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Health Monitoring System for Induction Motors

Dr.R. Udayakumar ,Dr.V. Khanaa
Bharath University
Ruskumar2007@hotmail.com
drvkannan62@yahoo.com

Abstract

To avoid unexpected equipment failures and obtain higher accuracy in diagnostic c for the predictive maintenance of induction motors, on-line health nitoring system plays an important role to improve the system reliability and availability. Among different techniques of fault erection, work on motor current signature analysis by using only stator current spectra has been well documented. In addition, the recent developments in MEMS technology shows increasing trend in integrating vibration analysis for fault diagnostic. Vibration-based detection by using the accelerometer is gaining popularity due to high reliability low power consumption, and low cost. A electric machine based on wireless sensor network (ZigBee$^{TM/}$IEEE802.15.4.

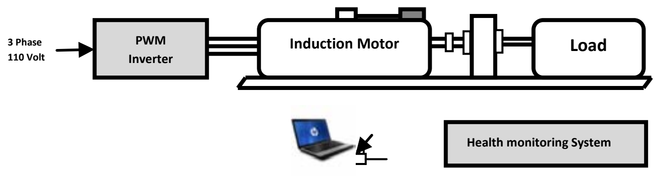
Keywords :

ZigBee, wireless sensor network, induction motors, health monitoring system, vibration detection.

Introduction

The focus in most industry is shifting from scheduled maintenance to the predictive maintenance by constantly observing and predicting the machine condition in advance Predictive maintenance by condition based monitoring of electrical machine is a scientific approach that becomes new strategy for maintenance management. Most industrial motors are being monitored using vibration, current and temperature sensors which either provide warning signals or shut down the system, before any catastrophic failure occurs. Though they are able to prevent permanent damage to the need of an advance system called on-line health monitoring system. Traditionally, health monitoring system is realized in wired systems formed by communication cables and various types of sensors. The cost of installation and maintenance are difficult and expensive especially when the equipments are not at the same location. To overcome these restrictions, using wireless sensor networks for monitoring is proposed in this paper. Wireless sensor network [2]-[3] is a new control network that integrates sensor, wireless communication and distributed intelligent processing technology. ZigBee is a newwireless networking technology with low power, low contant short time-delay characteristics. These favourable features are suitable for our application.

This paper proposes and develops a ZigBee based wireless sensor network for health monitoring of induction motors. The vibration signals obtained from monitoring system are processed with signal processing techniques. In order to predict the level of severity of rotor imbalance the vibration detection techniques with suitably modified.



The Proposed Wireless Health Monitoring System

As shown in Fig.1 the proposed wirless health monitoring system comprise of PWM Inverter, Induction motor and load station. The three-axis accelerometer is used to measure the vibration of the motor.

ZigBee TM /IEEE802.15.4. Standard

IEEE 802.15.4 standard defines the protocol and interconnection of devices via radio communication in apersonal area network (PAN). It operates in the ISM (Industrial, Science and Medical) radio bands, at 868 MHz in Europe, 915 MHz in the USA and 2.4 GHz worldwide. The system framework for health monitoring system based on wireless sensor network is made up of datacollection nodes and PAN network coordinator. The processing, and the IEEE 802.15.4 standard package framing to transmit data to the PAN network coordinator. In addition, they can also receive data frames from other nodes, and then adding multi-hop information, package framing, and then transmit the new data frames to the network coordination in the same manner.

Hardware Design and Implementation

The Hardware framework is illustrated in Fig.2. it is comprised of node and base station. The main circuits include the power supply, sensor and signal conditioning circuits, flash ROM and RAM memory, serial port interface, and three LEDs for status indication.

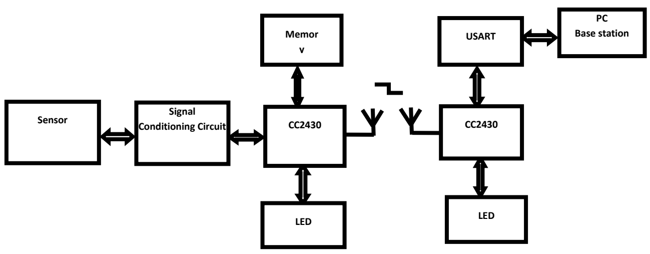
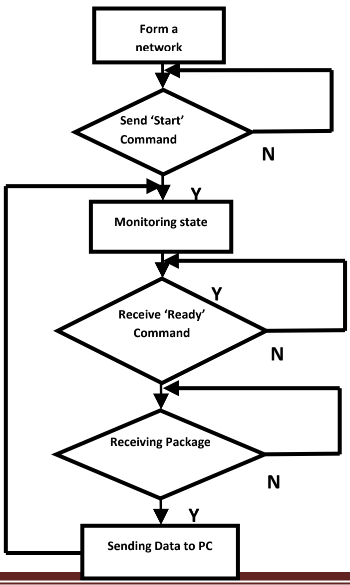


Fig : HardWare Frame work.

In the proposed system design, we adopt the IEEE 802.15.4 standard compliant transceiver CC 2430 from Texas enchanced 8051 microcontroller (MCU), with 128 KB flash memory and 8 KB RAM. The CC2430 also includes 12-bit ADC (Analog-to-Digital Converter) with up to eight inputs.

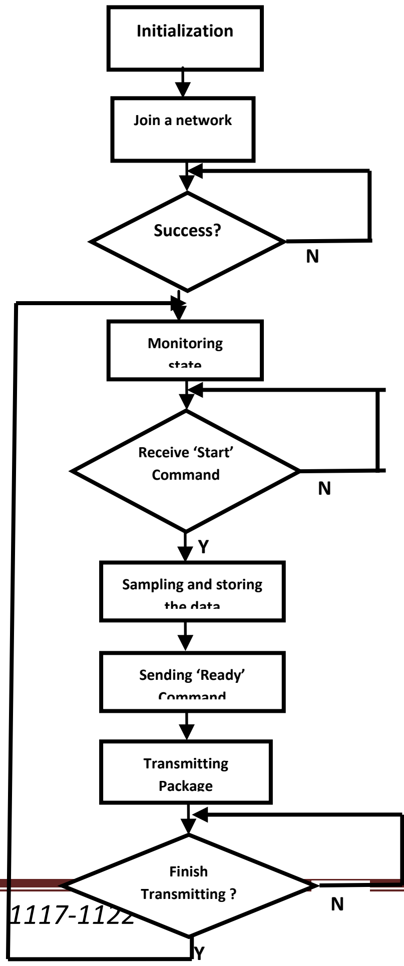
Software Flow

The Software flowcharts describe the working process of the network coordinator and data collect6ion node. The machine health identification can be obtained with the on-line monitoring system. In this proposed system, vibration signal from three axis accelerometer are recorded and stored at the base station. The recorded data bare fed to monitoring system to evaluate the important machine condition. Signal analysis is used to extract detailed.



As network coordinator, the CC2430 and the protocol stack is initialized firstly. Once the network is formed successfully, the network coordination will wait for user interrupt to send the – START|| command to the node. If anode is ready to transmit the data, it will send – READY|| command to the coordinator.

As data collection node, the CC2430 and protocol stack also initialise firstly. Once the node joins into network successfully, it will be put into monitoring state to monitor whether there are any commands coming from the network coordinator. It will perform the predefined task it data back to the network coordinator. After node finish transmitting all data, it will be returned back to monitoring stage again.



EFFECTS OF ROTOR IMBALANCE ON VIBRATION SIGNAL

Rotor imbalances are common mechanical faults in induction motors. In general, a mechanical fault in the load part of the overall system can be observed from the variation of the load torque. When a mechanical fault happends, it will result in a rotating eccentricity at the rotating frequency. These faults may also cause speed oscillations that have the effect on the stator current and finally lead to additional undesired harmonic components of power and torque at some particular frequencies in the spectra. A induction Motor under Rotor Imbalance.

To analyse the mechanical phenomena of the induction motor under rotor imbalance, the dynamic nature of a mechanical system with the assumption that the mechanical system with the unbalance is the horizontally installed along its rotational axis, the rotational dynamic for torque equation is derived from free body. Failure at the difference speeds. This small mass is fixed on a disk mounted on the motor shaft. The different distances(r) from the enter of the rotating part can be chosen.

We can see that the torque equation is as a function of time which is comprises of the constant component torque and the additional component varying at the mechanical rotor position. The total electromagnetic torque that is produced by the unbalance load makes it possible to detect the mechanical fault in induction machine.

Vibration Signature :

In general, there are numerous sources such as external source with particular frequencies that can cause the vibration of rotating machinery other vibrations do occur due to rotating asymmetries, such as rotor imbalance or misalignment. Among them, the largest low frequency vibration harmonic is normally due to the rotor imbalance of the rotational parts. From the vibration spectrum analysis, the low frequency harmonics are associated with the rotational frequency and can be force. Moreover, induction motors also vibrate at the twice of supply frequency due to their magnetic force between rotor and stator. This attraction force acts on the stator and induce the vibration on the motor frame. This also leads to significant harmonic peak at twice of the supply frequency in the vibration spectrum. Therefore, the harmonics of rotor imbalance can be modelled as an integer multiple of rotating frequency.

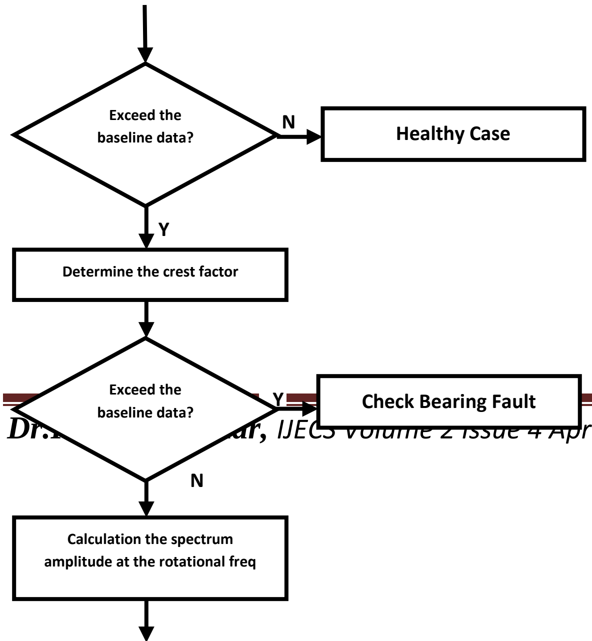
Determination of Rotor Imbalance Severity

Machine vibration analysis becomes one of the most important tools for machine health diagnostic. There are two types of analysis : time domain and frequency domain. In most research, the frequency domain analysis is more attractive because it is provide more detailed information.

About the status of the machine whereas the time domain analysis can give qualitative information about the machine condition. In general, machine vibration signal is composed of three parts, stationary vibration, random vibration, and noise. Traditionally, Fourier about the machine condition may be obtained. In this paper. Fast fourier Transform (FFT) is used to extract some useful features of the vibration signal i.e. root mean square (RMS) value, the crest factor. All the techniques used here for signal analysis and processing have been implemented by MATLAB software.

Implementation Of Root Mean Square.

In this study, the RMS value of the vibration signal is used for primary investigation of the machine health. The RMS values will be used to detect the severity of the abnormal condition. These values could also be used as input to training the neural network based fault classifier. All 3-axis vibration data are investigated.



Implementation Of Crest Factor :

The crest factor is the ratio of the peak value of the vibration signal of the RMS value. The purpose of the crest factor calculation is to give an analyst a quick idea of how much impacting is occurring in a waveform. It is meaningful where the peak values are reasonably uniform and repetitive from one cycle to another. Crest factor is often used to indicate the rolling element bearing faults. The rotor imbalance faults do not affect the value of crest factor. These values can give qualitative information about the machine condition if it is compared to the vibration signal standard and can be used to differentiate the bearing fault and rotor imbalance fault. The values of crest factor monitoring system, continuous monitoring of crest factor along with the historical record can provide useful information about bearing condition. Using both the RMS value and the crest factor for the machine health diagnostic may increase the overall system performance for health monitoring system.

Implementation Of Spectrum Analysis

In the present work, Fast Fourier Transform(FFT) algorithm is used to perform discrete Fourier transform (DFT) for all three axis vibration signals. In order to achieve earliest possible recognition of the fault in the machine, a comparison of the spectrum of the healthy case must be performed. The most significant vibration peak at the rotational frequency will be determined.

Conclusion

The hardware and software design of a wireless health monitoring system for induction machine is presented in this paper. Vibration signals have been analysed to detect the mechanical faults. Technique is verified with difference level of severity. Rotor imbalance indicator can be used to estimate the range of severity level which is very useful part of the predictive maintenance. The wireless health monitoring system is tested under various operating conditions and is found to work satisfactorily.

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