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Design and Implementation of Embedded Remote Monitoring System for Electric Drive

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Abstract-**Electric drive plays a vital role in industry and there is a strong demand for their safe and reliable operation. Wireless sensor network for industrial electric machine condition monitoring can significantly reduce the cost of maintenance and the risk of unexpected failures by allowing the early detection of potentially catastrophic faults and obtain higher accuracy in diagnostic for health condition of motor, efficient and data monitoring, collecting the data. A wireless data measurement, monitor and collection for electric machine health monitoring system are based on wireless sensor network. In this project this system has been described and developed. The important characteristic of ZigBee network such as low cost, high flexibility and low power hence select ZigBee as wireless standard and make them ideal for such wireless application. Various sensors have capability to monitor environmental as well as physiological conditions. Wireless sensor network for condition monitoring measurements taken while a machine is operating, to determine if a fault exists by observing various parameters and applied different conditions to detect the faults.**

Keywords—WSN, ZigBee, Embedded System,Coordinator device,end device.

I. INTRODUCTION

The priority in most industry is shifting from timely maintenance to the predictive maintenance by continuous observing and predicting the electrical machine condition by condition based monitoring of electrical motor is a scientific approach that becomes latest plan for maintenance management. Most industrial electric motors are being monitored using current, temperature and vibration sensors which either shut down the system or provide warning signals, before any severe failure occurs [9]. They are able to prevent permanent damage of drives to the need of an advance in system called as on-line health monitoring system. Traditionally, the health monitoring system is realized in wired systems formed by cables as communication medium and various types of sensors. Its installation and maintenance cost are difficult and expensive especially when the equipment's are not at the same places. To overcome these drawbacks, using wireless sensor networks for monitoring and collecting is proposed in this embedded system. WSN is a new control network that combines wireless communication, sensor and distributed intelligent processing technology. ZigBee is a new wireless networking technology with short delay time, low power characteristics. These appreciative features are suitable for our application [14].

II. SYSTEM OVERVIEW

The proposed system measures the voltage, current and temperature of an electric motor for further process and analysis. An end device and coordinator device has been developed to form a model system. Therefore proposed system provides flexible solutions that success of condition based maintenance is having an exact means of condition assessment and fault diagnosis.

In this project we are going to use the system processor LPC 2148 family which is useful to fulfill our requirements along with temperature sensor and CT, PT sensor, LCD for display purpose, Keil software, serial port RS232 For serial communication. In online machine health monitoring each sensor installed on end device node which sends its online reading through ZigBee module to the coordinator device. Purpose of coordinator device is to either store it on node or send it on maintenance manager mobile through GSM modem.

In this system we get the readings of electric machine parameters in analog form to convert it in digital form we used 8 bit ADC. In this project to form a network we designed two devices coordinator device and end device. End device is placed at the electric drive for monitoring various parameters. ZigBee module collects the parameters from each sensor node from each end device send it to the coordinator device, then coordinator device processes the data and it gives the reading on LCD display as well as we get the reading on both display means at factory floor as well as at remote control station obtained same data by a ZigBee transceiver module/ GSM modem.

By making changes in algorithm we can set the temperature, current parameter , this system also sends the live data from electric machine on maintenance management mobile number after every some minutes, due to which it is possible for management person to take appropriate action when emergency occurs. In this way this entire system provides the reduction in large fault and also provides the proper maintenance management [2].

III. SYSTEM BLOCK DIAGRAM

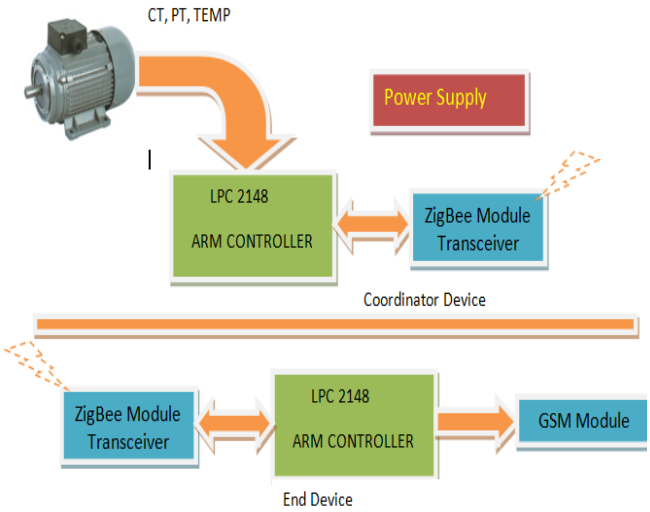

Fig.3.1 Block diagram of embedded remote monitoring system

Fig 3.1 shows the general structure of the wireless sensor system for remote monitoring. It consists of several end-devices (measuring devices) and one wireless data collection module (ZigBee coordinator device). The coordinator device reads sensor measured data from remote end-devices which located in electric machines and retransmits them to the database station through coordinator device. The wireless connection between coordinator device and the end-devices is easier through their ZigBee modules. The coordinator device and the database server can be connected through a GSM modem. This measurement system includes two communication modules (GSM and ZigBee) and several end-devices for monitoring temperature, current and voltage. Such a standard concept allows combining the different types of end devices with various communication capabilities according to environmental conditions. Every end devices can be used as a part of the large, complex system or independently [6].

A. Coordinator device

It can be used as complete independent measurement equipment with various types of communication capabilities. To easier the wireless network coordinating function, it is equipped with GSM modem for expanding the system, a ZigBee module. It could be used as a data logger system [2]. Its main components are shown in fig 3.1.

Microcontroller:

The main task of microcontroller is to manage the ZigBee wireless network and to acquire sensor data. It implements end-device association, radio channel configuration, remote sensor data acquisition, end-device ID configuration and network ID etc. It also performs configuration of ZigBee, GSM, GPRS, 3G are the different communication modules and control various part of electrical machine.

ZigBee:

The ZigBee module is used for easy wireless connection between the measuring end-devices and coordinator device. It is controlled via standard AT commands over a serial communication interface. It is most suitable for battery powered systems and has very low power consumption.

GSM:

This module is used as a gateway between the database server and ZigBee. It is controlled via standard AT commands over a serial communication interface. It is applied to retransmit the acquired sensor data from end device over the mobile cellular network.

Power supply:

In order to implement its entire functionality, the coordinator device is powered by 9 VDC and 5 VDC. The 9VDC power supply is given to the ARM microcontroller and 5VDC is supplied to the ZigBee module.

B. End-devices

The major purpose of end measured device is to measure temperature from temperature sensors such as LM35. Unlike the digital temperature sensors of the end-device LM 35 temp sensors achieve faster response time and greater accuracy. CT and PT are being used to measure current and voltage of the load respectively [10].

C. Sensors

Temperature Sensor:

The LM35 is temperature sensor with precision integrated-circuit, whose output voltage and temperature are in linearly proportional. The LM35 has an advantage over linear temperature sensors calibrated in ° Kelvin. The LM35 does not require any external trimming or calibration to provide typical accuracies of ±¼°C at room temperature. Low cost is assured by calibration and trimming at the wafer level. The LM35's linear output, precise inherent calibration and low output impedance make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55° to +150°C temperature range, while the LM35C is rated for a -40° to +110°C range (-10° with improved accuracy) [17].

CT Sensor:

Many devices are used to measure current in electronics equipment or motors. A current transformer is a type of "instrument transformer" that is designed to provide a current in its secondary which is accurately proportional to the current flowing in its primary. Current Transformer Basics involve either an alternating voltage or alternating current proportional to the current being measured. The CT used with the Watt node transducers produce an alternating voltage

when the rated current is measured. The OSI power transducers employ CT's that produce 5V output at rated value. Current Transformer stated that power flow and provides electrical input to power transformers and instruments. Current transformers are of two basic types wound and toroidal. Donut-shaped or toroidal current transformers do not contain a primary winding. Instead, the wire that carries the current is threaded through a window in the toroidal transformer. Wound current transformers consist of an integral primary winding that is inserted in series with the conductor that carries the measured current. Wound current transformers have been selected for the above application.

Signal conditioning circuit is as shown in figure 3.2 for CT contents bridge rectifier circuit. Its output will be provided in voltage to ADC pin of the LPC 2148 microcontroller. Appropriate resolution will be selected for ADC depending upon result requirement.

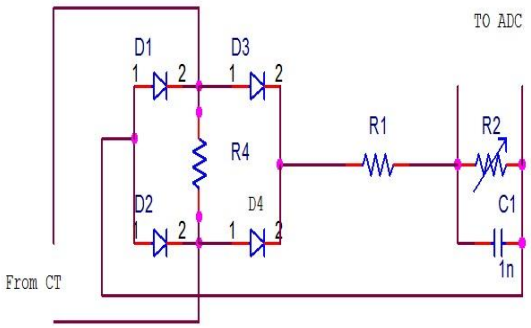

Fig.3.2Diagram for CT signal conditioning circuit

PT Sensor:

Whenever the values of voltage or current in a power circuit are too high to allow convenient direct connection of measuring instruments, coupling is made through transformers. Such measuring transformers are required to produce a scaled down replica of the input voltage to the accuracy expected for the particular measurement; this is made possible by the potential transformer. The signal conditioning circuit as shown circuit diagram below.

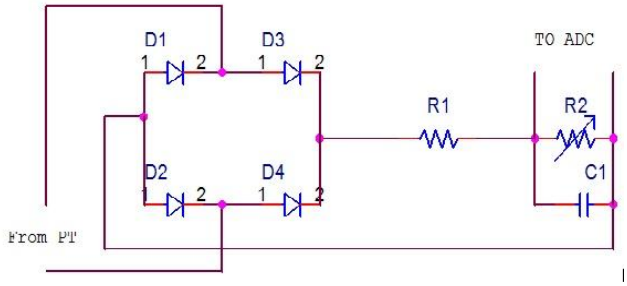

Fig.3.3 Diagram for PT signal conditioning circuit

IV .IMPLEMENTATION OF SYSTEM

Overall System Prototype:

This automated system is designed to overcome the problems of manual techniques. Here the hardware model is designed which contains data base station, data monitoring nodes and remote monitoring center ,ZigBee modules, GSM module, LPC2148 controller, LM35 for temperature measurement, CT sensor for current measurement, PT for voltage measurement, and water salt sensor, LCD display on field, mobile phone. The system works on 3.3V/5V dc power supply.

System Architecture:

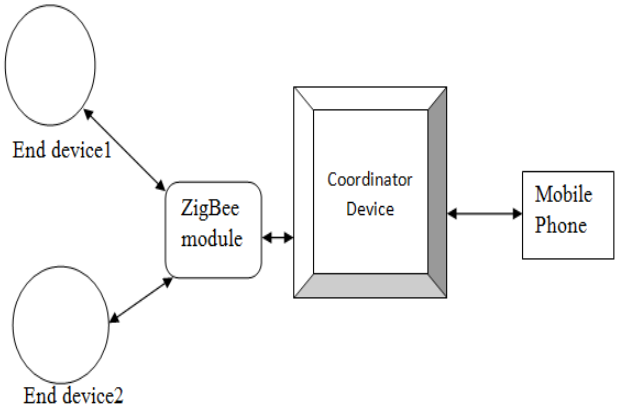

Fig.4.1 Embedded remote monitoring system based on WSN

The whole system is divided in three parts Data monitoring nodes (end devices), Data base station (coordinator device) and remote monitoring center (mobile phone) for machine health parameter detected to avoid faults. Different data monitoring nodes distributed in electric drives which is placed in factory floor difficult to measure all the parameters such as temperature, current, voltage, vibrations etc. The data monitoring nodes also performs the task like temperature compensation, linearization and data packaging. Collected parameters routing and memorizing to a data base station the data from monitoring nodes is transfer to a remote by the base station via ZigBee network.

The monitoring center processes and analyzes the electric drive parameters to monitoring center and through graph and reading of particular parameters we comes to know that whether the condition of electric machine is good or bad . From the measured parameter of electric drives we could have compare with standard ratings and calibrate the device to know whether there is need of maintenance or not, another thing is that we can set the threshold value for each parameter and when that parameter crosses that threshold after few minutes it will send SMS on maintenance management person mobile number which contain the information about need of maintenance for particular drive.

A. Data monitoring node:

The measuring functions of Data monitoring nodes are collecting the parameters such as temperature, current and voltage of electric machine monitored. Three sensors temperature sensor, Current sensor and Voltage sensor installed on to a monitoring nodes can gather the above needs and realize the temperature compensation and realization for the data collected Setting up the wireless sensor network based on ZigBee protocol. Via which the temperature, current, and voltage data routed to a base station.

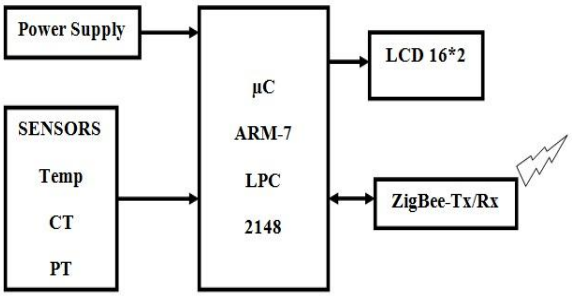

Fig 4.2 System architecture of data monitoring node

Fig.4.2 shows the structure of data monitoring node which can be divided in to five modules power module, transmitter, processing module sensing module and ZigBee module, out of this the sensing module is placed on electric machine in such way that it will not fall and connected through cable. The sensors collect the parameters such as temperature, current and voltage of target electric machine, then converts it into suitable format gives to ADC which is internal part of ARM. The processing module processes the incoming data in order to send it on display module. Same data measured by node transmitted to base station by ZigBee module via UART serial communication. The power modules provide the electricity to the controller and ZigBee module. Each node connected with data base station and controlled by the base station by the ZigBee communication protocol.

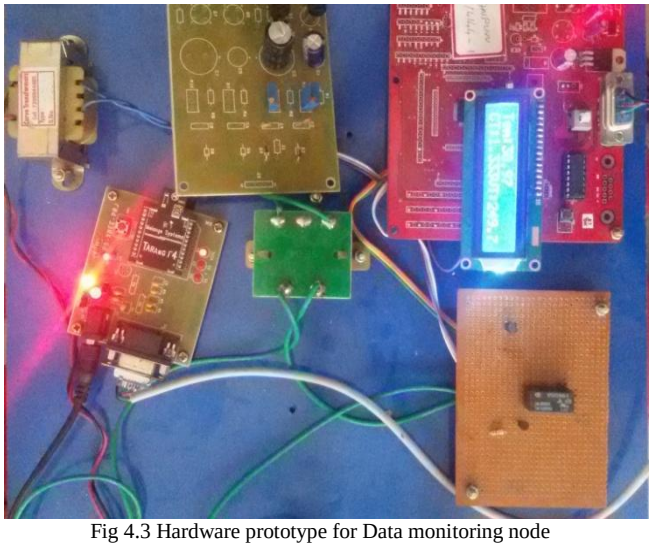

Fig 4.3 Hardware prototype for Data monitoring node

B. Data base station:

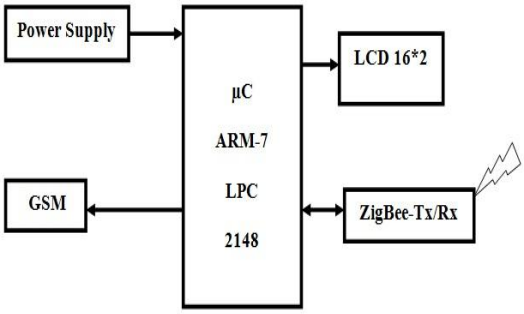

Fig.4.4 Hardware for data base station

The controller is main hardware for data base station. It also uses the co-processor to transmit monitoring data based on the ZigBee protocol between data monitoring sub-network and data base station.

A ZigBee module is used to realize remote data communication between data monitoring center and data base station. The Flash memory can used to store the historical data and also provided with man-machine interface. The main hardware processor improves the real time performance of the system.

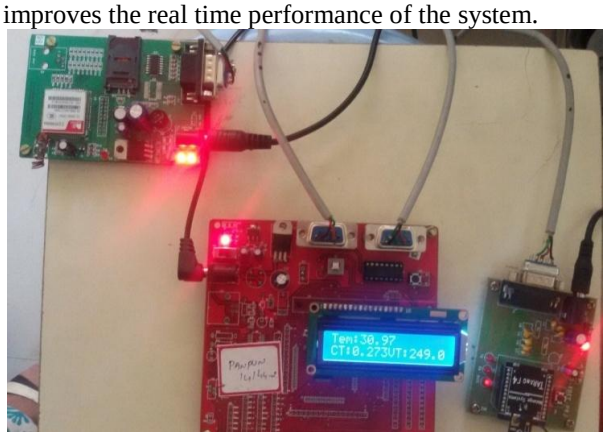

Fig 4.5 Hardware prototype for Data base station

C. Remote monitoring center:

The remote monitoring center mainly communicates with various types of communication standards such as GSM, GPRS, 3G and Ethernet etc. The remote monitoring center is used to collect the data from remote location where sensor node is placed. It collects all these data and work on it. Either it store in database center or depending upon the information received by it take necessary actions. Remote monitoring center also consist of monitoring software and database. The monitoring software provides an entire monitoring interface to conclude historical data queries, display real time data, analysis report and alarming for non-normal status or sends the message to the management mobile number. The complete remote monitoring center is accountable for monitoring the fault of electric machine and diagnoses it quickly as possible early.

V. RESULTS

Here we had done the measurement of electrical machine parameters such as temperature, current and voltage. We collected the online measurement of all these parameters which help us to know the health of electric drive. In this project we measured both ambient and motor temperature because high temperature can harm people as well as electric motor. In fact, operating a motor at just 10 deg C above rated temperature may shorten its life by half of total life. By providing this facility to observe the temperature regular basis will pay huge dividends by preventing unexpected shutdown and extending motor life. In Experimental setup we firstly measured the ambient temperature of location where electric drives placed and then we actual temperature of electric motor and observed the changes occurred in temperature readings. We took observation temperature vs. time for duration of 200 to 300 minutes. After every 20 minutes reading observed and plots the chart as shown below.

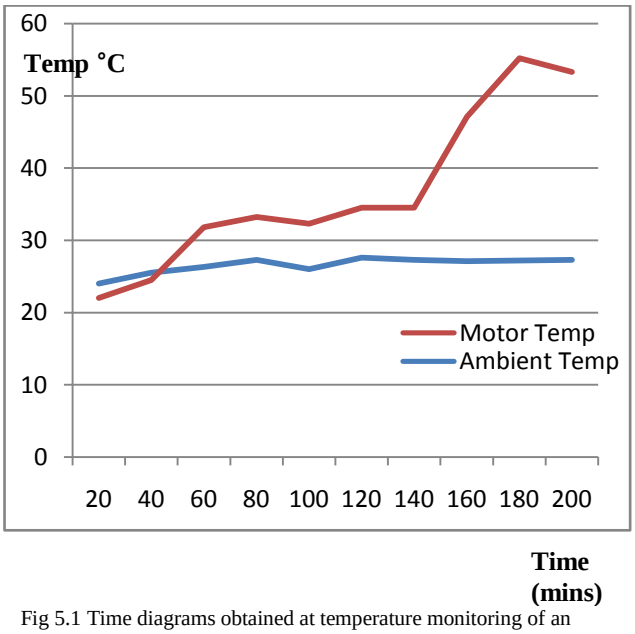

Fig 5.1 Time diagrams obtained at temperature monitoring of an electric motor.

As per our requirement we set the threshold for temperature and when temperature crosses it will send message on mobile phone of factory maintenance manger person. As soon as manager got the message from system he/she will take necessary action as needed.

VI.CONCLUSIONS

As we know electric drives are the heart of automation industries so its health of machine should have taken into account**.** This project discussed various wireless standards and selects the one ZigBee as short distance communication. An embedded remote monitoring system is based on WSN is realized the system has the advantage of high speed, high measuring accuracy and low cost. It will have a good prospect in different environment like dust, moisture, large vibrations etc. This system will make the work of maintenance management monitoring easily.

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