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Wireless Earthquake Alarm

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Abstract: 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.

Keywords: XBee S2, P-wave, S-wave and GSM.

1. INTRODUCTION

An earthquake consists of many individual elastic waves. The functioning of EWS is based on the principle that these waves have travelled from the epicenter to recombine at the recording site as a function of their respective velocities, focal distances, and propagation paths. Body waves propagate within a body of rock and appear in the first arrival.

A. SEISMIC WAVES:

All earthquakes are made of two types of wave. The P-wave compresses the earth as it moves, like a sound wave. It moves fast but does not cause much damage. The S-wave that follows deforms rock up and down like an ocean wave. It delivers most of the tremor's violent energy .The fastest among these body waves is the primary or P-wave. The P-wave is the first elastic wave to reach the recording site. The secondary arrival contains body and surface waves such as S, Rayleigh, and Love waves. These later arriving waves often produce both horizontal and vertical ground motion. The combination of their peak velocities, peak accelerations, and duration of time they persist cause significant damage to infrastructures. As P-wave arrive onset of an earthquake, there are systems built for earthquake monitoring using P wave based technique.

B. CAUSES OF EARTHQUAKES:

Most earthquakes are causally related to compressional or tensional stresses built up at the margins of the huge moving lithospheric plates that make up the earth's surface. The immediate cause of most shallow earthquakes is the sudden release of stress along a fault, or fracture in the earth's crust, resulting in movement of the opposing blocks of rock past one another. These movements cause vibrations to pass through and around the earth in wave form, just as ripples are generated when a pebble is dropped into water. Volcanic eruptions, rock falls, landslides, and explosions can also cause a quake, but most of these are of only local extent. Shock waves from a powerful earthquake can trigger smaller earthquakes in a distant location hundreds of miles away if the geologic conditions are favorable.

C. DAMAGE CAUSED BY EARTHQUAKES :

The effects of an earthquake are strongest in a broad zone surrounding the epicenter. Surface ground cracking associated with faults that reach the surface often occurs, with horizontal and vertical displacements of several yards common. Such movement does not have to occur during a major earthquake; slight periodic movements called fault creep can be accompanied by micro earthquakes too small to be felt. The extent of earthquake vibration and subsequent damage to a region is partly dependent on characteristics of the ground.

For example, earthquake vibrations last longer and are of greater wave amplitudes in unconsolidated surface material, such as poorly compacted fill or river deposits; bedrock areas receive fewer effects. The worst damage occurs in densely populated urban areas where structures are not built to withstand intense shaking. There, L waves can produce destructive vibrations in buildings and break water and gas lines, starting uncontrollable fires. Damage and loss of life sustained during an earthquake result from falling structures and flying glass and objects. Flexible structures built on bedrock are generally more resistant to earthquake damage than rigid structures built on loose soil. In certain areas, an earthquake can trigger mudslides, which slip down mountain slopes and can bury habitations below. A submarine earthquake can cause a tsunami, a series of damaging waves that ripple outward from the earthquake epicenter and inundate coastal cities.

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D. WARNING SYSTEM:

The high precision sensor with trending advancements technology, dedicated damage mitigation control systems can be made. These systems can not only record seismic activity but can also take control measures to alleviate the disastrous effects of a catastrophic seismic event on critical infrastructures. Developing such a site-specific EWS that works on a threshold based triggering algorithm. In this site specific approach, seismic signals are processed locally for determining instantaneous tremor magnitude of earthquake. This approach is suitable because it intend to install the system on-site for damage mitigation in a EWS facilitated infrastructure, rather than a regional paradigm approach which takes into account the measurement of complex earthquake parameters e.g. locating epicenters, depth etc. The EWS can effectually be implemented in sensitive sites such as next to a nuclear reactor or a chemical depot. Use of embedded system keeps the development cost low, so that the system can be made available to households in earthquake prone zones in underdeveloped countries. It attempts to observe the beginning of the ground motion (mainly P wave) at the site using direct sensor fusion technology to detect the ensuing, weak ground motion. At the same site, no attempt is necessarily made to locate the event and estimate the magnitude. This system shows the design of low cost earthquake alarm system using ATmega328p, ADXL335,GSM Module and XBee S2 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 Fig.1.

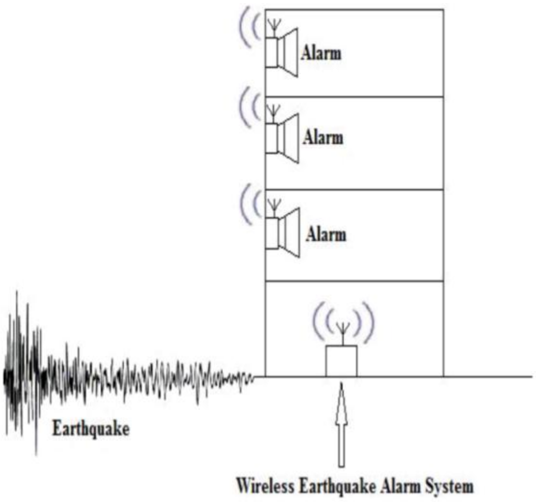

Fig1: Wireless Earthquake Alarm System used in multistoried building.

In modern earth quake detection has been implemented the algorithms in TinyOS and conducted ex-tensive evaluation on a test bed of 24 TelosB motes as well as simulations based on real data traces collected during 5.5 months on an active volcano. It shows that the approach yields near-zero false alarm/missing rate and less than one second of detection delay while achieving up to 6-fold energy reduction over the current data collection approach[1].

2. PROBLEM STATEMENT

A large number of earthquakes are felt all over the globe every year. The small ones are unnoticed while the large ones are felt over thousands of kilometers. Earthquakes have damaged and destroyed human lives since time.
It is therefore important to design low cost earthquake alarm system which can be used by the people in their home to save their lives at the time of earthquake.

3. SYSTEM ARCHITECTURE

3.1 BLOCK DIAGRAM

The structure of wireless Earthquake Alarm System includes one transmitting part and one or more than one receiving parts. 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 and GSM module. Fig 2 & 3 shows the block diagram of the transmitting part and receiving part respectively.

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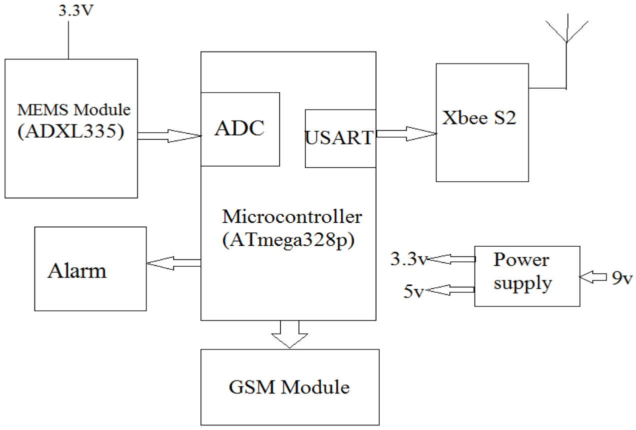

Fig2: Transmitting part of wireless earthquake alarm system.

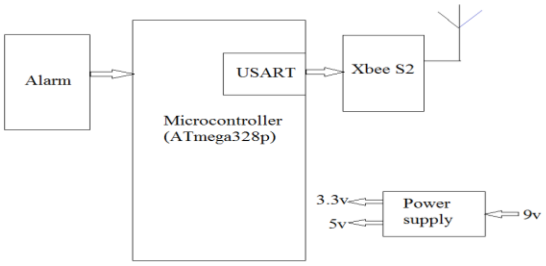

Fig3: Receiving Part of wireless earthquake alarm system.

3.2 Principal of Operation

The ADXL335 is a complete 3-axis acceleration measurement system. The ADXL335 has a measurement range of 3g minimum. It contains a polysilicon surface-micro machined sensor and signal conditioning circuitry to implement open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration. The sensor is a polysilicon surface-micro machined structure built on top of a silicon wafer. Polysilicon springs suspend the structure over the surface of the wafer and provide a resistance against acceleration forces. Deflection of the structure is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration. Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration. The demodulator output is amplified and brought off-chip through a 32 kΩ resistor. The user then sets the signal bandwidth of the device by adding a capacitor. This filtering improves measurement resolution and helps prevent aliasing.

3.3 Mechanical Sensor

The ADXL335 uses a single structure for sensing the X, Y, and Z axes. As a result, the three axes' sense directions are highly orthogonal and have little cross-axis sensitivity. Mechanical misalignment of the sensor die to the package is the chief source of cross-axis sensitivity. Mechanical misalignment can, of course, be calibrated out at the system level.

3.4 Performance

Rather than using additional temperature compensation circuitry, innovative design techniques ensure that high performance is built in to the ADXL335. As a result, there is no quantization error or no monotonic behavior, and temperature hysteresis is very low (typically less than 3 mg over the −25°C to +70°C temperature range)

4. RESULTS AND DISCUSSION

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. Figures 4, 5 & 6 some snap shots of Wireless Earthquake Alarm System using ATmega 328p, ADXL 335, Arduino UNO, GSM Modem, XBee S2, Buzzers and a House Model for Demonstration Purpose.

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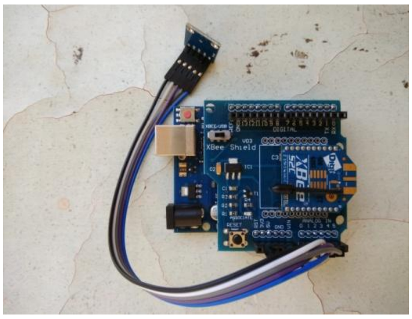

Fig4: Transmitter section with ADXL335 Sensor.

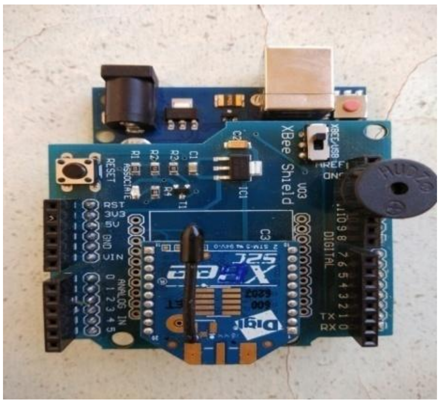

Fig5: Receiving part terminal.

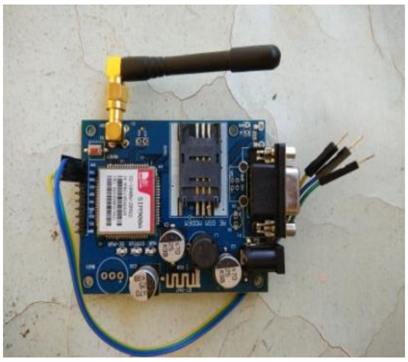

Fig6: GSM Module.

5. CONCLUSIONS

Early Earthquake Warning system is one of the useful developments to save human lives. EEW detects the P-waves and generates warning as the most destructive S-wave follows the P-wave. 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. 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.

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