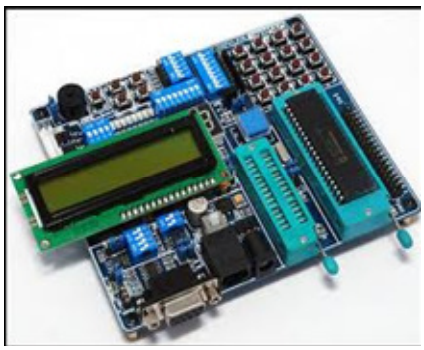

Figure 6. PIC16F877A

motors,current and voltage measures are gathered. These signals arelocally processed byan embedded system. The results obtained after processingare sending tothe mobile phones for real time monitoring.

RELATED WORK

It explains an advanced method of monitoring the speed, torque, rotor angle and vibration of induction motors in domestic and industrial environments. Three sensors are used are IR sensor, MEMS sensor and vibration sensor. An embedded system is employed for acquiring electrical signals from these sensors in a noninvasive manner. The obtained signals are locally processed for the estimation of speed, torque, rotor angle and vibration. The values calculated by the embedded system are transmitted to the mobile phones (Takahashi et al., 2009) as SMS by using GSM modem.

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-arc valves, solid-state diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches. Rectifiers have many uses, but are often found serving as components of DC power supplies and high-voltage direct current power transmission systems.

A 3 phase inverter is an electrical power converterthat converts direct current (DC) toalternating current (AC). The inverter performs the opposite function of a rectifier. The electrical inverter is a high-power electronic device.

Figure 7. GSM Modem

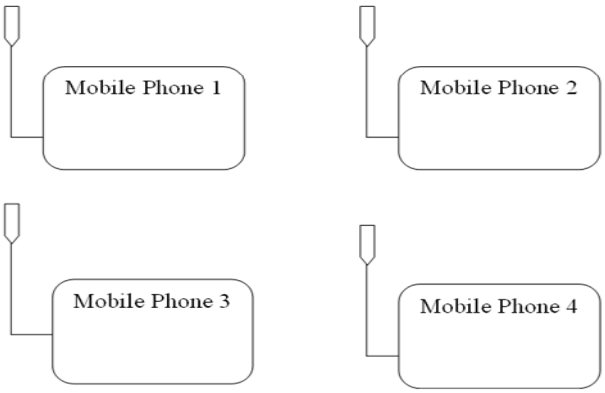

Figure 8. Receiver

Workbench for System Analysis

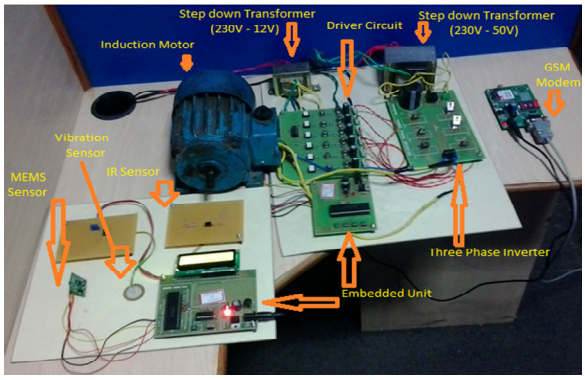

Figure 9. Experiment setup

A basic three-phase inverter consists of threesingle-phase inverterswitches each connected to one of the three load terminals. Three-phase inverters are used for variable-frequency drive applications and for high power applications such as HVDC power transmission.

An infrared sensor is a type of photoelectric beam system which transmits infrared light beams across an area, where these beams may be obstructed. Infrared radiation enters through the front of the sensor, known as the 'sensor face'. At the core of an IR sensor is a solid state sensor or set of sensors. Materials commonly used in IR sensors are gallium nitride (GaN), polyvinyl fluorides, caesium nitrate ($CsNO_3$), derivatives of phenylpyridine, andcobalt phthalocyanine. Here theinduction motor shaft is rotating between two IR sensors. The signals from IR sensors are taken by the

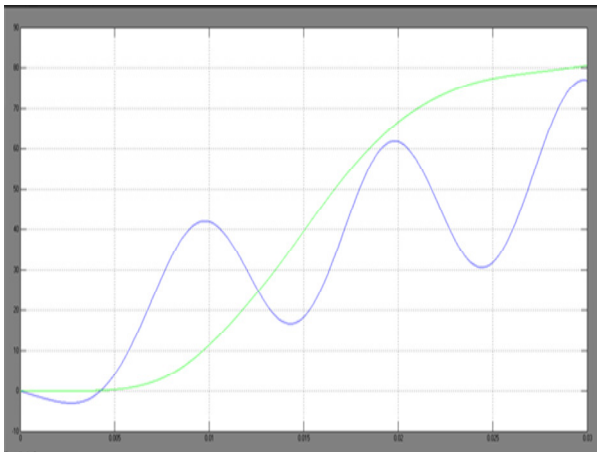

Figure 10. Plot for Speed

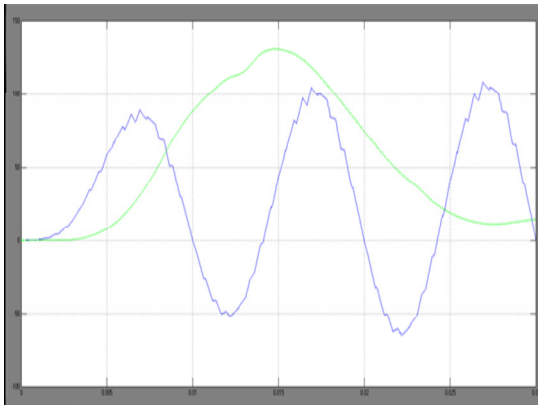

Figure 11. Plot for Torque

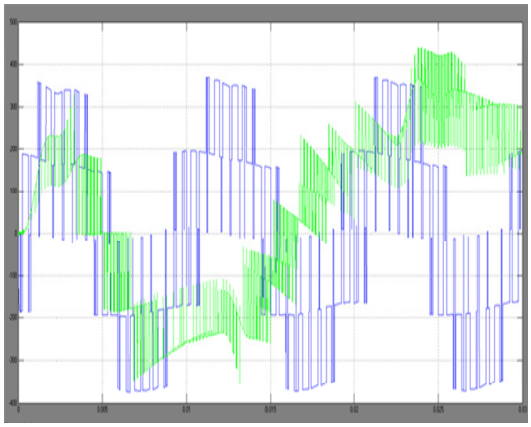

Figure 12. Plot for stator voltage

embedded system for processing.

MEM is micro electromechanical systems sensor. It usually consists of a central unit that processes data (microprocessor) and several components that interact with the outside such as micro sensors. Materials used for MEMS manufacturing are silicon, polymers, metals and ceramics. MEMS sensor can find out the angle of the rotor. It in turn improvesthe accuracy of the torque value.MEMS sensor are used in inkjet printers, accelerometers In modern cars, accelerometers inconsumer electronicsdevices such as game controller, personal media players, cell phones and a number of digital cameras. It is also used in PCs.

The vibration sensor is used to find out the vibrations in

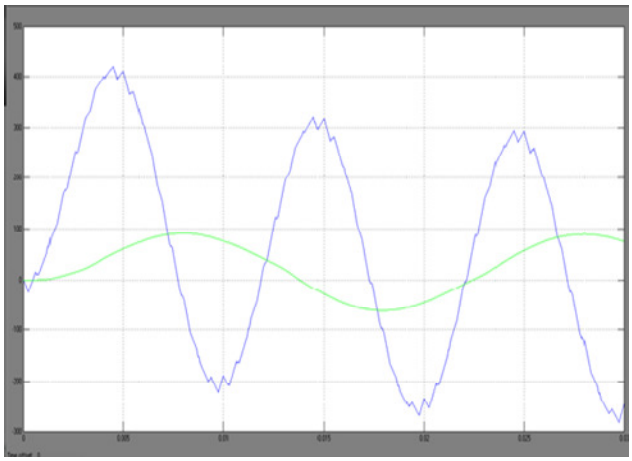

Figure.13. Plot for stator current

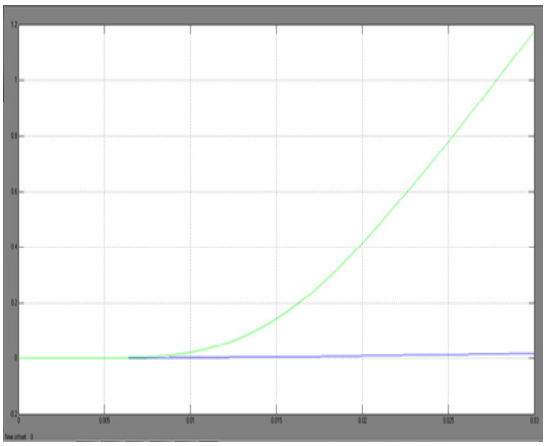

Figure 14. Plot for Rotor Angle

motors. It has high vibration detection sensitivity. Vibration Sensor is suitable for measurements of flexibility, vibration, impact and touch. This sensor is having a piezoelectric transducer. As the transducer is displaced from the mechanical neutral axis, bending creates strain within the piezoelectric element and generates voltages.

The embedded system used here is peripheral interface controller, PIC16F877A. It is an 8 bit open loop peripheral controller having 40 pins. Microcontroller PIC16F877A is one of the PIC micro family microcontrollers which are popular at this moment. Because very easy using PIC16F877A and use flash memory technology so that can be write-erase thousands of times. The operating frequency is 20MHz and flash memory is 14.3 kb. Itfeatures an ICD, 256 bytes of EEPROM data memory, 200 ns instruction execution, self-programming, 2 comparators, 2 PWM functions, 8 channels of 10-bit analog to digital converter (ADC), a synchronous serial port, a USART, and a parallel slave port.Program tofind out the speed and torque are written in this microcontroller. With the help of rotor angle obtained from MEMS sensor, the PIC microcontroller finds out the accurate value of torque.

A GSM modem is used to send the datas estimated by the embedded system to the mobile phones. It is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. The GSM modem comes with a serial interface through which the modem can be controlled using AT command interface. An adapter and an antenna are provided. GSM modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. The modem can either be connected to PC serial port directly or to any microcontroller. It can be used to make/receive voice calls, send and receive SMS and can also be used in GPRS mode to connect to internet. A GSM modem exposes an interface that allows applications such as SMS to send and receive messages over the modem interface. To perform this task, a GSM modem must support an “extended AT command set” for sending /

receiving SMS. This GSM modem is a highly flexible plug and play quad band GSM modem for direct and easy integration to RS232 applications.
The serial port used is RS-232. It is the traditional name for a series of standards for serial binary single-ended data and control signals connecting between a DTE (Data Terminal Equipment) and a DCE (Data Circuit-terminating Equipment). It is commonly used incomputer serialports. The standard defines the electrical characteristics and timing of signals, the meaning of signals, and the physical size and Pinout of connectors. An RS-232 serial port is a standard feature of a personal computer, used for connections to modems, printers, mice, data storage, uninterruptible power supplies, and other peripheral devices.

EXPERIMENT METHODOLOGY

The workbench was designed to obtain the speed, torque, rotor angle and vibration of induction motors. Fig. 8 shows its sketch, which consists of a 110-W induction motor with nominal rotation speed of 1500 RPM. A metallic disc was fitted on the output shaft. IR Sensor, MEMS sensor and vibration sensorare used here. The disc on the shaft rotates in between the two IR sensors. Then the signals from the IR sensor, MEMS sensor and vibration sensor are transferred to the embedded unit. The embedded unit processes the signals locally and the speed, torque, rotor angle and vibration are obtained. The obtained values are sending to the mobile phones using GSM modem.

Proposed work

Data transfer using IP SMS, reduction in delay and monitoring the different parameters of induction motors in different industrial areas with the help of satellites.

SIMULATION RESULTS

Plot for speed, torque, stator voltage, stator current and rotor angleare obtained. Two cases are considered here. Applying a load of 10 kg and 40 kg. Different parameters are found out in both the cases. As the load increases speed reduces. It is shown in the first plot. Asthe load increases torque also increases. It is shown in the second plot. The rotor voltage and rotor current are shown in the third and fourth plot. Rotor angle is shown in the fifth plot.

CONCLUSION

This paper presented an embedded system integrated into a communication systemfor the monitoring of induction motor parameters. Electrical signals from the motors were taken in noninvasive manner and given to the embedded system. The calculations for the targeted values are done locally and then send to the mobile phones as SMS.The presented system was able to provide useful monitoring information.

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