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# REMOTELY OPERATED VEHICLE (ROV) PROTOTYPE

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**ELECTRICAL & ELECTRONICSENGINEERING
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**REMOTELY OPERATED VEHICLE (ROV) PROTOTYPE**

By

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Submitted to the Department of Electrical & Electronics Engineering

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**CERTIFICATION OF APPROVAL**

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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

October 2012

i

# CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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MARTINA MUHAIZIRA BINTI MOHAMAD

# ABSTRACT

This paper describes the Remotely Operated Vehicle (ROV) prototype where the objectives are to study and theoretically design the prototype for Final Year Project (FYP). This dissertation starts with the introduction of the whole idea of the project, followed by the objectives to be achieved, literature review, methodology, and lastly results and discussions. The scopes of ROV are first discussed based on the current international applications, then focused down to Southeast Asia region and lastly, the ROV applications in Malaysia. Generally, the work class ROV (Class III) is the most famous ROV which currently being applied in the industry. However, the work class ROV is big in size and came up with complex control. Thus, a ROV prototype is done as a project that will be able to provide one alternative which can be further expanded in terms of its functions into smaller and easier tasks that can be carried, such as for educational purposes and fishery industries. Few steps are taken to ensure the successful of the prototype. The theoretical studies are made to ensure that basic understandings of the working of each basic part of ROV that includes lighting, propulsion, buoyancy, camera and its frame shape are obtained. Based on theoretical studies, designs and simulations made, all designs of each part are constructed into real circuits or prototype The ROV prototype is designed with the most simple, reliable and also importantly to meet the budgeted cost. The ROV prototype is also designed to ensure that its subsystem is compatible with each other. As example, the creation of the frame is planned to be constructed by using suitable material, which is combined together to form the rectangle shape the frame. The same method applied to the other parts of ROV. Lastly, after all the constructions are done, the prototype is being tested and modified accordingly to ensure that it can work safely. Trough out the project, it is observed that a simple ROV can be made to carry stated simple tasks. The project is considered success however more underwater tests should be done to the prototype because a lot of enhancements especially on the buoyancy and propulsion system can still be modified.

# ACKNOWLEDGEMENTS

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# ABBREVIATIONS

AME                            Malaysia Allied Marine and Equipment

AUV                            Autonomous Underwater Vehicle

CCD                            Charged Coupled Device

CCTV                           Closed Circuit Television

CW                             Clockwise

CCW                            Counter Clockwise

D                              Depth

DC                             Direct Current

DPDT                           Double Pole Double Throw

FYP                            Final Year Project

IEEE                           Institute of Electrical and Electronics Engineers

ISS                            Integrated Subsea Services

MOSFET                         The metal–oxide–semiconductor field-effect

                               transistor

MOSTI                          Ministry of Science, Technology and Innovation of

                               Malaysia

PVC                            Polyvinylchloride

PCB                            Printed Circuit Board

PWM                            Pulse Width Modulation

ROV                            Remotely Operated Vehicle

| | |
|---|---|
| SEA | South East Asia |
| SMIDEX 2010 | SME Bank Innovation Showcase 2010 |
| SUT | Malaysia Society for Underwater Technology |
| STRIDE | Science and Technology Research Institute for Defense Malaysia |
| USM | Universiti Sains Malaysia |
| USYS06 | Underwater System Technology: Theory and Applications |
| UUV | Unmanned Underwater Vehicle |

# CHAPTER 1

# INTRODUCTION

## 1.1    Background of study

Remotely Operated Vehicle (ROV) is a tethered underwater robot, commonly used for the underwater tasks. ROV operation is conducted by a control box from a remote location such as on land or on the surface of the vessel [1]. In details, basic parts of ROV can consist of:

i.      Controller and navigation circuit

ii.     Thrusters for maneuvering (propulsion)

iii.    Lamps

iv.     Camera

v.      Frame

vi.     Buoyancy system

vii.    Tether management

Technically, ROV business however had long ago growing internationally however, there are still very few of ROV manufacturers and suppliers in Malaysia. Instead of assisting an oil and gas industry, ROV functions can be expanded to many scopes such as to search and rescue, education, underwater exploration, fisheries and ship wrecking investigation. There are five classes of the ROV system as shown in table below [2]:

*Table 1: ROV Classes*

| No | Class | Name | Depth Rating |
|----|-------|------|--------------|
| 1 | **I** | Eye – Ball Class | D < 100 m |
| 2 | **II** | Observation Class | D < 1000 m |
| 3 | **III** | Work Class | 1000 m < D < 3000 m |
| 4 | **IV** | Trekker Class | 1000 m < D < 3000 m |
| 5 | **V** | Wireless - Autonomous Underwater Vehicles (AUV) Class | D < 500 m |

## 1.2 Problem Statements

Subsea tasks and jobs are not widely known to the public as one of most famous and important jobs. However, the fact where only people with certain skills and special knowledge can undertake and implement underwater jobs successfully and hence, ensuring that human life goes well. As examples, subsea jobs are said to be important because if offers human with great values in modern technology as well as food supply, hydrocarbon well and many others. Among the examples are:

i. Underwater electricity generation (wind and wave turbine)
ii. Exploration of oil and gas industry
iii. Fisheries industry
iv. Education
v. Discovery of earth core geology trough underwater medium
vi. Marine park and tourism
vii. Inspection of ship wreckage
viii. Marine biology and archeology
ix. Armed services and police

Figure 1 show the importance of ROV in oil and gas industry where ROV is needed when the problems occur at the oil rig. The main cause of burning occurs at 5000m depth underwater. The faulty is due to malfunction of blow out pressure that cause the oils to spill out more when the pipeline is damaged. Thus, ROV is sent to the underwater to fix for the malfunction blow out valve as shown in figure 2.



*Figure 1: Embedded ROV Used to Fix for the 5000 feet Oil Leakage Underwater of Deepwater Horizon Owned by Transocean and British Petroleum in 2010* [3]

*Figure2: Picture taken by the ROV while fixing the Blow Out Pressure that fails to react when the Leakage occurs at Deepwater Horizon Oil Rig* [3]

Widely known, the most in demand and most common ROV used in related business is the Class III, Work Class ROV. Work Class ROV is the biggest in size compared to other class. However, all class of ROVs usually offers huge size where the control, deployment and the tether management are complicated for a small simple task involving huge space. Thus, a simple system is required.

In addition, some of the tasks also may require quite greater depths, or can be up to hundreds of meters. To the extent where the greater depths may be inconvenient to the people known as divers and their conventional breathing apparatus will no longer see as a safe and secure method to be used. Conventional methods are subject to the effects at ambient temperature and pressure at specific depth. As example, inspection carried on RMS Titanic with the depth of approximately 3800m and pressure region around 380 atmospheres will require an advance technology of Remotely Operated Vehicles (ROV) and manned submersibles [4].

## 1.3    Significance of Project

ROV used in the technology development today has boosted a lost of industry confidence and where a prediction of the ROV as a new technology for past 20 years had proven true. Thus, due to all the reasons mentioned earlier, a scaled down ROV seems appropriate for this project. Scaled down version of ROV can be expanded in terms of its functions as previously stated.

The small size ROV, or ROV prototype, seems will be very useful for education purposes where children can use the ROV prototype for exploration in rivers or lakes. As for security industry, ROV prototype provides underwater closed-circuit television (CCTV) security video for shipping business. In other words, it also offers a mean of intervention, theoretically applied for all depths without any limitations. This tether vehicle control signals and power for CCTV, lights, the propulsion and its buoyancy system and the most important of its feature is the ability to provide human with navigation and control.

Other than that, it will be very beneficial to the fishing industry where the fisherman can use their own portable ROV to check for the location with high intensity of fish population. By considering all the expanded functions of ROV, the prototype for the Final Year Project (FYP) will be designed as portable, easy to handle and small in size, easy enough for the user to carry around and accomplished simple tasks.

## 1.4    Main Objectives

i.    To study and analyze ROV designs and improvised the system
ii.    To develop electrical system configuration for the prototype
iii.    To obtain an optimal design of ROV

## 1.5    Scopes of Study

The scope of this project is to understudy all the matters involve with the designing, structuring and building the portable ROV system. After the studies has complete, the fabricating process of the ROV prototype will be done, where the process involve are:

i.    Determination of power distribution system
ii.    Navigation and control system
iii.    Visual and light control system
iv.    Buoyancy and propulsion system

Improvements and testing method take precedence in the end of the project.

## 1.6     Project Relevance

ROV prototype can give a lot of benefits to human being. As for achieving all the objectives, ROV prototype is more than enough. The construction on ROV prototype can be used for education where the children will be able to experience themselves on maneuvering the ROV as the ROV is a tethered devices. The concept of controlling the ROV is about the same with the controller used to the toy racing car and mini aircraft, but it only differs in wireless control.

As for maximum of three meters depths, the material needed in order to build the ROV might consume less cost with its basic functions stay the same. The model will also helps a lot in fishing and in conserving the marine park activities that is crucial for the future.

## 1.7     Project Feasibility

The project is planned to be done within two semesters. During the first semester, focus will be more on the conceptual and theoretical design of the ROV, while the second semester will be a lot more on constructing the ROV prototype according to the design made during the first semester. Testing and improvisation of the ROV will also be done after the construction process is done.

Furthermore, the design is focusing on the education and fisheries industry, so it is supposedly to be used less cost as possible, but still reliable. The prototype will also seem to be very useful in helping the students to learn the underwater scopes instead only looking for the pictures themselves.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1    Definition and Classification

In the advanced development of technology today, the use of robotics which is a mixed application of mostly from mechanical and electrical area has be able to provide humans with easiness in performing hard tasks and jobs onshore, offshore, on air and underwater applications. However, we can see that the underwater technology and machine has now become more interesting as the exploration of the sea is increasing and developing.

Examples of the developing underwater technology and machines are the use of wind and wave as renewable energy and the construction of underwater vehicles. Underwater vehicles fall into two categories that are Unmanned Underwater Vehicles (UUVs) and Manned Underwater Vehicles [5]. By referring to figure 3, classification of these two categories can be further divided into the sub categories. According to definition made by the US Navy, UUV in other terms can also be defined as Autonomous Underwater Vehicles (AUVs) where UUV definition is;

*Self-propelled submersible whose operation is either fully autonomous (pre-programmed or real time adaptive mission control) or under minimal supervisory control and is untethered except, possibly for data links such as a fiber optic cable.* [5]

The difference between AUV and ROV is that the absence of direct hardwires communication between the vehicle and the surface. Remotely Operated Vehicle (ROV) is a tethered underwater robot, commonly used for the underwater jobs. A further detail is shown in figure 4.
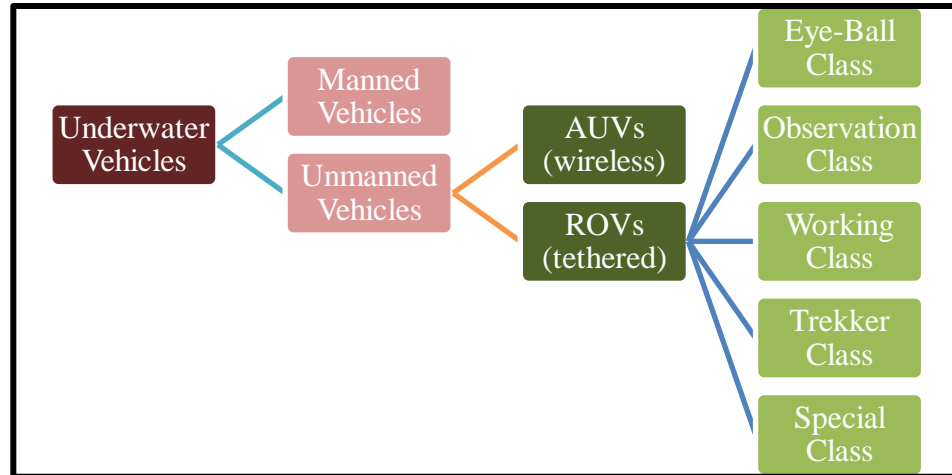
*Figure 3: The divisional diagram of underwater vehicles to ROVs*
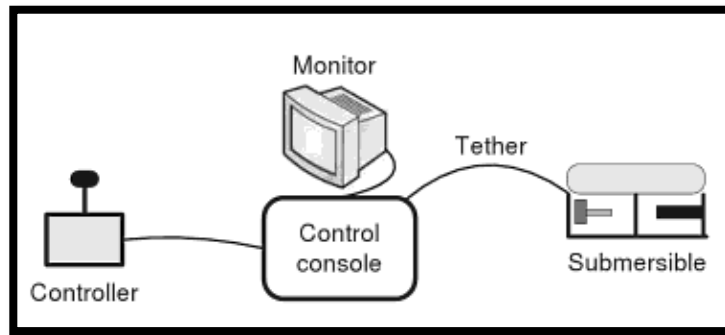


*Figure 4: Basic ROV system components* [5]

An ROV is also defined as a waterproof set of equipment with a camera mounted in a waterproof enclosure, thrusters for maneuvering, attached to a cable to the surface which signals are transmitted.

## 2.2    A Bit History

### 2.2.1    ROV at International Level

Internationally, ROV development now is reaching its maturity level. This is because of the number of the industrial ROV in the end of 1982 only has grows up to 500 [5] and now, for the year of 2012 the number can be expected to even grows bigger. The development of ROV is rapidly increased from 1982 to 1989 where in this period,

the replacement for human dive is needed for the sake of safety and also where the multipurpose functions can be carried with no harms or risks. Due to the fast increment, the first ROV conference which called as ROV'83 is done where the theme carried was 'A Technology Whose Time Has Come!'[5]. From the conference held, there are 27 ROV providers being exhibited, and from the numbers, Hydro Products, AMETEK, and Perry Offshore had been identified as most largest producers for industrials ROVs at that time. Table 2 shows the production of the observation class vehicles by companies with their own specifications where during that period, over 25 ROV were sold successfully.

*Table 2: Observation-class vehicles – small vehicles that weigh less than approx. 70kg (150lbs) with over 25 sold [6]*

| Name | Company | Wt. (kg) in air | Depth (m) | Built |
|------|---------|-----------------|-----------|-------|
| AC-ROV | AC-CESS CO, UK | 3 | 75 | 75 |
| Firefly | Deep Ocean Engineering, USA | 5.4 | 46 | 30 |
| H300 | ECA Hytec, France | 65 | 300 | 24 |
| Hyball | SMD Hydrovision Ltd., UK | 41 | 300 | 185 |
| Little Benthic Vehicle (LBV) | SeaBotix, Inc., USA | 10–15 | 150–1500 | 300 |
| Navaho | Sub-Atlantic (SSA alliance), UK | 42 | 300 | 35 |
| Offshore Hyball | SMD Hydrovision Ltd., UK | 60 | 300 | 50 |
| Outland 1000 | Outland Technology Inc., USA | 17.7 | 152 | 39 |
| Phantom 150 | Deep Ocean Engineering, USA | 14 | 46 | 27 |
| Phantom XTL | Deep Ocean Engineering, USA | 50 | 150 | 81 |
| Prometeo | Elettronica Enne, Italy | 48–55 | – | 36 |
| RTVD-100MKIIEX | Mitsui, Japan | 42 | 150 | 310* |
| Seaeye 600 DT | Seaeye Marine Ltd., UK | 65 | 300 | 63 |
| Seaeye Falcon | Seaeye Marine Ltd., UK | 50 | 300–1000 | 72 |
| Stealth | Shark Marine Technologies Inc., Canada | 40 | 300 | 50+ |
| VideoRay[†] | VideoRay LLC, US | 4–4.85 | 0–305 | 550+ |

After that, due to the business market competition, the size of ROV construction is start to be reduced, but still all the functions can still be carried by the small-sized ROV. With the small size, ROV applications are widen into more categories such as stated in the introduction. Currently, thousands of ROVs had been built in order to assist the new advanced technologies for only oil and gas industry. This is proven where according to the 2006 edition of *Remotely Operated Vehicles of the World*, over 450 builders and developers of ROVs (including AUVs) and over 175 operators are exists. Among all ROVs, Japanese ROV named JAMSTEC Kaiko is a deepest ROV that has

been successfully built so far, shown in figure 5, defeating the other ROVs when it can dive into the deepest point of Mariana Trench.



*Figure 5: Kaiko – the world's deepest diving ROV with 10909 m depth built by Japan* [5]

### 2.2.2   ROV at South East Asia (SEA) Region

As for the ROV development in South East Asia region, the increment of the services is progressing. Integrated Subsea Services (ISS) are among the international companies who owned by the Scottish offers their services on diving, survey services and ROV business. Ian Herd, who is a founder and managing director of ISS, says:

*"On the back of client demand, we have been investigating the potential in South-east Asia for some time and are pleased to have appointed high caliber people with proven experience in this market to drive forward our operations in the region. Submec (company name) was keen to re-focus on the delivery of tooling services and this presented us with a golden opportunity to acquire their ROV services business which is one of our main focus areas and where we are now a market leader"* [7].

From the statements made, it is clearly proven that the business on ROV is keep growing as long as the business involving the deep water is needed. Furthermore, on the 1st of May 2009, Ian Herd however stated that although his company is well progress in the business they carry, the use of independent subsea services is South East Asia is needed where a huge profit can be obtained.

*"There is a real need for an independent provider of subsea services in South-east Asia and we anticipate deriving significant growth by filling this gap. Currently 80% of our business is in the North Sea but we are forecasting increasing our international business from 20% of turnover to 40% in the next 3 years."* [7]

The quotes above proves that even though the technology is progressing, independent ROV need us to pay much attention to its applications in the South East Asia region, and Malaysia too has to be active in providing the multifunction of ROV technology which can generate more benefits in future.

### 2.2.3   ROV in Malaysia

For the purposes of enhancing the underwater system technology in Malaysia, an international conference had been held at Universiti Sains Malaysia (USM) in July 2006 entitled Underwater System Technology: Theory and Applications (USYS06). According to Assoc. Prof. Dr. Mohd Rizal Arshad from Universiti Sains Malaysia,

*" This conference has provided a platform to researchers, scientists, engineers, academicians, as well as industrial professionals from all over the world to present their research result and development activities on underwater system technology and applications. USYS06 was organized by the School of Electrical and Electronic Engineering, Universiti Sains Malaysia, and co-organized by the Ministry of Science, Technology and Innovation (MOSTI), Malaysia and the Science and Technology Research Institute for Defense (STRIDE), Malaysia. Society for Underwater Technology (SUT) and University of Southampton was the co-supporter of the conference. "* [8]

Complementing the world, the underwater development in Malaysia, the use and development of ROV is still young compared to other countries. Besides ISS, SMD also is among of the company offering services on ROV. In January 2012, SMD has successfully sold a work class ROV named ATOM to the Allied Marine and Equipment (AME) Malaysia [9] where again, the roles of ROV is required by the country for the underwater technology enhancement.

At present, there are only few companies in Malaysia that are responsible for ROV and AUV services and productions. They are Subsea Explore Services (M) Sdn. Bhd. and ROV Resources (M) Sdn. Bhd.. Most of the project studies on ROV systems and construction are based on first Malaysian companies in ROV business that is Subsea Explore Services (M) Sdn. Bhd. and various articles and research available in the internet. Subsea Explore Services (M) Sdn. Bhd. is pioneered in 2005 where it manufactures very own Malaysia ROV of Work Class, Class III [10]. The company however mainly focuses on manufacturing world class ROV, provides the services and also in house trainings for ROV pilots and technicians.

Subsea Explore Services (M) Sdn. Bhd. first invention of Work Class is SATRIA 101, as shown in Figure 6, which is used for assisting the oil and gas industry in the Caspian Sea, Iran. The second invention of their Work Class, which is SATRIA 102, shown in figure 7, is produced as an improvised version of SATRIA 101 and start operates in 2011. SATRIA 102 is officiated by the Malaysia Prime Minister, Dato' Seri Najib Tun Razak during the SME Bank Innovation Showcase 2010 (SMIDEX 2010). Both datasheet of SATRIA 101 and SATRIA 102 are attached at the Appendix C: SATRIA 101 and SATRIA 102 datasheet.



*Figure 6: SATRIA 101 and ROV personnel* [11]



*Figure 7: SATRIA 102* [11]

Subsea Explore Services (M) Sdn Bhd also owns two sets of Class II, Observation Class ROV, named FALCON where it system functions to assist various clients' demands. Figure 8 shows the FALCON system. The datasheet of FALCON is available in Appendix D: FALCON Datasheet.



*Figure 8: FALCON system* [11]

Generally, the services provided by the ROV are to support the oil and gas industry in terms of assisting in construction, drilling, inspection and maintenance of the pipeline and platform. Besides that ROV is also used for search and rescue missions or for underwater exploration. Figure 9 below shows the variety classes and functions of ROV provided by the Subsea Explore Services (M) Sdn Bhd.



*Figure 9: Remotely operated vehicle classes and functions* [11]

In this research however, the need for ROV can be expand into a wider scopes and applications. For education purpose, a small an easy-to-use ROV system can be used for river, lake and underwater exploration. In the fishing industry, the fishermen can easily use a ROV system to see the concentration of fishes in a certain area of the sea and to know the best place for fishing and thus boost their total catch of the day. In the security industry, a ROV can provide underwater CCTV security video for those involved with the shipping business. Underwater research and exploration can also benefit from ROV system to observe and record the underwater life ecosystem and also act as an assistant for divers in ship wreckage discovery.

## 2.3    ROV Basic Components

Basically, ROV is considered as a simplest type of robot. The only thing that differentiates a robot from its immovable counterparts is its ability to move using its own power [12]. Together with the movements, they are also equipped with the ability to navigate the robot to reach multiple objectives. For the ROV system, the complexity of any objectives can be achieved with only simplified construction. Thus, designing efficient and cost effective ROV which is suitable with the user desires can be done so that it can accomplish the tasks require. Due to the reason that ROV is usually needed to work at the water depth level which can endangers the divers, ROV is specifically design to achieve the mission at certain depth. In order to ensure that the ROV is reliable at the specified depth, all the components used must meet the rated depth and safety factors.
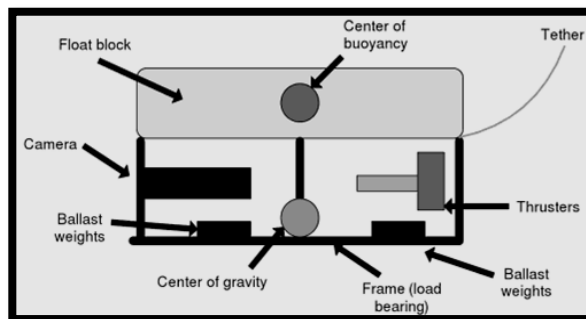


*Figure 10: Remotely operated vehicle submersible components* [12]

As denoted by figure 10, there are some major components of ROV that are usually used.  The main components of ROV contains of:

      i.     Frame

     ii.     Camera

    iii.     Ballast Weights

    iv.     Tether

     v.     Thrusters

    vi.     Lamps

Each of the components that will be assembled must meet its functions, its reliability and effectiveness, instead of cost saving, the most important factors contribute to excellent ROV.

**i.    Frame**

The frame is design to ensure that it can be a platform for the components that will be attached to the design. The frame must conform to support the equipments weight, and also have a higher strength. Its material can be in the range of plastic to aluminum, depends on the certain factors. Since weight is much relates with the gravity and buoyancy, the material choose is critical. Figure 11 below shows the design made of future ROV prototype using AutoCAD software.
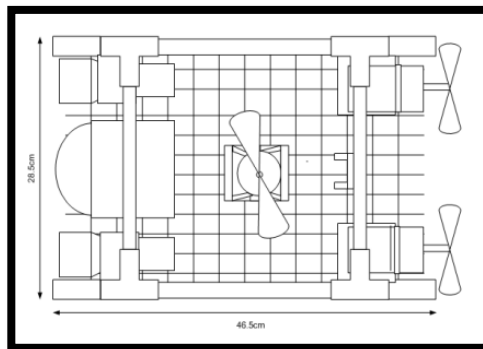


*Figure 11: ROV prototype body frame design*

## ii.   Camera

As ROV is considers replacing the divers of deepwater, the camera will function as a pair of 'eyes' of human. Instead, the camera can be used to record the data in the shape of pictures and videos. Instead of recording, the camera is also important as a safety to the ROV.



*Figure 12: ROV prototype camera*

## iii.   Ballast Weight

Ballast weight is important to control the buoyancy of the ROV. The amount of the weight and air must be appropriately control so that the center of gravity of the ROV is at the right position. Else, the ROV can be lead to the unbalance state, contributing to the rotational movement. In this case, it will be hard for the ROV to successfully work.

## iv.   Tether

Tether functions as a medium that carry the instructed movement done by the controller at the water surface. Thus, a tether must be built from the suitable and reliable bundle of wires. The wires are assembled in one cover where the cover must protect the wires from the water. Else, the wires use must have a rated ingress protection so it can work successfully in the presence of water. The tether

must also be managed to protect the wires from scratch. Thus, strong, light and flexible material must be chosen as best option of wire characteristics.

## v.   Thrusters

Thrusters relates to the propulsion and navigation system of the ROV. The size of thrusters chooses must be able to withstand the ROV weight so that it can push the water with high torque. For a propeller (thrusters fan) with a large diameter with a fairly coarse pitch, a slower motor with more torque is needed [13].  The torque is required to spin the propeller because it is moving a fairly large amount of water on each revolution, at slow speed. With the ROV being close to neutral buoyancy, or slightly positive buoyancy, a little of power is needed to keep the vehicle moving at constant depth. Thruster constructional part is shown by the figure 13 below.
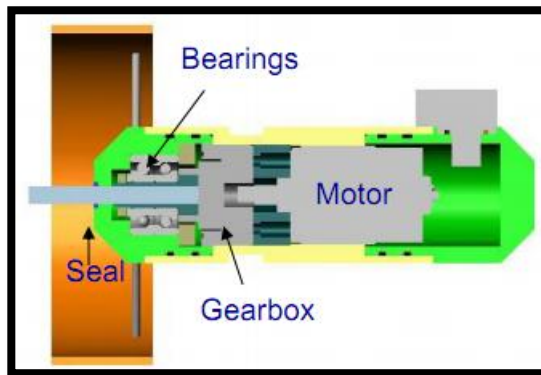


*Figure 13: Main thrusters* [14]

## vi.   Lamps

The lamps is required as deeper as the ROV goes into the water. It will help the camera to get clearer underwater pictures. The lamps must also be able to strike the suitable light color to be used in water. As example, orange light is more suitable compare to the white as while light will be extracted more by the water compare to the orange light.

16

# CHAPTER 3

# METHODOLOGY

## 3.1    Procedure Identification

To ensure that the project is successfully completed, it is to be sure that all the objectives can be accomplished. For the process of accomplishing the project, the famous procedure of applying a flow chart method is applied and shown as in figure 14.

Financial review of all equipments and itemization needed is constructed so that it meets the FYP budget estimation. As for the itemization process, the main parts identified are thrusters with its motors, power supply, lighting system, camera, the control screen, umbilical cord, buoyancy and control system.

Determination of the power supply needed can be find from the total power consumed by all equipments in the design. As for the lighting system, a circuit which can control the intensity of the light, called light dimmer circuit, must be design.

The intensity of the light and the movement of the thrusters must be able to be controlled by the control navigation system design. By using PSpice software, the obtained circuits can be simulated and modified accordingly. Then, the signal flow system design, the ROV and its buoyancy structure designs drawings and layouts will be carrying out.

In the end, the completed prototype will be tested and any improvements or adjustments must be carried out.

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                │ Determine the DC Power Supply │
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                │   Lighting system PCB design  │
                │        • Light dimmer         │
                │      • PSpice Simulation       │
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                │ The control navigation system │
                │            design             │
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                │      • PSpice Simulation       │
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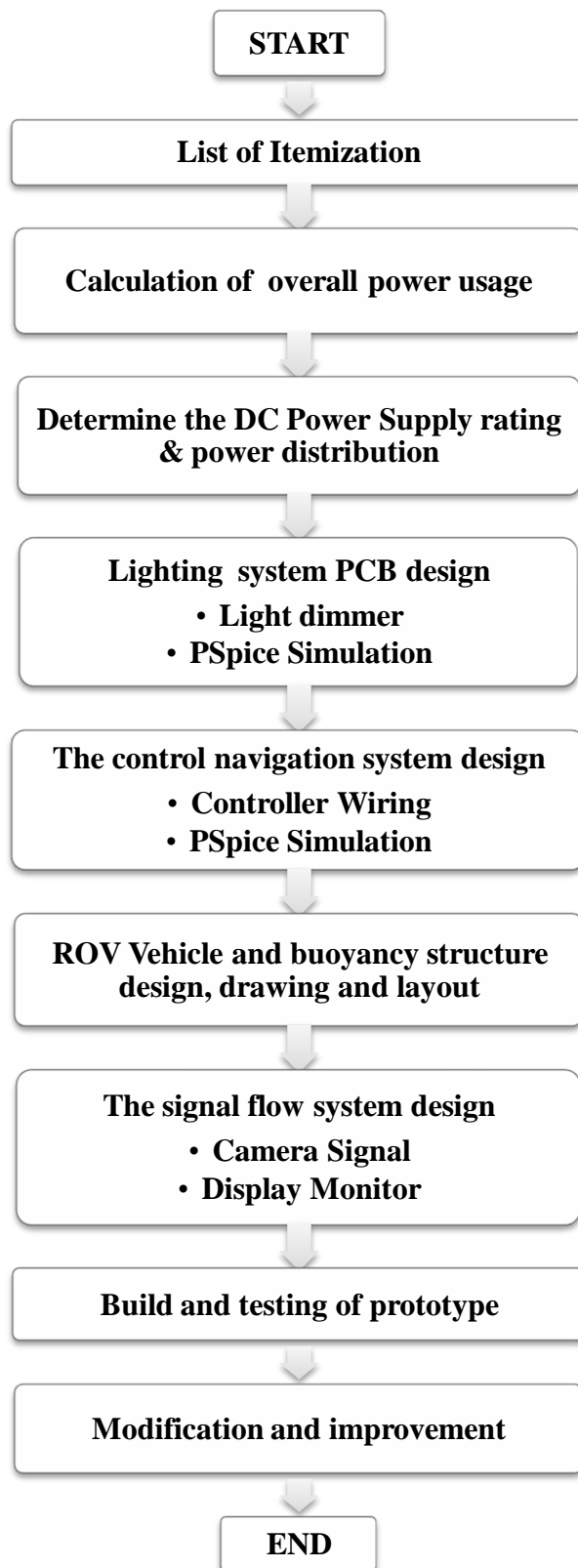
*Figure 14 :Procedure Identification Flow chart*

### 3.1.1 List of Itemization

Firstly, after all information is gathered, list of itemization is made. All possible equipments that can contribute to the reliability, suitability and cost efficient to the prototype is listing and choose.

### 3.1.2 Calculation of Overall Power Usage

When the items to be used are decided, the overall power usage is determine by calculating the rated power use by each items. As example, power consume by the lighting system is determine by calculating the current need multiply with the voltage supply. Same method applies to the other devices.

### 3.1.3 Determine the DC Power Supply Rating and Power Distribution

When all power usages is determine, the suitable DC Power Supply rating and power distribution is decided. In this case, DC power supply is use instead of AC Power Supply because it will be simpler and easier for the portable ROV to use battery instead of power supply by the generator.

### 3.1.4 Lighting System PCB Design

There are two things to be done which is first is to design a light dimmer circuit using the PSpice simulations and second, build the circuits.

### 3.1.5 The Control Navigation System Design

Same as lighting system, control navigation system design will also require simulation by PSpice software. Controller wiring diagram will be drawn and tested as a control box for the operational purposes.

### 3.1.6 ROV Vehicle Structure and Buoyancy Design, Drawing and Layout

As soon as each parts of the prototype are theoretically determined, the designs in shape of drawings are made using AutoCAD software. Drawings must be done according to the specifications and ensure that right parameters such as length is designed.

### 3.1.7 The Signal Flow System Design

As for the signal flow system design, camera signals will need to be sent to the display monitor so each image underwater can be captured. Suitable camera that meets the requirements of the project and budget is determined.

### 3.1.8 Build and Testing of Prototype

Surely after all other devices are set up and configures, the project can be start by building and testing the project outside, and within the water. Control and navigation system will be test so as lighting and propulsion system of the ROV prototype.

### 3.1.9 Modification and Improvement

Last but not least, modifications, adjustments and improvements will be done as to ensure that the objectives of the project are met. As the model is considers as prototype, many improvements can be done to further expand the ROV prototype functions.

## 3.2 Tools and Software

The list of tools and equipments that is used for this ROV prototype is listed as below:

i. 12V DC Power Supply
ii. 12V DC Torchlight
iii. 12V DC Motor
iv. 12V CCTV Camera
v. PVC Pipes
vi. PTFE Tapes
vii. Electrical Tape
viii. Water Resistant Glue
ix. Soldering Kit
x. Cable Tie
xi. Controller Box
xii. Bottles
xiii. Wire Cover

As for the software used:

i. Microsoft Visio (drawings)
ii. AutoCAD (drawings)
iii. PSpice Software (circuit simulation)

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1    List of Itemization

Table 3 below is the list of the equipment needed to build the ROV. However, the list below does not include the necessity tools.

*Table 3: ROV Items*

| No | Items Needed | Supplier | Quantity |
|----|--------------|----------|----------|
| 1 | 12V DC Power Supply | Rahmat | 1 |
| 2 | 12V DC Torchlight | Rahmat | 2 |
| 3 | 12V DC Motor | Wintec Electronics | 3 |
| 4 | 12V CCTV Camera | Sonnylux Camera | 1 |
| 5 | PVC Pipes | Rahmat | Sufficient |
| 6 | PTFE Tapes | Rahmat | 10 |
| 7 | Electrical Tape | Winstar Electrical Supply | 3 |
| 8 | Soldering Kit | - | 1 |
| 9 | Wire Cover | Electrical Lab block 22 | 4 meters |
| 10 | Controller Box | - | 1 |
| 11 | Water Resistant Glue | - | 1 Set |
| 12 | Cable Tie | Rahmat | 2 packet |
| 13 | DPDT Switch | Wintec Electronics | 2 |
| 14 | Light Dimmer Circuit | Wintec Electronics | 2 |

## 4.2    Calculation of Overall Power Usage

The overall power usage of the whole system is drawn in Figure 15 below. Each of the equipment comes with their own rated power usage. The rated power usage is then being added to get the overall power usage consumed.
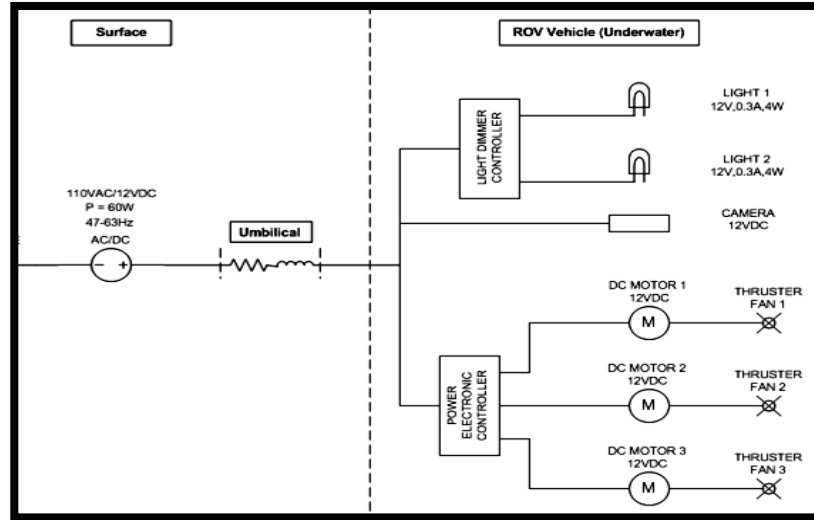
*Figure 15: Overall Power Consumption [11]*

Basically, there are six loads with the rating of 4 watts each. Thus,

$$6 \text{ Loads x } 4 \text{ W} = 32 \text{ W}$$

Therefore, the minimum required total power of supply is 40 watts. Shown in the figure 16 below is the assembled prototype of the ROV with respective loads that are already calculated.
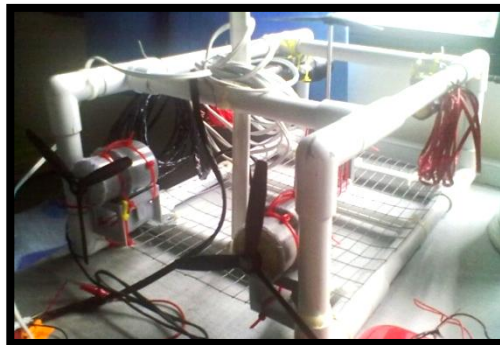


*Figure 16: Assembled ROV Prototype with Loads*

## 4.3    Lighting System PCB Design

Shown by figure 17 below is the diagram for the light dimmer circuit that will be used for the prototype.
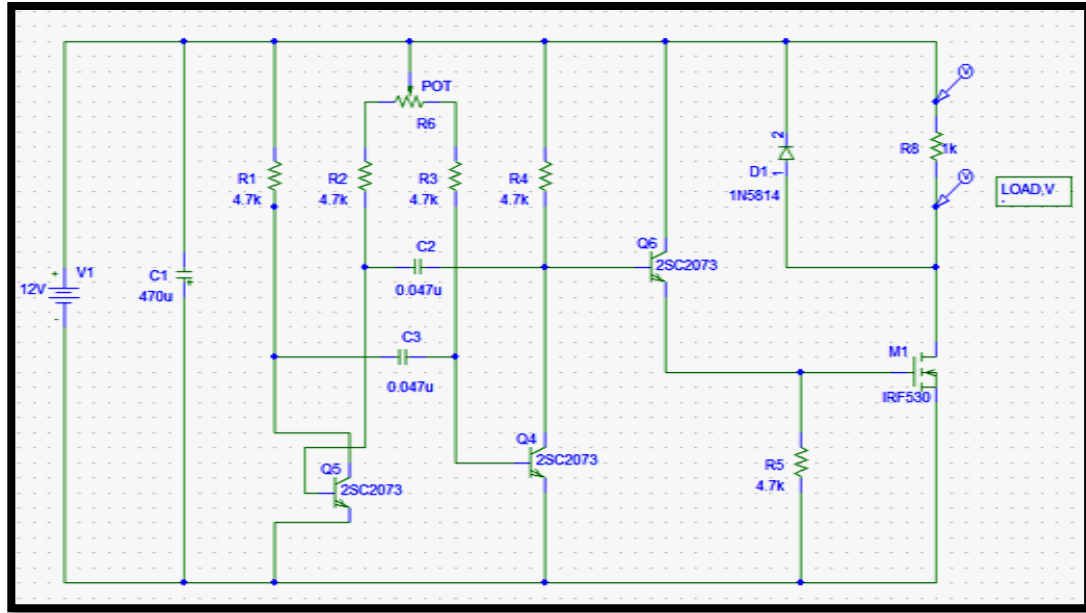
*Figure 17: Light Dimmer Circuit Simulation* [15]

Based on the circuit above, the 12V/2A light dimmer circuit will controls the intensity of light bulbs using pulse width modulation (PWM) application to control the load power. Referring to the graph in Figure 18, the $T_{on}/T$ ratio can be altered by regulating the potentiometer, hence, determine the power delivered to the load. The advantages of this circuit is that the switching transistor dissipates very little amount of heat, which means that it has higher efficiency. Besides, there is also a wide range of control (0-100%) as well as having controllability of high current loads [15].
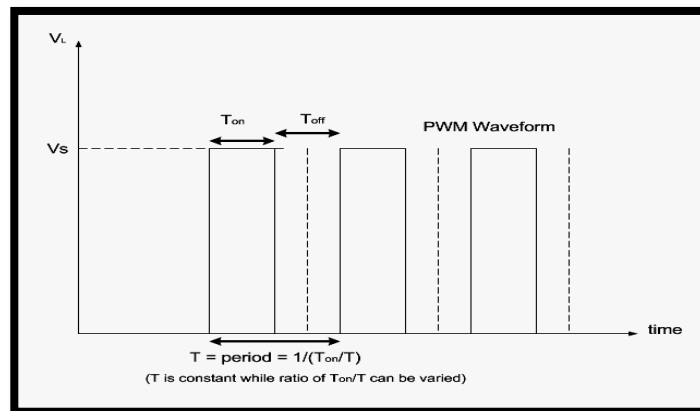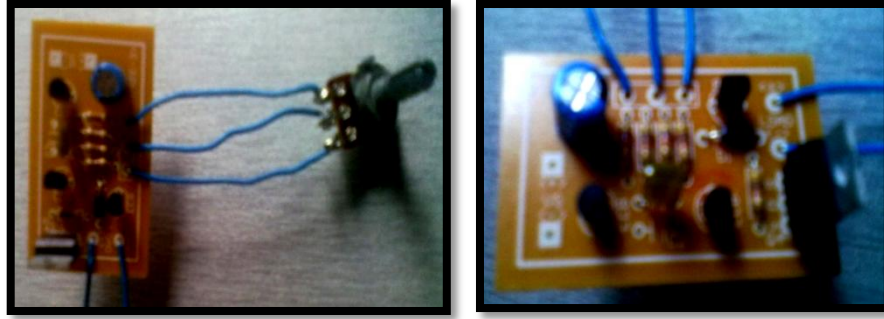


*Figure 18: PWM Waveform of $V_L$ versus time graph* [15]

*Figures 19: Actual Light Dimmer Circuits Prototype*

As for the light dimmer circuit that is simulated, figures 19 above showed the real circuit constructed. In addition to that, Table 4 shown below is a list of the components used to construct the light dimmer circuit. As the circuit construction done, its functionality is carried using the actual lamps.

*Table 4: The equipments used for light dimmer circuit*

| No | Components name | Description | Quantity |
|----|----------------|-------------|----------|
| 1 | Resistors (yellow-violet-red) R1, R2, R3, R4, R5 | 4.7kΩ | 5 |
| 2 | Diode D1 | 1N4001 ~ 4007 | 1 |
| 3 | Transistors Q1, Q2, Q3 | C945/C1815 | 3 |
| 4 | Power Mosfet Q4 | BUZ 71 IRFZ44 N CHANNEL | 1 |
| 5 | Capacitors C2, C3 | 473µF | 2 |
| 6 | Capacitors C1 | 330µF /470µF | 1 |
| 7 | VR variable resistor | 100K POTENTIOMETER 'B' TAPPER | 1 |

The testing of the circuit to the actual lamps are carried in different stages in order to see the difference intensities of the light are obtained. The results of the testing are shown in Figure 20 below.

*Figures 20: Light Dimmer Circuit Testing [11]*

## 4.4 The Control Navigation System Design

Below is the dimension for the control box of the ROV. The material that will be used in the design is Perspex or plastic sheet. As shown by the drawings in Figure 21 and Figure 22, the control box is divided into two parts, which is A and B. Part A will be specialize for the circuits used to control the ROV, while part B will be used for placing the battery or 12 volts power supply.
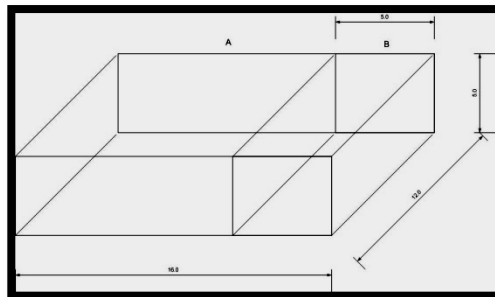


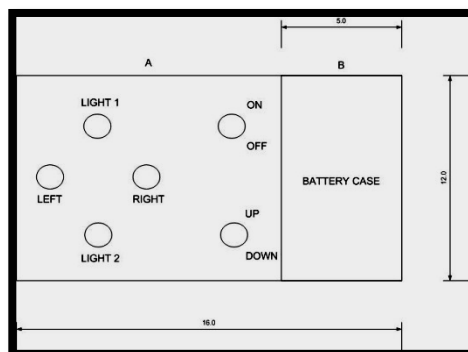*Figure 21: ROV Controller Box (Drawing)*



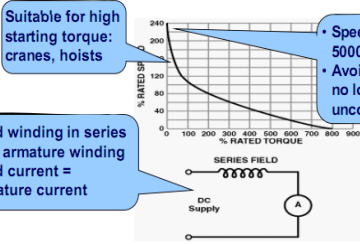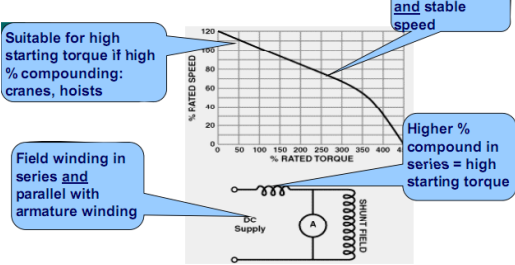*Figure 22: Upper View of ROV Control Box (Drawing)*

26

As designed above for part A, the main switch of power supply is the ON-OFF toggle switch at the top right corner. The UP-DOWN toggle switch is at the bottom right corner, controlling the vertical motor of the prototype. The RIGHT button navigates the prototype to the right direction by controlling the left motor while the LEFT button navigates the prototype to the left direction by controlling the right motor. In order to go FORWARD, both RIGHT and LEFT button must be on simultaneously. While for part B, a 12 volts power supply (battery) will be used. Other alternatives for the power supply will also be available, in case the power supply in the lab is to be used by using the connectors or crocodile clips.



*Figures 23: Prototype Controller Switches*

Other than that, to ensure that the navigation can be carried out properly, a careful choice and construction of motor and its system will need to be done. As stated earlier, the motor that will be used is for the prototype is DC motor that meets the high torque requirements. Basically, there are two types of DC motors that are associated with the high torque requirements for the prototype; the Self-excited DC Series Motor and the DC Compound Motor [16]. The two types of DC motors torque-speed characteristics are as shown in Table 5.

*Table 5: DC Motors [16]*

| Self-excited DC Series Motor | DC Compound Motor |
|---|---|
| Suitable for high starting torque: cranes, hoists • Speed restricted to 5000 RPM • Avoid running with no load: speed uncontrolled • Field winding in series with armature winding • Field current = armature current | Good torque and stable speed Suitable for high starting torque if high % compounding: cranes, hoists • Field winding in series and parallel with armature winding • Higher % compound in series = high starting torque |

In order to make a good propulsion system for the prototype, a 12 volts DC motor with a powerful propeller blade like the one applied in remote controlled toy boats can be assembled or another method will be using a modified version of 12 volts bilge pumps like the one used in fish tanks. An example of bilge pump thrusters that can be used is shown in Figure 24.

*Figure 24: A Bilge Pump Thruster [11]*

*Figure 25: Waterproofing Process of the 12V DC Motor*

As the 12VDC waterproof motor is not available in Malaysia and need to be exported, the other alternative is taken which is by using the self-made waterproof motor. A 12VDC motor known as RS540SH motor is used and waterproofed using the special glue (one kind used for protecting and sealing the circuit from short circuit). The openings available around the motor are sealed and then placed inside the PVC pipes. The pipes is then sealed again using the glue. As result, waterproof motors are successfully made and their function is also successfully tested in the water as shown in Figure 26 below.



*Figure 26: Testing the Waterproof Motor in the Water*

To ensure the clockwise (CW) and counter clockwise (CCW) movements of the motors underwater are synchronize with the speed, a bidirectional DC motor controller can be used. It can control the rotation direction of the motor as well as to control its speed. There many ways for bidirectional DC motor controller and among them are using voltage regulators and MOSFETs or by using a Double Pole Double Throw (DPDT) switch motor controller.

### 4.4.1 Bidirectional Motor Control Circuit using Voltage Regulators and MOSFETs

The motor controller circuit is as in Figure 22 while the circuit construction is shown in Figure 27.
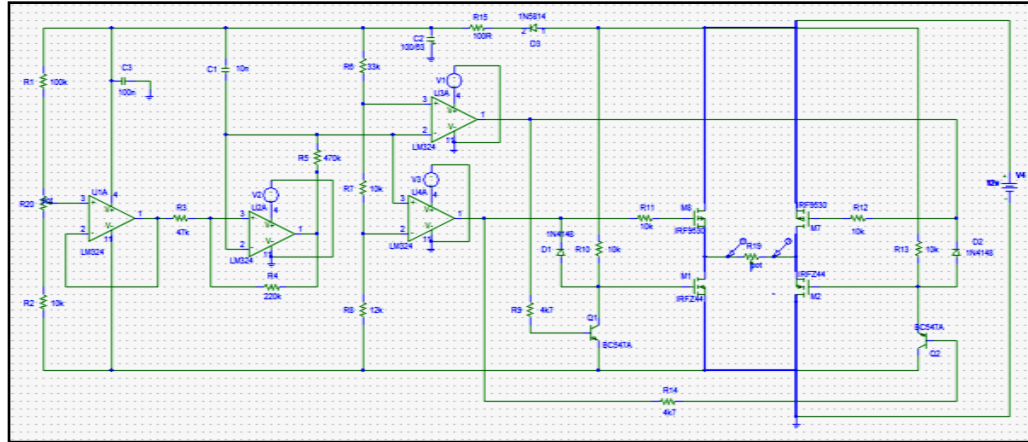
*Figure 27: Bidirectional Motor Control Circuit using Voltage Regulators and MOSFETs [17]*

Inventors usually use the switches to change the direction of motor rotation. Only by changing the applied voltage polarity, the motor can spin the other way. However the disadvantage that a Double Pole Double Throw (DPDT) switches has to be added to change the voltage polarity applied. It is bad idea actually to suddenly reverse the DC motor voltage while it is spinning as this can cause a current spike that can burn out the speed controller and cause mechanical stress. The circuit in Figure 27 overcomes both these problems. The same circuit in Figure 27 can be found in Appendix F: Kit 166 Bidirectional DC Motor Controller. A single potentiometer can be used to control the direction and by turning the pot in a path will cause the motor to start revolving. With turning the pot in the other direction will cause the motor to spin in the opposite way. The middle point on the pot is OFF will force the motor to slow and stop before changing direction [17].

Referring to Appendix F, when MOSFET Q3 and Q6 are ON, the current flows through the motor and it roll in one route. When Q4 and Q5 are ON the current flow is inverted and the motor turns in the reverse direction. Op-amps IC1: C and IC1: D control which MOSFETs are turned on and are configured as voltage comparators. The reference voltage that triggers is a resultant of the resistor voltage divider rule of R6, R7 and R8. IC1: D is triggered by a voltage larger than its reference (connected to the '+' input) whereas IC1: C is triggered by a voltage less than its reference (connected to the '-' input). [11]

30

Op-amp IC1: B, the triangle wave generator gives the activating signal for the voltage comparators. It is not possible for both comparators to be triggered simultaneously because the peak-to-peak output level of the triangle wave is less than the difference between the two voltage references and is centered on a DC offset voltage. The DC position of the triangle wave changes accordingly by raising or lowering the offset voltage. Shifting the triangle wave up cause the comparator IC1: D to trigger; lowering it causes comparator IC1: C to trigger. When the voltage level of the triangle wave is between the two voltage references then neither comparator is triggered [17].

The DC offset voltage is controlled by the potentiometer P1 via IC1:A, which is configured as a voltage follower, providing a low output impedance voltage source, making the DC offset voltage less susceptible to the loading effect of IC1:B. As the potentiometer is turned, the DC offset voltage changes, either up or down depending on the direction the pot is turned. Diode D3 provides reverse polarity protection for the controller. Resistor R15 and capacitor C2 is a simple low pass filter, designed to filter out any voltage spikes caused by the MOSFETs as they switch to supply power to the motor [17] [11].
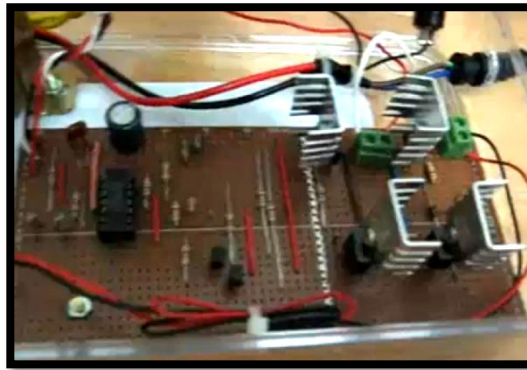


*Figure 28: Bidirectional Motor Control Circuit [18]*

### 4.4.2 Double Pole Double Throw (DPDT) Switch Motor Controller

The simplest way to control direction of the DC motor is by using DPDT switch (Dual ON-ON). A Dual ON-ON DPDT switch is a pair of ON-ON switches which can operate together. The polarity of the output, the DC motor, can be reversed by just

flicking the toggle switch. There are three terminals in a DPDT switch. The power is connected to the centre pair of the switch's terminals. So, the switch can be switched in turn to either of the two other pairs of terminals. The connection of the DPDT switch can be seen in Figure 29 [18].
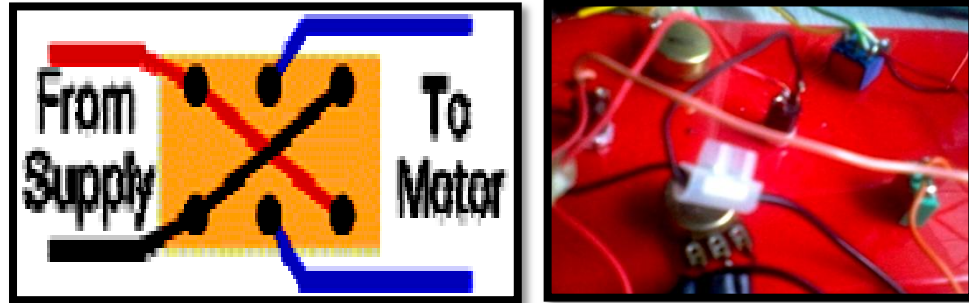

*Figure 29: DPDT Switch Terminal Connection [18]*

### 4.4.3   Thrusters and Tethers Management

Bohm and Jensen [20] suggest using submersible 12 volts bilge pumps intended for small boats. Bohm and Jensen also illustrate a method of waterproofing the DC motor found in toys using 35 mm plastic film canisters filled with wax. The method should be within the capabilities of a teenager, given time and patience, but the results are not immediate enough for younger children. This method has been experimented by IEEE with adapting motor pods for bath toy submarines by removing the battery and replaces it with the wires that make up the tether. It has proved very satisfactory, but sourcing the mechanism has been a problem. [21]

Wax-sealed and bath toy methods of waterproofing can give unreliable sealing, make it compulsory to dismantle and dry the thrusters after use. It is dispensed with the need to waterproof the thrusters entirely by running the motors open in the water. To permit this, two conditions need to be met which are first, only fresh potable water is used and second, the supply voltage is restricted to just 1.5 volts or 3 volts. Potable water has a very low electrical conductivity. The motors used by the IEEE are inexpensive metal brushed, round can, DC motors rated at 1.5 to 4.5 volts. With careful drying and lubrication the motors can last for several years. The viscous drag of the water on the armature is a major source of the load for the motor and small propellers, suitable for the

needs to contribute to just a small additional load. Tests done by IEEE indicates that motors will run for at least 24 hours continuously before failing by keeping the voltage and shaft speed low, When the voltage is increased to the maximum rated voltage the motors burn out within 2 to 3 hours, accompanied by the steady production of gas. When examined, the brushes are found to be eroded away. It is speculated that at higher speeds, the brushes start to break contact frequently. By removing the need to waterproof the motors, construction of thrusters is reduced to attaching the supply wires forming the tether, an inexpensive toy boat propeller (approximately 30 mm diameter) and providing a means of attaching the thrusters to the frame [21]. Thus, these methods can be tested to the ROV prototype construction with 12 volts DC motors being used.

## 4.5    ROV Vehicle Structure and Buoyancy Design, Drawing and Layout

Figures 30 below are the proposed designs drawings are made using AutoCAD software. The frame is planned to be built by using many parts of PVC pipes which are, 1/2 inch PVC pipes, PVC elbows, PVC tee- joint, PTFE tape, steel net for support and also cable ties for tying the equipments to the ROV frame. PVC is used due to its characteristics of high reliable, high durable, light and easy-to-obtained materials. However, carbon graphite will give better performance, but due to cost and supplier constraint, PVC pipes are used. Figures 30 and 31 below show the designed ROV using the AutoCAD software. Larger views are available at Appendix E: ROV designs
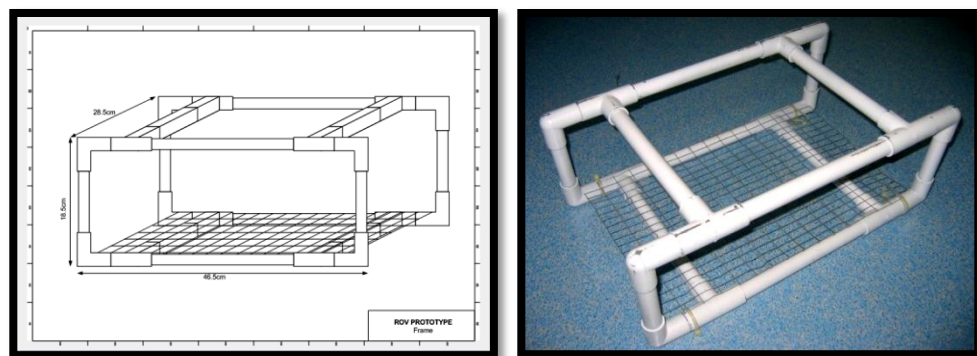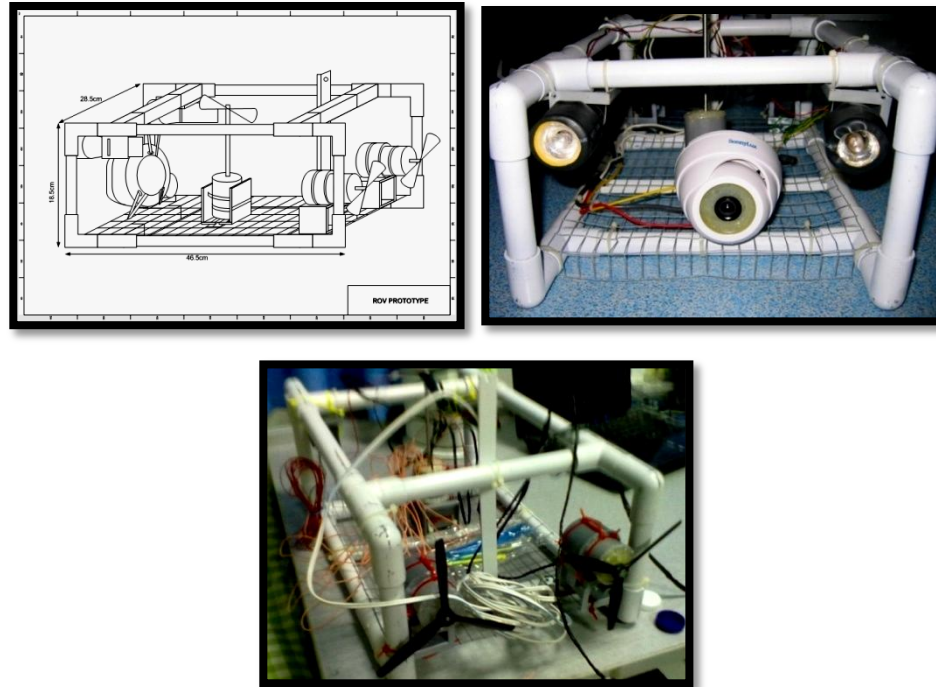


*Figure 30: ROV Frame [11]*

*Figure 31: Complete ROV Design for Prototype*

As for the buoyancy and propulsion system, these two elements are also those that made the main and important characteristics of ROV. The good buoyancy and propulsion system of the prototype's vehicle is what makes it mobile underwater, moving along the *x*-, *y*- and *z*-axis. Six main directions of the ROV movements which are forward, reverse, up (surfacing), down (submerging), left and right [11].

In propulsion, there are three methods available for surfacing and submerging of the ROV vehicle, which are either considering the submarine application of using a ballast tank or simply by using DC motor thrusters, or both. For the submarine ballast tanks, when the submarine is on the surface, the ballast tanks are filled with air and the submarine's overall density is less than that of the surrounding water [22]. As the submarine submerges, the ballast tanks are flooded with water and the air in the ballast tanks is vented from the submarine until its overall density is greater than the surrounding water and the submarine begins to sink. Figure 32 shows how the ballast tank and the air valve work for surfacing and submerging the submarine.
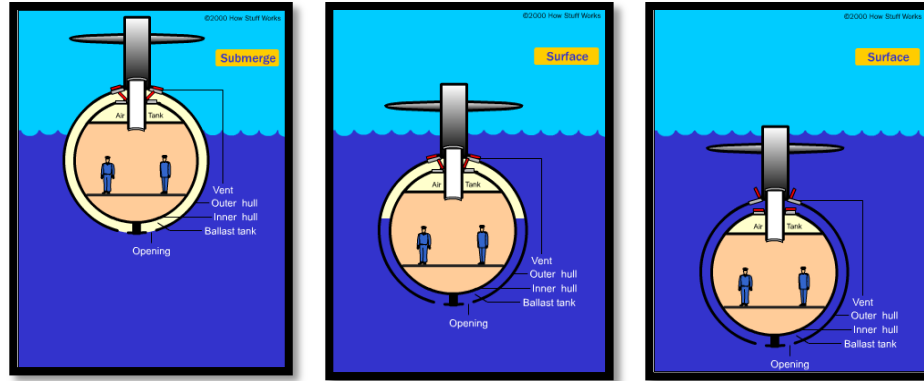
34

*Figure 32: How the Ballast Tank Work In Submarines [22]*

To apply this method, a winch-action piston type of ballast can be assembled to control the surfacing and submerging of the vehicle [23]. The schematic diagram of the ballast system is in Figure 33.
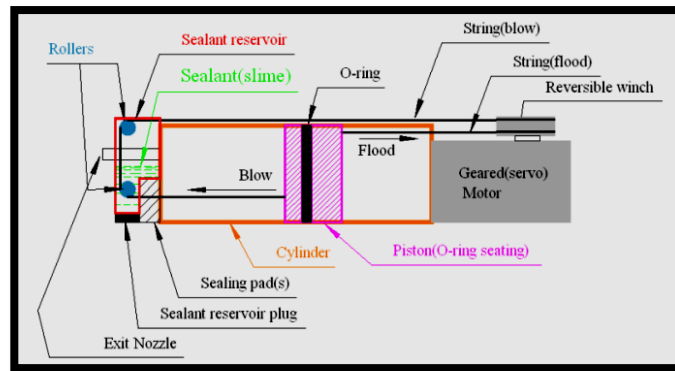


*Figure 33: Winch-Action Ballast Piston Type [23]*

The second method of using the thrusters only will actually be sufficient enough to help the ROV prototype sink and surface, but then a very strong motor with balance weight of equipments placement that has being attached to the frame, and also correct centre of ROV gravity will need to be achieved as a condition. Else, the prototype may result in unstable movement or worse, it can be rotating while be in the water.

Besides using the ballast tank method and only thrusters, DC motor thrusters together with ballast tank will be more convenient. This method is easier and more applicable for the prototype in accordance to its small size. By using the slightly positive

buoyancy to the prototype together with fine combination of DC motor thrusters, it can help the ROV to go surface and moving underwater becomes easier. With DC motors, speed can be controlled without any impact on the power supply quality. As for the project, three thrusters are enough for a small sized ROV prototype. One will be used to control the surfacing and submerging direction, and the other two to control the left, right, forward and reverse direction. A power electronic controller can be applied to control these three thrusters. The motor speed can be controlled by changing the armature voltage or changing the field current.

As well as propulsion system, buoyancy factor will also need to be focused on. Buoyancy is defined as the weight of displaced fluid when an object is in the fluid [24]. The buoyant force on an object is equal to the weight of the fluid displaced by the object, or the density of the fluid multiplied by the volume submerged. Thus, the greater the volume of an object, the greater the buoyancy of the object is.

The buoyancy concept is shown in Figure 34. The boat in Figure 34 has buoyancy when the weight of the water is displaced by the boat being in the water. By theory, the buoyant force the boat is the opposite of the gravitational force and is equal to the density of the water multiplied by the volume submerged.
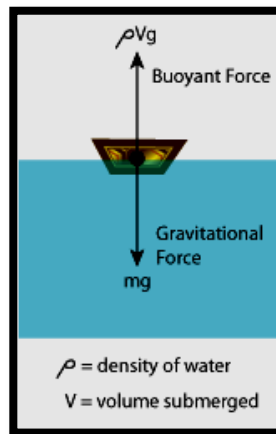


*Figure 34: Buoyancy [24]*

A submarine can float because the weight of water that it displaces is equal to the weight of the ship. Submarines can dive and surface by controlling its buoyancy by using

a ballast tank and a trim tank. When the submarine begins to sink the buoyancy is negative. When the submarine maintains a balance of air and water in the trim tanks so that its overall density is equal to the surrounding water, it reaches the neutral buoyancy. When the submarine surfaces, compressed air flows into the ballast tanks and the water is forced out of the submarine until its overall density is less than the surrounding water where the buoyancy is positive and the submarine rises.

Hence, in order for this ROV prototype to sink, the total vehicle weight needs to be more than the water displacement weight. The following calculation can be done to estimate the amount of ballast that is needed [25].

Let,

DE = dry weight of vehicle (empty ballast tank)
WD = weight of water displaced by vehicle
B = weight of ballast

Neutral buoyancy is when:
$$DE + B = WD \qquad (1)$$

Therefore, the ballast weight is,
$$B = WD - DE \qquad (2)$$

*Note that 1 cc of water weighs 1 g, so 1 L of water weighs 1 kg (1 L = 1 cubic decimeter = 1000 cc).*

However, the buoyancy will be hard to be controlled, and thus it will be easier to make the prototype sinking by controlling the weight, rather than controlling the buoyancy.

## 4.6    The Signal Flow System Design

As for the signal flow system design, a camera signal will needs to be sent to the display monitor so each image underwater can be captured. Suitable camera which meets the requirements of the project objectives and budget will be determined.

Figure 35 shows the closed-circuit television (CCTV) security camera that will be used for the prototype. As given by the Figure 37, the data sheet of the camera, this type of CCTV is known as a CCD colored video camera rated at DC 12 volts and 250 mA current. CCD stands for "Charged Coupled Device" and they are actually the sensors that are used in digital cameras and video cameras to record still and moving images [26]. CCD is often considered as the digital version of film as it captures light and converts it to digital data that is recorded by the camera.

Although the camera has a day and night infrared function, this function would not be used in the prototype as infrared works in a different way underwater as the water wave dissemination differs than air wave propagation. Infrared in underwater will end up boiling the water instead. The datasheet of the camera can be found at Appendix J: CCTV Specifications
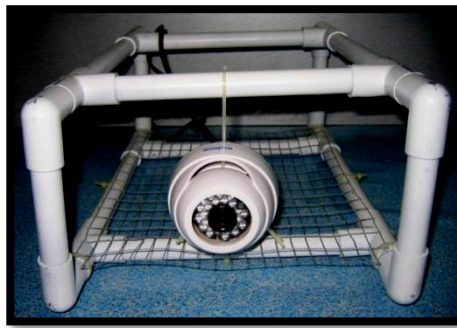


*Figure 35: CCTV Camera Attached to Frame*

# CHAPTER 5

## CONCLUSIONS AND RECOMMENDATIONS

### 5.1    Conclusions

Wrapping up all the information available, the project of Remotely Operated Vehicle (ROV) is sure can be scaled down into a smaller size and the scope of function can be expanded into the education, security and fishing industry. For the propulsion system, bilge pumps made of DC motor and propeller can be used. A CCTV security camera or webcam can be installed at the prototype as its eyes, and the ROV frame is designed by using material of the PVC pipes. To help the CCTV gaining clear visions, the lightings system consists of two 12 volts DC bulbs with a light dimmer circuit is applied.

The project objectives of studying and analysis the ROV development as well as developing the electrical system configuration (simulation) for the prototype are achieved. Besides, the optimal design for the ROV can also be achieved giving many tests should be done to the ROV prototype when its construction is finished. Thus, with this, the Final Year Project 1 and 2 objectives which  to plan and build (simulate and construct) the prototype is a success.

### 5.2    Recommendations

The designs of the prototype can be modified according to its application. When the prototype is built, more underwater test should be done and to rectify any error. Additional studies, especially on the CCTV camera functions, the propulsion, buoyancy in term of balancing the weight, and control unit system are needed. Enhancement can also be made to the lighting system where waterproof torch light can be used to avoid the vaporization inside the lamp and also to simplify the task of waterproofing them.

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# APPENDIX A : PROJECT'S GANNT CHART FYP 1

| No | Activities/Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Selection of FYP Title | G | | | | | | | | | | | | | | |
| 2 | Data Gathering | | G | G | G | G | G | G | G | | | | | | | |
| 3 | Proposal Submission | R | | | | | | | | | | | | | | |
| 4 | Itemization | | G | G | G | G | | | | | | | | | | |
| 5 | Budgetting | | | | | G | G | G | | | | | | | | |
| 6 | Power Distribution System | | | | | | | G | G | G | G | G | | | | |
| 7 | Buoyancy System Design | | | | | | | | | G | G | G | | | | |
| 8 | Propulsion System Design | | | | | | | | | | G | G | G | G | | |
| 9 | Parts and Materials Purchase | | | | | | | | | G | G | G | G | G | G | |
| 10 | Extended Proposal Submission | | | | | | R | | | | | | | | | |
| 11 | Overall Prototype Design | | | | | | | | | | G | G | G | | | |
| 12 | Proposal Defence and Progress Evaluation | | | | | | | | R | | | | | | | |
| 13 | Prototype Progress Enhance | | | | | | | | | | | | G | G | | |
| 14 | Result Compilation and Finalization | | | | | | | | | | | | | G | G | |
| 15 | Submission of Draft Report | | | | | | | | | | | | | | R | |
| 16 | Submission of Interim Report | | | | | | | | | | | | | | R | |
| 17 | Preliminary Design Review (Oral Presentation) | | | | | | | | | | | | | | | R |

# APPENDIX B : PROJECT'S GANNT CHART FYP 2

| No | Activities/Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|----|-----------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
| 1 | Light Dimmer Circuit | ■ | ■ | ■ | | | | | | | | | | | | |
| 2 | Motor Controller Circuit | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | |
| 3 | Prototype Drawing | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | |
| 4 | Prototype Building (Resemble) | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| 5 | Submission of Progress Report | | | | | | | | ▰ | | | | | | | |
| 6 | Poster Exhibition (Pre - EDX) | | | | | | | | | | | ▰ | | | | |
| 7 | Submission of Dissertation (soft bound) | | | | | | | | | | | ▰ | | | | |
| 8 | Draft Report Submission | | | | | | | | | | | | | ▰ | | |
| 9 | Final Report Submission | | | | | | | | | | | | | | ▰ | |
| 10 | Viva (Oral Presentation) | | | | | | | | | | | | | | | ▰ |
| 11 | Submission of Dissertation (hard bound) | | | | | | | | | | | | | | | ▰ |

# APPENDIX C: SATRIA 101 DATASHEET



## SATRIA 101 WORKCLASS ROV SYSTEM

| | |
|---|---|
| Original Equipment Manufacturer | : Subsea Explore Services (M) Sdn Bhd |
| ROV Type | : 100 HP Work / Survey Class |
| Standard Depth Rating | : 1500 Meters, 140 Kg Payload |
| Dimension | : 2500mm (L) x 1300mm(W) x 1600mm(H) |
| Propulsion System | : 5 Curvetech 300mm diameter 10kw/13.5Hp Thrusters individually servo valve controlled |
| Standard Power Pack | : 75KW / 100HP 3 Phase 4 Pole, 2.5KV motor, Oil filled and compensated. Bosch Rexroth PD Pump, output 140 lpm @ 200bar |
| Video & Telemetry | : Fiber Optic and Copper 2 Coax |
| Lighting | : 1250 Kw from 5 x 250watt dimmer channel 2500 m rated lights |

| | |
|---|---|
| Control & Navigation | : Flux Gate Compass & Rate Gyro System Tritech Seaking Sonar, Depth Transducer System, Auto Functions, Heading, Altitude & Turn Rate |
| Standard Components | : 1 x 7 Function Rate Manipulator 1 x 5 Function Rate Manipulator 10 Station Solenoid Valve Pack Toolings Manifold Servo Valve Subsea Hydraulic Pan and Tilt Colour Camera Monochrome Camera |
| Vehicle Instruments | : Fiber optic video and telemetry transmission system Focal Single Mode Video/Data Transmission System 8 Video + 16 Data Channels |
| Vehicle status sensors | : Hydraulic pressure and temperatures Hydraulic reservoir oil level Motor temperature Motor oil compensation level Voltage and current |
| Control Van Container | : 6140mm(L) x 2438mm(W) x 2750mm(H) |
| Tooling Container | : 6140mm(L) x 2438mm(H) x 2750mm(W) |

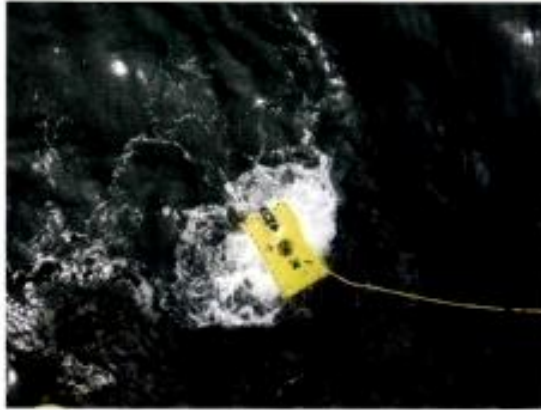# APPENDIX C: SATRIA 102 DATASHEET



## SATRIA 102 WORKCLASS ROV SYSTEM

| | |
|---|---|
| Original Equipment Manufacturer | : Subsea Explore Services (M) Sdn Bhd |
| ROV Type | : 125 HP<br>Work / Survey Class |
| Standard Depth Rating | : 2000 Meters, 150 Kg Payload |
| Dimension | : 2845mm(L) x 1585mm(W) x 1840mm(H) |
| Propulsion System | : 6 x 300mm diameter 10kw/13.5HP;<br>Vectored Thrusters individually servo valve controlled |
| Standard Power Pack | : 93KW / 125HP 3Phase 4Pole, 3.0KV motor, Oil filled and<br>compensated. Bosch Rexroth PD, Pump,<br>output 140lpm @ 200bar |
| Video & Telemetry | : Fiber Optic |
| Lighting | : 1.25Kw from 5 x 250watt dimmer channel,<br>250 or 500 watt 2500 rated lights |
| Control & Navigation | : Intelligence Gyro Compass,<br>Tritech Seaking Sonar, Depth Transducer,<br>System, Heading & Depth Auto Functions |

| | |
|---|---|
| Standard Components | : 1 x 7 Function Rate Manipulator<br>1 x 5 Function Rate Grabber<br>16 Station Solenoid Valve Pack<br>Tooling Manifold<br>8 Channel Servo Valve Pack<br>SES Hydraulic Pan and Tilt<br>Color Camera<br>Monochrome Arm<br>CP Actuator Arm |
| Vehicle Instruments | : Control Panel System<br>Fiber optic video and telemetry transmission system<br>Single Mode Video/Data Transmission System<br>8 Video + 16 Data Channels<br>DVD Recorder System |
| Vehicle Status sensors | : Hydraulic pressure and temperatures<br>Hydraulic reservoir oil level<br>Motor temperature<br>Motor oil compensation level<br>Voltage and current |
| Control Container | : 6058mm(L) x2438mm(W) x 2591mm(H)<br>Certified to DNV 2.7-1 / EN12079<br>Rated to Zone-2 A60 |
| Tooling Container | : 4267mm(L) x 2438mm(W) x 2591mm(H)<br>Certified to DNV 2.7-1 / EN12079 |

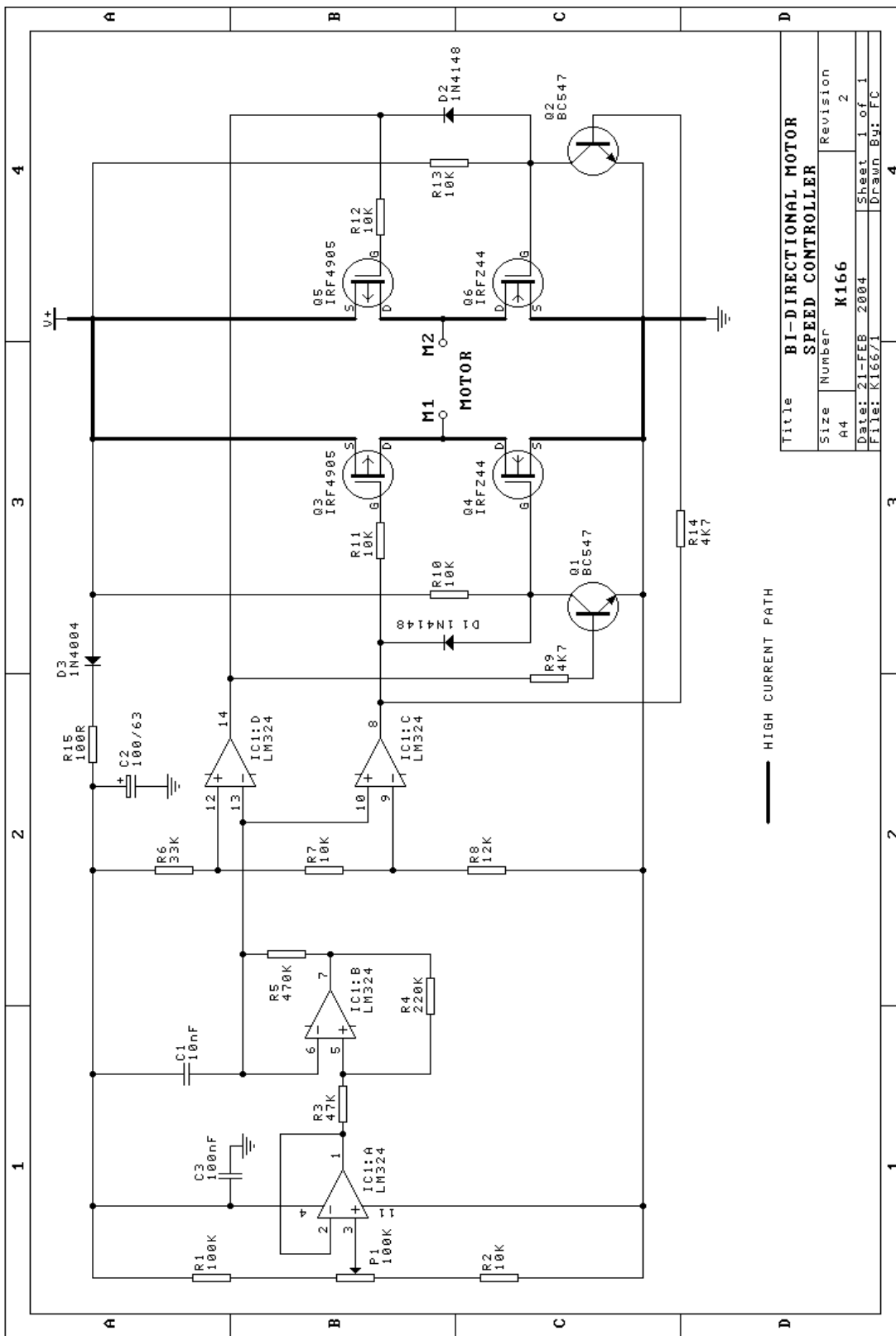## OBSERVATION CLASS ROV SYSTEM

ROV Type : Observation Class

Standard Depth Rating: 300 Meters, 16 Kg Payload

Dimension : 1000mm(L) x 600mm(W) x 500mm(H)

Propulsion System : 4 Vectored and 1 Vertical thruster

Lighting : Variable Intensity 150 Watts of Lighting

Control & Navigation : Auto Heading, Depth, Compass and Rate Gyro. Sonar Tracking System with Distributed Intelligence and Diagnostic Control System. Portable Surface Control System with Single Phase A/C Power Input - Auto Selecting Universal 100-270 VAC at 2.8 Kw.

Control Van Container : 10foot(L) x 8foot(W) x 8foot(H)
l4foot(L) x 8foot(W) x 8foot(H)

Standard Component : 5 Function Manipulators
Color Camera
Hand Control Unit

**SUBSEA EXPLORE SERVICES (M) SDN BHD** 692906-P
Lot 20, Jalan PJU 3/39, SME Bank Factory Complex, Sunway Damansara, 47810, Petaling Jaya, Selangor
Tel: +603-78858700 Fax: +603-78859700 Email: ses@subsearov.com Web: www.subsearov.com
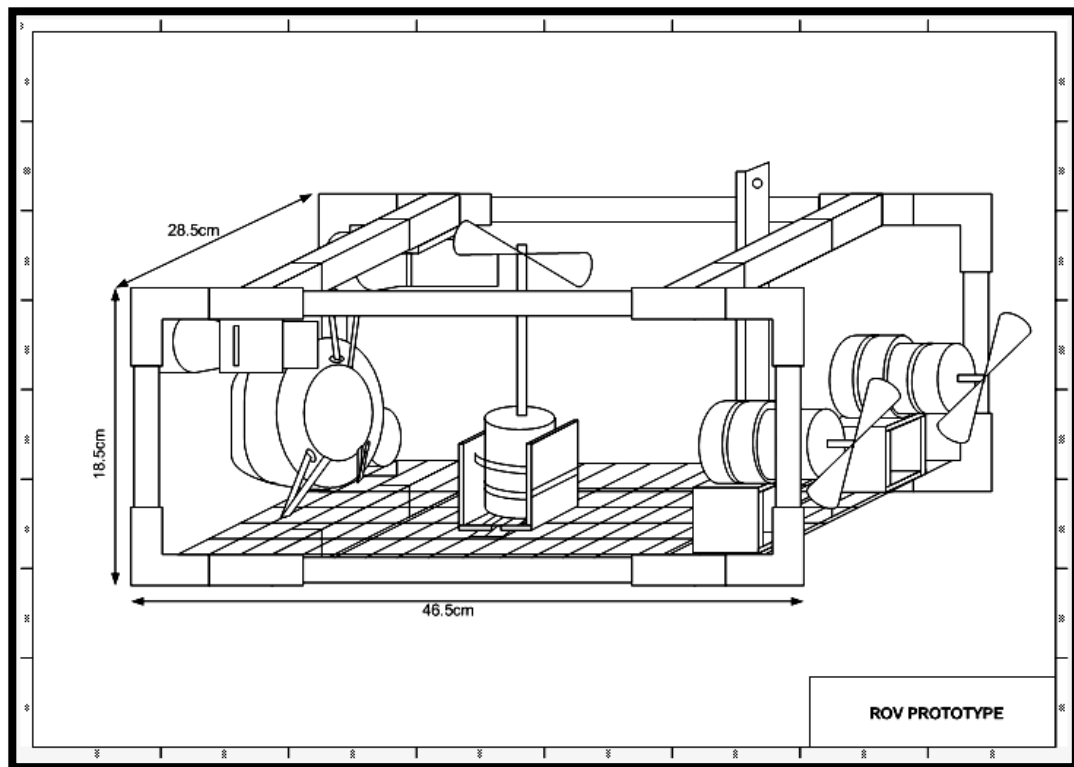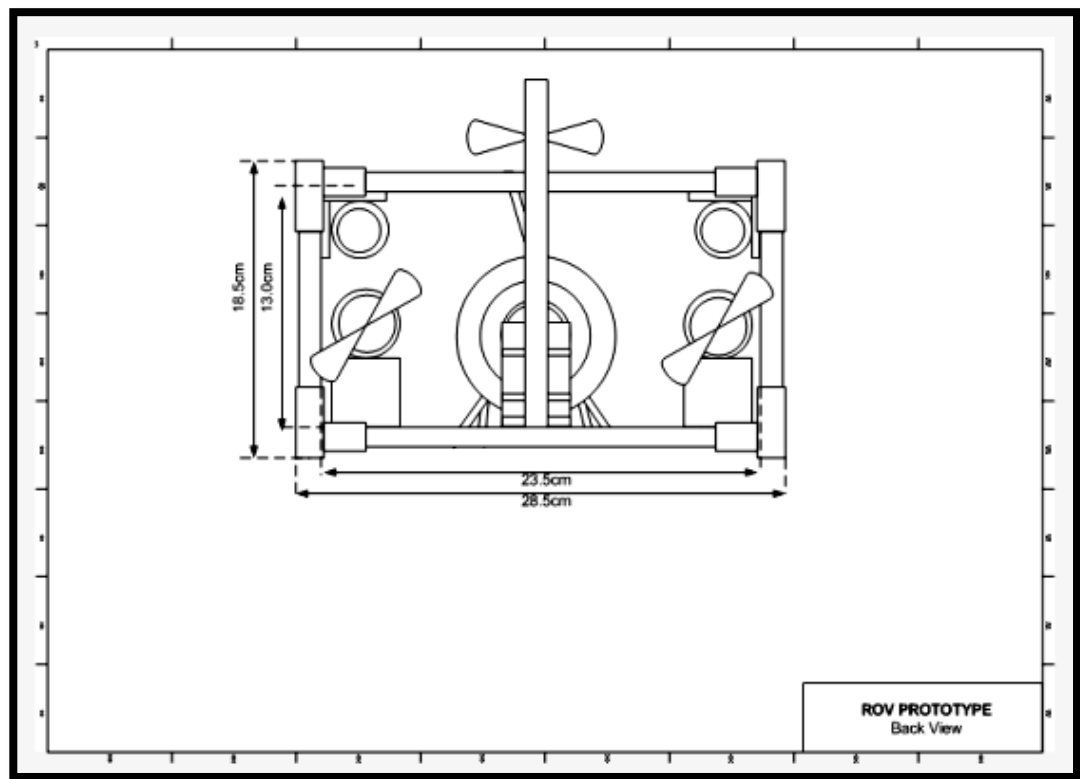
IMCA Member

## APPENDIX F: KIT 166. BIDIRECTIONAL DC MOTOR CONTROLLER

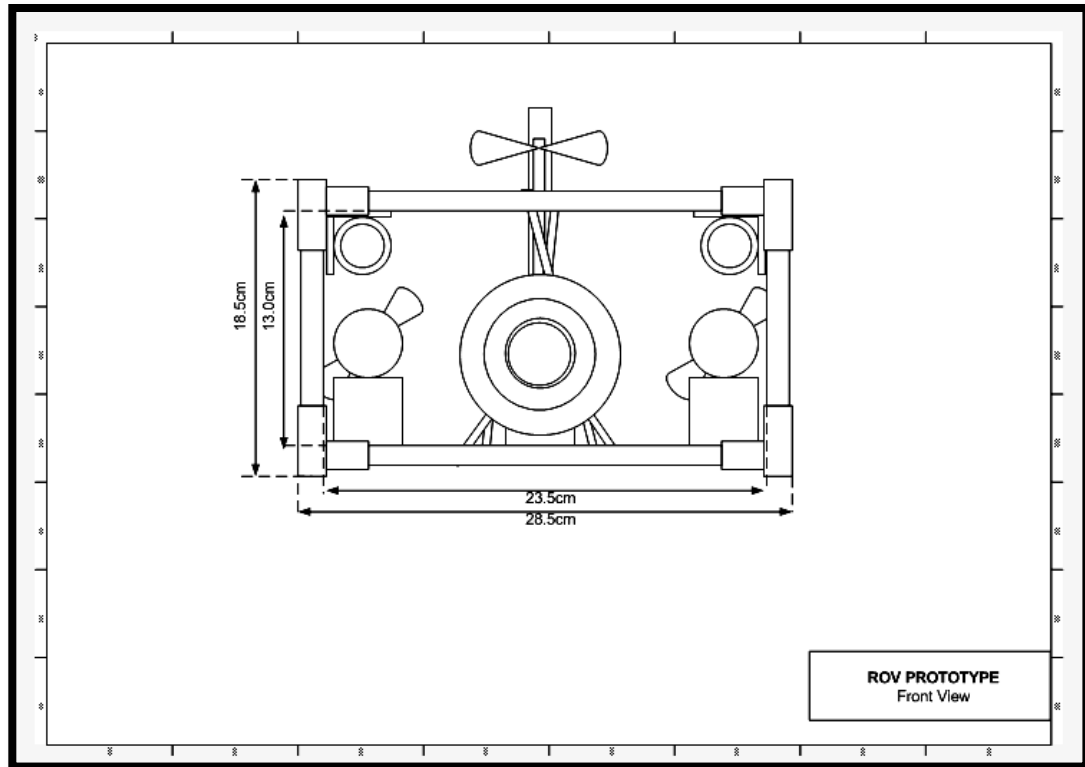# APPENDIX H: LIGHT DIMMER CIRCUIT
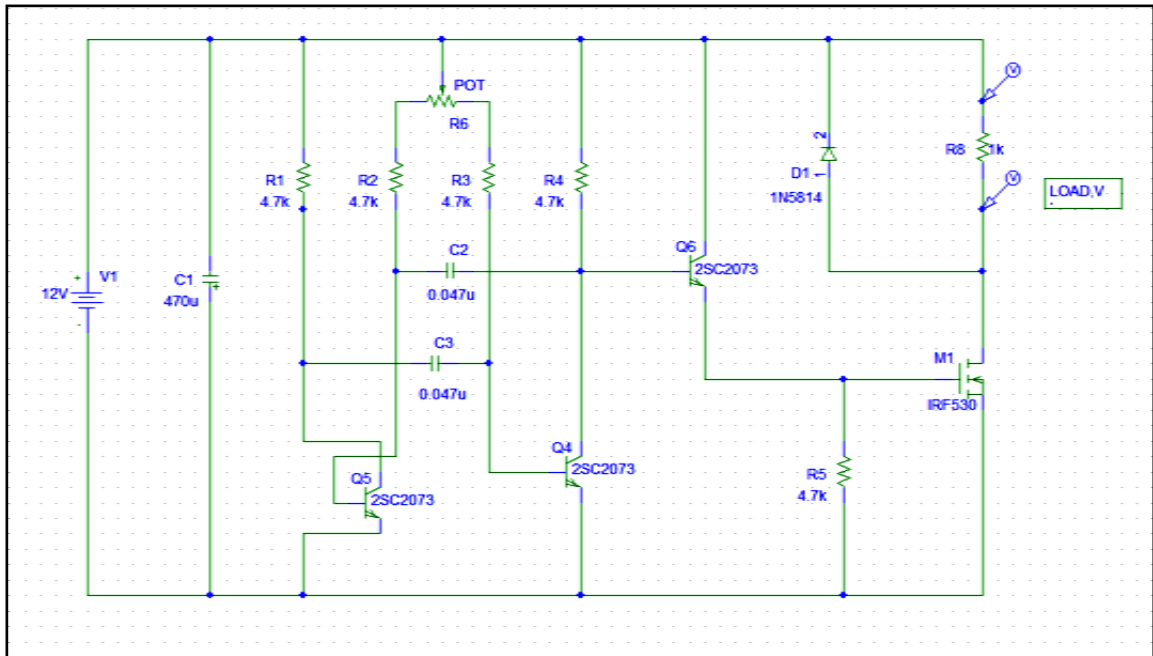


# APPENDIX I: PROTOTYPE SCHEMATIC DRAWING

**ROV PROTOTYPE**
Front View



**ROV PROTOTYPE**
Back View

**ROV PROTOTYPE**
Left Side View



**ROV PROTOTYPE**
Top View

51

# APPENDIX J: CCTV SPECIFICATIONS

## LIRDPHF36



**Features**
Plastic IR Dome Camera
SONY/SHARP Color CCD
IR LED: ¢5X24PCS ,IR Distance: 20M
Back Light Compensation(BLC)
Auto White Balance(AWB)
Lens: Board Lens 3.6mm/F2.0
Dimension : ¢94 x 69(H) mm

**Specifications**

| | LIRDPHF36 |
|---|---|
| **Model :** | *SonnyLux* |
| **Brand :** | |
| Image Sensor | 1/4"SHARP |
| Horizontal Resolution | 420 TV Line |
| Pixels | PAL:500(H)×582(V)  NTSC:510(H)×492(V) |
| TV System | PAL |
| IR Series Distance | ¢5 X 24PCS |
| Lens | Board Lens 3.6mm/F2.0(Optional) |
| Sync System | Internal |
| IR Status | Under 10 Lux By CDS |
| Usable Illumination | 0 Lux/F2.0 (LED ON) |
| IR Power On | CDS Auto Control |
| S/N Ratio | ≥48dB (AGC OFF) |
| Gamma Correction | 0.45 |
| Video Out | Composite Signal (1.0Vp-p, 75Ω) |
| Scanning System | PAL:625 Lines, 50 Field/Sec;NTSC:525 Lines, 60 Field/Sec |
| Electronic Shutter Time | Auto:PAL 1/50-1/100,000Sec;NTSC 1/60-1/100,000Sec |
| Operation  Temperature | -10℃ ~ +50℃ RH95% Max |
| Storage  Temperature | -20℃ ~ +60℃ RH95% Max |
| White Balance | Auto |
| Power Source | DC12V 250mA |
| | ¢94 x 69(H) m |