الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحري

Arab Academy for Science, Technology & Maritime Transport

College of Management and Technology, Cairo-Heliopolis

ROV shark Team

The name of our company is **The Blue Ocean**.

The community organization name is Arab academy for science and technology located in Cairo (Sheraton).

CEO/Pilot	Mohaned Youssef Mustafa
Mechanical Designer/ Co-pilot	Mohamed marouf Shurrab
CFO	Mostafa Assem Shneshen
Manufacturing	Mohamed Samir Abdel Latif
Fabrication	Norhan Hamdi Ali
Fabrication	Salma Hussam Sedky
Mentor	Dr.Sameh Shaaban

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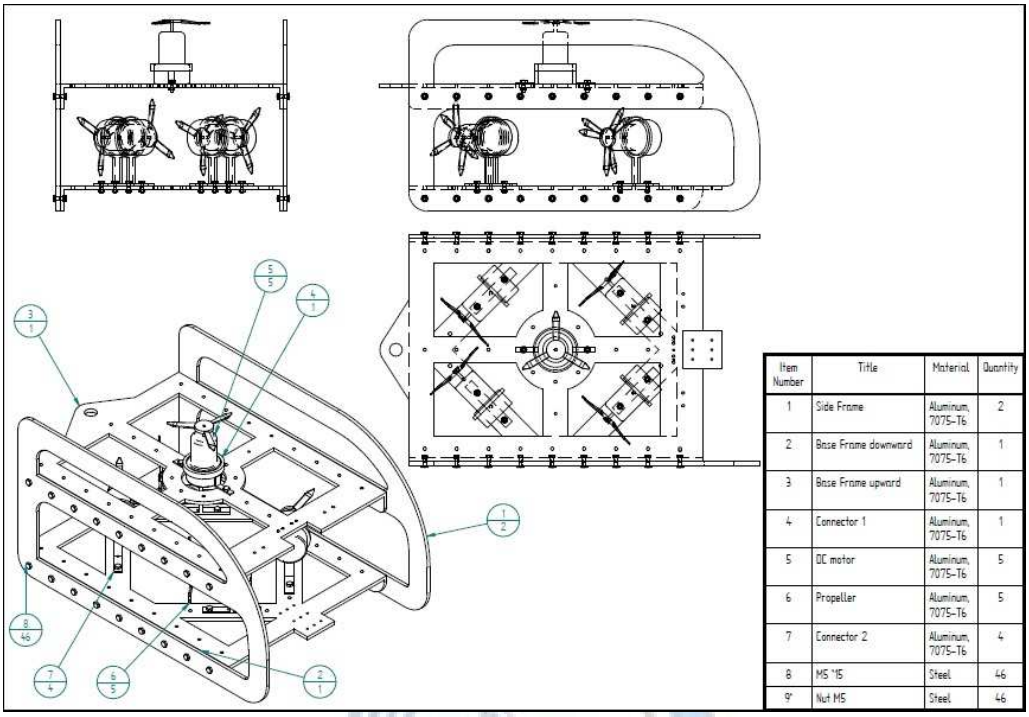
1. Abstract

ROV stands for “Remotely Operated Vehicle” It is an underwater robot that allows the vehicle's operator to remain in a comfortable environment while it performs the work underwater .Vehicles are highly nonlinear and complex systems, Which makes it extremely difficult to design the autopilot. The project divided into mechanical system which is constructed from aluminum sheets that was cut by LAZER CNC machine according to a solid edge design. The selected material is highly corrosion resistant material and can stand high pressure. The electric system in the project consists of 6 Dc motors (bilge pumps), 2 DC-DC converter , one for the motors and one for waterproof Camera,2 Servo motor for the robotic arm and electric fuses to protect the circuit, all the electric system is placed in a survivor box (waterproof box). The ROV is controlled by Arduino Mega with a joystick attached to the computer controlling a 6 motors with their propellers (2 of them are responsible for moving downward and upward ,the other 4 motors are used to move the ROV forward ,backward ,left and right) using Lab View as an interface. The ROV is balanced by using Foam sheets fixed on the ROV’s body. The project Team represents Mechatronics department in AAST Cairo in the local ROV competition and was qualified to the Regional competition. This is the first time for our team to participate in this/any competition.

2. FINANCIAL STATEMENT

Purchases	**Number of Pcs**	**Items price**
Dc-DC converter 48-12v	4	1600 LE
Plasti Dip	2	150 LE
O rings	1	50 LE
Robot arm	1	300 LE
Flotation Foam	1	350 LE
Aluminum sheet 6mm ,LASER cut and manufacturing	1	2300 LE
Arduino prototype Kit	6	230 LE
Arduino Mega + UNO	1	460 LE
CCD underwater Camera	2	1400 LE
5 Blade ducted fan 64mm	10	550 LE
Gland nylon	10	200 LE
USB booster	2	400 LE
RTV silicon	3	200 LE
Plumber Goop	2	120 LE
Waterproof Servomotors	6	820 LE
DVR USB converter	1	270 LE
30 ft USB Cable	2	150 LE
Pressure sensor	3	250 LE
bilge pump 1100 gph	7	2100 LE
Casting Epoxy	2	300 LE
Joystick USB	1	300 LE
H- bridge 10A	6	930 LE
Battery 12V 14A	4	650 LE
B6 charger	1	250 LE
Competition Bank deposit	1	500 LE
Waterproof Case	1	600 LE
Isolation tools	1	800LE
Total		16185 L.E

Purchases for the ROV is shown below in the Table



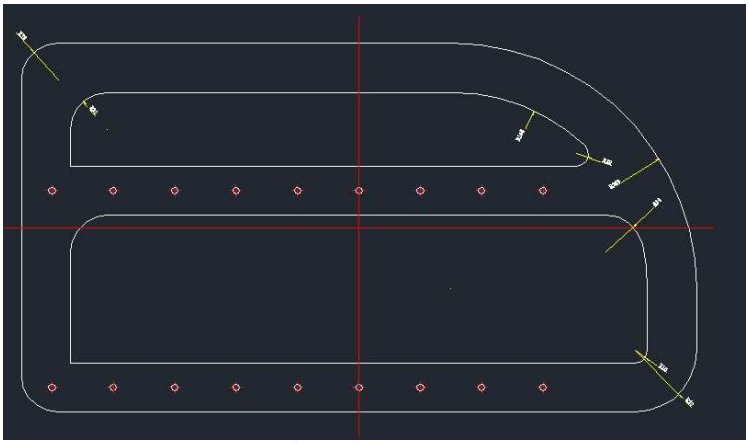
Item Number	Title	Material	Quantity
1	Side Frame	Aluminum, 7075-T6	2
2	Base Frame downward	Aluminum, 7075-T6	1
3	Base Frame upward	Aluminum, 7075-T6	1
4	Connector 1	Aluminum, 7075-T6	1
5	DC motor	Aluminum, 7075-T6	5
6	Propeller	Aluminum, 7075-T6	5
7	Connector 2	Aluminum, 7075-T6	4
8	MS *15	Steel	46
9*	Nut M5	Steel	46

Figure ROV 3D design

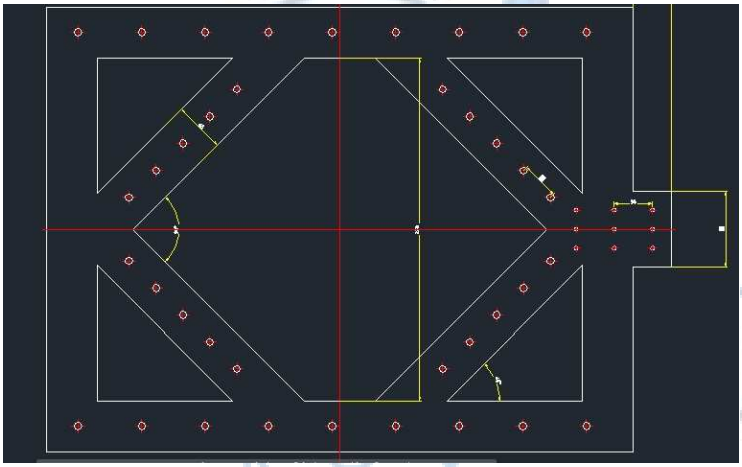
The ROV team designed the project in 3D and 2D by Solid edge and AutoCAD, aluminum sheets were used for its light weight, doesn't rust and withstands pressure, the aluminum sheets were cut using a LASER CNC machine, the ROV consists of 4 main parts constructed with each other to make the ROV .The design has no sharp edges for more safety .Rubbers were placed between the parts to reduce the vibration created by the DC motors.

3.1. AutoCAD design:

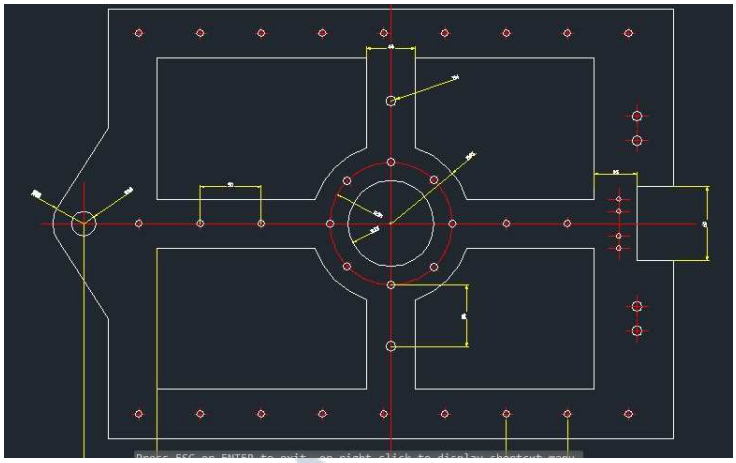
Side Part



Bottom Part



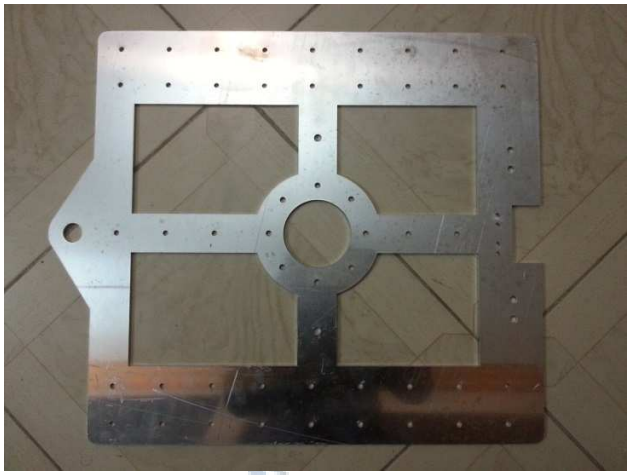
Top part



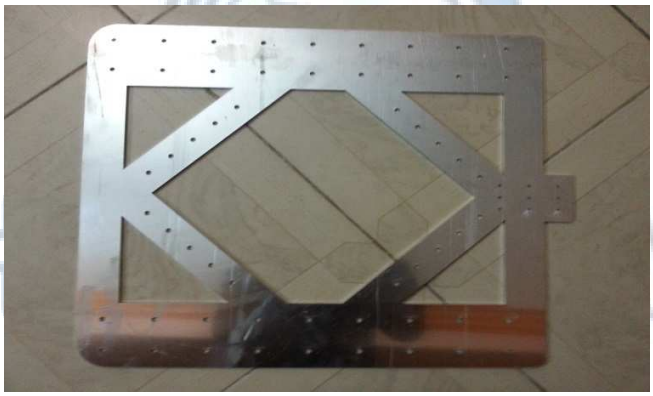
3.2. Aluminum Parts after LASER cutting:

Side Part

Top Part

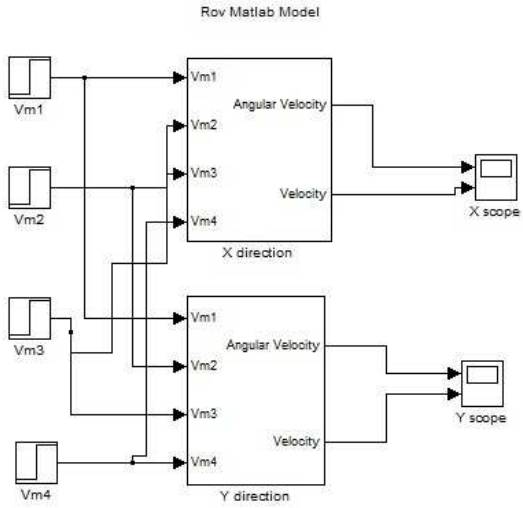


Bottom

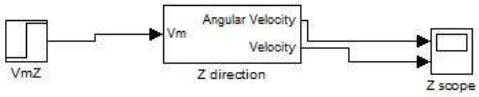


The Design was simulated on Matlab, the control circuit consists of a Dc-Dc converter and an H-bridge, the basic controller is Arduino which controls the H-bridge that is connected to DC motors which are controlled through a joystick connected to the labview .Arduino UNO to control the servo motors on the robot arm , all the control circuits are sealed inside sealing waterproof box which has holes for the wires to pass through .Nylon glands fixed in these holes and isolated by silicon and Plumper Goop.

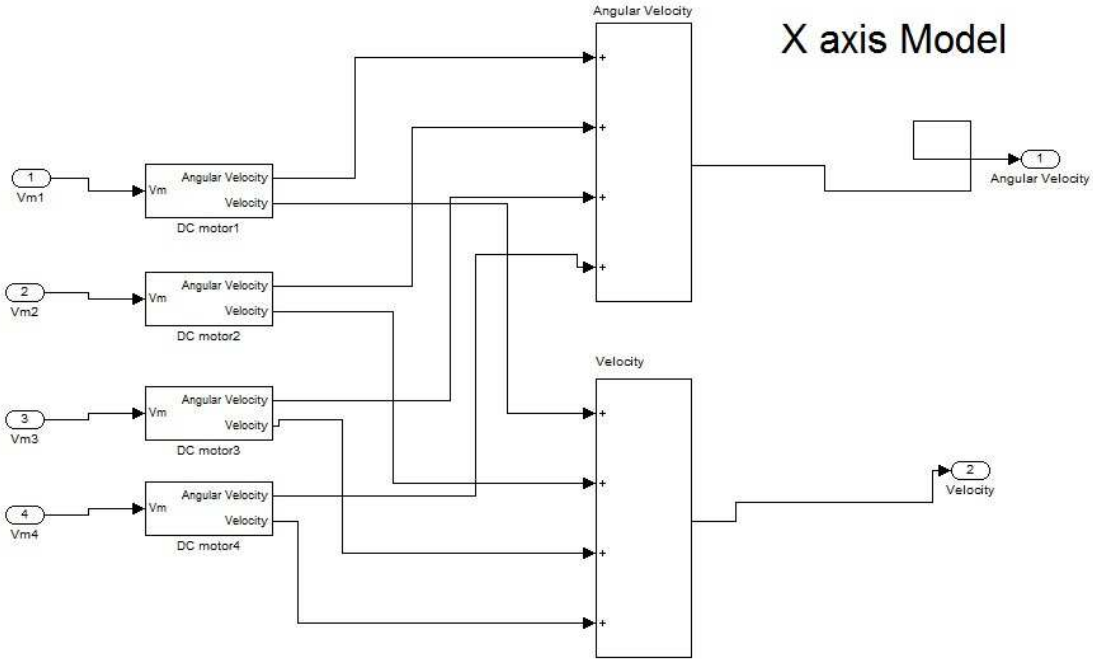
4. Matlab Simulation

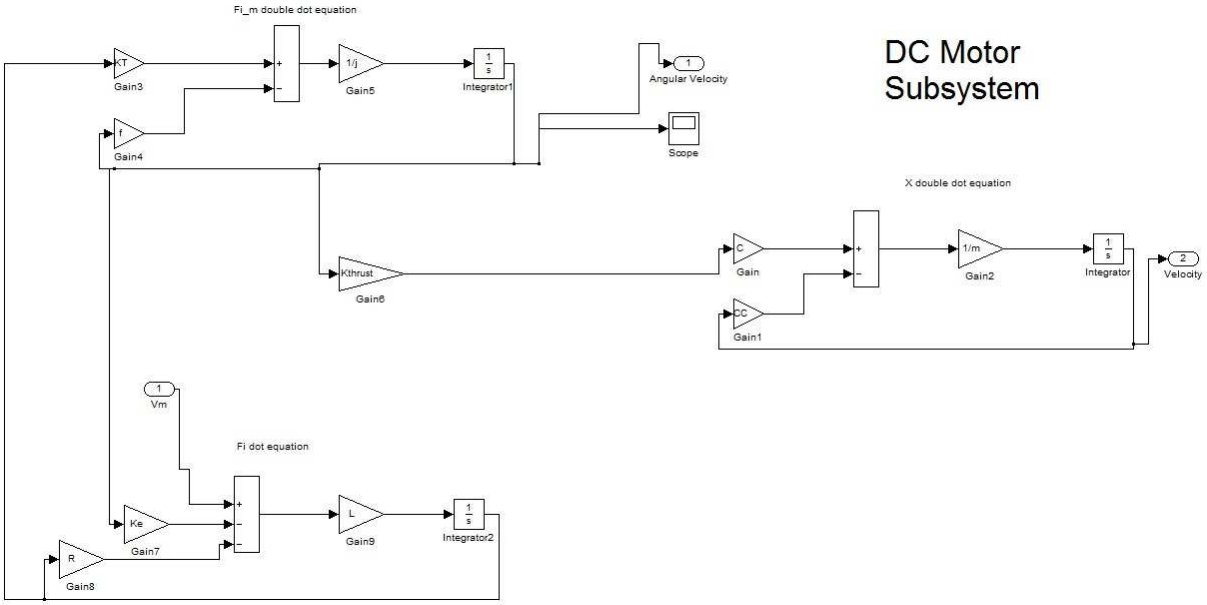


3 Directions Matlab Model



X axis Model




Fi_m double dot equation
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Gain3
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Integrator1
1
Angular Velocity
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Scope
DC Motor Subsystem
X double dot equation
Kthrust
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Integrator
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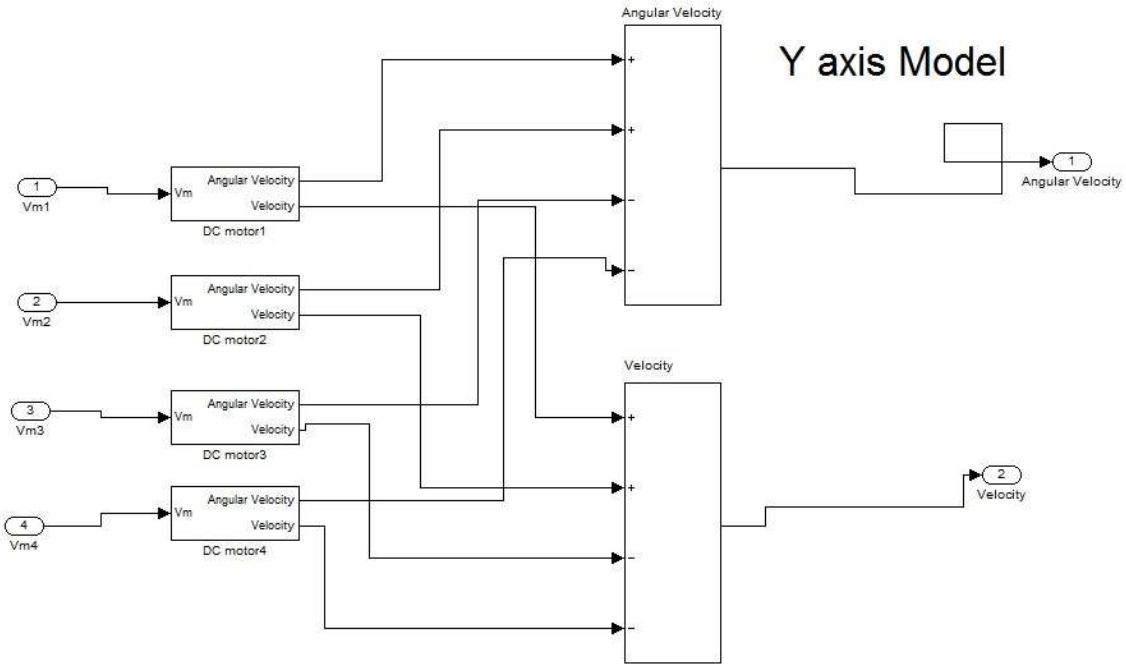
Angular Velocity
Y axis Model
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Vm1
Vm
Angular Velocity
Velocity
DC motor1
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Vm2
DC motor2
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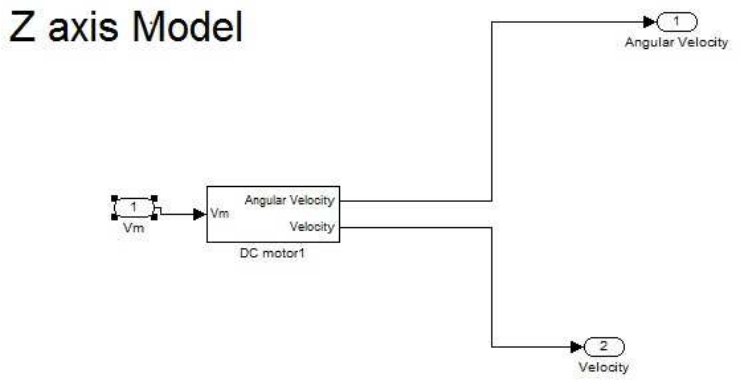
Vm3
DC motor3
4
Vm4
DC motor4
Velocity
1
Angular Velocity
2
Velocity



5. ROV Components

5.1. Bilge Pump:

The Bilge pump used in this project is a fully submersible pump has a silent and vibrartionless operation it is mainly a Dc motor that is covered and sealed, it will be controlled by Arduino circuit through an H-bridge. This pump is ignition protected doesn't burn out when it runs dry, has rust and corrosion protection. The pump will not pull water up to itself its discharge hose must run continually upwards, if the polarity was reversed the pump will run at 20% capacity,

5.2. Specification about the pumps operation:

It operates at 12.0 Volts and consumes (7 - 7.5) amps

Its fuse size is 10 amps

Its discharge opening is 1-1/8"

Its housing material is ABS

Its strainer material is ABS

The impeller is made of nylon

The shaft is made of stainless

May withstand up to 200F

Its typical life time is 1500 hrs

It weighs 10 oz, 4-1/4” height, 2-3/8”width and 2-3/8” in depth

5.3. H-Bridge 10A:

Enhanced 10 amp Dc motor driver

MD10C is designed to drive high current brushed DC motor up to 10A continuously. Such as support for both locked-ant phase and sign-magnitude PWM signal as well as using full solid state components which result in faster response time and eliminate the wear and tear of the mechanical relay.

5.3.1. The MD10C has been designed with the capabilities and features of:

• Bi-directional control for 1 brushed DC motor.
• Support motor voltage ranges from 3V to 25V.
• Maximum current up to 10A continuous and 15A peak (10 second).
• 3.3 V and 5V logic level input.
• Solid state components provide faster response time and eliminate the wear and tear Of mechanical relay.
• Fully NMOS H-Bridge for better efficiency and no heat sink is required.
• Speed control PWM frequency up to 10 KHz.
• Support both locked-antiphase and sign-magnitude PWM operation.
• Dimension: 75mm x 43mm

Before using the MD10C, user needs to determine the power source for the board by using The on board jumper. By default, VIN is selected as the board supply and this can be used in all cases. In this mode, 12V must be supplied to the VIN pin at the input port.

If the MD10C is used to drive a DC motor from 14V – 25V, the board can be optionally powered by the motor power input. To do so, just select PWR by using the onboard jumper.
In this mode, the VIN pin at the input port can be left unconnected.

5.4. Servomotor:

Is a servo mechanism. More specifically, it is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is either analogue or digital signal, representing the position commanded for the output shaft.
The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

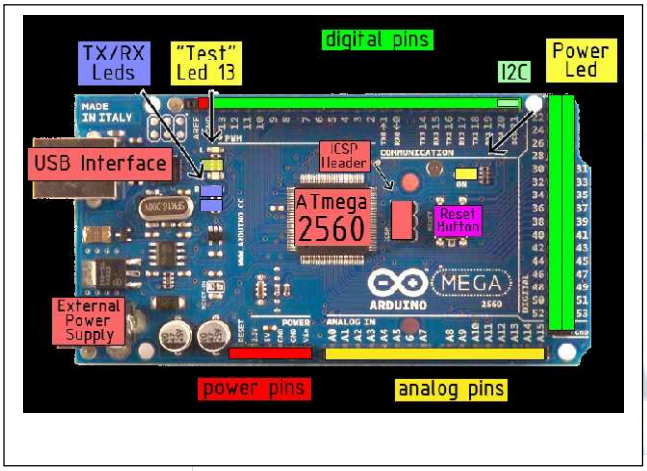
5.5. DC-DC Converter:

DC-DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltage declines as its stored power is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing.

Most DC to DC converters also regulate the output voltage. Some exceptions include high-efficiency LED power sources, which are a kind of DC to DC converter that regulates the current through the LEDs, and simple ‹ ltage.

5.6. Arduino Mega 2560:

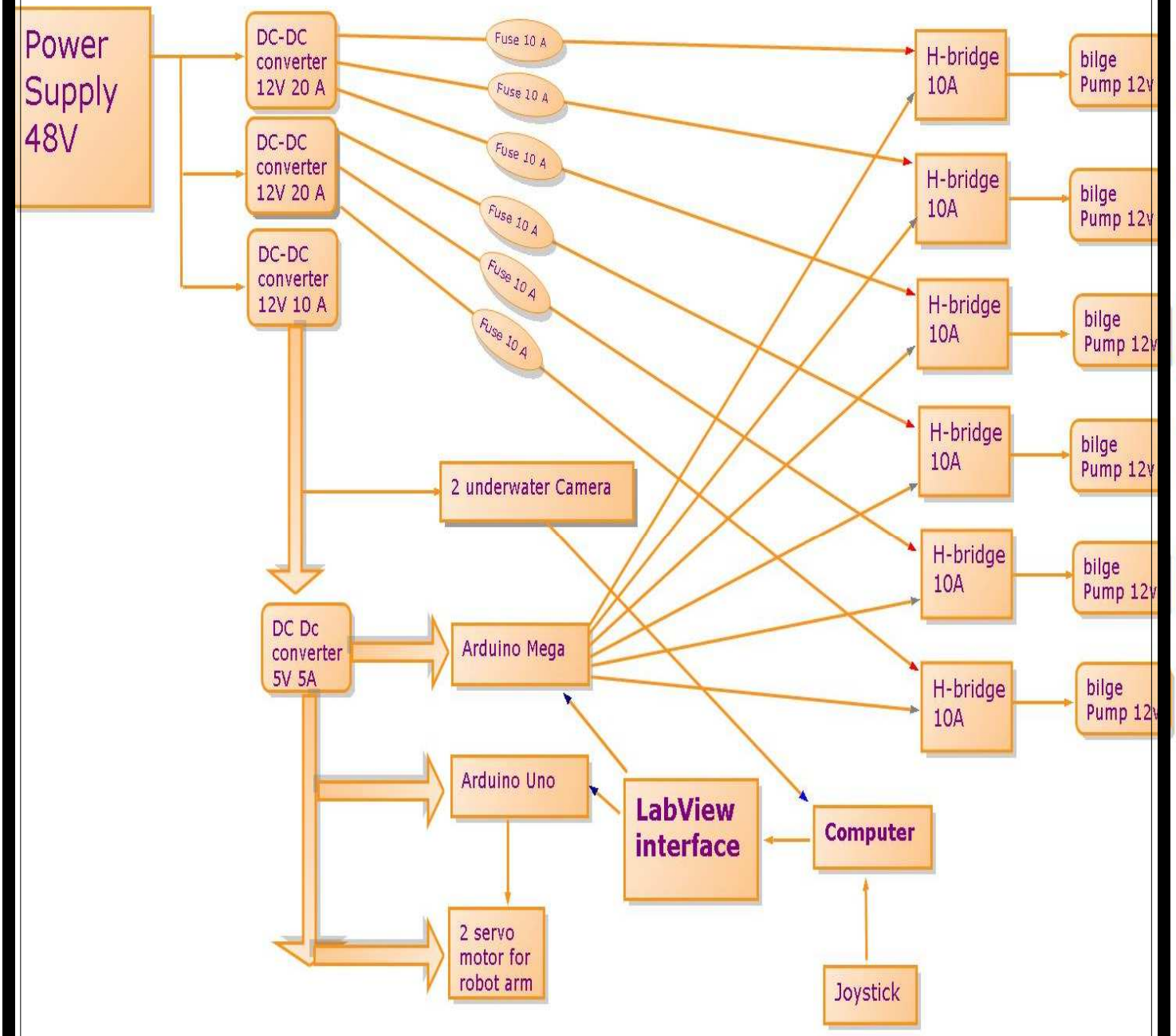
The Arduino Mega 2560 is a microcontroller board based on the ATmega2560
It has 54 digital input/output pins (of which 14 can be used as PWM outputs),
16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB Connection, a power jack, an ICSP header, and a reset button. It contains everything Needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.



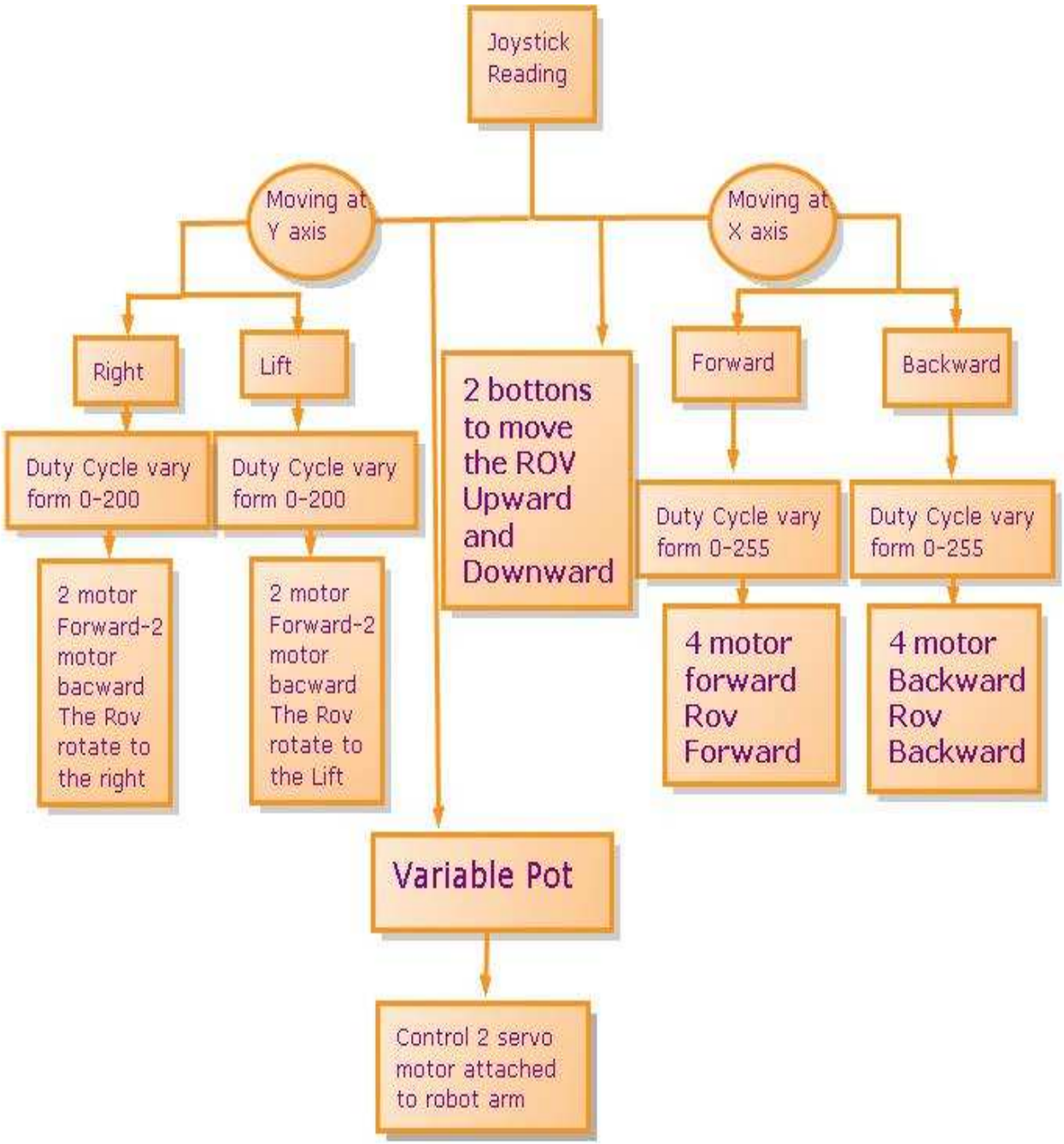
5.7. Robotic arm:

We assembled the pre-design robotic arm and added the servomotors to control the robotic arm .The arm is made of aluminum and have two degree of freedom.

6. Electrical schematic



7. Software Block Diagram



8. SAFETY

8.1. Circuit breaker:

This circuit fixed to the positive feed of the ROV power and it automatically operated when the ampere exceed to 40 ampere.

Circuit breakers can cut the electricity supply when a fault is detected to protect an electrical circuit from damage caused by overload or short circuit.

8.2. Fuses:

6 fuses are used before each motor to provide them from an over current protection.

8.3. Dc-Dc converter:

3 Dc-Dc converters are used to distribute the power. When one of the Converters damaged the ROV can still do his functions partially.

8.4. Waterproof Box:

The box contains all the electronics components. The Box is watertight and sealed with oil-ring. It can easily open to keep the require maintenance for the damaged components.

8.5. Isolation:

The wires that pass through the box are sealed using Nylon gland and isolated by RTV silicon and Epoxy.

9. Challenges

1- Travelling to Alexandria several times to search for the suitable propellers and totally sealed camera.
2- Finding the components used in the ROV (bilge pumps, propellers, Dc-Dc converters), so we bought these components from China and USA.
3- Choosing the sealing tools was also a challenge, since it is the most critical problem faced underwater.
4- Travelling to participate in the competition by the ROV and the tools needed was a problem in carrying and transporting.
5- During the competition there was a critical problem that caused a huge delay in the time of the two trials that was because of using a single electrical fuse for the whole circuit including the H-Bridges, Dc-Dc converter and the 6 Dc motors, so we wasted a long time in changing this electrical fuse.

6- The camera used was not a waterproof camera, so we tried to seal it as much as we can, but unfortunately water entered between the materials used in sealing, so the camera went off.
7- Using a small single-axis (horizontally) robotic arm, made the bowling pins catching process so difficult.

10. Skills gained and Reflections on the experience

During design and building process we gained a lot of skills that improved our characteristic and improve our knowledge. Experiences and skills we gained is the real award from participate in the competition.

This is some of our gains:

1- **How to use interfacing through labview program with Arduino control :-**

This control enables the pilot to control the ROV by a joystick very efficiently and it gives more accurate orientation under the water.

2- **Different methods of isolation:-**

The Team learned how to use Different material like silicon to isolate the different electrical parts; servo motors and control box .To make sure, the control units were kept isolated from water.

3- **Decreasing vibration of the ROV :-**

Pieces of rubber were used under the ROV motors to decrease its vibration and keeping the bolts and nuts from untangle .Vibration may cause inaccurate movement under the water

4- **Use fuse and electric breaker** :-

Protect electronic components and control from over-current loading in order to be safe.

5- **Facing problems and overcome them**

The Team learned how to face problems whatever how big the problem by working hard ,working as a team .Putting our trust in Allah then everyone in the team then choose the reasonable solution.

6- Learn how to achieve our goal and how to try every possible way to achieve it and learn from who has the experiences to help us.

11. Discussion of future improvements:-

There are a lot of improvements which we can use it to improve the ROV performance in the future. These improvements allow the ROV to do more tasks and allow the pilot to control the ROV much easier.

1- Design the ROV with pressure sensor to help the ROV not to pass the allowable depth.

2- Modify the ROV with Arduino auto pilot kit that make the ROV more stable with environmental changes.
3- High definition camera will be added to improve the vision of the ROV pilot under the water.
4- Master slave arm is a highly controlled arm this enable the pilot to control the ROV and the arm in the same time.
5- Sonar sensor that helps the pilot to see any objects can not seen on the camera .that prevent any collision happen to the ROV
6- The camera will be able to move around Z- axis that will help the pilot to control the view sight.

12. References

[1]www.nts.no/norsok.Last access (5/10/2012).

[2] The ROV Manual Robert D. Christ, Robert L. Wernli (page 208).

[3]http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html. Last access (6/10/2012)

[4]http://dwiajengpramesti.wordpress.com/2010/05/06/rov-remotely-operated-vehicle. Last access (6/10/2012).

13. Acknowledgment

First we would like to express our deep gratitude to Hadath and MATE Center for their great effort in making this competition organized and gives us the opportunity to participate in such event.

We would like to express our deep gratitude to our supervisor and mentor **Dr. Sameh Shaaban** for his guidance, suggestions and invaluable encouragement in our graduate education and throughout the development of this project. He was very enthusiastic about the project, which gave us a motive to work harder and harder.

Then we would like to present our greatest gratitude for the help and support of the following people:

1. **Dr. Salem Haggag**, for his support on this project. And, for his great supervision along our years of learning.
2. **Dr. Mostafa Rostom**, Head of the Mechatronics department of the Arab academy for science and technology by providing mechanical solutions.
3. **Dr. Hesham afifi** for his great effort.
4. **Captain. Khalid gad elmowla** for his great effort.
5. **Eng.Amany Khalid** Graduate teaching assistance at AAST, for her help and support.

It is difficult to acknowledge everyone who was involved in preparation of this project by name. Nevertheless we appreciate their contribution no matter how simple it might have been.

Finally, we would like to thank our parents for their endless given, trust, encouragement, and support throughout our life.