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AN INNOVATIVE WAVE ENERGY CONVERTER FOR MARINE DATA BUOY APPLICATIONS

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ABSTRACT: - A current research focus is on how to give steady and dependable power to offshore equipment with unique power needs, such as marine data platforms and buoys that are located far from the coast. Most of these gadgets currently make use of photovoltaic power generation, high-capacity batteries, and routinely replace electrical supply systems. Wave energy is being examined as a solution due to the significant reliance of photovoltaic power generation on solar radiation and the expensive cost associated with frequent battery replacements. Wave energy converters (WECs) are machinery that transform wave energy into electrical energy. Their main benefit is a steady supply of electricity. In this study, a brand-new integrated wave energy converter for marine data buoys is proposed and examined. It has great dependability and low maintenance costs. A magnetic lead screw (MLS)-based direct-drive energy conversion unit serves as its central component. To maximise its power production, the device can passively track the buoy' s pitching status as it is being affected by waves. Voltage, current, and power for marine data buoys were measured using specific data values that were depending on the turbulence. In order to improve the system's accuracy and decrease power dissipations, artificial neural networks (ANN) are used. Using the necessary power for the data buoy and the remaining energy stored in the electric battery to power another marine system

INDEX TERMS: - Oscillating-body buoy, magnetic lead screw, and wave energy conversion.

I Introduction:

In fact, 71% of the surface of our planet is covered by water, making up the greatest portion of its surface. Ocean water is constantly moving in the shape of waves. The earth, moon, and sun come into touch to create ocean waves. Wind flowing across the ocean's surface also causes ocean waves to form. Tidal waves are similar to wind waves but are bigger and rise higher because of the gravitational pull of the earth, moon, and sun. Due to its mobility, the planet does not have the capacity to hold a large amount of ocean water. The water is held in place by gravity. The earth's oceans are pulled by the moon's gravity, causing waves to rise and fall. The ocean water is drawn toward the moon when it is closer to one side of the planet. At the water's surface, waves are created by the wind; these waves can hold enormous amounts of kinetic and potential energy. The marine data buoy is a floating object positioned offshore and pointing out to sea. Below the buoy is a complex and powerful anchor mechanism that keeps the buoy in one spot. The data buoy has been fitted with sensors to capture and collect data on oceanographic and atmospheric conditions. A 10 foot reading at 20 seconds would be classified as a long period swell, whereas a 10 foot reading at 12 seconds would be classified as a short period swell. Data buoys autonomously measure, broadcast, and communicate in real time using satellite communications systems in a predictable controlled manner. Data buoys are employed in a range of applications because of their straightforward construction. Real-time sensors offer the capacity to detect, track, and anticipate weather events and human activity early on. These sensors are incredibly accurate at detecting changes in the sea level of less than a millimeter. Before that, photovoltaic (PV) panels and power storage batteries were typically used as the power source for marine data buoys.

Since solar panels are extremely sensitive to environmental factors such cosmic radiation levels, salt crystallization, seawater corrosion, and bird damage to the top of the panel, difficulties can arise. An artificially intelligent neural network (ANN) is a flexible system with layered structure that learns by employing interconnected nodes. Learning rule is the process of figuring out the neural network. A neural network can be trained to recognize patterns, classify data, and anticipate future events by learning from data. The input layers of abstraction are torn down by ANN. The neural network is made up of connections between nodes, much as the brain is made up of connections between neurons. Its behavior is determined by the connections between its component parts and by the weight and strength of those connections. As you train, the weights are dynamically altered based on the chosen learning rule. As opposed to a multi-layer neural network, which has one input layer, one hidden layer, and one output layer, a single-layer neural network has input layers and output layers.

II.STRUCTURE OF WEC AND OSCILLATING BODY BUOY

The structure diagram for the suggested WEC and oscillating-body buoy is shown in Fig. 1. The middle cabin of the buoy is where the proposed WEC is mounted; the device is positioned along the diameter of the middle cabin, as indicated by the red dotted line in Figure 1. It consists of a bracket fixed to the buoy cabin and a guide rail (the guide rail is further separated into two limit guides and a magnetic lead screw wound with a permanent magnet). The rotor, the transmission mechanism, and the DC generator are components of the central power generation unit . The oscillating-body buoy will pitch as the waves hit because of their impact force. The WEC will tilt since it is fixed to the bottom of the buoy compartment and is affected by the buoy's pitch. The core power generation unit is currently being moved left to right along the bracket and guide rail by gravity. Thus, the MLS transforms the mover's linear motion into the rotor's rotary motion, and the high-speed motor's rotor is then urged to rotate by the action of the transmission belt to achieve power generation. After this method, the buoy's high-force, low-speed linear motion will be transformed into a low-torque, high-speed rotational motion through the WEC, which will power the motor and produce electricity. A MLS with a lead of 14 mm, for instance, may translate a linear speed of 2.2 m/s into a rotational speed of 4700 rpm, which is a reasonable value for a WEC system.

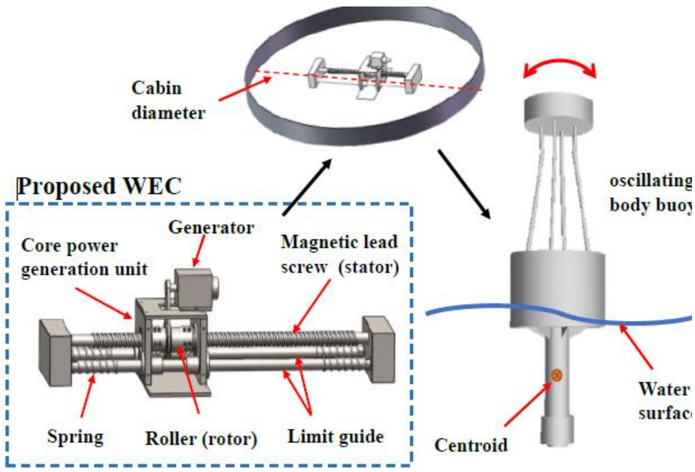

Fig. 1 Schematic diagram of WEC device and oscillating-body buoy

III. PROPOSED SYSTEM:

The magnetic lead screw (MLS) is used in the suggested wave energy converter to transmit motion. By reducing friction between moving mechanical components, the construction will reduce energy loss. The MLS is most frequently used in WEC, and depending on the sea wave circumstance, the buoy will go up and down depending on the wave locations. The rotor and starter are the two essential components in this MLS. The starter is a moving item, while the rotor is a rotating portion that can slide and revolve simultaneously. In the proposed system WEC, the wave to energy converter for the maritime data buoy is generated via MLS. The buoy will fluctuate & drop depending on the sea's floating conditions. However, the buoy sways oddly at sea, which will prevent the MLS from traveling as far as it needs to and will limit how much guide rail can be used. In particular, the motion state and energy flow of the main power generation under two different circumstances, one in which the angle is fixed and the other in which it is changeable. We performed sea wave simulation using ADAMS, took coordinate values for input velocity, entered those values into a look-up table, and then connected the input velocity to the PMSM generator, which is used to convert mechanical energy into electrical energy. Following the usage of a boost converter over pulse width modulation (PWM) boost, a diode rectifier was used to convert input AC into output DC, which produced clock pulses 0 and 1. To produce a steady DC output, depend on the PWM boost in the DC boost converter active region. As a second input source, we employed an inverter bridge with a MOSFET and PWM to power the DC load after connecting the battery to the storage. When employing MOSFET to generate the maximum clock pulses and PWM to output AC loads, inverter bridges can provide output RLC loads with zero ripples. We accelerate and smooth out the output RLC load to produce pure output load using ANN. In order to keep PMSM motors from producing unsteady output power and to lessen output power ripples, ANN is employed to accelerate input velocity. The following equation is applicable to the force analysis of the central power producing unit.

$$F_c = \int dF_{nor} \cdot \cos\theta = 2\pi \int_R^{R+h} J_c \cdot B_r \cdot r dr \quad (1)$$

There is no contact between the guide rails wound with the magnetic screw and the limit guide rail because the contact between them uses a ball construction. Consequently, the following formula can be used to represent the friction force:

$$F_c = \int dF_{nor} \cdot \cos\theta = 2\pi \int_R^{R+h} J_c \cdot B_r \cdot r dr \quad (2)$$

The following formula can be used to calculate the work of gravity when the inclination angle changes in real time with the pitch of the buoy.

$$W_G = \int P_G dt = \int mg \sin(\theta) \cdot v dt \quad (3)$$

Electric generator Equation can be Implemented as:

$$W_E = \int P_E dt = \int U \cdot I dt \quad (4)$$

the energy conversion efficiency of the WEC can be obtained as:

$$\eta = \frac{W_E}{W_G} \quad (5)$$

IV ARTIFICIAL NEUTRAL NETWORK

A cluster of adequately coupled, relatively simple nonlinear units with the capacity for learning and adaptation constitutes an ANN. These networks can be identified by their architecture, how they interact with their surroundings, how they were taught, and how well they can interpret information. ANNs have become an effective control method due to their simplicity of use, inherent reliability, and fault tolerance. Neural controllers, which are frequently an alternative to fuzzy controllers, share the necessity to switch out hard controllers for intelligent ones in order to improve control quality. As a generator of compensating signals, a feed-forward neural network is used. Three layers make up the structure of this network. the hidden layer with 21 neurons, the output layer with seven, and the input layer.

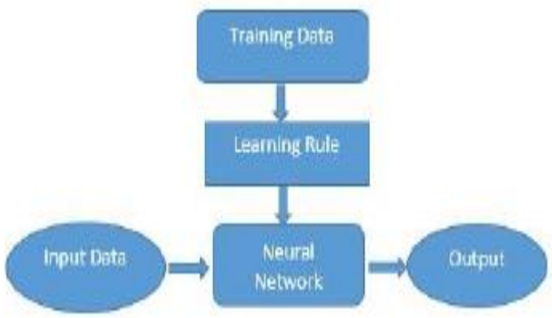

Fig: 2 Neural network

For hidden neurons and output neurons, respectively, sigmoidal and linear transfer functions are utilized. We provided input weights to the p(1) model, and delays are used to convey the data in one-by-one formation. To modify the output and provide the PMSM motor a stable velocity, weights and bias are used.

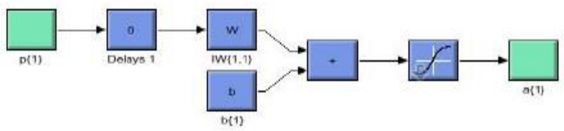

Fig3 : ANN weights and bias

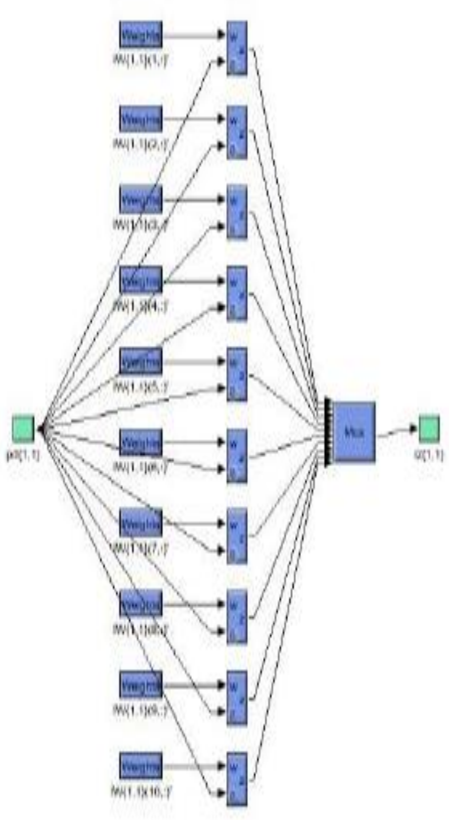

Fig 4: Hidden layer for day-ahead load Demand forecaster

Shows how a day-ahead load demand forecaster for a system is implemented using an ANN. There are ten hidden neurons considered. MLS are transferred through this buoy, which will move based on the state of the water. If the buoy is moving up and down, the MLS is moving at one angle, the stator is lowering at another angle, and the ANN is adding more delay to the downward angle, the buoy will travel faster. To boost speed, the ANN will alter the weights.

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V SYSTEM IMPLEMENTATION AND RESULTS:

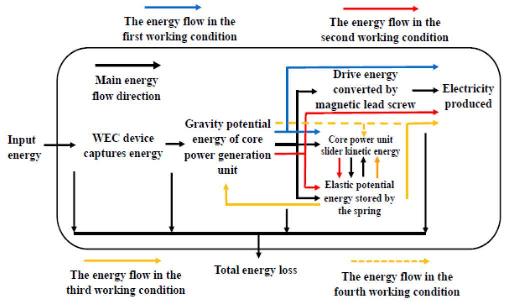

Fig5 Energy conversion flow chart (from wave energy to electrical energy)

A kinematics simulation model of the proposed WEC was built in MATLAB based on the hydrodynamic simulation results . The core power generation unit's minimum sliding angle from one end to the other, as determined by the prototype's real measuring experiment, is 6 degrees. As a result, it is possible to measure an angle every two degrees and then compute the weighted mean to get the average power of the WEC. In this part, two models will be developed to examine the various motion outcomes of the core power generating unit under the conditions of a fixed inclination angle and, correspondingly, a time-varying rotating inclination angle Fig 5 shows the system implementation flow chart and fig 6 Shows MATLAB implementation at Fixed Angle

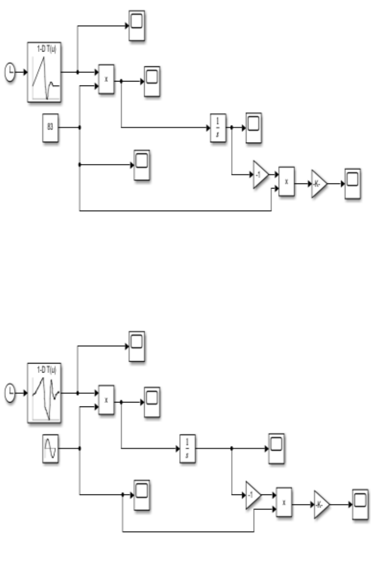

Fig 6: Matlab Implementation with Fixed Angle

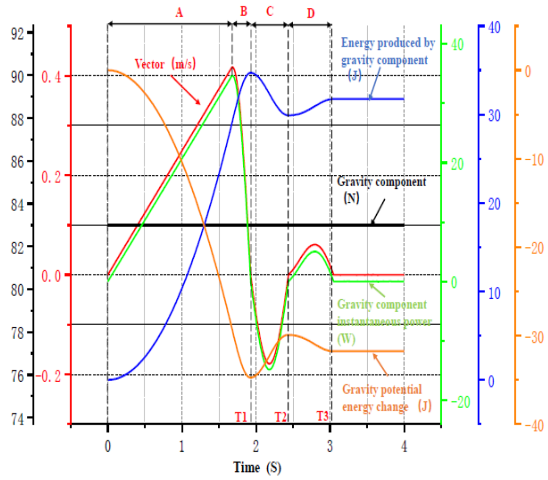

Fig7 : Movement data curve of the core power generation unit at a fixed inclination of 10 degrees

A kinematics simulation model of the proposed WEC was built in MATLAB based on the hydrodynamic simulation results . The core power generation unit's minimum sliding angle from one end to the other, as determined by the prototype's real measuring experiment, is 6 degrees. As a result, it is possible to measure an angle every two degrees and then compute the weighted mean to get the average power of the WEC. In this part, two models will be developed to examine the various motion outcomes of the core power generating unit under the conditions of a fixed inclination angle and, correspondingly, a time-varying rotating inclination angle. In Figure 7, the black straight line represents the component of gravity along the rail direction, and the red curve depicts the core power generating unit's velocity curve (the force is a constant force at a set angle). the instantaneous power of the gravity component, represented by the green curve in the picture, is equal to the product of the gravity and velocity components. The energy curve is created by integrating the instantaneo`us power curve The blue curve in the illustration depicts the derived product that is produced by the gravity component. The change in the core power generating unit's gravitational potential energy that was discovered during the entire movement operation is represented by the orange curve. By examining the gravity work curve, it can be seen that the gravity work is 34.7 J at the time instant T1, when the spring is compressed to its fullest extent. The work done by gravity is 31.8 J at T3 time instant, or when the main power producing unit is stationary. Fig 8 represents the Simulation circuit under time-varying inclination angle of wave energy converter under the impact of a wave cycle

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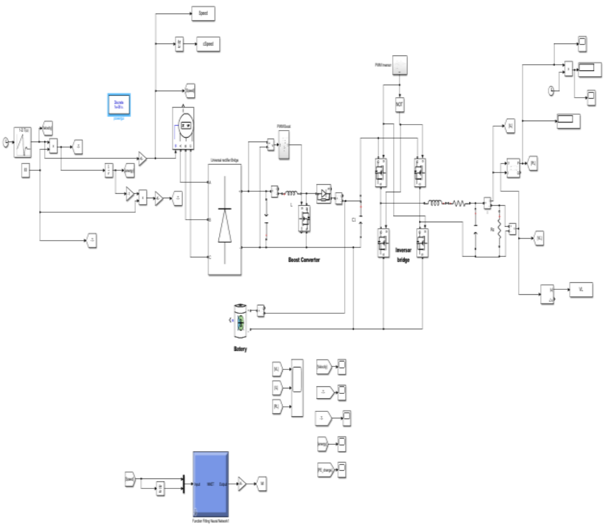
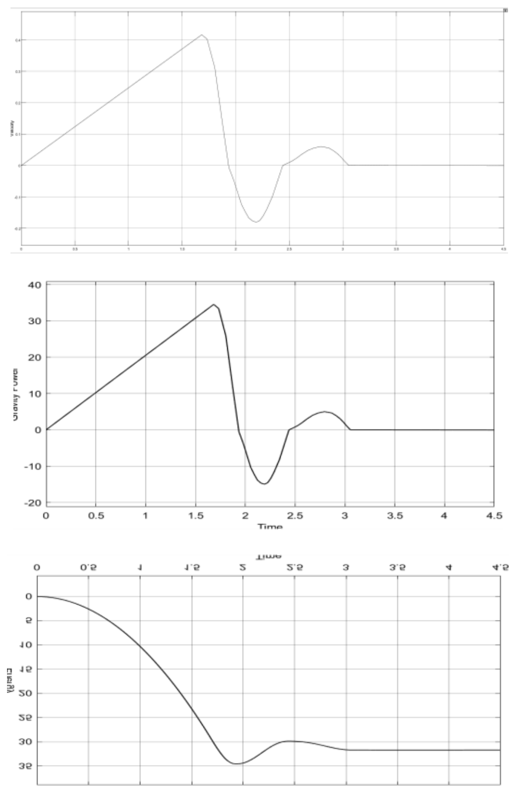


Fig 8: circuit with Impact of wave cycle

Fig 9 represents the output wave forms of voltage ,current, power of load in Proposed System



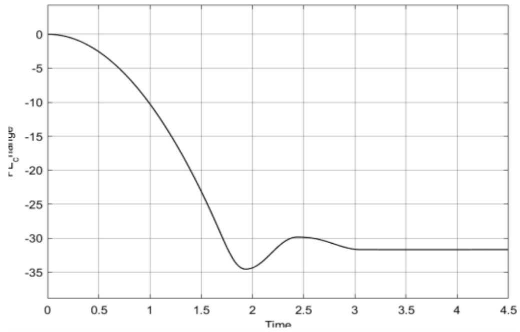


Fig 10 Represents Velocity,Gravity Power,Energy,PE energy

This section creates the simulation model for how wave impact affects the WEC's inclination angle in real time. The horizontal plate in the model represents the bottom plane of the buoy cabin. In order to simulate the buoy tilting movement, a spinning pair is attached in the middle of the horizontal plate to provide a rotating drive, with the WEC being assumed to be in its center. The simulation of buoy hydrodynamics with wave impact has produced the following findings. The spinning pair drives the rotation of the WEC using time-varying data from the buoy tilt. PWM is created, and in accordance with the clock pulses, the clock pluses 0 and 1 activate the inverter bridge to produce the output energy. In order to activate the PWM inverter more effectively and produce clock pulses at a high rate, the ANN is utilized in this. Increased PWM pulses and consistent power were also created via an inverter bridge. In this inverter bridge, the output power was produced by MOSFET. Total harmonic distortion (THD), a measurement of the harmonic distortion present in the signal, is reduced using neural networks in this Simulink. It shows how much harmonic energy the current and voltage waveforms have.

Conclusion:

In this work, a new WEC has been introduced in order to establish complementary power supply for the self-sufficient power supply of marine data buoys. The results of the simulation and tests show that the WEC can constantly produce electricity by keeping track of the buoy oscillation in reaction to wave impact. Use ANN to stabilize the input power to the marine data buoy and reduce output load fluctuations. This arrangement extends the device's useful life and accomplishes the goal of powering the buoy as a backup power source.

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