Development of new system for earthquake data based on ARM

Miss.N.S.Marne, Prof.Dr.M.S.Nagmode,Prof.R.D.Komati

Abstract— Seismology would be a very different science without instruments. The real big advances in seismology is done from around 1900 and onwards and was mainly due to advancement in making more sensitive seismographs and so that earthquakes could be properly located. the importance accurate measurement of the true ground movement became evident for studying seismic wave attenuation, and the magnitude scale depends on calculation of the ground displacement from recorded seismogram. In the last ten years, recording devices based on digital technology have completely replaced their old analog System. The latter systems are costly, require specialized maintenance and are incompatible with computer data processing and analysis. The Seismometers which uses now a days are costly, require specialized maintenance and consumables, and are incompatible with computer data processing and analysis. They are no longer produced although being still in operation at many older seismological stations and network centers.hence we are developing new system which required less maintenance and easy to processing with computer that means compatible with data processing.

Index Terms— Accelerometer, ADC, ARM processor, wireless Tx/Rx .

1 Introduction

The seismic data is useful for monitoring or study of effects of the earthquake. Degree of the damage depends upon the distance between the affected area and the epicenter, and the magnitude which indicates how much energy is released from the origin to earth crust [1]. These phenomena mostly historically reported for the site and surrounding area of the earthquake. Analysis of seismic signals is done by determining magnitude and recorded by seismometers at monitoring stations. The seismic data is useful for monitoring or study of effects of the earthquake. Conventional Seismometers which was used in previous day's record signals in a permanent way such as a chart or drum recorder. The Seismometers which uses now a days are costly, require specialized maintenance and consumables, and are incompatible with computer data processing and analysis [2]. They are no longer produced although being still in operation at many older seismological stations and network centers. Here we want to developed new system for measurement of earthquake signal.

- *Prof.Dr. Manoj S. Nagmode Currently he is working as Professor, in Department of Electronics and Telecommunication Engineering, MITCOE, Pune, India. manoj.nagmode@gmail.com*
- *Rajkumar D. Komati Currently he is working as Assistant Professor, in Department of Electronics and Telecommunication Engineering, MITCOE, Pune, India. rdkomati@gmail.com*
- *N.S.Marne is currently pursuing masters degree program in electronics and telecommunication in University of Pune,India. nitalmarne@gmail.com*

2 Literature Survey

The overview was made by Lee and Stewart (1981), which, 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.

Gunter Asch said in Seismic Recording Systems, A recording device is autonomous, self-contained equipment; it is designed to measure the output signal of a sensor, that system digitizes the signal and records it [9]. In Earthquake measurement signal, all three components of ground movement are important, whereas in reflection experiments, only the vertical component up to now has been taken into account. Specialized multi-channel recorders with more than 6 channels are not covered here

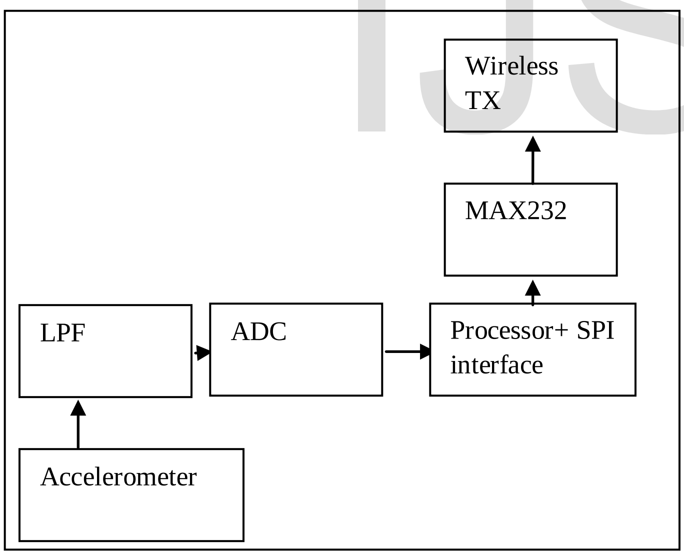
ISSN 2229-5518

[7]. Since 1990's analog seismogram is replace with digital one to increase the dynamic range and frequency band which is needed for Earthquake signal. In previous days seismometer and geophone was used for the measurement of earthquake data. But the requirement of the maintenance is more because it consists of mechanical part also seismometer is not compatible with the computer for processing data[12].

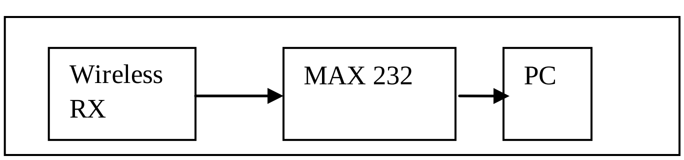
3 System Concept

HARDWARE DESIGN

The proposed seismic data analysis system is shown in Figure 1. It consists of two section first one is transmitting section (A) and second one is receiving section (B). In the transmitting section first we are using MEMS sensor which measures acceleration due to gravity. It basically can be used to measure vibrations along different X,Y,Z axes. Then analog signal is generated which is given to the ADC for conversion of analog to digital signal. Here we are using inbuilt ADC with SPI software. SPI software will enable us to have better control over data exchange between ARM and ADC. Data is stored and can be used for further analysis. That means data is transfer to the receiving section.



(A) Transmitting section



(B) Receiving section

Fig -1: System for measuring earthquake data

The first block 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. The output of Accelerometer is given to the low pass filter. It survives the shock input up to 10000g. Accelerometer operated at 1.8 to 3.6 V supply voltage.

Output of Accelerometer is given to the LPF which passing only low frequency component and block high frequency component. 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 this formulae 1/(2II×32K×C). Following Table-1 shows that how we can choose value of capacitor for appropriate bandwidth.

Table -1
Filter capacitor selection

Bandwidth (Hz)	capacitor(μf)
1	4.7
10	0.047
50	0.10
100	0.05
200	0.027
500	0.01

Output of the LPF is given to the ADC for conversion of analog signal into digital signal. 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.Anlog signal are available in the range of -0.6 to 2.5 V,+4.5 to 5.5 V. And Output will be logic 1, logic 0.The Conversion time for this ADC is 2.44 us.

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. Supply voltage of this IC is 3.3 V (Vref). It is having Two 10-bit ADCs - 14 analog inputs. And the conversion times is 2.44 μs per channel. It is having Output in the range of ±3V to ±15V (11V). The output of controller is given to MAX232 with the help of SPI interface.

The SPI is a full duplex serial interface, design to If a single slave device is used, the SS pin may be fixed to logic low if the slave permits it. 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.

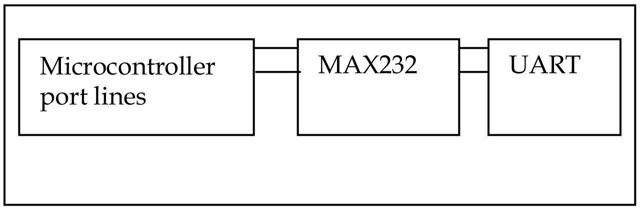


Fig- 2: Communication between controller and UART

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.
Frequency of this transreceiver is 2.4 GHz.
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.

SOFTWARE DESIGN

Philips flash utility software allows uploading and execution of code. Keil tool by ARM uvision 4 software is used for compilation purpose. MATLAB software is used for displaying final output that is earthquake signal according to input vibration. In the final code we are describing that first we have to select COM port according to our system then serial communication is starting. Select the value of row and column for displaying signal for 20 digital values. This cycle is continuing for next 20 value of digital signal. According to the input vibration and displacement output data is display on MATLAB screen.
Software used-
Philips flash utility
Keil tool By ARM
MATLAB software

4. ALGORITHM

In order to have cost effective and small size system we are using MEMS accelerometer and ARM7 controller. Realization steps of the algorithm proposed is as follow, with which effective earthquake signal are plotted on MATLB.

1. Initialization of system.
2. Initialization accelerometer with RC filtering. Selection of capacitor is according to bandwidth range as per requirement.
3. Initialization inbuilt ADC for conversion of analog to digital conversion, output of this is in digital form..
4. Start ADC conversion and read analog data in digital form.
5. Initialization communication in serial form with MAX 232.
6. Initialization communication with wireless module and send data to wireless module.
7. Data is collected by server from different nodes, receiver is collected all data at receiver side.
8. Display the seismic data at the receiver side proportional to the input with the help of MATLAB software.

5. FLOWCHART

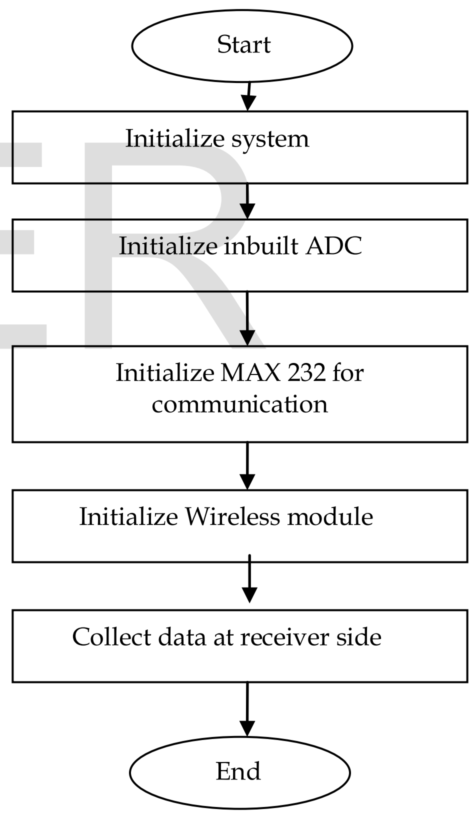


Fig- 3: Flow chart of the system

6. RESULT

Figure shows the result of the system which a earthquake signal also called as seismic data. The graph is plotted time on X-axis Vs Amplitude on Y-Axis. When particular area is affected because of earthquake 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 and plots the output signal on the

MATLAB screen.

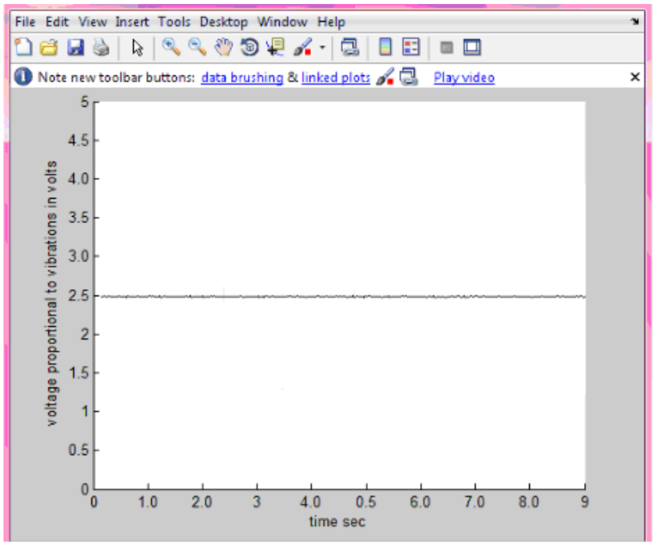


Fig-4: Signal without any vibrations

Above fig-4 shows that straight line of the earthquake signal
Because there is no any vibration available at the input side Hence there is no any peak available on the earthquake waveform.

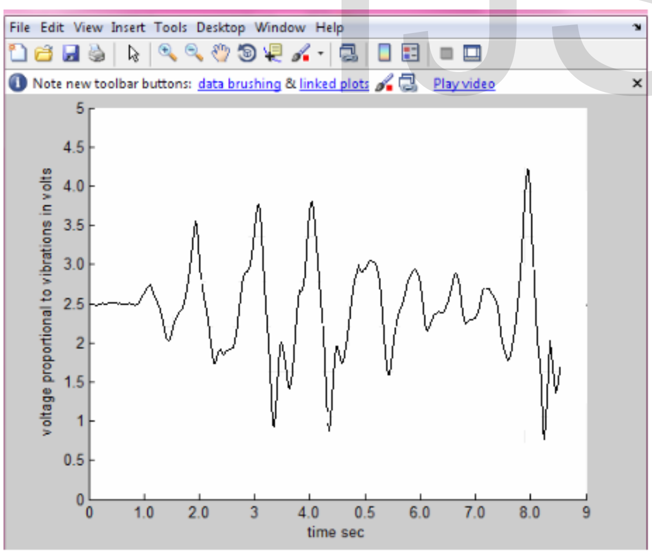


Fig-5: Signal of diagonal Vertical movement Vibrations

Above fig-5 shows that low peak and high peak in the graph because of diagonal vertical movement vibration which is at Z direction that is diagonal direction. It shows that maximum peaks of signal are changes according to the input vibration of the accelerometer.

If mobile vibrate continuously then small peak which is shown in the graph will appear in continuous fashion because movement of mobile vibration is less. Mobile keeps changing their position at very small amount.

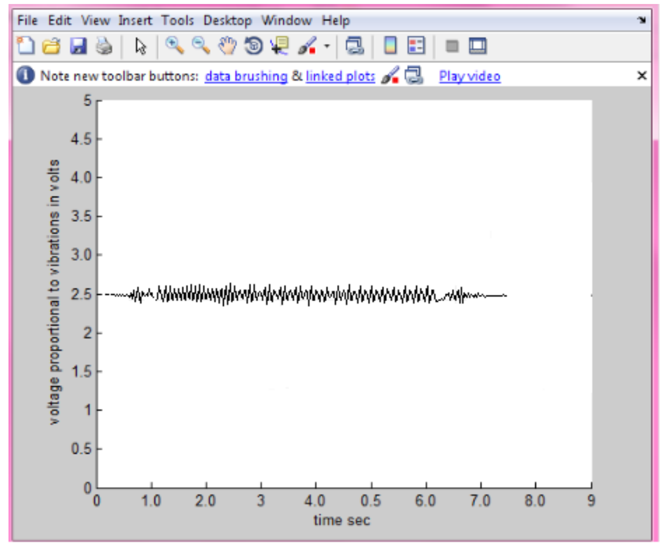


Fig-6: Signal of Mobile vibration

Above fig-6 shows Earthquake signal of Mobile vibration when Mobile get vibrate small peak present in the waveform when vibration stops signal is available at reference line. It shown that on Y-axis voltage is given and on X-axis time is available in second.

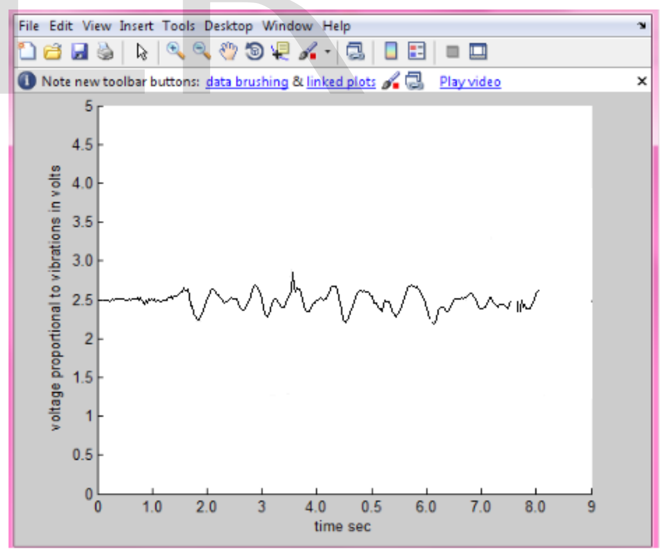


Fig-7: Signal of horizontal movement vibration

Above fig-7 shows that small peaks present in the waveform of the Earthquake signal.Because movement of the vibration is horizontal we are connecting only Zout in the system and not Xout and Yout that is why we are getting small peak when vibration present on X direction that is horizontal direction.

TABLE -2
% ERROR COMPARISON BETWEEN CONTROLLER AND ADC

System	ADC resolution	speed	Input Voltage	Measured voltage	% error
ADC 0808 + 8051	8 bit	11.2ksps	1.02	1.0280	0.784
			1.92	1.9388	0.9791
			2.8	2.8168	0.6
LPC2148/PIC16F877A	10 bit	420 ksps	1.02	1.0224	0.23
			1.92	1.9224	0.125
			2.8	2.8016	0.0571
AD7171	16 bit	0.125ksps	1.02	1.0200024	0.00023
			1.92	1.9200648	0.003375
			2.8	2.800031	0.0011

7. CONCLUSION

As was stated in the introduction, the purpose of this paper is development of new system for earthquake signal. In the Result table:-2 shows the comparison of % error with different controller and ADC. It is shown that in first case we are using ADC 0808 which of 8-bit with 8051 microcontroller we are getting speed as well as % of error more. In third case we are using AD7171 here we are getting less speed as well as less % error. In second case we are using ARM7 LPC2148 and inbuilt ADC which is of 10 bit here we are getting more speed and % of error is also less. Because of that we are selecting ARM7 LPC2148 microcontroller for our system. 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. Where as 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 bit 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 stored the data for further analysis in database.when we get information of particular area then we can save life of many people.

REFERENCES

[1] JIANG H T, GUO ZH Y. “Design of aircraft tilt measurement system based on mems accelerometer sensor”, Computer Measurement & Control, 2010,18(1):107-109.
[2] D. Bottazi, A. Corradi, and R. Montanari, “Context-aware middleware solutions for anytime and anywhere emergency assistance to elderly people,” IEEE Communications Magazine, vol.44, pages 82–90, 2006.
[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 measurementand detection system using MEMS sensor”, pp 220-260, 2008.
[5] M. Griffin, Handbook of human vibration. London: Academic Press,1990.
[6]] M. J. Griffin, “Evaluating the effectiveness of gloves in reducing the hazards of hand-transmitted vibration, Occupational and environmental medicine”, vol. 55, pp. 340-348, 1998.
[7]] K. L. McGeoch, I. J. Lawson, F. Burke, G. Proud, and J. Miles, “Diagnostic criteria and staging of hand-arm vibration syndrome in the United Kingdom, Industrial Health”, vol. 43, pp. 527-534, 2005.
[8] Ontario government, Workplace safety and insurance act. Toronto: Insight Press, 1997.
[9] T. J. 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.
[10] Alejandro Martinez, Pereira Michael Jones “Fundamentals of Borehole Seismic Technology” 1-17,2000.
[11] Hatton, L., Worthington, M. H. and Makin, J., “Seismic Data Processing Theory and Practice”. Blackwell Scientific Publications, ISBN 0-632-01374-5, 1986.
[12] Yilmaz, O, “Seismic Data Processing”, Society of Exploration Geophysicists, USA, 102-130 1989.
[13] Aki, K. and P. G. Richards W. H.San Francisco, “Quantitative

Seismology", Vol 1, Chapter 10: principles of seismometry, 477-524.(1980).
[14] Allen, R. V. (1978) " Automatic earthquake recognition and timing from single traces". Bull. Seism. Soc. Am. 68,1521-1532
[15] Shyam Sadasivan. ARM white book ARM Cortex-M3 introduction in PDF[EB/OL].http://www.zlgmcu.com.
[16] Guoliang Bai, Hongxing Li and Yongtao Bai: Experimental Study and analysis of the hysteretic behavior of the RC scattered shear wall-SRC frame-bent structures for thermal power plant[J]. China Civil Engineering Journal. Vol. 44(8)(2011), p59.