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Arduino Based Earthquake Detector using Accelerometer

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ABSTRACT: An unexpected movement of the earth's surface is called an earthquake. When two parts of the earth surface move suddenly in relation to each other along a fault line, due to tectonic forces, an earthquake occurs. An earthquake (also known as a tremor or temblor) is the result of a sudden release of energy in the earth's crust that creates seismic waves. Earthquakes are recorded with a seismometer, also known as a seismograph. The moment magnitude of an earthquake is conventionally reported, or the related and mostly obsolete Richter magnitude, with magnitude 3 or lower earthquakes being mostly imperceptible and magnitude 7 causing serious damage over large areas. Intensity of shaking is measured on the modified Marcella scale. An earthquake is an unpredictable natural disaster that causes damage to lives and property. It happens suddenly and we cannot stop it but we can be alerted from it. Now-a-days, there are many technologies which can be used to detect the small shakes and knocks, so that we can take precautions prior to some major vibrations in earth. This work uses an accelerometer to detect the pre-earthquake vibrations. Accelerometer is highly sensitive to shakes and vibrations along with all the three axes. The advantage of building an Arduino based Earthquake Detector using Accelerometer is to reduce its destructivelosses.

KEYWORDS: Earthquake, Vibration, Disaster, Aurdino, Accelerometer, Detection.

I.INTRODUCTION

An earthquake is the shaking of the surface of the Earth, resulting from the sudden release of energy in the earth's lithosphere that creates seismic waves. An earthquake is what happens when two blocks of the earth suddenly slip past one another. The surface where they slip iscalled the fault or fault plane. The location below the earth's surface where the earthquake starts is called the hypocenter, and the location directly above it on the surface of the earth is called the epicenter [1]. During earthquake, degree of the damage caused is depends on the magnitude that indicates the amount of energy released from Earth crust. The magnitude of earthquake which is less than 5 is measured using local magnitude scale called as Richter magnitude scale. It measures the magnitude of earthquake by observing the amplitude on a seismogram. In recent years, a standard magnitude scale is used which represents energy released at the time of earthquake more precisely including large magnitude events. This technique makes use of devices like seismometer, geophone, and accelerometer. Meanwhile before selecting any seismic sensor we need to know that the seismic sensor should provide signals which are unaffected by the sensors inherent characteristics and as closely as possible reflect the true soil response to the seismic source wave traveling through it. In terms of frequency response of the receiver, its output should be constant for all input frequencies. In addition, the phase of the input frequency should be unaffected so that the wave's shape does not change. In general terms, it isdesirable to have a seismic sensor with a fast response time and a small settling time [2]. When it comes to the selection of a seismic sensor though Geophones have larger peak time and settling time compared to accelerometer but the accelerometer are selected for the seismic activities because of their low noise, fast response times, and high bandwidths compared togeophones.

1.1 Seismic Waves

As these Tectonic Plates are moving the energy that would normally cause the blocks to slide past one another is being stored up. When this force overcomes the friction of the Fault edges, all the stored energy is released. This energy is radiated outward s from the focus in all directions in form of Seismic waves. These Seismic waves produced tend to shake the earth surface as it moves through it. When we talk about Seismic wave , these are further of two types , Body waves and Surface waves [4].We focus more on body waves rather than surface waves because the source regions can be constrained in both azimuth and distance using conventional array technique . Also, the velocity of Surface wave is even less than 2 mi. per sec as compared to velocity of Body wave. Body waves are classified into Primary waves (P waves) and Secondary Waves (S waves). P waves are the longitudinal waves and travel with a velocity of 6.4 km per sec while S waves are the transverse waves and travel at 3.2 km per sec [5]. Therefore, P waves being the fastest

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among all the Seismic waves are the first to be detected on the seismograph and help predicting it. Frequency range for P waves varies from 1Hz to 10 Hz with wavelength of range 600 m to 6km. While the Frequency range of S waves is from 0.1 Hz to 0.2 Hz with a wavelength of 10 km .The seismic data collected for the earthquake prediction can also be used to detect vibrations due to heavy vehicle transport or heavy drilling. In seismological experiments, each component of acceleration that is along x, y, and z axes is important, however in seismological calculations only one component has been considered [6]. This measurement can be done when any seismic source start generating seismicwaves.

1.2 Causes of Earthquake

Earthquakes can be caused by two ways: natural or caused by humans. The constructions and deforestation of the green belt are the causes of many calamities [7]. The trees help in binding the soil which helps in preventing landslides and earthquakes. The deforestation of these jungles or green belt leaves the soil loose and more prone to fall free. Earthquakes are mostly caused due to the tear of the geological faults and also by various other disasters such as landslides, mine blast, volcanic eruptions, and nuclear tests. These disasters cause the cosmic plates to fall apart which leads to earthquakes. They cause imbalance in the earth surface and leads to loss of lives and property.

On the surface of earth, earthquakes occur due to the shaking and displacing or disrupting the earth's surface. These causes the casualties on life and on properties. Tectonic earthquake may occur anywhere in the surface of the earth, where there is enough stored elastic strain energy for driving fracture propagation within a fault region [8]. The movements within these tectonic plates cause disruption of the plates and fractures the planes within that region. These often cause the upliftment of the 13 plates as the position cannot be the achieved as it was placed earlier. Some even cause the downfall of the plates which results in the large gap within the plates as the plates cannot be placed in their original places. The release of this energy which was stored as a combination of radiated elastic strain seismic waves, breaking of rocks and fault surface heating caused by friction, which causes an earthquake [9]. This breaking of rocks often results in the growing of the land mass and thus may cause calamities as the sea or water level may increase which can cause damage to the lives and the surroundings. The fault surface heating caused by the friction between the tectonic plates may result in the causing of an earthquake. The radiated elastic strain of the seismic waves causes disruption within the earth surface and causes the moving of the plates within the surface of the earth. The three important types of faults that can cause an earthquake within the plates are: - Reverse, Strike – slip, Normal 14. Any seismic activity in the earth surface is used to describe the earthquake [10]. These seismic events disrupt the actual layout of the earth crust thus resulting in mountains and valleys, which are the result of the inappropriate and the disruption of the earth crust and the alignment of the earth's tectonicplates

1.3 Literature Review

The authors in [1]presented an Arduino based security system. The basic idea behind this workis that all the bodies generate some heat energy in the form of infrared which is invisible to human eyes. But, it can be detected by electronic motion sensor. Since, at home there will be present of domestic animal like cat, mice, dog etc. but we need to detect only human being so, we use a seismic sensor which will detect the footfall vibration frequency of human being which is 4Hz to 8Hz and above depending on the floor but footfall of animal like cat, mice etc. is less than 0.5Hz, so the sensor will not detect these animals. The system in [2] focuses on monitoring water level & earth vibrations via sensors, and generates alert signal when water level or level of earth vibrations crosses a threshold. Alert message in the form of SMS will be sent to concerned authorities through the GSM. It alsoincludes siren to broadcast the messages to the local people, nearby the river side. The system can also shows status of water level through the LCDdisplay. This work [3] designed a system just as a proof of qualitative concept and was not tested on a large scale during actual earthquakes. The prototype did manage to detect simulated earthquake-like tremors with magnitudes of 4.0. Several improvements may be brought to this system. A 3 axis accelerometer can replace the FSR for detection in all planes independent of frequency. 2D Multi-gas mapping techniques with cascading module system over a wireless sensor network can be used to monitor the gas leaks at multiple points. 3 Pattern recognition algorithms based on positive decision logic may be integrated into this system. The authors in [4] proposed a low cost earthquake alerting system. A NodeMcuEsp8266 with GY-61 board is placed at the epicenter of the earthquake location. The warning system can be provided to the recipients before the earthquake reaches theirlocalities. This work [5] mainly used to monitoring the Wireless Earthquake alarm design using MEMS accelerometer. In order to mitigate earthquake disaster caused by the structure of building, the strong motion observation is the most important means to scientific understanding of above problem. Earthquake alarm researched in this paper was based on the strong motion observation theory adopted MEMS accelerometer and wireless transmission technology, was more advanced and practicaldevice.

The authors in [6] developed a system usingATmega328microcontroller.Themaincomponents used in this system are

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sensors, GSM and Wi-Fi module. In the proposed project, various types of real time conditions are tested. This work can be also useful to the scientists for their studies on earthquakes using the graphs plotted and futureconditions. Earthquake Detection Using Machine Learning was presented in [7]. The drawbacks of the analog systems are replaced by digital systems so that data can be recorded digitally. Using different sensor to identify the natural disaster, MEMS, VIBRATION sensor is used to monitor the earth condition , the different values of the different sensor is given to the ADC to convert the values in digital format, if any changes occurs or in abnormality condition BUZZER will ring. The work proposed in [8] involves design and development for the earthquake alarm detection circuit based on electronic devices only which will be highly helpful for the determination of high frequency vibrations which will trigger an impulse when the S wave is detected by the earthquake sensor which in this case is a shaft with load that represents a steel or building structure that shakes vibrations when the corresponding surface wave reaches the ground. The circuit is activated to read for 10 seconds with the use of an Arduino microcontroller that latches the output as high for 10 seconds and reads the shaft output vibration data for further diagnosis. Arduino is an open-source prototype platform based on easy-to-use hardware and software [9]. Arduino boards are able to read inputs-light on a sensor, a finger on a twitter message- and turn it into an output-activating a motor, turning on an LED, publishing something online. We can tell your board what to do by something a set of instructions to the microcontroller on the board. To do so we use the Arduino programming language and the Arduino software based on processing. The work in [10] aims at designing an earthquake monitoring and warning system that is capable of detecting earthquakes as well as warning people to take necessary precautions. The low cost automatic microcontroller based system has been designed and implemented using low cost locally sourced electronic components, which senses earthquakes and gas leaks through accelerometer and gas sensor respectively. The designed system will not only try to save human lives, but will also store the data for later use by professionals working at this sector.

1.4 Objectives of the Work

With the extensive literature review above, the following are the objectives formed:

- Designing and development of earthquake alarm detection circuit based on electronic devices which will be helpful to save lives andproperty.
- Main objective is to detect S-waves (seismic waves) or we can say high frequency vibrations at the Arduino Uno input through accelerometer which will give us an indication about earthquake before it strikes at the core of thatplace
- Another thing is to make a device compact, cheap and error free because earthquake is a very big event in this error may cause very bigloss.

To make a device error free we have to find a position where the device should bemounted on the building which will sense the best frequency vibrations, and the device should not damage until the building do not fall. Because the device has done its work it alarmed all the members of building to escape before the building fallover.

II. PROPOSED METHODOLOGY

2.1 Block Diagram

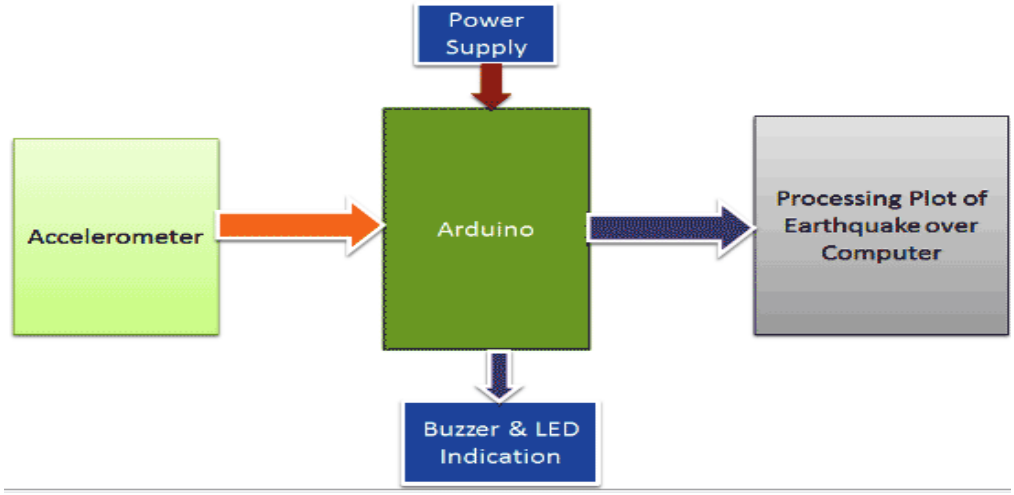

Fig: 1: Block Diagram of the proposed work

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2.2 Block Diagram Description

Working of this earthquake detector is simple. As we mentioned earlier that we have used Accelerometer for detecting earthquake vibrations along any of the three axes so that whenever vibrations occur accelerometer senses the vibrations and convert them into equivalent ADC value. Then these ADC values are read by Arduino and shown over the 16x2 LCD.

First we need to calibrate the Accelerometer by taking the samples of surrounding vibrations whenever Arduinopowers up. Then we need to subtract those sample values from the actual readings to get the real readings. This calibration is needed so that it will not show alerts with respect to its normal surrounding vibrations. After finding real readings, Arduino compares these values with predefined max and min values. If Arduino finds any changes values are more then or less then the predefined values of any axis in both direction (negative and positive) then Arduino trigger the buzzer and shows the status of alert over the 16x2 LCD and a LED also turned on as well. We can adjust the sensitivity of earthquake detector by changing the predefined values in Arduino code.

2.3 Circuit Diagram and Working Principle

2.3.1 Circuit Diagram

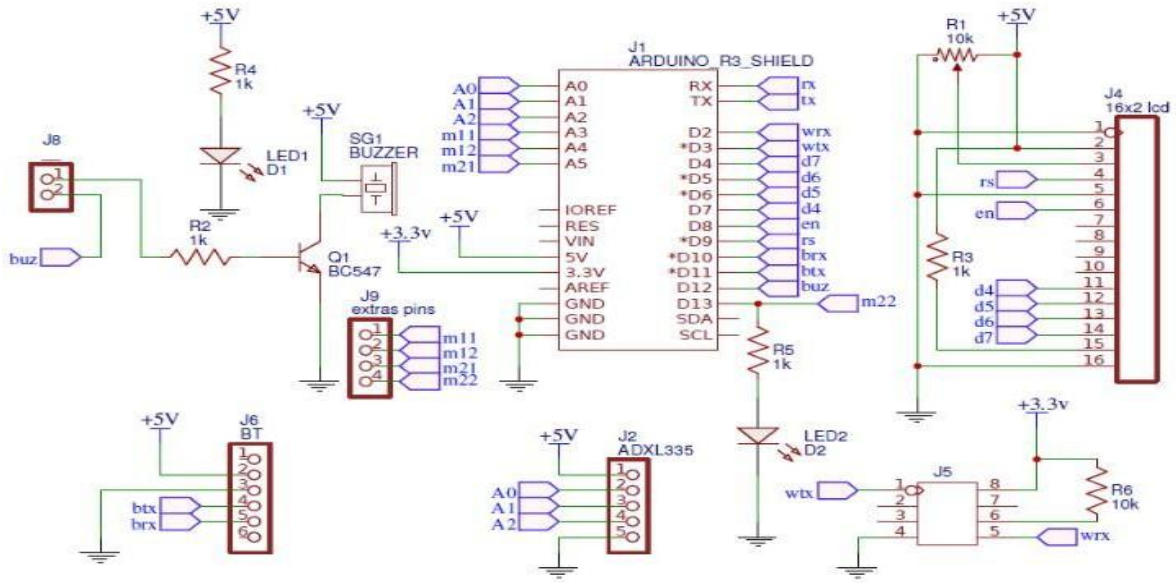

Fig: 2: Circuit Diagram of the proposed work

2.3.2 Working Principle

Circuit of this Earthquake detector Arduino Shield PCB is also simple. In this project, we have used Arduino that reads accelerometer's analog voltage and convert them into the digital values. Arduino also drives the buzzer, LED, 16x2 LCD and calculate and compare values and take appropriate action. Next part is Accelerometer which detects vibration of earth and generates analog voltages in 3 axes (X, Y, and Z). LCD is used for showing X, Y and Z axis's change in values and also showing alert message over it. This LCD is attached to Arduinoin 4-bit mode. RS, GND, and EN pins are directly connected to 9, GND and 8 pins of Arduino and rest of 4 data pins of LCD namely D4, D5, D6 and D7 are directly connected to digital pin 7, 6, 5 and 4 of Arduino. The buzzer is connected to pin 12 of Arduino through an NPN BC547 transistor. A 10k pot is also used for controlling the brightness of theLCD.

2.3.3 Programming Explanation

In this Earthquake Detector Arduino Shield, we have made two codes: one for Arduino to detect an earthquake and another for Processing IDE to plot the earthquake vibrations over the graph on Computer. We will learn about both the codes one by one:

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Arduino code

First of all, we calibrate the accelerometerwith respect to its placing surface, so that it will not show alerts with respect to its normal surrounding vibrations. In this calibration, we take some samples and then take an average of them and stores in a variable. Now whenever Accelerometer takes readings, we will subtract those sample values from the readings so that it can ignore surroundings vibrations. Then Arduino compares those calibrated (subtracted) values with predefined limits. And take action accordingly. If the values are higher than predefined values then it will beep the buzzer and plot the vibration graph on computer using Processing.

Processing code

We have designed a graph using Processing, for earth quake vibrations, in which we defined the size of the window, units, font size, background, and reading and displaying serial ports, open selected serial port etc. In below function, we have received data from serial port and extract required data and then mapped it with the size of the graph. After this, we have plotted unit space, max and min limits, values of x, y and z-axis. After this we plot the values over the graph by using 3 different colors as Blue for x-axis value, green color for y axis and z is represented by redcolor.

III. RESULTS AND DISCUSSION

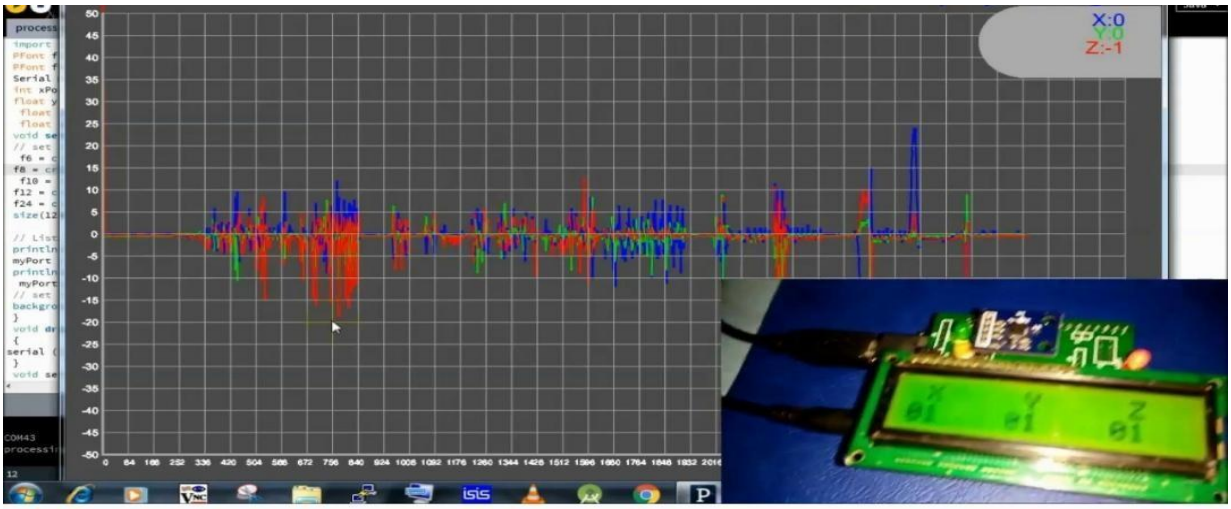

Fig. 3: Earth Quake alert at X, Y, Z axes

The graph shown above indicates the earthquake alert at the X, Y and Z axes. Whenever there is no vibration in the earth, the values are at the zero axes. If the motion is violent enough during an earthquake and crosses a certain threshold i.e., max limit reaches (20) at the x-axis (blue color), LED glows, a buzzer sounds as well as it shows alerting message on LCD. The Arduino based earthquake detector using accelerometer has been tested and it is working satisfactorily. All the components of the system found to be working appropriately. Detection of pre earthquake using accelerometer and giving alerting massage on predefined time will be achieved successfully. Accelerometer ADXL335 senses pre earthquake vibrations and gives analogue voltage equivalent to imposed acceleration in X, Y and Z axes. The three analogue outputs are applied to Arduino Uno ADC pins. Any acceleration caused due to movement in any of the axes is detected by the accelerometer and hence by Arduino ADC. If motion is violent enough during an earthquake and crosses a certain threshold, LED glows, a buzzer sounds as well as it also shows alerting message on LCD and graph can be plotted using software processing IDE.

ADVANTAGES OF PROPOSED SCHEME

- An earthquake detector can be useful home safety devices because it alerts people to earthquake before it happens.
- It is simple to interface and rugged in design.
- The given system is handy and portable, and thus can be carried from one place to another.
- The circuitry is not that complicated and thus can be easily troubleshot.
- The given system is sets off a powerful buzzer, and it is effective than other alarm system available in the market.

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APPLICATIONS

- Accelerometer can be used for tilt sensing applications as well as dynamic acceleration resulting from motion, shock or vibration.
- In the developed project is based on code-based control.

IV. CONCLUSIONS

This work entitled "Arduino based earthquake detection using accelerometer", is successfully developed and working satisfactory. Thus to sum up we have introduced this product with a view to reduce the destruction caused by earthquakeby alerting the people. It is economical and its price is quoted in such a way that it is affordable by every individual. We have presented a novel technique to solve the automatic detection and classification problem of earth tremor in single step by using Arduino based earthquake detecting device. In our system the majority of cases offer real practical benefits in the event of an earthquake to safeguard lives and resources. We can easily set up this system for household purposes as it consumes less power. The proposed work can be modified and used as a knock-and-shake detector for ATMs, vehicles or door-break alarms. Ultra-Compact High accuracy earthquake detection sensor module can be used for accurately detecting vibration when an earthquake occurs.

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