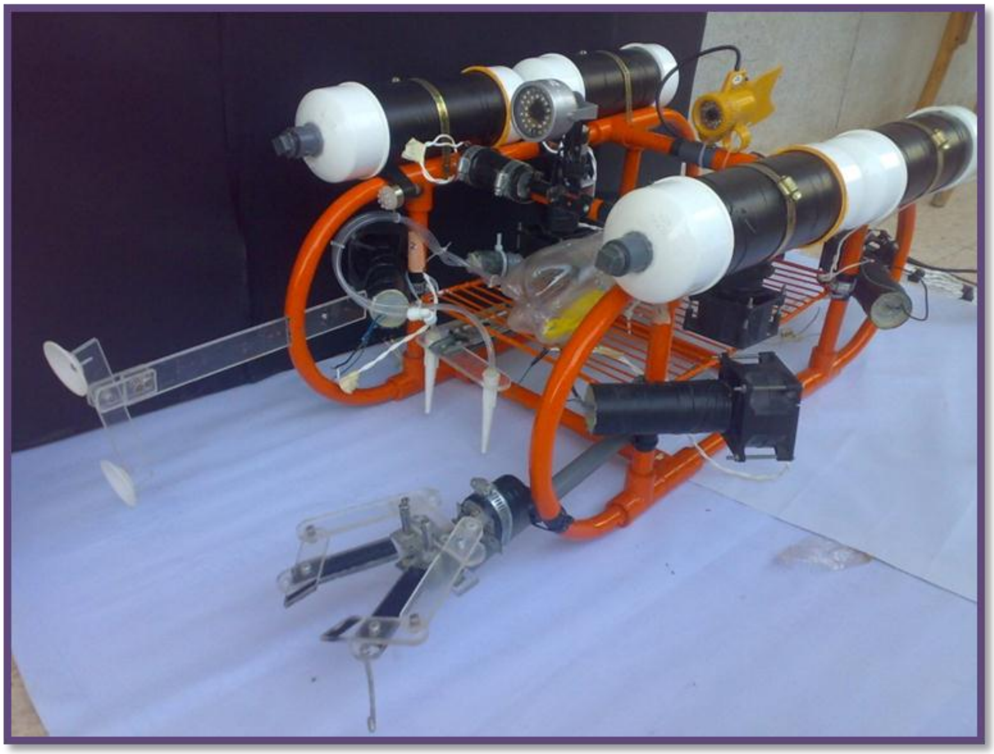
CAETUS TEAM
2012 MATE ROV international competition
Mansoura university,Mansoura,Dakahliya.
EGYPT



EXPLORER CLASS
CAETUS TEAM – TECHNICAL REPORT

Mentors		
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CAETUS members	Position
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Abstract

CAETUS was designed to work as EXPLORER CLASS ROV to participate in MATE competition 2012 and it can face the challenge of recovering and finding of shipwrecks , the potentially hazardous material and fuel oil that is one of the residue world war II.

The vehicle is designed to dive into history and find ship wrecks to identify the ship sinking circumstances, identify the environmental conditions around the wreck, the danger rate caused by the wreck on the environmental area around it that is an important part of the oceans world

In this report we are going to give a feedback about our work, steps and challenges that we faced and also what we learned over this experiment.

The vehicle can find wreck ships and snap live pictures of the wreckage site by using a camera to determine the length of the wreck, and also determine the orientation of the ship on the seafloor.

It can determine if the debris piles are metal or non-metal using Electronic circuits. We designed the left bag to be Inflating by a compressor that enables it to remove the fallen mast from the worksite.

Our CAETUS is Equipped with a manipulator to recover coral reefs and penetrate the fuel tank discharging it safely without damaging the surrounding water to avoid environmental pollution.

Our CAETUS consists of 7 motors to give it a horizontal and vertical motion. Another two were added for the camera and manipulator.

Figure 1: CAETUS TEAM

Budget

Purchases	QTY	Price EGP
Motors	11	440
Fan	14	70
Wires	20 M	540
PVC	8 meter	35
Camera 1	1	200
isolated camera	1	500
Easy cab	2	100
Silicon	5 bottle	37.5
Glue	1 box	37
Paint Spray	5 bottle	37.5
Thin plastic	2m	From home
compass	1	50
Electronic component	100	400
switch 2 way	4	5
switch 3 way	4	15
Travel	4 times	340
	--	
Mechanical component	Strap	25
acrylic	12cm*70cm	30
Used Gear	7 piece	10
screws	30	10
Additional cost	***2882 EGP*** ***480.3$***	
Source of money	Team members & our university	

Table 1: Detailed Team Budget

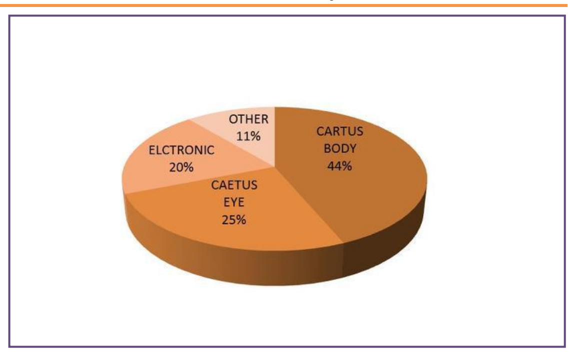

Figure 2: Team Budget

Design rationale

During the design phase we tried to design a simple and easily implemented ROV. We started studying about ROVs, searching the web and MATE web-site. Our mechanical team made some meetings to discuss different ways of ROVs manufacturing and we decided to work using the *wet hull* design concept because of its high stability.

We used PVC with length of 82 cm, width of 38cm and 32 cm height. We made our free hand sketch, and after a long discussion about the design, it was confirmed by the team members then we drew it on CAD as in figure (4).

Our team had a previous experience in robotics competitions concerning the performance of specific operations. We could summarize our design concept as follows:

1. Stability and efficiency.
2. Smooth Shape.
3. Ease of implementation "Simplicity".
4. Modularity.

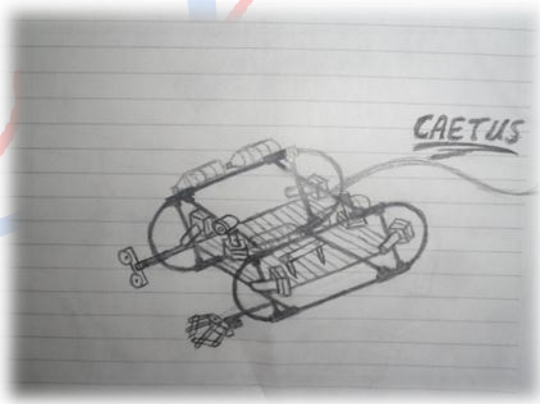

Figure 3: ROV Hand Sketch

Overcoming the Drag force

The smooth shape of our ROV using $\frac{1}{2}$Inches PVC pipe was chosen to reduce total friction about the edges. We took care that the shape of the arc must be a half circle and that enabled it to move freely under water. We have reduced the skin friction by using a small size PVC and using a grid instead of solid plate in the ROV bottom. We have also painted the total surface to retain a smooth and good-looking.

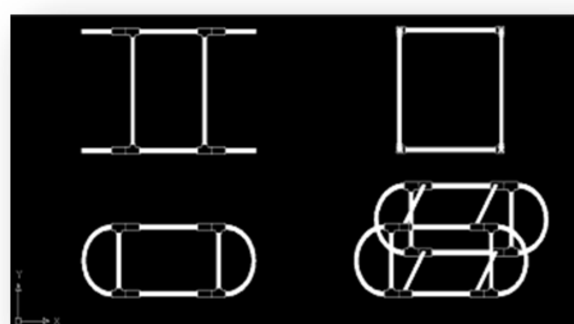

Figure 4: CAD Design

Calculations

Volume of ROV

Total volume of the body (without motors, arm and other instillation)

$= (3.14/4)*((2.2)^2)*595= 2260.643\ cm^3$

Volume of motors (6) $= (3.14/4)*(5)^2*12*6=1413.717\ cm^3$

Total volume (neglecting arm and other instillation)

$= 1413.717+2260.643= 3674.36\ cm^3$

Bouncy force =the density of fluid * the total volume of body * gravity force

$= 1000 *3674.36 *10^{-6} * 9.81$

=36.045N

Required air tanks volume

$W=Fb + Fb_{air\ tanks}$.

W= 9.9*9.81=97.119 N , Fb = 36.045N

$Fb_{air\ tanks}$ = W- Fb = 61.074N

$Fb_{air\ tanks} = V_{tanks}$ * density of fluid * gravity acceleration

V_{tanks} = 61.074 / (1000*9.81) = 6.225*10^-3 m3

V_{tanks} = 6.225 liter.

The tanks

Our tanks were divided into four tanks distributed on ROV frame. In the regional competition the tanks were empty bottles, due to the depth of the international competition we decided to replace them with a PVC tanks to resist the high pressure as the bottles usually gets compressed by it affecting the buoyancy and causing us other problems.

Propulsion system

Driving the ROV needs a driving force -called thrust- to be greater than the total towing resistance. The towing resistance is the combination of forces working against the direction of motion. The main forces in this towing resistance are the total drag force.

Thrust

Seven motors were used for propulsion system. The motors were unsuitable for working under water so it was one of the most challenges we faced. A silicone tube was found by the same size of the motors and has a cap to close its end. It was the perfect choice and we had them already so we saved money.

ATX power supply fans are used in replacement of propellers, it supposed to work with air dynamic but we found that, it is suitable for our motors, cheap and available.

Thruster preparation process

The motor was put inside empty silicon tube, putting silicon, closing its end by the tube cap and finally putting Rolling bearings with oil seal on motor rotary shaft. a coupling is made to couple the shaft of motor with the power supply fan, a housing nozzle for the fan is made to ensure high motors protection and avoid human injures that might be caused by the fans and protect them.

Figure 5: Fans

Figure 6: Thruster Component

Motion plane

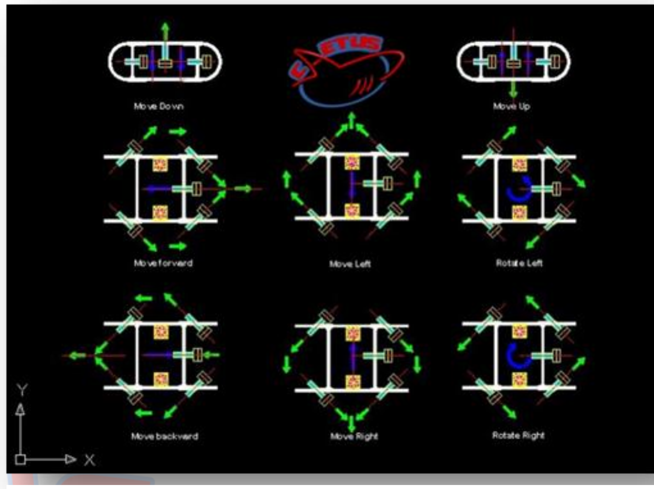

Figure 7: Thruster directions and movements

We installed six motors to give the vehicle up-down, left-right, forward-backward motions and rotate the vehicle left-right.

Four of them are fixed by 45° angle to achieve all possible horizontal movements with minimum number of motors. The other two motors are used for vertical motion. A 7th motor is installed to enhance the speed for forward-backward movement when needed.

Manipulator (Gripper)

Figure 8: Completed Manipulator

A fixed manipulator was placed in the front of the vehicle for accomplishing a wide variety of tasks. The Gripper is made of acrylic-sheet parts and put together with screws. We connected it to a gearbox for opening and closing with an appropriate speed and power.

The Gearbox consists of 7 gears to transfer the movement; we can reduce speed and increase power of motor to hold different required targets. Worm gear is the leader of the group therefore the group movement comes only from the motor (self-lock).

Arm Motor specifications:

Name : Copal Ax040097 Hg37-060-ab-04.
Manufacturer : Copal.
Motor Number : AX040097.
Voltage : 24V DC.
Force : 19.6N.CM.

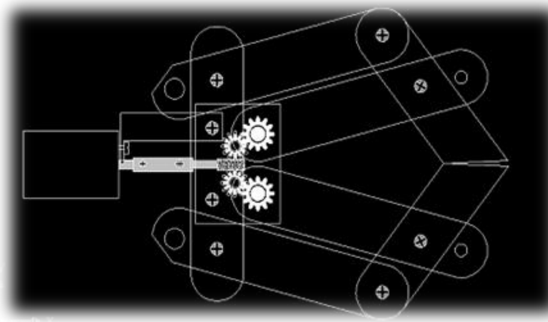

Figure 9: Manipulator CAD Design

Pumping system

We developed a new technique that uses one pump for sucking the oil and expelling the salty water at the same time and the same flow rate.

Process:

1. Penetrate two holes using two plastic cones.
2. Pump will suck the fuel oil into a balloon, using a unidirectional valve to allow the fuel flow inside the balloon and prevent the balloon to push the oil out from it again.
3. The balloon will expand compressing the salty water in the bottle forcing it to flow out of the bottle. We have used another unidirectional valve to allow the salty water flow out without allowing any surrounding water to enter.

Pump Specification:

Name : Window shield Washer Pump (YC 607)
Model : YC-608
Displacement : 1800ml/min
Durability : 12V or 24V

Figure 10: Pump

Lift Bag

Left bag was made from water proof cloth. We used 23 meter of hose connecting between the compressor and ROV. There was a small piece of cork to save the lift bag in upright position. A hook was fixed to the left bag to enable it to carry things.

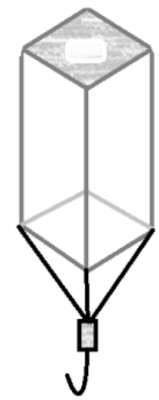

Figure 11: Lift Bag

<u>Specifications</u>

- Weight of fallen mast = Bouncy force of lift bag
- $W_{Mast} * g = V_{Lift\ bag} * \rho_f * g$

$W = 8$ kg $\rho = 1000$ kg/m^3 ➔ $V = ??$ m^3

$8*9.81 = V*1000*9.81$

So volume must be: $V_{Lift\ bag} = 8/1000$ m^3 $= 8$ liter $= 8000$ cm^3

Vision system

We used two cameras one of them was already isolated and the other one was isolated by us later. We filled them with glue in order to keep the original camera body without putting it in an isolation cap.

Figure 12: Cameras

We opened the camera, filled it with glue then reclosed it making sure that glue is on all inner components.

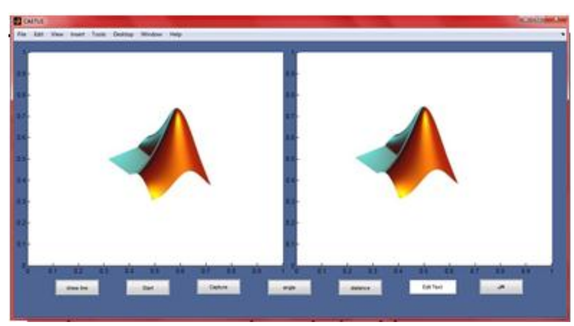

Figure 13: GUI

GUI and Image processing

Our GUI -Graphical User Interface- was made by MATLAB, as it is strong and rich by GUI tools. The GUI as shown consists of buttons for starting video and capturing image to process it, also contains space for processing to calculate length and angle of the wreck. A text box for getting real length, finally button for Exit.

Length/Angle

The idea is to capture an image from a live video of the wreck, determining the bound and edges of objects. We call a MATLAB function that makes processing on the captured angle.

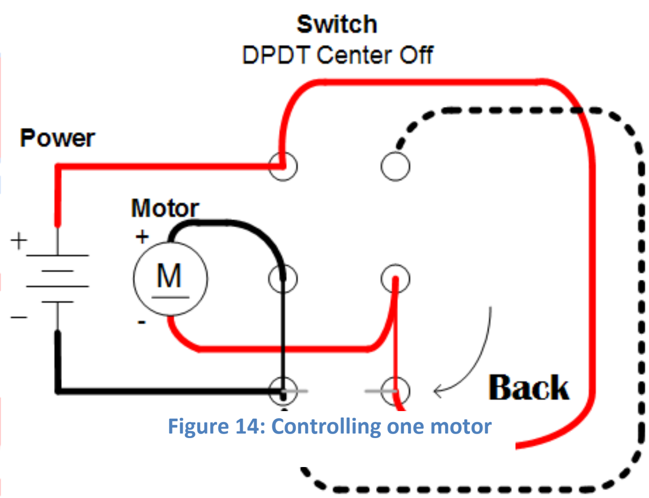

Figure 14: Controlling one motor

Electronic House

Control Box

Electronic circuits are the heart of our CAETUS. Simplicity, Safety, and comfort for the pilot were our goal. There were many methods controlling a motor direction but we chose the simplest method "switches". Reversing a motor direction simply change the motor terminals or reverse the supply voltage itself. We have done both in our motors control. We used a DPDT -Double Pole Double
Through- switch as in fig (14).

Switches

A DPDT switch has two or three states as in fig (15). The idea of using this concept of controlling the thruster directions came after creating table (2).


Figure 15: Switches

We have found that there are thrusters that work in the same direction while moving in some other direction.

Motor / Direction	Mot1		Mot 2		Mot 3		Mot 4		Mot 5		Mot 6	
	A	B	A	B	A	B	A	B	A	B	A	B
Forward	0	1	0	1	0	1	0	1	-	-	-	-
Backward	1	0	1	0	1	0	1	0	-	-	-	-
Right	0	1	1	0	0	1	1	0	-	-	-	-
Left	1	0	0	1	1	0	0	1	-	-	-	-
Rotate C.W	0	1	0	1	1	0	1	0	-	-	-	-
Rotate C.C.W	1	0	1	0	0	1	0	1	-	-	-	-
Up	-	-	-	-	-	-	-	-	0	1	0	1
Down	-	-	-	-	-	-	-	-	1	0	1	0

Table 2: Movements configuration

Note: GND=0, Volt=1.

Horizontal movement control

Four thrusters have to move in some direction to perform a specific move. A DPDT switch is added to each thruster. The first motor takes its input from the source power while the other three powers are connected in parallel with the first motor. Now there is a main switch that controls the power source polarity and the other three switches is to control the direction of each thruster with some configuration shown in table (3).

	SW1	SW 2	SW 3	SW 4
Forward	↑	↓	↓	↓
Backward	↓	↓	↓	↓
Right	↓	↑	↓	↑
Left	↑	↑	↓	↑
Rotate C.W	↓	↓	↑	↑
Rotate C.C.W	↑	↓	↑	↑

Table 3: Switches Direction

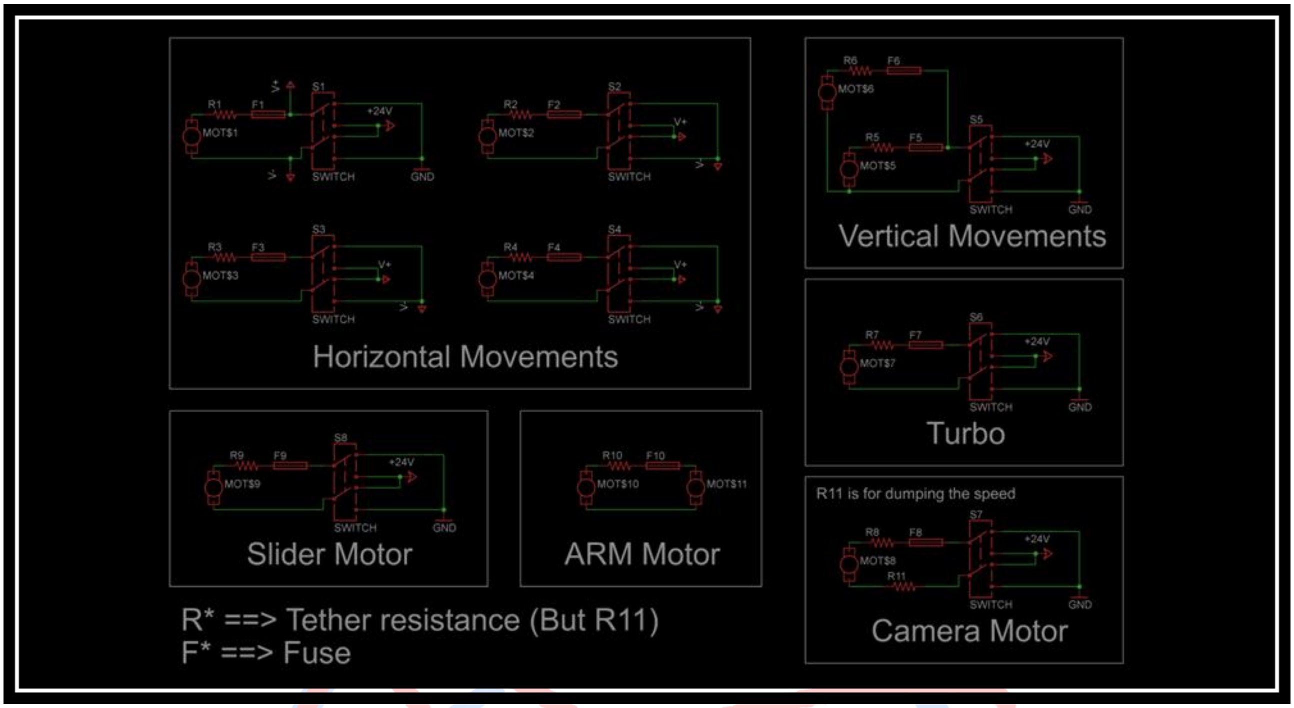

Figure 16: Controlling Motors

Junction box

It has all the connections of the terminal blocks and fuses. LEDs are supplied to indicate which motor is on.

Fuses

A fuse contains a short piece of wire made from alloy that melts quickly cutting the traffic stream in case of extra load. It is connected series on the positive side of each thruster. A main 40A fuse is added on the main power to insure that ampere don't exceed the rating of the power supply.

Tether

Figure 17: Tether

The Tether is considered as the arteries and veins. After searching and asking many shops and making our tests, there were many different types of wires. The challenge was to choose the best, durable, cheap and highest quality material. We chose a 25*1 cable to cover all the connections of the ROV. Every cable has a resistance. The Resistance of this cable per 20 meters is 2.1 Ω out of water and in the water is nearly 2.5 Ω. Every Thruster consumes 5A, hence and according to Ohm law the voltage drop will be around 12.5 Volts and the motor can stand the 35.5 volts with no problems.

Metal Detector

We wanted to test and detect metal from plastic. Generally metal detectors use one of three technologies:

1. Very low frequency (VLF)
2. Pulse induction (PI)
3. Beat-frequency oscillation (BFO)

None of them was used but we used the concept of the BFO. A 555 timer circuit is used to oscillate depending on the coil inductance. As the inductance changes the output frequency do so. The output can be taken on a speaker or a head phone. Its sensitivity wasn't so good; here comes the use of reading the previous technologies. We used the same concept of BFO. We used two 555 timers to generate oscillation depending on the coils. Coils are rectangle in shape and put on each other to increase the overall inductance. The output is taken on a headphone and connected to the output of the two timers. It senses just the different in frequency that happens when a metal exists and that's what the aim was.

Time and frequency has inverse relationship. When a metal exists, the periodic time increases and frequency decreases. That is what appears on the oscilloscope in fig (18).

Figure 18: Oscilloscope Output

The Schematic Diagram:

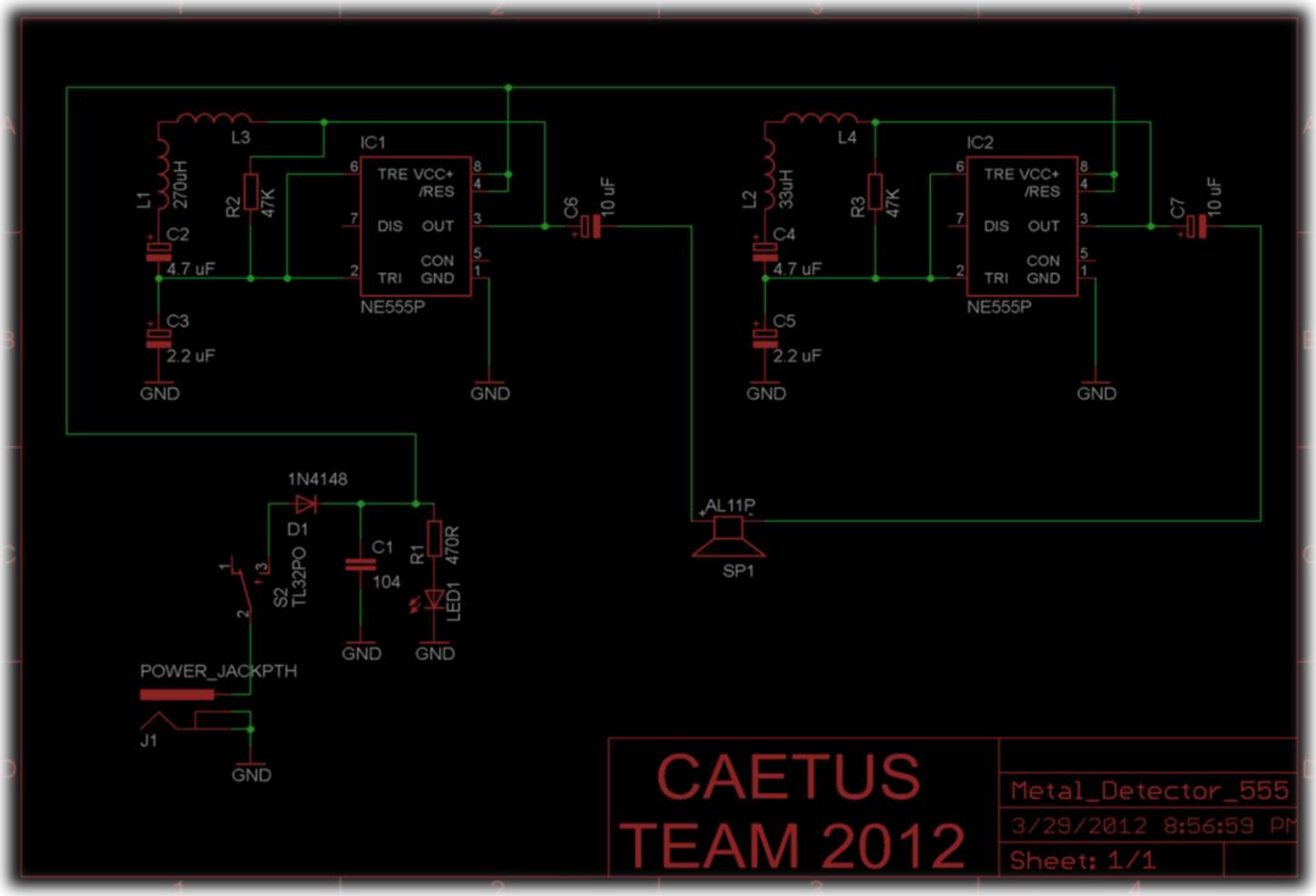

Figure 19: Metal Detector Circuit

Parts list:

Part	Value	Description
C1	104	Ceramic CAPACITOR
C2	4.7 µF	POLARIZED CAPACITOR
C3	2.2 µF	POLARIZED CAPACITOR
C4	4.7 µF	POLARIZED CAPACITOR
C5	2.2 µF	POLARIZED CAPACITOR.
C6	10 µF	POLARIZED CAPACITOR
C7	10µF	POLARIZED CAPACITOR
D1	1N4148	DIODE
IC1	NE555P	General purpose bipolar Timer
IC2	NE555P	General purpose bipolar Timer

Figure 20: Enameled wire

J1	--	Power Jack
L1	270µH	INDUCTOR
L2	33µH	INDUCTOR
L3		Winded from 0.3 mm enameled wire- Rectangle 12 cm*5 cm
L4		Winded from 0.3 mm enameled wire- Rectangle 12 cm*5 cm
LED1	RED	LED5MM
R1	470R	RESISTOR
R2	47K	RESISTOR
R3	47K	RESISTOR
S2	--	SWITCH

Figure 21: Metal Detector

The gripper power

We have used a special way to control the arm motor. We connected a motor in parallel with it. The other motor acts as a generator as a current flows while rotating it. That gives us accurate control on the motor.

SAFETY

Safety is one of the most important standards that have been taken into account during the stages of designing OUR CAETUS we took into account safety in the following terms:

1. Design: the selection of design to be a smooth surface with no sharp edges.
2. Motors: Isolating motors with safe materials, putting fuses.
3. Thrusters: Propellers are covered to keep it away from anything would reach it; hence no one would be harmed.
4. We put safety labels for less safe parts in the ROV.

Acknowledgment

High performance teams do not result from nothing. But they are grown, nurtured and exercised under supervision. We are grateful to MATE center as it enabled us to break the ice with ROV and we gained a lot from that experience, like the team work ,feeling like we play a role in the work being done and generating a diversity of ideas.

We are although thankful to MATE and Hadath company for allowing such competition to enter Egypt, thankful to our Mansoura University for facilitating out work. Thanks for the team members.

Prof. Mohamed Fanni is our Godfather and technical support, also Prof. Mohamed Sherif and our college stuff. Other support like financial, technical, logistical, are stems from our co-operative members. We can ever deny the role of our parents, friends and also our pacemaker Hanaa Jossef.