

RF Communication of Vibration Signal for Condition Monitoring

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Received: 20th September 2018, Accepted: 11th October 2018, Published: 31st October 2018

Abstract

This paper describes a system for communication of vibration signal using radio frequency. In this work, we are using the fact that vibration analysis provides relevant information about abnormal working condition of machine parts. Vibration measurement is essential for vibration analysis which is used for condition monitoring of machinery. The vibration measurement is done using 3axis accelerometer sensor. The implemented prototype system is based on use of NRF24L01 RF module i.e. standard IEEE802.15.4 for wireless communication. The system provides wireless communication of vibration signal between vibration sensor and vibration monitoring unit. Visual studio software is used for the system interface. It works in real time and can be used at remote places.

Keywords

RF Module, Accelerometer, RF Transmission

Introduction

Bearings of a shaft of any mechanical systems are generally subjected to sever transient load. This intern induces severe vibrations in the bearing caps. If these vibrations are continuously monitored, then we can predict likely machinery failure to occur in near future. But in certain system this continuous monitoring is not possible because of all the time unavailability of experts near the systems. Hence conventional method of monitoring of vibration signal of bearing is to check it periodically but this kind of monitoring is inadequate in certain situations. This situation leads to unawareness of happening of heavy breakdown of a system.

In such situations, there is a need of continuous monitoring of vibrations of bearing. The solution to above problem is to communicate vibration signals continuously to the place where experts are available all the time for monitoring.

There is a problem for communicating the signal in urban construction sites or in rural areas. The signal cannot travel at a long distance in remote places, so to overcome this problem this system has been designed. There are different types of wireless communication technologies used for wireless transmission. Like Radio Frequency (RF) Transmission, Infrared Transmission, Light Wave Transmission, Microwave Transmission. But RF Transmission are used commonly because of their property to penetrate through objects. Various protocols are available for RF transmission like ZigBee, Wi-Fi, Bluetooth, WLAN, Wi-Max etc. Bluetooth based systems provide range of only upto 10m, while range of Wi-Fi and Zigbee based systems is from 10-100meters. So these systems are not suitable for the application under consideration.

In our system, we are using wireless RF module due to which data can travel for long distance and in a fast and effective manner [1, 2].

The system is using RF module based transmitter and receiver, Accelerometer for vibration sensing.

Materials and Methods

The system is developed with the help of which we can transmit and receive a signal at a long distance without any interference

A. Transmitter and Receiver

Block diagram of Transmitter and Receiver is shown in figure 1.1 below. Transmitter and receiver consist of RF module for RF transmission and reception. This RF module uses higher order modulation techniques like GFSK. The range here depends upon the type of RF module used for communication. Accelerometer is used to acquire vibration signals of bearings. This vibration signal which is electrical in nature is given to the microcontroller and is displaying it on LCD display. Vibration signal is displayed in digital form on LCD display. We can also observe the vibration signal in analog form on computer screen. Vibration signal is given to RF module. The RF module first up-convert this input signal to RF frequency before transmission.

The signal is received by RF module based receiver. RF module at receiver down-convert the signal which is then processed by microcontroller.

B. Accelerometer

Accelerometers are electromechanical devices that convert the mechanical signals, such as vibration and force, to electrical signals, and are extensively used for condition monitoring and fault detection in many machines. Selecting an appropriate accelerometer and the way of mounting it on a process machine bearings are significant factors in determining the success of any condition monitoring system. Various parameters which need to be considered for accelerometer selection are sensitivity, range,

bandwidth, frequency resolution, reliability, accuracy, operation environment and cost. After taking the all-important technical requirements in to consideration, the ADXL335 accelerometer has been chosen for making prototype system. The AADXL335 is a micro-electro-mechanical system (MEMS). The ADXL335 is a small, thin, low power, complete 3-axis accelerometer. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. [3, 8]

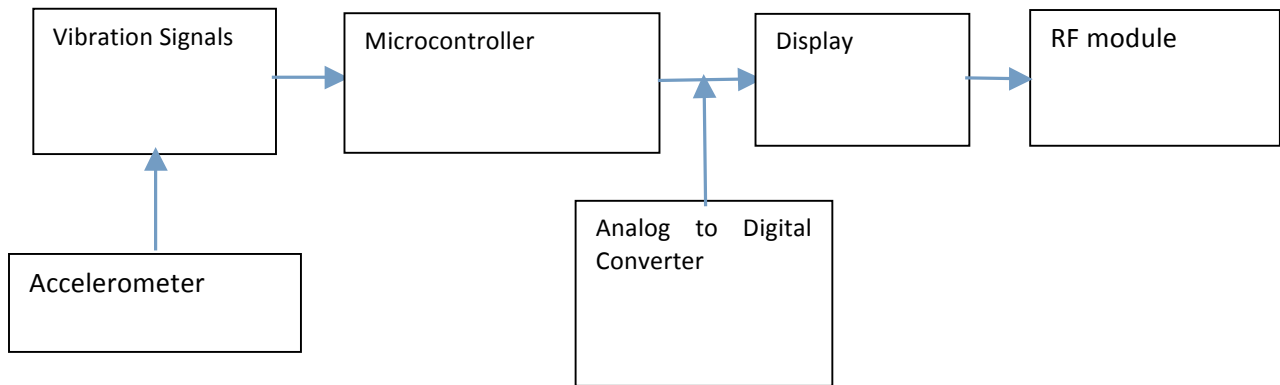


Figure1.a: Block Diagram of Transmitter

C. RF Module

Vibration signal is transmitted wirelessly using Radio Frequency (RF) communication. We are using RF module for communication of vibration signal between machine and monitoring system. Here RF24L01 module is selected for RF transmission but any other RF module can be used depending upon the range required [4, 5]. This module is an ultra low power single chip RF transceiver, supports an air data rate of 250 kbps, 1 Mbps and 2Mbps and operating at 2.4 GHz. SMA Connector is used for maximum RF range, and there is the PA and LNA circuit on board, with the external antenna. It can operate and configure through a serial peripheral interface (SPI). The radio front end uses GFSK modulation. The range of this module is 800m - 1km communication distance on open air.

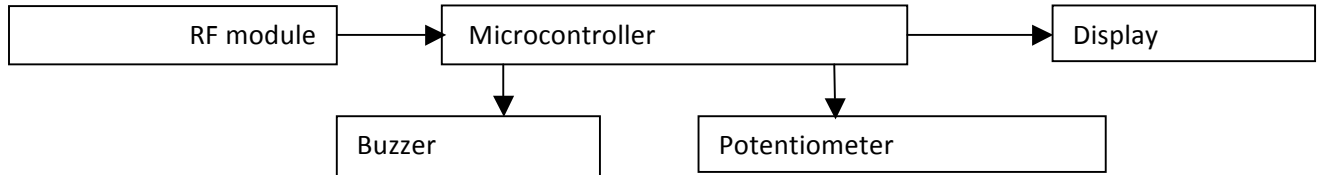


Figure1.b: Block Diagram of Transmitter

D. Microcontroller

Microcontroller is used for executing the IEEE802.15.4 protocol. The microcontroller collects the data from the wireless nRF24L01+PA+LNA transceiver module and processes it to make it convenient for display. The received signal is observed on computer screen/display or LCD display of the system. SPI interface is used for data communication between the computer and system.

Results and Discussion

A. Observing Vibration Signal in Digital Form

A prototype system consisting of transmitter and receiver using ATmega16 microcontroller and NRF24L01 module is developed. Vibration signal of bearing of motor are acquired using accelerometer ADXL335. This vibration signal after converting into digital form is given to LCD display for displaying digital values of vibration signal. Vibration Signal is given to the NRF24L01 module which is interfaced to the port D of microcontroller. NRF24L01 module up converts it to 2.4GHz and then transmit. Signal is received by receiver and the range that is the distance between transmitter and receiver used was 100 m. NRF24L01 module in the receiver down converts the received signal to the original frequency. This signal is displayed on LCD display. This LCD display at receiver show digital values of received vibration signal. It was found that transmitted values are same as that of received values. Figure 2 shows the transmitter system and figure 3 shows receiver system.

The results are also obtained for the range of 400m. It was found that transmitted values are same as that of received values but we observed some delay. So we have received signal upto the range of 400m successfully using the chosen RF module.

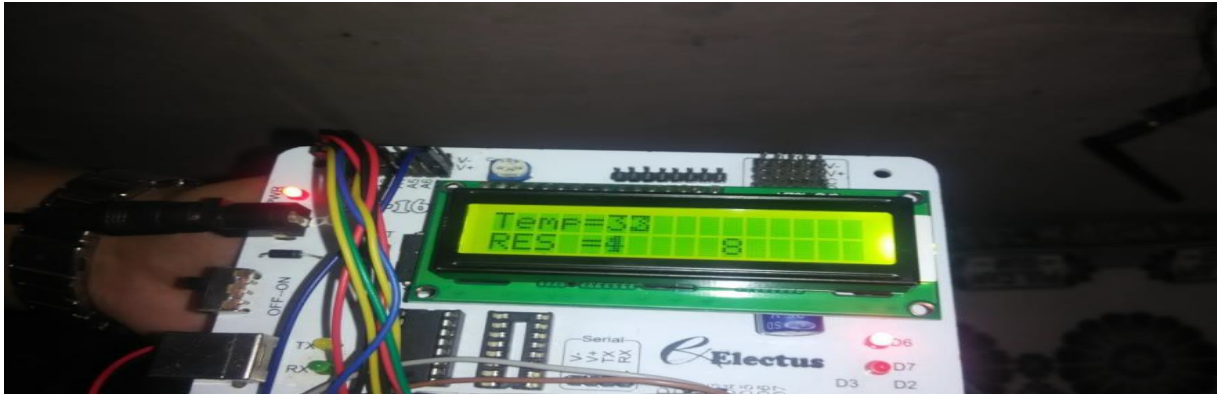


Figure 2: Connection at Transmitter



Figure 3: Connection at Receiver

B. Observing Vibration Signal in analog form

Vibration signal was also observed in analog form on computer display at transmitter as well as at receiver and we found that the transmitted and received signals are same and hence the vibration signal is transmitted and received correctly.

For data communication between the computer and microcontroller of receiver, Serial to peripheral interface (SPI) is used. In order to realize the communication between computer and microcontroller, the baud rate is chosen as 9600bps. Using D to A conversion vibration signal is converted into analog form. Computer display is used for observing waveform of vibration signal. It was found that transmitted waves are same as received waves. Waveform of vibration signal at transmitter is shown in figure 4. Temperature of machine is also sensed using temperature sensor. So figure 3 is showing display of temperature signal also. The vibration and temperature signals of a stator part of a motor are transmitted and received successfully. The received vibration and temperature signals are shown in figure 5.

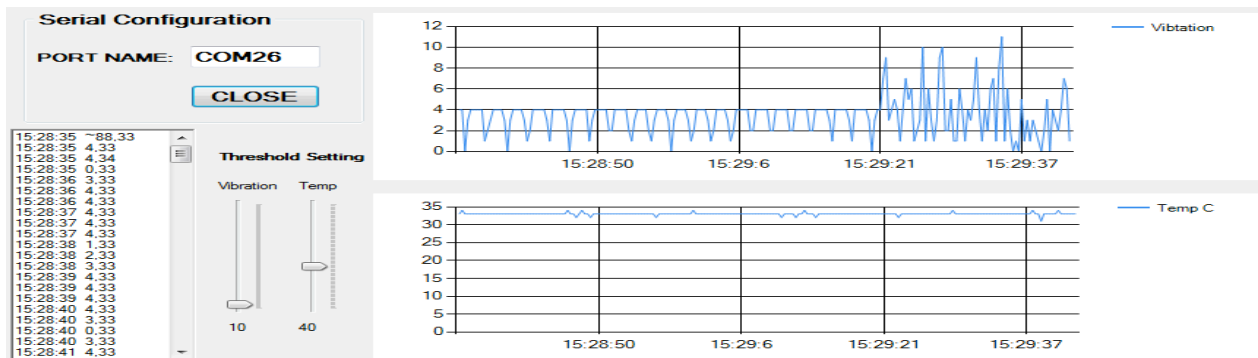


Figure 4: Vibration Waveform of Stator Part of a Motor and Temperature Waveform at Transmitter

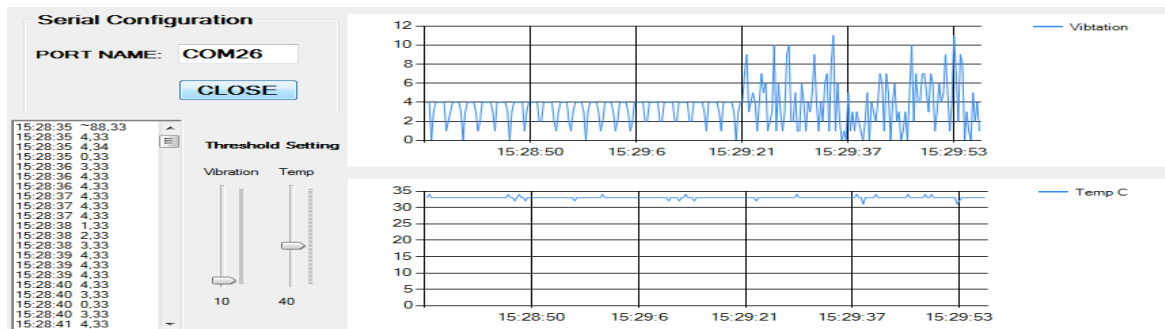


Figure 5: Vibration Waveform of Stator Part of a Motor and Temperature Waveform at Receiver

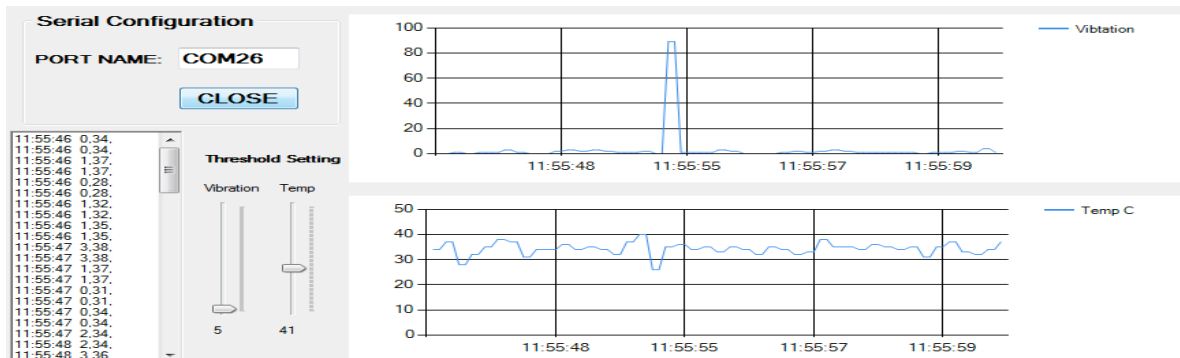


Figure 6: Vibration Waveform of Bearing Cap of a Motor and Temperature Waveform at Transmitter

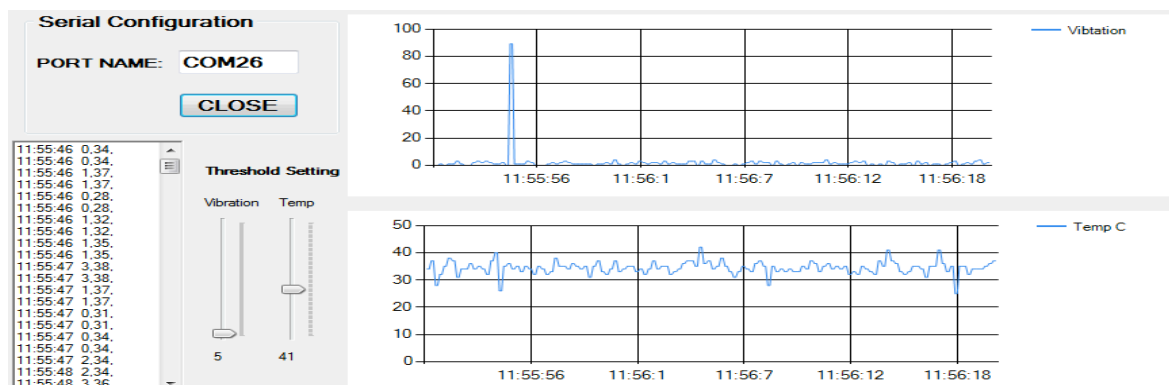


Figure 7: Vibration Waveform of Bearing Cap of a Motor and Temperature Waveform at Receiver

The procedure is repeated for a bear cap of a motor and it was also transmitted and received successfully as shown in figure 6 and 7 respectively

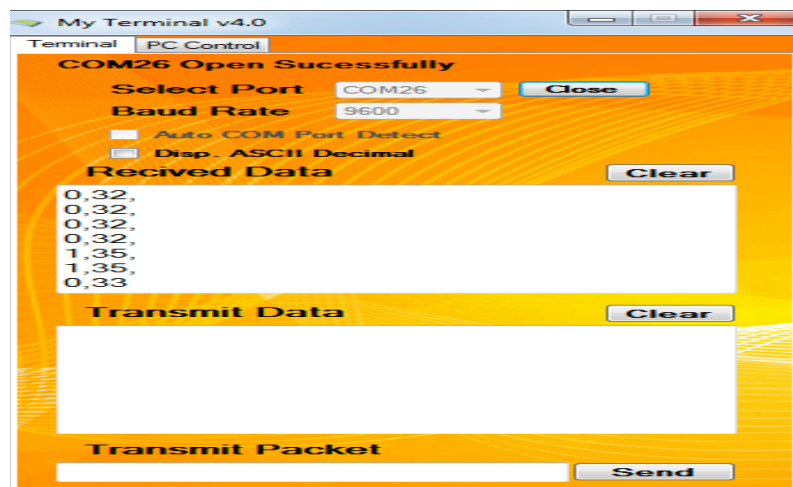


Figure 8: System Interface Showing Baud Rate, Com Port and Received Values

C. System Interface

'My terminal' Software is used by which we can select the com port and baud rate. When the com port is selected the GUI shows received data which is shown in figure 8. This figure is showing values of temperature and deflection of accelerometer in the GUI window of software. This software is commonly used as interface between user and microcontroller.

Conclusion

The system provides continuous communication of vibration signal from machine to monitoring system. This helps in continuous monitoring remotely to detect the fault which reduces the losses. This way, vibration signal can be constantly measured & monitored.

The transmission and reception of a signal has been tested successfully using the developed system. Signal is received successfully at a distance of 400 meter without any loss using chosen RF module. Other RF modules such as DRF7020D27 provide communication range of 2.8Km to 3.5 km. and the other one is DRF1278DL2 and its communication distance is 3-4km. The range can be increased to desired value by proper selection of RF module. So we conclude that RF module based system is well suited for the application under consideration.

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