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INTEGRATED OCEAN OBSERVATION SYSTEM (IOOS) FOR UNDERWATER STATION

MUHAMMAD NAQIUDDIN BIN AHMAD ZAKI

Bachelor of Mechatronics Engineering

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SUPERVISOR'S DECLARATION

"I hereby declare that I have read through this report entitle "Integrated Ocean Observation System (IOOS) for Underwater Station" and found that it has comply the partial fulfilment for awarding the Degree of Bachelor of Mechatronics Engineering"

Signature : ………..

Supervisor's Name : ....

Date : ....

INTEGRATED OCEAN OBSERVATION SYSTEM (IOOS) FOR UNDERWATER STATION

MUHAMMAD NAQIUDDIN BIN AHMAD ZAKI

A report submitted in partial fulfilment of the requirements for

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STUDENT'S DECLARATION

I declare that this report entitle "Integrated Ocean Observation System (IOOS) for Underwater Station" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : ....

Date : ....

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ABSTRACT

Since the establishment of marine technology, buoys have been developed with the capability to provide high quality oceanographic data that supports not only the near surface currents, but can also provide meteorological, biological, chemical and directional wave data for research, education, search and rescue. There is the clear opportunity and responsibility to use the Integrated Ocean Observation System (IOOS) resources, emerging knowledge, and advances in technology to address a broad range of user applications. The IOOS can support and help to find solutions for problems in a diverse range of areas, including natural hazards, marine operations, human and environmental health, resource sustainability, climate and weather, and national security. The various regional observing systems that have been, or are being, established address a number of these problems areas. However, as the regional systems are integrated and sustained, it will be increasingly important for successful components to convincingly demonstrate the feasibility of preoperational regional observing systems and their relevance to national needs. IOOS is our eyes on our oceans, and coasts that enable country to track, predict, manage, and adapt to changes in our marine environment and deliver critical information to decision makers to improve safety, enhance our economy and protect our environment. IOOS enables decision making every day and fosters advances in science and technology. In this project is studied, discussed and designed the component parts that are needed to be assemble together to Integrated Ocean Observation System (IOOS) buoy for underwater station. This buoy system will be equipped with sensors to sample oceanographic and meteorological data, and also will have hydrophone and camera to capture audio and visual data from the surrounding of the buoy. Even there are available buoy in the market nowadays, but the main function of this buoy is to act as the control room for the underwater station. This is because all the electronic board for underwater vehicle will be located inside the buoy. It also will give power supply for that station. The material produced in this report is definitely the beginning of new knowledge which can be deeply developed.

ABSTRAK

Sejak tertubuhnya pelbagai teknologi marin, pelampung telah dibangunkan dengan keupayaan untuk menyediakan data oseanografi berkualiti tinggi yang menyokong bukan sahaja arus permukaan terdekat, tetapi juga boleh menyediakan meteorologi, biologi, kimia dan data gelombang arah untuk penyelidikan, pendidikan, mencari dan menyelamat. Terdapat peluang dan tanggungjawab yang jelas untuk menggunakan Sistem Pemerhatian Lautan Bersepadu (IOOS) sumber, pengetahuan baru muncul, dan kemajuan dalam teknologi untuk menangani pelbagai aplikasi pengguna. The IOOS boleh menyokong dan membantu untuk mencari penyelesaian bagi masalah dalam pelbagai bidang, termasuk bencana alam, operasi marin, kesihatan manusia dan alam sekitar, kemampanan sumber, iklim dan cuaca, dan keselamatan negara. Pelbagai sistem serantau memerhati yang telah, atau sedang, alamat menubuhkan beberapa kawasan-kawasan masalah. Walau bagaimanapun, sebagai sistem serantau yang bersepadu dan berterusan, ia akan menjadi semakin penting bagi komponen yang berjaya untuk meyakinkan menunjukkan kemungkinan sistem memerhatikan serantau preoperational dan kaitannya dengan keperluan negara. IOOS adalah mata kita di lautan kita, dan pantai yang membolehkan negara untuk mengesan, meramal, mengurus dan menyesuaikan diri dengan perubahan dalam persekitaran marin dan menyampaikan maklumat kritikal kepada pembuat keputusan untuk meningkatkan keselamatan, meningkatkan ekonomi kita dan melindungi alam sekitar kita. IOOS membolehkan kita membuat keputusan setiap hari dan memupuk kemajuan dalam sains dan teknologi. Dalam projek ini dikaji, dibincang dan direka bentuk bahagian-bahagian komponen yang diperlukan untuk memasang bersama-sama untuk Sistem Bersepadu Lautan Pemerhatian (IOOS) boya untuk stesen bawah air. Sistem boya akan dilengkapi dengan sensor untuk sampel data oseanografi dan meteorologi, dan juga akan mempunyai hidrofon dan kamera untuk menangkap data audio dan visual dari sekitar boya. Malah ada boya yang terdapat di pasaran pada masa kini, tetapi fungsi utama boya ini adalah untuk bertindak sebagai bilik kawalan untuk stesen bawah air. Ini kerana semua papan elektronik untuk kenderaan bawah air akan terletak di dalam boya. Ia juga akan memberikan bekalan kuasa bagi stesen itu. Bahan yang dihasilkan dalam laporan ini pasti permulaan pengetahuan baru yang dapat sangat maju.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is about an introduction of this project. This chapter will covers briefly about the research background, motivation, problem statement and objectives. The project scopes of work are determined and explained in detail. The report outline is executed.

Today, buoys are used for many purposes besides aids to navigation, including use as platform for scientific or engineering investigations, for gathering synoptic data, and supporting ocean operations such as oil tanker loading/unloading at production sites. There are strong supported from the institution for a sustained Integrated Ocean Observation System (IOOS) buoy to optimize use of existing resources and facilitate new technologies to deal with a variety of knowledge and application desires. Therefore, IOOS buoy can increase capability to satisfy challenges associated to predict the change of weather and its effects on coastal communities, marine operations, marine ecosystems, and sustained use of marine resources. Based on the Oxford Dictionary, buoy is outlined as navigation aids with floating objects, mounted to the lowest of the ocean or stream, that indicates reefs or different hazards, or for mooring. Each types of buoy have their own specifications, with different size, colour, shape and function.

The purpose of this report is to study on how to design an Integrated Ocean Observation System (IOOS) buoy for underwater station. An existing observation system features a stationary single or multiple measurement points with built-in data logger. Measurements of surface parameters require sensors that are mounted on an anchored buoy while the measurements of the bottom parameters require anchor-mounted sensing modules.

The contributions of all these observation and measurement method have been proved for several decades by providing us with significant amount of oceanographic data. However, there is still plenty of room for improving for increasing the efficiency of the system. Existing monitoring and observation systems are passive systems, whereby periodic data collections are required for further processing and interpretations. Passive observations system is exposed to several conceptual and technical disadvantages.

1.2 Motivation

This project is conducted at the Universiti Teknikal Malaysia Melaka (UTeM). The reason for conducting this research work is to Integrated Ocean Observing System (IOOS) buoy for underwater station. This buoy is very important because its work as a platform for underwater station. This platform and underwater station will connected each other through wire. Buoy can generated 12V electricity from solar panel or batteries and supply it to the station. It also gives information about weather condition such as wind speed, wind direction, surrounding temperature and rainfall.

1.3 Problem Statement

The problem for this project was to investigate the use of new flexible materials and construction techniques for use in the construction of lightweight buoys. Such buoys are expected to last longer, cost less, and resist collision damage better than the current steel and plastic designs. Besides, meteorological data such as wind speed and temperature surrounding are easier to collect systematically and can cover a wider area rather than measurements of wave parameters which very difficult to collect in real situation.

1.4 Objectives

The objectives of this project are:

a) To design and develop Integrated Ocean Observation System (IOOS) buoy for underwater station that can withstand high current environment.
b) To sample meteorological data from the weather station for the buoy.

1.5 Scope of Works

There are some scopes was outlined to achieve the stated objectives of the project.

1. To fabricate the buoy based on the design in SolidWorks.
2. To test the buoy from the point of the forces and equilibrium, and buoyancy Archimedes' principle and buoyancy force equation by immersed the buoy into water tank.
3. To test the sensors to take reading of meteorological data in real situation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there are elaboration about the literature review from journals that I had study about buoy system based on some criteria that are design, controller algorithm, and performance.

2.2 Design

From journal Zdenka Willis, 2014, [1], some suggestion about the design of the buoy was emphasized. There are many factors to consider when designing buoy to ensure it serves the intended purpose. The first step when designing an IOOS buoy is to decide on the types of parameters to be collected and how they will be collected. Common parameters collected from an IOOS buoy are sea water temperature, air temperature and humidity, wave height and direction, current speed and direction and wind speed. Some buoys have visual, audio observation equipment and several specialized sensors. Stanley J. Boduch, 2006, [8] stated that the next consideration is designing IOOS buoy is power requirement for the buoy. It is depends on how large the sensors will be used and types of the sensors used. There are several options for generating power on a buoy system such as batteries, solar panels, and diesel generators. While based on Alan Jack Herr, 1971, [10] the buoy hull is a very important part because its act as a primary component of the buoy system, so it must provide the necessary buoyancy and positive stability for all conditions. It must support its own payload including power supplies, electronic equipment and antennae. It must also sustain the mooring forces and those of the environment including wind, current and wave drag. The positive stability will assure the buoy will not capsize due to the environmental loads or during routine maintenance operations. This may be accomplished by the proper location of weights, counterweights and by the design of the buoy geometry itself.

Figure 2.1: Model of Buoy

In conclusion, based on Figure 2.1, most buoys will have round shape for it based. This is because that shape will make less resistance to the waves. The lower part of buoy body is designed for high waves so that it can reduce the wave pressure. It is assumed a solid structure in consideration of use in case of the high wave condition. Other than that, the size of buoy depends on the component that will equip on it and the total weight of these components. The buoy should support its own payload neither normal condition nor extreme environment to carry out its duty as an IOOS buoy.

2.3 Controller Algorithm

In most systems, oceanographic and marine meteorological observation data usually only can get collected by additional delays, a day for minimum time while it can reach until a month long to get the "raw" data before transformed it in a usable format to the scientist. Norman L. Guinasso, 2009, [3] the buoy method had advanced, the method is underneath the actual time control of a laptop via a radio link. The info can then be presented to the scientist in any layout desired from the laptop in seconds after the observations are made. From journal [2], written by Kulkarni Amruta M, 2013, the power supply has end up tremendously important predicament, oftentimes even the bottleneck of the system. Utilising wires to attach nodes to vigour lines local just isn't realistic, considering the fact that the nodes mostly distribute in far off areas, and the total rate in connecting all these nodes is insufferable. A further approach is to make use of battery handiest. The benefits was apparent, however batteries have restricted lifespan and can't stand for a long time. Changing depleted batteries often is inconvenient. To prevent pointless work and make the method extra flexible to deploy, solar panel is to use on this system to supply vigour for the sensor node, at the side of the battery to recharge when sunlight is not sufficient, corresponding to at night time.

2.4 System Performance

Based on paper John C. Daidola, 1990 [14], it describes recent attempts to analyse the dynamics of typical buoys moored with synthetic line in shallow water, using an existing numerical model. Large-scale model wave tank tests have shown that the weight and drag of the synthetic line are negligible when compared to the tension forces. This allows the use of a single linear segment in the modelling of the mooring line. The procedure for extracting buoy hydrodynamic coefficients from wave tank data is outlined, along with the current capabilities of the numerical model to estimate mooring line tensions and buoy attitudes in various wave conditions.

Based on paper James Irish, 2006 [8], the buoy is powered by solar panel and wind energy. It can generate 60-watt electricity throughout clear, sunny days through solar panel and also wind generator can provides power throughout moderate wind. These systems can charge 24V and transfer it into 24V battery that can be used when sunlight is not sufficient like at night or in rainy day. The power from batteries will control all mechanism at the buoy. This provides power to the radio and controller to the pumps, valves, run down the most battery bank, and additionally permits diagnostic info to be measuring to shore to help within the identification and repair of the matter.

The system was designed and programmed to permit for land-based upgrading of the management programs while not having to be physically at the offshore website. 2 cameras strategically placed at intervals the fish cage to look at fish feeding and behaviour. This second measurement system has been tried to figure well systematically from land, however, camera and underwater cabling failure has caused the system to be unreliable to boot, a temperature and physical phenomenon sensing element is put in within the submerged cage. The four antennas on the left area unit for communications with shore management and also the relay of video to watch the temperature and salinity from at intervals the cage with a 15-minute sampling resolution each the instrument information and also the video stream area unit transmitted to the buoy through the conductors embedded in an exceedingly tailored, high-stretch feed hose wall. This feed hose, with embedded conductors, has tried to be very helpful for effort information remotely and such a system could also be utilized in future feed systems [3].

2.5 Buoyance Force

When an object is immersed in a fluid, the upward force on the bottom of an object is greater than the downward force on the top of the object. The result is a net upward force (a buoyant force) on any object in any fluid. If the buoyant force is greater than the object's weight, the object will rise to the surface and float. If the buoyant force is less than the object's weight, the object will sink. If the buoyant force equals the object's weight, the object will remain suspended at that depth. The buoyant force is always present in a fluid, whether an object floats, sinks or remains suspended [17].

The buoyant force is a result of pressure exerted by the fluid. The fluid pushes on all sides of an immersed object, but as pressure increases with depth, the push is stronger on the bottom surface of the object than in the top. The buoyant force can be calculated on an object by adding up the forces exerted on all of an object's sides.

The top surface has area A and is at depth h_1, the pressure at that depth is:

$$P_1 = h_1 \rho g \tag{2.1}$$

Where ρ is the density of the fluid and g = 9.81 ms^2 is the gravitational acceleration. The magnitude of the force on the top surface is:

$$F_1 = P_1 A = h_1 \rho g \tag{2.2}$$

This force points downwards. Similarly, the force on the bottom surface is:

$$F_2 = P_2 A = h_2 \rho g \tag{2.3}$$

If it is cylindrical, the net force on the object's sides is zero the forces on different parts of the surface oppose each other and cancel exactly. Thus, the net upward force on the cylinder due to the fluid is:

$$FB = F_2 - F_1 = \rho g A(h_2 - h_1) \tag{2.4}$$

2.6 Archimedes Principle

Although calculating the buoyant force in this way is always possible it is often very difficult. A simpler method follows from the Archimedes principle, which states that the buoyant force exerted on a body immersed in a fluid is equal to the weight of the fluid the body displaces. In other words, to calculate the buoyant force on an object we assume that the submersed part of the object is made of water and then calculate the weight of that water.

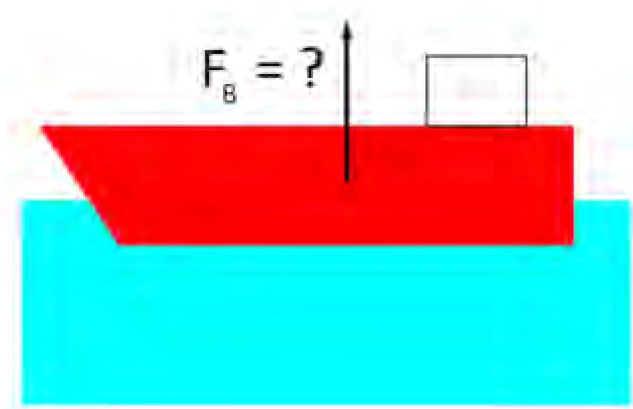


Figure 2.2: Buoyance force of the ship (a) [17]

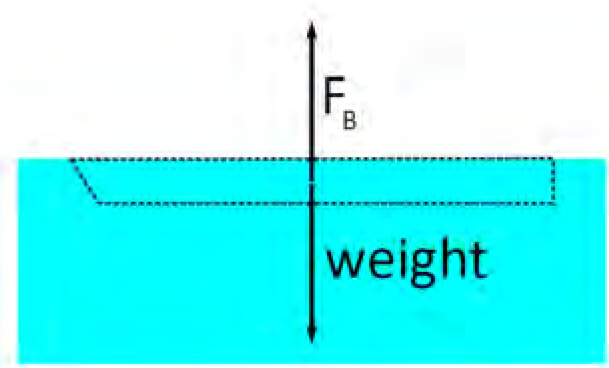


Figure 2.3: Weight of ship is equal to water displaced of the ship (b) [17]

The principle can be stated as a formula:

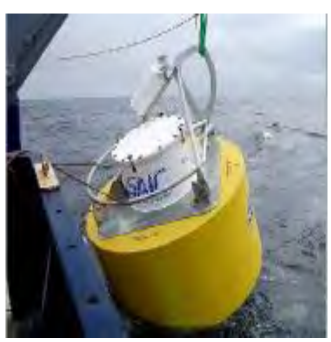
$$F_B = w_{fl} \tag{2.5}$$

The reasoning behind the Archimedes principle is that the buoyancy force on an object depends on the pressure exerted by the fluid on its submerged surface. Imagine that we replace the submerged part of the object with the fluid in which it is contained, as in (b). The buoyancy force on this amount of fluid must be the same as on the original ship. However, we also know that the buoyancy force on the fluid must be equal to its weight, as the fluid does not sink in itself. Therefore, the buoyancy force on the original object is equal to the weight of the displaced fluid in this case, the water inside the dashed region (b). The Archimedes principle is valid for any fluid not only liquids such as water but also gases such as air.

2.7 Comparison between Current IOOS Buoy

Table 2.1 show the comparison between design of current IOOS buoy and the different between components that install on each design.

Table 2.1: Comparison between Current IOOS buoy

Journal No	Design Picture	Components Include In Design
Glen Dennison, 1997, [5]		• Simple design with mooring.
John N. Walpert, 2009, [6]		• This buoy use solar panel that can support 24V of power source.
R. A. Lawson, 2007, [7]		• Have GPS that can transmit signal and give warn to weather center.

Stanley J. Boduch, 2006, [8]		• This buoy is equip with sensor such as wind speed, air humidity, wind direction and wave high to sample of oceanographic and meteorological data..
Marshall D. Earle, 2000, [9]		• This design is using spherical shape make it have less resistance to ocean wave and wind.

2.8 Summary

In this chapter, all of the journals have been researched properly and being executed into three criteria of literature review that is design, controller algorithm and system performance. Based on Table 2.1, all the features from each journal will be include on my buoy system. This will make my buoy better from the available buoy in market and it can achieve the requirement for my project. From all these research, the process to design and develop IOOS buoy will be ease and fasten. In the next chapter, the method to develop the IOOS buoy will be explained briefly. All the procedure will be included throughout the next chapter.