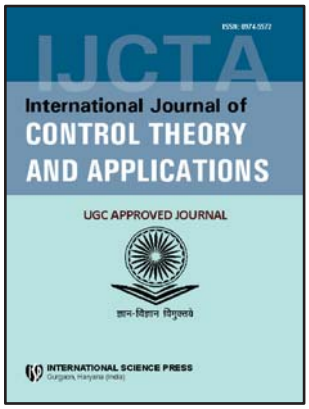

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Seismic Wave Detection using Mems Accelerometer

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Abstract: Seismic waves and other vibrations in civil structures being one of the most dangerous disaster, need to be detected in the less span of time before the actual disaster happens. It is necessary to monitor the shocks in the earth crust and civil structures on time to time basis. This is the driven force behind proposed paper work. The conventional method for detecting the seismic waves is by Geophone which produces electromagnetic signals when the seismic waves hits the Geophone. In this proposed work an MEMS accelerometer is used to sense the vibrations developed on earth's crust and civil structures. The proposed system transmits the accelerometer sensed data and is received by the control station wirelessly by SPI and I2C communication protocols which rules out the analog transmission method which is currently in use.The main purpose of using MEMS Accelerometer is the 13-bit resolution at±16g, SPI and I2C compactible and high shock survival.

Keywords: *Seismic waves, Accelerometer, Earthquake Detection, Seismograph, MEMS.*

1. INTRODUCTION

Recent advancements in MEMS (Micro-Electro-Mechanical Systems) technology lead to more precise and accurate measurements in acceleration with 3-Dimensions. This made immense opportunity to implement the accelerometer and to detect the seismic waves on the surface of the earth and in civil structures [1-6],which are occurred naturally and artificially caused by the interference of the humans. This provides embraced and vivid opportunity for inspections of the abrupt distractions of the earth's crust and in civil structures]

The proposed work is to detect the seismic waves which are very useful in observing the conditions of the earth and the civil structures which can help in analyses and warning the people before any disaster happens. The seismic data is complex and curtail data for the locating epicenter which helps in predicting the possible characteristics and behavior of the seismic waves and their effects in that surroundings.

The MEMS Accelerometer(ADXL345)[8] used in this proposed work is a small, thin, ultralow power(23μA), 3-axis accelerometer which comes with a high resolution of 13 bit at ± 16g, single tap/double tap detection, free-fall detection, low supply voltage(2.0V to 3.6V),wide temperature ranges of –40°C to + 85°C. It also measures the static acceleration of gravity in tilt sensing applications and enables measurement of inclination changes less than 1°.

2. SEISMIC WAVE CHARACTERISTICS AND PROPAGATION

The Seismic waves are the form of the energy which are propagated through the earth and has elastic properties. They are further classified into different types depending onthe characteristics and velocity. They are Primary waves, S(Shear) or Secondary Waves, Love waves and Rayleigh wave [2].

Whenever there is disturbance generated in the epicenter the seismic waves then originate and then propagates in all possible directions.

Primary wave (P) which isalso called as compressional waves travels faster than the other waves which have the velocity range of 5 to 8 km/s. They are the first waves which will be detected by the accelerometers and they are mainly of vertical component waves.

S waves or Shear waves are the waves which travel after the P waves but due to the property they can't travel through the liquids or air and they oscillate in the right angles to the direction of propagation with shearing effect.

Rayleigh and Love waves, this are the surface waves which travel along the surface of the earth and has very devastating effect. They are 3 dimensional waves and travel much slower compared to the other waves. Love wave have back and forth movement in direction of travel with shearing effect, were as Rayleigh waves moves both vertically and horizontally in a vertical plane towards the vertical plane in the direction of travel.

Propagation of the waves depends upon on the variable factors which are dynamic in nature consider the p waves where the velocity changes with the different is not uniform in the interior of the earth depending upon the variable materials present at that instance in the direction of propagation[6].

$$v_p = \sqrt{\frac{k + 4/3G}{\rho}} \tag{1}$$

$$v_s = \sqrt{\frac{G}{\rho}} \tag{2}$$

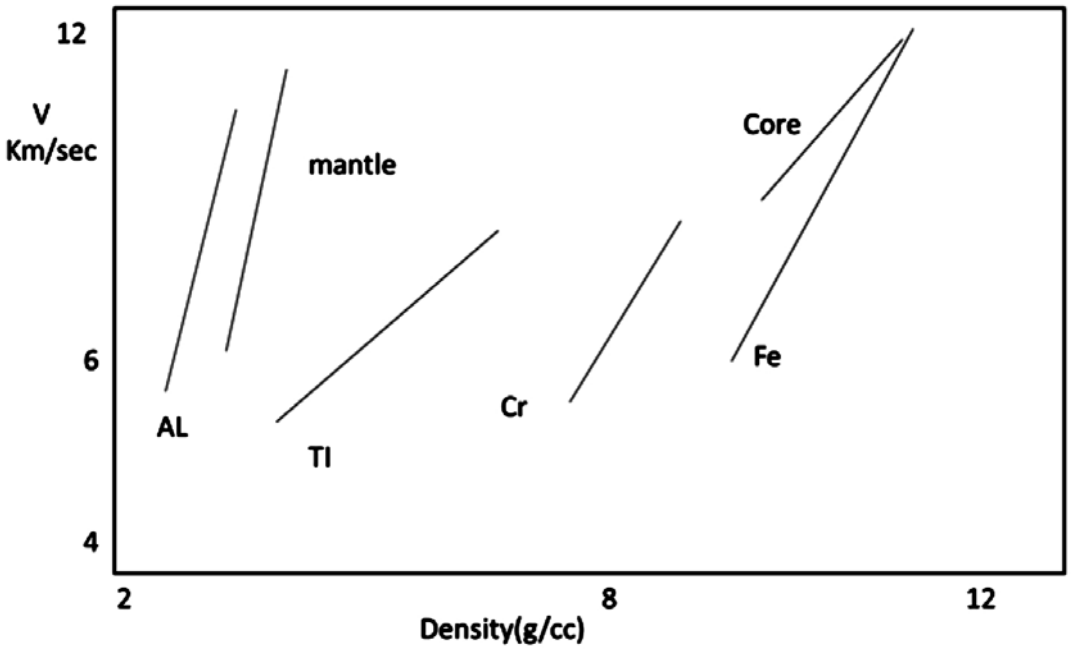

Figure 1: Velocity of P-wave v_s. concrete age for three mixes

The above equations are for calculation of the velocity for the P and S wave where v_s is for the calculation of the S waves and the v_p is for the calculation of the P waves, G stands for rigidity modules, K is the bulk modules and ρ is for the density.

The figure 1 shows the propagation of the Waves in the different regions of the earth with velocity versus density plot with different metals which are majorly present in the earth this graph is form the estimated data present in the[2] espiesdata. The seismic waves refract, reflect, has wave fronts and obeys Snell's law of wave propagation.

Due change of substances the wave tends to refract and reflect this will pose the loss of energy. They will propagate all over the earth region in all possible directions except the seismic shadow region due to the core of the earth interference of the earth.

3. DETECTION OF SEISMIC WAVES WITH ACCELEROMETER

The detection of different kinds of seismic waves plays curtail and vital role in analyzing the situation or any possible further predictions about earth and civil structures.

When the initial wave is noticed by the accelerometer in the vertical axis it is detected as the seismic waves and then starts the detecting the following other waves as mentioned and then the post analysis follows.

Accelerometers are used of the MEMS technology which again belongs to the capacitive type in which it contains micro sized structures which are like tuning fork conductive electrically placed with conductive metal in between so if any change in the accelerations occurs, due to inertia they will tend to move or change in their structure so this will change capacitance as there is electrical connections to both of the structures and dielectric medium which make it capacitor and then change is then converted into electrical signals so these are many of them present in accelerometers which are ready to take different vibrations[5].

The Seismic waves will travel and then all the waves are stored in solid state drives for further processing and predictions of earth and civil structures. For detection an ADXL345 which is an MEMS accelerometer is used with the ATmega328 and data which is plotted is graphically using Arduino an open source software.

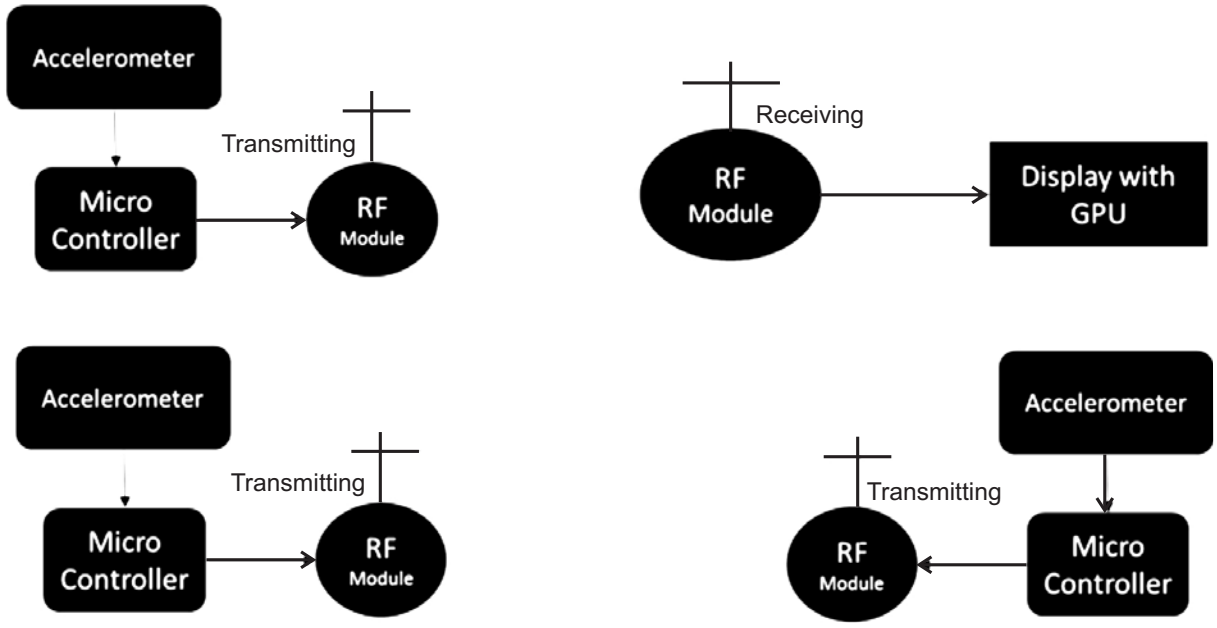

Figure 2: Block diagram of Seismograph

When the seismic waves are originated and detected there is change observed with respect to gravity varying from –0.1g to + 0.1g for few seconds this range of vibrations can be detected by using sensitive accelerometers. The accelerometers are capable of directly measuring the vibrational changes there is no need of post processing the accelerometer only conversation is required to observe the seismic waves.

The apparatus is set up as shown in the figure 1.2 in the field where the earthquake is to be measured and then data is transferred wireless using Radio frequency modules to the process station. There are three of them located in different direction and planted in to the ground to observe the seismic waves.

4. ANALYSIS OF THE SEISMIC WAVES DATA

First the P wave is detected and then after identification of the S wave we can confirm the wave as Seismic and then the calculation's as mentioned are done in order to obtain the epicenter and calculation of the intensity of the disturbance or an earthquake using Richter scale.

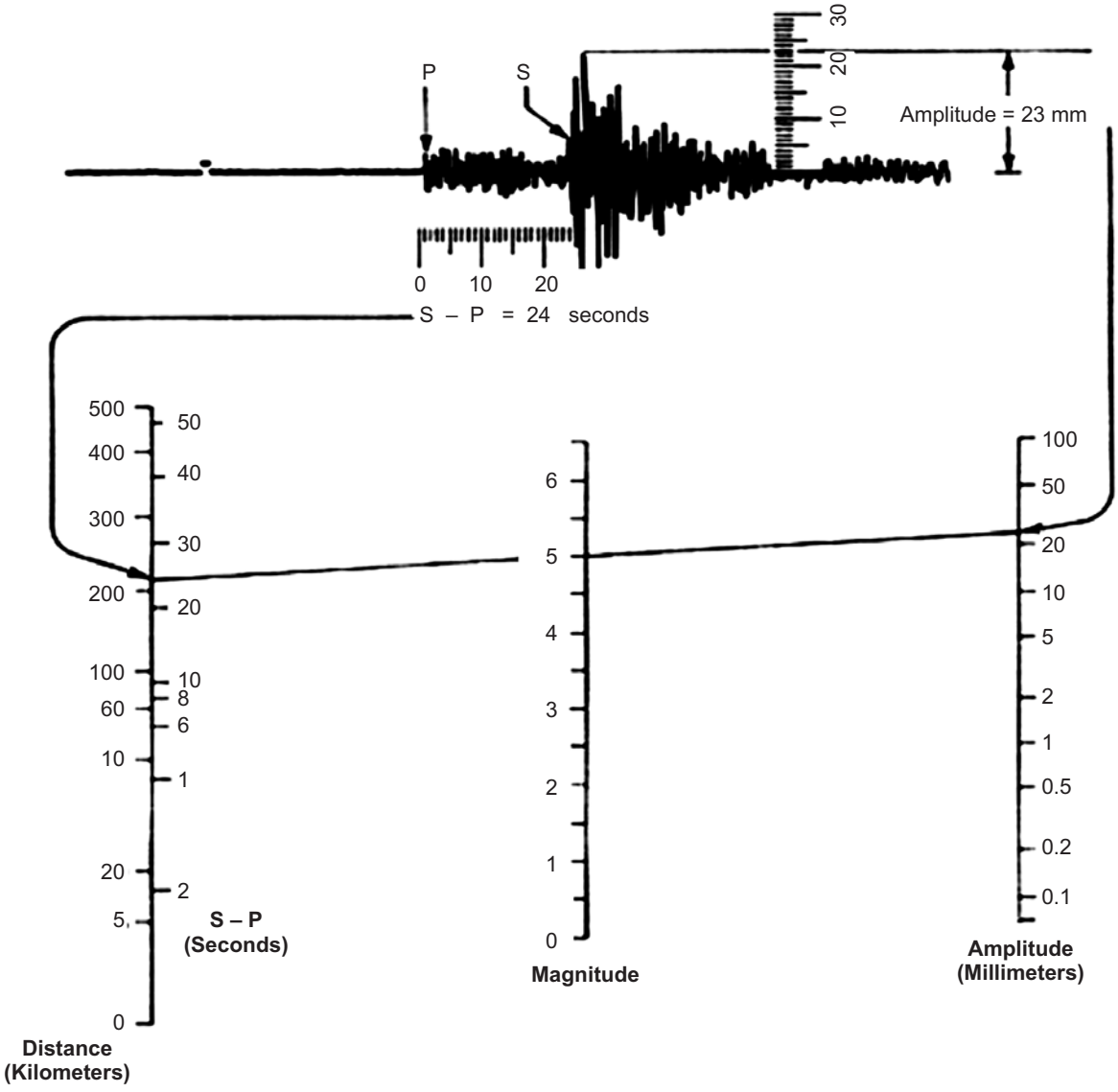

Figure 3: Chart demonstrating Richter scale

The Hypocenter is the point the seismic waves actually inside the earth or civil structure. After finding the epicenter and Hypocenter we can identify where the faults so to warn entering into the area since the surface which causes huge damage will travel slowly compared to the P and S wave so this can leave and some time to warn which is considerably less time but which can warn before actual destruction happens, from the chart 1.4 we can observe how the magnitude of the seismic waves is deduced the velocity calculation crucial role and we have to know the actual substances present under the surface to have exact data in order to have full knowledge about the earth and the civil structures.

The applications of analysis can actual give us the more knowledge about the inner earth where we can't see the upcoming disasters and all the active earthquake hypocenters can be found in order to stay alert and to protect Living and properties on the earth.

Courtesy: Scedc.caltech.com

5. CIRCUIT MODEL

Fig 4 shows the actual circuit design for the proposed paper work

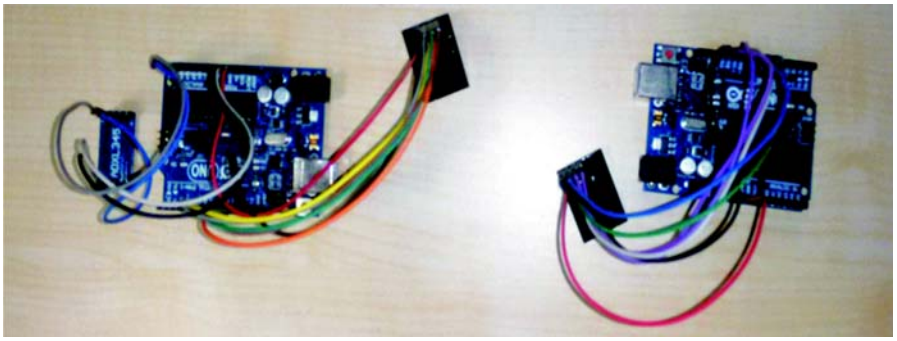

Figure 4: Accelerometer(ADXL345) and nRF24L01 (Transceiver) interfaced with Arduino Uno

6. APPLICATIONS AND RESULTS

From the seismic wave data, we can actually know the interior of earth and the stability in civil structures if any defects are found and then resolved or safeguard people from that detected region.

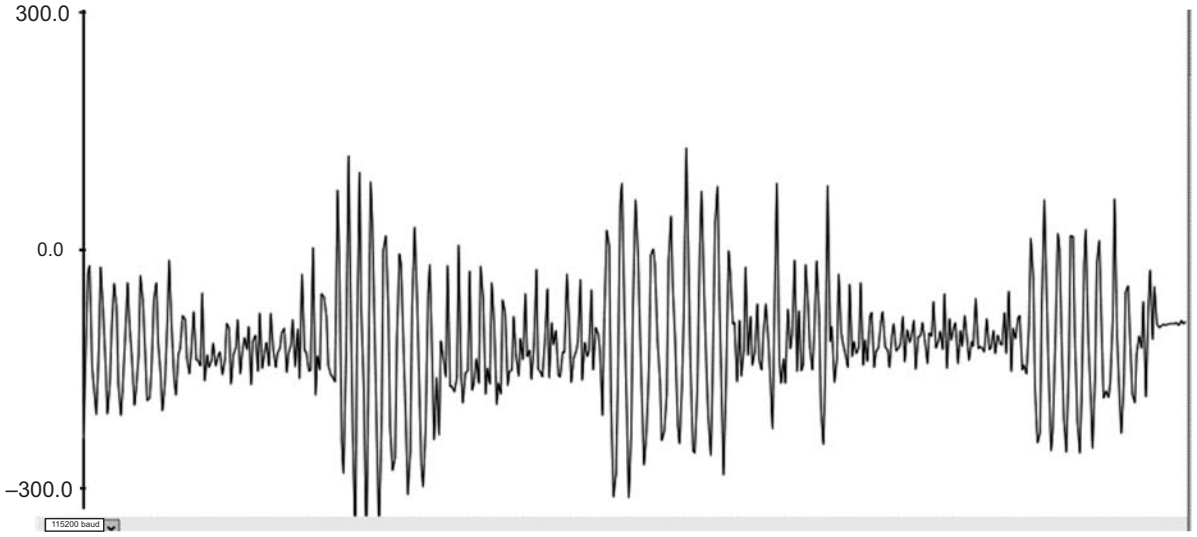

Figure 5: Horizontal axis with simulated P and S waves

The above figure 5 is from accelerometer and graph is plotted real time with the Arduino software, from that we can observe peak amplitude those are the S waves and in between we can notice the small amplitude those are P waves which are observed by artificially creating it.

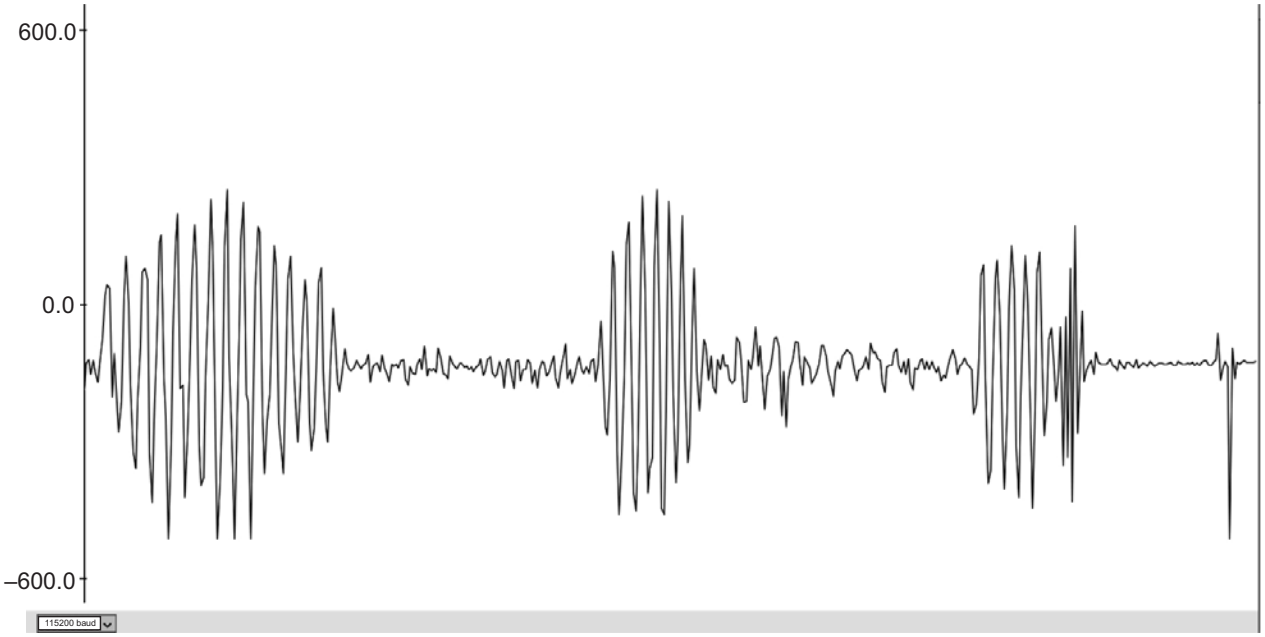

Figure 6: Vertical axis with simulated P and S waves

Form the figure 6 the Wave of larger amplitude are the P waves and Small amplitude in between are S waves of the vertical waves.

7. CONCLUSION

In this paper the use of MEMS Accelerometer for the development of Seismic wave detector helps to transmit the data of the 3 axes using the radio transmitter. This data is then processed to plot the seismograph for the detection of P(primary) waves and hence predict the possibility of an earthquake accordingly.

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