Wireless Earthquake Alarm System using ATmega328p, ADXL335 and XBee S2

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***Abstract* - Many life and properties have been lost due to the earthquake. Many countries have implements EEW (Early Earthquake Warning) System to save human lives. In this paper an idea of low cost earthquake alarm system using ATmega328p, ADXL335 and XBee S2 has been discussed.**

***Keywords*- Earthquake, EEW, ADXL335, ATmega328p, XBee S2.**

I. INTRODUCTION

One can't ignore natural laws in spite of many developments in science and technology. Nature has forced the scientific community to think or predict some natural warnings. Earthquake is one of the most damaging natural activities which offer serious threat to areas near major active faults on land or subduction zones offshore.

Earthquake happens due to the sudden release of large amount of energy from the earth's crust. Because of this energy earth generates some destructive waves known as seismic wave. It has been found that the seismic waves include shear-wave, longitudinal wave and surface wave. The longitudinal wave and shear wave are also known as P-wave and S-wave respectively. Out of all waves surface wave is the most destructive in nature, but the speed of the surface wave is slower than the other waves. The P-wave's vibration direction and the forward motion are found to be same, which is the fastest in nature among the all waves. However, the destructive force of P-wave is found to be low. The

S-wave's vibration is perpendicular to the forward direction, whose speed is lower than P-wave but the destructive force is high.

Due to the urbanization, earthquake offer serious threat to human lives. According to Geller R.J. [1] et.al, the prediction of earthquake is impossible. Still many research works are still going on for the prediction of earthquake.

Early Earthquake Warning system is one of the useful developments to save human lives [2]. EEW detects the P-waves and generates warning as the most destructive S-wave follows the P-wave. It has been reported that some countries have already implemented EEW to rectifying earthquake hazards [3-4]. But still many countries don't have EEW, as the cost of implementation is too high. For those countries there must be some low cost earthquake alarm system to save human lives.

This paper shows the design of low cost earthquake alarm system which can be used by the people in their home to save their lives at the time of earthquake. If the acceleration of the seismic wave is greater than the predefined value, the system blows the alarm. This system can be used in multistoried building as the alarm is connected wirelessly as shown in the Figure 1.

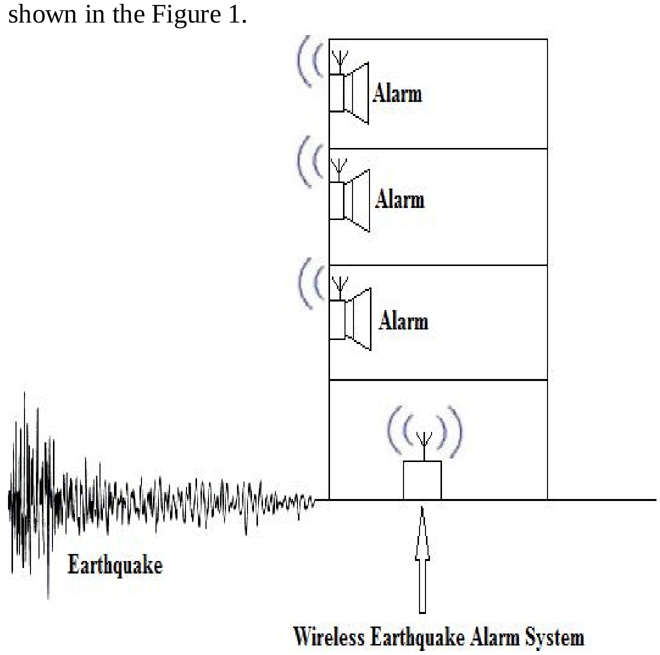

Figure 1: Wireless Earthquake Alarm System used in multistoried building

II. STRUCTURE OF THE SYSTEM

The structure of wireless Earthquake Alarm System includes one transmitting part and one or more than one receiving parts.

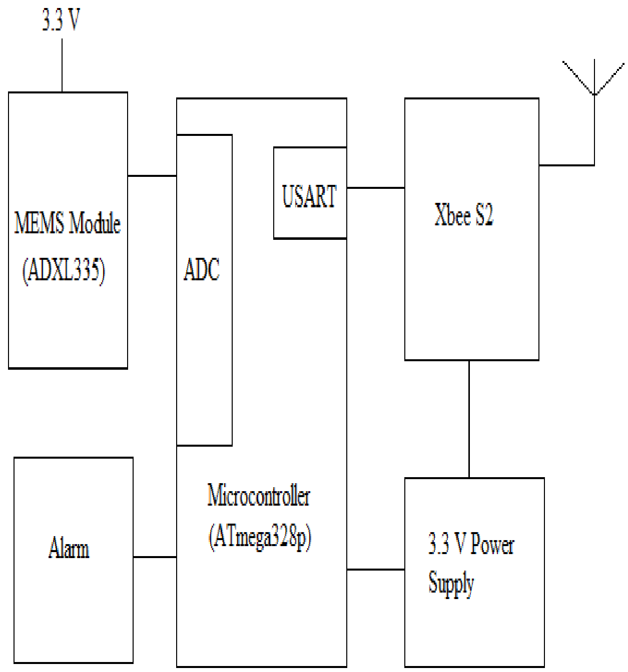

Figure 2: Transmitting part of wireless earthquake alarm system

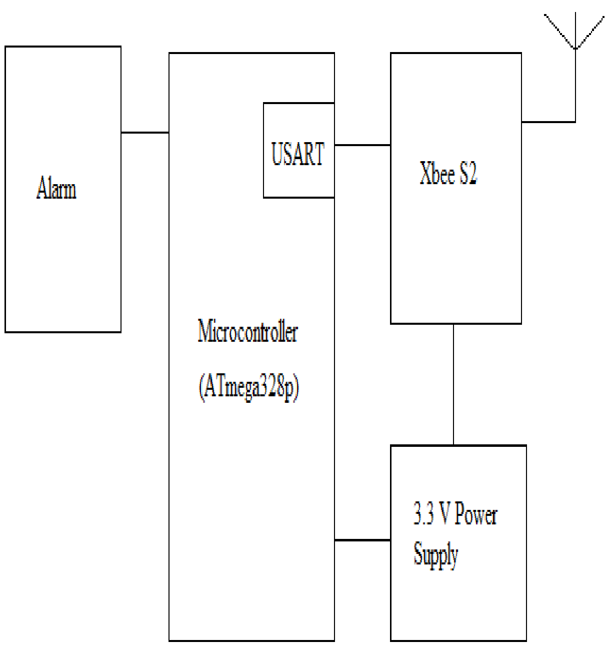

Figure 3: Receiving Part of wireless earthquake alarm system

The transmitting part includes the ADXL335 MEMS accelerometer made by Analog Devices, which can detect the vibration (Peak Ground Acceleration) produces due to earthquake. This part also includes a microcontroller (ATmega328p) to process the values getting from ADXL335 and generate a signal when the ground acceleration is greater than the threshold value. The signal generated by the controller is then send to the receiving part wirelessly using XBee S2. Figure 2 and 3 shows the block diagram of the transmitting part and receiving part.

ADXL335: As reported earlier ADXL335 is a MEMS accelerometer made by Analog Devices. MEMS Accelerometer is a device which can detect gravity, vibration and shock etc. It has been found that MEMS Accelerometer has various applications such as for gaming applications in mobile phones, image rotation and stabilization in digital camera, automotive air bags etc. [5-6].

ADXL335 is a thin, low power, 3-axis accelerometer with a minimum full scale range of ±3g. Figure 4 shows the functional block diagram of ADXL335.

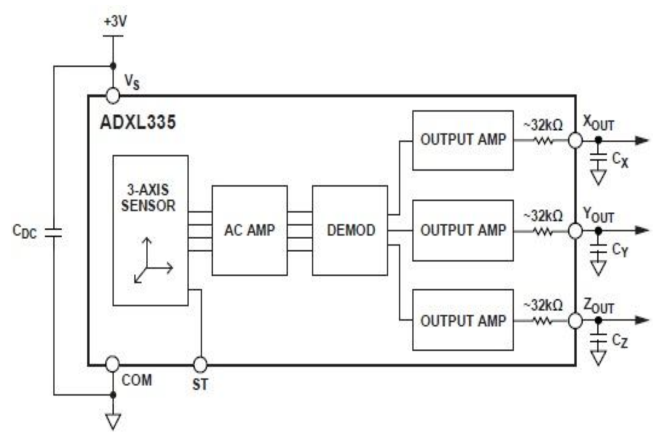

Figure 4: Functional Block Diagram

ADXL335 is connected to ADC pins of ATmega328p. It sends voltage levels to the microcontroller.

ATmega328p: ATmega328p is a high performance, low power AVR 8-bit Microcontroller. It has 23 programmable pins and operating voltage is low (1.8-5.5v).

The main function of this module is processing the acceleration signal and comparing with the predetermined threshold value. ATmega328p has 10-bit successive approximation ADC. The ADC is connected to an 8-channel Analog Multiplexer which allows eight single-ended voltage inputs constructed from the pins of Port A. The single-ended voltage inputs refer to 0V (GND). In this system, 3 pins of Port C are connected to ADXL335 and the USART (Universal Synchronous and Asynchronous serial Receiver and Transmitter) is connected to XBee S2 to send signal to the receivers. The microcontroller calibrates the values (voltage levels) get from ADXL335 and calculates the peak ground acceleration. As reported earlier, if calculated value is greater than threshold value then it generates alarm and sends a signal to the receivers.

XBee S2: XBee S2 is one of the powerful modules to communicate wirelessly. It has 40m in urban/indoor range and 120m outdoor line of sight range. It has been found that point-to-point, point-to-multipoint and peer-to-peer topologies are supported by XBee S2. X-ctu software is used for configuring XBee S2.

In this system XBee S2 is connected to the USART of the microcontroller. XBee S2 Dout pin is connected to Rx pin of ATmega328p. However, Din pin is connected to Tx pin of ATmega328p.

III. SYSTEM WORK FLOW

A workflow of a system is the stepwise representation of the operation of the system. The steps are represented as the boxes of various sizes. Figure 5 shows the workflow of the transmitting part and Figure 6 shows the workflow of receiving part.

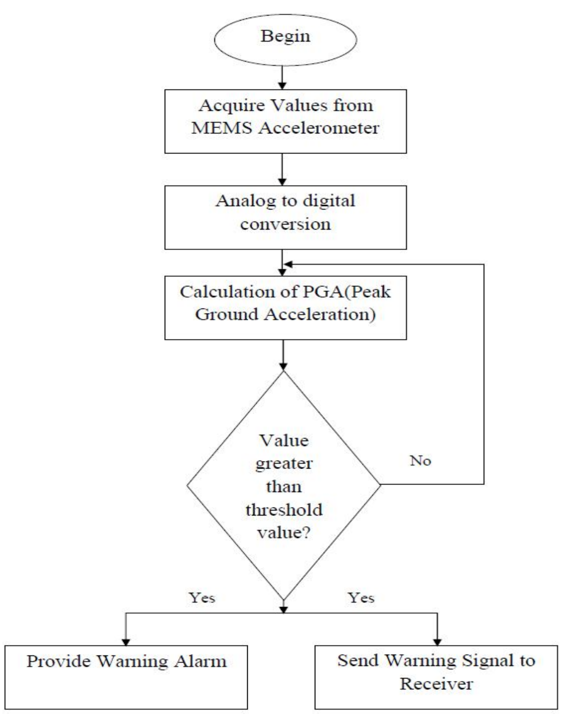

Figure 5: Transmitting part work flow

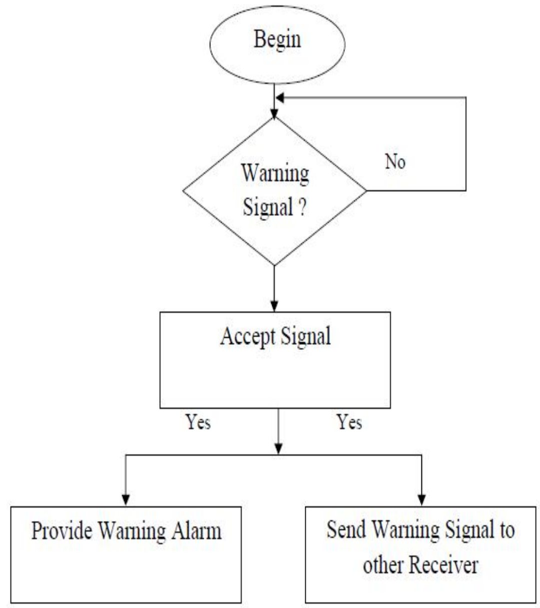

Figure 6: Receiving part work flow

IV.ADXL335 CALIBRATION

As reported earlier ADXL335 send voltage levels to the ADC of the microcontroller. The values from the ADC from the microcontroller when ADXL is placed at top position are shown below [Figure-7].

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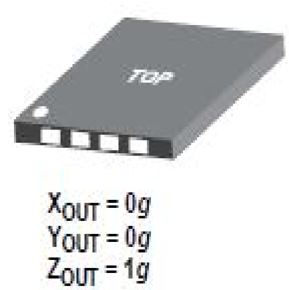

Figure 7: Values of Z=1g position

For measuring the Peak Ground Acceleration ADXL335 must be calibrated. It has been found that there are many ways to calibrate accelerometer. One of the calibration methods is Least-squares and Gauss-Newton method. In this method the accelerometer is placed in six perfect axial positions and collects the values.

Let m_x, m_y, m_z and d_x, d_y, d_z are the values of the accelerometer when it placed in six perfect axial position (m stands for the values when it placed 1g position and d stands for the values when it placed -1g position). Again let a = (a_x, a_y, a_z) is the acceleration vector in x, y and z plan.

Therefore the acceleration values can be written as,

$$a_x = (x-m_x) / d_x ,$$

$$a_y = (y-m_y) / d_y ,$$

$$a_z = (z-m_z) / d_z$$

Where x, y, z are the three axial value at all the position. If the values are taken at zero noise condition sum of the square of all the above values are equaled to 1.

$$a_x^2 + a_y^2 + a_z^2 = 1$$

But in presence of noise there might be some error. And these errors are nonlinear. It has been found that the non linear Least-Square problem can be solved numerically using Gauss-Newton method.

V. XBEE CONFIGURATION

For communicating XBee, they must be configured. It has been reported earlier that X-ctu software is used to configure the XBee. Figure 8 shows some part of the X-ctu software.

Figure 8: X-ctu Software

In this system the transmitting part XBee is configured as Coordinator and the receiving part XBee's are configured as Router or End Device. In X-ctu XBee can be configured as AT mode or API mode. It has been found that for transmitting between XBee's the PAN ID should be configured same for all the modules. Figure 9 shows a network of one coordinator connected to two routers in X-ctu software.

Figure 9: Coordinator and Routers in X-ctu

VI.RESULTS

As reported earlier, wireless earthquake alarm system is a low cost system which can be used by people in their home as a consumer product to save their lives. However, this system also consumes less power as the microcontroller and XBee consumes less power and they can be used in sleep mode too. Figure-10 and Figure-11 shows some snap shot of wireless earthquake alarm system using ATmega328p, ADXL335 and XBee S2.

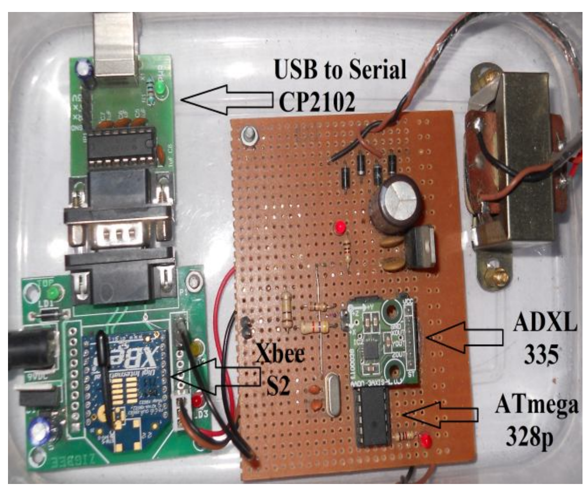

Figure 10: Transmitting part

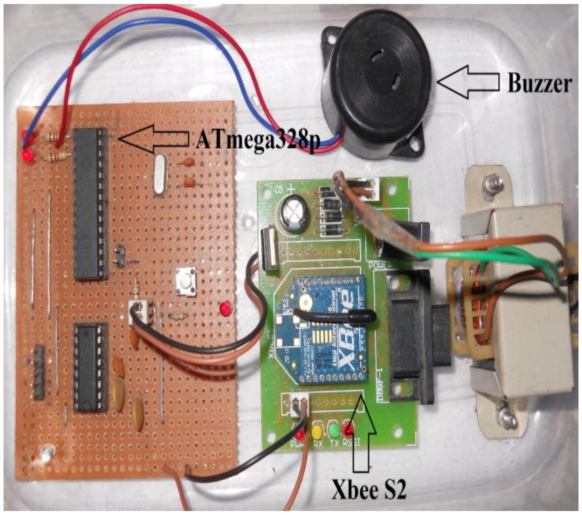

Figure 11: Receiving Part

VII. CONCLUSION

Through this paper a design of wireless earthquake alarm system is discussed. This system has many advantages such as low cost, low power consumption and small in size. As mentioned earlier it can be used in multistoried building with many receiving part with single transmitting part.

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REFERENCES

[1] R.J.Geller, D.D. Jackson, and Y.Y. Kagan, and F. Mulargia, “Enhanced Earthquakes cannot be Predicted” , Science, Vol 275.pp.1616-1620. 1997.

[2] Yih-Min Wu; Kanamori, H. “Development of an Earthquake Early Warning System Using Real –Time Strong Motion Signals” Sensors 8, pp1-9, 2008.

[3] Richard M. Allen, Paolo Gasparini, Osamu Kamigaichi and Maren Bose; “ The Status of Earthquake Early Warning around the World: An Introductory Overview”, Seismological Research Letters; Volume 80, Number 5, September/October; doi:10.1785/gssrl.80.5.682.

[4] Sanjib Kalita, J.N. Borole, “Needs of Early Earthquake Warning System in North-Eastern Region of India”, International Journal of Engineering Research & Technology (IJERT), pp501-504, ISSN: 2278-0181, Vol.3 Issue 3, March-2014.

[5] Sanjib Kalita, J.N.Borole, “Application of MEMS Accelerometer To Consumer Electronics” International Conference on Modeling and Simulation in Engineering and Technology, ICMSET-2014, pp188-190, Feb15-16.

[6] Sanjib Kalita, “Uses of MEMS Accelerometer in Seismology”, International Journal of Advanced Research in Engineering and Technology (IJARET), ISSN 0976-6480(print), ISSN 0976-6499(online), Vol-4,Issue-6,pp57-61,2013.