Real Time Vibration Analyzer using Bluetooth Technology

Y.S.Rao, Anish Raut and Ninad Sawe

***Abstract*-- Vibration sensors are vital components in any industry. The problem of sensor's connectivity with database can be resolved by use of Bluetooth technology. Bluetooth features many properties which makes its implementation into vibration sensors clear troubles regarding wired connectivity. The tests undertaken provide the results which indicate the successful application of Bluetooth technology into vibration sensor microcontrollers. The industrial application of this project can help reduce the chaotic situations created by wired connections.**

***Index Terms*—Wireless LAN, vibration measurement, microcontrollers.**

I. Introduction

BLUETOOTH is a leading keyword in wireless communication today. This ubiquitous technology from Ericsson Company and others boasts features like low cost, easy integration, security measures, ad hoc capability and low power global radio system. No wonder most of the industrial wireless applications rely on Bluetooth for connectivity.

Another advantage of Bluetooth is its capability to easily get integrated into a variety of applications. It perfectly fits into mechanical and electrical applications like the vibration sensor implemented and discussed in this paper.

Vibration sensors are small electronic circuits used to measure vibrations in machinery. Vibrations are inherent part of any electrical machine which cause deterioration in product quality and increase production cost. They can not be removed but can be reduced. Vibration sensors provide their information to the corresponding circuitry which reduces them, playing a vital role in production process. Vibration sensors are microcontrollers usually mounted on machines to clearly note the vibrations. Microcontrollers do not have large memory making it mandatory to transmit data continuously to some remote database. Now, the area a factory covers could be vast causing congestion of wires used by microcontrollers.

This work was supported in part by Sai Technologies Private Limited, Mumbai.

Y.S.Rao is the Director, Sai Technologies Private Limited, D-1, Plot No. 8, Sagar Lahari CHS, Gorai – 1, Borivali (west), Mumbai – 400092, Maharashtra, INDIA, E-mail: sai.tech.mumbai@gmail.com

Ninad Sawe is working with Capgemini, India, E-mail: ninad.sawe@gmail.com.

Anish Raut is working with Sai Technologies Private Limited, Mumbai, E-mail: anishraut@rediffmail.com.

This is where Bluetooth can be integrated into vibration sensors to make life easier. Assimilation of Bluetooth technology into vibration sensors generates great results and hence, is the topic for this paper.

II. Bluetooth Architecture

The basic unit of a Bluetooth system is **piconet**. Piconet is a collection of devices connected via Bluetooth technology in an ad hoc fashion. It starts with two connected devices, and may grow to eight connected devices. When establishing a piconet, one unit will act as a **Master** and the other(s) as **slave**(s). A piconet exists in the range of 10 meters. Multiple piconets can exist in same area and even be interconnected by means of a bridge slave. An interconnected collection of piconets is called **scatternet.**

III. Protocol Architecture

The wide range of possible Bluetooth applications implies many Bluetooth software layers. Different applications may run over different protocol stacks. However, they will all have one imperative factor that will allow them to be interoperable and that will be the use of a common Bluetooth data link and physical layer. The complete Bluetooth protocol stack is shown in Fig 1.

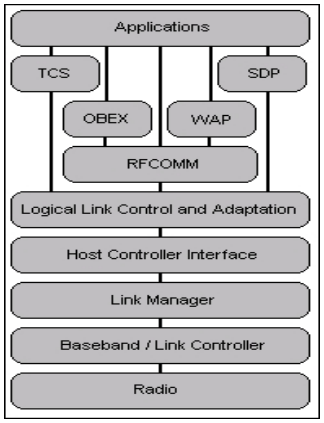

Fig.1: Bluetooth protocol stack

The radio frequency layer

This layer's job is to move bits from master to slave and vice-versa. This layer works within a range of 10 meters in the 2.4 GHz ISM band. The band is divided into 79 channels of 1 MHz each using frequency hopping.

The baseband layer

This layer performs bit to frame conversion. One settling period is required for every frame being transmitted. Thus, longer frames give better efficiency. The master and slave are connected by **link**. This link could be **ACL** (Asynchronous connection less) or **SCO** (Synchronous connection oriented).

The HCI

The Host Controller Interface is not a software layer, but a transport and communications protocol that aids interoperability between different manufacturers' solutions.

The L2CAP layer

The logical link control and adaptation protocol is responsible for breaking of packets into frames of 64 Kb and their transmission. [2]

IV. POWER MANAGEMENT

The Bluetooth specification offers a range of power-saving features, tailored to suit the needs of different applications, which can give your applications a real edge .The drawback is that if you use these features badly, you will slow down the response time of your application, making it infuriating to use.

Active Mode:

In active mode, the device actively participates on the radio channel. The master schedules data transmissions as necessary and the slaves must listen to all active master-slave slots for packets that may be destined for them. It not only consumes the most power but also has the highest achievable data throughput due to the devices being able to use all available slots.

Hold Mode:

Master and slave devices negotiate for the duration of hold mode. Once a connection is in hold mode, it does not support data packets on that connection. It can either save power or participate in another piconet.

Sniff Mode:

This low power mode achieves power savings by reducing the number of slots in which a master can start a data transmission and correspondingly reducing the slots in which the slaves must listen.

Park Mode:

Park mode is the Bluetooth low power mode that allows the greatest power savings. However, while parked, a device cannot send or receive user data and cannot have an established SCO link. In this mode ,the slave does not participate in the piconet , but nevertheless remains synchronized to the channel .This mode has the further advantage of allowing the master to support more than seven slaves by parking some whilst activating others.[3]

Security Management

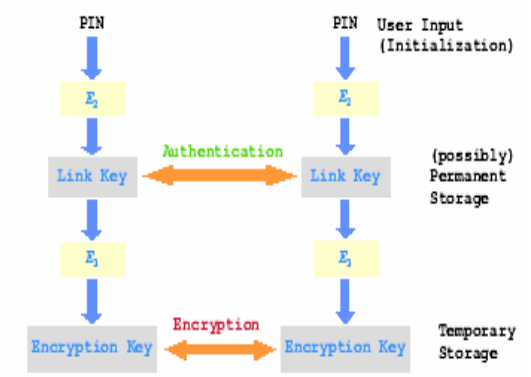

Fig.2: Link layer security architecture

At the link layer, the Bluetooth radio system provides Authentication, Encryption and Key Management of the various keys involved. [2]

V. INTEGRATION

The main intention and the purpose behind undertaking this particular project is to save the machinery cost by increasing the efficiency of certain devices by detecting the faults on time using sensors and thus increase the profitability of the industry. But, why use Bluetooth? Since we are using microcontrollers and we know microcontrollers have limited means of memory. So, it is necessary to constantly transfer the readings to storage device where database can be prepared for proper monitoring of the devices. Also, in industry, the device can be remotely monitored wirelessly using Bluetooth. This eliminates the need to implement congested wiring all over the places.

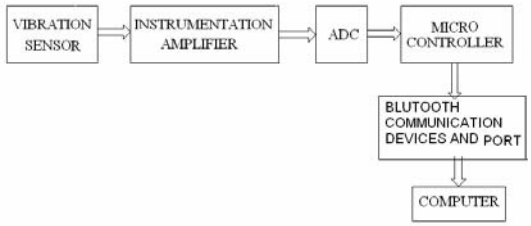

Fig.3: Block Diagram

Vibration sensors are placed on a part of a machine or any structure of which we have to monitor the vibration, since vibrations can cause malfunctioning of the machine which will lead to degradation in the product quality and increase in the product cost. There are various methods a vibration sensor can use to perform sensing. An example can be given of infra red sensors which use continuous infra red rays in the concerned area. As soon as the vibration occurs, infra red waves are disturbed which gives the corresponding readings. The sensors can also implement logic of capacitance to sense vibrations.

When vibrations are produced sensors convert these vibrations into an electrical analog signal. The produced analog signals are weak and they require amplification. So, we

use an instrumentation amplifier. To convert these analog signals into its equivalent digital signal, we use an ADC for computation purpose. In this project we are using ATMEGA8535 microcontroller. The choice is done on the basis of its capability to handle the real time data, the memory space provided. To transfer data from microcontroller to the computer, we use Ericsson's Bluetooth dongle so we can have an advantage of wireless networking.

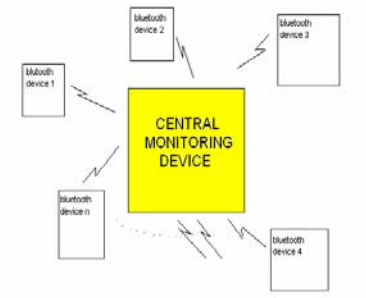

Fig.4: Basic setup of project

VI. LABORATORY RESULTS

The vibrations produced are sensed by sensor which produces analog signals. These analog signals are processed in the microcontroller and using ADC, they are converted into digital signals. After implementing DFT, the sampled output is sent via Bluetooth to the central monitoring system where we can monitor the vibrations using any coding language. In this case, MATLAB is used. Here are some snapshots taken while processing(Fig. 5):

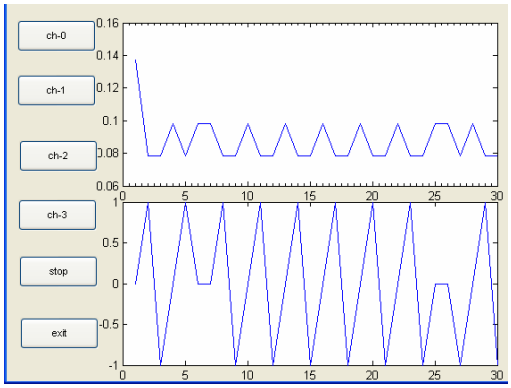

Fig.5: MATLAB output of vibration monitoring

The upper axis shows magnitude graph while the lower one displays phase values at corresponding frequency.

The transmission process occurs as follows(Fig. 6):

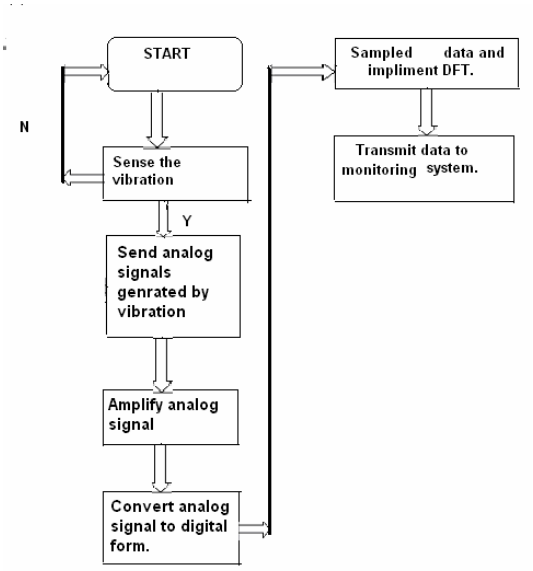

Fig.6: Flow diagrame of vibration system.

Sensor senses the vibrations and generates vibration signals. These signals are amplified by instrumentation amplifier. Ahead, signals go to microcontroller where they are converted to digital and sampled using DFT. Serial port is initialized and data is transmitted.

Fig. 7 explains the connection and termination methodology used by Bluetooth devices. After configuring the devices, master node searches for connection requests. When such a request is found, it connects to corresponding device and scans for available data. If data is found, it is logged to a file or a disconnection request is sent causing termination of connection.

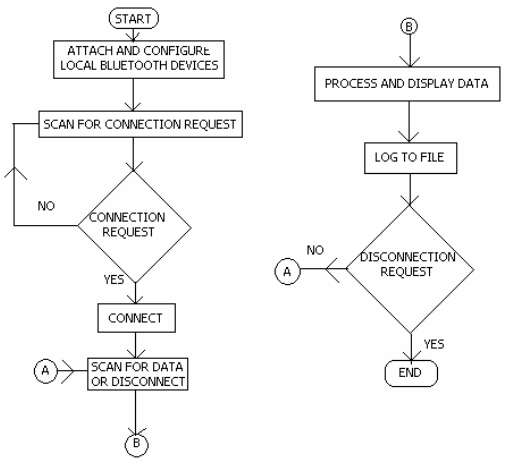

Fig.7: data flow diagrame of Bluetooth connectivity.

VII. Components

Bluetooth Dongle:

Fig. 8: Ericsson Bluetooth dongle.

The wireless signal transceiver used in the project is Bluetooth dongle by Ericsson Company. It is provided with serial port connectivity and is directly connected to the microcontroller ATMEGA 8535.

Complete assembly of project

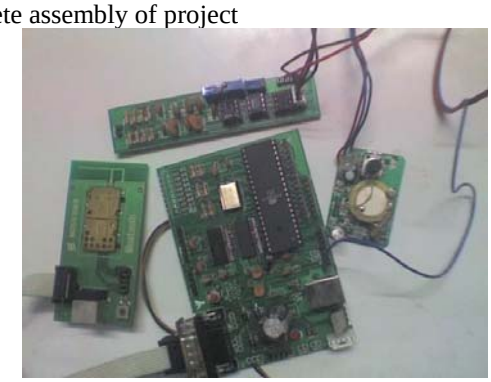

Fig.9: Complete assembly of project

The complete assembly of project is shown in figure where vibration sensor is connected to the instrumentation amplifier and digital signal processing circuitry.

VIII. Future Scope

Bluetooth implementation in vibration sensors provides many advantages of wireless technology. However, Bluetooth still being in phase of development, there are many issues to be resolved like:

- Range of Bluetooth is still limited from industrial point of view. There is vast scope for increasing the range.
- Bluetooth continuously consumes considerable power which makes it undesirable in some positions. If power issue is solved, Bluetooth will be better replacement for wired networks.
- Bluetooth works in the frequency range which is used by many other electronic devices. This causes intermittent interferences, sometimes causing data loss.
- The way that the Bluetooth radio system is used in mobile devices and the type of data carried on these devices makes security an extremely important factor.

IX. Conclusion

In today's situation, vibration monitoring systems make an important part of many industries. The tedious job of their wired networks has been eliminated by Bluetooth technology. Bluetooth also allows monitoring of multiple devices simultaneously.

This paper covers a small aspect of industrial need of Bluetooth networks and an attempt to emphasize the need of Bluetooth vibration monitoring system.

X. References

[1] Bluetooth Specifications, Bluetooth SIG at http://www.bluetooth.com
[2] Bluetooth Architecture Overview, James Kardach, Mobile Computing Group, Intel Corporation, Intel Technology Journal Q2, 2000
[3] Designing a wireless network – Jeffrey Wheat, randy hiser, Jackie Tucker, Alicia Neely, Andy McCullough by Syngress Publications