

DESIGN OF AN EMBEDDED SYSTEM FOR THE DETECTION OF TSUNAMI

A THESIS SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
In
Electronics and Communication Engineering

By

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Department of Electronics and Communication Engineering
National Institute of Technology, Rourkela
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National Institute of Technology

Rourkela

CERTIFICATE

This is to certify that the thesis entitled “**Design of an embedded system for the detection of tsunami**” submitted by Sidharth Das and Biram Baburay Baskey in the partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Electronics and Communication Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other university / institute for the award of any degree or diploma.

Date:

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DECLARATION

I do hereby declare that the Project Work entitled “**Design Of Embedded System For Tsunami Detection**”, submitted to the Department of Electronics and Communication, National Institute of Technology, Rourkela is a faithful record of bonafide and original research work carried out by me under the guidance and supervision of Mr. D.P.Acharya, Asst. Professor, Department of Electronics and Communication, National Institute of Technology, Rourkela, Odisha.

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ABSTRACT

The embedded system is required for the Deep-ocean Assessment and Reporting of Tsunamis (DART). Each Deep-ocean Assessment and Reporting of Tsunamis (DART) gage is designed to detect and report tsunamis on its own, without instructions from land. The function is achieved with the help of a tsunami detection algorithm. The tsunami detection algorithm in the gage's software works by first estimating the amplitudes of the pressure fluctuations within the tsunami frequency band and then testing these amplitudes against a threshold value. This algorithm is based on bottom pressure recording(BPR). There are other algorithms based on tidal gauges (TG) and Wind wave gauges (WWG).

The amplitudes in the DART algorithm are computed by subtracting predicted pressures from the observed pressures to obtain a filtered signal, in which the predictions closely match the tides and lower frequency fluctuations. The predictions are updated at every 15 seconds, which is the sampling period of the DART gages. Therefore in one hour we get 240 samples. Background oceanic noise determines the minimum detection threshold.

Based on past observations, a reasonable threshold for the North Pacific is 3 cm (or 30 mm). If the amplitudes exceed the threshold value, the tsunameter goes into a rapid reporting mode, also known as event mode, to provide detailed information about the tsunami. It remains in this mode for at least four hours.

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1.INTRODUCTION

1.1 TSUNAMI – What is a tsunami?

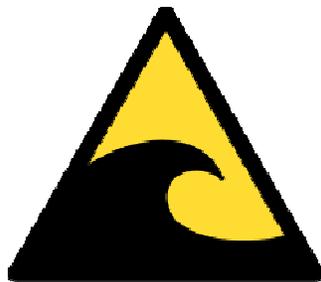
“TSUNAMI” refers to a word in Japanese which implies “harbor wave” in English.

It is one of those natural disasters which always results in the loss of properties and lives. A tsunamican be described by a large wave which is mainly caused due to underwater earthquake or volcanicor landslide.

However the displacement of water caused is very less at the point of origin of the tsunami wave which gradually goes on increasing as the tsunami wave approaches the sea shore. They can be up to a height of one meter at the shore. Their intensity can vary to a great extent depending on the type of disturbance caused under the water.

They differ from the other waves in their time period and wavelength. For a normal wave generated by wind the wavelength and time period are about 160 meters and 12 seconds respectively. On the other hand, the tsunami waves generally have a period of around one hour and a wavelength of about 150 meters.

The tsunami waves lose energy as they approach the sea shore. Some amount of the energy of the wave also gets reflected at the sea shore. However, the remaining energy is still very large and has the potential to cause the loss of the life and properties to a great extent.



TSUNAMI WARNING SIGN

Before reaching the coast, a vacuum effect is produced that sucks water from the shore seawards and exposes the sea floor. This effect can be followed as a warning of a tsunami.

1.2 Tsunami Occurrences in the last 10 years:

1. In 2004, a tsunami was caused due to the earthquake in the Indian Ocean whose magnitude was around 9.2 ; it was the deadliest tsunami that killed roughly 2,30,000 peoples.
2. In 2006, a tsunami was caused in the java island due to an earthquake in the Indian Ocean whose magnitude was around 7.7
3. In the same year 2006, another tsunami occurred in the Kurii Islands due to an earthquake of magnitude 8.3
4. In 2007, in the Solomon Islands, a tsunami was caused due to an earthquake of magnitude 8.1 in the East Pacific Ocean.
5. In the same year 2007, another tsunami occurred in Niigata, Japan due to an earthquake of magnitude 6.8 in the Northwest Japan.
6. In 2009, another tsunami was caused due to the Samoa Earthquake of magnitude 8.1 which was the largest earthquake of that year.
7. In 2010, a tsunami occurred due to the seismic activity in the Southern region of the Pacific Ocean.
8. In 2011, tsunami waves were formed due to the earthquake in South Island, New Zealand of magnitude 6.3
9. In the same year 2011, another tsunami occurred due to an earthquake of magnitude 9.0 in the Pacific coast near Japan which caused large damage to life and properties.

2. TSUNAMI WARNING SYSTEM

2.1 WHY WE NEED IT?

Tsunamis are one of the most destructive natural disasters known to man. One can imagine tsunami as a kind of flood and its source being an ocean and then you can think a little bit of destruction that tsunamis can create. For most of the people who live near sea shore, tsunami is the greatest threat of their live. Tsunami causes rivers and other water paths to overflow. This surplus water can builds deadly currents and drag away people, causing them to drown. It also does a lot of damage in the initial rush and then also with standing water. A tsunami has all of these damaging effects plus the added destructive power crashing waves.

We all know that tsunami is caused by a strong earthquake or by a volcanic eruption on the ocean bed. The resulting vibrations propagate through the water body traveling sometimes thousands of kilometers. However, a tsunami acquires its true destructive power as it comes near the land. The water level becomes lighter causing the waves caused by the earthquake to compress and combine. This is what creates the massive and devastating waves that can cause so much of destruction.

This immediate destructive process is only the commencement of the damage. After the waters drew back there was the elevated risk of disease created by stagnant and polluted water. Generally most of the tsunamis occur around the south of the Equator and In the Pacific which only brings up the risk of disease further.

Therefore, a Tsunami warning system (TWS) is used to detect tsunamis as soon as possible and issue warnings to the coastal peoples so as to prevent the loss of life and damages. It comprises of two equally significant components: a network of sensors to detect the tsunamis before sufficient time and a communications infrastructure to bring out an official document so that nearby coastal guards can give timely alarms to permit evacuation of coastal areas.

2.2 SYSTEM OVERVIEW

Tsunami Warning System consists of two physical components: a tsunameter which is located on the ocean floor and a surface buoy which is located at the surface of the ocean. The figure 1 shows a DART II system and the related telecommunication nodes.

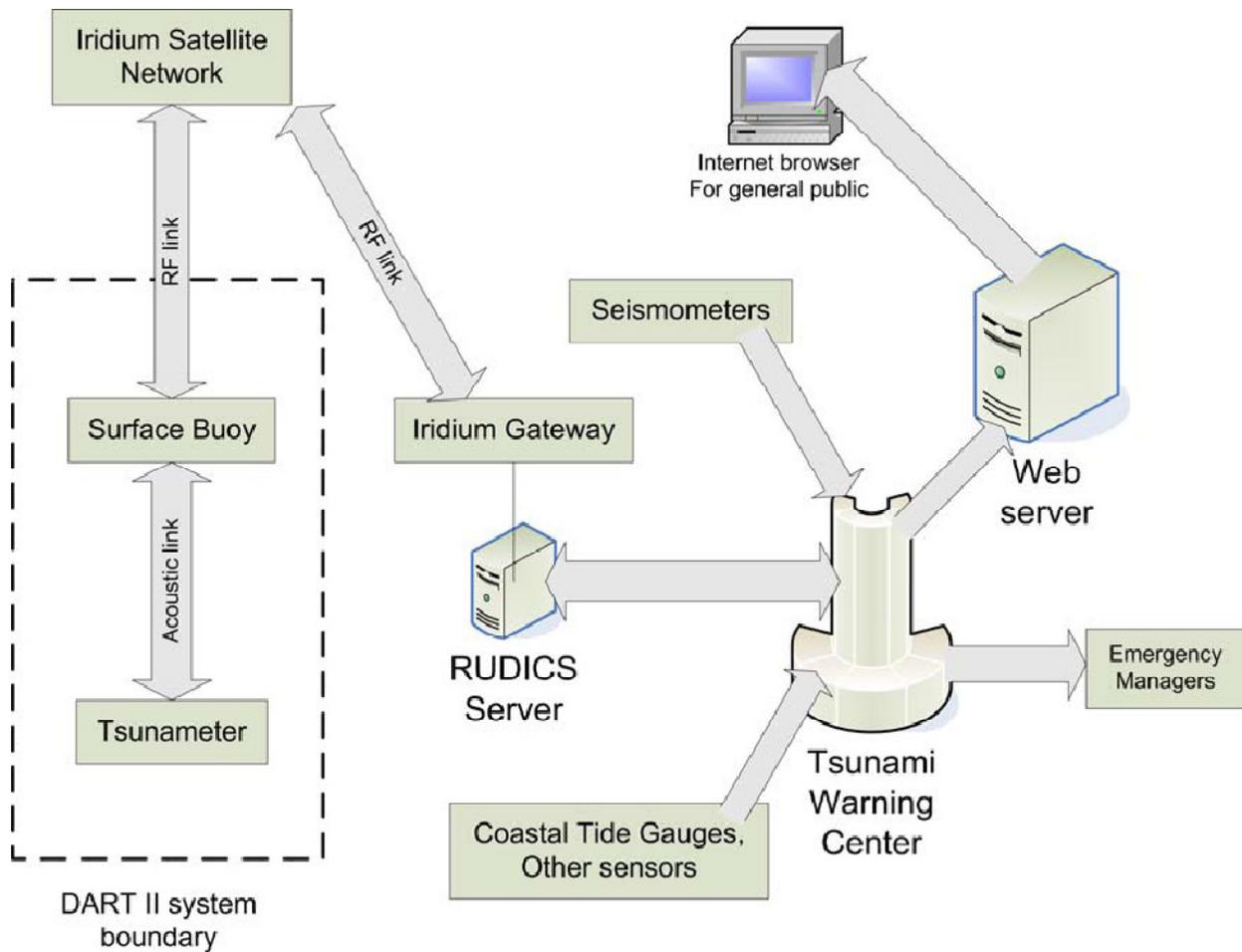


Figure 1 Block diagram of DART II system and its various telecommunication links

2.3 TSUNAMETER

The block diagram in Figure 2 shows how the various physical components of a tsunameter function together. The computer reads pressure readings from the pressure sensor via reciprocal counter, executes a tsunami detection algorithm (can be a DART or an ANN), and sends and receives data to and from the surface buoy via an acoustic modem.

2.3.1 PRESSURE SENSOR

It is used to monitor the pressure at the ocean depth continuously. It can detect a very small change in pressure at water depths. It should be noted that changes in water depth due to tsunami is less than 1cm. It comprises of a Bourdon tube which acts as a pressure to load generator. When is applied to the input of the Bourdon tube, an uncoiling force is generated which applies

tension to the quartz crystal[1]. Change in the frequency of the crystal gives the value of the input pressure. Mathematically, we can express as

$$P=A(1-T_0/T)-B(1-T_0/T^2)$$

Where T_0 and T denotes period of oscillation when the applied pressure is zero and P respectively.

The output of the pressure sensor is a frequency modulated square wave signal which is proportional to the ambient pressure and temperature,

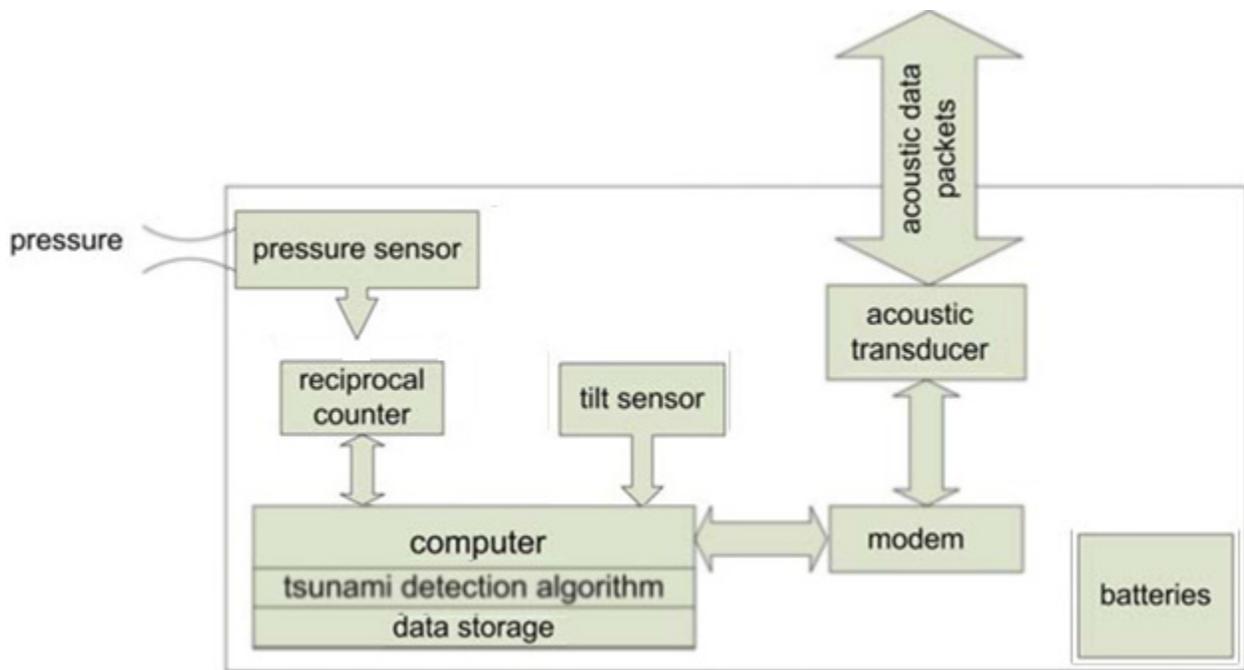


Figure 2 Block diagram of a Tsunameter

2.3.2 RECIPROCAL COUNTER

It continuously measures the pressure and temperature signal which are the outputs of the reciprocal counter. These frequency modulated signals are integrated over the sampling interval of 15 sec... Mathematically,

$$f = \frac{\text{counted input pulses}}{\text{counted clock pulses} * \text{time of one clock pulse}}$$

At the end of each sampling time, the computer reads the pressure and temperature data from the reciprocal counter and stores the data in a flash memory card. Pressure data's are used for thermal compensation.

2.3.3 COMPUTER

The embedded computer system which is present in the tsunameter was designed to be a 32-bit, 3.3 volt Motorola 68332 microcontroller. It was programmed in C. It was built to be energy efficient for long-term battery powered deployment. The computer has 4 Mb of flash memory which is used to store the pressure data's and also the simulation results. It also contains a 12-bit ADC having 8 input channels, two RS232 channels for connecting it with the acoustic. This embedded computer performs the function of implementing and regulating the primary functions of the surface and seafloor units like transmission of data communications, running of the tsunami detection algorithm (it can be either a DART or an ANN algorithm), storing and recovering the water column heights, generating the checksums, and conducting automatic mode switching (two modes are present: standard mode and event mode).

2.3.4 ACOUSTIC MODEM AND TRANSDUCER

Modem is used to transmit the digital data between the tsunameter and the surface buoy. Modems transmit digital data via Minimum Frequency Shift Keying (MFSK) modulated sound signals having options for redundancy and convolutional coding. Transducers are restrained to minimize ambient noise from entering the receiver.

2.3.5 TILT SENSOR

Each tsunameter contains a tilt sensor which is mounted in the base of one of the housings. It is used to determine the orientation of the acoustic transducer when the whole system is settled down on the seafloor. If the tilt of the tilt sensor is found to be greater than 10 degrees then the tsunameter is retrieved and redeployed.

2.3.6 BATTERIES

The computer and the reciprocal counter of the tsunameter use an Alkaline D-Cell battery pack which has a capacity of 1560 watt-hours. The acoustic modem which is present in the tsunameter is also powered by Alkaline D-Cell battery packs that can deliver about 2,000 watt-hours of energy. These batteries are designed so that it can last for at least four years on the seafloor. This whole design of the batteries is based on an assumption that how much number of events that may occur and the volume of data requested from the shore during this period. Battery monitoring is essential for maximizing the life of the system.

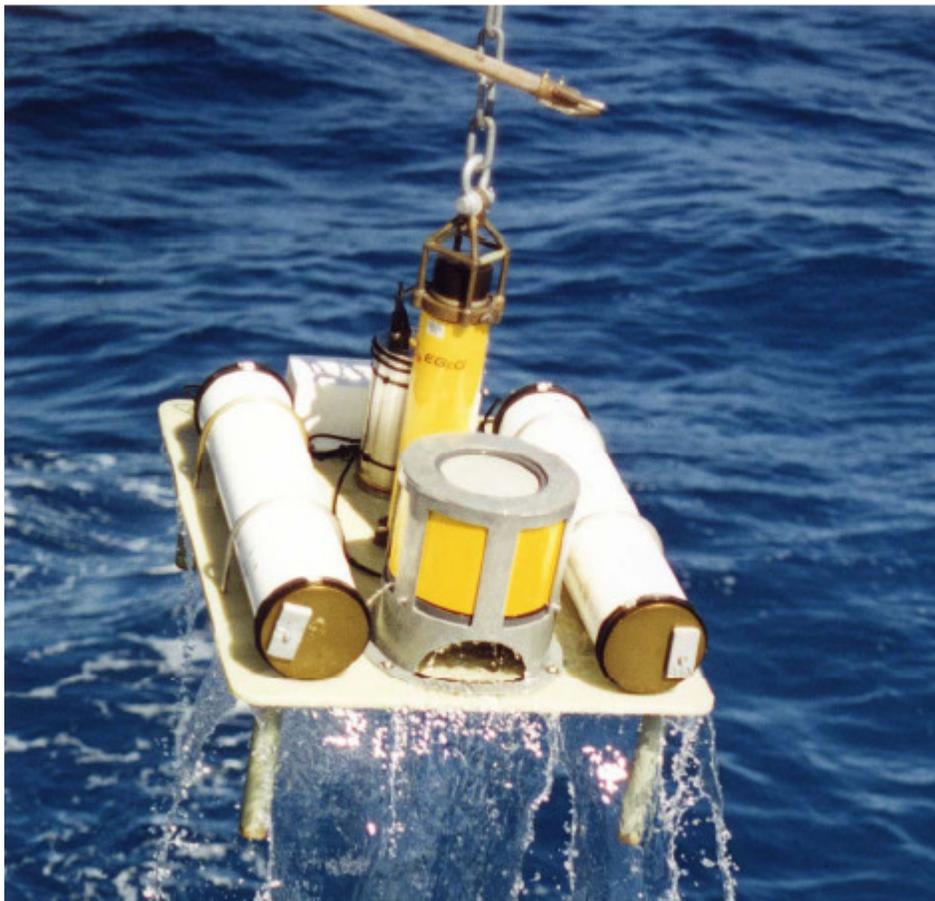


Figure 3 Recovery of Tsunameter

2.3.7 TSUNAMI DETECTION ALGORITHM

The main purpose of a DART II tsunameter is designed to detect and report the occurrence of tsunamis automatically[2]. The Tsunami Detection Algorithm works by first predicting the

amplitudes of the pressure variations within the tsunami frequency band, and then comparing these amplitude values against a prescribed threshold value. The filtered signals are obtained by subtracting predicted pressures from the observations. If the amplitudes of the filtered signal exceed the threshold value, then the tsunami meter goes from standard mode to Event Mode to provide required information about the tsunami.

2.4 REPORTING MODES

Tsunami meters are designed to operate in one of two data reporting modes: “Standard Mode” which is primarily a low power mode and an “Event Mode” which is also called as a triggered.

In Standard Mode, tsunami meter will report to ground station once every six hours. It sends information related to the average height of the water column and battery voltages. These continuous measurements are required so as to provide an assurance that the system is working correctly.

Event Mode comes into picture when earthquakes and /or tsunamis or other underwater explosions take place. At that time filtered signal exceed the threshold value. Waveform data related to this filtered signals are transmitted immediately (less than a three-minute delay).

Tsunami waveforms data's are continuously transmitted at every hour until the Tsunami Detection Algorithm once again come back into non-triggered status. At this point the system returns to its Standard Mode.

2.5 SURFACE BUOY

The DART II surface buoy [3] which is shown in Figure 4 passes information and commands from the tsunami meter to the iridium satellite network. The surface buoy contains two identical electronic systems to provide redundancy in case one of the units fails. The Standard Mode transmissions are not immediately transmitted by both systems simultaneously but are handled by both electronic systems on a preset schedule. But the Event Mode transmissions are immediately transmitted by both systems simultaneously because of their importance and urgency,

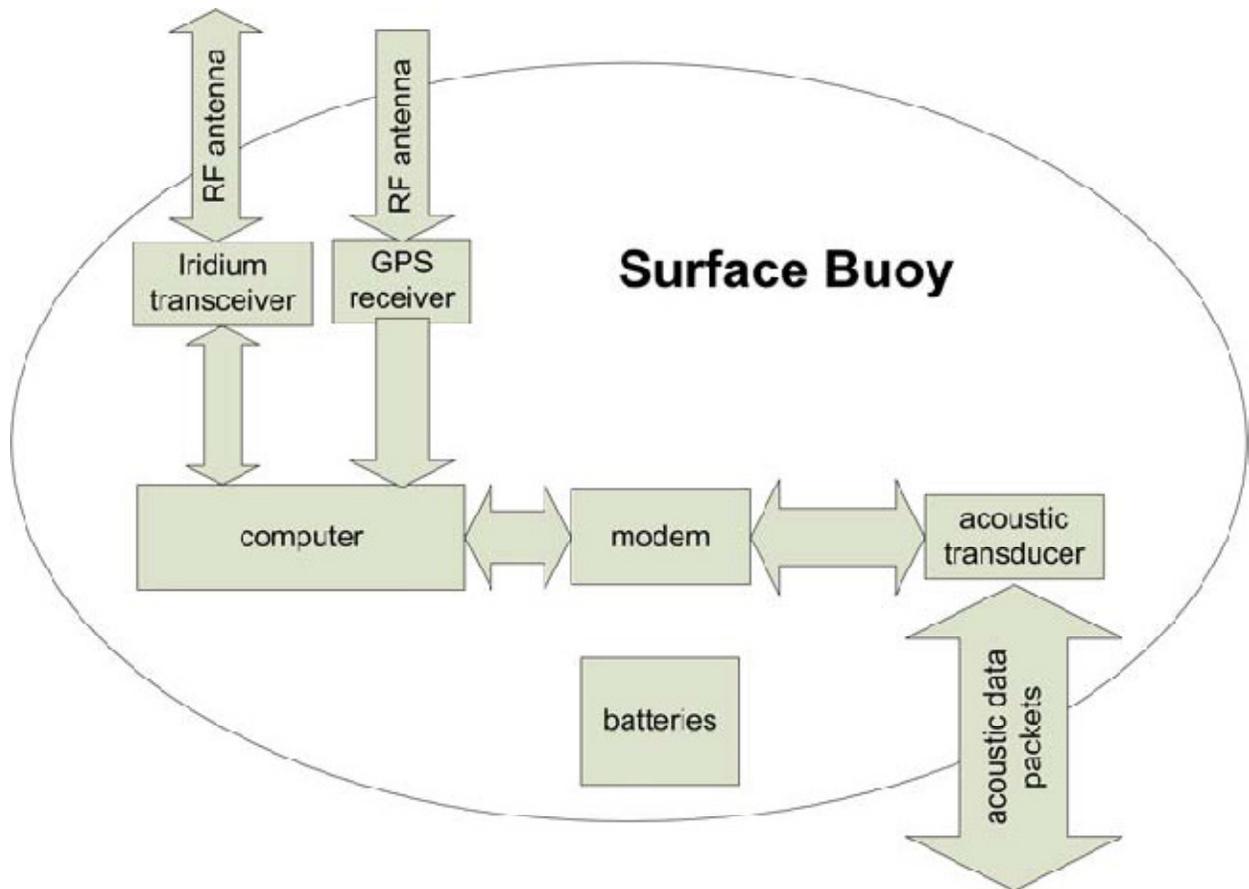


Figure 4 Block diagram of a Surface Buoy

2.5.1 MODEM AND ACOUSTIC TRANSDUCER

The acoustic modems and transducers present in the surface buoy are the same as used in the tsunameter. Same modems and transducers are used so as to improve the reliability of data transmission.

2.5.2 COMPUTER

The computer used in the surface buoy is also the same type as that of computer which is used in the tsunameter. It processes messages and commands from both the iridium satellite and the tsunameter.

2.5.3 IRIDIUM TRANSRECEIVER

The transceiver provides data connectivity via the Iridium Satellite Network. The computer present in the surface buoy is connected to the transceiver through an RS232 serial port. Data is

transferred at a rate of 2400 baud which is similar to that of the familiar dial-up modem connections.

2.5.4 GPS

It is used to maintain the buoy's computer clock's accuracy to within approximately 1 Sec of *Greenwich Mean Time (GMT)*. Moreover, a GPS position is also used to report the position of the surface buoy once per day.

2.5.5 BATTERIES

The computer and the iridium transceiver use D-cell alkaline batteries. The computer and iridium transceiver uses batteries which are powered by 2,560 watt-hour batteries and the acoustic modem uses batteries that can deliver about 1,800 watt-hour of energy. These batteries are designed so as to power the buoy for at least two years.



Figure 513 Surface Buoy ready for deployment

2.6 DATA COMMUNICATION

This section depicts all the messages that are sent and received to and from the DART II systems [4]. Telemetry reports how the data is physically transported over the distance between the hardware components. Content relates to the information contained in the messages. Format depicts how the message is formatted.



Figure 6 DART II system

The Tsunami Warning Center distributes the commands that are lined up in a server until the DART II buoy is in Listen Mode, which operates on a 20% duty cycle. The redundant systems will activate their respective Iridium transceivers at alternate times for 3 min out of 15 min. This will result in a maximum inaccessibility of only 6 min. This scheme is employed to control the buoy power requirements by decreasing the standby power draw of the Iridium transceivers.

Data from each DART II system is downloaded and stored on a server via the Iridium Gateway and RUDICS server. The Warning Centers keep an eye on this data stream in real time and are responsible for issuing warnings. Moreover, the data is posted to a web server, and can be viewed in real time on the Internet.

3. OVERALL MECHANISM

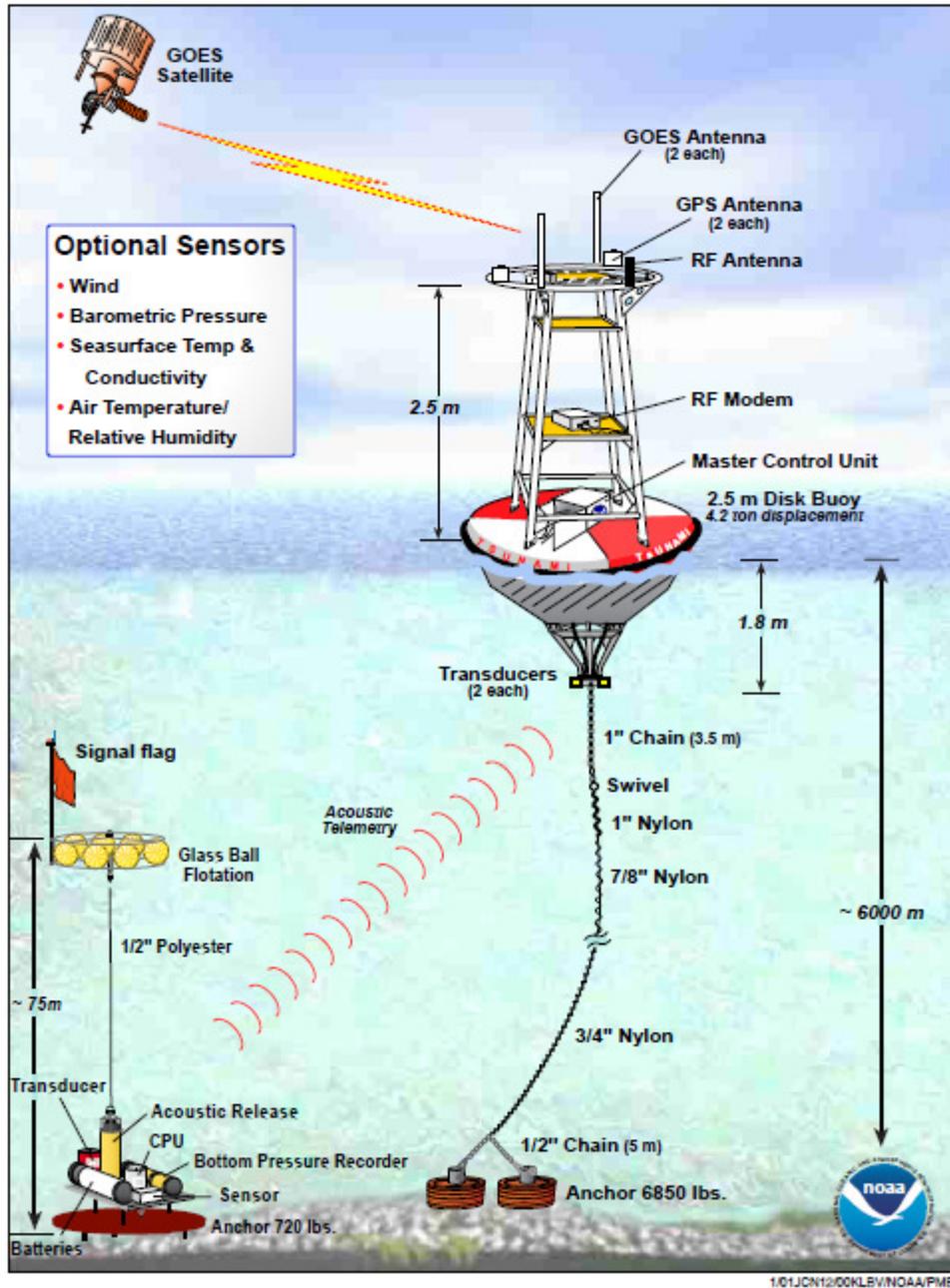


Figure 14 Overall Mechanism Of Tsunami Warning System

Each tsunami detection system consists of a surface buoy and a tsunameter which contains the bottom pressure recorder for recording pressure values and it also contains a modem and acoustic transducer for sending of data to the surface buoy.

Then the surface buoy receives the data values from the tsunameter through the acoustic link and then transmits this data to the satellite.

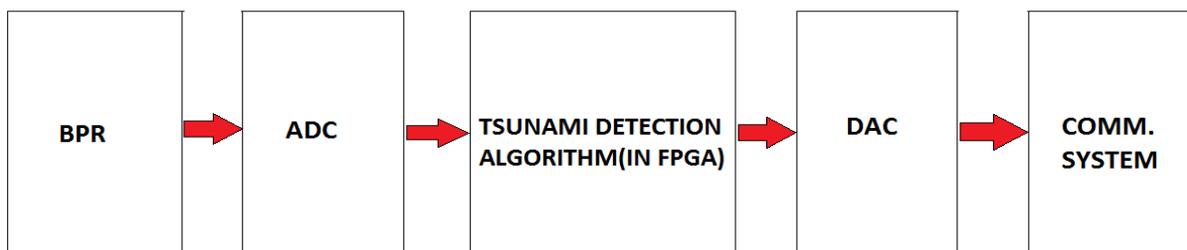
The satellite then transmits the data to the ground stations which then broadcast the data to the Tsunami Warning Centers.

The tsunami detection algorithm is implemented as a code or software in FPGA which will identify the possibility of tsunami occurrence.

The above figure corresponds to the DART-II system which is a two way communication system unlike the first generation of DART, i.e. DART-I, which had only one way communication facility.

In DART-II system, we can change the modes from standard to event or vice-versa directly from the ground station. We change them to event mode when we expect an arrival of a tsunami by referring to the data outputs which are transmitted through the satellite.

3.1 FLOW DIAGRAM



This figure describes how to implement the DART Algorithm in FPGA .

At first, the observed pressure values are obtained using bottom pressure recorders (BPRs) and then the values are given as input to an analog to digital convertor (ADC).

Then the digital data are provided as input to the tsunami detection algorithm which is already configured into the FPGA.

Then the FPGA outputs are recorded as they give the prediction pressure outputs. These values are converted back to analog form using digital to analog converter(DAC)

This final output is then passed to the comparator along with the observed pressure values, and the comparator output is used to check if it exceeds the threshold pressure amplitude.

The comparator output determines whether a tsunami warning signal is to be sent or not depending on the threshold pressure amplitude and the comparator output.

If the comparator output exceeds the threshold pressure amplitude then a tsunami warning signal is to be sent.

4. ALGORITHM

The Tsunameter works with the help of a tsunami detection algorithm. Characteristics of an algorithm:

1. It should identify a tsunami wave from other disturbances and noise.
2. It should be able to form the wave of tsunami and represent it in forms of a signal having amplitude and time period.
3. The computational time of the algorithm should be small for faster operations.
4. Moreover, the power consumption should be as less as possible.

The tsunami detection algorithms under bottom pressure recorders are

1. DART Algorithm
2. ANN Algorithm

4.1 DART ALGORITHM

This algorithm was developed by Mofjeld[5] in 1997. This algorithm is based on checking the pressure amplitude of the comparator output with the threshold amplitude.

The comparator compares the prediction pressure values and the observed pressure values, i.e. it checks the amplitude of the signal obtained by subtracting the observation from the prediction.

So if the pressure amplitude of the comparator output is greater than the threshold value then the algorithm will send a tsunami warning signal.

$$\zeta_p(t_{i+1}) = \sum_{j=0}^3 w_j \bar{\zeta}(t_i - 0.5p - 60j)$$

The above equation refers to the DART Algorithm.

Here, the coefficients ω_j are as follows:

$$\omega_1 = +1.16818457031250$$

$$\omega_2 = -0.28197558593750$$

$$\omega_3 = +0.14689746093750$$

$$\omega_4 = -0.03310644531250$$

The term in the left hand side of the above equation stands for the prediction pressure value and the term multiplied by the coefficient is the average observed pressure value in the interval 'p' minutes. 'p' is generally considered to be ten minutes.

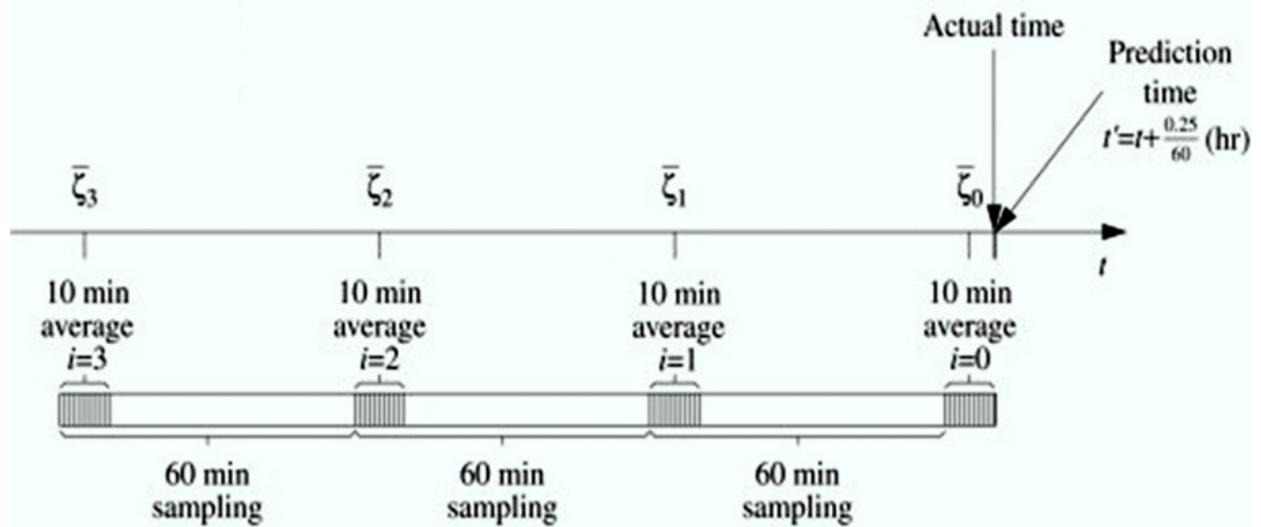


Figure 8 DART Algorithm Scheme

The standard sampling interval is fifteen seconds and the four averages observed pressure values are obtained from the shaded region in the above figure

4.2 THE ANN ALGORITHM

The ANN algorithm which is given by that by Beltrami [6](2008) is similar to that of the DART algorithm given by Mofjeld (1997) in the sense that both the algorithm filters out the astronomical and meteorological surges recorded by a (Bottom Pressure Recorder) BPR by subtracting at each new time step the predicted pressure values from the observed pressure values and then examines the actual propagation of a tsunami by comparing the amplitude of the filtered signal against a prescribed threshold value.

Therefore, the ANN algorithm (similar to that of DART algorithm) also belongs to the category of the amplitude-discriminating ones.

In order to update the prediction of disturbing variations at every 15 Sec, the ANN algorithm which is proposed by Beltrami (2008) uses a two adaptive-weight (feed-forward) network which is shown in Figure 15 consists of four input units plus bias, six hidden units plus bias and one output unit (*I4H6O1*). The network's inputs also consist of the same p -minute averages ζ of bottom pressure observations ζ as those used by the DART algorithm.

$$\zeta_p(t_{i+1}) = \tilde{g} \left\{ w_b^{(2)} + \sum_{h=1}^6 w_h^{(2)} g \left[w_{bh}^{(1)} + \sum_{j=0}^3 w_{jh}^{(1)} \bar{\zeta}(t_i - 0.5p - 60j) \right] \right\}$$

In this equation, t_i denotes the actual time (in min),

$w_{jh}^{(1)}$ and $w_{bh}^{(1)}$ denotes the adaptive weights which connects input units and the bias to the hidden units and

$w_h^{(2)}$ and $w_b^{(2)}$ those connecting hidden units and bias to the output unit.

Moreover, $g(\cdot)$ and $\tilde{g}(\cdot)$ denotes the activation functions of hidden and output unit.

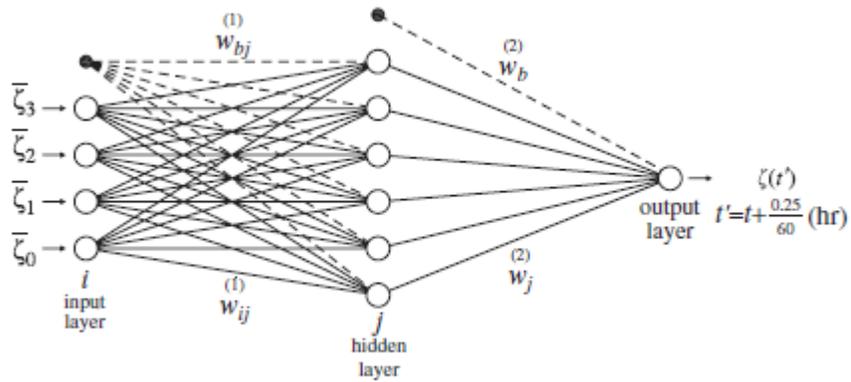


Figure 9 Feed-forward Network[7]

The above figure shows the feed- forward network on which the ANN algorithm is based.

5. RESULTS AND DISCUSSIONS

Initially the Tsunami Detection Algorithm (DART) is tested with random signals in matlab.

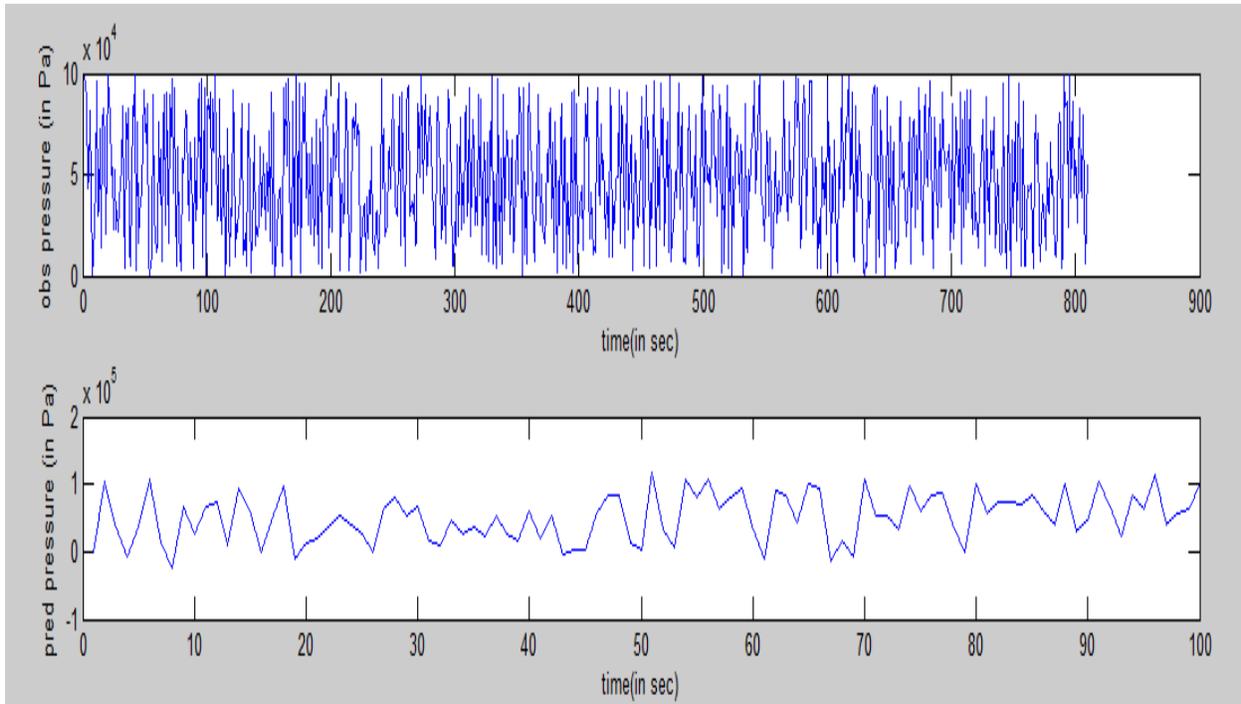


Figure 16 Observed and Predicted Pressure

Figure 10 shows the observed pressure which is a random signal in this case and a predicted pressure which is obtained through the use of the DART algorithm. The predicted pressures are updated at every sampling interval (i.e. every 15 sec) using the observed pressure and the prediction time is also set equal to 15 sec in the future with respect to the actual time.

Now the next step is to obtain a filtered signal using the predicted pressure. The filtered signal is obtained by subtracting at each new step the predicted pressure from the observed pressure. The algorithm then monitors the actual propagation of the tsunami waves by comparing the amplitudes of the filtered signal against a prescribed threshold value.

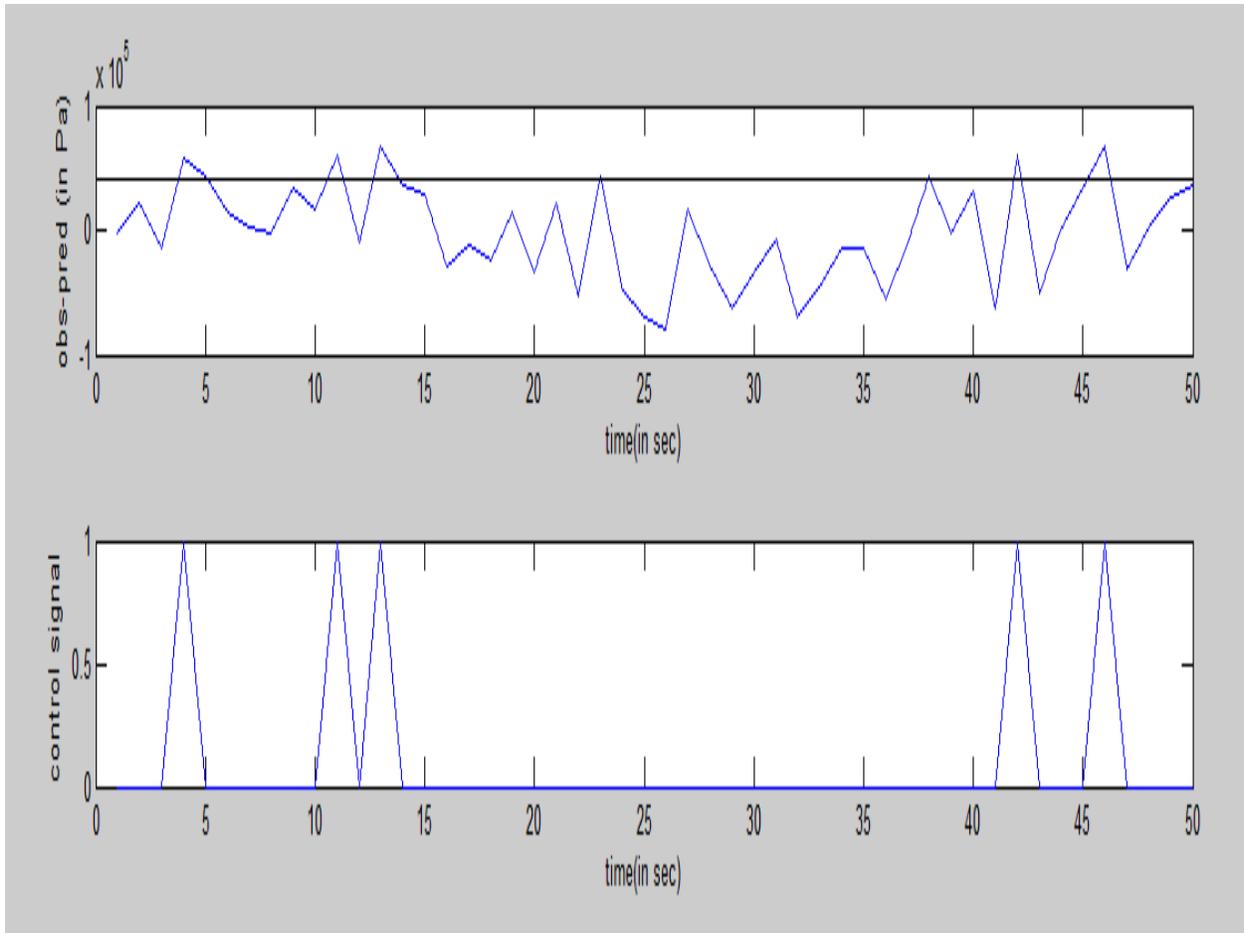


Figure 17 Filtered Signal and Control Signal

Figure 11 shows the filtered signal which is the observed minus the predicted pressure and a control signal. In this case the threshold is set at 3cm... Whenever the filtered signal exceeds the threshold value, a control signal is generated which is send to the surface buoy through the modems.

To validate the fact that the design of the DART algorithm is correct, it has to test through some real observed data. One of such observations is obtained from a site named as www.sonardyne.com . Figure 10 shows a raw absolute pressure in Pascal. Here the data are obtained at every 15 minutes.

REAL DATA

Acoustic data
hourly message, data points every 15 minutes

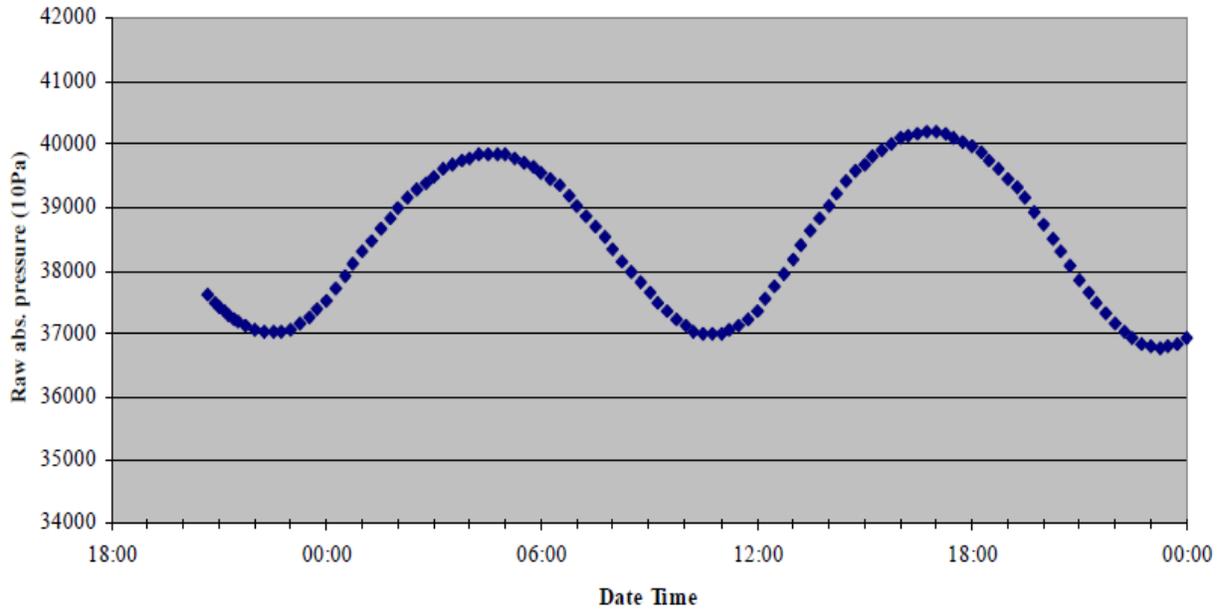


Figure 12: Real Observed Data

When the DART algorithm is tested by using the above data, we obtained the result which is shown in the Figure 13.

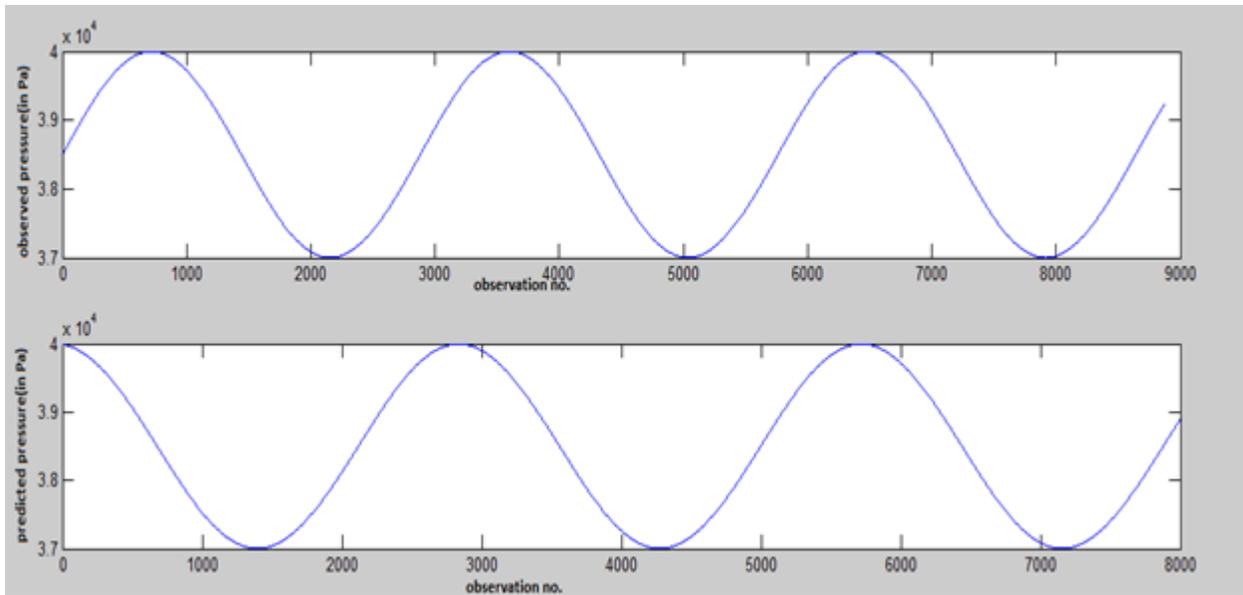


Figure 13.1 Real Data Results

It is clearly observed from the figure that tsunami is not occurring as the filtered signal obtained in this case didn't cross the prescribed threshold.

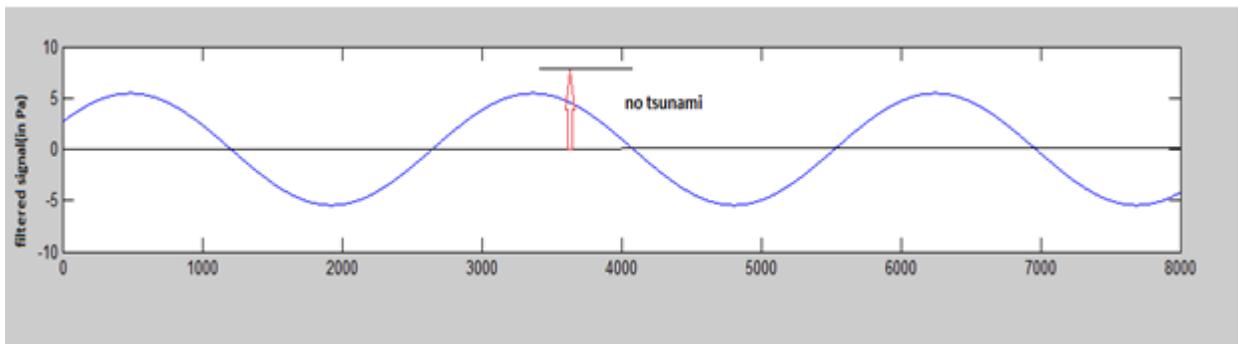


Figure 13.2 Real Data Results

Another example is taken from the same web site www.sonardyne.com which shows the occurrence of the tsunami.

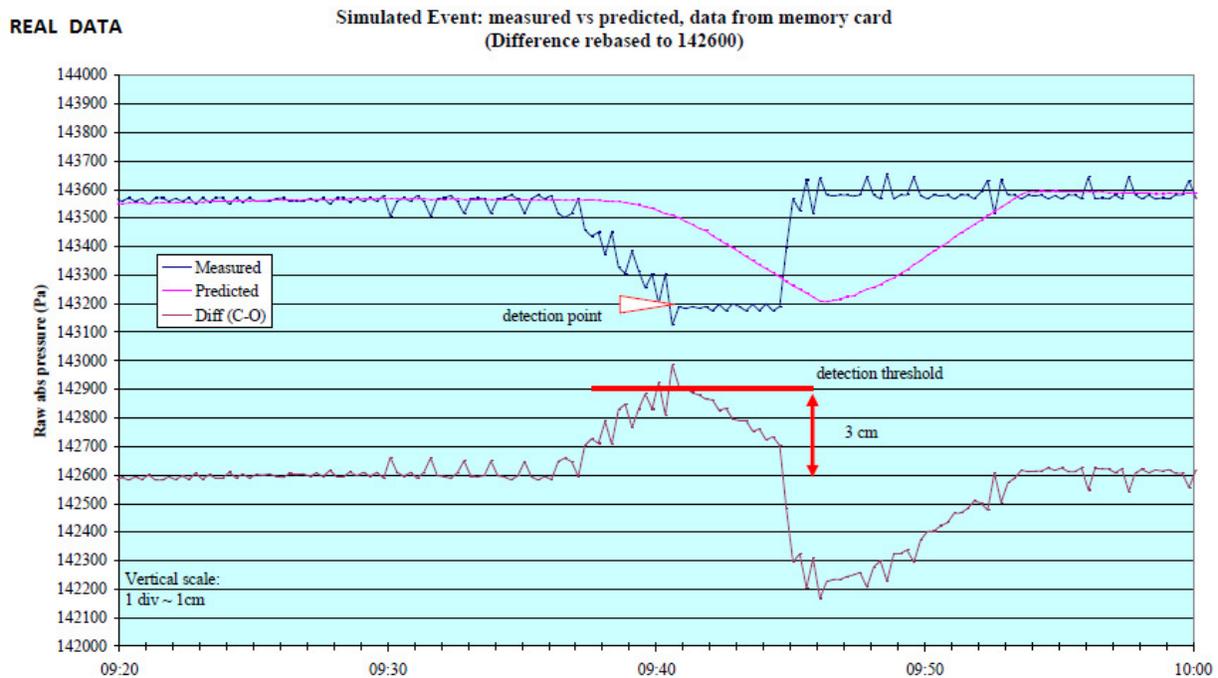


Figure 14 Showing Occurrence of Tsunami[8]

The above figure shows the detection of tsunami. When the data collected from the graph is used to test the DART algorithm we obtained the following results which are shown in Figure 15.

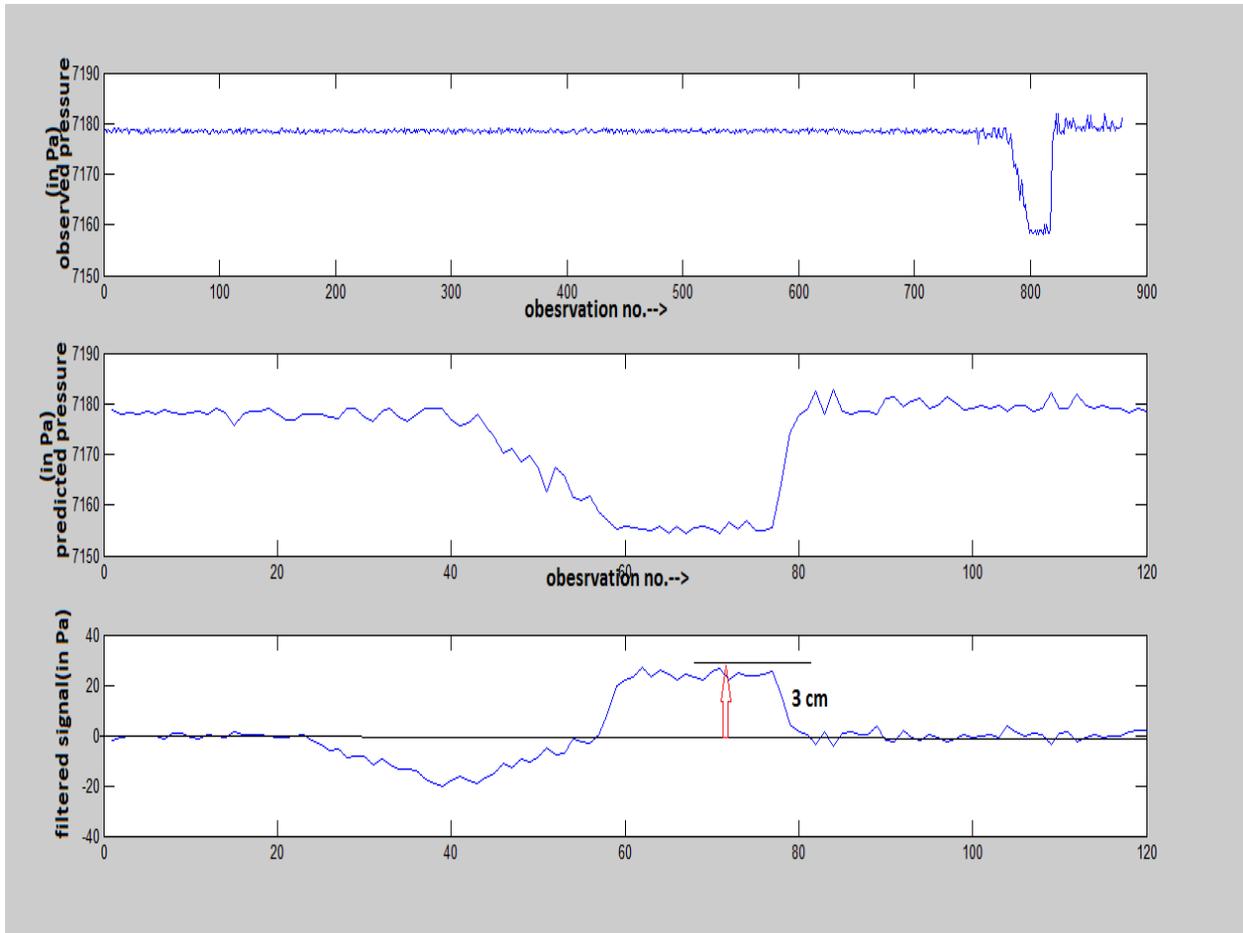


Figure 15: Tsunami is detected

The above figure shows the observed pressure, predicted pressure and the filtered signal. Here also the threshold is set to 3 cm. And it can be observed that the filtered signal has crossed the threshold value which gives the indication that tsunami is detected and it should be immediately informed to the ground station.

The above result coincides with that of the result which is shown in Figure 14. So, we can conclude that the design of the DART algorithm can be validated.

So, the next step is to implement the design in VHDL.

The results obtained from the Xilinx are shown in figure 16.

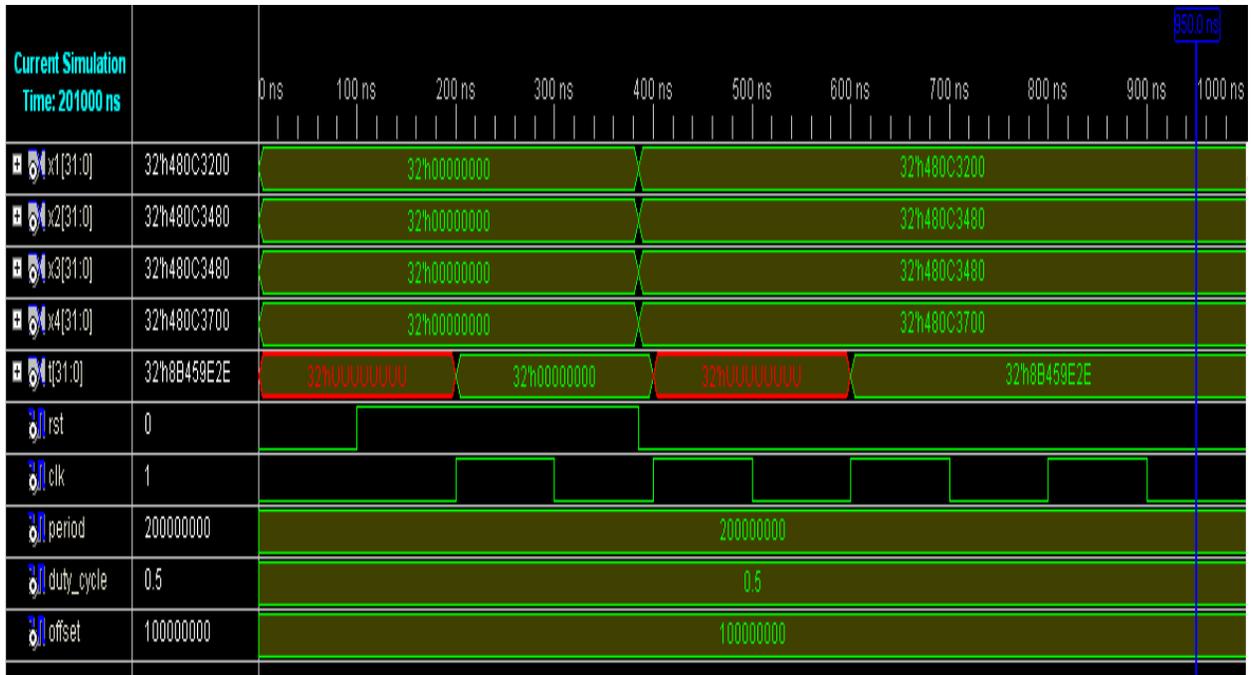


Figure 16: Output waveform of different input

The above figure is the test bench waveform obtained for the DART algorithm.

To study the above figure elementary knowledge of Vhdl and Xilinx is essential.

Here we have obtained only 1 output which is the prediction pressure value using the 4 coefficients and the 4 average observed pressure values in hexadecimal.

The coefficients were first converted to binary form using the website <http://www.ecs.umass.edu/ece/koren/arith/simulator/FPAdd/>

Their values in hexadecimal are

$$\omega_1 = 3F958106$$

$$\omega_2 = BE905532$$

$$\omega_3 = 3E16872B$$

$$\omega_4 = BD072B02$$

Then those binary values were converted to hexadecimal value and then they were multiplied with the respective average pressure inputs respectively and all are added finally to get the prediction output in hexadecimal form.

The DART algorithm is also tested in ALTERA and the results obtained from that are shown in the figure below.

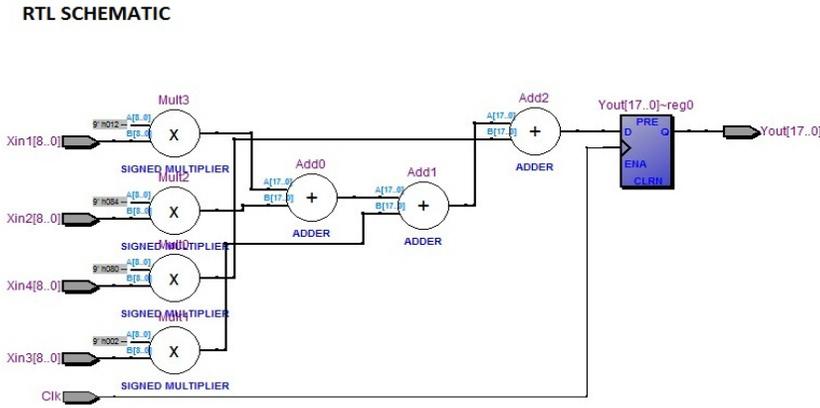


Figure 17: RTL Schematic obtained in ALTERA

The above figure shows the RTL schematic obtained for the DART algorithm. This is the case for obtaining one prediction pressure output.

This circuit uses four multipliers and three adders to obtain one output according to the DART algorithm. The code was written in VHDL and the target device used was Cyclone-II. Also the device name was EP2C20F484C7.

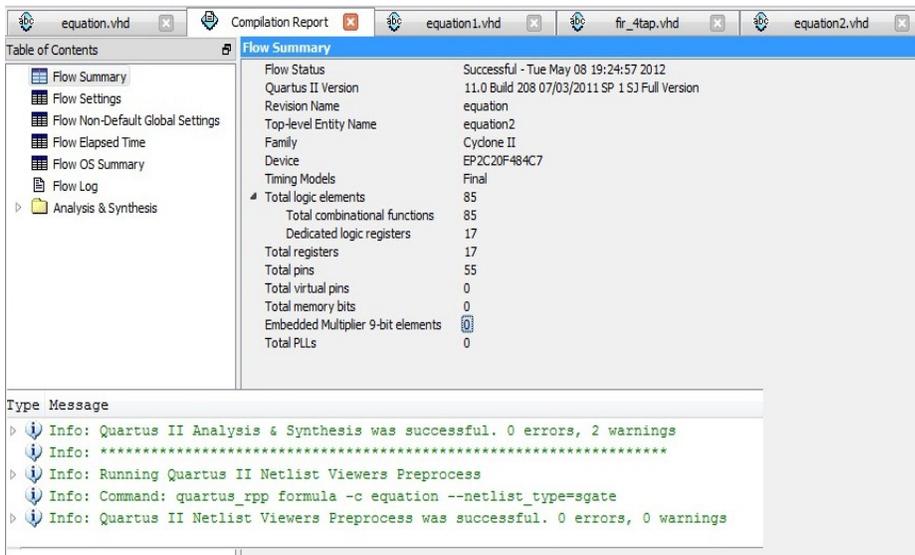


Figure 18: Flow summary of the code in ALTERA

The above figure shows the summary output of the VHDL code written in ALTERA.

The outputs obtained are as follows:

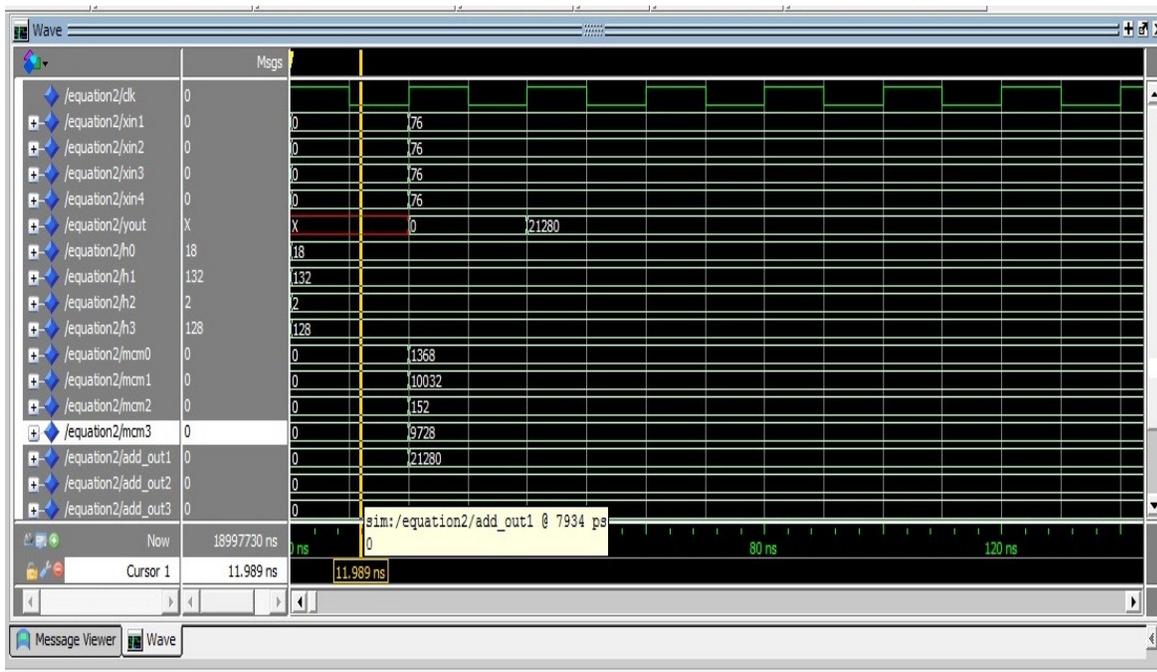


Figure 19: Output waveform of the same input

Here all the four inputs are taken as 76 and the coefficients are 18, 132, 2, and 128 respectively. Here both inputs and coefficients were converted to fixed point binary values. Thus the corresponding output obtained is 21280.

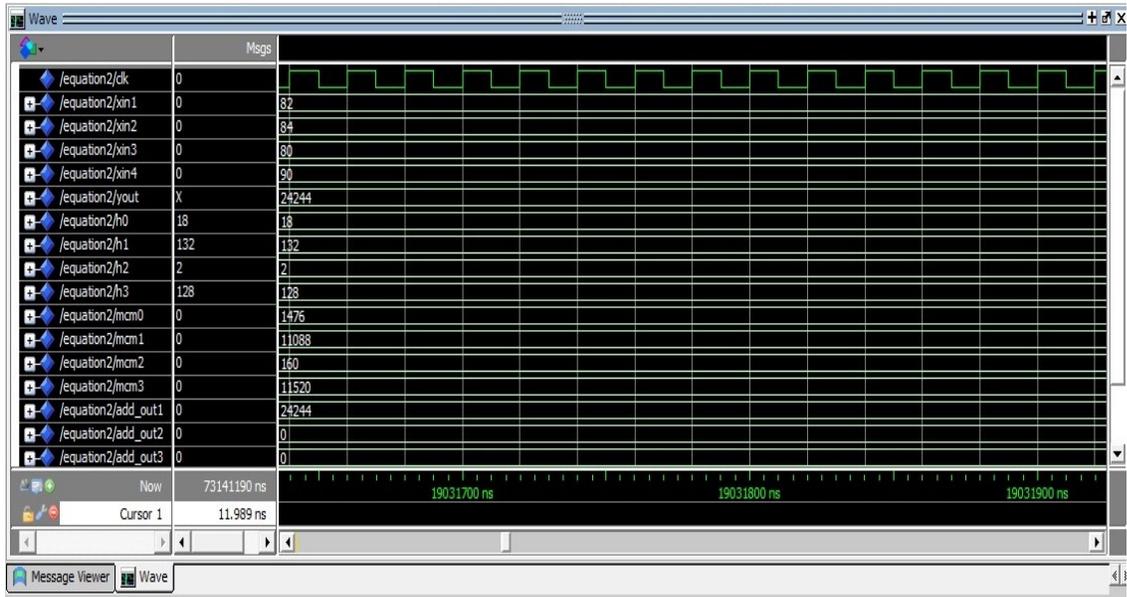


Figure 20: Output waveform of different input

Here the four inputs are taken as 82, 84, 80, 90 and the coefficients are taken as 18, 132, 2, and 128 respectively.

And the corresponding output obtained is 24244.

Here also both inputs and coefficients were converted to fixed point binary values and the output obtained is also in fixed point binary.

The calculation begins only after the reset is '0' and then the second red area in the output is due to the fact that the calculation takes some time to get the output. That can be considered as a delay in the output.

This is the case for getting just one output. However to run the algorithm continuously, we have to take the inputs from a text file, four inputs at a time which have to be arranged in the required order as needed in the DART algorithm.

6. CONCLUSION AND SCOPE FOR FUTURE WORK:

With the increase in the number of occurrences of the tsunami, it has become quite essential to develop an efficient tsunami warning system for the detection of tsunami before it arrives so that the loss of life and property could be minimized.

As a system cannot be hundred percent efficient, so there is always scope to improve the tsunami warning system in terms of speed or accuracy or power consumption, etc.

When an earthquake occurring under the sea is very close to the sea shore, then the tsunami warning system cannot provide sufficient time before the arrival of the tsunami.

This thesis is a step taken to get knowledge of the existing tsunami detection algorithms and to study and implement them in MATLAB and VHDL. However implementation in the VHDL needs to be improved for the actual working of the tsunami detection algorithm continuously.

In this case we have applied the existing DART Algorithm, but after this the other algorithm called the ANN algorithm needs to be applied as it is more efficient and accurate.

Simulation results by experts in this field have shown that a fifteen minute sampling rate of ANN algorithm is more effective than a fifteen second sampling rate of the DART Algorithm.

The present tsunami detection systems are implemented in microcontrollers but here we want to implement this in FPGA so that we can have many components of the Tsunameter on the same board. This will help in improving the speed of the tsunami detection system.

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