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Designing a Sea Wave Simulator to Determine the Energy Potential of a Marine Wave Power Plant Using IMU GY-86 Sensor

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Abstract

This study intended to create a sea wave simulator to find out the potential of ocean wave power plants. To achieve the objective, this study used two systems: generation and reading. Generation used a DC motor as a drive from sea waves, while readings employed an IMU-GY86 sensor for readings of altitude and energy potential generated. The result of this study is that air and air pressure affect the results of measuring the wave height of seawater. Air pressure is inversely proportional to the elevation of a place: the higher the area, the lower the air pressure. The highest potential energy density of seawater waves amounts to 2405.33 J/m², and the lowest was 550.18 J/m², with an average value of seawater wave density energy of 1342.41 J/m².

Keywords: Ocean wave simulator, Potential ocean waves, IMU, GY-86

Abstrak

Penelitian ini dimaksudkan untuk membuat simulator gelombang laut untuk mengetahui potensi pembangkit listrik tenaga gelombang laut. Untuk mencapai tujuan tersebut, penelitian ini menggunakan dua sistem: generasi dan membaca. Pembangkitan menggunakan motor DC sebagai penggerak gelombang laut, sedangkan pembacaan menggunakan sensor IMU-GY86 untuk pembacaan ketinggian dan potensial energi yang dihasilkan. Hasil dari penelitian ini adalah udara dan tekanan udara mempengaruhi hasil pengukuran tinggi gelombang air laut. Tekanan udara berbanding terbalik dengan ketinggian suatu tempat: semakin tinggi suatu daerah, semakin rendah tekanan udaranya. Rapat energi potensial gelombang air laut tertinggi sebesar 2405,33 J/m², dan terendah sebesar 550,18 J/m², dengan nilai rata-rata energi rapat gelombang air laut sebesar 1342,41 J/m².

Kata-kata kunci*: Simulator gelombang laut, Potensi gelombang laut, IMU, GY-86*

1. Introduction

Ocean waves are a renewable energy source with enormous potential to produce electrical energy. Indonesia has this potential, with the second largest coastline with a density of up to 20 kW/m^2 [1]. Currently, the use of ocean wave technology is still at the prototype stage, with several weaknesses such as erratic ocean waves, tides and ocean currents so that it can affect the power generated in the energy of ocean waves. The conversion of ocean wave energy will produce maximum power, if you know the characteristics of ocean waves that can be utilized as electrical energy. Among the advantages of ocean wave energy are: (1) it can be utilized, (2) it will never run out, (3) it produces no waste, (4) it contains changes in mechanical energy, (5) its kinetic energy intensity is greater than that of other renewable energy (6), and it can be predicted [2][3].

Some countries develop the prototypes of ocean wave energy. The devices used to produce ocean wave energy are oscillating water column (OWC), wave energy raft, nodding duck [4], overtopping device, and point absorber [5]. The success factor of underwater energy depends on the conversion used [6]. Indonesia is a maritime country composed of several archipelagos consisting of 17,480 islands with a sea area of 6 million square kilometers [7]. The need for alternative energy sources can take advantage of the energy potential of Indonesia's oceans. The conversion of ocean wave energy will produce maximum power, if you know the characteristics of ocean waves that can be utilized as electrical energy.

Several relevant studies in ocean wave energy systems using PMLG have been carried out by researchers, especially in Indonesia. Irhas and Suryaningsih [8] formulated Oscillating Water Column Technology on the south coast of Yogyakarta using meteorology, climatology, and geophysics data to determine sea waves. BBPT knows the potential of 510 GW in the Indonesian sea. Anggraini, et al. [9] used OWC and data from BMKG Indonesia resulting in a power estimation of 20 kW to 198 kW according to the height of the sea wave. Alifdini [10][11] used OCW floating type and fixed on shore on the Bengkulu sacred river beach and got a generatable power capacity of 1,0073 MW. The aforementioned research that focused in Indonesia are in the prototype stage. This research makes sea waves randomly to find out the conditions in the sea waves. To find out the parameters of randomly generated waves, the converter system must be operated in wave conditions like sea waves on the coast of Cilacap.

The use of generators and point absorber methods are based on ocean waves that are like sine waves. Some studies on the use of point absorbers [12] modeled a tubular under the sea and [13] developed a PMLG model based on the topology of ocean waves. In addition to the selection of PMLG, the use of electronic power converters is very influential on the results of electricity to produce, as in research [14] looking at the performance of ocean waves with energy conversion. The most vital thing in designing the marine wave is to know in advance the sea waves to be raised.

2. Method

To achieve the purpose of this study, several problems were solved by designing ocean waves and knowing their potential from the period of the sea waves generated. Figure 1 is a block diagram divided into two parts: the marine wave generator and reader.

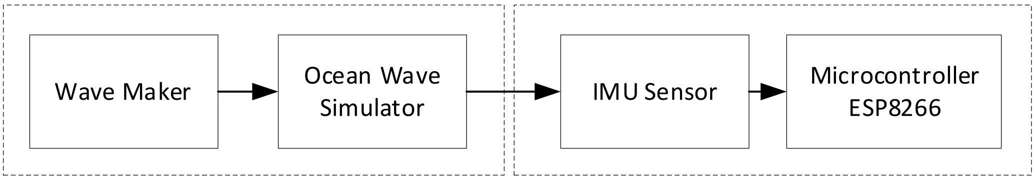

Figure 1. Ocean Wave Generator and Reader Block Diagram

Block diagram in Figure 1 is the system in this study. This research focused on plants that would be able to generate ocean waves using DC motors. Figure 2 is an overall view of the sea wave simulator to comprehend the power to generate. Wave makers use DC motors as a drive and to generate ocean waves, while buoys detect the movement of the waves.

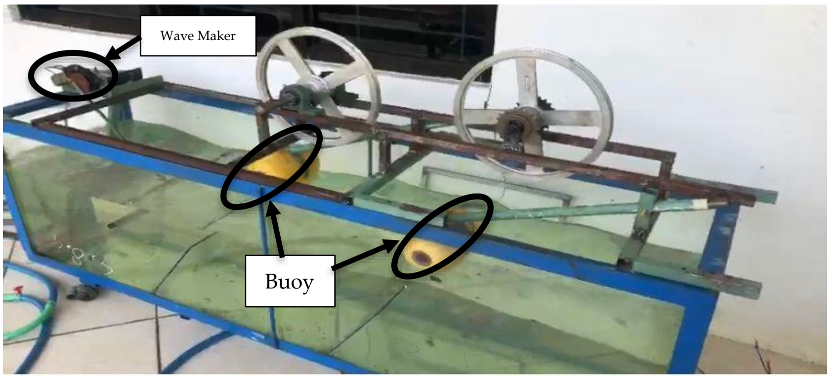

Figure 2. Ocean wave simulator

Figure 2 above is an overall simulator consisting of two parts: the kit and the ocean wave reader. The plant, with the help of a DC motor drive and produces a marine wave simulator, was used for its readings by using the IMU GY-86 sensor to find out the waves, temperatures on the surface, and air pressure converted to altitude. The buoys illustrate the movement up and down the waves. To show ocean waves, it requires a configuration between the ESP8266 microcontroller and the IMU GY-86, as depicted in Figure 3 below.

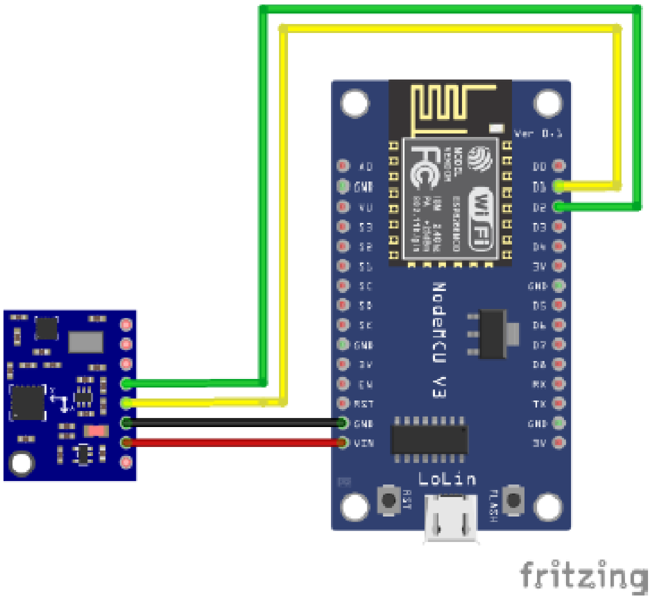

Figure 3. IMU sensor configuration with GY-86

Figure 3 is an IMU sensor configuration with the ESP8266 microcontroller. IMU GY-86 sensor uses four pins, namely, the VCC pin connected to the NodeMCU Vin, the GND pin connected to the NodeMCU GND, the SCL pin connected to the NodeMCU D1 pin, and the SDA pin connected to D2 which is the SDA pin on the NodeMCU. The GY-86 IMU sensor was tested with a connection rate to find out how far the NodeMCU was from the network access point. This test was carried out to ensure the performance of the GY-86 IMU sensor. Seawater wave height was tested by comparing the height measurements by GY-86 IMU sensors and direct measurements. Some of the parameters tested in this system were to find out the design of the simulator by knowing the height of the ocean waves.

a. Air Pressure

Air pressure refers to the power that works to move air masses in a certain unit of territory from one place to another. Air pressure is strongly influenced by the level of density of air masses. Air density is the mass per unit volume of atmospheric gases. It is denoted by the Greek letter rho (ϱ). The air density depends on the temperature and pressure of the air. The SI unit of density of air is kilograms per cubic meter (kgm^{-3}).

b. Barometer

A barometer is a sensor for measuring air pressure with an output value from a unit of Pa (pascal). By utilizing air pressure, the sensor can also measure the height.

$$Altitude = \left(\frac{T}{a}\right) * \left(1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.255}}\right) \quad (1)$$

Where:

P = Pressure

P_0 = Sea atmosphere standard level pressure (101325 Pa)

T = temperature (°K)

A = Lapse Rate temperature (0.0065 °$/m$)

$Altitude$ = Altitude (m)

c. Energy density

Energy density is the magnitude of the energy density produced by ocean waves per 1 unit of surface area. To determine the amount of energy density (EWD) produced by ocean waves, the following equation is used:

$$E_{WD} = \frac{1}{2}\rho g A^2 (J/m^2) \quad (2)$$

Where:

E_{WD} = Energy Density (J/m^2)

ρ = Density of Seawater (1030 Kg/m^3)

g = Earth's gravity (9.81 m/s^2)

A = Amplitude of Ocean Waves (m)

3. Results and Discussion

To ensure this truth, the design of this simulator was divided into two, namely the generator and the sensor reading. The generator itself was arranged in such a way that a wave is generated in the sea. The ocean wave reading using the GY-86 IMU sensor was validated by direct measurements. Measurements were to ensure the IMU GY-86 sensor by knowing the air temperature and the height of ocean waves. The air temperature is displayed in the **Table 1** below.

Table 1. Temperature Sensor Validation

No	Measurement		Difference
	Sensor	Thermometer	
1	28,27	27,8	0,47
2	28,66	28,0	0,66
3	30,08	29,9	0,18
4	31,46	30,7	0,76
5	32,57	32,0	0,57
Average			0,528

Based on the test results in various time and place conditions of the GY-86 IMU sensor shown in **Table 1**, the GY-86 IMU sensor can read changes in air temperature. In the tests carried out, data on the difference in the value of air temperature measurements between the GY-86 IMU sensor and measurements made using a thermometer were obtained. The average difference in air temperature measurements on the GY-86 IMU sensor was 0,528 °C.

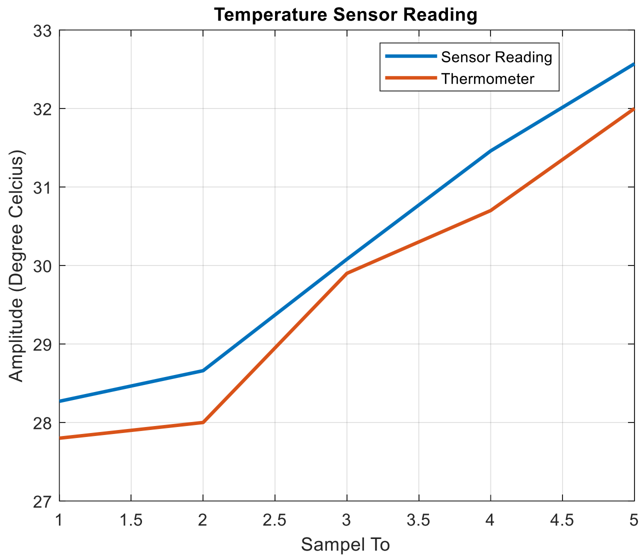

Figure 4. Comparison of Temperature Readings on GY-86 IMU

The GY-86 IMU sensor, in addition to being able to read temperature, is also able to read altitude. The height data were compared with direct measurements. The data displayed is difference and error data that were read from sensors and direct measurements, as in **Table 2** below.

Table 2. Sensor Height Reading

No	Height (cm)	Sensor Readings (cm)	Difference (cm)	Error (%)
1	50	55	5	10
		74	24	48
		74	24	48
2	100	116	16	16
		133	33	33
		133	33	33
3	150	158	8	5,3
		166	16	10,1
		166	16	10,1
4	200	199	-1	0,5
		208	8	0,5
		199	-1	4

Based on the ground test results of the GY-86 IMU sensor shown in **Table 2**, the GY-86 IMU sensor can read the change in the position of the tool as an output of the value of the change in the height of the tool position. In the measurement experiment, the positions of the tool changed three times for each height. It was found that from the data above 150 cm, the presentation of the error is getting smaller.

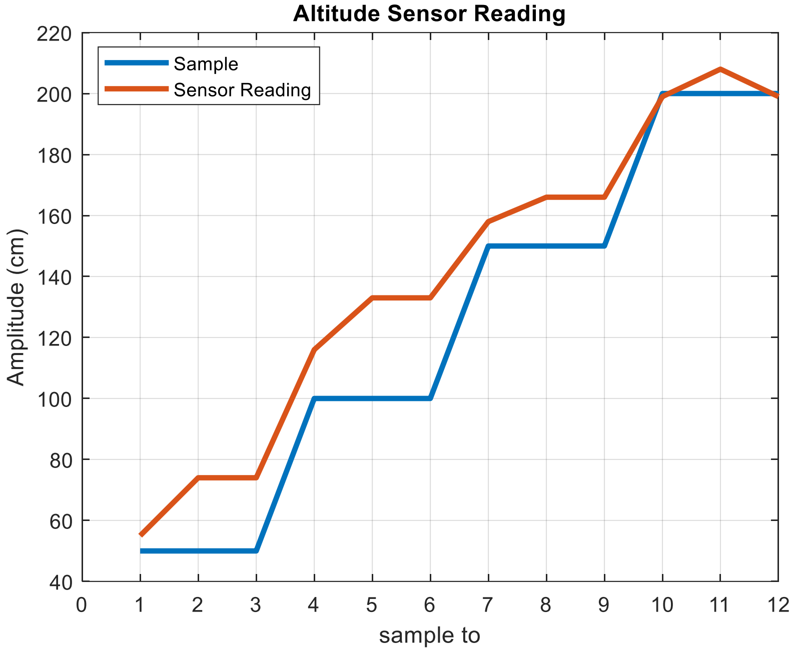

Figure 5. Sensor Height Readings

Figure 5 shows that the higher the area, the greater the accuracy. From this sensor data, you will obtain measurement data on the ocean wave simulator. The ocean wave simulator displayed data from the height of the wave that will be the potential energy power.

Based on the measurement of wave height in the ocean wave simulator, the calculation was done by calculating the energy density of seawater waves by taking wave height data on the test results. The following **Table 3** is the energy density of seawater waves calculated.

Table 3. Comparison of potential ocean waves

Wave Height Seawater (cm)	Energy Density Calculation Results Seawater Waves (J/m²)
133	2234.19
133	2234.19
66	550.18
88	978.10
83	870.11
100	1263.04
88	978.10
108	1473.21
109	1500.61

The calculation of seawater wave density energy calculated from the measured seawater wave height found the highest seawater wave density energy was 2234.19 J/m^2 and the lowest was 550.18 J/m^2 with an average of 1342.41 J/m^2. Figure 6 below shows the result of ocean waves generated on the constructed tool.

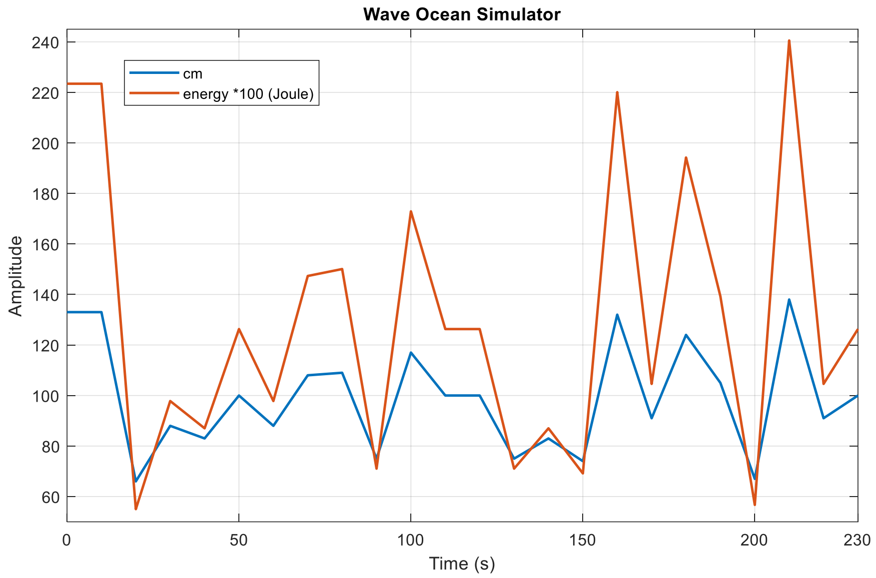

Figure 6. The Role of Ocean Waves with Energy Potential

Figure 6 is a graph of the height of a sea wave with the potential for energy to be generated. The orange one is a graph of the potential power in Joule/m2 units with an amplitude reading multiplied by 100. Figure 6 above also illustrates the result of the energy generated in 0 to 230 seconds. The average energy gained for 230 seconds was 129.92 J/m^2. The data ensures that the height of the ocean waves is very influential for the potential power to generate.

4. Conclusion

Air temperature and pressure affect the results of the height of seawater wave measurement. Air pressure is inversely proportional to the elevation of a place. The higher the area, the lower the air pressure. The highest potential energy density of seawater waves amounted to 2234.19 J/m^2, and the lowest was 550.18 J/m^2, with an average value of seawater wave density of 1342.41 J/m^2. The average energy gained for 230 seconds was 129.92 J/m^2.

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