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Earthquake Monitoring & Early Warning System

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Abstract: The aim of this project is to design the system that can detect P-wave before the first S-wave spike. Typically, P-wave travel 1.68 to 1.75 times faster than S-wave. Our proposed designed device consists of a pendulum type earthquake detection device which is interconnected with fault point finder, wireless alarm, GSM kit and automatic turn off system. when P- wave strike the pendulum it activates relay and send the pulse to stimulate the wireless alarm which can be install at any place as it detects the P-waves and can save human lives as they will be aware of how to deal with this situation.

Keywords: Earthquake Monitoring, Early warning system, Earthquake warning system.;

I. INTRODUCTION

Earthquake is the vibration of earth crust due to the movement of the earth plates. Earthquake occurs due to pressure released from inside of earth layer where plates do not move well together with each other and occasionally jammed. Earthquake energy spreads out in the form of seismic waves from the focus (spot in the earth layer where tension is released). Waves closer to epicenter are most powerful and as they move away from epicenter they become less powerful. the brutal smash up of earthquake will happen near the epicenter as shown in Figure (1) [1]. Different kinds of seismic waves are generated like P-wave and S-wave, P-waves are harmless and faster comes first at the destination and S-wave are harmful and slower than P-wave that reaches second at the destination.

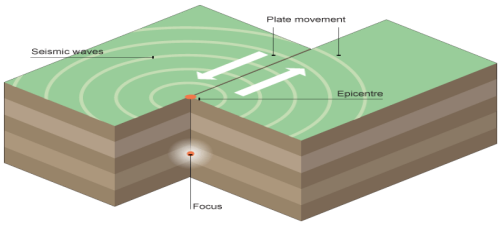

Figure 1: Earth Quake breakdown at its epicenter

The aim of this project is to design the system that can detect P-wave before the first S-wave spike. Typically, P-wave travel 1.68 to 1.75 times faster than S-wave. Thus there is typically a one second separation between the P- and S- wave for every eight (8) kilometer traveled [2]. Our proposed designed device consists of a pendulum type earthquake detection device which is interconnected with fault point finder, wireless alarm, GSM kit and automatic turn off system. The huge ground vibrations from an earthquake are usually from the S-wave and coming after surface waves, which rotate at about 3.5 km/s, when P-wave strike the pendulum it activates relay and send the pulse to activate the wireless alarm which can be install at any place as it detects the P-waves and can save human lives as they will be aware of how to deal with this situation. As we know that electronically information signal travels at about 300,000 km/s, which is much faster than seismic waves, that is when, our pendulum based earthquake detector system detects the earthquake and sends the pulses to all connected systems by using microcontroller and through the GSM facility. The alerts are sent to all possible numbers as a text message, warning the user of possible earthquake activity. By the using of direction meter, we can easily analyze and indicate visually that from which side it is coming either from the west or north shown in Figure (2). An automatic turn off system is also connect to turn off all possible connections such as turn off the gas, turn off the electricity to protect from the short circuit or any fire burning and open the safety doors as it detect the P- wave

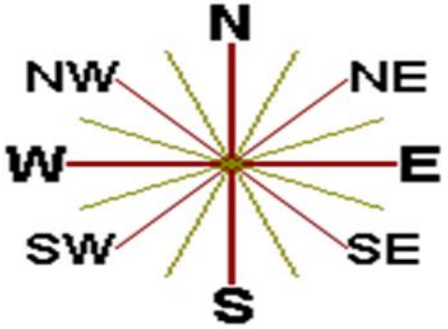

Figure 2: Full circle division of coordinates

A. Primary wave (p-wave)

Primary wave (p-wave) is 1.68 to 1.75 times faster than S-wave, whose rotation is about 3.5 km/s. Therefore, there is typically 1 second separation between every 8 kilometer traveled. Earthquake early warning system can utilize P-wave as source of information of earthquake. the Electromagnetic waves which is faster than P- wave and much faster than S-wave sending of early warning message is possible. The movement of primary wave power on the earth is the cycle of forward and backward shaking in a x-axis and y-axis plane, spreading in similar direction of the seismic wave. The movement of wave on the earth is the reason of the pushing (compression) and pulling (dilation) of earth elements in its path and it can pass from any type of soil structure such as solid and liquid. There are three kinds of waves Primary waves, secondary waves and in the last surface. P-wave is faster than other seismic waves. Movement of P-waves passing through the earth shown in Figure (3) [2].

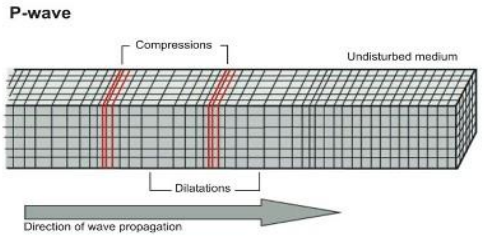

Figure 3: Movement of primary waves (P-Wave) passing on the earth

B. Secondary wave (S-wave)

S-wave or secondary wave also called as shear wave due to the movement of up-and-down at the right angle of earth surface. It is dissimilar with P-wave because of the movement, it can move only in solid unlike the P-wave which can also travel in liquid. Due to the movement of shear wave the element of earth causes propagate in all direction. Its velocity is slower than P-wave and between the P-waves and surface waves show in Figure (4) [2].

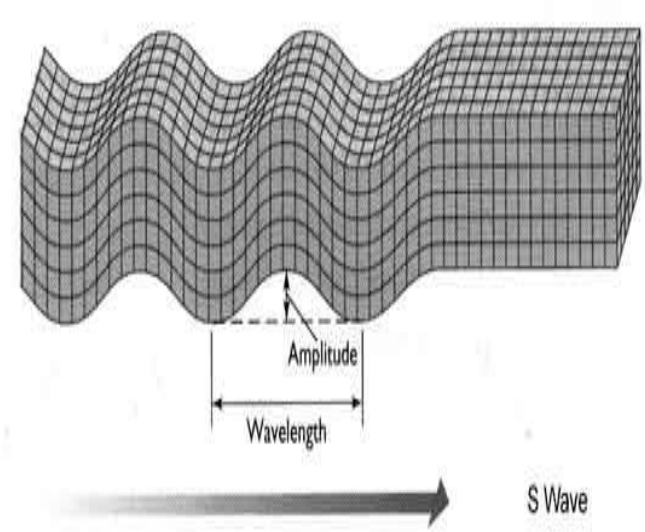

Figure 4: Up and down movement of surface waves (S-Waves)

C. Surface Wave

Surface wave is slower than other P-wave and coming after P-wave which is secondary wave and most destructive than all types of waves. Surface wave are of two types Rayleigh an loves wave: Rayleigh waves shearing in horizontal pattern comparable to s-waves shown in Figure (5) while loves waves destructive motion in rolling type pattern like a water waves shown in Figure (6) shows the movement of both surface wave (Rayleigh and loves) along the earth [2].

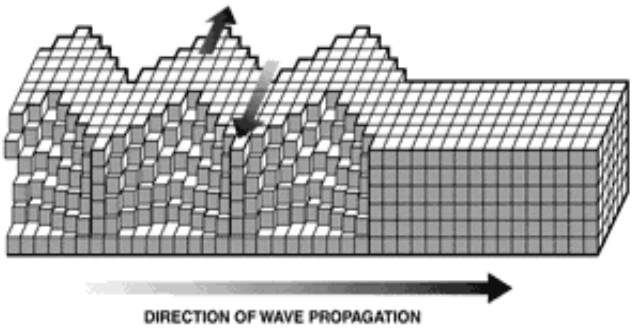

Figure 5: Rayleigh wave shearing movement

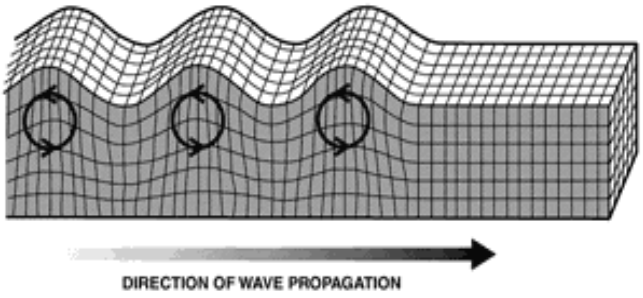

Figure 6: Loves waves rolling pattern movement

D. Aims and objectives:

The primary aim of this project if to detect Earthquake and provide an early warning through mobile text messaging, prior to damaging ground shake of earthquake. This system can reduce the number of causalities and the cost in the earthquake affected areas. The GSM connectivity will be used to send the alert warning messages through SMS, to all by near base stations. The wireless alarm facility can also be incorporated into the system to warn the people which can be at any place. An automatic turn off system is also aimed, to turn off all the possible connections and open safety door in buildings, houses, offices etc. An additional key feature using fault point finder is also included, to detect the direction from which side the earthquake is coming. The earthquake early warning system can be installed in various different facilities and locations including but not limited to Factories and mills, Industries, Houses, Offices, Fire brigade's headquarters and Hospitals.

E. Historical Background:

Initially the historical background of various earthquakes that have occurred in Pakistan region, are analyzed. The previous earthquakes, which have occurred in this country, have brought devastation and chaos as a nightmare in which thousands of people had died, millions of people became homeless and millions of were left injured. The country uphill bearded billions of loss during these causalities in natural disaster. In this section we will discuss worst disaster of earthquake of the history. The data provides a key aspect in order to understand in detail, the various earthquake magnitudes and their patterns as given in Table 1. This information, will help to understand how to make the public aware from such type of disaster and how to deal from this situation.

Table 1: Recent past earthquake and its disasters in Pakistan

year	Location	Magnitude	Deaths
1827	Lahore, Punjab	7.8	1000
1935	Alijan(Quetta), Baluchistan	7.7	40000
1945	Baluchistan	7.8	4000
1974	Hunza, Kpk	6.2	5300
2005	Muzaffarabad, Ajk	7.8	80000
2008	Ziarat, Balauchistan	6.4	215
2011	Dalbandin, Baluchistan	7.2	NIL
2013	Awaran, Baluchistan	7.8	600+

As it can be seen from the Table 1, the earth quake in the region of Muzaffarabad AJK region was one of the worst natural disasters Pakistan had seen, with maximum casualties. The earthquake which occurred on Saturday, October 8th 2005 at exactly 8:2:37, was of 7.8 magnitude. The depth of the earthquake was found to be at 26km below the surface.

F. Time Estimation and Analyzing of Earthquake:

Most people caught in earthquakes have a feeling of helplessness. Especially if they have never experienced a quake before, they have no idea how long it is going to last or what will happen next [5]. Every second counts to save the human life, therefore, initially a technical analysis is done regarding these types of disasters, determining how much time will be given to warn the people and save people, if the earthquake system is installed. First the 2005 and 2008 horrible earthquakes are analyzed, which occurred in Pakistan, in which heavy losses were incurred.

The epicenter (origin) of earthquake which occurred in 2005 in AJK, was at the 100 km North East (NE) of Islamabad city. It is necessary to keep in mind, that those areas which are situated near the epicenter are the most affected areas of earthquake. As already discussed, the P-wave is information carrier wave and it is about 1.68 times faster than S-waves, which is energy carrier or also knows as the Destructive wave. There is about one second separation between P-wave and S-wave, over a distance of every 8 kilometers per traveling path. In 2005, the earthquake epicenter was 100 km from NE of Islamabad, so there is a typically 13 seconds gap between P-wave and S-wave over 100 km travel. Another earthquake which occurred in 2008, its epicenter was at away 600 km South-West (SW) of Islamabad. If the time estimation is done as previously, then it is determined that there was about 60 seconds of window between the first P-wave and actual destructive S-wave, and thus these 60 seconds could have been utilized to warn people and get them out of buildings and in open areas saving their lives. Suppose you have the 13 seconds to save your life, thinks

what you can do. You can move away from the large objects which may be in your house such as large shelves, mirrors large pieces of furniture topple over. If you are outside not in home you can move away from trees, signboard or from the large hanging objects or when you are driving you can stop the car to prevent any vehicle accident.

II. RELATED WORK

The thought to give early warning by the using of seismic waves to coming prevent disaster is not new. In 19th century 1856, a seismologist named Dr. JD cooper bring out the idea in an san Francisco editorial column daily evening bulletin, in which he said "a various plot can be used to take different point in san Francisco between 10 to 100 miles, by this method an earthquake wave is high enough to destroy anything can be prevent by ring the bell through the electric wires which is rotating from this city and by hang the high tower in the center off city monitoring can be possible" [6]. In the middle of 20th century well known seismologist Thomas Heaton architect a modern life view, which he named SCAN (seismic computerize alert network. He said that this system can be implemented to cutoff power grids, auto turn off natural gas valves, provide possible guard to protect computer system and railway lines [7].

In late 1950s, basic seismometers implement to give alarm for warning to railway stations. After the bullet train project start in 1964, an automatic turns off system was put into operation to stop or slow the train as it detects the seismic waves. Recently used URDEAS (urgent earth quake detection and alarm system) has a complicated algorithm for finding the location and waves of earthquake recently using by the Japanese railway system. Some companies develop efficient real time ground motion detection system for quick response in emergency. Recent the city yokohama start a project to install a 150 stations network for real time monitoring [9].

Hiroo kanamori, a Japanese seismologist researcher stated that "Recent advances in seismic sensor technology, data acquisition systems, digital communications, and computer hardware and software make it possible to build reliable real-time earthquake information systems. In the long term these systems also provide basic data for mitigation strategies such as improved building codes" [8].

Taiwanese seismologist Yih-Min Wu developed a Virtual Subnet Work (VSN) which reduced the earthquake warning time to 30sec [10]. H. Serdar Kuyuk presented a research paper in world conference on earthquake engineering, where he discussed an application of Earthquake Early Warning Systems (EEWSs) mainly centers on alerting or providing information to the public offices such as the emergency, fire departments, and hospitals [11]. Chu-Chieh Jay Lin developed a concept of Structural Response with On-Site Earthquake Early Warning System Using Neural Networks. The real-time strong motion signals recorded the characteristics of the sensed earthquake and "accelerograms" [12] were learned. The neural networks provide a seismic profile of the arrival ground motion instantaneously after the shaking is felt at the sensors by analyzing the three components of the earthquake signals. By producing informative warnings, the neural network based methodology has shown its potential to increase significantly the application of earthquake early warning system (EEWS) on hazard mitigation [12].

III. CONSTRUCTION OF EARTHQUAKE ALARM HARDWARE DEVICE

In this project, the following tools and techniques are used to develop and construct the earth quake early alarm system.

- AT89C51 Microcontroller
- Global System for Mobile (GSM)
- Mobile
- Fault point finder
- Visual indicator
- Wireless alarm
- Automatic turn off system
- Embedded Assembly and C language
- Proteus simulator
- Serial Port Communication
- RS 232 Protocol
- Power supply
- Computer

A. Earthquake detector:

In this project four systems are developed and interconnect with Pendulum form earthquake detector shown in Figure (7) to build up a system called GSM based early warning wireless earthquake alarm system. A free swing sensitive pendulum is fitted inside a cylindrical shape tube, to detect the earthquake vibration. When seismic wave collides with pendulum it sideways from its resting equilibrium position in cylindrical shape because of energy stored in it and it oscillate like a Foucault pendulum. The four pulse receiver is connecting in bottom side of cylindrical body in all four direction east, west, north, south respectively. When it collides with any pulse receiver data acquisition process become complete and the receiving pulse send to all four systems which is interconnect with earthquake detector to do perform task.

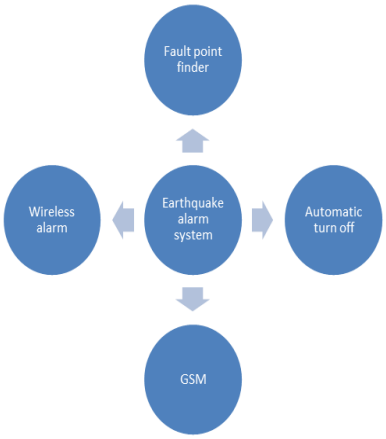

Figure 7: Earthquake alarm system connected with another systems

After recognizing the seismic wave direction, it will send information to visual Indicator, the function of visual indicator is it visually shows the warning from which point seismic wave is coming either from the east or the west. The automatic turns off system has a very key role in modern system in which every single device is automatic. When the P-wave strikes with pendulum it sends the pulse to the base station, trigging an alarm to automatically turn off the system. In the late 1954 automatic turn off system is installed in Japanese railway station to stop or slow down the train. It can be used in atomic reactor plant, industries and where the people working with heavy machinery, especially where casualties may be occurring.

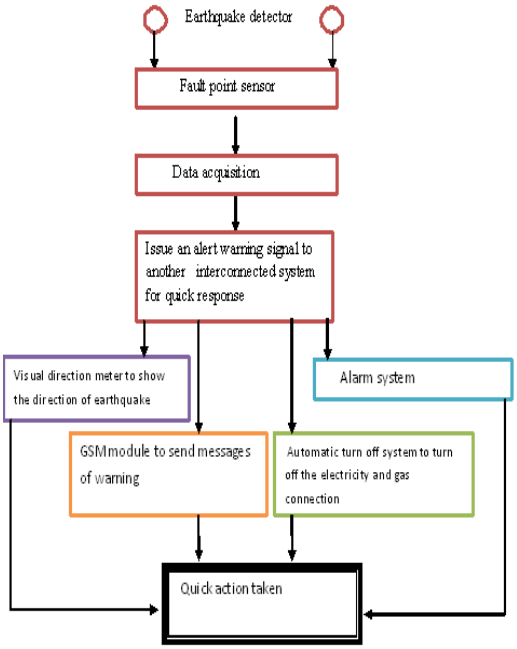

Figure 8: Block diagram

The GSM has a very important role here in order to warn the people. In modern world, where a mobile has become every person's need and every individual has an access to it. The alert warning massage can be sent to people and it can save the human life as they will get early warning of earthquake and will be aware of how to deal with this situation. Wireless alarm system is a technique to warn the people through wirelessly which can be install everywhere such as room, office, building or as per need when earthquake alarm system detects the P-wave it send the signal to wireless alarm to start the alarm and it is a very useful method and quick warn technique that may save life.

B. Microcontroller IC 8051:

In this project AT89C51 microcontroller is used. The microcontroller has a major role, as it is the brain of the system. Here the use of microcontroller is to connect the four individual systems with the microcontroller to work simultaneously. The microcontroller is used to communicate with all four devices, pin number from 21 to 24 is used for visual direction meter and pin number 27 to 28 is used for wireless alarm and automatic turn off system. Pin number 10 to 11 is reserved for max 232 for interface purpose and pin number 1 to 4 is used for pendulum pulse receiver and pin number 5 is used for system reset. Pin number from 18-19 11.059 MHz oscillator is connected and pin number 20 went ground and pin number 40 is connected to 5-volt power supply. The detailed circuit diagram of the system is shown in Figure 9.

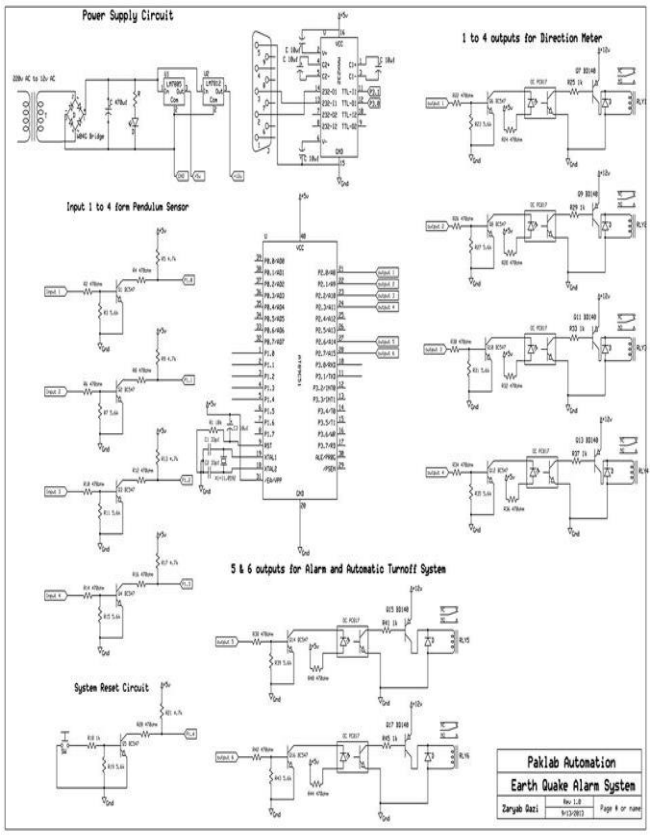

Figure 9: Circuit diagram

C. Construction:

Designing of this project is possible by using of AT89c51 microcontroller. The microcontroller has a central role in this project to design a GSM based early warning earthquake alarm system. The earthquake alarm system is interconnecting with four another system, this made possible by the use of microcontroller to work simultaneously. The circuit diagram of the system is shown in Figure 9. A free swing sensitive pendulum fitted in cylindrical shape to detect the earthquake vibration as shown in figure 10. When seismic wave collides with pendulum it sideways from its resting equilibrium position in cylindrical shape because of energy stored in it and it oscillate. The four pulse receiver is connecting in bottom side of cylindrical body in all four direction east, west, north, south respectively. When it collides with any pulse receiver data acquisition process become start and the receiving pulse send to all four systems which is interconnect with earthquake detector to do perform task. r. The microcontroller as receive the pulse from the pulse receiver it sends the warning pulse at the same time to four another system which is interconnect with earthquake system. when GSM kit receive the signal it sends the warning alert message to all mobile number which is stored in database of GSM, and may save the life by performing the early warning service. on the other hand, wireless alarm system which can be install at any place start alarm as it receives the alarm signal and by this action people can be aware that earthquake is coming and it may save the life as they will aware that how to deal with this situation. The automatic turns off system has a very important role in modern life where every signal device or system is automatic. As it receives the warning signal it quickly turns off the all possible domestic connection such as it turns off the electricity and gas for preventing any short circuit or fire burning due to leakage and open safety/ emergency door and in industry level it can turn off the machinery or any system to prevent any damages and start alarm to move away worker from heavy machinery may reduce the casualties. In the end visual direction indicator is used to visually show the direction that from which point earthquake is coming either from the east or west. This all system working quickly at the same time as it is receiving the pulse and performing early warning operation through the rapid action has a role of saving the human life is made possible by the use of microcontroller.

a b

Figure 10: Free swing pendulum fitted in cylindrical body

Figure 11: Construction progress

D. Software Used:

This chapter consists of information about software which is used in this project. There are many electronic software which is used for designing and simulating the electronic circuit. GSM based early warning earthquake alarm system has a very important role to save the life in natural disaster. To design a efficient earthquake alarm circuit it is very important to design a circuit correctly that's why we are using some of following software to accomplishing the GSM based early warning earthquake alarm system.

We used multisim software to check circuit through simulation. Micro Vision keil is used to convert the C language program into the HEX file and burned it into microcontroller IC. Express schematic is used to draw the diagram of the circuit and visual basic used for GSM interfacing purpose and for making the earthquake monitoring application.

IV. Results and Discussion

In this study, one of the most key problems occurs in real time prediction of earthquake system is tried to solve. This thesis proposed a new view point to add communication resources and others previous research in order to make a one new efficient system to warn the people in real time. By analyzing of previous earthquake record we reached at this point that life losses can be minimize if the authentic earthquake information reached from the identified institution to the people before the earth quake destruction then early warning concept fulfill. The proposed system methodology gives big contribution to making a efficient system with the usage of GSM for broadcasting the early warning message and wireless alarm for start alarm as it receive the signal and automatic turn off system for turn any system to prevent any damages during working.

The working of a system is made possible by the using of AT89C51 microcontroller which is the heart of the system and gives instruction to all the connected system for work simultaneously and to give the whole package of Earthquake detector and people warn system

V. Conclusions

In this study, Real time prediction and alarm system to warn the people has been accomplished. The main key problem to warn the people in real time mode is tried to solve. Using the GSM system, an early warning message sent as the earthquake detector detects the earthquake sound wave and generate the pulse to auto turn off system that would turn off the gas or electricity connection and send the pulse to alarm system to warn the people using voice audible alarm.

By analyzing the previous earthquakes we reached at this point that casualties can be minimize if the people get earthquake coming authentic information in real time to take action before the coming of destructive sound wave. The proposed system has a key role to make the useful earthquake system to warn the people in real time and send the message to the people as it receive the earthquake initial sound wave and people can take action before the coming of destructive wave.

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