UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF REMOTELY UNDERWATER VEHICLE (ROV) USING EMBEDDED SYSTEM

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours

by

MOHAMMAD ADIB BIN SALIKON

B071210234

911008 - 01 - 7075

FACULTY OF ENGINEERING TECHNOLOGY

2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design of Remotely Underwater Vehicle(ROV)Using Embedded System**

SESI PENGAJIAN: **2014/15 Semester 2**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours. The member of the supervisory is as follow:

……………………………….

(MR. MOHD ZAIDI BIN MOHD TUMARI)

ABSTRACT

The Remotely Underwater Vehicle or similarly called Remotely Underwater Vehicle (ROV) is a vehicle that used to dive underwater. It is non-autonomous vehicle and tethered by linking with neutrally buoyancy to remains constant underwater also can stable in rough condition in deeper water. The controlling signal is carry through multicore cable with 1.5 meter length to control box. The purpose is to replacing human limitation ability underwater where normal human can dive only 30 feet depth before facing sensory problem such as hearing and vision. This ROV is suitable for freshwater and controlling using smart phone. There are two main parts to develop this ROV which are software design and mechanical design. Software design provides Arduino 1.6.3 software, SolidWorks and MIT inverter. Using MIT Inverter open–source web application provide by Google, ROV apps is develop specially to control the ROV movement either downward, upward and turning right or left. Arduino 1.6.3 software is used to program Arduino Mega 2560 board as a ROV brain and SolidWorks 2013 software is to design its shape implement by 3D printing. In mechanical design, there are two divisions which are electrical development and part assembly. The electrical development established for operate the ROV system such as thrusting and communicating. Radio frequency uses as transmission medium via Bluetooth module between smart phone and Arduino board. There are four DC motors as thruster which is three of it is for dive motor and the rest is moving thruster. Part assembly is joining process of all 3D printing part with other equipment via SolidWorks software for designing process. As conclusion one new product must be create to replacing human to a robot underwater and new improvement from existing product will established higher precision and technology.

ABSTRAK

Kenderaan Bawah Air atau juga dipanggil Kenderaan Operasi Bawah Air (ROV) adalah kenderaan yang digunakan untuk menyelam di bawah air. Ia adalah kenderaan berpengawal dan terikat dengan apungan nuetral untuk secara berterusan stabil di bawah air dengan keadaan yang kasar pada kedalamannya. Isyarat kawalan dibawa melalui kabel berbilang sepanjang 1.5 meter panjang ke bekas kawalan. Tujuan utama ROV ini adalah untuk menggantikan kebolehan manusia yang terhad di dalam air di mana manusia normal hanya boleh menyelam sedalam 30 kaki sebelum berdepan dengan masalah deria seperti pendengaran dan penglihatan. ROV ini sesuai untuk air tawar dengan hanya menggunakan telefon pintar. Terdapat dua bahagian utama untuk membangunkan ROV ini iaitu reka bentuk perisian dan reka bentuk mekanikal. Reka bentuk perisian menyediakan perisian Arduino 1.6.3, SolidWorks 2013 dan MIT inverter. Menggunakan MIT Inverter iaitu sumber terbuka aplikasi laman sesawang yang disediakan oleh aplikasi Google, applikasi ROV telah dibangunkan khas untuk mengawal pergerakan ROV sama ada ke bawah, ke atas dan berpusing ke kanan atau ke kiri. Perisian Arduino 1.6.3 digunakan untuk memprogram papan Arduino Mega 2560 yang dijadikan sebagai otak ROV dan perisian SolidWorks 2013 adalah untuk merekabentuk ROV untuk di laksanakan oleh percetakan 3D. Dalam reka bentuk mekanikal, terdapat dua bahagian iaitu pembangunan elektrik dan pemasangan bahagian. Pembangunan elektrik yang ditubuhkan bagi mengendalikan sistem ROV seperti tujahan dan komunikasi. Frekuensi radio digunakan sebagai medium penghantaran melalui modul Bluetooth di antara telefon pintar dan papan Arduino. Terdapat empat DC motor yang digunakan, tiga daripadanya sebagai pendorong untuk selaman dan selebihnya bergerak sebagai pendorong kehadapan. Bahagian pemasangan adalah proses menyambung semua percetakan 3D dengan peralatan lain hasil dari penggunaan perisian SolidWorks untuk proses merekabentuk. Sebagai kesimpulan, satu produk baru harus dicipta bagi menggantikan manusia kepada sebuah robot di bawah air dan pembaharuan di perlukan untuk mendapatkan produk yang tepat dan berteknologi.

DEDICATIONS

Dedicate in thankful appreciation for support, encouragement and understandings to my beloved mother, father, lecturers, friends and brothers who‟s praying for my success.

ACKNOWLEDGMENTS

Firstly, Praise to Allah who‟s gives me strength for completing my PSM to building Remotely Underwater vehicle (ROV). Secondly, thank you to my supervisors which is MR.RAZALI BIN MOHAMAD SAPIEE and MR.MOHD ZAIDI BIN MOHD TUMARI who‟s gives me a lot of study and monitoring me to do this project. Thirdly, a lot of thank you to my beloved parent, siblings and friends who‟s give me moral support, motivation and also help me to complete this project. Thank you for borrowing your equipment friends. Lastly, thank you so much to Siti Nur Haifaa Binti Mohd Yasim who‟s give me inspiration along this study. THANKS ALL.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1

INTRODUCTION

1.0 Project Briefing

The remotely operated underwater vehicle (ROV) is tethered underwater vehicle. It is designed to replace limited ability in humans for diving underwater in certain depth. The ROV is control using smart phone application. It is an advancement of using manual board as before. There are thrusters and propeller that control the movement of the ROV either downward, upward, left and right rotation. This ROV is tethered by cable from control box that contains embedded board and other component such as Bluetooth module

The control box is linked to the smart phone that provides controlling applications for the ROV movement. It is powered by batteries and it is designed to dive underwater smoothly by its compact shapes. The material used to design the ROV is PVC and ABS material to maintaining buoyancy effect. This ROV is created for freshwater.

1.1 Problem Statement

The human ability is limited underwater. The ability for diving is only below 30 meter or 98 feet depth into the water before the nitrogen narcosis become the significant hazard cause dehydration. Human cannot dive beyond the range. The endurance of human body is lesser compared to underwater robot in deep water. At the other hand, human physical is not rugged compared to ROV that designed using PVC and hardy material. But, there is a problem to design a ROV using that material. The problem is to find ROV buoyancy underwater.

Unstable buoyancy underwater is the factor that cause the ROV cannot remains position. The wave or motion established from the water will change the position of

ROV. Movement of ROV is hard to control caused by this environment disturbance. Most of marine vehicles are used Archimedes‟s principle for maintaining buoyancy. This ROV is designed using this concept.

1.2 Objective

There are two main objectives in this project which are:

i. To develop Remotely Underwater Vehicle for replacing limitation human ability underwater using mobile application.
ii. To stabilize buoyancy underwater due to water motions.

1.3 Work scope

This ROV design is divided into three parts. The first part is Smartphone with android applications. Second part is control box and the last is ROV model. By controlling using the android apps, the command produced from smart phone is transferred using Bluetooth device to the control box. The distance range is about 2 feet depth. Commands from control box are transferred using cable to ROV. The cable length is about 1.5 meter. This ROV can dive in the freshwater up to 3 feet depth.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Before starting a project, the idea from previous researchers is vital and useful as reference and suggestion for the project in aspect of system control, programming technique and physical design. The literature review is the first step to begin a new project in order to understand clearly basic concept and method of project development. The ideas to create a ROV are much outside and various methods. In this chapter, details summary of component used, design procedure and some principle will be understand to get the best product. Some ideas will compare and discuss to begin the project.

The previous researchers declared various ideas about system control, buoyancy effect and communication of the ROV. Thus, some ideas will be applied to this project with various methods.

2.1 Programming System

According from Nima Harsamizadeh Tehrani, Mahdi Heidari, Yadollah Zakeri and Jafar Ghaisar members of IEEE 2011, their products is using Arduino to control ROV movement underwater. The calculation and coding learning is used to get the precise output when thruster face load from water. Each speed of the thruster is controlling by PWM to remains constant in one position. As example, the ROV is set to dive 2 meters constant using the PWM control. PWM must be set to one value where the ROV can stay in one place.

2.2 Communication medium

According to the J.N Lygouras (1999) the communication of their ROV is using RS232 and optical cable. The RS232 is used from the master computer to the slave computer and data collected by the sensor is transmitting by it. The cable is shown in Figure 2.1. By the way, this cable also used for transmits command to the slave computer and transferred to the ROV tethered by optical cable as shown in Figure 2.2. This optical cable transmits instruction through it to the motor drive mounted on ROV. The efficiency of this cable is high. Nevertheless, this cable need high costing and required additional board.

Figure 2.1: RS-232

Figure 2.2: Optical Cable

There is ROV product using wireless communication between the slave computer and motor drive. This method is not suitable for underwater vehicle because the required frequency is about 1 – 100GHz for micro-strip antenna. The loss is too much underwater and need repeater. Besides that, power to generate the signal is too high and it"s not economic. This research has been proven by Zhang Hao Geng in his journals (2013). Figure 2.3 shows micro-strip antenna used by Zhang Hao Geng on his researches.

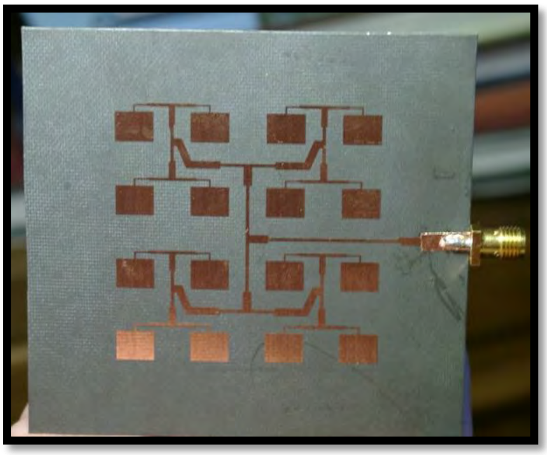

Figure 2.3: Micro-strip antenna

2.3 Thrusters and motor

Martin A. Skoglund and Fredrik Gustafsson(1995) is defined that the output force as quadratic function of the input voltage is absolute propeller direction as shown in Figure 2.4. The dynamics is fast compared to the rest of the system and is therefore neglected. Physics calculation is need to define the thruster power. In their ROV project the configuration of the thruster as seen from below where the force is pointing to the left.

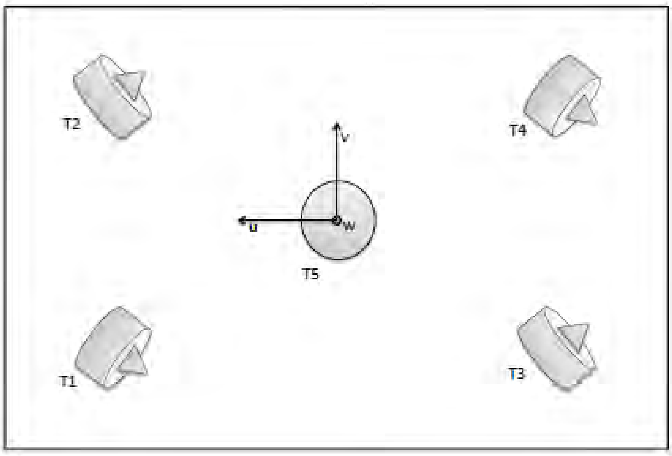

Figure 2.4 : Thruster configuration place

On the other reference by Taro Aoki and Takashi Murashima (1997) he describe industrial ROVs utilize high power, high efficiency underwater thrusters, which are very expensive for an educational, propose ROV so the thrusters for DENA are designed by use of low-cost, low power 24V DC motors. Each thruster consists of a DC motor which is mounted in a Teflon waterproofed Cylinder and sealed by a metal cap at the end. A stuffing- box is placed on the other side to waterproof the Motor shaft as shown in Figure 2.5. ROV has two vertical thrusters, two horizontal thrusters located on left and right and two additional motors placed for lateral moves.

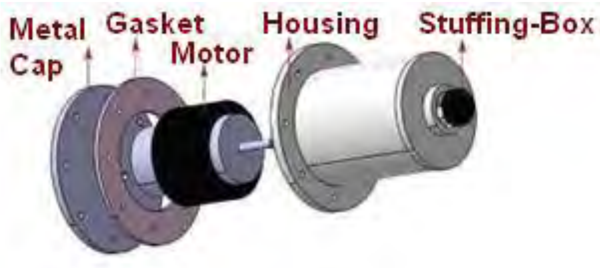

Figure 2.5: Motor housing

Their project consists of two separated dual motor driver. Both have high power DC motor drivers which can control a pair of ROV thruster. It does also provide internal H-Bridge purposed to changing direction of ROV thruster by change the flow current. Their Control board provides 4 control signals for selection of direction and one PWM signal for controlling the speed of rotation for each dual motor driver. These drivers have thermal shutdown circuits that prevent the driver from being damaged under extreme conditions. Two identical "Thruster Board" are installed in the ROV to help the control of 6 ROV thrusters**.**

2.4 Buoyancy and stability

According to Yunus A.Cengel and John Cimbala (2006), they defined a fluids exerted an upward force on a body immersed in it is a buoyant force. The buoyant force is caused by the increase of pressure with depth in a fluid. To build an ROV, this factor must be considered. The buoyant force acting on a body of uniform density immersed in a fluid is equal to the weight of the float displaced by the body, and its acts upward through the centroid of the displaced volume. Thus, $f_{B=\rho f}\, gV$. Where $'\rho'$ is density of force and „g" is gravity also volume. The buoyant force (FB) is equal to the displaced water. This fact is proven by Archimedes"s on his principle in Figure 2.6.

There are three conditions when a solid body drops into a fluid which is sink, float and remains at rest at any point in the fluid (neutrally buoyant). The figure 2.7 shows solid body will sink at the bottom when its average density is greater than the density of the fluid. When the average density is equal to the density of the fluid it is suspended body (neutrally buoyant). The solid body will rises to the surface of the fluids when average density of the body is less than the density of the fluid. The ROV must be located at neutrally buoyant to facilitate thrust process. Figure 2.8 shows what buoyancy is.

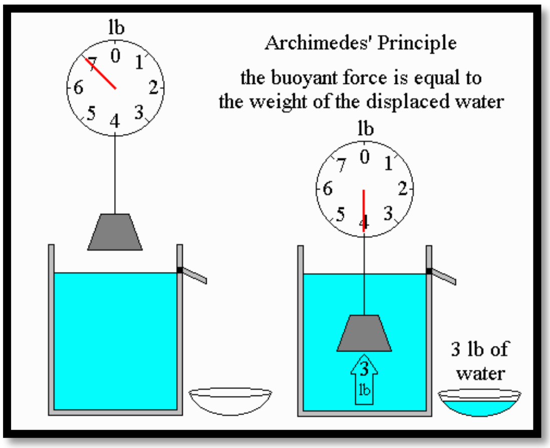

Figure 2.6: Archimedes"s principle

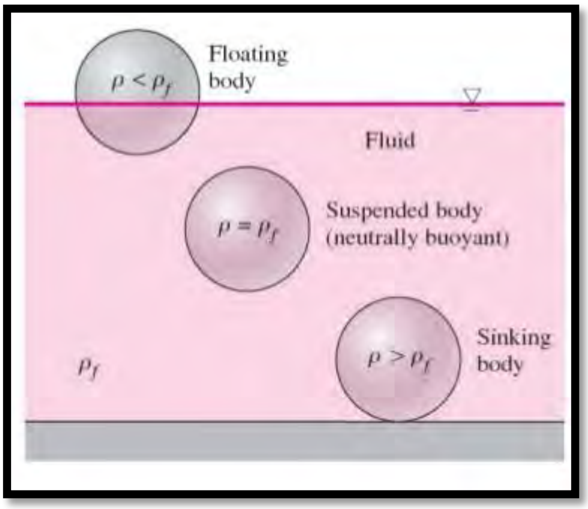

Figure 2.7: Solid body condition when drop into the water.

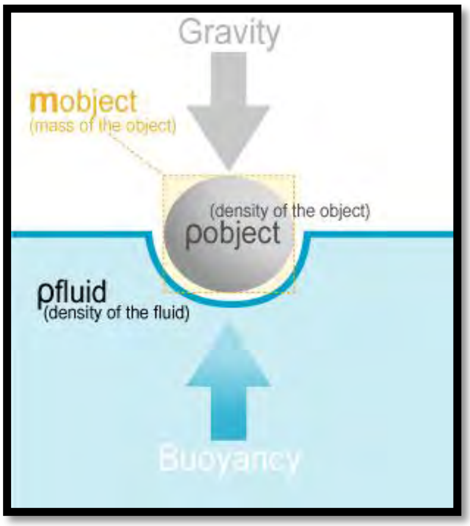

Figure 2.8: Buoyancy

In the buoyancy concept, the stability also is important application to floating bodies with external attachments. This concept usually used in ships and submarine construction. Stability is tending of an object to return itself in equilibrium position when there is a small displacement.

The stability also has three conditions which is stable, unstable and neutrally stable. Stable is movement of an object and its will return back to the initial position. Its centre of gravity must below the centre of buoyancy. The movement of an object to new location when there is any small displacement is neutrally stable. Centre gravity is coincident with centre of buoyancy. As example, ball on the field kicked by someone. The ball will stop in new position. It has no tendency to move back to its original location, nor does it continue to move away. Unstable condition is object maybe at rest or never at rest when there is disturbance. Its centre gravity is above the centre of buoyancy. Figure 2.9 shows about stability and centre of gravity.

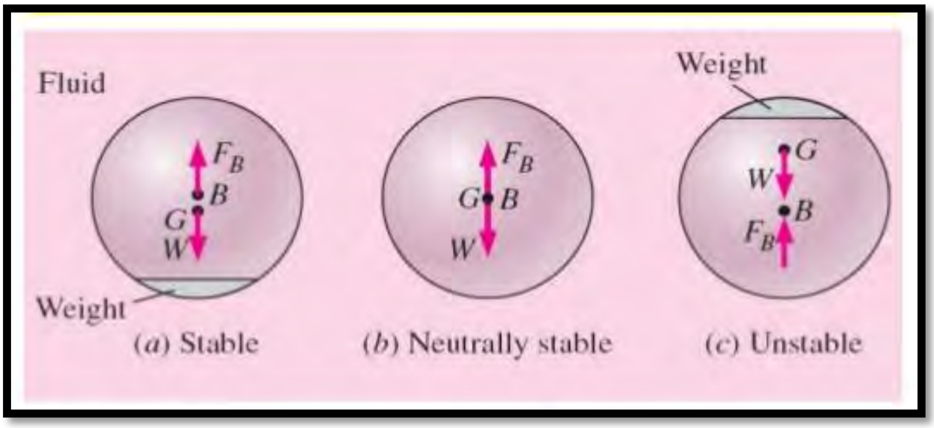

Figure 2.9 „G‟ is centre gravity and „B‟ is centre of buoyancy.

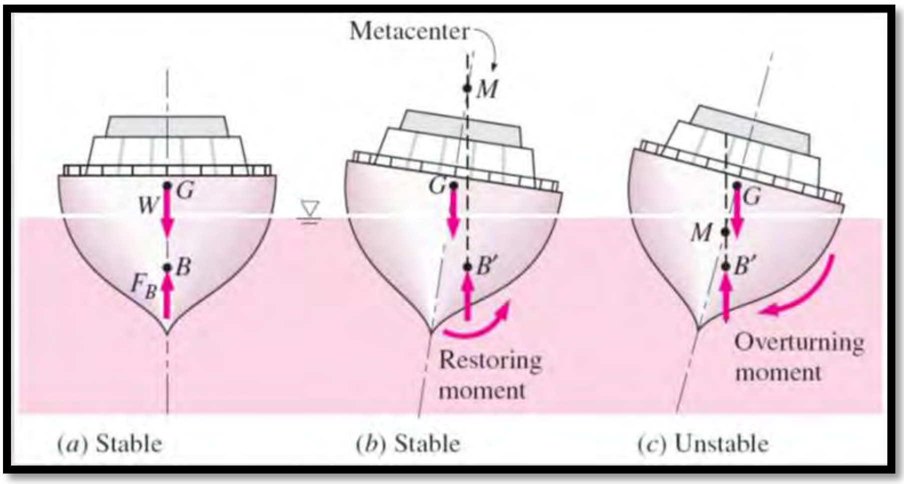

Figure 2.10: Stability concept used for the ship.

Figure 2.10 shows a floating body is stable if the body is (a) bottom bottom-heavy and thus the centre of gravity *G* is below the centroid *B* of the body, or (b) if the metacenter *M* is above point *G*. However, the body is (c) unstable if point *M* is below point *G*. While, Figure 2.10 is clarifies of submarine concepts, where (a) stable position is used.

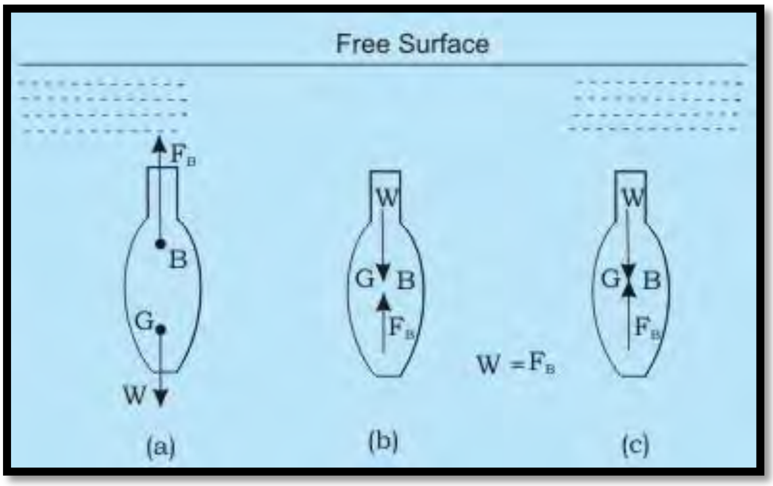

Figure 2.10: Submarine concept