International Journal of Computational Research and Development (IJCRD)
Impact Factor: 4.775, ISSN (Online): 2456 - 3137
(www.dvpublication.com) Volume 1, Issue 2, 2016

WEAK TSUNAMI DETECTION USING GNSS-R SEA SURFACE HEIGHT MEASUREMENTS

K. Kohila Vani* & S. Gowsalya**
* PG Scholar, Maharaja Prithvi Engineering College, Avinashi, Tamilnadu
** Assistant Professor & HOD, Department of Electronics and Communication Engineering, Maharaja Prithvi Engineering College, Avinashi, Tamilnadu

Cite This Article: K. Kohila Vani & S. Gowsalya, "Weak Tsunami Detection Using GNSS-R Sea Surface Height Measurements", International Journal of Computational Research and Development, Volume 1, Issue 2, Page Number 137-142, 2016.

Abstract:

A tsunami can be really disastrous, causing tremendous damage and much loss of life, such as that triggered by the 2004 Indian Ocean earthquake and the 2011 Japan's Tohoku earthquake. The present system are using wireless sensor networks, GSM-based seismic alert system and some mathematical averaging function to detect the tsunami and its height from the surface. By studying the patterns of many real tsunamis, one can determine the wave-propagation velocity, tsunami speed, their amplitudes, dynamic water-attenuation factors. The proposed system uses a triple axis sensor called accelerometer sensor which can measure the acceleration when there is shock, vibration and some movements in sea. When the measured (accelerated) value is greater than a pre-defined threshold value, a alert message is given to the operators through GSM. The GNS Modem helps to find the sensor's location (latitude and longitude), and also help the operators to find where the tsunami has going to be occur.

Key Words: Wave Propagation Velocity, Dynamic Water Attenuation & Accelerometer Sensor

1. Introduction:

In its simplest form, a tsunami comprises a single solitary wave. In the ocean, this single wave can evolve into a leading crest, i.e., "the lead," and a trialing wave train of progressively shorter and lower crests. Although a tsunami cannot be stopped, it is very helpful to obtain the knowledge of whether a tsunami will occur at a specific region and how strong it will be.Natural disasters are increasing worldwide due to the global warming and climate change. However, this disaster is largely unpredictable and occurs within very short spans of time. Therefore technology has to be developed to capture relevant signals with minimum monitoring delay. Sensors are one of the cutting edge technologies that can quickly respond to rapid changes of data and send the sensed data to a data analysis Centre in areas where cabling is in appropriate. The heart of the project lies with the use of accelerometer sensor and GNS Modem. In this phase, how accelerometer sensor detecting the earthquake has been explained. The ADXL335 is a small, thin, low power, complete 3- axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis. The ADXL335 has a measurement range of ±3 g mini-mum. 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. According to the measured values, the resistance changes in the sensor and are directly displayed in the LCD display. If the measured value is greater than a measured value, an abnormal is indicated in the LCD display.

2. Dart System:

The task was to design, develop, test, and deploy real-time reporting, deep-ocean tsunameters capable of surviving a hostile ocean environment while performing with the quality and reliability demanded of an operational tsunami warning system on which so many lives depend. The tsunameter system termed Deep-ocean Assessment and Reporting of Tsunamis (DART) was composed of four integrated subsystems. Due to the importance of tsunami data in responding to destructive tsunamis, these data had to be available in real time to the NOAA tsunami warning centers. In addition, it was essential to share these data globally so other nations could take. The first generation NOAA tsunameter, Deep-ocean Assessment and Reporting of Tsunamis (DART), illustrating the four major components that had to be integrated into a single system appropriate action is shown in Fig.1. An emerging technology that met the real time and global distribution requirements was the internet. A web-based data sharing system was developed for public and scientific distribution as part of the prototype DART system. In "standard mode," each DART system reports every 6 hr a set of pressure values spaced every 15 min. The "event mode" provides plots of the tsunami at 1-min data rates to rapidly evaluate the amplitude of the tsunami in the deep ocean is plotted in Fig.2.

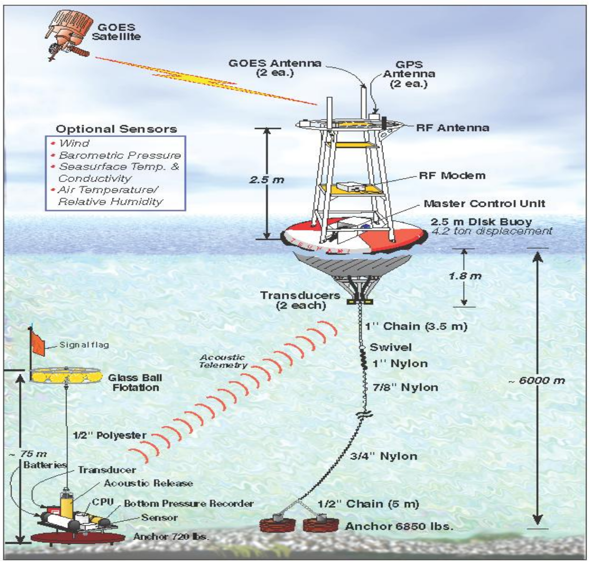

Figure 1: First Generation Tsunameter, Deep-Ocean Assessment and Reporting of Tsunamis (DART)

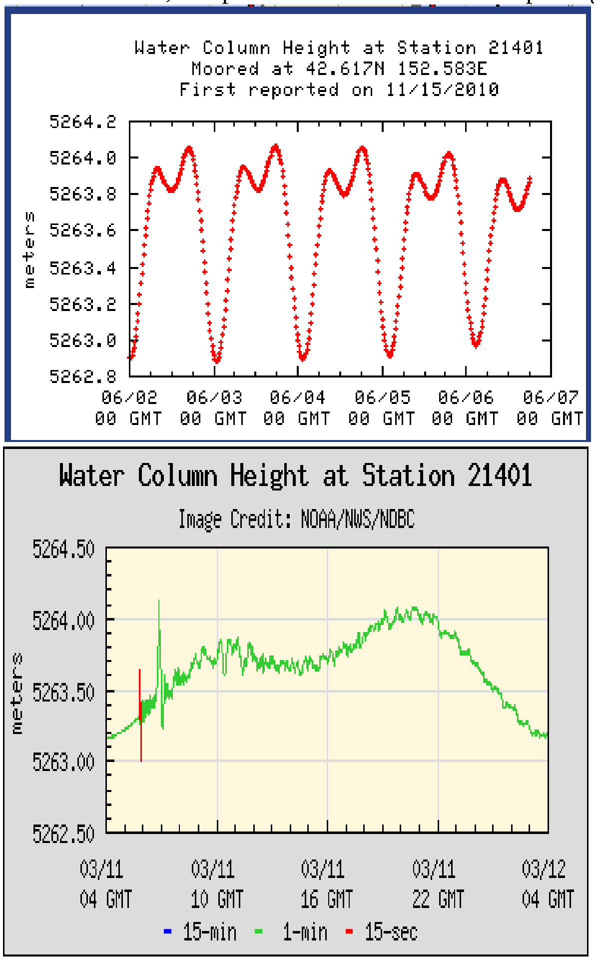

Figure 2: Typical Bottom Pressure (Converted into Equivalent Water Depth) Time Series of a DART System in Standard Mode and Event Mode

3. Determined Factors:

Wave-propagation velocity increases with the increase in bulk modulus, and the decrease in mass density of sea water, while tsunami speed increases with the increase in the ocean depth. Comparisons between wave-propagation velocity and tsunami speed have been carried out in details. The vertical and horizontal dynamic water-attenuation factors increase with the increase in the frequencies of the wave, the square root of water density and with the decrease in the square root of the bulk modulus of sea water. Initially, dynamic water heights are calculated with different values of air percentages, soils and frequencies, and finally, the tsunami amplitudes at the coast lines are also estimated. Shoaling amplification factor depends on many factors, such as the refraction rays, bulk modulus, density of water, and water depths.This paper presents (i) various velocities and speeds caused by earthquakes, in deep and shallow depths, and in the air, (ii) dynamic water heights and tsunami amplitudes, and (iii) shoaling amplification factors and dynamic attenuation factors in sea water.

4. GNSS Application and Methods Current and Planned GNSS Constellations:

GNSS are constellations of satellites designed to provide positioning and timing information for users on Earth or in space. Currently, the most widely used operational GNSS is the GPS. It consists of nominally 24 satellites in approximately 12-hour orbits. In addition to the military applications, a large suite of commercial and public sector users and applications have appeared. This is the basic method of GNSS navigation where only the received signals from a GNSS constellation, such as the publicly available GPS standard positioning service (SPS) are used. This includes applications such as assisting boats to find their way in and out of harbors using only a stand-alone receiver. The performance of stand-alone GNSS is sufficient only for a limited number of applications. Many applications either desire or require higher accuracy than a stand-alone SPS can provide. For this reason, GNSS is often combined with other sensors and signals. Differential systems are primarily intended to improve the stand-alone accuracy of a GNSS receiver position estimate, while also providing information on the position integrity. Surveying engineering work is an example of an application that often uses differential carrier phase GNSS is shown in the Fig.3. ‘‘Differential’’ indicates that a difference is being taken to mitigate some of the errors present in the stand-alone navigation estimate in an attempt to improve users’ knowledge of their position. This will typically consist of a reference system measuring some of the satellite system errors and relaying this information over a radio frequency link to users in the vicinity. An example of such a system providing coverage in North America is the wide area augmentation system (WAAS).

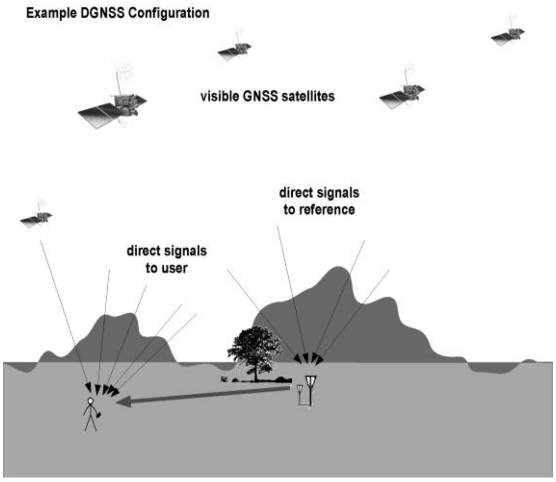

Figure 3: A Typical Example of A DGNSS User Configuration

Currently GPS is the GNSS primarily used by both military and civilian users. However; future users will have several additional GNSS options at their disposal as new systems come online. These GNSS signals, which, in many cases, are free and globally available, will be used to advance applications that were pioneered using GPS.

5. System Analyses:

A tsunami can be really disastrous, causing tremendous damage and much loss of life, such as that triggered by the 2004 Indian Ocean earthquake and the 2011 Japan’s Tohoku earthquake. weak tsunami detection using noisy sea surface height (SSH) measurement data such that recorded by satellite borne receiver and produced by the Global Navigation Satellite System(GNSS) Reflectometry (GNSS-R) technique. A Tsunami is a very long-wavelength wave of water that is generated by earthquakes that causes displacement of the seafloor, but Tsunami can also be generated by volcanic eruptions, landslides and underwater explosions. Tsunami velocity is dependent on the depth of water through which it travels Tsunamis travel approximately 700 kmph in 4000 m depth of sea water. The velocity drops to about 36 kmph at 10 m of water depth which cause damage near the shore. The proposed Tsunami warning system is basically an Embedded Systems. An embedded System is a microcontroller based system that is incorporated into a device to monitor and control the functions of the components of the device. In this system, we introduced an accelerometer sensor (ADXL335) which is a small, thin, low power, complete 3- axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. 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 location of the accelerometer is detected by using GNSS-R system. The measured value is intimated to the operators through GSM. Thus, it is being practically implemented with the future enhancement any natural disaster can be detected in advance without producing false alarms.

6. Block Diagram of the Proposed System:

This block diagram shows the proposed system. The proposed system uses a triple axis sensor called accelerometer sensor which can measure the acceleration when there is shock, vibration and some movements in sea. When the measured (accelerated) value is greater than a pre-defined threshold value, a alert message is given to the operators through GSM. The GNS Modem helps to find the sensor's location (latitude and longitude), and also help the operators to find where the tsunami has going to be occur. Very weak tsunami has also been detected by this sensor technique.

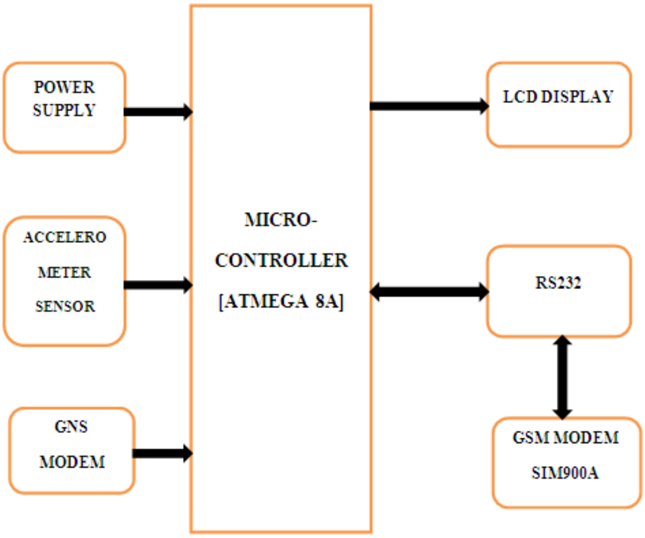

Figure 4: Block Diagram of Proposed System

7. Accelerometer Sensors:

The ADXL335 is a triple axis MEMS accelerometer with extremely low noise and power consumption only 320uA. The sensor has a full sensing range of +/-3g.This is the latest in a long, proven line of analog sensors. They included 0.1uF capacitors set the bandwidth of each axis to 50Hz and onboard regulator 3.3volts. It is a first generation 3 axis acceleration sensor is shown in the Fig.7 User could get acceleration value of X, Y, and Z axis. And it is widely used in shock, slope, and moving detection. Output sensitivity could be select by simply set voltage level on few pins. The output of MMA7260Q is analog mode, so one needsan A/D converter to read the acceleration value.

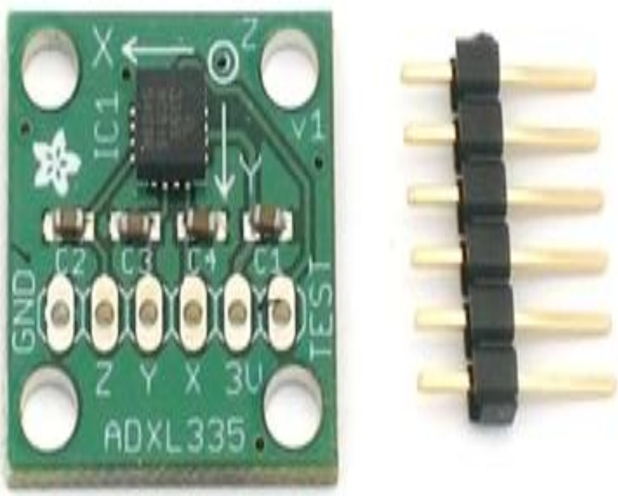

Figure 7: Diagram of Accelerometer Sensor

8. Results:

In the Tsunami Alert System, Accelerometer Sensor is shown in the Fig.8. It is used in order to detect the tsunami through the shock, vibration and any motion in the sea. From the measured accelerated values, the occurrence of tsunami is detected. The sensor can detect the very weak tsunami waves also.

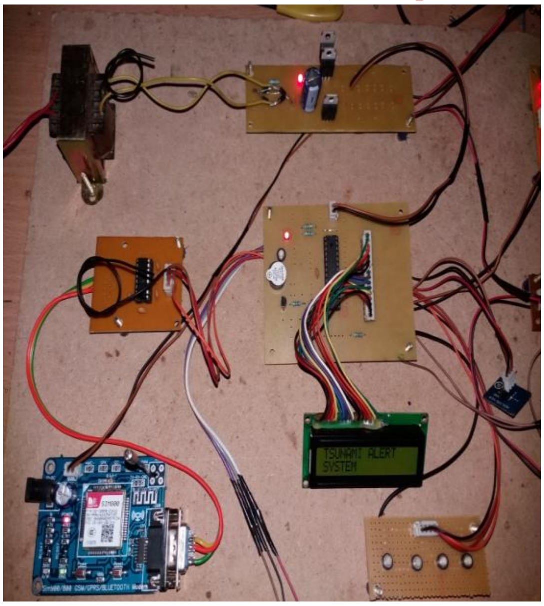

Figure 8: Tsunami Alert System Using Accelerometer Sensor

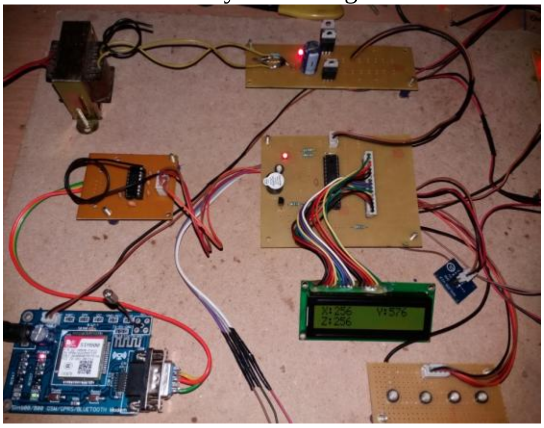

Figure 9: Measured Accelerometer Value-1

The accelerometer sensor can able to measure the value in three axes (X, Y, Z). The threshold value is chosen and it is compared with the measured value in the entire three axis. It should be less than the threshold value or else tsunami is detected in that axis. The Fig.9.shows the detection of tsunami in the Y-axis.

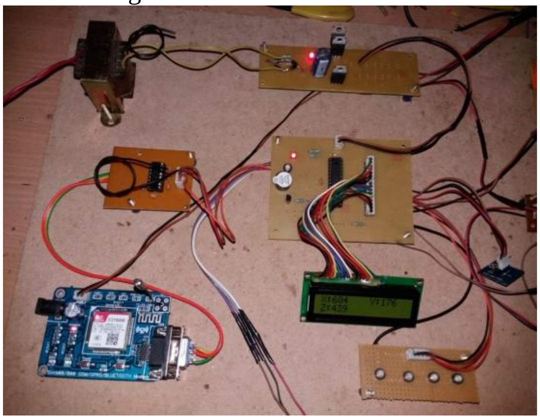

Figure 10: Measured Accelerometer Value-2

The Fig.10.shows the detection of tsunami in the X-axis is maximum and in the Z-axis is minimum if we set the threshold value is 256.The detected values will be shown in the LCD display.

9. References:

1. Kegen Yu, Senior Member of IEEE, "Weak Tsunami Detection Using GNSS-R-Based Sea Surface Height Measurement".
2. Bernard E.N. and Meinig C. Sep.2011, "History and future of deep-ocean tsunami measurements," in Proc. OCEANS, Kona, HI, USA.

3. Carreno-Luengo H., Park H., Camps A., Fabra F., and Rius A. Jun. 2013, “GNSS-R derived centimetric sea topography: An airborne experiment demonstration,” IEEE J. Sel. Topics Appl. Earth Observ. Remote Sens., vol. 6, no. 3,pp. 1468–1478.
4. Falck C., Ramatschi M., Bartsch M., and Merx A. Jul. 2010, “The GNSS-based component of the German-Indonesian Tsunami Early Warning System (GITEWS): Overview, first operation results and current developments,” in Proc. IEEE Int. Geosci. Remote Sens. Symp., Honolulu, HI, USA, , pp. 134–137.
5. Gleason S. and Gebre-Egziabher D. 2009, GNSS Applications and Methods. Norwood, MA, USA: Artech House.
6. Greensladeet al. D. J. M. May 2014, “An assessment of the diversity in scenario based tsunami forecasts for the Indian Ocean,” Continental Shelf Res.,vol. 79, pp. 36–45.
7. Heitsenrether R. M., Davis E., Sprenke J., and Teng C.-C. Oct. 2012, “Development and test of a real-time wave measurement system with an acoustic waves and current profiler,” in Proc. OCEANS, Hampton Roads, VA, USA, pp. 1–7.
8. Kato T., Terada Y., Nagai T., and Koshimura S. Jul. 2010, “Tsunami monitoring system using GPS buoy: Present status and outlook,” in Proc. IEEE Int. Geosci. Remote Sens. Symp., Honolulu, HI,USA, pp. 3043–3046.
9. Rius A., Cardellach E., and Martın-Neira M. Apr. 2010, “Altimetric analysis of the sea-surface GPS-reflected signals,” IEEE Trans. Geosci. Remote Sens., vol. 48, no. 4, pp. 2119–2127.
10. Shinde Y. S. and Gahir H. K. Feb. 2013, “Dynamic pressure sensing study using photonic crystal fiber: Application to Tsunami sensing,” IEEE Photon. Technol. Lett., vol. 20, no. 4, pp. 279–281.