Remotely Operated Vehicle (R.O.V.) Prototype

by

Nurliyana Binti Muhammad Fadhil Choong

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
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Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
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Approved by,

(Dr Nursyarizal Mohd Nor)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2011

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.

NURLIYANA BINTI MUHAMMAD FADHIL CHOONG

ABSTRACT

This dissertation consists of five main parts; the introduction, literature review, methodology, result and discussion as well as conclusions. Topics on Remotely Operated Vehicle (R.O.V.) system and its functions are discussed in details in the literature section, explaining on what can be expanded and applied in this project. The work class R.O.V. is the most common system in the R.O.V. business, being also the biggest in size and having the most complicated management system compared to the other four systems; eye-ball class, observation class, trekker class and wireless class. Thus, a scaled down version of the R.O.V. is appropriate to expand the scope of R.O.V.'s functions in education, underwater security and the fishing industry. This mini R.O.V. prototype is designed to be portable, easy-to-handle and small in size with the target maximum depth of 3 m. The R.O.V. is divided into 5 main parts; propulsion, lighting, camera, frame and buoyancy. The methodology for this project began with the itemization, calculation of overall power usage and followed by the design, building, testing and modification of each of the main parts. The significant of this mini R.O.V. prototype project is that it can help develop the R.O.V. business to increase its functions and marketability into the education world for children's exploration, underwater security in the shipping industry and also benefiting the fishing industry to observe the fishes' population. In this two semester duration of Final Year Project, the prototype is completed with a simple propulsion system; using a 12 VDC high-torque motor and propeller with bidirectional motor controller circuit, the lighting system; using a 12 VDC bulb with a light dimmer and a CCTV camera being installed in the prototype.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Remotely Operated Vehicle (R.O.V.) is a tethered underwater robot, common for underwater jobs. The R.O.V. business is growing worldwide, yet there are very few R.O.V. manufacturers especially in Malaysia. A R.O.V. system consists of its frame, buoyancy, control system, propulsion system, deployment, tether management, and maintenance. A R.O.V.'s tasks can expand from assisting oil and gas jobs to search and rescue as well as underwater exploration. There are 5 classes of the R.O.V. system [1]:

- **Class I:** Eye-Ball Class, with depth rating less than 100 m.
- **Class II:** Observation Class, with depth rating of less than 1000 m.
- **Class III:** Work Class, with depth rating between 1000-3000 m.
- **Class IV:** Trekker Class, with depth rating the same as work class.
- **Class V:** Wireless (AUV) Class, with depth rating of less than 500 m.

1.2 Problem Statement

The most in demand and most common R.O.V. system in the R.O.V. business is the Class III: Work Class R.O.V. A Work Class system is the biggest in size compared to the other classes. Class I and II R.O.V. system are seldom overlooked for their small size and the benefits they can provide. Most of the systems available are huge, where the control, deployment and the tether management is complicated for a small simple task, involving huge spaces as the system usually includes a 20 ft container and a launching and recovery system (L.A.R.S).

Due to that, a scaled down version of the R.O.V. seems appropriate for this project. A small size version R.O.V. can be expanded in terms of its functions. It will be useful especially in terms of education. Children can use a R.O.V. prototype to do exploration in rivers or lakes. As for the security industry, a small R.O.V. can provide underwater closed-circuit television (CCTV) security video for those involved with the shipping business. This will also be beneficial to the fishing industry, where fishermen can use a portable R.O.V. to check the intensity of fish population at their fishing area. Taking all these expanded functions of R.O.V., the prototype for this Final Year Project will be designed as portable, easy-to-handle and small in size, easy enough for the user to carry around anywhere and do simple tasks.

1.3 Objectives

The objectives of this final year project are:

- To study and analyse the R.O.V. designs available and see what can be improvised.
- To design the electrical power system for a portable R.O.V. system.
- To design and build a portable, easy-to-handle R.O.V. system with a maximum depth rating of 3 m.
- To contribute and help the R.O.V. business in the Malaysian market.

1.4 Scope of Study

The scope of study will be matters involved in the structure and design of the whole portable R.O.V. system. This project also involves designing and fabricating the overall power distribution of the system, the navigation and the control system as well as the visual and light control system.

CHAPTER 2

LITERATURE REVIEW

2.1 Subsea Explore Services (M) Sdn Bhd

Most of the project's studies did on R.O.V. systems are based on companies in the R.O.V. business such as Subsea Explore Services (M) Sdn Bhd and the various articles on R.O.V. in the internet. Subsea Explore Services (M) Sdn Bhd, which pioneered in the year 2005, is the only company in Malaysia which manufactures Malaysia's very own R.O.V. of Work Class, Class III [2]. The company mainly focuses on manufacturing work class R.O.V., providing R.O.V. services as well as providing in-house training for R.O.V. Pilot & Technician.

Subsea Explore Services (M) Sdn Bhd's first product of a Work Class R.O.V. system is the SATRIA 101 (Figure 1), which is currently attending a job, assisting the oil and gas industry in the Caspian Sea, Iran. The datasheet of SATRIA 101 can be found in Appendix C: SATRIA 101 Datasheet. The company's current project is their second Work Class system product, named SATRIA 102 (Figure 2). SATRIA 102, which is officiated by the Prime Minister, Dato Seri Najib Tun Razak himself during the SME Bank Innovation Showcase 2010 (SMIDEX 2010), is the improvised version of SATRIA 101 and is due to be fully operating in the year 2011. The specifications of SATRIA 102 can be found in Appendix D: SATRIA 102 Datasheet.

Figure 1: SATRIA 101 and R.O.V. Personnel

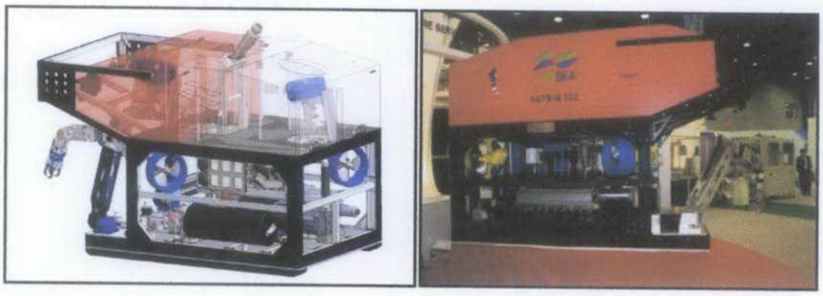


Figure 2: SATRIA 102

Besides work class R.O.V., Subsea Explore Services (M) Sdn Bhd also owns two sets of Class II, Observation Class R.O.V., FALCON system to assist various clients' demands. Figure 3 shows the FALCON system. The datasheet of FALCON detailing the specifications is as in Appendix E: FALCON Datasheet.

Figure 3: FALCON system

2.2 Class III, Work Class Remotely Operated Vehicle System

The whole system of a Class III: Work class R.O.V. system consists of five parts; the launch and recovery system (LARS), the vehicle, the hydraulic winch, a 20 ft container for a control van and a container for workshop as in Figure 4. The LARS is the system that controls the vehicle's deployment in the sea. Only the vehicle will be submersible underwater while the other parts will be on board a vessel. The vehicle will be controlled by the certified R.O.V. Pilot and Personnel in the control van. The hydraulic winch is where the umbilical cord are winded and deployed according to the vehicle's current depth underwater. The workshop container is just a basic small workshop so that easy maintenance and repairing job can be done. A typical Class III R.O.V. works at 100 HP rating with a maximum underwater depth of 1500 m.

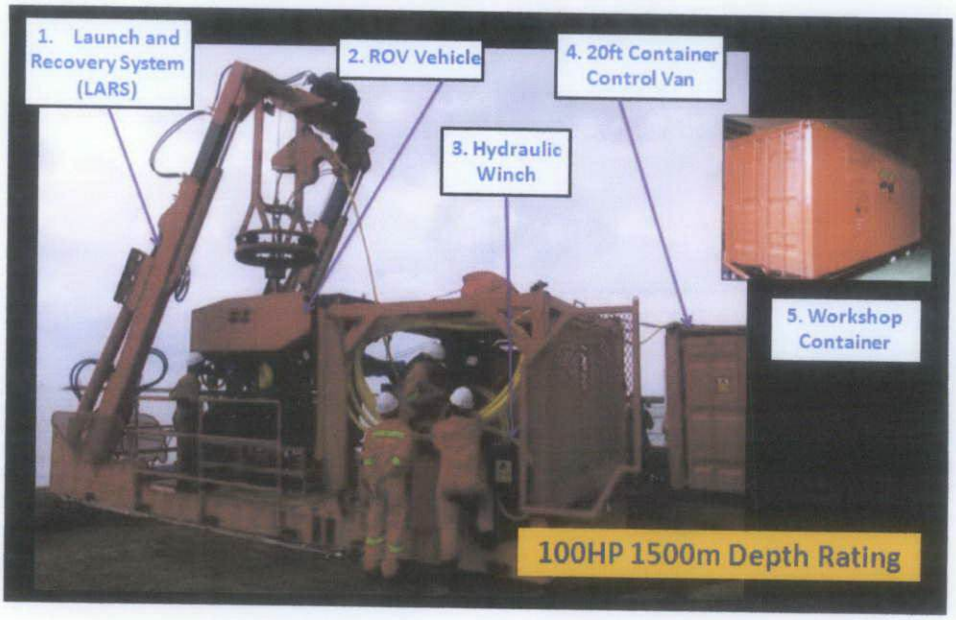


Figure 4: Work Class Remotely Operated Vehicle system

The services provided from R.O.V. are mostly to support the oil and gas industry in terms of assisting in construction, drilling, inspection and maintenance of the pipeline and platform. Besides that R.O.V. is also used for search and rescue missions or for underwater exploration.

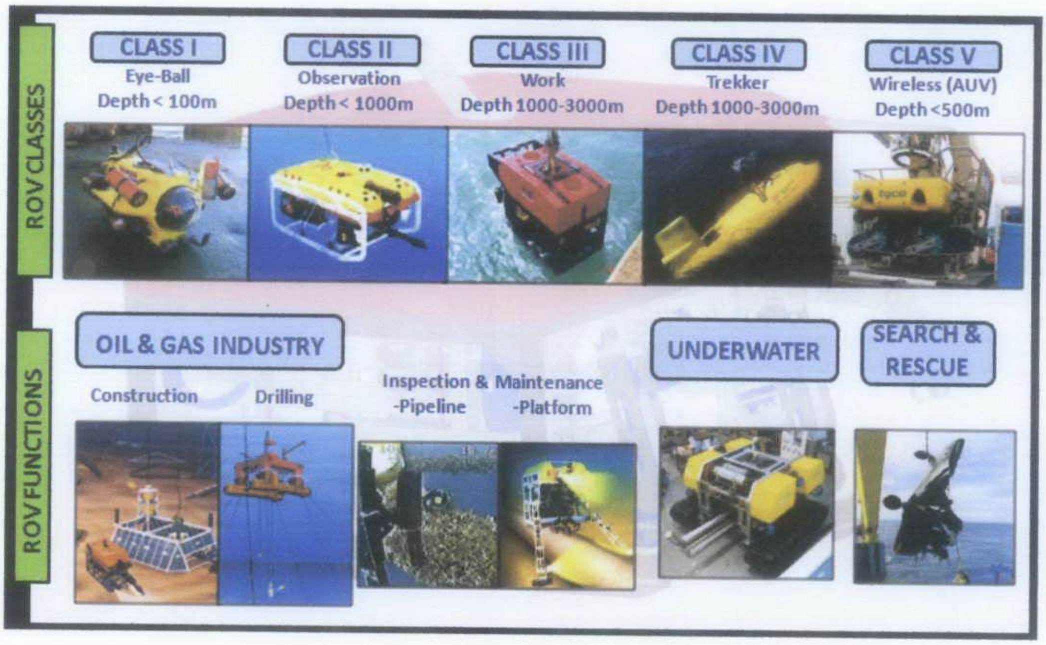


Figure 5: Remotely Operated Vehicle Classes and Functions

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

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

In complying with the objectives that have been set, the whole process of this project was constructed as the flow chart in Figure 6. A list of equipments and materials needed for the R.O.V. prototype was firstly done to know the estimation for this project's budget and so that the itemization can be started. The main parts that have been listed are; the thrusters with its motors, power supply, the lighting system, the camera, the control screen, umbilical cord, buoyancy and control system.

In order to know the DC Power Supply that is needed to be used and to determine the power distribution of the whole system, the total of power rating of every equipment used was calculated. The next step would be designing the light dimmer circuit followed 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 R.O.V. and buoyancy structure designs drawings and layouts needs to be done.

Lastly, after completing all the previous designs, the whole prototype system can be built and tested. Any improvements and adjustments can be done once the finished prototype is built and tested. The project's Gantt chart is showed in Appendix A: Project's Gantt Chart (FYP 1) and Appendix B: Project's Gantt Chart (FYP 2).

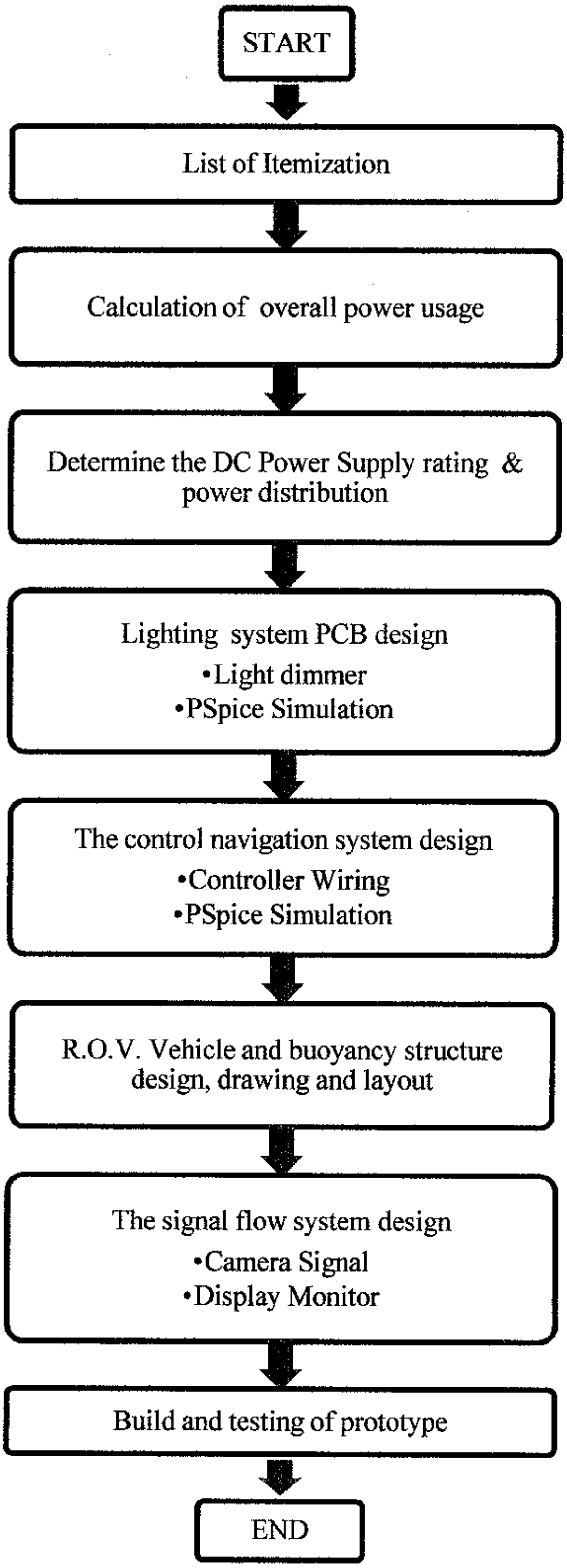


Figure 6: Procedure Identification

3.2 Tools and Software

The list of tools and equipments that is used for this R.O.V. prototype is listed as below:

- 12 V Power Supply
- 12 V Torchlight
- 12 V DC Motor
- 12 V CCTV Camera
- PVC Pipes
- PTFE Tape
- Electrical Tape
- Water Resistant Glue
- Soldering Kit

As for the software used, Microsoft Visio is used to do the related drawings of this project and PSpice software for circuit simulation.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Data Gathering and Analysis

Two basic equipments that are used for this project's R.O.V. prototype are the camera and the lights in line with the R.O.V. class of Class 1: the Eye-Ball class. The equipments along with its power ratings are shown as in Figure 7.

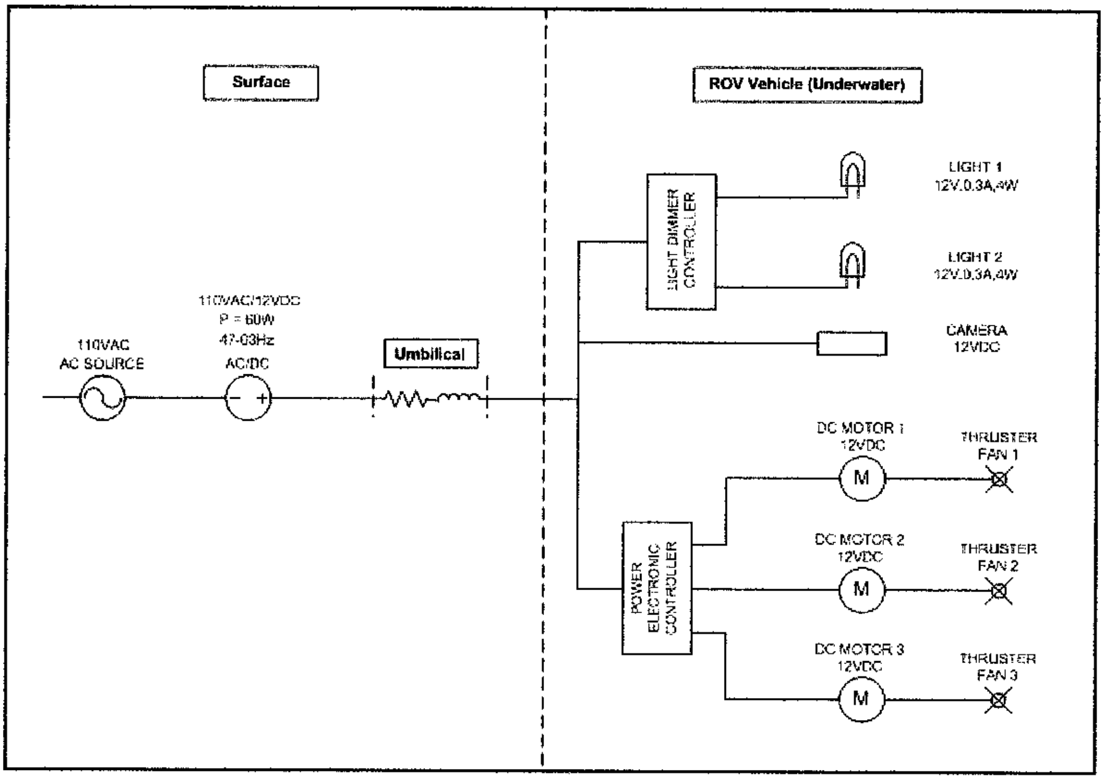


Figure 7: Prototype's Overall Power Rating

There are six loads with the rating of 4 W each. This means the minimum total of power needed for this system is

$$6 \text{ Loads} \times 4 \text{ W} = 32 \text{ W} \tag{1}$$

Therefore, the minimum required total power of supply is 40 W.

4.1.1 Propulsion

The propulsion of the prototype's vehicle is what makes it mobile underwater, moving along the *x*-, *y*- and *z*-axis. The six main directions of movement for the R.O.V. are forward, reverse, up (surfacing), down (submerging), left and right.

For the surfacing and submerging of the system's vehicle, either the submarine's method of using a ballast tank or using DC motor thrusters can be applied for the prototype. In the application of submarine's 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 [3]. As the submarine dives, 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 8 shows how the ballast tank and the air valve work for surfacing and submerging the submarine.

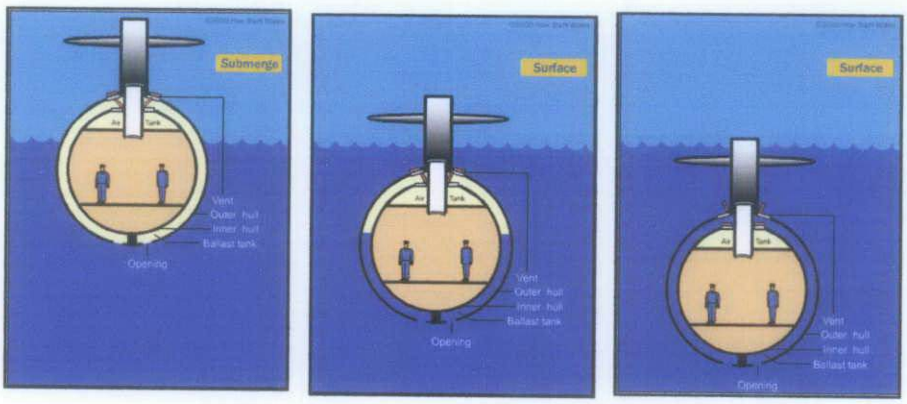


Figure 8: How the ballast tank work in submarines [3]

To apply this method, a winch-action piston type of ballast can be assembled to control the surfacing and submerging of the vehicle [4]. The schematic diagram of the ballast system is in Figure 9.

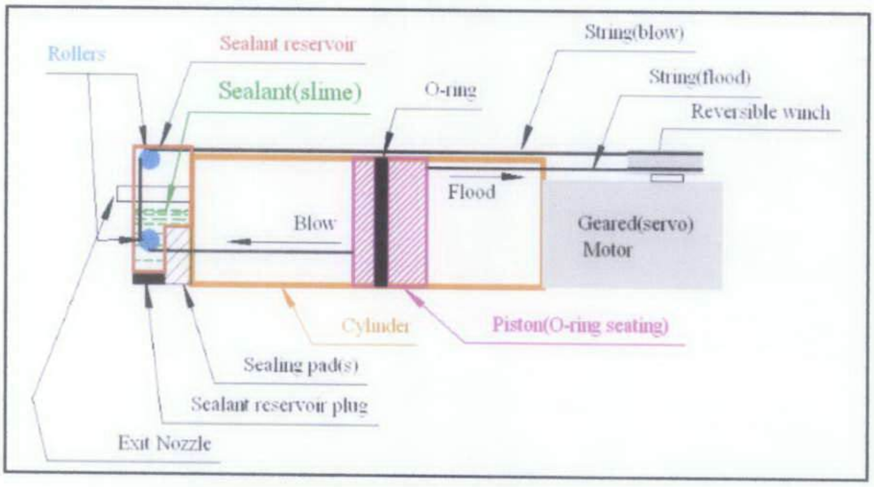


Figure 9: Winch-action ballast piston type [4]

Besides using the ballast tank method, DC motor thrusters can also be used. This method is easier and more applicable for the prototype in accordance to its small size. With DC motors, speed can be controlled without any impact on the power supply quality. Three thrusters are enough for a small sized R.O.V. prototype; one 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. The basic idea of the DC motor thrusters is as in Figure 10.

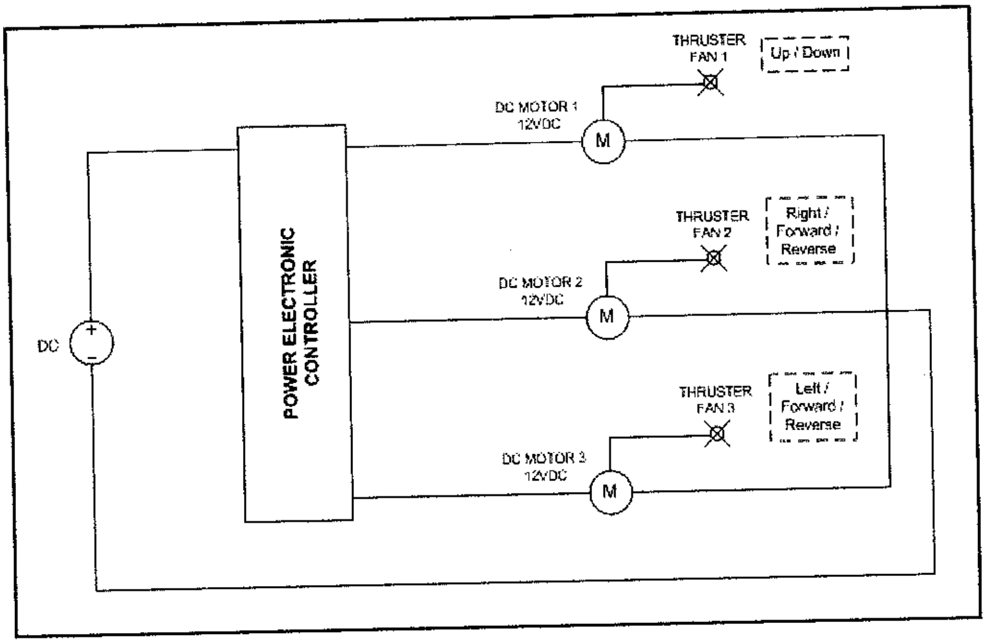


Figure 10: DC Motor Thrusters

4.1.2 Lighting

Lights are needed for the prototype so that the visuals recorded can be seen underwater. A 12-V light can be used and is easily obtained. A light dimmer circuit can also be installed to control the brightness of the light according to the depth the vehicle goes, as it usually is darker as you go deeper underwater. Light dimmer's concept is to control the voltage of the light and it regulates the voltage to the source they are connected to. This regulation of voltage increases or decreases the light intensity. As for the colour of the light, a yellow light is better than a white light as white light has a higher risk to be dispersed underwater, increasing the risk for disrupting the visuals that needs to be recorded by the prototype.

4.1.3 Camera

A web camera or a CCTV security camera will work for the prototype. The camera can act as the eye for the prototype and the image captured can be recorded.

4.1.4 Frame

The frame of Remotely Operated Vehicle prototype needs to be light but versatile. Carbon fibre mould would be the best material as it is very light, durable and rugged. However, due to the constrict budget, PVC pipe, common in hardware will work just as fine as the prototype's body frame. Specific positions for the camera and the lights are determined and the suitable shape and structure is designed around the equipments.

4.1.5 Buoyancy

Buoyancy is the weight of displaced fluid when an object is in the fluid [5]. 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 11. The boat in Figure 11 has buoyancy when the water's weight is displaced by the boat being in the water. 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.

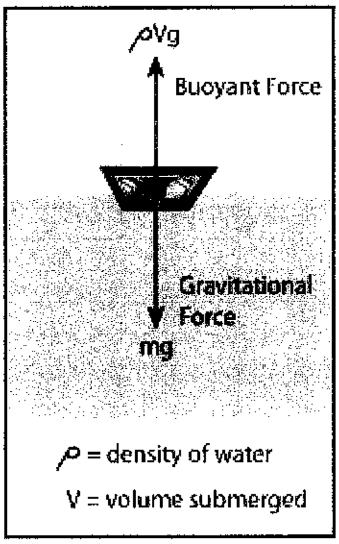


Figure 11: Buoyancy

A submarine or a ship 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.

Therefore, in order for this project's vehicle 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 [6].

Let,

WS = dry weight of vehicle (empty ballast tank)

WWD = weight of water displaced by vehicle

WB = weight of ballast

Neutral buoyancy is when:

$$WS + WB = WWD \qquad (2)$$

Therefore, the ballast weight is,

$$WB = WWD - WS \qquad (3)$$

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

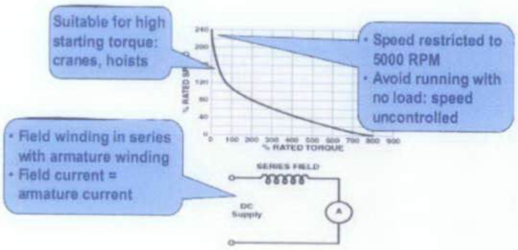
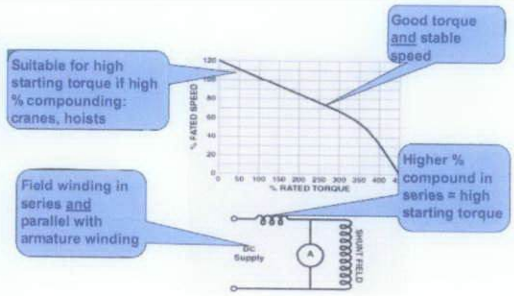
4.2 Results and Discussion

4.2.1 Propulsion

With the R.O.V. vehicle being close to neutral buoyancy, a lot of power is not needed for very long time, only long enough to overcome inertia. Then, only a little power is needed to keep the vehicle moving at a constant depth. For a propeller (thrusters fan) with large diameter with a fairly coarse pitch, a slower motor with more torque is needed [7]. The torque is required to spin the propeller because it is moving a fairly large amount of water on each revolution, at a slow speed. To move the same amount of water with a smaller diameter propeller with the same pitch, less torque, but more speed is required to turn the propeller fast enough.

There are two types of DC motors that are aligned with the high torque requirements for the prototype; the Self-excited DC Series Motor and the DC Compound Motor [8]. These two types of DC motors are as shown in Table 1.

Table 1: DC Motors [8]

Self-excited DC Series Motor	DC Compound Motor
	

In order to create a good propulsion system for the prototype by using the DC motor thrusters, either a 12-VDC motor with a strong propeller blade like the ones used in remote controlled toy boats can be assembled or modified version of bilge pumps like the one used in fish tanks can be used. An example of bilge pump thrusters that can be used is shown in Figure 12.

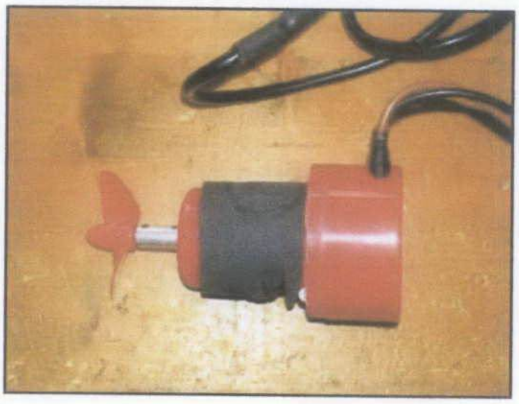


Figure 12: Bilge pump thruster

To save space and electronic components, it is better to use a bidirectional DC motor controller, which means it can control the direction of the motor spinning as well as to control its speed. There are three ways for bidirectional DC motor controller; using voltage regulators and MOSFETs, using a relay control circuit or by using a Double Pole Double Throw (DPDT) switch motor controller.

4.2.1.1 Bidirectional Motor Control Circuit using Voltage Regulators and MOSFETs

The motor controller circuit is as in Figure 13.

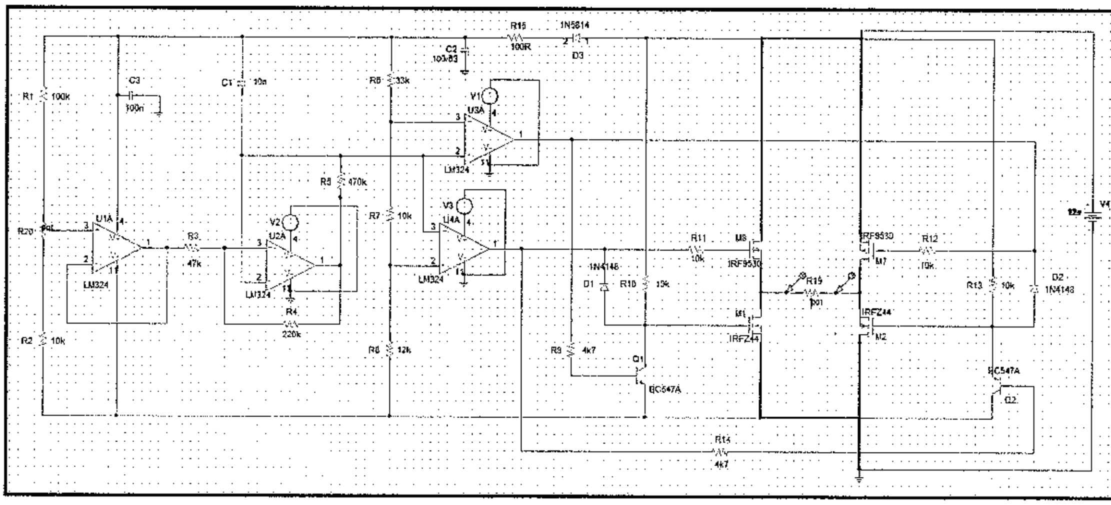


Figure 13: Bidirectional Motor Control Circuit using Voltage Regulators and MOSFETs

Switches are usually used to change the direction of rotation of a DC motor. By changing the applied voltage polarity, the motor can spin the other way. However this has the disadvantage that a Double Pole Double Throw (DPDT) switch has to be added to change the polarity of the applied voltage. It is not a good idea to suddenly reverse the voltage on a DC motor while it is spinning as this can cause a current surge that can burn out the speed controller and cause mechanical stress. The circuit in Figure 13 overcomes both these problems. The same circuit in Figure 13 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 one direction causes the motor to start spinning. Turning the pot in the other direction causes the motor to spin in the opposite direction. The center position on the pot is OFF, forcing the motor to slow and stop before changing direction [9].

Referring to Appendix F, when MOSFET Q3 and Q6 are ON, the current flows through the motor and it spins in one direction. When Q4 and Q5 are ON the current flow is reversed and the motor spins in the opposite direction. Opamps IC1:C and IC1:D control which MOSFETs are turned on and are configured as voltage comparators. The reference voltage that each triggers at is derived from the resistor voltage divider of R6, R7 and R8. IC1:D is triggered by a voltage greater than its reference (connected to the '+' input) whereas IC1:C is triggered by a voltage less than its reference (connected to the '-' input).

Opamp IC1:B, the triangle wave generator provides the trigger signal for the voltage comparators. It is impossible 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 around 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 causes 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 [9].

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 are 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 [9].

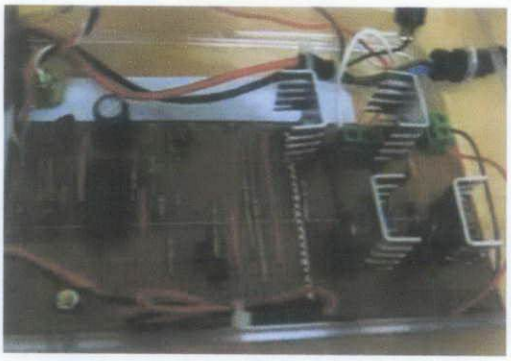


Figure 14: Prototype's Bidirectional Motor Control Circuit

4.2.1.2 DC Motor Reversing Relay Circuit

Another way to control the DC motor propulsion is by setting the direction of the two motors at the back and by using a DC motor reversing circuit for the vertical DC motor as in Figure 15. This circuit uses relay to control the up and down action of the R.O.V. prototype but the motor cannot be switched from the UP to DOWN button unless the STOP switch is pressed first.

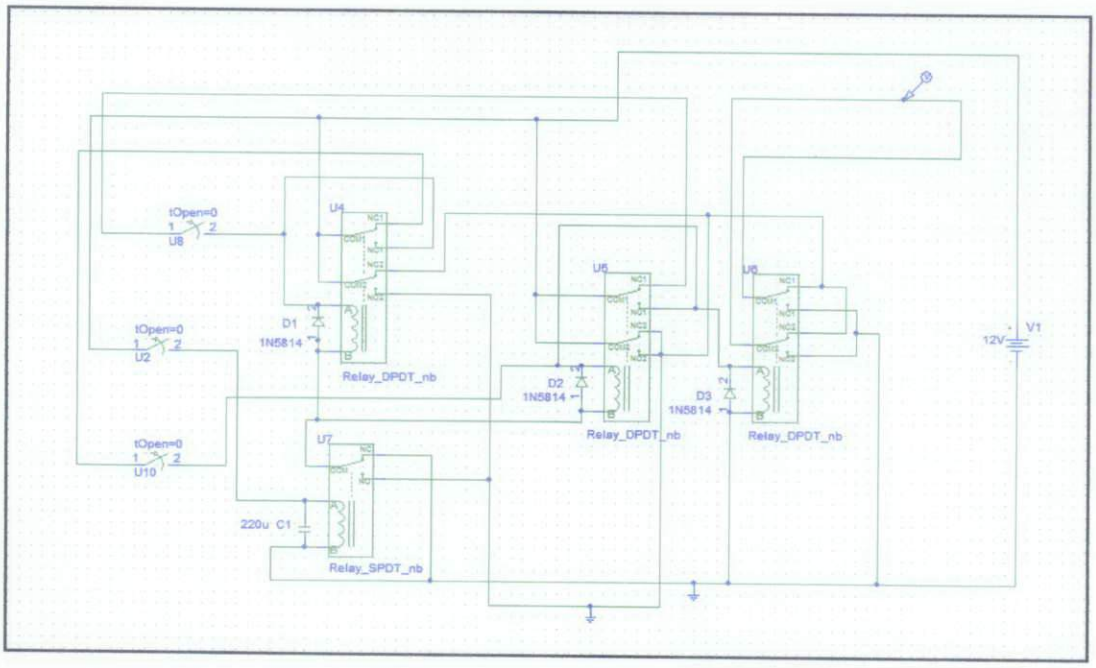


Figure 15: DC Motor Reversing Relay Circuit

Assuming the motor is not running and that all relays are unenergized, when the UP button is pressed, a positive 12VDC power supply is applied via the normally closed (NC) contacts of U5-1 to the coil of relay U4 (refer to Appendix G: DC Motor Reversing Relay Circuit). This will operate as the return path via the NC contacts of U7-1. Relay U4 will operate. Contacts of U4-1 maintain power to the relay even though the UP button is released. Contacts of U4-2 apply power to motor which will run continuously in one direction. If now the DOWN button is pressed, nothing happens because the positive supply for the switch is fed via the NC contact U4-1, which is now open because relay U4 is energized.

To stop the motor, the STOP button is pressed, Relay U7 operates and its contact U7-1 breaks the power to relays U4 and U5. If the DOWN switch is pressed and released, relay U5 operates via NC contact U4-1 and NC contact of U7-1. Contact U5-1 closes and maintains power so that the relay is now latched, even when the DOWN switch is opened. Relay U6 will also be energized and latched. Contact U5-2 applies power to the motor but as contact U6-1 and U6-2 have changed position, the motor will now run continuously in the opposite direction [14].

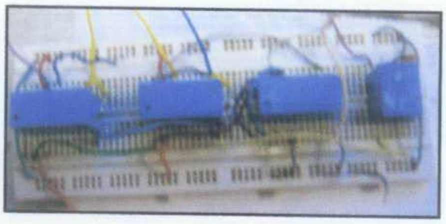


Figure 16: Prototype's DC Motor Reversing Relay Circuit

4.2.1.3 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 17 [15].

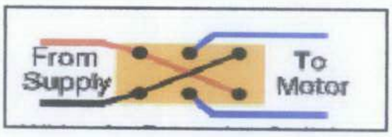


Figure 17: DPDT Switch Terminal Connection [15]

4.2.2 Lighting

For the lights, the tops of normal flash lights can be used and the bulbs can be replaced with 12 volt bulbs. As for the light dimmer circuit, the following circuit in Figure 18 can be used [10]. The circuit in Figure 18 can also be found in Appendix H: Light Dimmer Circuit.

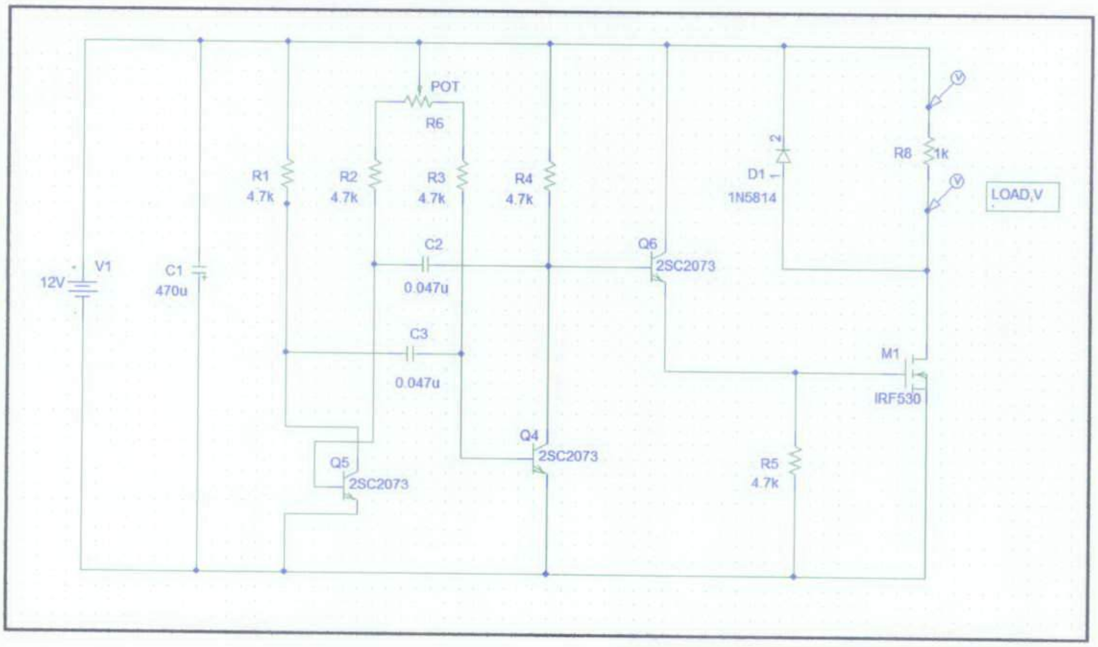


Figure 18: Light Dimmer Circuit

This 12 volt / 2 amp light dimmer circuit controls the brightness of light bulbs using pulse width modulation (PWM) to control the load's power. Referring to the graph in Figure 19, the ratio T_{on}/T ratio can be changed by adjusting the potentiometer, thus, determining the power delivered to the load. The advantages of this circuit is that the switching transistor dissipates very little amount of heat, thus it is higher in efficiency. There is also a wide control range (0-100%) besides having controllability of high current loads [10].

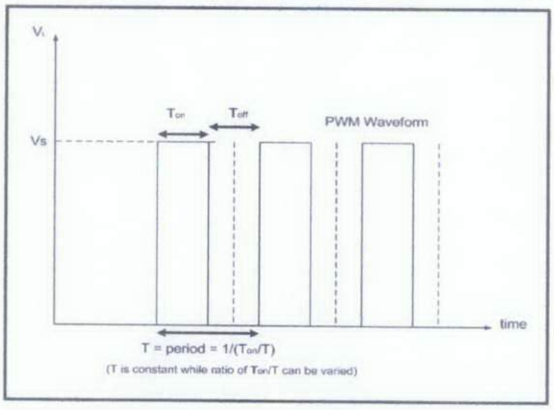


Figure 19: PWM Waveform of V_L versus time graph [10]

Figure 20 shows the light dimmer test while Figure 21 shows the light dimmer test for the prototype, showing the different brightness of the bulb as the potentiometer is turned. Figure 22 shows the actual circuit used for the prototype.

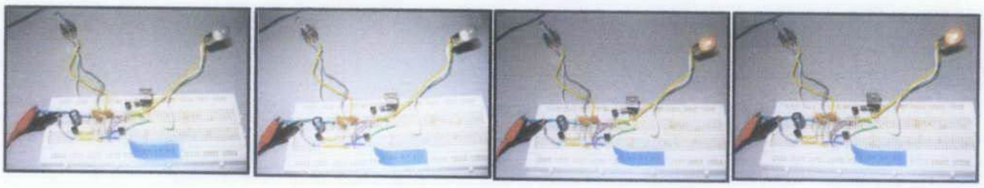


Figure 20: Light Dimmer Test

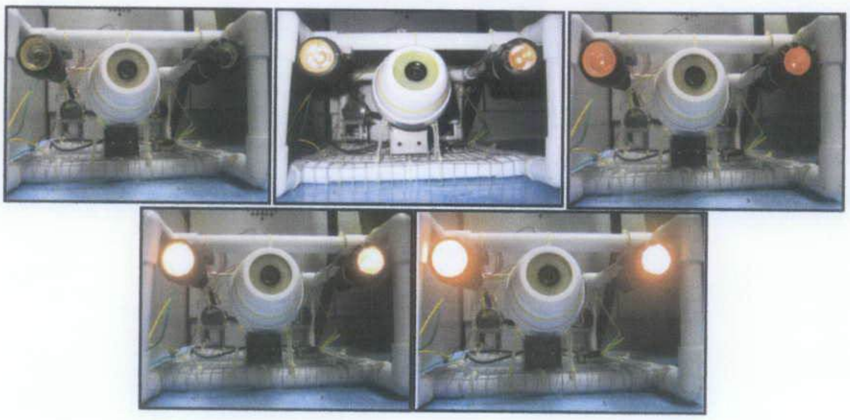


Figure 21: Prototype's Light Dimmer Test

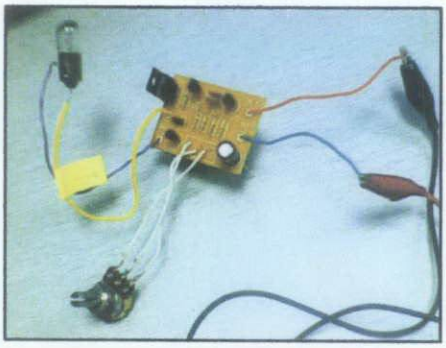


Figure 22: Light Dimmer Circuit for Prototype

The 12 VDC light bulbs are attached to torchlight's body which is then sealed with glue gun and heat shrink. Wet test as in Figure 23 was done to ensure that the light is waterproof and is operational underwater.

Figure 23: Prototype's Light Wet Test

4.2.3 Camera

Figure 24 shows the closed-circuit television (CCTV) security camera that will be used for the prototype. It is a CCD coloured video camera rated at 12 VDC and 0.3 A. CCD stands for "Charged Coupled Device" and they are sensors that are used in digital cameras and video cameras to record still and moving images [11]. 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 differently underwater as the water wave propagation differs than air wave propagation. Infrared in underwater will end up boiling the water instead.

Figure 24: Prototype's Camera

The CCTV camera is attached to a position in the prototype as in Figure 25.

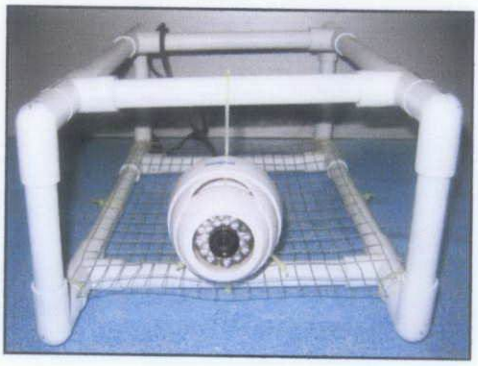


Figure 25: Camera's Position in the Prototype

4.2.4 Frame

The frame is built by using 1/2 inch PVC pipes, PVC elbows, PVC tee- joint, PTFE tape, wire net and cable tie. Figure 26 and Figure 27 shows the schematic drawing of the prototype's frame while Figure 28 shows the actual prototype's body.

Figure 29 shows the materials that were used to build the prototype's frame which includes PVC pipes, cable ties and PTFE tape.

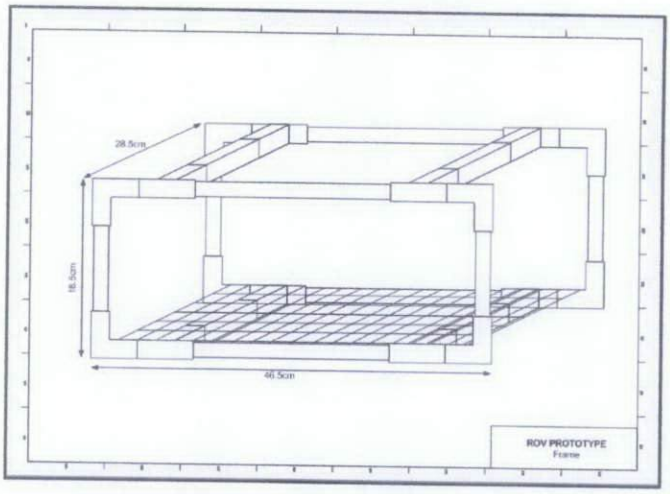


Figure 26: Prototype's Frame Schematic Drawing

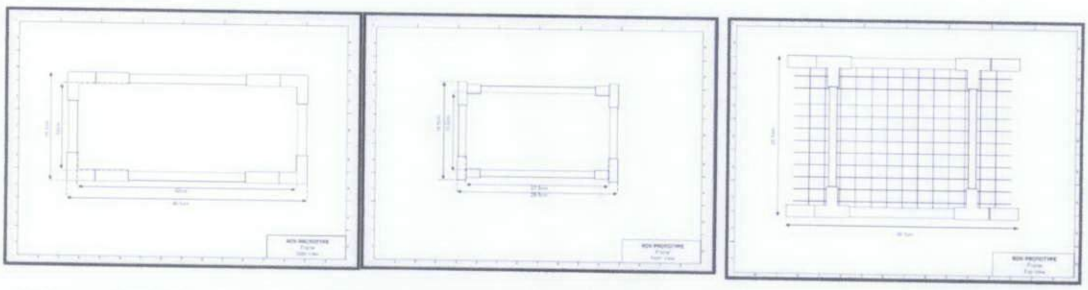


Figure 27: Prototype's Frame Schematic Drawing; Side, Front and Top View

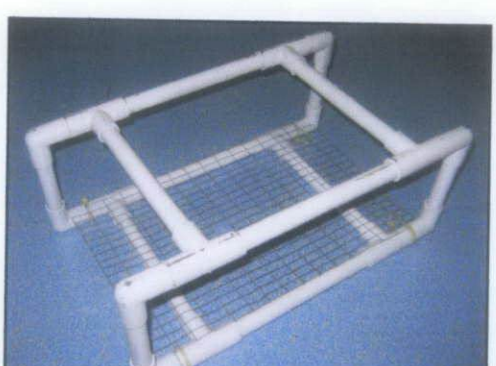


Figure 28: Prototype's Body Frame

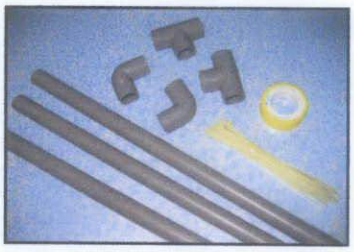


Figure 29: Prototype's Body Frame Materials

4.2.5 Prototype Assembly

The prototype's schematic drawing is as the shown in Figure 30 and Figure 31. The drawings can also be found in Appendix I: Prototype Schematic Drawing.

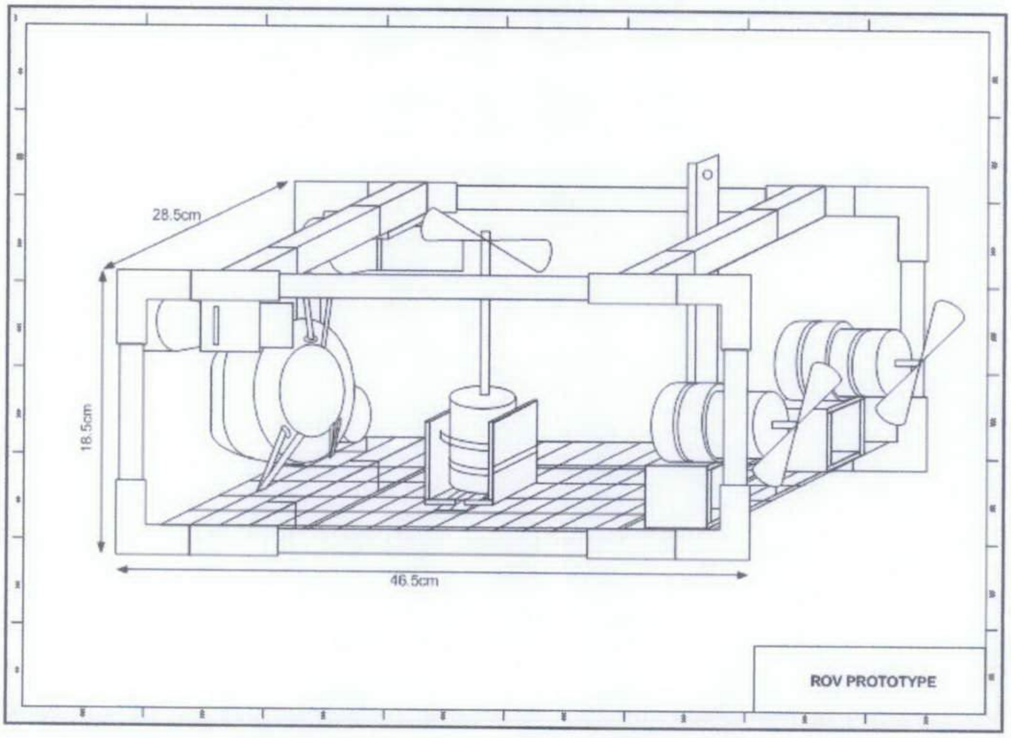


Figure 30: Prototype Schematic Drawing

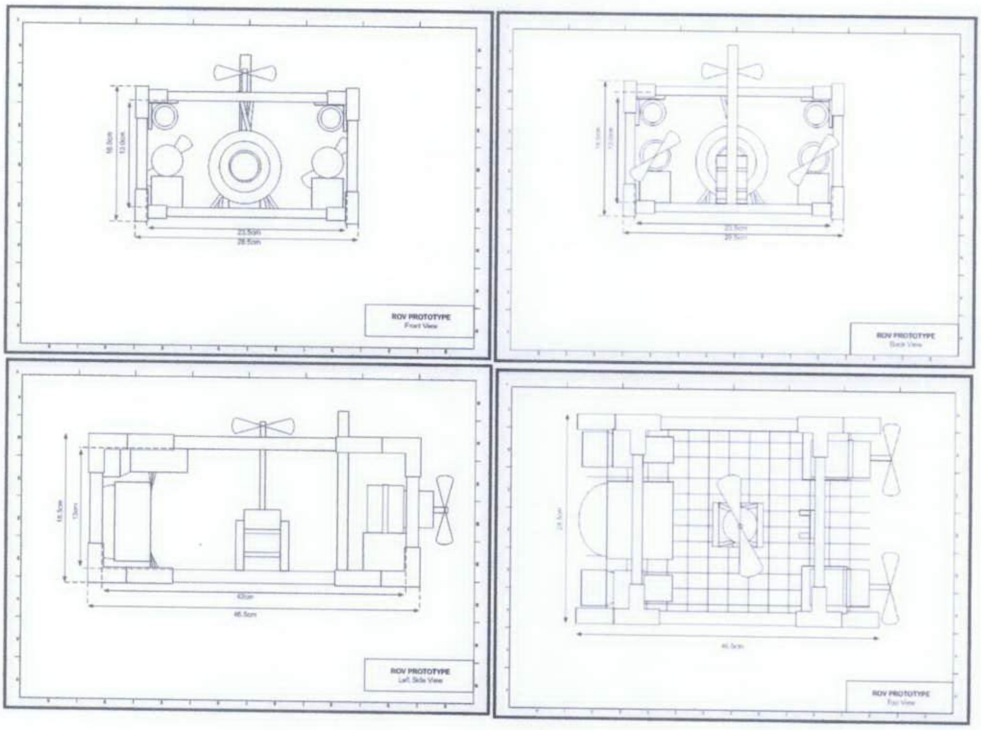


Figure 31: Prototype Schematic Drawing; Front, Back, Side and Top View

Figure 32 and Figure 33 shows the actual prototype with the camera, lights and motor attached.

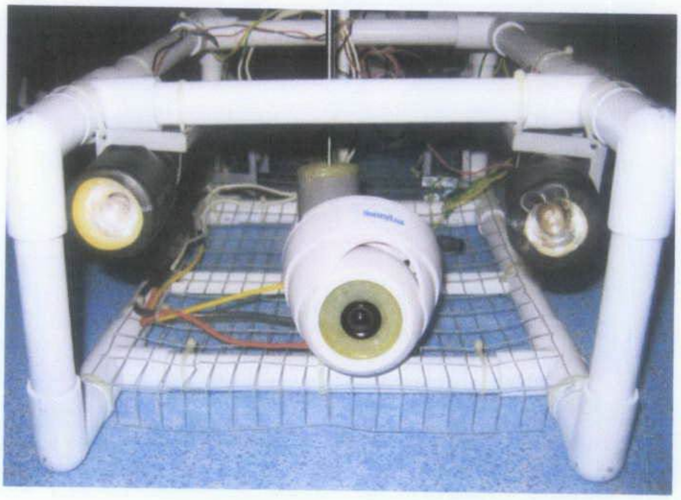


Figure 32: Prototype Front View

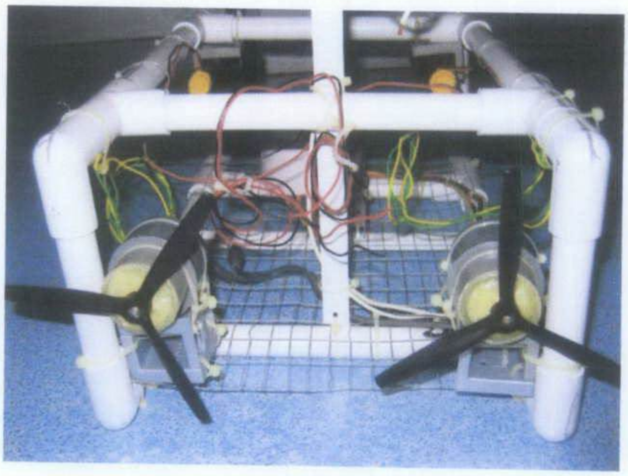


Figure 33: Prototype Back View

4.2.6 Controller

The prototype's controller is as in Figure 34. 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.

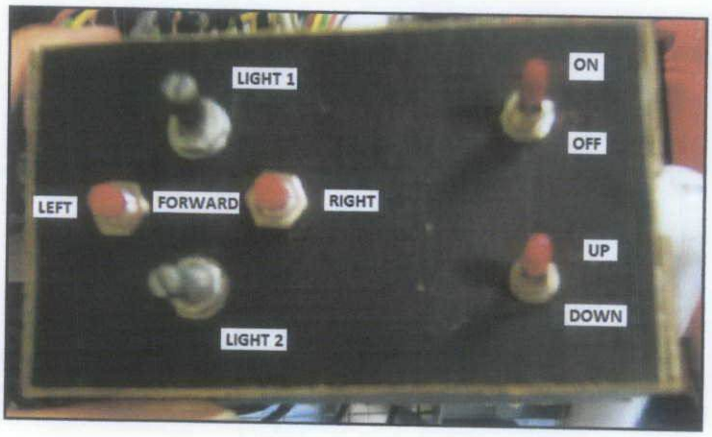


Figure 34: Prototype's Controller

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In conclusion, this project of Remotely Operated Vehicle (R.O.V.) can be scaled down into a smaller size and expand its scope of function into the education, security and fishing industry. For the propulsion system, bilge pumps made of DC motor and propeller is used. As for the lightings, 12-VDC bulb with a light dimmer can be applied. A CCTV security camera is installed and the frame is designed by using PVC pipe as the material. The project's objectives of studying and analysis of what is R.O.V. as well as finishing this prototype's electrical power system design and the prototype's design is achieved. Thus, with this, the Final Year Project 2's objective to build the prototype is a success.

5.2 Recommendations

Further studies, especially on the camera, the power electrical control of the propulsion, buoyancy and control unit system is needed. The designs of the prototype can also be modified according to its application. When the prototype is built, more test should be done and to rectify any error. More communications with R.O.V. personnel from Subsea Explore Services (M) Sdn Bhd can also be done to further improvise on the prototype.

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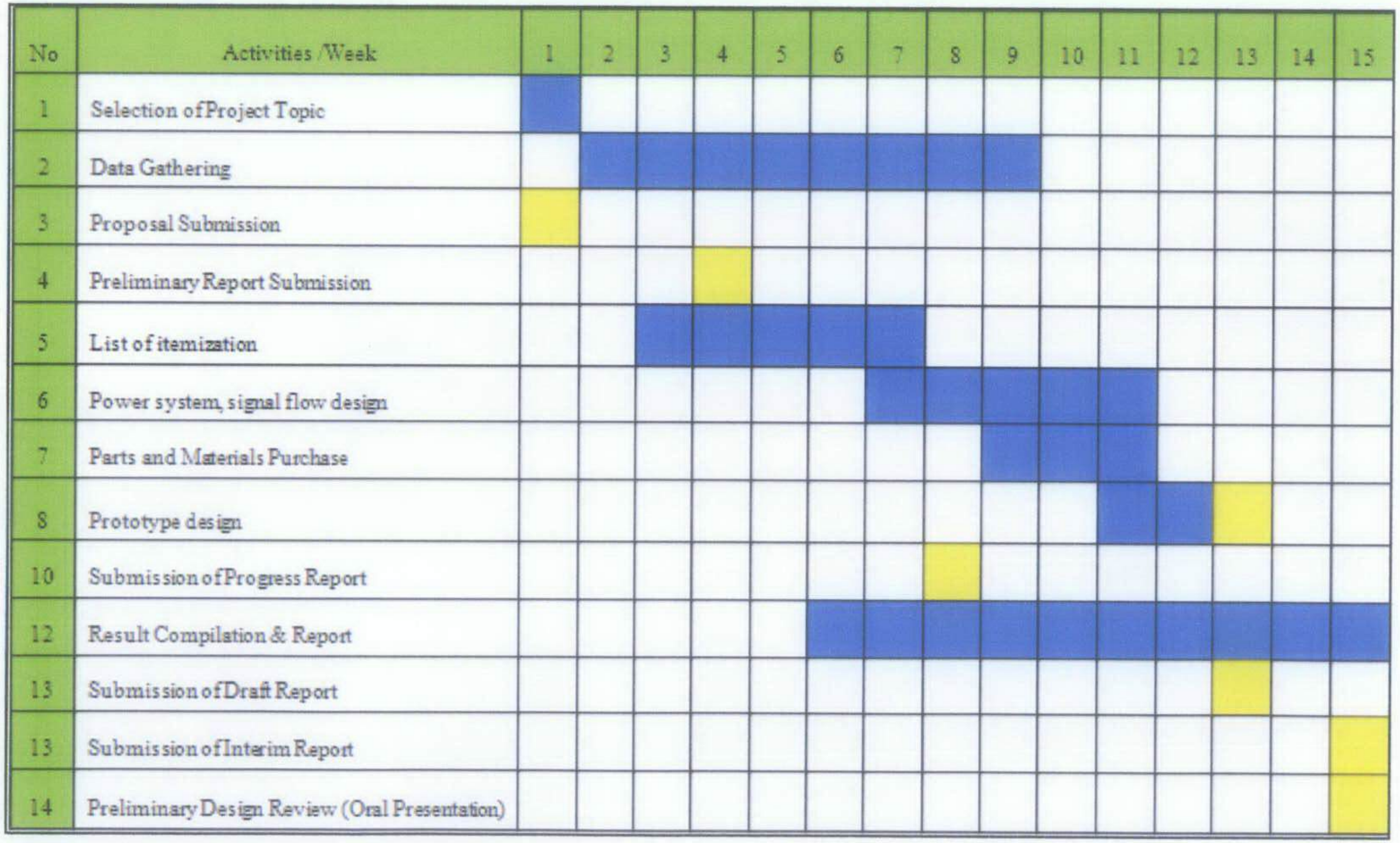
[15] Switches Explained, Nick Duxfield, retrieved in February 2011, www.gaugemaster.com/instructions/switches_explained.pdf

APPENDIX A: PROJECT'S GANTT CHART (FYP 1)

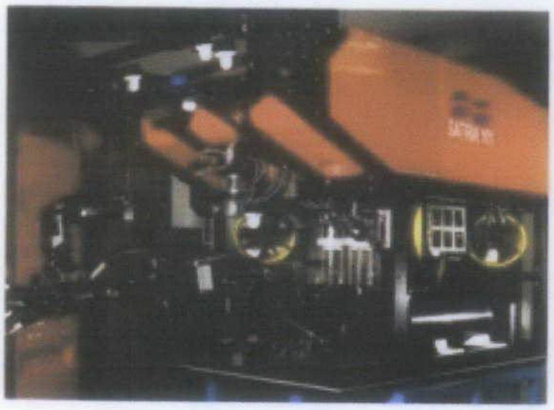


APPENDIX B: PROJECT'S GANTT CHART (FYP 2)

No.	Detail/ 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															
5	Submission of Progress Report															
7	Poster Exhibition															
8	Submission of Dissertation (soft bound)															
9	Oral Presentation															
10	Submission of Project 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

SUBSEA EXPLORE SERVICES (M) SDN BHD

IMCA Member

SUBSEA

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)

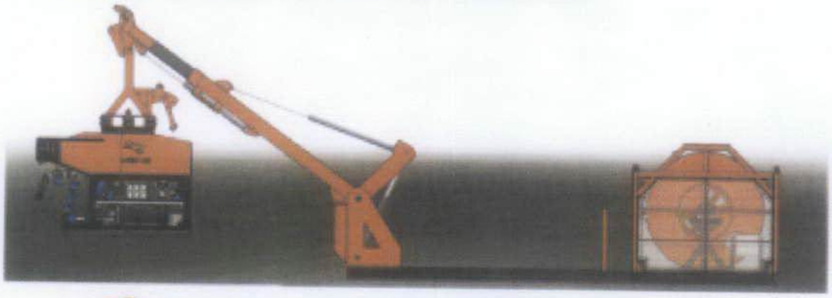
SUBSEA EXPLORE SERVICES (M) SDN BHD 692906-P
Lot 20, Jalan PJU 3/39, SME Bank Factory Complex, Sunway Damansara, 47810, Petaling Jaya, Selangor
Tel: +603-78858700 Fax: +603-78859700 Email: ses@subsearov.com Web: www.subsearov.com

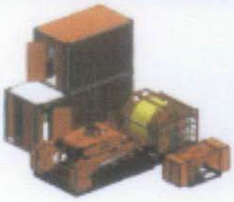
IMCA Member

APPENDIX D: SATRIA 102 DATASHEET

SATRIA 102 WORKCLASS ROV SYSTEM

SUBSEA





Original Equipment Manufacturer	: Subsea Explore Services (M) Sdn Bhd
ROV Type	: 125 HP 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, Vectored Thrusters individually servo valve controlled
Standard Power Pack	: 93KW / 125HP 3Phase 4Pole, 3.0KV motor, Oil filled and compensated. Bosch Rexroth PD, Pump, output 140lpm @ 200bar
Video & Telemetry	: Fiber Optic
Lighting	: 1.25Kw from 5 x 250watt dimmer channel, 250 or 500 watt 2500 rated lights
Control & Navigation	: Intelligence Gyro Compass, Tritech Seaking Sonar, Depth Transducer, System, Heading & Depth Auto Functions

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

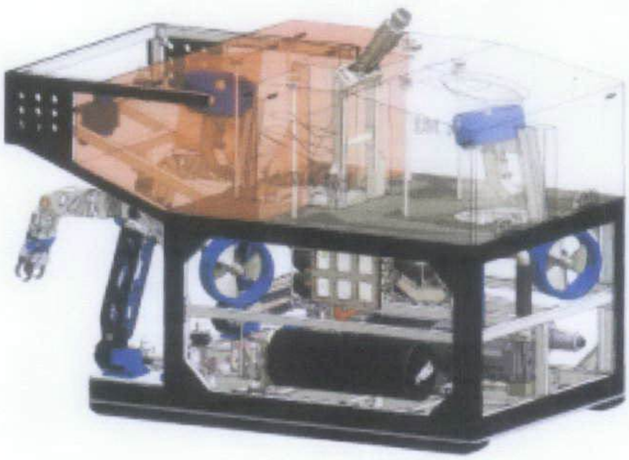
Standard Components: 1 x 7 Function Rate Manipulator
1 x 5 Function Rate Grabber
16 Station Solenoid Valve Pack
Tooling Manifold
8 Channel Servo Valve Pack
SES Hydraulic Pan and Tilt
Color Camera
Monochrome Arm
CP Actuator Arm

Vehicle Instruments: Control Panel System
Fiber optic video and telemetry transmission system
Single Mode Video/Data Transmission System
8 Video + 16 Data Channels
DVD Recorder System

Vehicle Status sensors: Hydraulic pressure and temperatures
Hydraulic reservoir oil level
Motor temperature
Motor oil compensation level
Voltage and current

Control Container: 6058mm(L) x2438mm(W) x 2591mm(H)
Certified to DNV 2.7-1 / EN12079
Rated to Zone-2 A60

Tooling Container: 4267mm(L) x 2438mm(W) x 2591mm(H)
Certified to DNV 2.7-1 / EN12079



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IMCA Member

APPENDIX E: FALCON DATASHEET

OBSERVATION CLASS ROV SYSTEM

SUBSEA

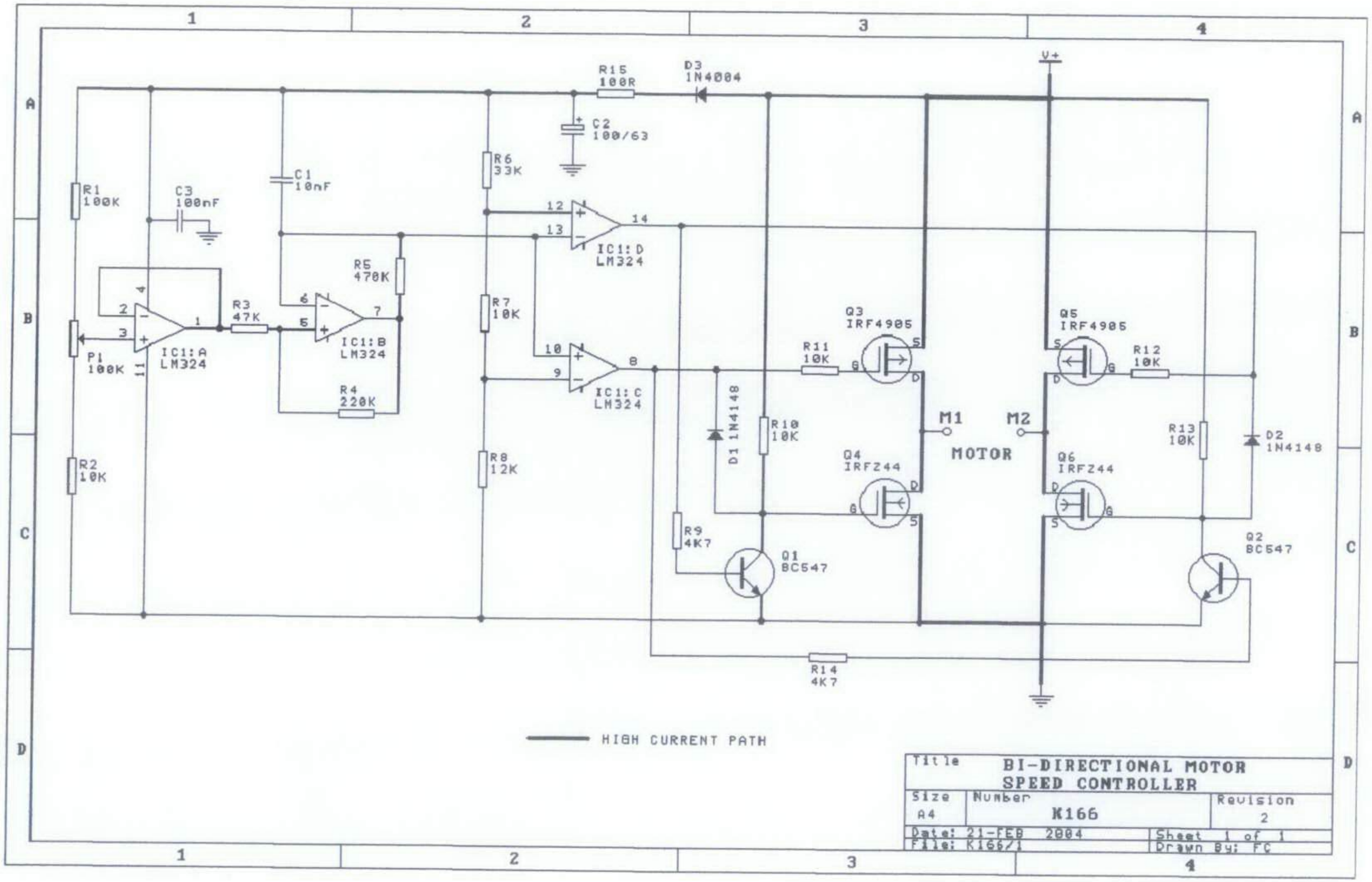
ROV Type	: Observation Class
Standard Depth Rating	: 300 Meters, 16 Kg Payload
Dimension	: 1000mm(L) x 600mm(W) x 500mm(H)
Propulsion System	: 4 Vectored and 1 Vertical thruster
Lighting	: Variable Intensity 150 Watts of Lighting
Control & Navigation	: Auto Heading, Depth, Compass and Rate Gyro. Sonar 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) 14foot(L) x 8foot(W) x 8foot(H)
Standard Component	: 5 Function Manipulators Color Camera Hand Control Unit

SUBSEA EXPLORE SERVICES (M) SDN BHD

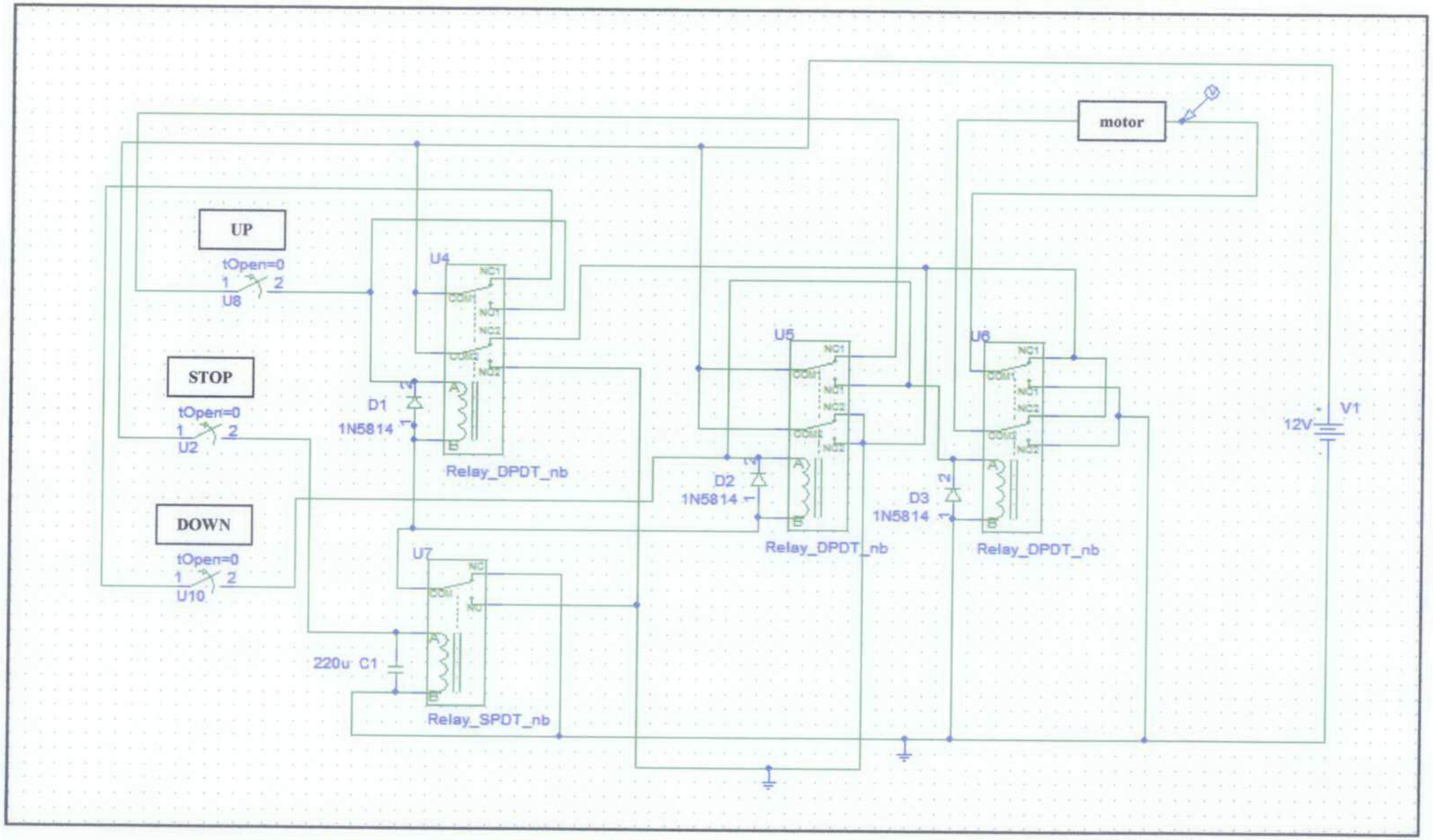
Lot 20, Jalan PJU 3/39, SME Bank Factory Complex, Sunway Damansara, 47810, Petaling Jaya, Selangor

IMCA Member

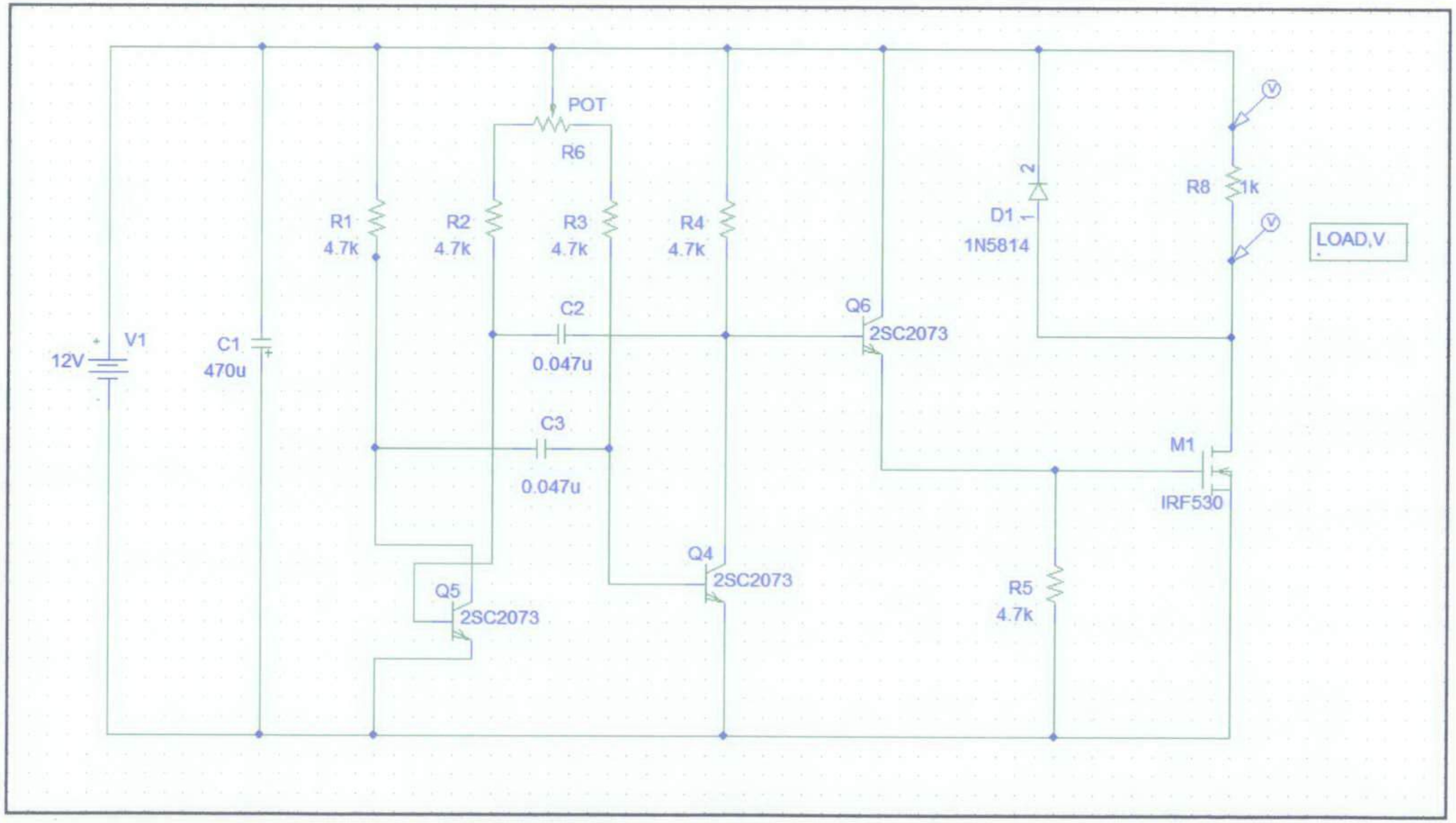
APPENDIX F: KIT 166. BIDIRECTIONAL DC MOTOR CONTROLLER



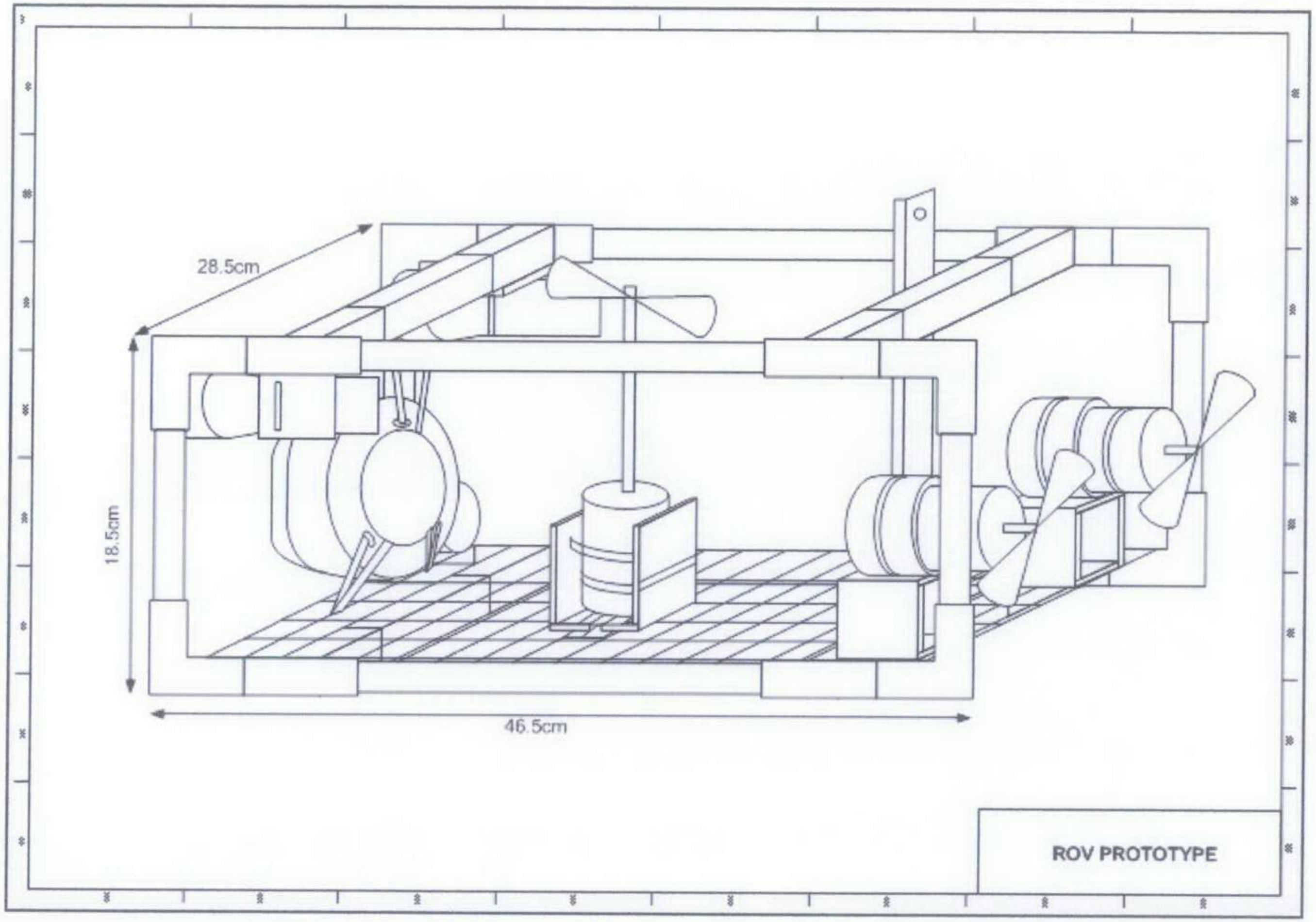
APPENDIX G: DC MOTOR REVERSING RELAY CIRCUIT

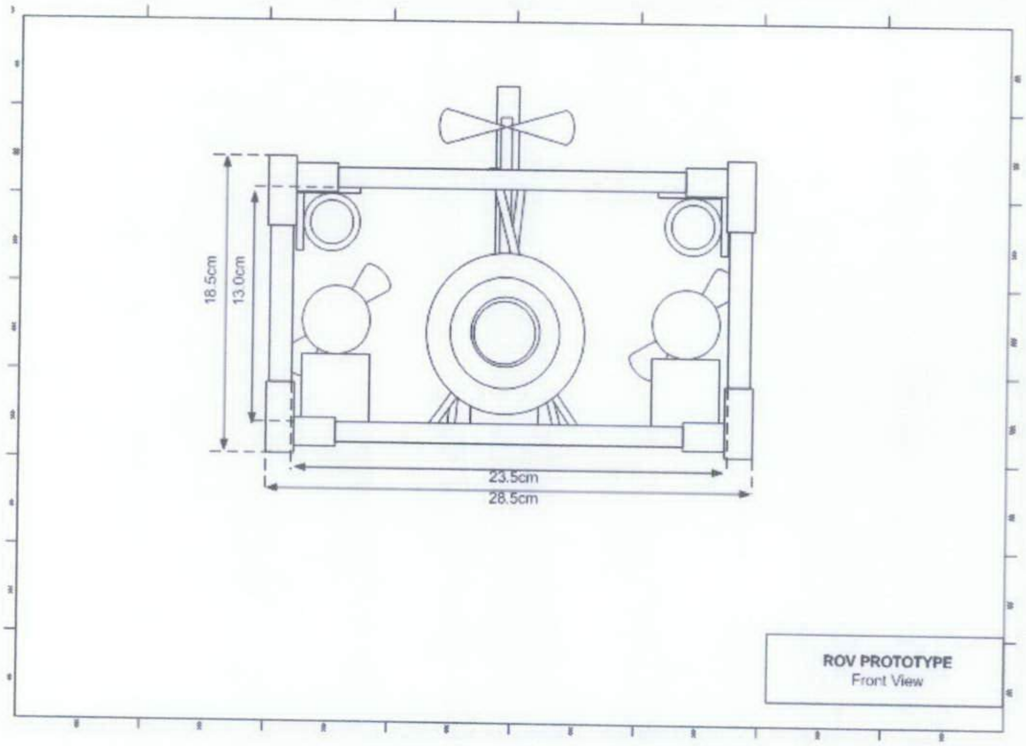


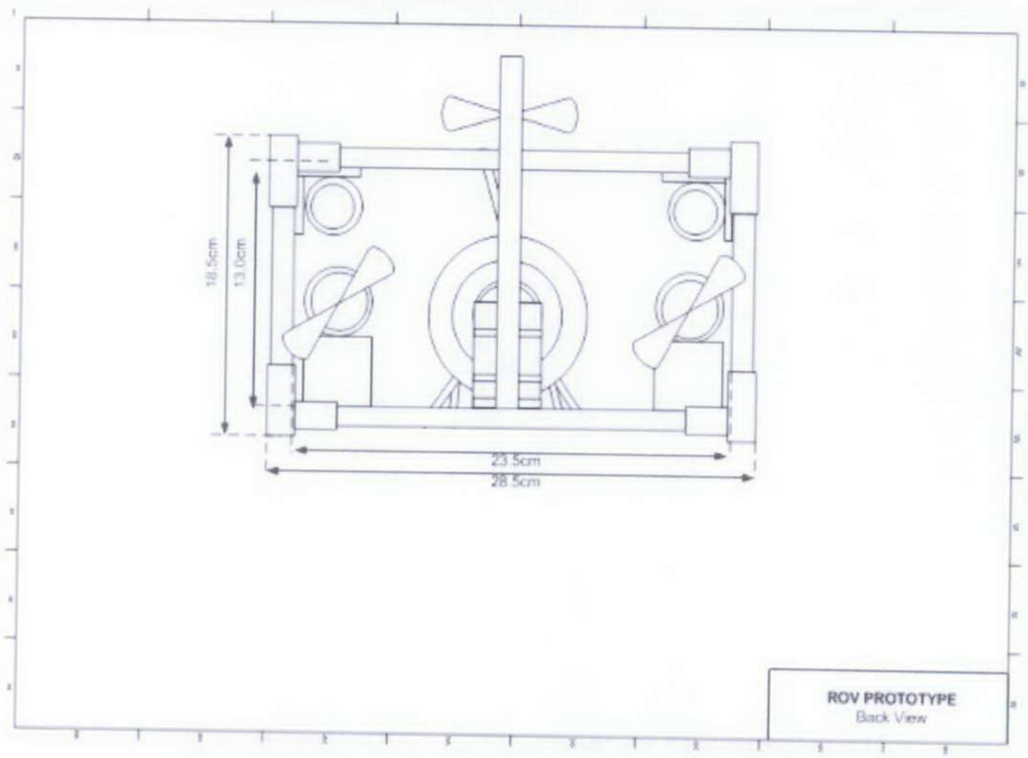
APPENDIX H: LIGHT DIMMER CIRCUIT

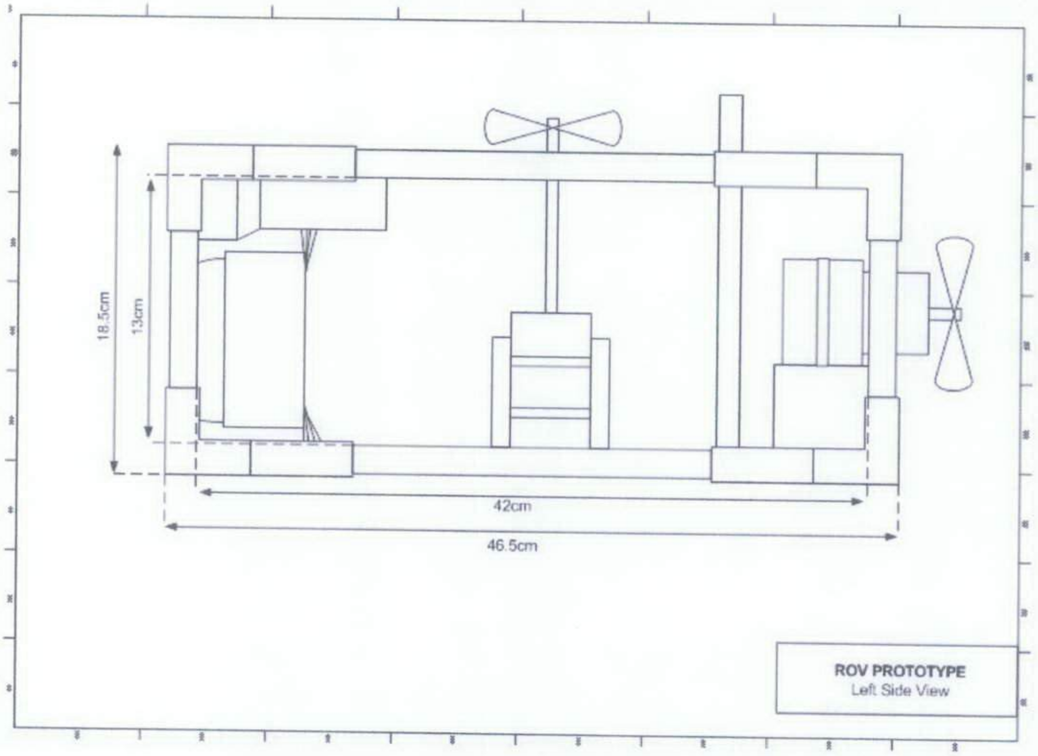


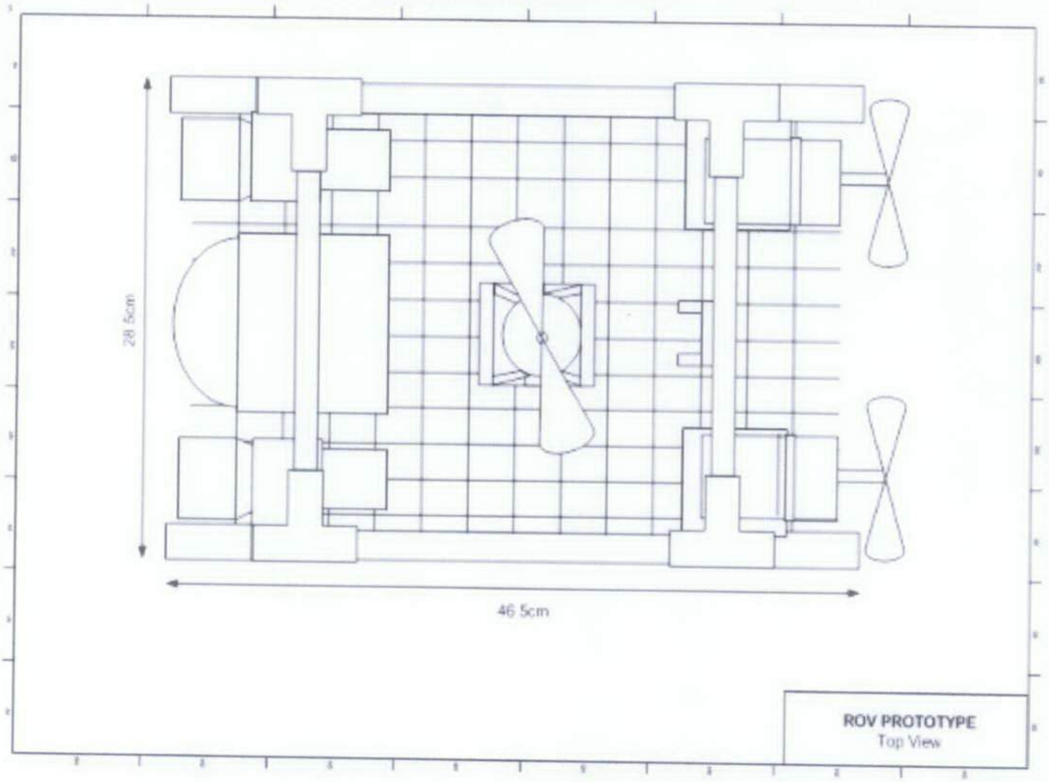
APPENDIX I: PROTOTYPE SCHEMATIC DRAWING




18.5cm
13.0cm
23.5cm
28.5cm
ROV PROTOTYPE
Front View


18.5cm
13.0cm
23.5cm
28.5cm
ROV PROTOTYPE
Back View


18.5cm
13cm
42cm
46.5cm
ROV PROTOTYPE
Left Side View


28.5cm
46.5cm
ROV PROTOTYPE
Top View