Measurement and Analysis of Vibration and Seismic Signal

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ABSTRACT
The science of measuring the magnitude of earthquake from instrument reading is called Seismology. The source processes of large earthquake are usually studied using seismological data. The rupture of the earth's crust will also generate a major earthquake which can be detected and measured by seismic instrumentation throughout the world. In this paper we are presenting the proposed system which is implemented for the measurement and analysis of Vibration and Seismic signal. Here we have made an attempt to help environment by creating a demo version of earthquake detector using seismology and processing the seismological data to predict earthquake and for other suitable applications. Here we have used a Micromachined capacitive accelerometer sensor to detect vibration/Seismic signal. The graphical data obtained on the computer screen is calibrated in terms of Richter scale to directly show the magnitude of the wave and for designing the hardware we are using the microcontroller and MATLAB coding is used for analysis the seismic signal.

Keywords
Seismology, Accelerometer sensor, MATLAB, Microcontroller, Vibration/Seismic signal.

1. INTRODUCTION
Seism scope is a device which indicates the occurrence of an earth quake but does not write a record while Seismograph, which writes a continuous permanent record of earth motion, also called seismogram. Seismometer is a seismograph whose physical constants are known sufficiently for calibration, so that actual ground motion may be calculated from the seismogram. The above is an account of various instruments used in accordance with earthquake detection. [5]

Seismology is the study of earthquakes and seismic waves that move through and around the earth. A seismologist is a scientist who studies earthquakes and seismic waves. Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth or an explosion. They are the energy that travels through the earth and is recorded on seismographs it is the sensitive instrument which records the earthquake waves. [3].

When a major earthquake occurs, the resultant energy released into the earth will propagate over a wide range of frequencies and velocities. Even though the earth movements discernible to the viewer may be confined to the general region of the earthquake origin, the various seismic wave phases propagating throughout the earth result in small, but measurable, ground motion which can be detected by a seismometer. A seismograph then provides a visual record of the ground motion at that station. For the purposes of the Tsunami Warning System, consideration is given to three significant seismic wave phases. The first, the P-wave, is a compressional wave traveling through the earth's interior at a velocity varying from approximately 8.0km/second near the crust-mantle interface to about 13.5 km/second at the mantle-core interface. As such it is the first seismic phase to be recorded at any one seismic station and is the first indication that a distant earthquake has occurred. The location of the earthquake can be determined by assuming the "best fit" of the pattern of P-wave arrivals at several stations compared to a standard table of P-wave arrival times for various distances and depths of earthquake focus or, in the case of local earthquakes in or near the limits of a relatively small area seismic station network, compared to the calculated arrivals based on a local crustal seismic velocity model. The moment magnitude (MwP) can be estimated very early, with the long period P waves recorded by broad-band or long-period seismometer. The second seismic phase of importance is the S-wave, or Secondary wave. This phase travels through the earth's interior as a shear wave, following approximately the same travel path as the P-wave but at a reduced velocity varying from approximately 6.7 km/second near the crust-mantle interface to about 8.0km/second near the core. These seismic wave phases are classified as body waves due to their propagation through the earth's interior. In addition to providing a location, body waves are useful in determining the size of an earthquake, especially when the earthquake's focus is deep within the earth.

1.1 Richter's Magnitude Scale of Intensity
Richter's magnitude scale of earthquakes is an instrumental measured scale and is the measure of the amount of force released at the earthquake source. It is calculated from the amplitude measured by the standard wood-Anderson seismogram and corrected in terms of seismogram supposed to be kept at distance of 100 kms from the epicenter. [2].

The idea of logarithmic earthquake magnitude scale struck into the mind of Richter after analyzing the roughly parallel curves generated by different size earthquakes on the plot of log of the recorded amplitude at various epicentral distances. The parallel nature of curves for different earthquakes suggested that a single number could quantify the relative size of different earthquakes. He proposed zero magnitude for an earthquake that would produce a record with amplitude of 1.0 µm at a distance of 100 km from the epicenter on Wood-Anderson (WA) seismograph with 1.25 Hz nature frequency and 2800 magnification factor. The logarithmic form of Richter magnitude scale (M_L) is given as:

$$M_L = \log_{10} A - A_0 \quad (1)$$

Where A_0 is the amplitude for zero magnitude earthquake at different epicentral distances and A is the recorded amplitude in µm. The zero magnitude amplitude can be computed for different epicentral distances taking into account the effects of geometrical spreading and absorption of considered wave.

The Richter scale used in Southern California for different epicentral distances and 18 km fixed focal depth is as follows:

$M_L = \log_{10} A$ (mm) + Distance correction factor ‘σ’ (2)

Distance correction factor ‘σ’ is log of inverse of zero magnitude amplitude measures in mm at an epicentral distance ‘Δ’ in km. The distance correction factors for different epicentral distances are given in Table 1.7. The distance correction factors given in Table 1.7 cannot be used in other regions of the world since considered focal depth was constant. So, to compute M_L In any other region like Himalayas, first zero magnitude amplitude at different epicentral distances should be determined according to the original definition of M_L at 100 km and different focal depths taking into account the geometrical spreading and appropriate measure of absorption. Since, sufficient time resolution of high frequency records is no longer a problem, therefore, frequency dependent distance correction factors, matched with Richter scale at 100 km distance, have been developed based on epicentral as well as hypo-central distances (Hutton and Boore, 1987; Kim, 1998).[5]

TABLE.1 DISTANCE CORRECTION FACTOR FOR ML (ELEMENTARY SEISMOLOGY, RICHTER 1958)

Δ (km)	σ(Δ)	Δ(km)	σ(Δ)	Δ(km)	σ(Δ)	Δ(km)	σ(Δ)
0	1.4	90	3.0	260	3.8	440	4.6
10	1.5	100	3.0	280	3.9	460	4.6
20	1.7	120	3.1	300	4.0	480	4.7
30	2.1	140	3.2	320	4.1	500	4.7
40	2.4	160	3.3	340	4.2	520	4.8
50	2.6	180	3.4	360	4.3	540	4.8
60	2.8	200	3.5	380	4.4	560	4.9
70	2.8	220	3.65	400	4.5	580	4.9
80	2.9	240	3.7	420	4.5	600	4.9

Seismologists use a magnitude scale to express the seismic energy released by each earthquake. The magnitude of an earthquake is usually expressed in terms of a logarithmic scale based on seismograph recordings of seismic-wave amplitudes is given as:

$M_L = \log10 A$ (3)

Where: M_L is the local magnitude

A is the recorded amplitude.

Following table shows the typical effects of earthquakes in various magnitude ranges:

TABLE. 2 EFFECTS OF EARTHQUAKE

Richter Magnitudes	Earthquake Effects
Less than 3.5	Generally not felt, but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0-7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

1.2 Block Diagram of the Proposed System

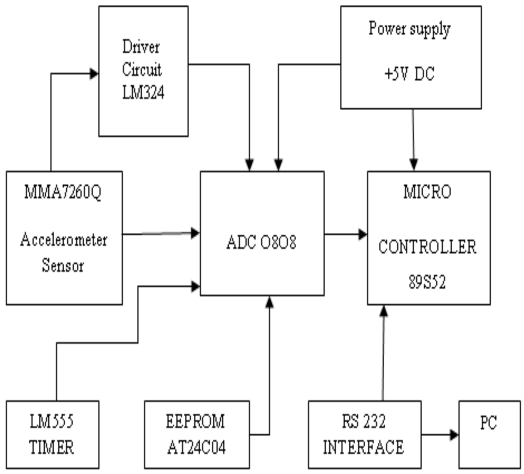

Figure.1 Proposed Block Diagram of Seismological Detection System

Above figure shows the proposed block diagram of seismological detection system. To achieve the aimed objective a system is developed around a general purpose micro-controller device. The heart of the system is the sensor. The sensor used in this system is low cost micro machined capacitive Accelerometer sensor which is highly sensitive. Frequency response of accelerometer is 2 to 10KHZ. The microcontroller used is this system is 89s52 microcontroller. The data is fed to a Microcontroller that process this data before it process by using MATLAB. Serial communication is used for transmitting the data from microcontroller to the computer this is done by using the IC MAX 232.The graphical data obtained on the computer screen is calibrated in terms of Richter scale magnitude. The detector will sense vibration caused by activities like drilling, boring, animals trespassing etc.fig indicate the theme block diagram of this system.

1.3 MATLAB

We use Matlab7.0 for processing data recovered from sensors. It is in the digital form. Matlab accept input in the nibble form as we get the input from the parallel port of computer. The digital data is then converted into a byte from which the decimal number is extracted. The average of decimal numbers obtained from sensor is calculated.

1.4 RESULT AND PERFORMANCE ANALYSIS

The experimental setup and result we are obtaining from this proposed work is shown in the following figures. Following applications are selected for the measurement of Vibration signal detection.

1. Vibrator table used in Civil Engineering department.
2. Drill machine
3. Earth dragging machine.
4. Oven used in Civil Engg Lab

Figure 2 Experimental Set Up For Vibration Measurement of Vibrator Table Tested In Civil Engg Lab

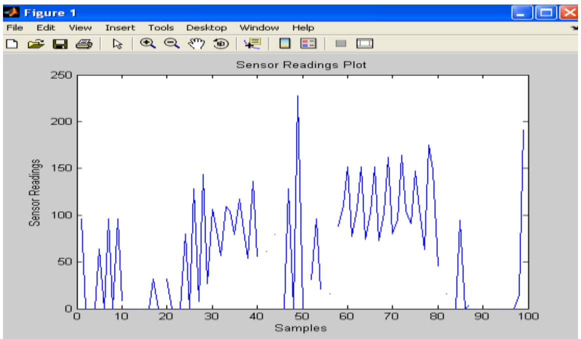

Figure 3 Vibration Signals Of Vibrator Table Tested In Civil Engg Lab.

Figure 4 Experimental Set Up For Vibration Measurement of Drill Machine

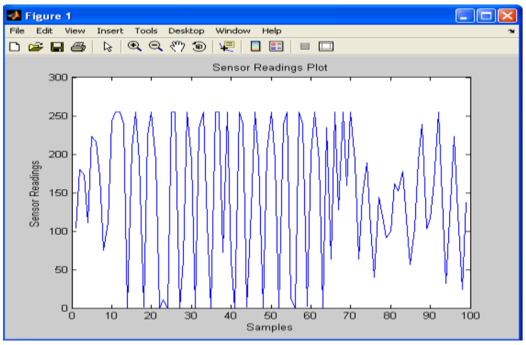

Figure 5 Vibration Signals of Drill Machine

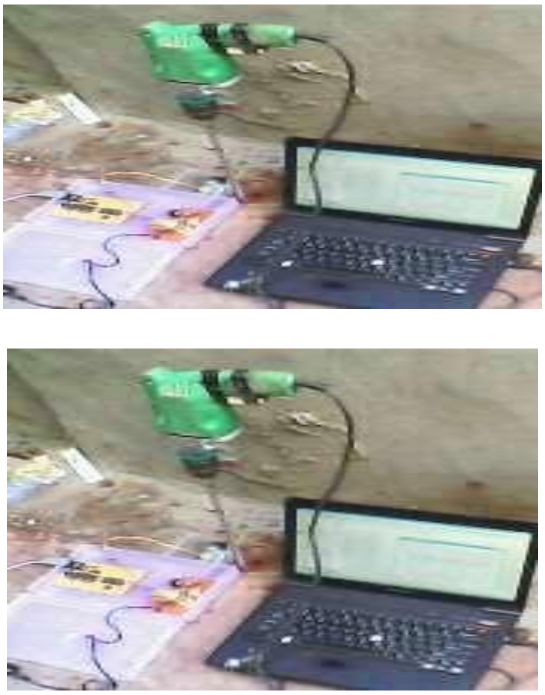

Figure 6 Experimental Set Up For Vibration Measurement of Earth Dragging Machine

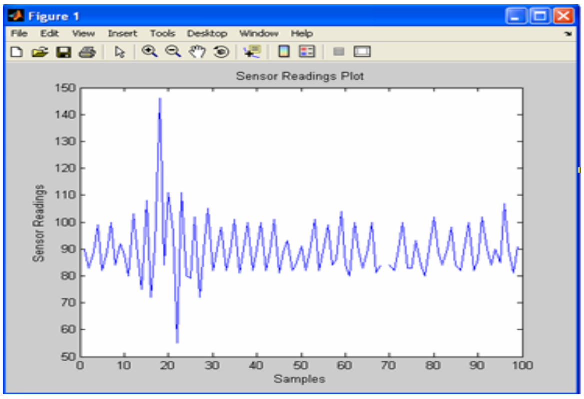

Figure 7 Vibration Signals Detection of Earth Dragging Machine When Sensor Buried In To the Earth

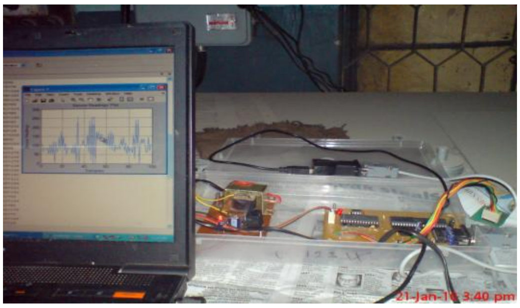

Figure 8 Experimental Set Up For Vibration Measurement of Oven

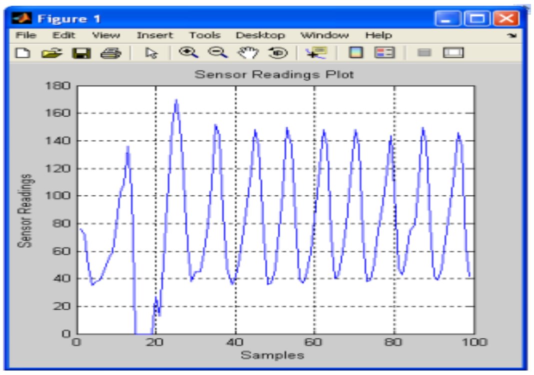

Figure 9 vibration signal of oven

1.5 CALCULATION OF MAGNITUDE

Calculation of magnitude of vibrator table tested in Civil Engg Lab

M_L = log10 A

From figure 3 the highest value of A=228

M_L = log10 228

Magnitude of vibrator table =2.35

Calculation of magnitude of Drill machine.-

M_L = log10 A

From figure 5 the highest value of A=255

M_L = log10 255

Magnitude of Drill machine =2.40

Calculation of magnitude of earth dragging machine

M_L = log10 A

From figure 7 the highest value of A=146

M_L = log10 146

Magnitude of earth dragging machine =2.16

Calculation of magnitude of Oven

M_L = log10 A

From figure 9 the highest value of A=170

M_L = log10 170

Magnitude of Oven =2.23

B. Comparison of all Applications with respect to their Magnitude.

For comparison of all applications the calculated magnitude the range is decided as in the following table.

TABLE 3 MAGNITUDE RANGE

Magnitude	Range
2 to 2.20	Minimum
2.21 to 2.35	Medium
>2.35	Maximum

TABLE 4 COMPARISION OF ALL APPLICATIONS WITH RESPECT TO THEIR MAGNITUDE

Sr No.	Applications	Calculated Magnitude	Range of Magnitude
1.	Vibrator table used in Civil Engineering department.	2.35	Medium
2.	Drill machine	2.40	Maximum
3.	Earth dragging machine	2.16	Minimum
4	Oven	2.23	Medium

TABL 5 COMPARISONS OF CALCULATED MAGNITUDE WITH STANDARD RICHTER MAGNITUDE SCALE (SHOWN IN TABLE 2) AND THEIR EFFECTS

Sr No	Calculated Magnitude of all Applications	Richter Magnitude Scale	Earthquake Effects
01	2.35	Less than 3.5	Generally not felt, but recorded.
02	2.40	Less than 3.5	Generally not felt, but recorded.
03	2.16	Less than 3.5	Generally not felt, but recorded.
04	2.23	Less than 3.5	Generally not felt, but recorded.

2. CONCLUSION

On the basis of the analysis carried out in the present work, the following conclusions are drawn

The applications which are used for the testing of vibration signals it is concluded that the magnitude of the drill machine and is maximum as compare to the other applications like vibrator table, earth dragging machine, electric oven *etc*. Also comparing these calculated magnitudes with standard Richter magnitude scale it shows that all these calculated magnitude is less than 3.5 so that earthquake effects generally not felt but it is recorded.

The measurement of vibration/Seismic signal system is programmed to display the waveforms for every minute and seconds as the vibration or seismic signal occurs.

Hence we have proposed to design a very simple apparatus which will aid even a layman in detecting and simultaneously measuring even the smallest of earthquakes. The result from this system can be used in comparative studies of earthquake signal obtained from other system. The simple graphical presentations of processed signals minimized the complexities in the analysis of earthquakes. The precursory characteristics of the earthquake signals helps to provide the alerts before the hazards happen. This system will give warning, which will help us to save lives as well as properties. This system can further improved by adding better quality of the sensor. Also by making the system wireless we can able to use the system at remote location.

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