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AQUAPHOTON

The Systems & Designs of

The Admiral 2

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Abstract

The Admiral 2 is a masterpiece ROV, designed and Fabricated by AQUAPHOTON Company to compete in Marine Advanced Technology Education (MATE) International ROV Competition. It is the third time for AQUAPHOTON team to participate in MATE competition. All team members are studying electromechanical engineering at Alexandria University, and are expected to graduate in June 2014.

Admiral 2 was such a hard ROV designed, built, and tested to accomplish underwater tasks involved in observing and simulating ocean activities. The ROV was brought to life after several designs using CAD programs to make sure that the vehicle would follow the necessary criteria to accomplish the required mission.

The hull was well designed to support good assembly, perfect shape, and minimum drag force. Admiral 2 is equipped with six powerful thrusters for smooth propulsion in both the horizontal and vertical planes. One degree of freedom manipulator is used to make sure that the job is done clearly and simply. The vision system of Admiral 2 has 3 wide angle cameras, which give a complete view of the environment and the manipulators using a camera tilting mechanism. Fibre glass is used to cover the foam upper layer for the maximum strength and the best shape. An electric canister -made of stainless steel- contains all the electronic circuits, which are custom built for Admiral 2 by our engineers for high efficiency and minimum budget. Safety precautions are very important for AQUAPHOTON Company for minimum careless accidents and maximum benefit for the project.

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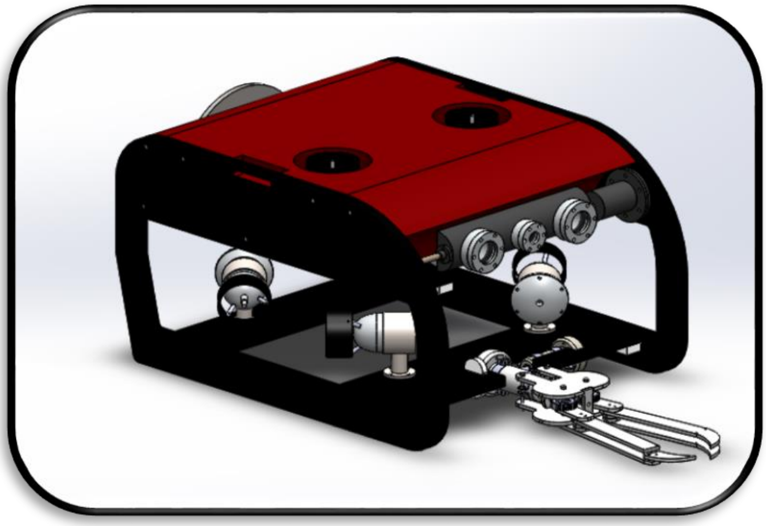
2.0 Design rationale

All the parts of Admiral 2 are designed and fabricated by AQUAPHOTON CO. in order to perform the specific mission tasks. The simplest way, the perfect shape, and market availability were our three main criteria for choosing our designs and the result was very satisfying for our Company. The first step in the design was brain storming to get largest number of ideas and choose the most suitable one for us. The company members used SolidWorks student license CAD software to help them in the design phase. The second step was manufacturing. The last step was the assembly and testing.



Full CAD Design

Full Real Design

2.1 Frame

The frame design is based on providing mechanical strength to the ROV, and providing a base structure to assemble different ROV systems. The frame shape is streamlined to ensure minimum drag on the ROV during operation. The design parameters for the frame are the mechanical strength, low drag resistance to water and ease of assembly

Available materials and manufacturing techniques

1.Aluminum-Fiber Composite.

It has the advantage of low cost, but the machining process is manual and not accurate

2.Polyurethane.

The raw material is in a liquid form and is poured in a mould and left to be cured. This choice was very good as the material provides a high mechanical strength. The only disadvantage is the high manufacturing cost as it needed a mould to get the required shape.

3. Nylon sheets - TECAMID PA6 GF30 polyamide. (The chosen material)

This material was used for its semi-crystalline thermoplastic with good damping capacity, good impact strength, high degree of toughness, and good wear-resistance. The machining process for the sheets is CNC router (computerized numerical control). It provided a very precise fabrication.

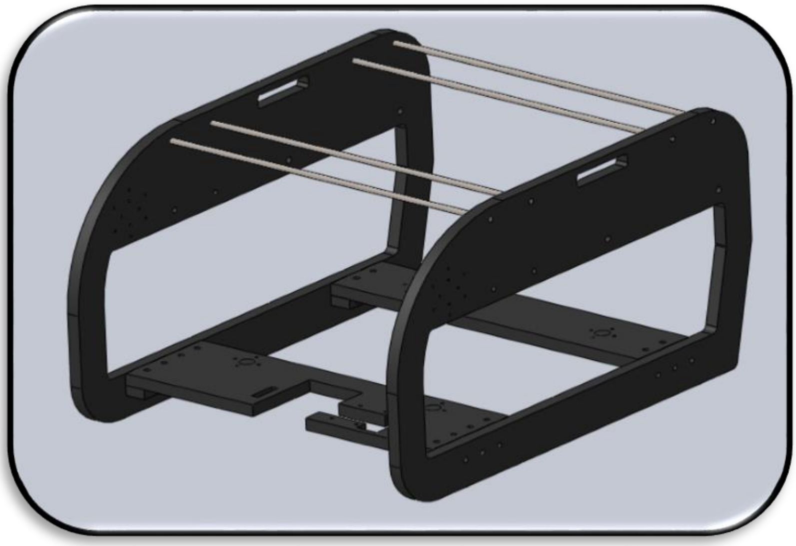


Fig.1 CAD design of the frame

Material properties in dry/wet conditions:
Modulus of Elasticity= 8500/6000 MPa
Ultimate Strength = 140/110 MPa (brittle)
Elongation at break = 2.5% / 5%
Hardness (ball indentation) = 147 MPa
Density = 1350 Kg/m^3

Water absorption at saturation = 6.6%

Fig.2 dissembled parts of the frame

Advantages of the frame shape
1. It was designed in such a way that allows putting the ROV on 5 of its 6 faces to provide an easy access to all ROV mechanical parts and thus providing easy maintenance.
2. Easy handling of the ROV
3. Ease of assembly: It is assembled with one tool because all fixation bolts are of the same size.

4. It gives an elegant shape because of the appearance of the material, and the stainless steel fixation bolts to avoid rust. Using this data, stress analysis on the frame was done to see points of maximum stress and ensure safe design. (Using SOLIDWORKS)

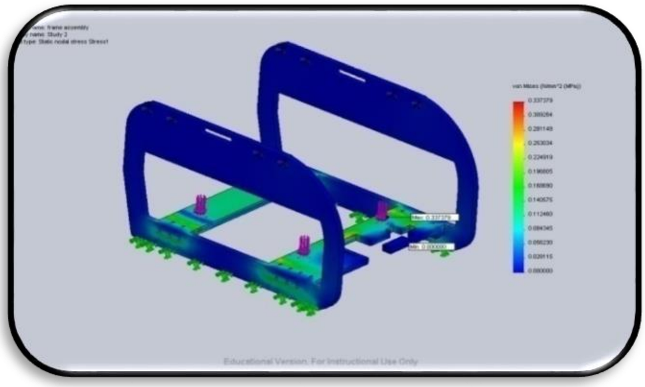


Fig.3Stress plot for the bottom plates of the frame

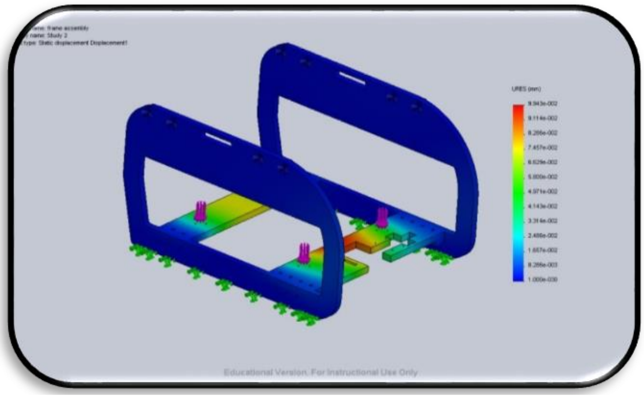


Fig.4Displacement plot for the bottom plates of the frame

2.2 Thrusters

The thrusters are the ROV's mechanical power source, which allows the ROV to move in all direction with the minimum losses of drag force. The thrusters enable the ROV to move smoothly in both the horizontal and the vertical planes. AQUAPHOTON Company decided not to buy the thrusters of any other company and started to build its own thruster. All thrusters used are fully designed and fabricated by the company.

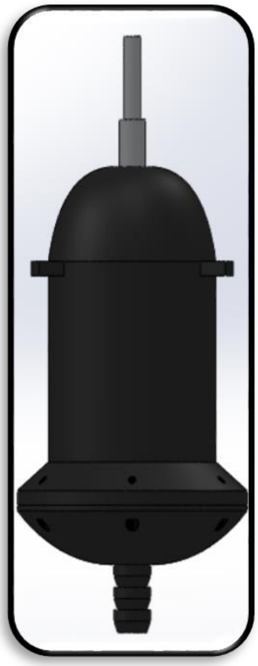


Fig 5CAD design of the thruster

Available materials and manufacturing techniques

1-Stainless Steel Material
it has the advantage of a high rust resistance, mechanical strength, and good appearance, so it was used as a shaft's material, but it was excluded as a main case material due to its high cost.

2-Aluminum
It was excluded due to its reaction with water forming salts on its surface.

3. TECAMID PA6GF30 polyamide. (The selected material) It is a thermoplastic material, so the rust is totally avoided. Moreover, high mechanical strength resulted in addition to its easy machining process.

This design has many advantages of low drag force, small size, ease of maintenance and high power to weight ratio. Machining methods used are centre lathe machine, gasket casting and welding for fixations.

The horizontal thrusters differ from the vertical thruster in shape and rated power.

Fig. 6 AQUAPHOTON's thrusters

Horizontal thrusters' specification
Type: Canon brushed DC motor
Voltage Rating: 24 V
Noload Current: 0.4A
Load current: 3A
Full load current: 8A
Power : 72 Watt
RPM : 1350 rpm

Vertical thrusters' specification
Type: Ampflow brushed DC motor
Voltage Rating: 36 V
Noload Current: 1A
Load current: 8A
Full load current: 22A
Power : 150 Watt
RPM : 3500 rpm

Fig. 7 used propeller

Propllers are the only part not fabricated by AQAPHOTON CO. due to lake of supplies and weak Possibilities. Our propellers have three fins, the pitch is P1.4 and the Diameter is 70mm.

2.3Electric cylinder

The goal of this design is to make a totally secured cylinder for electric boards which give the maximum safety considerations and prevent any leakage with the minimum drag force

The available material and manufacturing techniques

1-plastics
Using the plastic cylinder was avoided for its bad machining, high cost and fragile material.

2-stainless steel (The selected material)
This material was used due to its high surface finish, and its ability to withstand impact loads and high pressures.

Most of the electric canisters have two shapes, box shape or a cylinder shape. The cylinder shape was used because it produces a low drag resistance to water, and it is easier in machining compared to the box shape. Besides, the cylinder shape can with stand higher pressures than that of the box shape. The dry housing designed was a perfect fit for all of the electronic circuits and left no wasted space.

Fig. 8 Electric canister

According to our design, we had two options in machining the electric canister. The first one was using CNC machining, which is so expensive according to our budget. The other solution was centre lathe machine, which is characterized by acceptable surface finish and low cost.

2.4 Sealing

To give the best sealing standards and prevent any leakage, AQAPHOTON CO. was so concerned about sealing and divided it into 3 individual branches.

1- Static Sealing

Static sealing is used in each component as thrusters, electric canister, lights and camera casings. Our engineers depended on square cross-sectional surface seals in sealing the cap. A groove is machined in the casing itself according to Parker Co. standards. Also a group of bolts are used to insure the full contact between the casing and the cap of any components .For more safety, a double square cross-sectional surface seals in the electric canister and a group of eight M6 bolts are used.

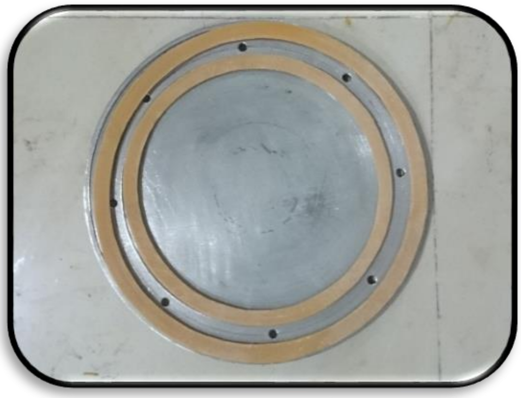


Fig 9 double surface seal of electric canister

2- wire sealing

For sealing the wires, one of our engineers came up with a great idea. We used nozzles and hoses system used in gaseous application. This idea was very effective and used for sealing the wires of the whole ROV. The nozzles is installed in each component in the ROV, all components are then connected to the junction boxes via the hoses, then all the wires are collected in two big hoses and connected to the electric canister. To insure the zero leakage approach, we used a jubilee clips on each nozzle.

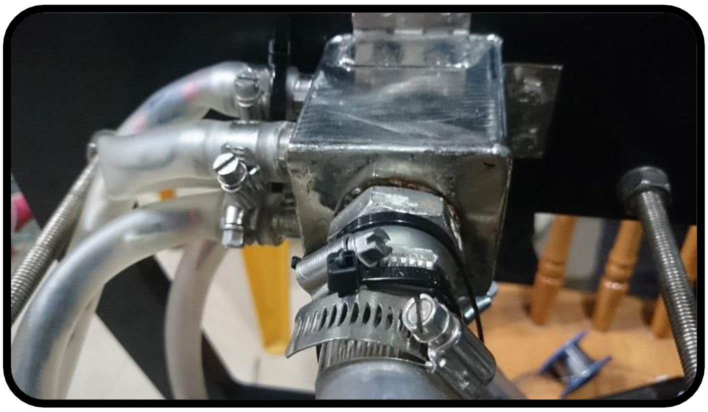


Fig 10 Junction Box

Fig 11 wire sealing with hose and jubilee clips

3- dynamic sealing

There is no doubt that dynamic sealing is the hardest type ever, that's why most of other companies use bilge pump or seabotix thruster to avoid the dynamic sealing problems, but our company insisted that all components used are our products. Many prototypes are made and most of them failed until 2 of our engineers invented a great idea of shaft sealing. A 2RS SKF bearing is used, 2 O-rings are used as a secondary sealing. The first one to prevent leakage between the bearing and the casing, a groove is machined in the casing for the O-ring. The second O-ring to prevent leakage between the bearing and the shaft. Another groove in the shaft is machined. All grooves' dimensions and specifications according to Parker Co. standards. The thrusters are tested for long time under 5 meter depth for more than 20 working hours and the result was so magnificent.

2.5 Vision System

The goal of the cameras is to provide a clear vision to the pilot and help him locate and navigate the ROV at subsea levels. Admiral 2 has 3 cameras for a complete view of the environment and the manipulator. The first camera is installed on a tilting mechanism enabling a wide range of vision for the pilot. This main camera is used to show the pilot his target and measure the shipwreck dimensions. There are two powerful light spots installed on the tilting mechanism for a better vision underwater.

Fig. 12 tilting mechanism

The second camera is used to show the platform under the ROV to help the pilot interact with the manipulator easily. The position of this camera can be changed according to the mission/task needed to accomplish. The third camera is installed for the rear view of the ROV as part of the mission may require backward motion. The casing is made of a thermoplastic material called polyimide characterized by low cost, good shape and ease of machining. A surface seal is used in insulation of cameras and lights casing. As for the wire insulation, the same idea of nozzles and hoses was used. We used USB DVR which allowed us to monitor our 3 cameras simultaneously on a laptop screen with a live view. This DVR is used to record a live video or take snapshots.

Fig. 13 cameras casing

The admiral 2 has 2 light spots to make the vision more clear in the dark areas. The spots casing are designed and manufactured by our company.

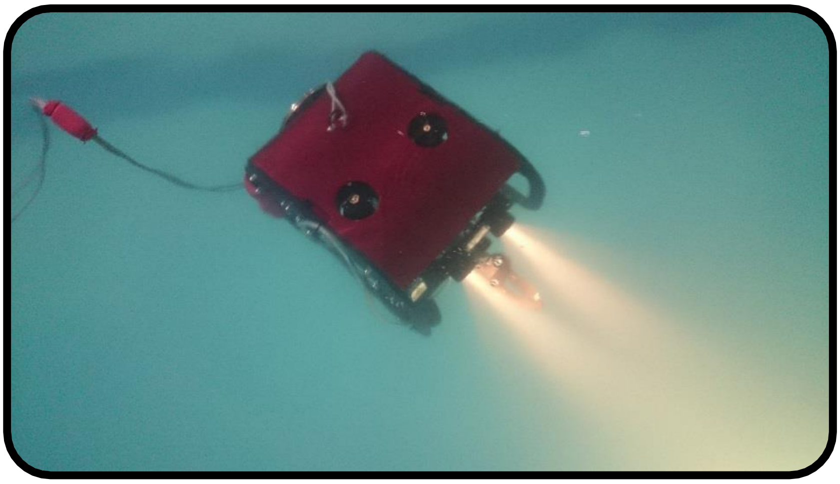


Fig. 14 The admiral 2 lights

2.6 Buoyancy

The design requirement was to make slightly positive buoyant ROV in order to be easier in flying and manoeuvring, and to allow the ROV to return to the surface in case of an electric or mechanical failure. This was done by calculating the overall weight of the ROV, including the weight of the foam in order to calculate the amount of foam needed to reach the design goal.

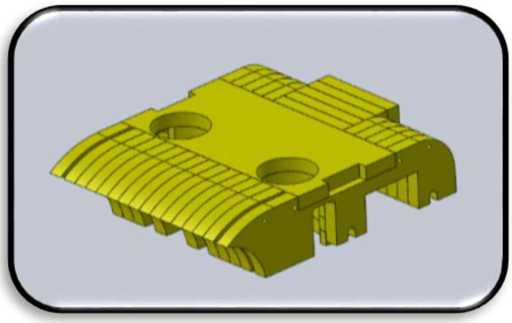


Fig. 15 CAD assembled Foam parts

ROV total weight = 48 Kg
Foam Volume needed = 0.020766 m^3

According to these calculations, Archimedes law was used. The total weight was slightly lower than the buoyant force resulting from the volume displaced by the ROV and thus making the ROV slightly floating.

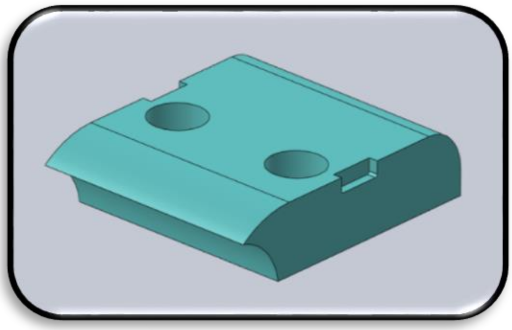


Fig.16 overall shape of the foam

The material used in manufacturing the buoyancy is extruded polystyrene foam with density of 35 Kg/m^3 and a compressive strength of 300 KPa. This material saves its quality and properties to 20m depth under water. We used a unique method to manufacture the buoyancy foam with the designed shape. The total volume of the foam was divided into small parts so that we can cut the foam parts using CNC laser cutting. These small parts were then assembled and glued together to form the integrated shape of the foam. The foam was then covered by a layer of fiberglass for more strength and for a good looking shape to the ROV. The mould for the fiberglass was made of acrylic to give the fiberglass a better surface finish.

2.7 Balance Box

The main goal of using the balance boxes is to easily shift the Cg (centre of gravity) point to the required place between the two vertical thrusters. We made 2 balance boxes fitted on the 2 sides of ROV along its length to shift the Cg forward and backward, and 1 balance box fitted along the width of ROV to shift the Cg left and right for any asymmetry.

The balance box consists of washers and a shaft between them, so if you want to increase the weights, all you have to do is to increase the number of washers. If you want to shift the weights to shift the Cg, you have to move the washers on the shaft. We chose steel washers to give us maximum weight to volume rate. As an initial start in the balancing terminology, we started by a small percentage of the total mass of balance boxes, which is 306 gm, of the total mass, which is 865 gm. This allowed us to have additional backup weights in case the ROV floats or is not stable in the balance experiment. These balance boxes are small, simple in building and considers a quick release masses.

Fig. 17 three balance boxes

2.8 Manipulator

Admiral 2 has one manipulator with one DOF (degrees of freedom), used for gripping. These simple motions allow the pilot to easily interact with any part on the playground depending on the rov motion itself. This unique design is custom built for the Admiral 2 to accomplish all needed tasks easily. The gripper material and gripper motor casing are made of nylon sheets TECAMID polyamide (Artinol) where this material has the strength needed and it can be machined easily. The gripper is made of 6mm thickness sheet and assembled with set screws. CNC Router is used to fabricate the required part for the manipulator assembly.

The casing of the gripper motors is designed to insulate the motors from water. The insulation techniques used for these motors are the exact same techniques used for thrusters' insulation.

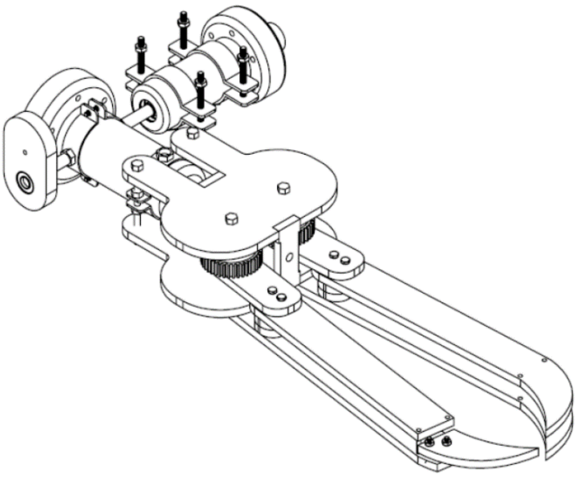


Fig. 18 CAD design of Manipulator

The gripper mechanism consists of a worm and 2 worm gears to transfer the motion from the rotating shaft to the two end effectors. The end effector has a special design to enable the pilot catch the plate inside the shipwreck

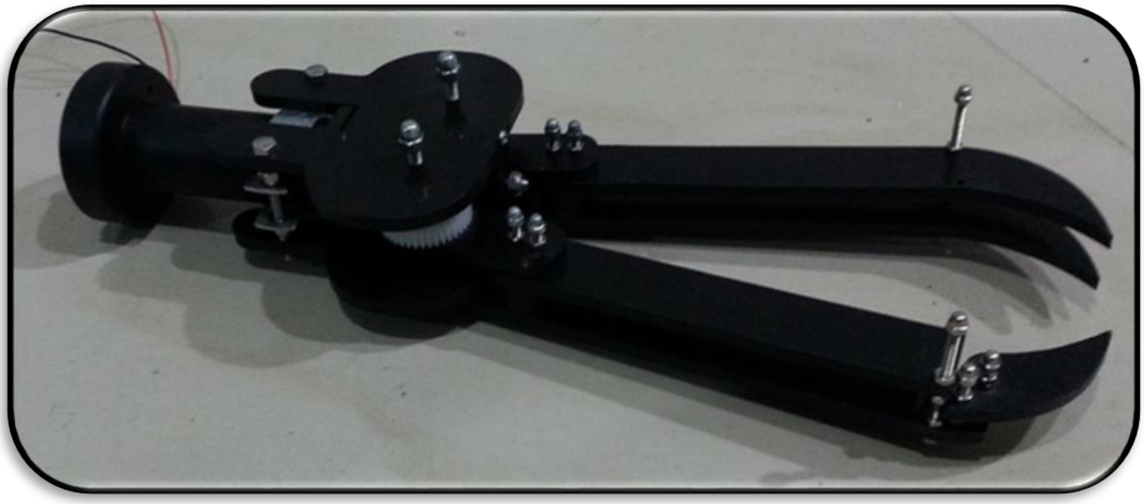


Fig. 19 assembled Manipulator

The main advantage of this design is the ability of changing the end effector to another one according to the mission or the task required to accomplish. Another advantage is the self-blocking of the gripper and no power consumption due to the worm and worm gear nature so that no need to keep the motor power connected to securely grip and block any item. The gripper's lay out has 2 position one for vertical gripping and the other for horizontal gripping.

Gripper Motor Specification

Motor type: brushed DC motor

Rated Voltage: 12 Volt

Speed: 200 RPM

Load current: 0.4 ampere

Full Load Current: 1 ampere

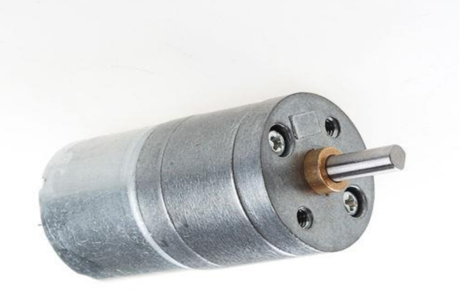


Fig. 20 Gripper motor

2.9 Electric system

The electrical circuits are enclosed in a stainless steel electric can fixed over acrylic sheet. It includes 2 types of circuits, communication circuits and power control (that will be illustrated later). Fast connection plugs were added inside the electric can to avoid high cost and shipping problems of buying fast connectors. These plugs allow fast assembly and disassembly for the electronic boards for maintenance and troubleshooting problems

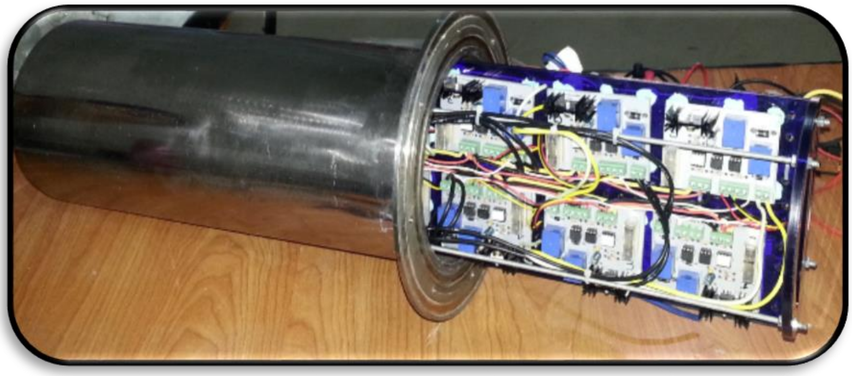


Fig. 21 electric circuits in the canister

Communication

We tried first to use RS485 communication between PICs, but unfortunately that communication was unstable. As a result, we had to use Arduino. Five pins were used to transmit data from Arduino UNO (surface controller) to Arduino MEGA (underwater controller), and this provides us with the ability to give 32 commands, while our needs is 18 commands. That communication was stable. We were able to interface the Arduino UNO with PS2 Controller through PS2X library. **See Appendix B (Communication system).** As a backup plan, we interfaced the Arduino UNO with a laptop through serial communication through Putty software.

Electronics System Flow

Data is sent from PS2 Joystick to Arduino UNO that sends data to Arduino MEGA (underwater controller) to control the motion of motors (used for thrusters, agar sample collecting mechanism, arm, gripper and camera motion) and lights. Arduino boards are easy to interface and have a stable operation. See Appendix C (System Interconnection Diagram)

Motors

We used Brushed DC motors with sufficient speed and torque. We had problems with surges at “start” and “stop”, especially for thrusters’ motors, so we added soft starting and soft braking to prevent the damage of our circuits, or damage of the fuse added to protect the circuit.

Motor Driver

We had problems with high current, so we used MOSFETs (Metal Oxide Semiconductor Field Effect Transistor) with heat sinks installed to dissipate heat. We also had problems with the MOSFET H-Bridge drivers available, so we had to give up the idea of making H-bridge with 4 N-Channel MOSFETs. Instead, we used 2 relays with 1 N-Channel MOSFET to provide us with the required operation. A freewheeling diode is used to provide a path to the current. 48 volt is the input to the circuit. PWM (Pulse Width Modulation) and direction signal are the input to the circuit so that 24 volt is the output voltage to the thrusters. We don’t have control over speed; instead, a fixed PWM is assigned to each motor to give an adequate smooth motion underwater.

Light Circuit

Based on a 1N-Channel MOSFET, to its gate PWM is input to control voltage over the Lights to give adequate light intensity.

Voltage Regulation

There were many options for voltage regulation part but our choice was to buy a DC to DC converter to regulate a 48 volt to 12 volt as a power source for cameras. This converter is characterized by a stable output voltage, suitable current rating for our application (5A), and it is protected by a 5 Ampere fuse.

Another 48 Volt to 5 volt converter is used as a power source for the Arduino. This converter is characterized by isolated ground.

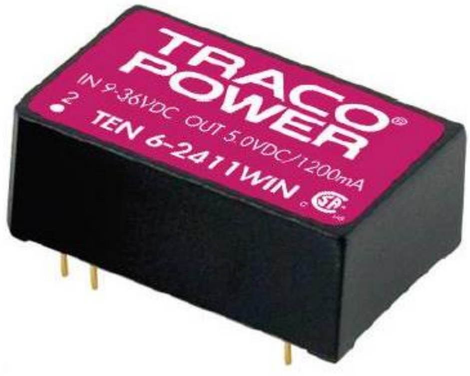


Fig. 22 48V to 5V DC to DC converter

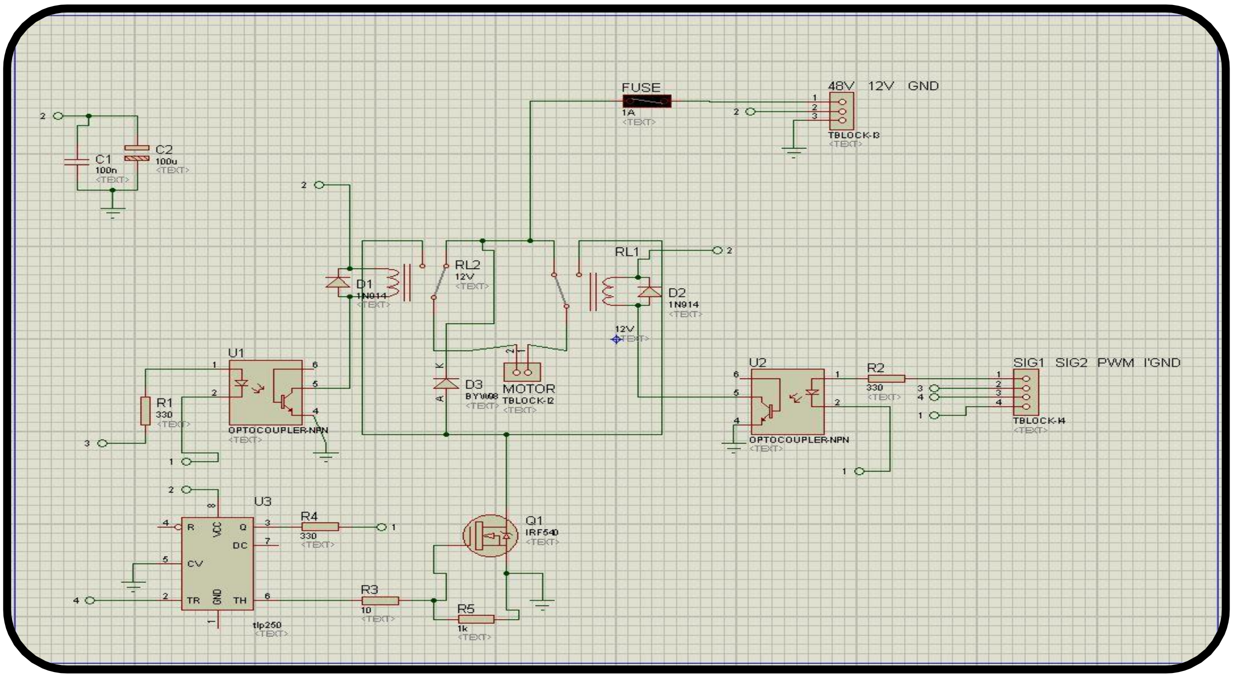


Fig. 23 electric schematic of motor driver

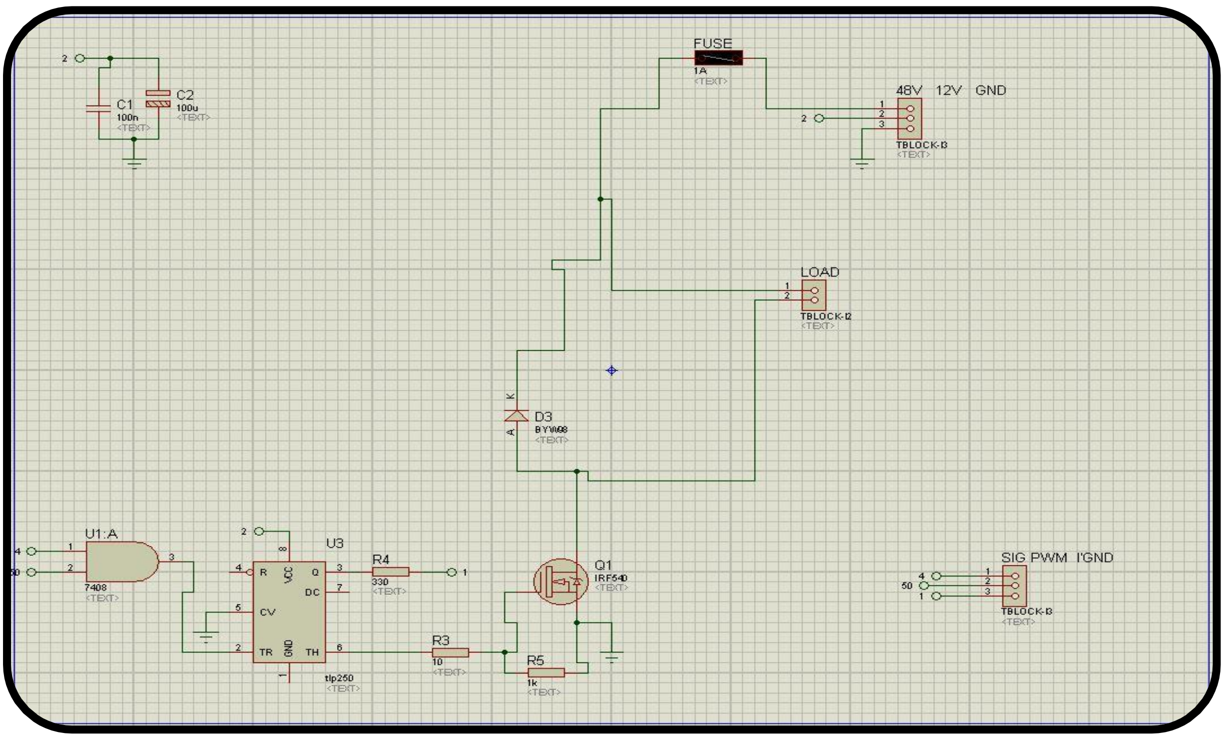


Fig. 24 electric schematic of Light circuit

Tether

One of our defects in the Admiral 1 in 2013 was the heavy tether. Last year, we used a 25 terminals tether; each tether's thickness is 1.5mm. It was made of copper which was really heavy. This year, Admiral 2 has 2 tethers. The first one consists of two terminals of 4mm thickness used for power transmission to the ROV. The second tether consists of 12 terminals of 0.5mm thickness; 6 of them are used for the vision system (2 terminals for each camera), while the other 6 terminals are used for the communication between the surface control and the ROV.

Fig. 25 The Admiral 2 and the tether

2.10 Surface control

The surface control of the Admiral 2 consists of 2 main components. The first component is the control box. It is custom made for AQUAPHOTON CO. by our engineers. This box contains a monitor, 32 ampere main feeder circuit breaker, a 25 ampere fuse and LCD for sensor readings. It also contains the DVR to connect the cameras to the pilot's screen. The main advantage of our control box is the fast connecting system for the tether and power source input. Another advantage is the ease of connection to any external computers. The admiral 2 is controlled via a PS2 joystick. The second component is the co-pilot's external laptop to collect any data required for the mission.

Fig. 26 the pilot controller

Fig. 27 the co-pilot controller

3.0 Payloads

The Admiral 2 is supported with extra tools to help completing tasks in the minimum possible time.

3.1 Zebra mussel quadrat

It is required to estimate the total number of zebra mussels on shipwreck which is difficult to be counted due to long dimensions, so it is required to fabricate a quadrat with dimensions of 0.5m*0.5m which will be placed on the top of shipwreck's hull to know the number of mussels in this area by using our front camera, so it will be easy to estimate the total number by using the shipwreck dimensions.

3.2 Conductivity sensor

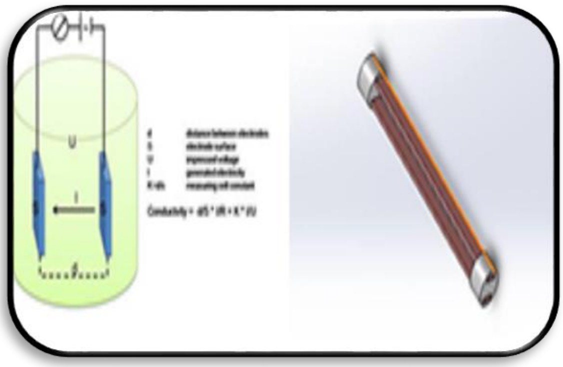


Fig. 28 Conductivity sensor CAD design

One of the important tasks this year is to design and deploy a sensor to accurately measure the conductivity of the venting groundwater which will be more conductive than the ambient pool water. Simply it is 2 copper plates (electrodes) parallel to each other with a small gap between them, and a resistor is connected in series with one electrode; 12 volt DC is an input to the sensor. Voltage across the resistor changes according to the water salinity.

3.3 Microbial mat system

Microbial mat is simulated by agar. This system is designed and fabricated by AQAPHOTON CO. to accomplish the required mission. The system consists of a stainless steel cup and a manual vacuum pump which is connected to the cup via the hose. When cup penetrates the agar sample depending on the vertical thrust force downwards, the vacuum is applied and the sample is attached to the cup due to the rough inner surface of the cup. This system is well tested and succeeded to bring the sample to the surface. Our team is making modifications to the system to insure bringing the required volume of the sample (150 ml) to the surface.

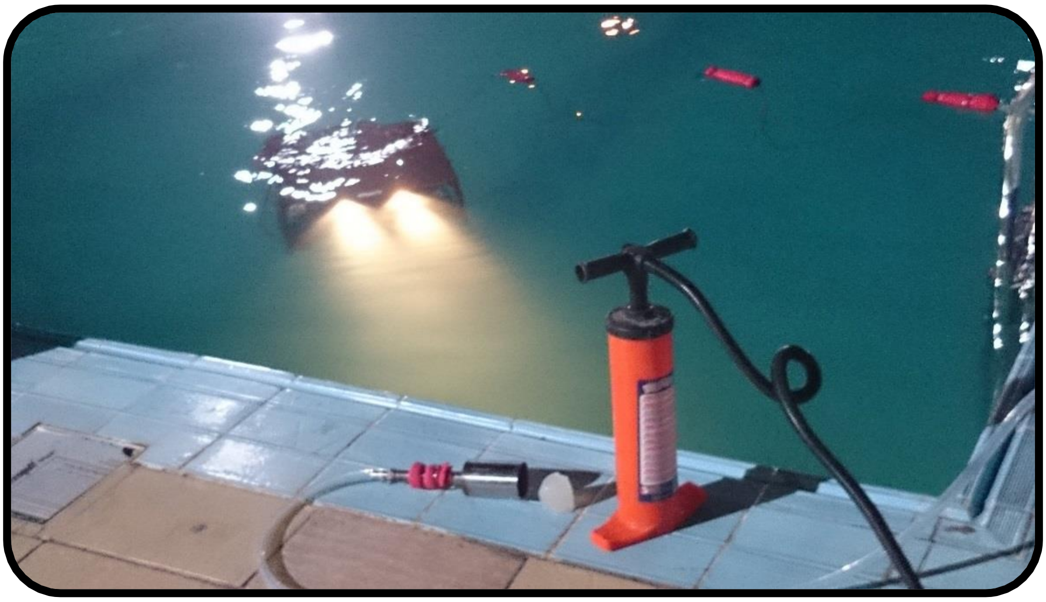


Fig. 29 agar system after testing

4.0 Safety first philosophy

AQUAPHOTON promotes improvements in quality, health, safety and environmental standards through the publication of information notes that are a mix between popular guidelines and our trials in raising the safety rate. Members are self-regulating through the adoption of these guidelines as appropriate. They commit to act as responsible members by the following relevant guidelines.

Fig. 30 Moataz Tarek wearing the PPE (personal protective equipment)

Safety includes three main branches:

1) **Workers' safety** concerning health of workers and avoiding injuries from manufacturing tools; safety clothes is a must which consists of gloves, eye goggles, face mask and ear protection headphones.

A. Handling precautions:

Safe working practice dictates that personnel should not work alone when dealing with heavy lifts

A handling team consisting of four members is responsible for dealing with the whole system to ensure safe transportation to the poolside. Those members should wear special protective clothing (safety shoes, hand gloves). Two persons for ROV lifting, one for tether, and one for surface control unit.

B. Operation precautions:

The skill sets of the ROV team must be carefully chosen to ensure a safe efficient operation; a minimum crewing level of three persons is necessary in order to have proper complementary skill sets to operate safely and efficiently. Sufficient competent personnel is available at critical times to launch and recover the ROV

Example of avoided accident:

One of our company's faith is how to avoid any accident consequences with minimum losses.During early electronics experiments, there was a fault (short circuit) in a printed circuit board which leads to spark and small fire while testing. We succeeded to overcome this accident in nearly half a minute by using Fire Extinguisher.

2) ROV safety features

Admiral 2 is designed to meet safety guidelines by mechanical & electrical means. As for mechanical features, it has no sharp edges that can hurt during handling or operation. Propellers are shrouded which reduces the possibility of getting in contact with the propeller; all gears are covered by guards which secures contact during operation. Safety labels are sticked on propeller's casing to give attention for rotating propeller, which may cause severe hurt, and for gear's guard to prevent contact during rolling.

As for electrical features, all cables inside the hull are secured inside hoses and well attached to the components. Tether is well attached to the surface control unit, and there is a single inline fuse for the whole system which saves all components if the current exceeds the maximum operating value; however, each power driver circuit is guarded with separate fuse. A main circuit breaker is provided at the beginning of the control unit as on/off switch to start and end operation safely. **See Appendix E (safety checklist).**

3) Environmental considerations our ROV is free of any chemical substance or pollutants that can mix easily with water.

Pre- and Post-Dive Checks

A visual and physical inspection should indicate potential or existing problems prior to turning on electrical power. The vehicle should be examined for cracks, dents, loose parts, unsecured wires or hoses, dirty camera lenses and obstructions in the thrusters. If possible, vehicles should be washed with fresh water after a dive. All command controls should be briefly operated and the vehicle response should be checked.

Fig. 31 The Admiral 2 with gear safety guards & labels

5.0 Challenges

5.1 Technical

AQUAPHOTON team faced two major challenges this year. The first one was the fiberglass fabrication. When the team members wanted to fabricate the fiberglass in a specialized company, we found that the cost was so high according to our budget. Therefore, the company decided to self-learn the proper way of fabrication by watching a plenty of tutorials and succeeded in fabricating the perfect one for us with an efficiency not so far/different from the big company one.

Fig. 32 Moataz and Ahmed making the Fiberglass

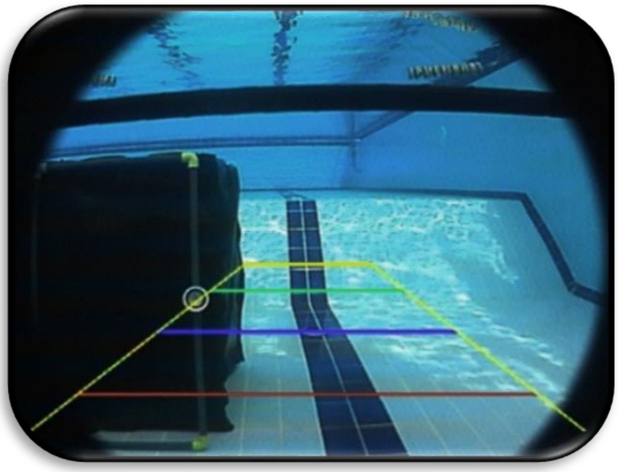


Fig. 33 front camera screenshot

The second technical challenge we faced was to find an underwater ultrasonic sensor to accomplish one of our missions of measuring the parameters of the shipwreck but we failed to find the suitable one in the local markets. As we know great ideas can come out of tragedy, one of our members found a special camera used in cars to help the driver in parking by mentioning the distance to the other cars. After we calibrated the distance under water, the idea was successfully working with a negligible error.

5.2 Non-technical

When the electrical team captain travelled abroad for about a month and another electrical team member was not able to work for a while. Great responsibilities and great amount of tasks were for only one electrical member in a short time. As a result, two of the mechanical team members were overloaded with extra work and started to share tasks with the electrical team and successfully finished them.

6.0 Troubleshooting

It is a must to face some difficulties in critical moments when you are working on great projects, so troubleshooting is a basic technique for anyone working in such a project.

After our local competition we found that there is a leakage in sealing hoses because our sealing system is interconnecting among all components via hoses which means that water may go to electronics' canister and cause failure of the whole system.

It takes time to know where the leakage comes from, so first of all, each component should be isolated separately to inspect where the fault has occurred. After this process, we found that the leaking comes from one of the vertical thrusters. Such a problem should be solved rapidly. We found that the flat seal wasn't installed in the right position, so the thruster's cap isn't closed correctly.

This problem can be solved by replacing the flat seal with a new one to avoid any deformation occurred in the old one and then reclosing the cap carefully.

After this action, the thruster should be tested separately to make sure that the problem is solved then, it should be installed in its position to check the whole vehicle.

7.0 Lesson learned

7.1 Technical

One of the most important lessons learned is the criteria of the proper static and dynamic sealing. During the past two years, we got used to sealing by silicon gasketmaker as a one-use sealant, which was very expensive and not effective at all. However, this year for the static sealing, we designed and fabricated gaskets that meets our needs, and for the dynamic sealing, we used O-rings. The result is zero leakage.

7.2 Interpersonal

In the non-technical side, all company members learned a set of soft skills through the process like presentation skills, effect of team chemistry on the technical side and a little of feasibility study. However, the main lesson we learned was the time and task managing techniques, especially how to make a time balance between personal and professional life.

8.0 Future improvement

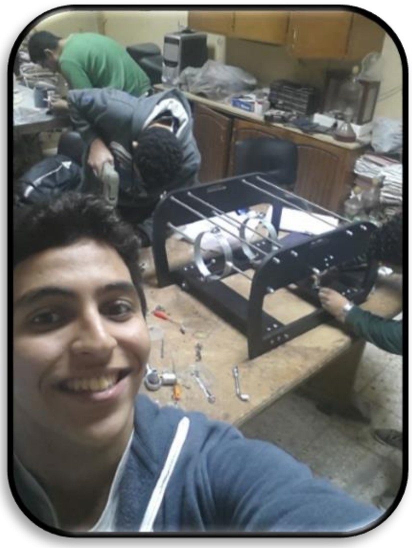
- Thrusters are a very important component that should be carefully selected to match the design of the whole vehicle to produce the smooth propulsion. AQUAPHOTON CO. is aiming to increase the thrusters' efficiency in two different ways. First, they are designing and fabricating propellers that meet our needs using advanced technologies in design by simulation programs and in fabrication using 3D printers and CNC machines. Second, they are improving the design of thruster out casing for less drag force.

Another improvement AQUAPHOTON CO. is planning during the next year is to have fast connecting system outside the electric canister for ease of maintenance and to separate the tether from the body.

9.0 Reflections

"*As a mechanical team member, I learnt how to think practically using my academic knowledge and I learnt the basic design steps that must be accomplished in order to get the best product, in adition to teamwork. As a teamleader, I learnt how to lead a discussion in a diplomatic way to make the right decision , and how to think in steps with critical thinking. I learnt self – control and I understood the true meaning of responsibility.*" Abd Elrahman Samir,
Mechanical ngineer, CEO

Fig. 34 Abd Elrahman Samir in the pool testing the ROV



"*Looking back to what has been accomplished throughout our design process, many improvements have been made. Not only have we all learned a great deal of knowledge, but we have also built on our technical skills in the fabrication process for our ROV."*
Ahmed Saeed, Mechanical Engineer, pilot

Fig. 35 Ahmed Saeed selfie in the Workshop

10.0 TeamWork

“Do it with passion or not at all”

The above quote says it all. Admiral 2 was designed, built and tested by 10 Passionate engineers having one target, winning the international competition, June 2014. From the first day, all AQUAPHOTON CO. members decided that nothing would be acceptable less than the perfect. We chose success to be our destiny, and we believed that the way to this must be well organized, so we started to plan for a reasonable timeline to stick to it, prepared our workshop and equipped it with the needed tools. Finally, we started our beloved project. Since day one, every single member knows his duties. **See Appendix A (Gantt-chart)**. Due to spending many hours together, the engineers learned to work as a team, think creatively, and be open minded to each other’s thoughts.

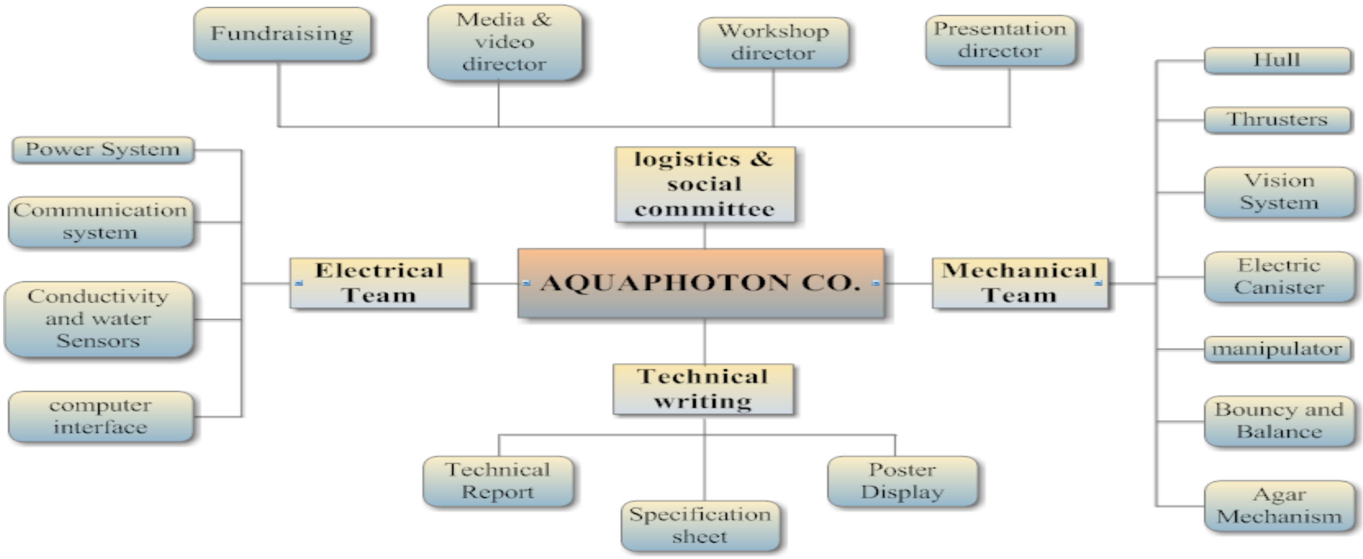


Fig. 36 task management chart

The above diagram illustrates the task managing of the company. Every single part of Admiral 2 is designed by the company members. Even the technical report and the poster display was the company’s effort.

Fig. 37 three mechanical engineers working together on thrusters fixations

11.0 Behind the competition (Extraordinary work)

AQUAPHOTON Company has many activities related to ROV besides MATE competition. Our engineers give sessions through many big events in Alexandria University to raise the awareness of ROV industry and importance. In fig (38) Mostafa Hafez, the mechanical team captain, is giving a lecture for the newcomers about admiral 1 and the participation in MATE competition.

In figure (39) Moataz Tarek and Ahmed Saeed are in a session in the opening ceremony of RAS (Robotics & Automation Society), IEEE (institute of electrical and Electronics Engineers) student chapter. February 2014

In July 2014, Aquaphoton CO. is aiming to make a group of workshops about “How to build your ROV” with the association of Alexandria University Student union.

In addition, our company participated in many project fairs; one of our achievements was winning the first place in IEEE project fair, March 2013, figure (40). Also, we won the **second place** in inventors, creators and scientific researchers Forum, **Ministry of State for Youth Affairs,** May 2014

Fig. 38 Mostafa Hafez in the Newcomers Event

Fig. 39 Ahmed and Moataz in IEEE RAS session

Fig. 40 AQUAPHOTON members in IEEE project fair

12.0 Budget

SEE Appendix E (Budget Pie chart)

	Component	Material	Price/ unit	Quantity	Total U.S $	Donation (Cash)
Mechanical	Thrusters	Polyamide	90	8	720	Business association
	Buoyancy kit	Fiber glass	175	1	175	
	Agar mechanism	Stainless steel	34	1	34	
	Lift bag	PVC	26	1	26	
	Frame	polyamide	169	1	169	
	Hoses	Silicon	0.5 $/m	20m	10	
	Manipulator	Polyamide	94	1	94	
	Cameras & lights	Polyamide	43	3 / 2	215	
	Tools& Toolbox	polypropylene	500	1	500	
	Junction box	Stainless steel	40	2	80	
	Safety tools	N/A	65	1	65	
	Prototypes & wasted materials	N/A	1430	-	1430	
Electrical	Electric canister	Stainless steel	218	1	218	
	Arduino controller	N/A	47	3	140	
	Power supplies	N/A	7	4	28	
	Dc to dc converters	N/A	14.5	3	43	
	DVR	N/A	78	1	78	
	Tether	copper	120	1	120	Engineers syndicate
	PS2 Joystick	N/A	18	1	18	
	Conductivity sensor	N/A	29	1	29	
	H-bridges	N/A	22	12	264	
	Control box	polypropylene	115	1	115	
	Prototypes	N/A	140	-	140	
General	*Poster*	N/A	30	1	30	
	Regional competition registration	N/A	71.5	1	71.5	
	T-shirts	N/A	11.5	10	115	
	Jackets	N/A	25	10	250	
	Local competition transportations	N/A	41.5	1	41.5	
International Competition	Visa applications & transportations	N/A	165	9	1485	
	Flight tickets to U.S.	N/A	1233	10	12330	Alexandria UNI. + Ezz Steel CO.
	Rov shipping	N/A	2644	1	2644	Science club
	U.S. Transportations	N/A	1400	1	1400	Faculty of Engineering
	Accommodation	N/A	2025	1	2025	
				Total	**25,103**	**U.S $**

Note: Machining prices:
Centre lathe machining = 30$ / hour
laser cut machine = 18$ /hour
CNC router machine = 15$ / hour

13.0 References

Safety

AODC 032 ROV intervention during diving operations
AODC 035 Code of practice for the safe use of electricity under water
IMCA C 005 IMCA guidance on competence assurance & assessment – Guidance document and Competence tables – Remote Systems & ROV Division

Electric box

http://en.wikipedia.org/wiki/Gear_pump

Electronic

www.arduino.cc/playground/Main/PS2Keyboard

www.pjrc.com/teensy/td_libs_PS2Keyboard.html

Frame

http://www.ensinger-online.com/en/materials/engineering-plastics/polyamides/#c608
http://www.lairdplastics.com/product/brands/tecamid/856-tecamidatrade-nylon
http://www.plastral.com.au/page_sheet.php?id=34&categorie=Engineering%20Plastics%20-%20Ensinger
http://www.ensinger.com.br/upload/download/pt/arquivo_MzAw13095302670.pdf

Buoyancy

http://www.atlasest.com/uploads/XPS_-_CATALOG.pdf

Thrusters

http://www.propellerpages.com/?c=nozzles&f=How_Nozzles_Work

http://www.seabotix.com/?gclid=CNv79b-867wCFUjItAod218Alw

http://openrov.com/forum/topics/thruster-layout

14.0 Acknowledgements

AQUAPHOTON CO. would like to thank the following individuals, organizations and companies for their assistance, support and guidance in building our masterpiece “Admiral 2”

. Parents- motivating us and Moral supports

.DR. Mohab Hossam- guiding us and technical support

. MATE- giving us such a terrific chance

. Hadath-organizing both the local and the regional competition

. Arab Academy for science, Technology and Maritime transport- organizing the regional competition

. Alexandria University science club- providing funds, workshop and transportation to the local competition

. Faculty of Engineering – providing fund

. Engineers Syndicate- providing funds

.SolidWorks- providing AQUPHOTON CO. with 11 Student licenses.

. Ezz Steel Company - providing fund

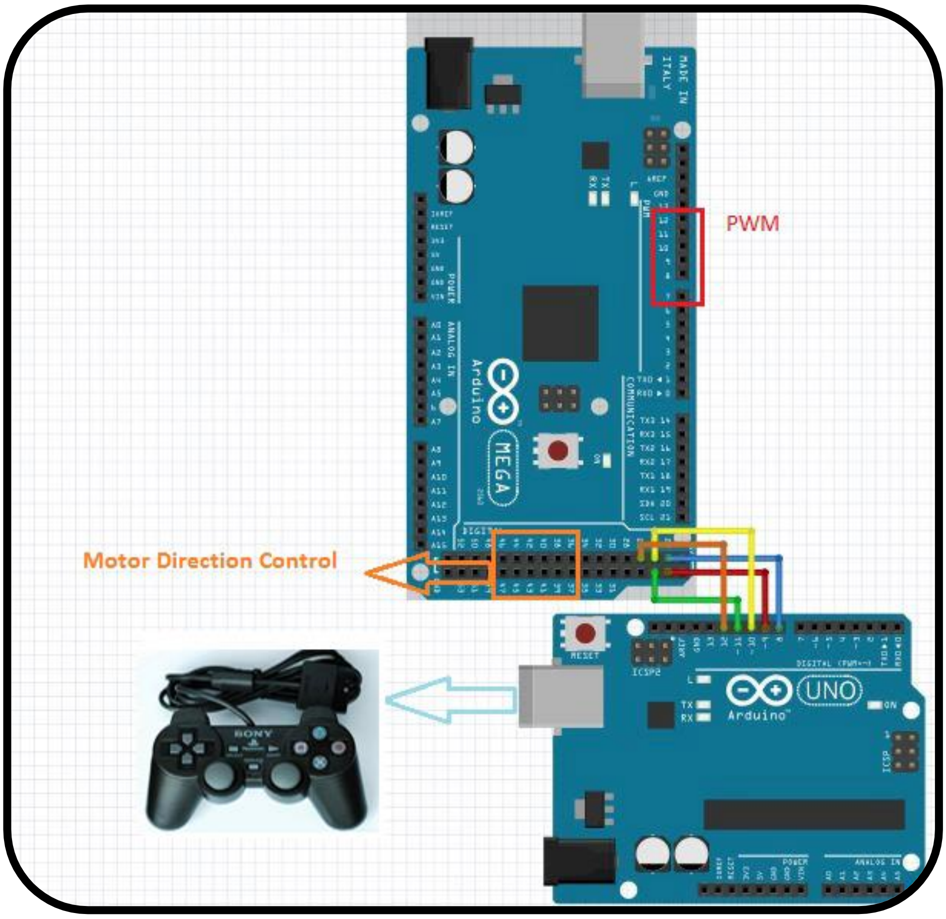
.Businessmen Association – providing fund

15.0 Appendices

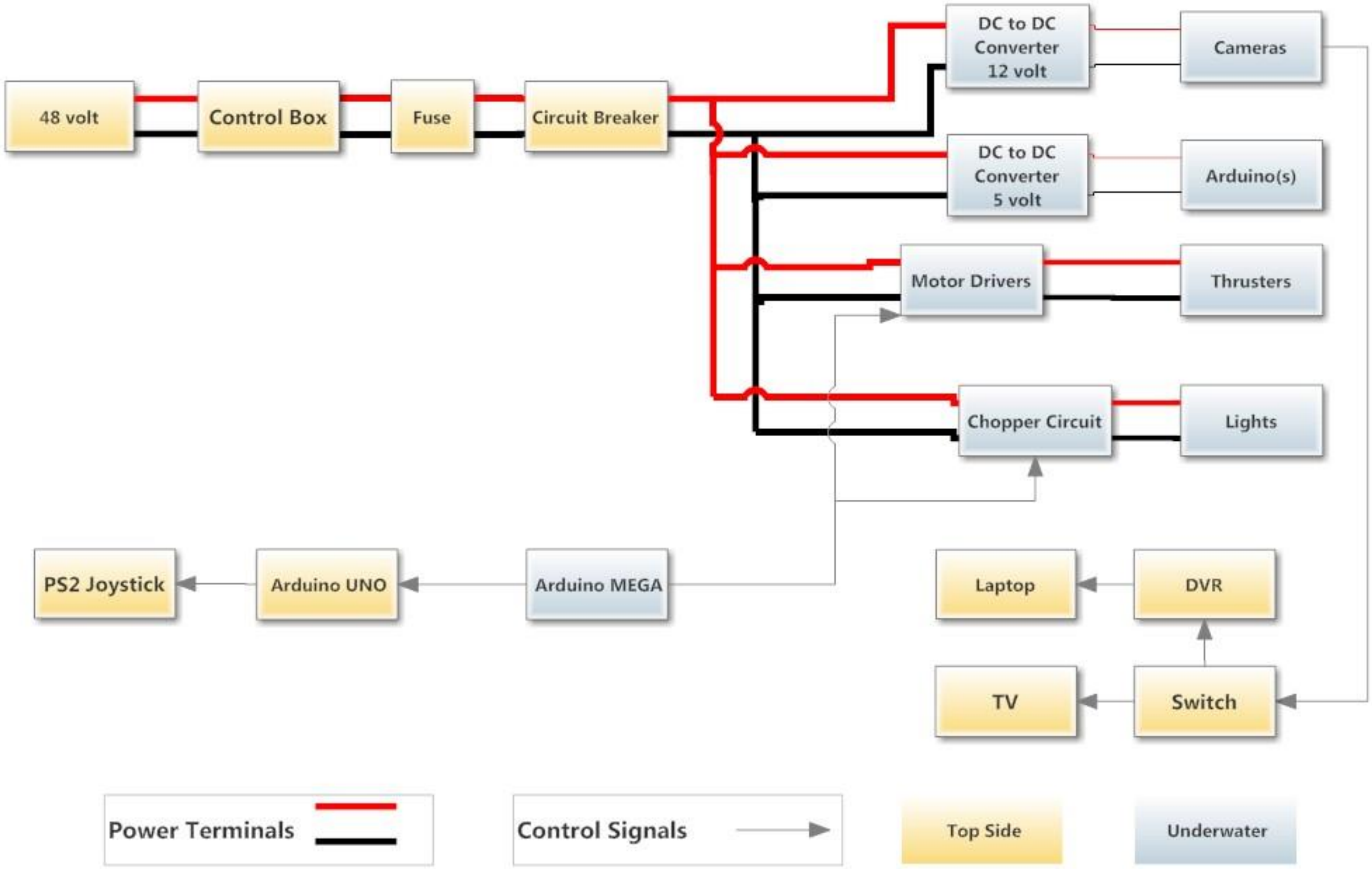
Appendix A (Gantt-chart)

Number	Task	Start	End	28/10	4/11	11/11	18/11	25/11	2/12	9/12	16/12	23/12	30/12	6/1	13/1	20/1	27/1	3/2	10/2	17/2	24/2	3/3
1	company elections and system	1/11/2013	7/11/2013																			
2	competition orientation & task managing	7/11/2013	12/11/2013																			
3	Mechanical Team phase one (design & brain storming)	12/11/2013	12/12/2013																			
4	Mechanical Team phase two (fabrication)	12/12/2013	20/1/2014																			
5	Mechanical Team phase three (testing)	20/1/2014	28/1/2014																			
6	Mechanical Assembly	28/1/2014	6/2/2014																			
7	electrical Team phase one (learning and brain storming)	12/11/2013	12/12/2013																			
8	Electrical Team phase two (communication system)	12/12/2013	30/12/2013																			
9	Electrical Team phase three (power system)	30/12/2013	16/1/2014																			
10	Electrical Team phase four (sensors)	16/1/2014	21/1/2014																			
11	Electrical team phase five (testing)	21/1/2014	28/1/2014																			
12	Electrical Assembly	28/1/2014	6/2/2014																			
13	pilot training, maintenance & local competition preparation	6/2/2014	22/2/2014																			
14	Technical Report	23/2/2014	28/2/2014																			
15	Poster Display	23/2/2014	6/3/2014																			
16	presentation preparation	23/2/2014	6/3/2014																			
17	Regional competition	7/3/2014	9/3/2014																			

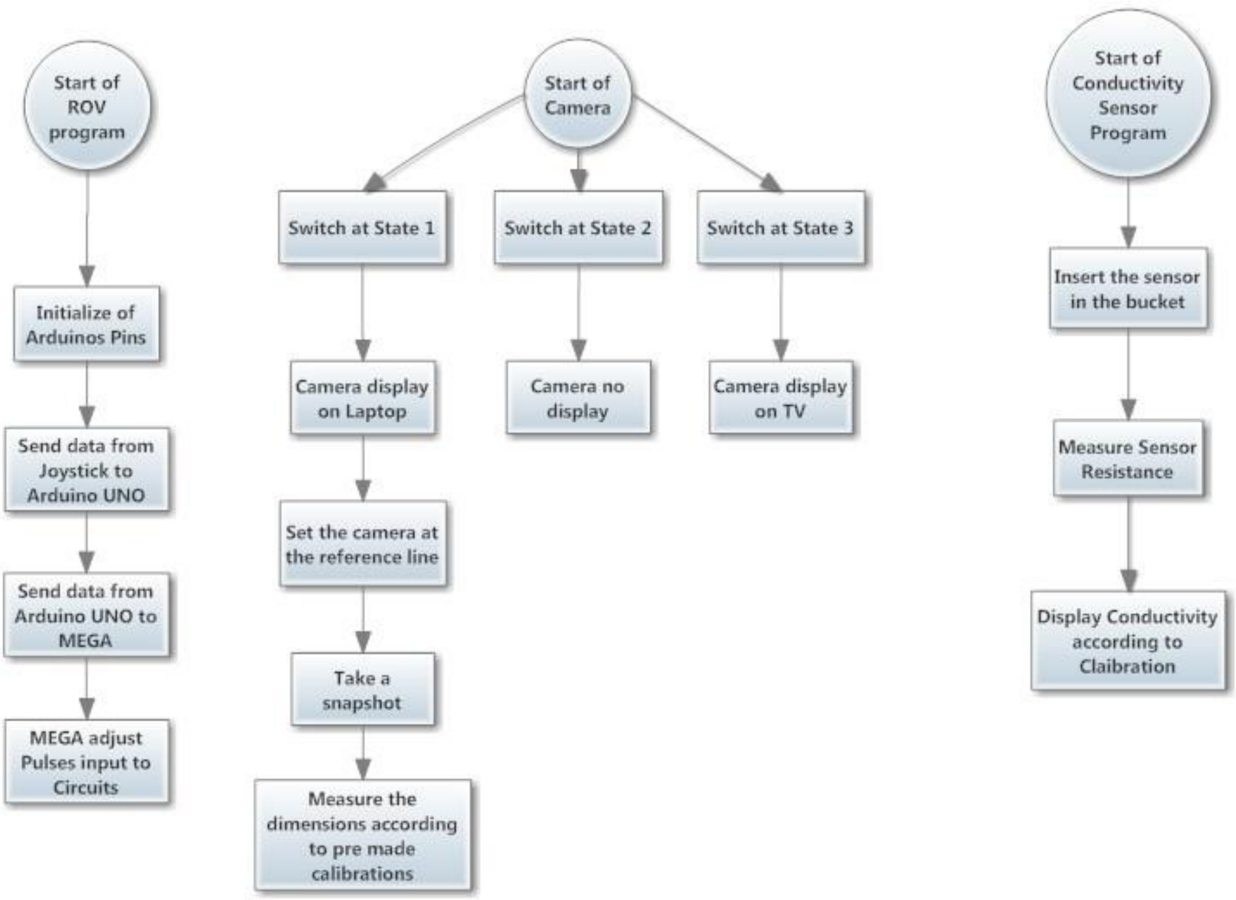
Appendix B (Communication system)



Appendix C (System Interconnection Diagram)



Appendix D (Flowchart)



Appendix E (safety checklist)

Item	Check
Control area is safe & dry	
Cameras & lights glasses are clear	
Thrusters and propellers are properly attached	
Gear's guards in place	
Rust free from mechanical parts	
Well closed electric canister	
Tether is securely attached to ROV body.	
No exposed wires	
Main fuse in place	
Tether well connected to control unit	
Plug power to connectors (48v Dc , 220 v Ac)	
Check the voltage rating (48 DCV, 220 ACV) using voltmeter	
Circuit Breaker is on, Check green lamps are on	
Make dry test for all components	
Wearing safety clothes for launching	
Check the buoyancy	

Appendix F (Budget Pie chart)