

Vibration Measurement System with Accelerometer Sensor Based on ARM

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Abstract— These Vibration amplitude may be measured as a displacement, a velocity, or acceleration. Vibration amplitude measurements may either be relative, or absolute. The basic scheme of vibration measurement is outlined first. Descriptions are given of transducers devices which transform physical variables into equivalent electrical signals and of vibration pickups. The increasing demands of higher productivity and economical design lead to higher operating speeds of machinery and efficient use of materials through lightweight structures. How we can measure vibration or earthquake signal of any device is describe in this system. These trends make the occurrence of resonant conditions more frequent during the operation of machinery and reduce the reliability of the system. Hence the periodic measurement of vibration characteristics of machinery and structures becomes essential to ensure adequate safety margins. Accelerometers develop a voltage from a piezoelectric crystal that has a mass mounted upon it. When the mass fixed to the crystal vibrates from the motion of the device upon which the sensor is attached, the crystal generates a voltage proportional to the force applied by the mass as it vibrates with the machinery. While no external excitation is required for the sensor to produce its voltage signal, the signal is small (self-generated) and requires a preamplifier.

Keywords— Accelerometer, ADC, ARM processor, wireless Tx/Rx.

I. INTRODUCTION

Depending on the quantity measured, a vibration measuring instrument is called a Vibrometer, a velocity meter, an accelerometer, a phase meter, or a frequency meter. If the Instrument is designed to record the measured quantity [8]. In some application, we need to vibrate a machine or structure to find its resonance characteristics. For this, electrodynamic vibrators, electro hydraulic vibrators, and signal generators (oscillators) are used. Here we want to develop cost effective system for measurement of earthquake signal. With the help of this system we can measure any vibration present at the input side with the help of accelerometer sensor. Here we are considering main parameter is Acceleration. We are measuring Acceleration with the help of accelerometer.

Acceleration which is getting on output graph is proportional to voltage with respect to input displacement. Accelerometer measures signal in three direction such as X-axis, Y-axis, Z-axis [4]. When a transducer is used in conjunction with another device to measure vibrations, it is called a vibration pickup. The commonly used vibration pickups are known as seismic instruments. A seismic instrument consists of a mass-spring-damper system mounted on the vibrating body [9].

II. LITERATURE SURVEY

There are two types of devices used to measure ground vibrations: seismometers and accelerometers. Accelerometers are used to record very strong vibrations, while seismometers are used to detect weaker vibrations. A seismometer is a sensor used to detect ground motion, containing a mass or pendulum mounted on a spring. When the ground moves, the seismometer moves with it; however, the mass remains stationary [6]. A recording device, called a seismograph, records the relative motion between the mass and the unit, producing a record of the movement. Modern seismometers utilize electronic circuits to measure the electrical voltage created by this motion rather than mechanical means [7]. These modern devices are capable of detecting vibrations as small as semidiurnal gravitational tide movements and distances almost as small as atomic spacing.

The overview was made by Lee and Stewart (1981), who, on the instrumental side, that was mainly dealt with micro Earthquake networks. During 1970's all observatories were upgraded and seismic signal were available for the analysis [3]. The Wilmore (1979) dealt with all the classical analog seismographs, but it is not consider now. Seismograms give the basic information about earthquakes, chemical and nuclear explosions. Accordingly, our review knowledge of seismicity, Earth's structure, and the various types of seismic sources is mainly the result of analysis and interpretation of seismograms [4]. The more completely we quantify the signal of Earthquake, the more we understand the Earth's structure, seismic sources and the Causing processes.

III. MEASUREMENT PLATFORM

Earthquakes release energy in the form of ground vibrations, called seismic waves. These waves radiate outwards in all directions. There are three types of seismic waves, or vibrations. The fastest are pressure waves, called P waves. These waves are also known as compression waves. Slower than P waves, S waves are vertical and horizontal waves that run perpendicular to their direction of travel. Finally, surface waves, the slowest moving vibrations, follow behind the P and S waves. In this figure, the motion (or dynamic force) of the vibrating body is converted into an electrical signal by the vibration transducer or pickup. In general, a transducer is a device that transforms changes in mechanical quantities (such as displacement, velocity, acceleration, or force) into changes in electrical quantities (such as voltage or current). Since the output signal (voltage or current) of a transducer is too small to be recorded directly, a signal conversion instrument is used to amplify the signal to the required value. The output from the signal conversion instrument can be presented on a display unit for visual inspection, or recorded by a recording unit, or stored in a computer for later use.

An accelerometer is an instrument that measures the acceleration of a vibrating body. Accelerometers are widely used for vibration measurements and also to Record earthquakes. From the accelerometer record, the velocity and displacements are obtained by integration. Transducer is a device that transforms values of physical variables into equivalent electrical signals. Several types of transducers are available; some of them are less useful than others due to their nonlinearity or slow response. Some of the transducers commonly used for vibration measurement.

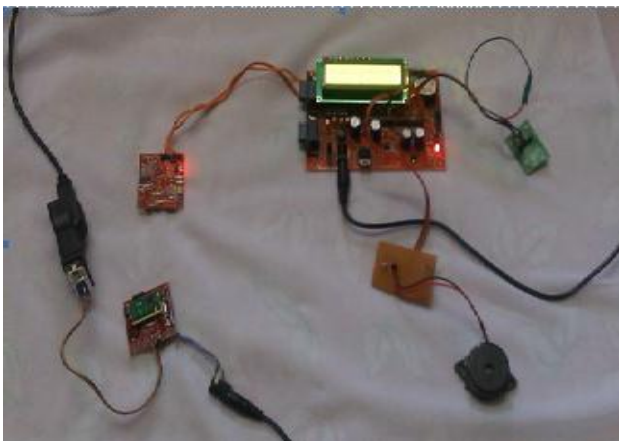


Fig-1: Measuring platform of the System

The first device is Accelerometer sensor which converts nonelectrical signal into electrical quantity which is in the range of (0-1.76V). The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ± 3 g. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis. The output of Accelerometer is given to the low pass filter.

Ground vibrations, or seismic waves, are most commonly caused by earthquakes. However, there are numerous other sources for these vibrations, including volcanoes, large explosions and impacts. These vibrations spread out from their source as seismic waves and are measured by a world-wide seismographic network of seismometers and accelerometers. One of the most common types of vibration sensor is an accelerometer. Accelerometers come in a variety of designs, and they can detect a wide range of different vibrations. One of the most popular versions of the accelerometer is a piezoelectric sensor. This sort of sensor contains a material (such as crystal quartz) that gives off an electric charge when it detects changes in pressure. By measuring the amounts of electric charge that piezoelectric accelerometers give off it becomes possible to determine the amount of vibration going on in the connection. Accelerometer having input up to 10000g shock survival. And output voltage range is 0.1 to 2.8 V (Analog form). It requires very less supply voltage that is 1.8 to 3.6 V.

Output of Accelerometer is given to the LPF which passing only low frequency component and block high frequency component. Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration. In low frequency applications (up to 20 kHz), passive filters are generally constructed using simple RC (Resistor-Capacitor) networks. We can calculate frequency with the help of these formulae $1/(2\pi \times 32K \times C)$.

In this system we are using 10-bit ADC which is in built in the ARM circuit. It also includes an onboard temperature sensor to monitor ambient temperature. LPC2148 consists of two analog to digital converter each of 10 bit successive approximation method. While ADC0 has six channel and ADC1 has eight channels. Therefore total number available ADC inputs are 14. Conversion time of this ADC is 2.44us. And ADC having output in terms of binary form like logic 0 or logic 1.

We are using LPC2148 microcontroller which is based on 32-bit ARM7TDMI CPU with real time emulation and embedded trace support that combines microcontroller with high speed flash memory. Due to tiny size power consumption is low. This is having input as logic 0, logic 1. And output will be in the range of $\pm 3V$ to $\pm 15V$ (11V). It is having 60 MHz maximum CPU clock with settling time 100 μs .

UART (universal asynchronous receiver transmitter) are one of the basic interfaces which provide a cost effective simple and reliable communication between one controller to another controller or between a controller and PC. Having input voltage $\pm 3V$ to $\pm 15V$ (11V). This application report describes a 2.4-GHz frequency-hopping system consisting of a designated Transmitter and Receiver, each with distinct functions to avoid RF-channel interference. The Transmitter board emulates the control device (e.g., remote control) by sending commands to be processed on the Receiver side (e.g., TV, stereo, set top box, or gaming console). The specific radio device used for this demo is the TI CC2500 (2.4 GHz) RF transceiver module.

The Transmitter board is scanning each RF channel looking for the Receiver board, the Antenna icon is cleared during this time. The Transmitter board periodically sends out a broadcast beacon to the Receiver. If the Receiver sends back an acknowledge to the beacon request, the Transmitter board remains on its currently-selected preset RF channel. When the Receiver board is first powered up, it parks itself on frequency #1 (denoted as F1 on the LCD display).

IV. RESULT

Figure 2 shows the result of the system which a earthquake signal also called as seismic data or vibration of the system. This data is not separated from noise. For noise free data we have to do addition in to filtrations process. When because of earthquake particular area is affected then seismic data reaches at maximum level in the graph. According to area of affection it reaches its peak value. When area is less affected then it reaches at small peaks. Following graph consists of 256 digitals levels because here we are using 8-bit ADC. And Alarm value is set as per our Requirement. Here Alarm set value is 140. When output that means Seismic signal value is greater than set value then Alarm will give Buzzer if not it will not provide any sound.

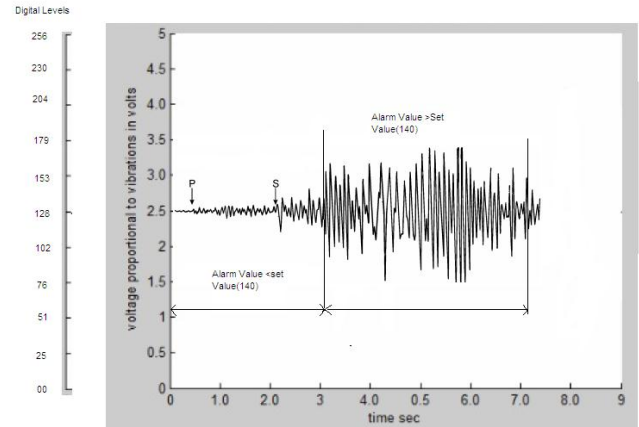


Fig-2: Result of the earthquake signal

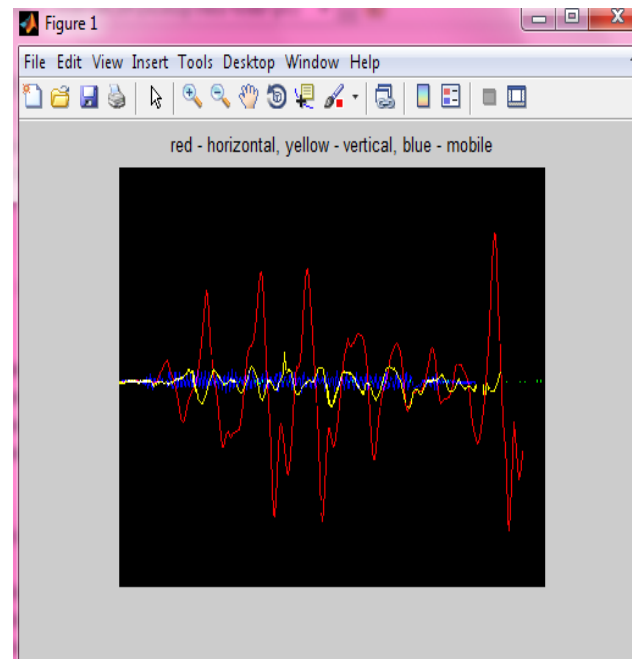


Fig-3: Result of the earthquake signal

Above graph that is Fig-4 shows that all signal are combine here in one graph this is done in MATLAB programming. In previous section we have shown that signal of different vibration like horizontal, vertical, mobile and no signal movement is shown in individual graph. In the above figure all signals are combining in MATLAB.

Red color is used for horizontal movement, yellow color is used for vertical movement, blue color is used for mobile vibration and white color is used for no vibration. White signal is very feint it is behind of all signal. In practical application we cannot implement this because practically when signal is coming from transmitter side is of same color so we cannot identify the waveform of the different vibration signal. This graph is used for analysis purpose.

V. USER INTERFACE

Below fig-4 shows that GUI of seismic data in which on X-Axis we are plotting time and on Y-Axis voltage is available. Start is provided for data initialization. After pressing start button we are getting seismic signal based on input vibration or displacement. The time which is of on X-axis is continuously varying and on y-Axis maximum voltage we are giving is 3.5 V. If we want to plot X-axis signal then we have to click on start of x- signal, same for Y-axis signal, Z-axis signal, also stop button is also provided.

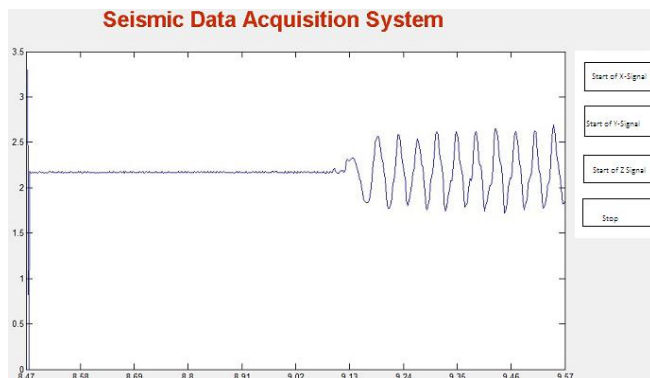


Fig-4: Result of the earthquake signal

VI. ADVANTAGES OF THE SYSTEM

- In this project seismic data acquisition system based on ARM7 designed. High sensitivity sensor and high range wireless transceiver are selected.
- Time complexity of this system is less as compared to other systems. The new system has a significantly reduced size and weight, which improves its versatility and mobility.
- Accelerometer senses the vibration in three direction x, y, z. That signal is transmitted through transmitter and received at the receiver side. If input signal is greater than reference signal then controller will on the buzzer.

- In previous days seismometer and geophone was used to measure earthquake signal but the requirement of maintenance is more. Because mechanical rotary part present in the seismometer is more.
- Also Seismometer is covered in a case for improvement in the performance. And that are expensive. Hence the cost of that device is more as compare to this system.
- Seismometer and geophone is not compatible with the computer hence we cannot process that device with the help of computer.
- The price of Seismometer is approximately twelve thousand to fifteen thousand. Whereas cost of propose system is approximately seven thousand to eight thousand.
- We can increase the resolution of the signal for that we have to use more number of bits ADC but the disadvantage is that speed will decrease.
- By putting number of system at the different places we can form one network like many transmitter and single receiver. We can store the data for further analysis in database. When we get information of particular area then we can save life of many people.

VII. LIMITATIONS OF THE SYSTEM

In this system we are measuring any vibration which is available at the input side. Very small vibration we can measure with the help of this system. Hence we cannot separate out noise signal which is present with the input information signal. For that purpose we have to use additional circuitry to separate out input signal and noise signal. So this is one of the limitations of this system.

REFERENCES

- [1] Miss.N.S.Marne,Prof.Dr.M.S.Nagmode,Prof.R.D.Komati. "Development of new system for earthquake data based on ARM", 2014:1387-1392.
- [2] JIANG H T, GUO ZH Y. Design of aircraft tilt measurement System based on mems accelerometer sensor [J].Computer Measurement & Control, 2010, 18(1):107-109.
- [3] HUANG G, ZHANG J P. Over sampling and used in temperature compensation for acceleration sensor[C]. The Ninth International Conference on Electronic Measurement & Instruments, 2009:736-739.
- [4] Khairul Anuar abd Wahid university sains malaysia Development of tilt and vibration measurement and detection system using MEMS sensor, 220-260, 2008.
- [5] M. Griffin, Handbook of human vibration. London: Academic Press, 1990.

International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 4, April 2014)

- [6] Bullen K. E., and Bolt B. A. (1993), An Introduction to the Theory of Seismology. Cambridge University Press, Cambridge. (Fourth edition). Burg K. E., Ewing M., Press F., and Stulken E. J. (1951), A seismic wave guide phenomenon. Geophysics 16,594-6 12.
- [7] Gri_n, Handbook of human vibration. London: Academic Press,1990.
- [8] Armstrong, M. M. Marshall, B. J. Martin, J. A. Foulke, D. C.Grieshaber, and G. Malone,"Exposure to forceful exertions and vibration in a foundry," International Journal of Industrial Ergonomics, vol. 30, pp. 163-179, 2002.
- [9] lejandro Martinez, Pereira Michael Jones, Fundamentals of Borehole Seismic Technology 1-17,2000.
- [10] Halit Eren, Acceleration ,vibration, shock measurement, Curtine University of Technology,second edition.