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Harnessing the Ocean's Wave Power for Bangladesh's Dynamic Coastal Areas

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ABSTRACT
The current energy crisis needs to be solved through renewable and clean energy sources. Now-a-days, the energy transformation technologies from oceanic waves has craved large attention. An extremely promising source of energy exists in the world's oceans. Many energy transformation systems have been introduced to transform the mechanical force of oceanic wave into electrical power. Ocean energy inhabits in the shapes of wave, marine currents, tidal, salinity and fervent (temperature gradient). This research finds out the flourished electric technologies for grid power enhancement of various offshore wave energy transformation devices. The experimental outcomes and simulations for introduced modified inverter technology are submitted. The mentioned Ocean Wave Energy Converter craves lesser construction area and is guileless to conduct. The electrical conjunction configurations for enhancing the electric power of the multi wave energy transformation devices are flourished by applying the most feasible lowcosts grid interface electrical technologies based on power electronics.

Keywords: Ocean wave, Buoying force, Wave energy converter, Offshore wave power, Grid enhancement.

1. Introduction

Keeping pace with the accelerated development of worldwide economy, the decline of energy, like as coal, oil and natural gas, is becoming more and more dangerous and particularly in current years it is seen that energy demand has been befalling. Among many other sources of renewable energy ocean wave energy is that kind of renewable energy which empowers a titanic potential which may contribute to the globally increasing requirement of power [1]. An essential characteristic, high density which places ocean wave energy the highest one among the renewables. For emerging electrical power from the ocean encirclewave power, tidal power and ocean thermal energy transformation are the most well flourished technologies [2] which have been implemented and inflicted for years. Since the wave energy industry is yet in R&D [1], in order to make wave energy an economically serviceable technology there is much that can be versed from the adeptness of developers in allied industries. In the wind industry, for instance, various generic turbine dynamics of large-scale dominion wind turbine schemes [3], as well as the potentials of large-scale wind farms. For calculating power output at a dynamic installation position corresponding generic designs for ocean wave energy converters can be used [2] from which wave energy researchers, developers, investors and consumers can be vastly benefited.

For conducting wave energy technology there can be seen various compelling controversies and they are:

Wave energy belongs high power density [2] and for this it is one of the most downcast cost renewable energy generation process. Solar and wind energy are less unpredictable than the wave energy [3], delivering a better possibility of being transmitted to an electrical grid system. For generating electricity thetransformation of ocean wave energy to electrical energy is regarded to be one of the most environmentally efficacious ways; hence it doesn't render any kind of extravagance to be reserved or annihilates the environment. Wave energy researchers, developers or investors locate the wave energy devices far away from the shore (offshore) that they are commonly not noticeable. While propagating wave power devices there can be found below challenges:

For transforming wave energy to electrical energy, continuous motion [4] of waves is needed. The wave power can be achievable at inefficient speed and elevated forces. The movement of forces is not in solo approach. Supreme speeds [3] and a constant input are generally required for operating an electric generator. Storm damage and saltwater deterioration are needed to be endured by the wave power converter devices. Wave power converter's costs, installation & observance cost and electricity distribution costs are considered as total cost for converting wave energy to electrical energy.

Wave energy researchers and developers have been revealing a number of Wave Energy Converter (WEC) technologies[5,6] for several location patterns with various performing methodology. This paper is embodied as follows. Section 2 represents why ocean wave power can be an alternative for Bangladesh. Section 3 presents a background about concept of production of ocean wave energy. In section 4, the classification of wave energy converters will be discussed. Section 5 represents how wave energy can be extracted and implemented with power or national grid. Section 6 presents circuits & simulations for wave energy converters. Finally, concluding outlooks will be given in section 7.

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2. Why Ocean Wave Power can be an Alternative Power Source of Bangladesh

Tides in Bangladesh coast hatch in the Indian Ocean. It penetrate the Bay of Bengal through the two submarine ravine, the ‘Swatch of No Ground’ and the ‘Burma Trench’ and thus takes place very near to the 10 fathom adumbration line at HironPoint and Cox’s Bazar respectively at about the same time (As-Salek and Yasuda, 2001). Outstretched shallowness of the north-eastern bay provides rise to partial repercussion there by rising the tidal range and the abrasion distortions concurrently. The geomorphology [7] of the coastal side plays a very significant figure in tide propagation from the coastline towards inland. Tidal waters go longer distances on the plain land with low surface slopes compared to plain land with medium to steeper slopes. Coastal flooding from the tide is straight away influenced by the variation in elevation and surface form. For that reason, there is a clear connection between geomorphology [8] and tidal water altitude. The higher the altitude of the surface form and steeper the slope, the lower the percolation of tidal waters inland and vice versa. The coastal morphology of Bangladesh is ruled by: (i) a boundless network of rivers; (ii) an abundant discharge of river water heavily encumbered with sediment; (iii) a big number of off-shore islands and sand bars; (iv) the Swatch of No-Ground coursing NE-SW partially across the continental shelf about 24 km south of the Bangladesh coast; (v) a funnel sized, shallow and wide estuary; (vi) a lightly sloping wide continental shelf; (vii) a confined strip of coastal landforms fronting hill ranges and (viii) strong tidal operations. The Sandwip channel is known for funnel shape, which causes a high revelation of the tidal wave towards the upper end of the channel. The triangular shape [7] at the top of the Bay of Bengal helps to funnel the sea water pushed by the wind towards the coast and causes further amplification of the tidal levels. This is generally what happens in the amplification of tidal levels on the Bangladesh coast [7]. The tidal waves associated to the class of long gravity waves. In deep water, the long gravity wave circulates[6] much faster than the speed with which the weather system travels. So, the weather system cannot keep up with the water wave and hence cannot convey any momentum. But on the mainlandshelf, where the water depth is smaller, the gravity wave voyages much slower than in deep water and a noteworthy transfer of energy from the weather system to the water wave transpires by resonance. Therefore, the tides which have zero amplitude in the deep water, quickly forms up to several meters amplitude on the shallow inland shelf [8]. As this enlarged water level approaches the coast it creates heavy wave. Normally these waves washed away with time. But we have to account a fact that these waves carry a good number of energy. As Bangladesh is currently suffering from energy crisis our resources are very limited to our demand. If we use this wave energy & convert it to electrical energy then it can be the new power source of Bangladesh besides the conventional power system. As this is a renewable power source [8] it will not affect our environment & we can gain endless power by harnessing our Bay of Bengal ocean water.

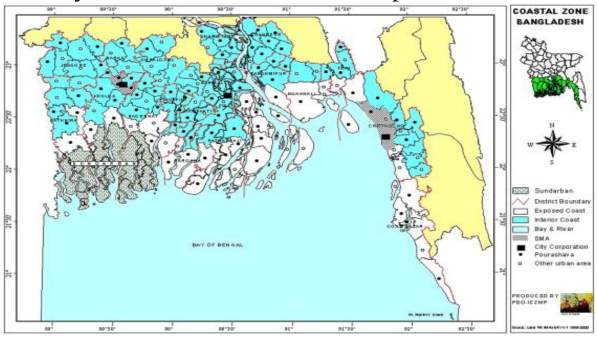

Fig.1 Costal Zone of Bangladesh [7]

3. Concept beneath Ocean Wave EnergyProcreation

3.1. Energy from Ocean Wave

Ocean waves represent an affluence of renewable energy which is one of the green energy sources. Ocean wave’s kinetic energy is explored as the circularly [4] roaming particles of the ocean waters and the high particles with respect to the plane water margin are considered to have a dynamic energy, the energy flux is instantaneously affiliated with the period and the waves’ square of amplitude as in (1)

$$\Phi_w \alpha\, h^2 T$$

$$\text{Therefore, } \Phi_w = kh^2T \quad (1)$$

Where wave energy flux is represented by $\Phi_{w,}$ wave amplitude is represented by h and T indicates period of wave. k is irreversible. 50 kW energy oversteps for every meter breadth of the wave, when enormous amplitudes and lengthy periods are possessed by the waves [9]. The ocean wave is able to conjectural as a sinusoidal wave. The sea wave power can be typically illustrated by equation (2) from this approximation,

$$P = \rho_{sea}\, g\, 2\, h\, 2\, T/\,(32\,\pi) \quad (2)$$

Where, the power of wave is indicated by P, seawater density (1025 kg/m^3) is presented by ρ_{sea},g indicates gravity, period is T and wave height is represented by h [10]. The energy which is acquired from this power can be transformed to several forms of energy to procreate, forinstance,electricity.

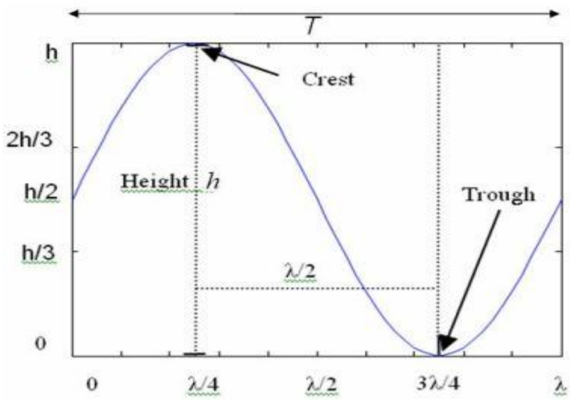

Fig.2 Approximation of sinusoidal wave for ocean wave [3]

The sinusoidal wave movement of the ocean waves is imitated consummately by a buoyant, if we know the ordinary wave behavior [9], then we can calculate the turnover of a buoyant object (Fig. 3). The conjectural utmost turnover can be computed from equation (3)

$$\theta = \tan\text{-}1(h/\,(\lambda/2))^{0} \quad (3)$$

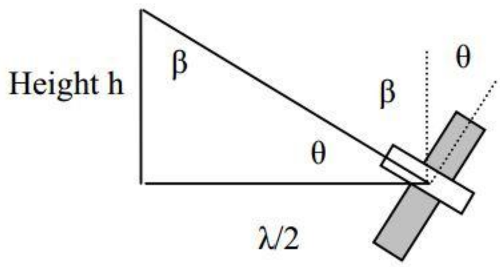

Fig.3 Turnover angle of a buoyant system, θ and approximation via a line from the peak to the channel. The perpendicular state is taken as the cornered relevance [4]

3.2. Energy of water-flourished rapidity & tides

Current energy acts beneath the identical principles as hydraulic embankments [5] where the kinetic energy of one-way movement of bodies of water revolves a turbine, which, severally, transforms the kinetic energy into electrical energy via a cyclic generator.

Ocean and tidal are the two principal forms of water-based currents. Flowing in an unseparated approach and force is the tendency of ocean currents. These samples are influenced by water salinity, wind and temperature by which currents can drift in one channel. Gravitational [10] pull from the moon and sun controls tidal currents. They are found nearby shore and are directional because of being low and high modeled tide.

Large quantities of energy can be gained from comparatively small devices in the ocean which exposes in high power density of water [4]. On the other hand, it would need a wind turbine three times the volume of an ordinary-sized underwater turbine to procreate equal quantity of power from wind that can be disseminated from water.

The equation for the power generation of a turbine harnessing the kinetic energy of tidal currents can be deliberated as,

$$P = \zeta\rho_{sea}AV^3 / 2 \quad (4)$$

Where P indicates power generated in watts, turbine efficiency is indicated by ζ, seawater density (1025 kg/m^3) is represented by ρ_{sea}, sweep area of turbine (in m^2) is presented by A and velocity of flow is determined by V. From equation (4) total power originated is proportional to the cube of the flowing velocity [9].

Using several processes such as tidal barrages the energy of water periphery altitudes during tides can also be seized [5]. As tide's frequency is emblematically twice a day and the season of a tidal wave would be 12.5 hours that makes the similar power given by vast. Pretending identical ocean wave and tidal wave altitudes, the power companioned could be 5 to 10 thousand times larger with tides than ocean waves.

4. Alignmentof Wave Energy Conversion Systems (WEC)

Many wave energy conversion systems (WECS) have been invented through these years, only a small portion has been evaluated and tested. Besides, only a small amount has been examined at sea, in ocean waves, rather than in laboratory wave tanks [11, 12]. A WECS may be installed in the ocean in various feasible situations and locations. It may be made shifting or engrossed completely in the sea offshore or it may be lying on the shore. A WECS on the sea bed may be completely sunken, it may prolong above the sea surface, or it may be a converter system located on an offshore platform. Apart from wave-powered rowing buoys, nevertheless, most of the prototypes have been settled at or near the shore [12]. Land-based systems comprise the tapered channel (TAPCHAN) and different types of fixed oscillating water column (OWC) devices. Caisson-emerged systems include static OWC devices, pivoting flaps, and enclosed, swelling floats. Offshore devices filled with floating OWC devices, swelling buoys and other devices [4]. WECS can also be sorted as: (1) oscillating water columns; (2) wave surge or focusing devices; or (3) floats or pitching devices [13,14].

• Oscillating Water Columns (OWC) - These machines produce electricity from the wave-exerted rising and falling of water in a cylindrical shaft. The rising and falling water column directs air into and out of the peak of the shaft, energizing an air-guided turbine.

• Focusing Devices or Wave Surge - These shoreline machines also entitled as "Tapered Channel" or "TAPCHAN" systems, depends on a shore-connected construction to channel and coagulate the waves, driving them into a squatted reservoir. Water flow out of this repository is used to generate electricity, using standard hydropower technologies.

• Floats or Pitching Devices - These machines produce electricity from the pitching function of a floating object. The object can be seated upon floating a raft or to a machine adjusted on the ocean plane.

Oscillating Water Column: The main device spread out worldwide is the Oscillating Water Column (OWC). This is made of a partially drowned, notch structure that is open to the sea below the water line. This detain a column of air on top of a column of water. Waves move the water pillar to rise and fall, that alternately compresses and decompresses the air of the chamber. This trapped air is allowed to flow to and from the atmosphere via a Wells 10 turbine, which has the caliber to rotate in the same direction regardless of the direction of the airflow. The circulation of the turbine is used to produce electricity [15]. By anaccelerate edge, the most money and attempt being spent worldwide on wave energy Evolution employs the OWC [16].

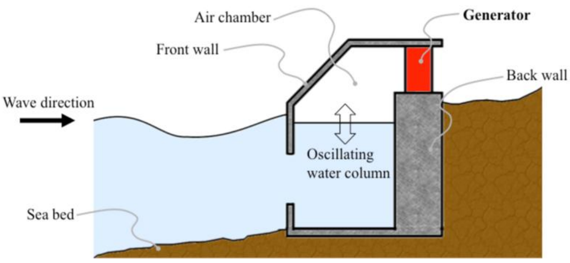

Fig.4 Oscillating Water Column (OWC) System[14]

Tapered Channel Systems (TAPCHAN): This is the unostentatious conversion process, harmonious in many ways to common low-head hydroelectric technology. Where site circumstance allows construction of a large coastal repository without widespread blasting or dam-building, it is the most cost friendly wave energy machine developed to date [11]. The tapered channel (TAPCHAN) composed of a collector that funnels waves into an ever-narrowing drain that increases their height. The kinetic energy of the traveling wave is converted into potential energy as the water is gathered in the repository. Water flow back into the sea through a conventional hydroelectric turbine that produces electricity [13].

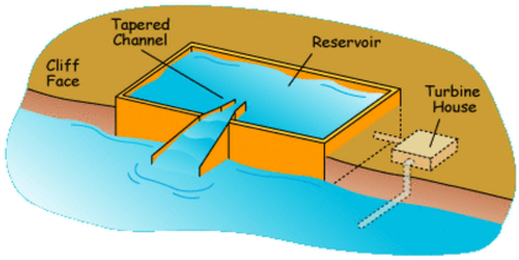

Fig.5 Tapered Channel System (TAPCHAN) [17]

Floating Devices: One of the benefits of floating devices over fixed devices it that they can be placed in deeper water, where wave energy is far greater than onshore (since waves lose energy with decreasing water altitude). There is no necessity for significant earthworks, either, as there is with onshore machines [17]. The Salter Duck, Clam and various floating wave energy machines produce electricity by the harmonic movement of the floating section of the device, on contrary to permanent systems which use a stationary turbine that is powered by the movement of the wave. In these systems, the devices rise and fall according to the course of the wave and electricity is generated through their motion [17].

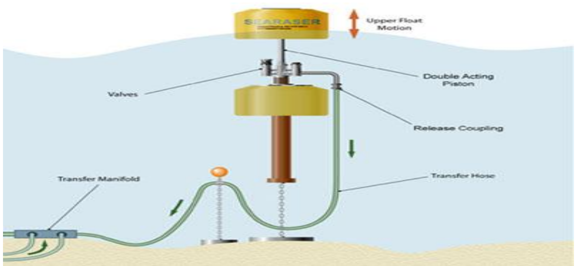

Fig.6 Floating devices [17]

5.Wave Energy Extirpation &Implementing with Power Grid

Figure 6 summarizes the varied shift stages. In particular this illustration shows that there is a demonstration of distance to acquire knowledge from waves: pneumatically and hydraulically (PTO) [4]. For transforming the slow cyclic speed or interchanging motion into high speed cyclic motion for attachment to a operable revolving electrical generator, this kind of mechanical interface is exercised[13].

Simple generators are an option on the investigating representation, but they are not yet currently used in most developed WECs. In peculiar, different types of linear generators were observed for the AWS WECs [14]. These investigations conducted researchers to the end that the transverse flux enduring magnet source is a beneficent for the status of higher powerfulness of spacing and efficiency. The use of stable magnet synchronized maker is a medium choice. The use of functional generators [16] implies a circumstantial automatic PTO that induces added losses touching the WEC gross efficiency. In this environment, there are console mechanical challenges. Table summarizes the PTO systems [17] and the electrical generator options for the both of WEC projects.

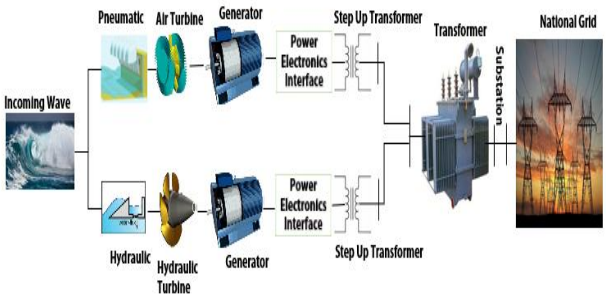

Fig.7 Diagram of several types of WEC and integratingwith National Grid

Table 1WEC Projects PTOS and Generators

WEC	PTO	Generator
PELAMIS	Attenuator /Hydraulics	Cage induction generator
POWERBUOY	Point absorber	Permanent magnet synchronous generator
OYSTER	Oscillating wave surge converter	Cage induction generator
LIMPET	Oscillating water column & Wells turbine	Cage induction generator
OCEANLINX	Oscillating water column & Dennis's-Auld turbine	Cage induction generator

6. Circuits, Simulations and trial results

6.1 Ocean power propagator and circuit:

In this example, an essential charging identify track for the hardware capacity was used. Originally, the dictation circuitry was completed as a fall commit racecourse and a 6V and 4.5AH high-grade graphite Elvis battery was chosen for store purposes. With the innovative parameters, low signaling emf and new levels were achieved during the fleshly experiments. Fig.8 illustrates the adapted diagram draw of the charging journey for this program. During simulations using the NI MULTISIM software way, parameters were familiarized from initial calculations to create a charging circuit that would hold the inputs prospective from the source. The model results for the outputs of the voltage regulators LM7805CT and LM7812CT are shown in Fig.9 and Fig.10. Fig. 9 shows a up rise time of -32.6m seconds. Here, voltage regulator LM7805CT input voltage range 7V-35V, output current rating 1A and output voltage range 4.5V-5.2V.Another voltage regulator LM7812 input voltage range 35V maximum, output current rating 1.5A output voltage 12V.Patch investigating the devices, an extreme of 12.19 V DC was achieved crosswise a 12 V fire with no load. A 12 V DC efferent was successfully operated at contemporary levels of 2.5 A.

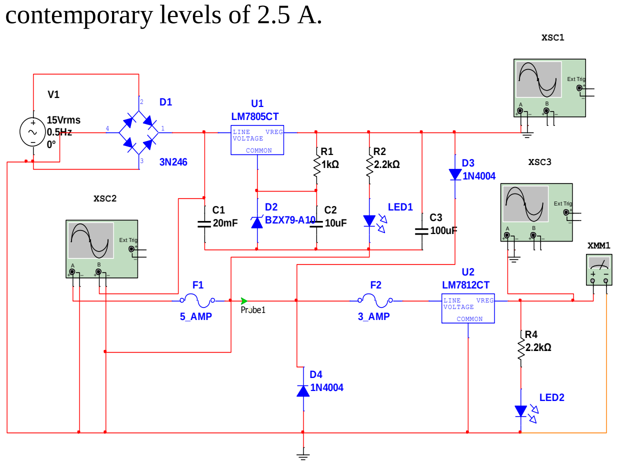

Fig.8 Charging circuit diagram of Ocean Current Energy Converter

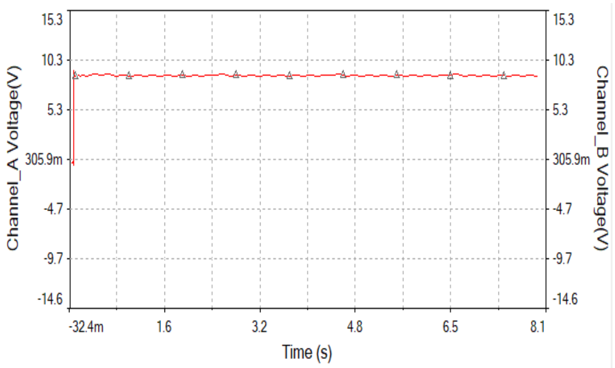

Fig.9 Simulation test results of the charging circuit forthe output of LM7805CT

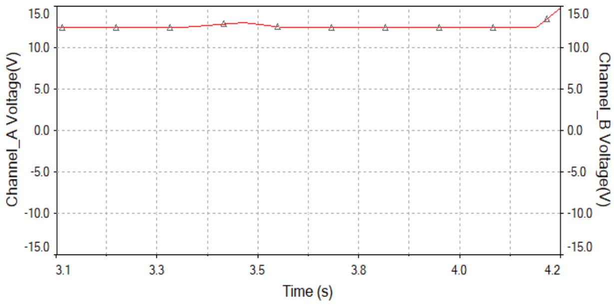

Fig.10 Simulation results of the charging circuit for the output of the LM7812CT

6.2Tidal energy propagator and tankage system:

Fig.11 shows the altered schematic plot of the charging journey for this ascribe, similar to Fig.8. During simulations using the NI MULTISIM, parameters were attuned from initial calculations to make a charging track that would withstand the inputs awaited from the shaper. The technique results are shown in Fig.12 and Fig.13. A charging circuit shown in Fig11includes a 12V DC source (battery) as represented in Fig.13. As can be seen in Fig.13, the sign emf is some 11.78 V and 1.129A. This is a drop in the middling production of emf for this signal which is unvarying.

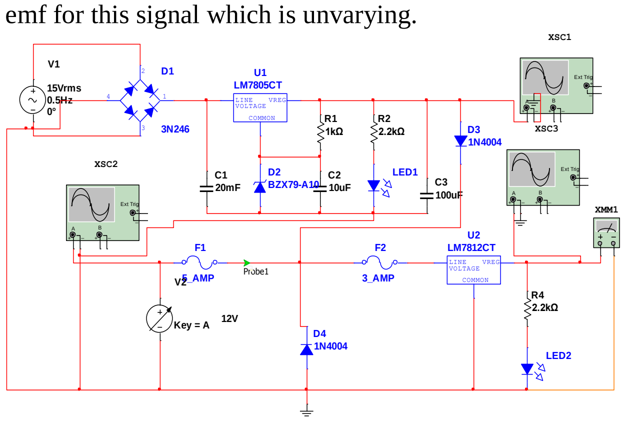

Fig.11 Charging circuit diagram of the tidal wave electricity generator

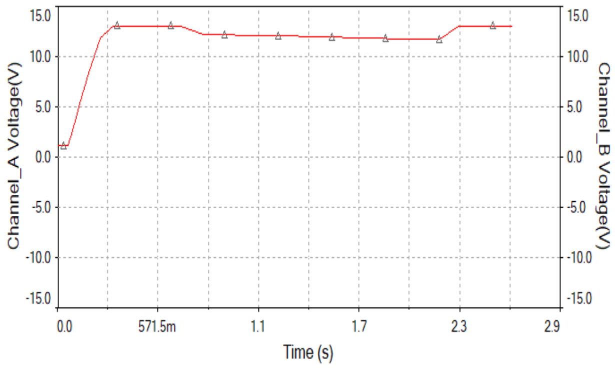

Fig.12 Simulation test results of the charging circuit for the output of LM7805CT

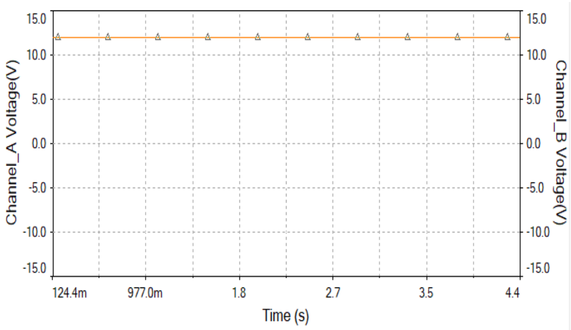

Fig.13 Simulation test results of the charging circuit for the output of LM7812CT

7. Conclusion

An enormous amount of unimproved energy is held by the ocean waves. Different processes and systems for transforming this energy into electrical energy have been introduced. In the face of progress concerning last few years, technologies reside immature as shown by large number of several technologies and instrument sizes that indicates wave energy is at a comparatively untimely stage of improvement and presents many incentive challenges. For converting the experimental processes into feasibleand expenditure-effective wave power stations, much research, improvement and engineering acts is still mandatory. Efficiency from wave energy conversion technology would be maximized if the expenditure of wave generated energy is competitive likened to other alternative renewable energy sources. A conjunction of aimed research and the establishment of government stimulus for aforetime adopter market must be in place for circulation of wave energy conversion technology forward.

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NOMENCLATURE

Φ_w : wave energy flux, W/m^2
h : amplitude, m
T : period of wave, second
P : power of wave, W
ρ_{sea} : sea water density, kg/m^3
g : gravity, m/s^2
h : wave height, m
ζ : turbine efficiency, no SI unit
A : sweep area of turbine, m/s^2
V : velocity of flow, m/s

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