

A Review: Prototype Gyro-Stabilizer for Buoys

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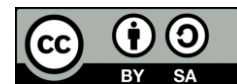
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ABSTRACT

With buoys, tsunami waves caused by underwater earthquakes can be detected. The buoy will monitor and record changes in the sea level in the ocean. Indonesia has already installed several tsunami buoys. Nine buoys were made by Indonesia, two buoys made by America, one buoy from Malaysia, and the other nine buoys donated by Germany. These buoys are placed at all points in the Indonesian seas, such as in the Sumatra, Java, Flores, Maluku, and Banda Seas, so they can assist the Meteorology, Climatology and Geophysics Agency (BMKG) in providing tsunami early warnings. But unfortunately, the tsunami buoy network was not functioning from 2012 to 2018, because it was damaged and lost. Therefore, a tool is needed to maintain the presence, function, and performance of the buoy system so that it can operate properly. A Gyro-Stabilizer device can maintain the stability of the buoy. The Gyro-Stabilizer prototype is made of a simple circuit: a DC motor with a speed of around 18000 rpm and a mechanical gyroscope. The power supply uses the same power supply used by the buoy itself. As long as the Gyro-Stabilizer keeps rotating it will maintain the orientation of the buoy and make it stable. With good buoy stability, the durability and function of the electronic components inside can be maintained because the impact force from waves or sea waves can be reduced by using this Gyro-Stabilizer.

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1. INTRODUCTION

Early detection or early warning systems are very important when natural disasters occur. With this system, the impact of damage and losses due to natural disasters can be minimized. A weather buoy is one such warning system.

Buoys are floating devices that can detect tsunami waves caused by underwater earthquakes. The buoy will monitor and record changes in sea level in the ocean [15]. Like other types of weather stations, weather buoys measure parameters such as air temperature above the ocean surface, wind speed (steady and gusting), barometric pressure, and wind direction. Since they lie in oceans and lakes, they also measure water temperature, wave height, and dominant wave period [17]. Raw data is processed and can be logged on board the buoy and then transmitted via radio, cellular, or satellite communications to meteorological centers for use in weather forecasting and climate study. Both moored buoys and drifting buoys (drifting in the open ocean currents) are used. Fixed buoys measure the water temperature at a depth of 3 meters (9.8 ft) [9]. Many different drifting buoys exist around the world that vary in design and the location of reliable temperature sensors varies. These measurements are beamed to satellites for automated and immediate data distribution [9]. Other than their use as a source of meteorological data, their data is used within research programs, emergency response to chemical spills, legal proceedings, and engineering design [17]. Like other types of buoys, moored weather buoys can also act as navigational aid. Weather Buoy records atmospheric and chaos data. This tool works automatically and is placed in the ocean. In the Pacific Ocean, at least Currently, there are more than 50 buoys

installed by research institutes in America's atmosphere and oceans (National Oceanic and Atmospheric Administration-NOAA) since the 1980s. With these tools, we get sea surface temperature data [16].

A large network of coastal buoys near the United States is maintained by the National Data Buoy Center [13], with deployment and maintenance performed by the United States Coast Guard [14]. For South Africa, the South African Weather Service deploys and retrieves its buoys, while the Meteorological Service of New Zealand performs the same task for their country [10]. Environment Canada operates and deploys buoys for their country [19]. The Met Office in Great Britain deploys drifting buoys across both the northern and southern Atlantic oceans [20].

In Indonesia, several buoys have been installed. Nine buoys were made by Indonesia, two buoys made by America, one buoy from Malaysia, and the other nine buoys donated by Germany. These buoys are placed at all points in the Indonesian seas, such as in the Sumatra, Java, Flores, Maluku, and Banda Seas so that they can assist the Meteorology, Climatology and Geophysics Agency (BMKG) in providing tsunami early warnings. But unfortunately, the tsunami buoy network was not functioning from 2012 to 2018, because it was damaged and lost [15]. Therefore, a tool is needed to maintain the presence, function, and performance of the buoy system so that it can operate properly. In this research, the authors plan to make a Gyro-Stabilizer Prototype for buoys to maintain the stability of the buoys when they are released into the ocean. Buoy stability is the buoy's ability to return to an upright position or original position when exposed to external actions such as wind, waves, and current [1].

2. DATA AND METHOD

The solution offered is the addition of a component in the form of a gyroscope stabilizer that serves to stabilize the angle of inclination due to rolling waves [8]. The gyroscope is a device in the form of a rotating disc on its axis and generates the angular momentum that maintains its position if present outside influences [4]. In this research, the dimensions of the gyro-stabilizer prototype were adjusted according to the type of weather buoy.

Weather buoys range in diameter from 1.5–12 meters (5–40 ft). Those that are placed in shallow waters are smaller in size and moored using only chains, while those in deeper waters use a combination of chains, nylon, and buoyant polypropylene [17]. Since they do not have direct navigational significance, moored weather buoys are classed as special marks under the IALA scheme, are colored yellow, and display a yellow flashing light at night.

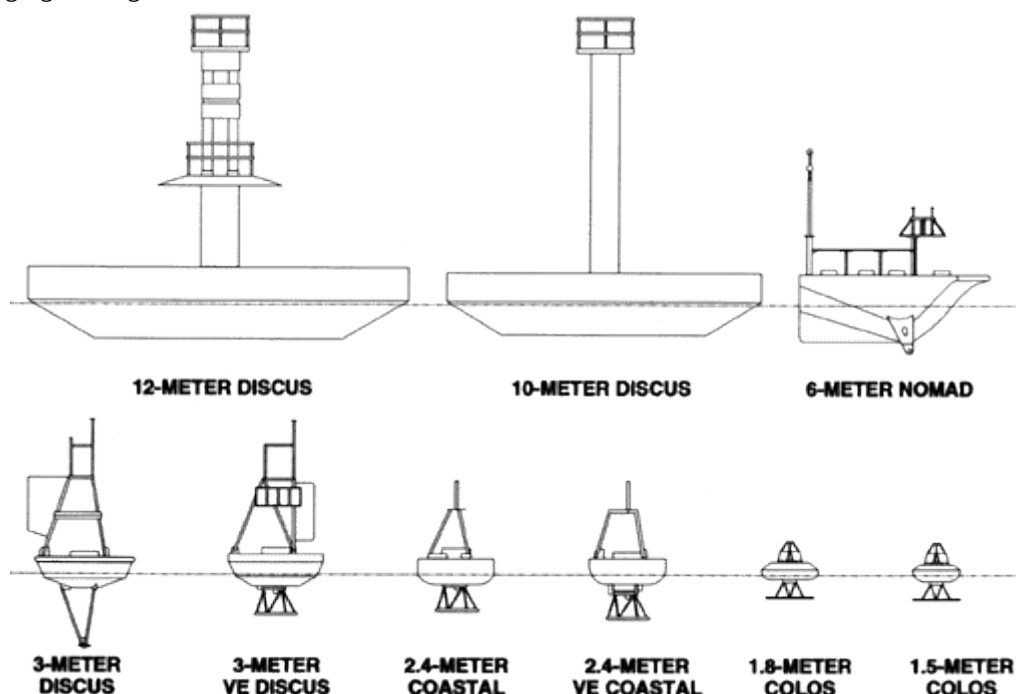


Fig 1. Types of moored buoys used by the National Data Buoy Center [17]

Discus buoys are round and moored in deep ocean locations, with a diameter of 10–12 meters (33–39 ft) [11][12]. The aluminum 33-meter (10 ft) buoy is a very rugged meteorological ocean platform that has long-term survivability. The expected service life of the 3-meter (10 ft) platform is more than 20 years and properly

maintained, these buoys have not been retired due to corrosion. The NOMAD is a unique moored aluminum environmental monitoring buoy designed for deployments in extreme conditions near the coast and across the Great Lakes [11]. NOMADs moored off the Atlantic Canadian coast commonly experience winter storms with maximum wave heights approaching 20 meters (66 ft) into the Gulf of Maine.

Drifting buoys are smaller than their moored counterparts, measuring 30–40 centimeters (12–16 in) in diameter. They are made of plastic or fiberglass and tend to be either bi-colored, with white on one half and another color on the other half of the float, or solidly black or blue. It measures a smaller subset of meteorological variables when compared to its moored counterpart, with a barometer measuring pressure in a tube on its top. They have a thermistor (metallic thermometer) on their base, and an underwater drogue, or sea anchor, located 15 meters (49 ft) below the ocean surface connected with the buoy by a long, thin tether [18].

Based on the types of weather buoys above, the authors plan to make a gyro-stabilizer prototype dimension for the type of weather buoy at 1.5 meters to 2.4 meters in size. The Gyro-Stabilizer will be built using a fixed gimbal concept. Single gimbal gyrostabilizer systems can provide larger stabilizing moments than double gimbal systems. Single gimbal gyrostabilizers transfer stabilizing moments through the gimbal structures, where the structure strength defines the maximum allowable moment. Double gimbal systems transfer the stabilizing moments through gimbal motor(s), limiting the maximum stabilizing moment to the maximum motor torque, unless the motor has some mechanical anti-backlash device, e.g., a ratchet mechanism [5].

The research method that the author uses in this study is a comparative method using a quantitative approach. Research using the comparative study method (Comparative Study) is done by comparing the equations differences as a phenomenon to find what factors/situations can cause a particular event to occur. This research begins by comparing which factors or variables are most influential to changes that occur in the results of research that is being carried out [7].

In this research, the general weather buoy prototype was used. The design of the weather buoy prototype uses a ball that is weighted in the middle of the bottom, with overall dimensions of around 1.5x0.5x0.5 meters. The Gyro-Stabilizer is assembled separately from the weather buoy frame, it will be assembled in a square box with a DC motor inside. However, the gyro-stabilizer box will later be placed in the middle of the weather buoy so that the two become one part.

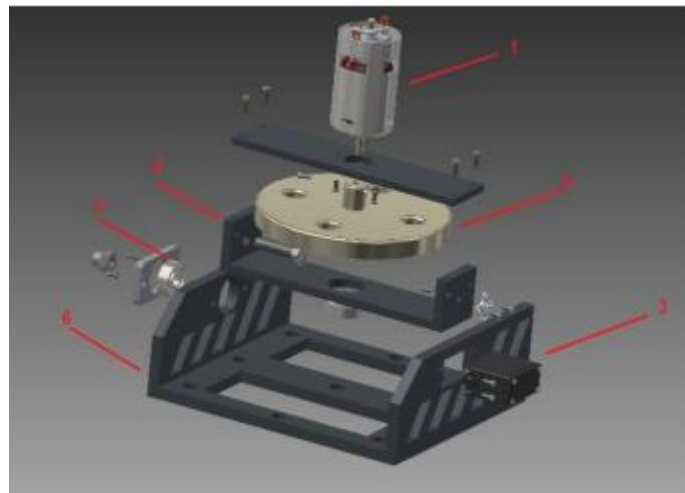


Fig. 2. Gyroscope Stabilizer [8]

Testing this gyro-stabilizer prototype uses the dependent variable, namely the angle of inclination of the boat which is carried out several repetitions so that the min, max, and average values are found. While variables are independent in the form of flywheel rotation speed (rpm), and wave height. To measure the tilt angle, the smartphone will be placed on top of the gyro-stabilizer box. The smartphone uses the LSM6DSL sensor in it. The LSM6DSL sensor will record the level of slope that occurs.

The LSM6DSL is a system-in-package featuring a 3D digital accelerometer and a 3D digital gyroscope performing at 0.65 mA in high-performance mode and enabling always-on low-power features for an optimal motion experience [6].

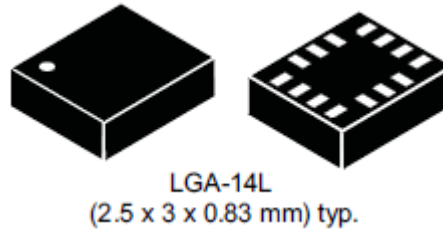


Fig. 3. LSM6DSL system-in-package

The equations of motion of a rigid body about a fixed point. Differentiating the equation $H = \sum (\mathbf{r} \times m\mathbf{v})$ concerning time, we have:

$$\begin{aligned}\frac{d\mathbf{H}}{dt} &= \frac{d}{dt} \sum (\mathbf{r} \times m\mathbf{v}) = \sum \left(\mathbf{r} \times m \frac{d\mathbf{v}}{dt} + \frac{d\mathbf{r}}{dt} \times m\mathbf{v} \right) \\ &= \sum [(\mathbf{r} \times m\mathbf{a}) + (\mathbf{v} \times m\mathbf{v})].\end{aligned}$$

But $m\mathbf{a} = \mathbf{F}$ and $\mathbf{v} \times \mathbf{v} = 0$. Hence the above relation becomes:

$$\frac{d\mathbf{H}}{dt} = \sum (\mathbf{r} \times \mathbf{F}) = \mathbf{M} \quad \text{by } (\mathbf{M} = \mathbf{r} \times \mathbf{F})$$

$$= M_x \mathbf{i} + M_y \mathbf{j} + M_z \mathbf{k}, \quad \dots (1.1)$$

where $\mathbf{M}$ denotes the sum of the moments of all the external forces acting on the body. From (1.1) and

$$\left. \begin{aligned} M_x &= yZ - zY, \\ M_y &= zX - xZ, \\ M_z &= xY - yX. \end{aligned} \right\}$$

$$\left. \begin{aligned} \frac{dH_x}{dt} &= \sum (yZ - zY) = M_x, \\ \frac{dH_y}{dt} &= \sum (zX - xZ) = M_y, \\ \frac{dH_z}{dt} &= \sum (xY - yX) = M_z. \end{aligned} \right\} \dots (1.2)$$

If no external forces are acting on the body, or if there are such forces but they have no moment about the axis of rotation, then $\mathbf{M} = 0$ and (1.1) becomes:

$$\frac{d\mathbf{H}}{dt} = 0.$$

Hence, $\mathbf{H} = \mathbf{a} \text{ constant } \dots (1.3) [3]$

3. RESULT AND DISCUSSION

In this stabilization experiment, a boat prototype was used. This is due to the lack or absence of research on weather buoy stabilization using a gyro-stabilizer. however, the data generated from the stabilization of the boat tends to be relevant when paired with the use of weather buoys.

Testing of the entire system includes testing the balance of the prototype boat against given waves. The test was carried out by taking 20 samples of the slope of the prototype boat in 60 seconds and then averaging it [8].

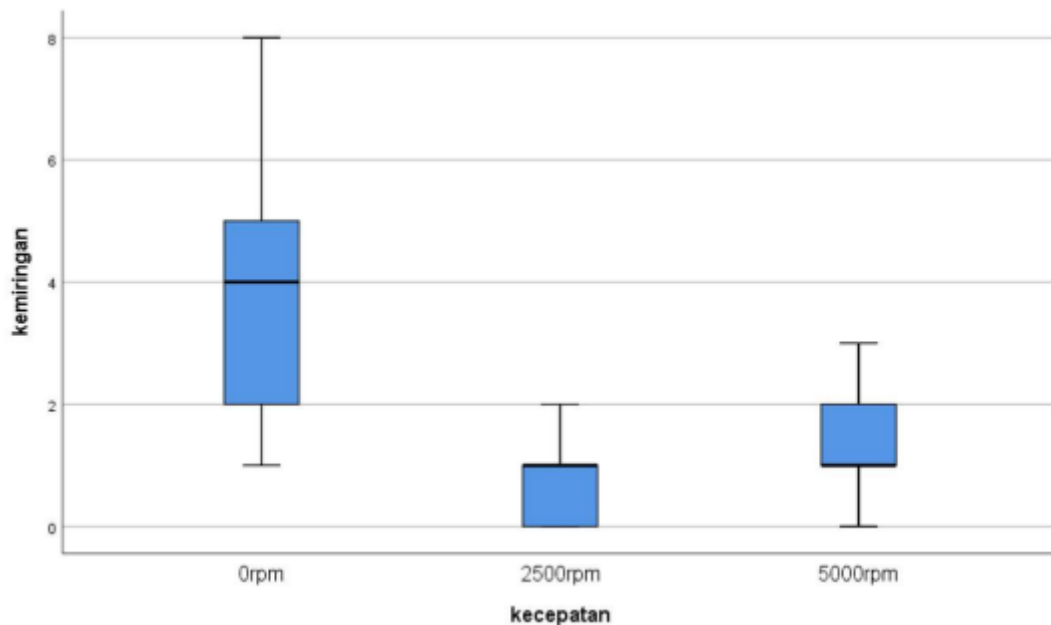


Fig. 4. Graph of test results with min, max, and average criteria [8]

The results in the figure show that without using the flywheel (0 rpm) it causes a tilt angle the highest boat in the test, when compared to the results of other tests using rotation flywheel as a stabilizer for the slope of the boat. The picture shows that at maximum rotation (500 rpm) produces a higher slope compared to medium rotation (2500 rpm) this is due to rotation which causes high vibrations on the boat structure so that the slope becomes unstable [8].

Table 1. Graph of the average boat tilt angle [8]

	ombak 3cm	ombak 5cm	ombak 10cm
0 rpm	2.15	3.75	5.4
2500 rpm	0.55	0.9	1
5000 rpm	1.05	1.25	1.6

The graph shows the height of the waves it can produce the angle of inclination of the resulting boat. The smaller waves received by the boat, the smaller resulting slope, and vice versa. At optimal results of 2500 rpm rotation, shows the angle of inclination the lowest is at a wave height of 3 cm and a height of 5 cm and 10 cm not too far adrift, this shows that the addition of wave height provides an additional of slope that is not too large, and shows that the results achieved have been optimal in that round [8].

4. CONCLUSION

The optimal results obtained from the test show that the gyroscope stabilizer can balance the tilt angle weather buoy/boat with a range of 0.55° to 1° with a flywheel speed of 2500 rpm, and the difference in the results of the wave heights of 5 cm and 10 cm are not far apart, this shows that optimal results have been achieved even though the height is an increased wave. The test results show that the rotation on the flywheel gives good results in overcoming slope when compared to without using this tool. But if the flywheel rotation is too high can result in instability and cause vibrations to the weather buoy/boat so that it can stabilize the slope becomes less than optimal [8]. This Gyro-Stabilizer may increase the safety risk to the impact of damage caused by natural disasters such as earthquakes or hurricanes [2].

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