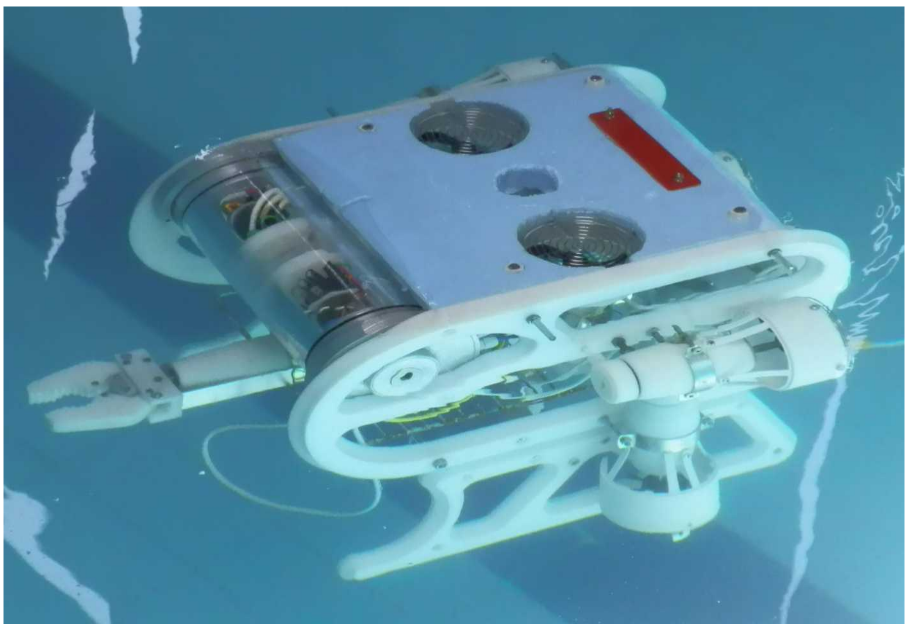
2013 CAETUS Technical Report

Mansoura University
Mansoura City, Egypt
2013 MATE International ROV Competition
Explorer Class

CAETUS COMPANY
ROV INFINITY



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Abstract:

CAETUS Co. has designed and constructed ROV INFINITY to meet and exceed the requirements set forth by the 2013 MATE ROV Competition. INFINITY ROV was designed to perform the required tasks on the regional cabled ocean observing systems. The manufacturing process of the ROV took us about 31 Weeks.

ROV INFINITY will be able to complete a primary node and install a secondary node on the seafloor, install a transmissometer to measure turbidity over time, replace an Acoustic Doppler Current Profiler (ADCP) on a water column mooring platform, and Locate and remove bio-fouling from structures and instruments within the observatory.

ROV INFINITY has an optimal design that gives it a smooth fly in water. Polyethylene was chosen for the body design and motor insulation. It has four thrusters for horizontal movement and two thrusters for vertical movement. Payload tools have been designed specifically for the mission including two grippers, and a transmissometer. The manipulator is designed with special features easing the mission completion. All the on-board electronics and control circuits were insulated inside a watertight enclosures. The control system, programmed in C#, is based on client-server architecture and implements a three-tiered architecture. Total expense for the development of the vehicle is *$1310.6*.

The remainder of this document covers the design process and specifications of ROV INFINITY.

Standing (From left to right):
Asmaa Raslan, Eng. Hanaa Zein El-Dein, Eng. Belal El-Naghy
Sitting (From *left to right):*
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Table of Contents

BUDGET AND FINANCIAL STATEMENT....4
Sponsorship....5
Design Rationale....5
Frame....5
Propulsion....6
CAMERA....7
HOUSING....7
MANIPULATOR....8
Electronic unit....8
Motor Controller....8
Power conversion....9
LED Lights....10
Breakout Board....10
TETHER....10
Tether Control Unit “TCU”....11
SOFTWARE....11
Graphical User Interface....12
Firmware....13
MAGNETOMETER (LSM303DLH)....13
Joystick....14
Payload tools....14
Task 1....14
Task 2....14
Task 3....15
Task 4....16
Safety Procedures and Precautions....16
Challenges....16
TROUBLESHOOTING TECHNIQUES....17
Lessons Learned....17
Reflections....18
Future Improvements....19
Acknowledgment....19
Teamwork and organization....20
References....20
Appendix A: Electrical block diagrams....21
Appendix B: Circuit schematics....23
Appendix C: Programming flow chart....25

BUDGET AND FINANCIAL STATEMENT

*	Item	Quantity	Price /unit ($)	Total price ($)
Mechanical	Thruster	13	20.3	263.9
	Electronics Container	1	165.0	165
	Polyethylene ROV body	-	120.0	120
	Manipulator	2	25.0	50
	Payload Electrical container	1	6.50	6.5
	Glue and Sprays	-	5.40	5.4
	Polyurethane Foam	-	8.10	8.1
Electronics and payload	Motor Driver	15	8.10	121.5
	Power converter	3	14.8	44.4
	PCB Sheet	-	12.2	12.2
	Tether	20 M	-	40.2
	Transmissometer	-	54.3	54.3
	Led lights	2	4.1	8.2
	Custom Electronics Component	-	43.2	43.2
Control	Magnetometer (Compass)	1	36.5	36.5
	Camera	3	-	202.7
	Joystick	1	54.0	54.0
	TCU	-	40.5	40.5
	USB to Serial Converter	2	27.0	54.0
	Easy Cap	2	10	20
Total ROV Expenses : $1310.6				
Other	TOOL BOX	-	9.2	9.2
	Screw driver box	-	4.3	4.3
	Screw drivers	-	6.7	6.7
	Power supply	-	81.0	81.0
	Electrical joint	-	4.3	4.3
	T-shirt	-	67.4	67.4
	Transportation	-	150	150
	Hadath registration	-	67.5	67.5
	Air tickets and accomodation	-	8108	8108
Total Team Expenses: $1310.6+ $8498.4 = $9809				

Sponsorship

Name	Amount
El-Ghareeb charitable association	$2000
Faculty of Engineering	$7809
Total: $9809	

Design Rationale

During the design phase we tried to design a simple and easy implemented ROV. We started to make some sketches of probable designs. We got an idea of making the payload tools on a separate extension that can be easily connected/disconnected from the ROV.

We could summarize our design concept as follows:

1. Stability and efficiency.
2. Strong and Smooth.
3. Ease of implementation.
4. Quick connect/disconnect capabilities.
5. Ease of finding the required material.

Fig.1: structural skids.

Fig.2: Payload Extension.

Frame

The basis of the vehicle's design is the frame. It was designed by SolidWorks™ 3D CAD software. It consists of four main component groups: the structural skids (Fig.1), the payload extension (Fig.2), bouncy and electronics container (Fig.3). The frame is made of polyethylene material because of polyethylene strength, durability and less density than water, granting the ROV additional buoyancy. There are two opposite plates forming the body and other two parallel plates for the payload extension. There is a buoyancy made of polyurethane foam mounted on top of the plates. We cut into the polyurethane foam to mount the vertical thrusters. The two plates are fixed together with a screw. There is also a metal grid for fixing payload tools and horizontal thrusters, fixed between the two plates. The frame is 60 CM(L), 45 CM(W), 30 CM(H) and the extension is 50 CM(L), 45 CM(W), 15 CM(H). The electronic container will be discussed separately.

Fig.3: Electronics Container.

Fig.4: Frame Machining.

Propulsion

Flying the ROV needs a 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.

We had three choices for the thruster; to modify a bilge pump, buy Seabotix thrusters or to isolate our own motors. We chose to do the isolation ourselves to have the balance between the thrust power and price. The thrusters have proven power and reliability.

ROV INFINITY is driven by seven modified thrusters (Fig.5), five for the horizontal movement and other two for vertical movement. Two of the horizontal thrusters are responsible for forward-back moves and the other two are responsible for left-right moves and can be used to give more forward-backward speed. The parts making the thruster is illustrated in (Fig.7).

CAETUS Co. decided to use polyethylene to isolate the motors. The polyethylene material is machined to enclose the motor including a place to a bearing and oil seal to prevent the water from leaking into the enclosure. A cap with o-ring is machined to ease the operation of replacing the motor in case of any problem. The resulting heat was great and the motor would not last for even ten minutes and get burnt. The solution we get to is to fill the motor enclosure with oil and that did great. The motor was tested for an hour and there was no problems. We also machined a coupling to extend the motor shaft length connecting the propeller. We bought a four-blade propeller and after testing, we found that the load on the motor was great so we modified the propeller to be a two-blade and it worked great (Fig.8). The propeller did also great in reducing the heat generated by the motor. The thruster input and control is discussed in the electronics and control part.

Fig.5: Thruster enclosure.

Fig.6: Side view of a mounted thruster.

Fig.7: Thruster parts.

Fig.8: Propeller

CAMERA

ROV INFINITY is equipped with three CCD (charge coupled device) analog cameras, two 700TVL (PAL 1024HX596V), and one with low resolution 420TVL. A CCD consists of several hundred thousand individual picture elements (pixels) on a tiny chip. Each pixel responds to light falling on it by storing a tiny charge of electricity. The pixels are arranged on a precise grid, with vertical and horizontal transfer registers carrying the signals to the camera's video processing circuitry. The cameras was chosen for reliability, low cost, small size, and high quality. The main front camera is an *HST Eyeball PDI1224* (Fig.9) camera but we get the chip out of its enclosure and fix it on a discrete RC Servo motor moving up-down to give a vision angle 180 degree. The second main camera is *HST Bullet IR1224 (* Fig.10) and it is fixed back the ROV and directed to the middle bottom for the ROV to give a scenes of what the pilot doing while making the tasks and missions. The third camera with low quality is fixed to give a vertical view. Switching between cameras is done by the pilot for the needed camera. The three cameras signals are transmitted through twisted pairs of an Ethernet cable. Cameras were put into the electronic container for safe housing. CAETUS Co. used an easy cap adapter to convert analog camera streaming data to be read by USB port of a computer.

Fig.9: PDI1224 Eyeball

Fig.10: IR1224 Bullet IR

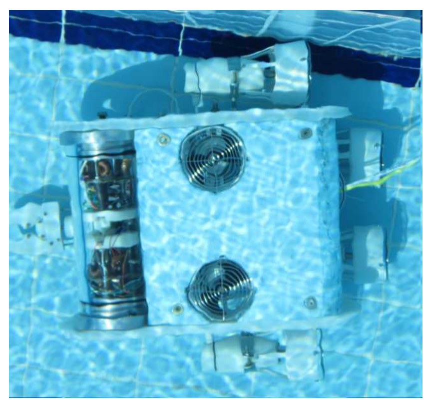

Fig.11: Infinity Vertical view.

HOUSING

Containers for the electronic component designed to withstand the pressure. Housing made of optically clear acrylic tube with two aluminum ends to close the tube (See Fig.11 for installed container). Metal glands are mounted on both the two aluminum ends for all cable connections (Fig.12). The tube has an outside diameter of 15CM and sealed by dual O-rings on each side. The electronics container is mounted in the front upper portion of the ROV to provide additional buoyancy and allow the camera within the can the maximum field of view. Electronic unit container is noteworthy, it is complex, but at the same time, the logical structure. Inside the container, multiple devices provide voltage

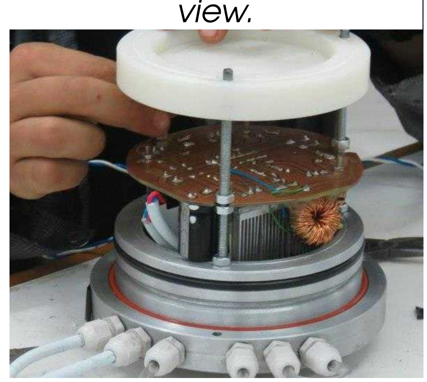

Fig.12: Early stage of electrical connections.

conversion, communications to the surface, thruster control and data acquisition. Another electronics container is made of a plastic food container for the payload electronics (Fig.13).

Fig.13: Payload Electrical container.

MANIPULATOR

ROV INFINITY has two fixed manipulators (Fig.14) to perform general gripping needs easily and efficiently. We have fixed the manipulators in the ROV front center, and bottom center. Instead of depending on a moving manipulator, the ROV's thruster layout is able to pitch up and down and so we can move the ROV to the required position. To create higher friction and ensure that there are no sharp edges at the gripping point, the tip of the manipulator is wrapped in rubber that gives a rubberized texture.

The manipulator was made from polyethylene material due to its strength. It is powered by an isolated motor with the same concept of our thruster isolation. A power screw is fixed on the motor shaft leading the group and so the only movement comes from the motor (self-lock).

Fig.14: Manipulator

Electronic unit

The electronic unit is like a human heart, it drives all other units and systems to precisely perform the orders of the pilot. Control signals to the electronics component are passed through the controller board, based on ARDUINO micro-controller providing complete user control over all of the ROV subsystems, including thrusters, video cameras, LED lighting, and payload tools. The tether communication protocol used is RS-485 providing noise immunity due to the differential pairs used. The vehicle requires three DC-DC converters, one for each thrusters side of the ROV and one for the logical control. The on-board H-Bridge only requires a PWM input to give the required direction controlling the thruster. The cameras stream is sent via a separate Ethernet cable to lower the interference as possible.

Motor Controller

CAETUS Co. decided to create a new motor controller (Fig.15) which is a device that serves to govern in some predetermined manner the performance of an electric motor. A motor controller includes starting and

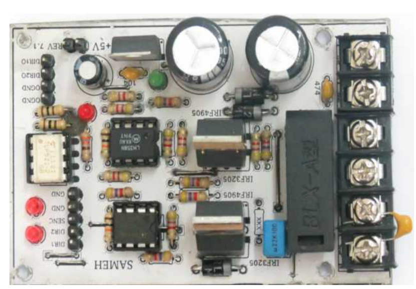

Fig.15: Motor Driver.

stopping the motor, selecting forward or reverse rotation, regulating the motor speed, and protecting against overloads and faults. An H-Bridge structure is used and it is an electronic circuit that enables a voltage to be applied across a load in either direction, allowing the motor to run forward and backward. The term H-bridge is derived from the typical graphical representation of such a circuit (Fig.16). The H-bridge is built with four solid-state switches (N-CH and P-CH MOSFETs). Using the nomenclature above, the switches in series should never be closed at the same time, as this would cause a short circuit on the input voltage source.

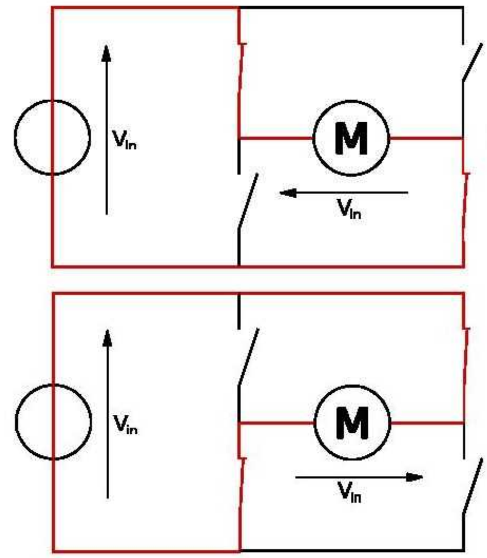

Fig.16: H-Bridge structure

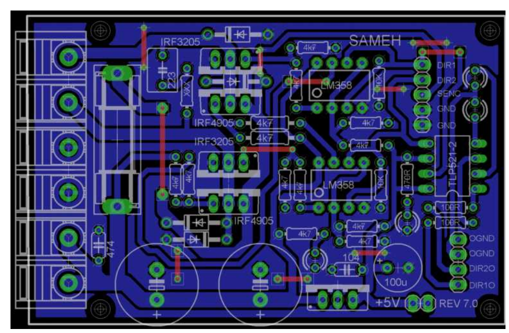
Fig.17: H-bridge PCB layout

The MOSFET driver was made using operational amplifiers. The voltage translation is done by comparing the logic level inputs to 2.5V generated with a voltage divider. If the micro-controllers output is higher or lower than 2.5V then the appropriate N-CH and P-CH MOSFET will be turned on or off giving the voltage direction.

Speed is controlled by holding one input low and PWM the other input. Opto- couplers are used for transmission of the PWM output of the micro-controller isolating the micro-controller ground from the motor voltage supply, protecting it from any damages and increasing the safety and reliability of the circuit. The opto-coupler consists of an LED and a photo-transistor in the same package.

The circuit is working with 24V input voltage and can stand 7A current without a heat sink. If a heat sink is added it can handle much more current, but our company preferred not to as the MOSFET retained the current and the circuit size is reduced.

A fly back diodes were added to maintain the back EMF (Electromotive Force), preventing it from damaging the MOSFETS. Counter EMF is a voltage developed in an inductor reversing the voltage polarity by its terminals at every moment the input voltage reversed. See (Fig.17) for the PCB design.

Power conversion

ROV INFINITY has been supplied with two DC-DC Converters designed by the company to output 12, 24 Volts. The maximum load of the 24V is 24A and the 12V is 7A. The 24V is designated to power the motors and the 12V to power the micro-controller, cameras, LED lights and an RC servo motor. We have used a Zener diode in conjunction with common bi-polar transistors to boost the output current (Fig.18). When a Zener diode is used as a voltage regulator, if the voltage across the load tries to rise then the Zener passes more current causing an increase in the voltage dropped across the resistor and so the voltage across the load remains at a constant value. In a similar manner, if the voltage across the load tries to fall, then the Zener passes less current and the voltage across the resistor falls, maintaining the correct voltage across the load. The current through the Zener will change to keep the voltage to within the design limits. Thus a zener diode is valuable in regulating the output voltage against both variations in the input voltage from an unregulated power supply or variations in the load resistance. The transistors are biased to function in its safe operating area. We used four parallel transistors to get a 24A. The PCB layout (Fig.19) was designed as 14CM circle to be enclosed easily in the electronics container taking less space.

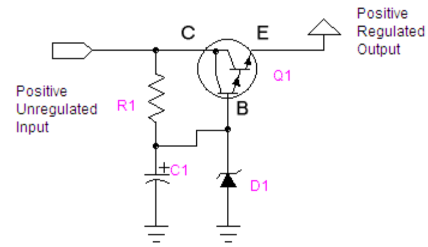

Fig.18: Zener diode regulation concept.

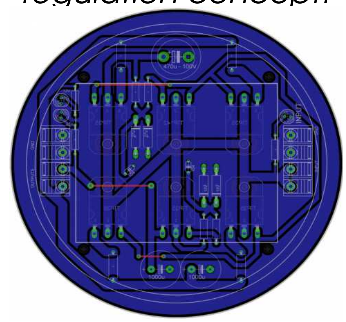

Fig.19: Converter PCB Design

LED Lights

Located in the electronics container a 360 degree white LED strips (Fig.20) providing illumination of the ROV work area. The controller is made by a simple switching circuit controlled by the ARDUINO micro-controller.

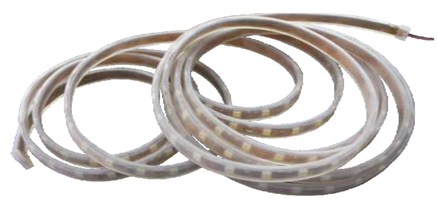

Fig.20: LED Strip.

Breakout Board

The breakout board helps to simplify the internal wiring (Fig.21). It has breakout headers for 12V, and cameras. It has two RJ45 connectors for the Ethernet cables responsible for the cameras stream and communication. It has a LED indicator to help to quickly determine the status of the power. It has a 5V regulator to power the RC servo.

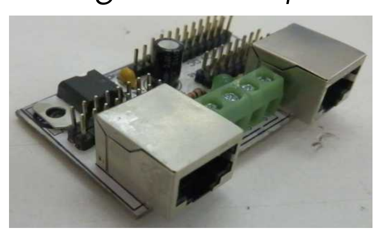

Fig.21: Breakout Board.

TETHER

The Tether (Fig.22) is considered as the arteries and veins. ROV INFINITY is equipped with a 20 meters long tether for power, and communication. For power, the tether has a pair of 1.0MM^2 wire. Two Ethernet cables is added for communication and cameras. The first cable is

Fig.22: Tether.

directed to communication (RS485) and connecting the power to the 12V DC-DC converter. The other Ethernet cable is used to transmit the cameras signal via two twisted pairs. To make the tether neutrally buoyant, a strip of foam is fixed along its length. To protect the tether and make it easier to manage, we added a spiral wrap along the tether.

Tether Control Unit "TCU"

TCU is used to separate tether into different lines: power, control and video. 48V from power supply comes to the TCU unit through the main fuse, which protects the circuit against excess current. The power is supplied to the TCU through a switch. The video signal passes through the easy cap over an Ethernet cable and then appears as a part of GUI on the computer screen. Control signals are transmitted between the operator console on the surface and the electronic unit on-board via an Ethernet cable through RS485 serial protocol. It also contains a USB hub to connect the two easy cap, USB to RS485 serial converter, and RS485 communication circuit. The TCU has also panel meter to give feedback about the voltage supplied and the current drawn by the ROV. See (Fig.23, 24) for TCU.

Fig.23: TCU Front view.

Fig.24: TCU Back view.

SOFTWARE

CAETUS Co. has developed a proprietary control system for ROV INFINITY using C# object oriented programming language, a client-server interface is setup using the Windows Communication Foundation framework. This framework allows real time communication and data transfer between application logic acting as the server and user interface as a client .

ROV INFINITY control system consists of 3 major branches controller, joystick, and serial communication. The data is sent from the computer to the Arduino to process the data. The Arduino is considered as system server and the computer is the client. Data transmitting is done using RS485 protocol through MAX485 and an Ethernet cable is used for transmitting. The whole component of ROV can be controlled from the Joystick such, flying in all directions (forward, backward, up, down, right, left rotating CW, rotating CCW), controlling camera servo angle, lights, the manipulator.

Graphical User Interface

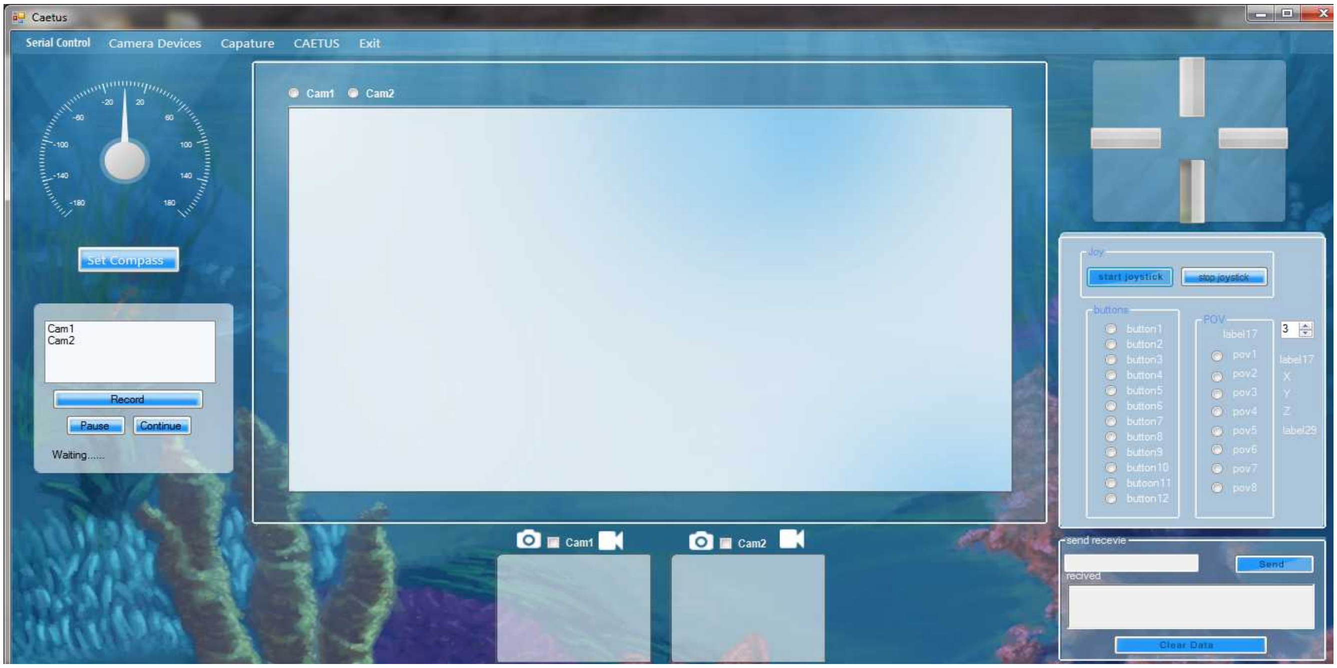

Fig.25: ROV Infinity Graphical User Interface.

The graphical user interface (GUI) should give the pilot all the abilities needed to smoothly operate the vehicle and help him get all the tasks perfectly done with simple, attractive and comfortable design. The GUI based on window based concept. The GUI is divided into four main windows: cameras view, Joystick simulation, serial data transmission (Read, Write) and finally sensors control view. The GUI communicates with the ROV system through the topsides computer service by sending and receiving a series of serialized objects. Important information is always clearly visible for the pilot.

The joystick is totally simulated on the GUI to ensure proper moves. Progress bar simulation is added for X, Y axis to show the scaled movement values sent to the motor drivers. The joystick can be started/stopped from GUI or from keyboard buttons.

The cameras have a separate views with small frames size for each one which can be separately running independent of each other. The GUI has a forth main camera view with large frame size to switch between the small cameras views for a bigger view which gives the pilot a clear and accurate ROV monitoring. Switching between cameras is done with different frame sizes according to selected camera which was a challenge process but we done it very successfully. All cameras control and switch can be done from specified keyboard buttons and from menu options in the GUI. The camera stream can also be recorded.

The serial control menu allows to choose the communication port and control the transmission speed choosing the required baud rate. For sending joystick movement control values from client (GUI) to server (ARDUINO) to apply these movements on the designated motors. The GUI can receive data from server on a rich box which can view messages providing feedback about motors for which worked, these data also can be sensors reading for temperature, compass, depth and acceleration.

Firmware

The firmware performs determined functions sending/receiving packets through the certain protocols, controlling the ROV, and collecting data from the sensors. An Arduino mega ADK is used as controller because it's rich features like 54 digital I/O (of which 15 provide PWM output), 16 A/D pins, 4 serial modules and other features.

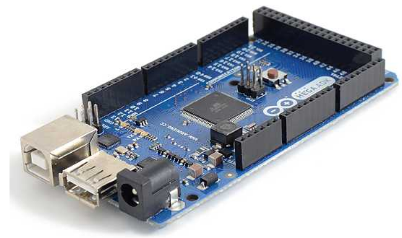

Fig.26: Arduino Mega ADK

MAGNETOMETER (LSM303DLH)

Fig.27: Magnetometer

The LSM303DLH (Fig.27) is a triple axis magnetometer (Compass) combined with a triple axis accelerometer. This breakout board uses the LSM303DLH to give data we need to feed into a micro-controller or Arduino and calculate Compass tilt-compensated and more accurate output. Traditional compass needs to be held flat (in horizontal plane) and it is a problem as the compass is only using the X and Y axis of the earth magnetic field. When the compass is not parallel to these axis the amount of magnetism will change based on how the alignment of compass is to those axises. The third axis, Z, which (when tilted) now collects the magnetic field lost by X and Y when they are tilted out of alignment measuring the gravity component G.

Joystick


Fig.28: Joystick.

Logitech Extreme™ 3D Pro Joystick was chosen by the company for its proper design. It gives the pilot comfortable and easy flying enabling him to control the speed of the ROV. The joystick has analog readouts in X, Y, Z axis, digital buttons and a slider.

Payload tools

CAETUS Co. have considered to design the proper tools to successfully operate in all the required missions. We have designed two manipulators to get the job done. The primary manipulator is fixed in front of the ROV and the secondary one is fixed under the ROV to be able to carry the different parts to its designated destination. A camera fixed inside the ROV to be able to monitor the secondary manipulator doing its job.

Task 1

Complete a primary node and install a secondary node on the seafloor.

The first task includes an extensive list of sub-tasks. The Science Interface Assembly (SIA) will be given to the company and then it will be fixed in the secondary manipulator and be carried to be completely rested within the Backbone Interface Assembly (BIA). We will be searching for the Cable Termination Assembly (CTA) in range of two meters around the BIA and when found it will be carried to be inserted into the bulkhead connector on the BIA. The pin of the secondary node will be released from the elevator and so we can remove it from the elevator. It will be carried to the designated location after measuring the required distance.

Two motors are installed in the ROV to adjust the level of the secondary node monitoring the level of the circular bubble via the camera. The company will be able to open the door using the primary manipulator. Then at last we will remove the secondary node cable connector from the elevator and insert it in into the bulkhead connector on the SIA.

Task 2

Design, construct, and install a transmissometer to measure turbidity over time.

ROV INFINITY will be able to carry the transmissometer which is a device for measuring the attenuation of light as it travels through water to measure the turbidity in the ocean. The instrument consists of a light source of known frequency and intensity which is a laser beam of class IIIa (650nm, 5W) and a detector which is a photo-transistor located at a known distance. The signal is then amplified with an

OPAMP. The light is converted into an electrical voltage that is proportional to the intensity of the light. The receiver output is connected to A/D pin of an Arduino UNO. The degree of transparency of the intervening water can be determined by measuring the proportion of light from the source that is recorded at the detector on a chart programmed in C#. The GUI simulates those values on chart that increase and decrease dynamically for actual simulation for real time sensor readings. We can start and stop the laser from our GUI. The GUI is also equipped with a stop watch to give us how long did it take in communication and charting, it starts with starting senor, stops when stopping the sensor, and pause added for continuing later.

The GUI (Fig.29) is divided into 2 parts, a serial communication control and a chart simulation for serial values.

Serial communication control:

- We choose COM serial port for RS232 communication with the Arduino UNO. Then we can start the sensor to receive the sensor values.
- We can turn the laser off and it dynamically stops the graph simulation and continues when we turn it on again.

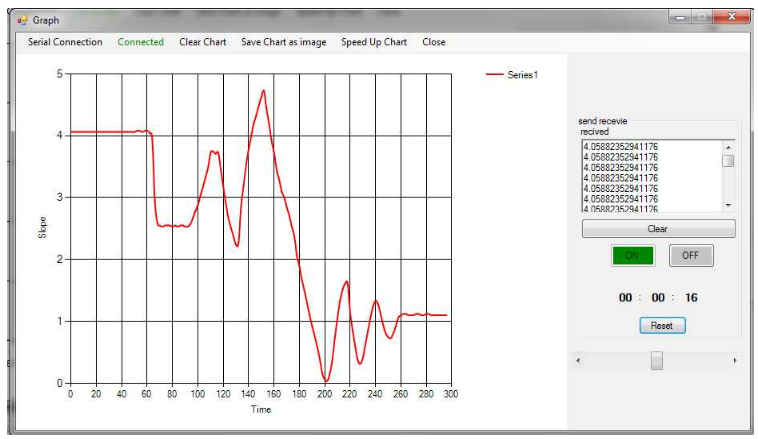

Fig.29: Transmissometer GUI

chart simulation:

- After mapping received values simulate them with time on graph, graph increase dynamically when reaches to its maximum, we can scroll for previous values and save chart as image.
- We can speed up drawing chart via controlling timer's interval and clear chart for staring new communication.

Task 3

Replace an Acoustic Doppler Current Profiler (ADCP) on a water column mooring platform.

There is eight sub-tasks to be done. The ROV will be able to disconnect the power to the platform. The handle will be turned to 90 degrees with the primary manipulator to be able to open the hatch. The ADCP will be removed from the mooring platform and then Install the new ADCP into the mooring platform. After this stage ends successfully we will close the hatch and turn the handle to lock the hatch. Finally we will insert the platform connector into the bulkhead connector to successfully reconnect the power monitoring the bolts of the platform connector protrude through the holes in the bulkhead connector.

Task 4

Locate and remove bio-fouling from structures and instruments within the observatory.

We will search for the different organisms and remove it using the manipulator during the whole mission time.

Safety Procedures and Precautions

Safety is one of the most important standards that have been taken into account during the stages of building ROV INFINITY. It was a major concern of CAETUS Co. throughout the whole process of design, building, development and testing of the ROV.

The ROV INFINITY has a number of safety features including:

- Designing the vehicle frame to be smooth, with no sharp edges.
- Completely shrouded thrusters and using appropriate materials in the isolation.
- Warning labels located near moving parts and electrical hazards.
- Over-current protection via a main inline fuse on the tether at the surface.
- Kill-switch for emergency stoppage.
- Fuse before each motor to protect the other system component.
- Electrical isolation of the high power motor component and the low voltage electronic component.
- Safety rope to avoid breakage or damage.

Operational and transporting precautions

- Life jackets and safety glasses required for all company employees.
- Training and practice in safety precautions.
- Protocol in a pre-dive check operations.

Challenges

While designing the vehicle, we have decided to create something special, something smart, reliable and capable of performing mission tasks with ease. The most technical challenge was the isolation of circuits and cameras so we decided to manufacture an electronics container with waterproofed ends. The motor isolation took much time of troubleshooting.

The biasing circuit of the MOSFET, we tried many ways to make it including transistors, transistor array chips ,MOSFET driver chips and OP-AMP. The best cheap and reliable method was OP-AMP after checking the signal on an oscilloscope. Choosing the operating PWM frequency of the motor driver, we set a table and tried many frequencies and finally we came to a decision. The lack of finding the required component in Egypt made us change our design to meet the specifications of the available component.

Non-Technical Challenges:

- The competition required a significant time commitment on the part of all team members so we have two meetings a week to discuss our progress.
- Last year's competition we didn't find a sponsor to cover the required budget so we have tried our best to find a proper and cheap solutions. This year we have targeted a level of technology and budget to ease the finding of a sponsor to cover the costs and to develop a smart system. After some time we get to find a charitable association to sponsor the team.

TROUBLESHOOTING TECHNIQUES

Troubleshooting is an inevitable process when testing the vehicle. The team utilized the process of troubleshooting many times throughout the year. Each component in the ROV was individually tested, and once the systems were assembled, the overall system was tested for stability and reliability. There was a problem with video streaming as the two camera signals were overlapping and we overcame by using twisted pair wires.

Lessons Learned

"إِنَّا لا نُضِيعُ أَجْرَ مَنْ أَحْسَنَ عَمَلاً"

"We shall not suffer to perish the reward of any who do a (single) righteous deed."

That is from Quran. It affected our company a lot in the last year competition and this year we considered it our motto.

Technical:

We decided to isolate our own motors. We used polyethylene to make an isolation system but the motors gets very hot and burnt after nearly 10 minutes of excessive heat. We tried many solutions and finally we get to put oil in the isolation "Tube" and that solved the heat problem. Now we have a very powerful motor with long operation life time.

The motor driver design took us a lot of time trying many solutions of relays, transistor (BJT or MOSFET), or even a combination of them. We need the ROV control to be analog and so relays was rejected. The transistor was the right solution but the BJT transistor wasn't a good choice because of its dissipated power. The solution we get to was the MOSFET but designing the driving circuit took us some time of testing MOSFET driver ICs, transistors and OPAMPs. We viewed the signal each time on an oscilloscope and finally we chose the OPAMP.

We tested DC-DC converters, switched mode and Zener regulators, and even tried to embed the conversion in each motor driver. Every time the transistors heats up very much and didn't last for long time. The solution was obviously a heat sink. We tried a computer processor heat sink with the Zener regulator converter circuit and finally we got a working and stable converter.

We faced a problem with sending the signals to control the ROV and transfer the cameras signal on the same cable. We needed something reliable and ease to use over at least 20M long. We decided to use an Ethernet cable for sending the control signal using RS485 and used the a 4 wires of the same cable to send the cameras stream.

Interpersonal:

The team gained a good experience from the last year contest but most of the team graduated and so we needed a new members. We chose just a new member and we had to pass him our experience to be on the same level. Every one of the three of us was responsible for one sector of the ROV and we had to help each other in different fields of interest.

The team members acts like one person and the team is above any other considerations. We also learnt to work under very high tension and tight schedules. We had to know what parts we need and what do we need for subsequent work days in order to put our schedule and to maintain it. The three members are from different departments and we had to work together in order to design and make modifications.

Reflections

Amr Mohammed

Last year I was the team mechanical engineer, but this year the situation has changed. I have very important role beside my previous one as team captain. It was a huge responsibility on my shoulders. I acquired knowledge in very unfamiliar fields such as management and leadership.

Mohamed Hamdy

Thanks to all our great mentors ,parents and especially MATE and Hadath for making such a wonderful competition in Egypt. I am studying at the university to become a good communications Engineer, but I fond of the programming. This competition I had the opportunity to realize my potential of the programmer. It is the first time in my life when such a big responsibility is laying on me. Through dealing with the team realized that one would not succeed if he do not sense a full responsibility incumbent upon him and deal with it. This experience made me more organized, disciplined and responsible.

Sameh Galal

Sameh is addicted to electronics and it was a great adventure for him to work in power electronics and deal with such a current, voltage, and frequency.

Interfacing circuits are the back bone of the whole system as it should satisfy both the mechanical and programming requirements, that was a great load to make a reliable and stable circuits. It was a great time and I had what I wanted to get which is "FUN". Thanks to those who trusted me getting things done, specially if I am doing things alone!

Future Improvements

Communication:

Using Fiber optics for transmitting the data and camera stream on just one cable. It has a small size and high speed which will benefit us to apply our control on different cable lengths.

Control system:

We will change the Arduino micro-controller to a credit card sized computer like a Raspberry PI or a Beagle Bone for more data handling and sensors. PID control will be considered for stable ROV control.

Electrical system:

We are willing to improve the motor driving circuits to handle more current and increase its PWM frequency to get a lower vibration. We will also add more safety features to the driver circuit. The power converter also will be changed to switched mode which will be much more stable and safe than zener regulator.

Acknowledgment

High performance teams do not result from nothing. But they are grown, nurtured and exercised under supervision. Thanks to Allah for giving us the chance to compete and for the chance that our team worked together. We thank MATE center and HADATH company for organizing the competition and giving us the chance to compete with other teams. Thanks to the Arab Academy for Science, Technology & Maritime Transport for hosting the local competition.

We would like to extend our sincere gratitude to our great mentors Prof. Mohamed Abd-Elazem, Eng. Hanaa ZeenEldeen, Eng. Belal Shehata, Eng. Amera Magde who found time in their schedule to share experience and give us feedback on our progress which improved the final quality of the ROV. We also want to give Dr. Mohammed Fanni a special recognition of his work with us last year and his encouragement for us in this year.

Thanks to our college for permitting us to work in a laboratory to give birth to our ROV. Special thanks to our parents and family for encouraging us to innovate and get our job done. We were not home for days and that even did not bother them. We want to give them our sincere appreciation. Thanks to Ahmed Abo-Zeid, Anas Emad, Samar Ali, Adel Youssef, and Saad Zanfal.

Our most sincere thanks goes to El-Ghareeb charitable association for covering the ROV expenses, and our college for covering the team travel expenses.

Teamwork and organization

In order to organize the company and ensure that all the tasks were completed on time, each company member was designated to a specific role. While all members were involved in all processes (design, construction, testing, and communications), it was possible to delegate responsibility and ensure that everything would be completed on time. The scheduling process and time table was set forth and a Gantt chart was created at the beginning of the year (Fig.30).

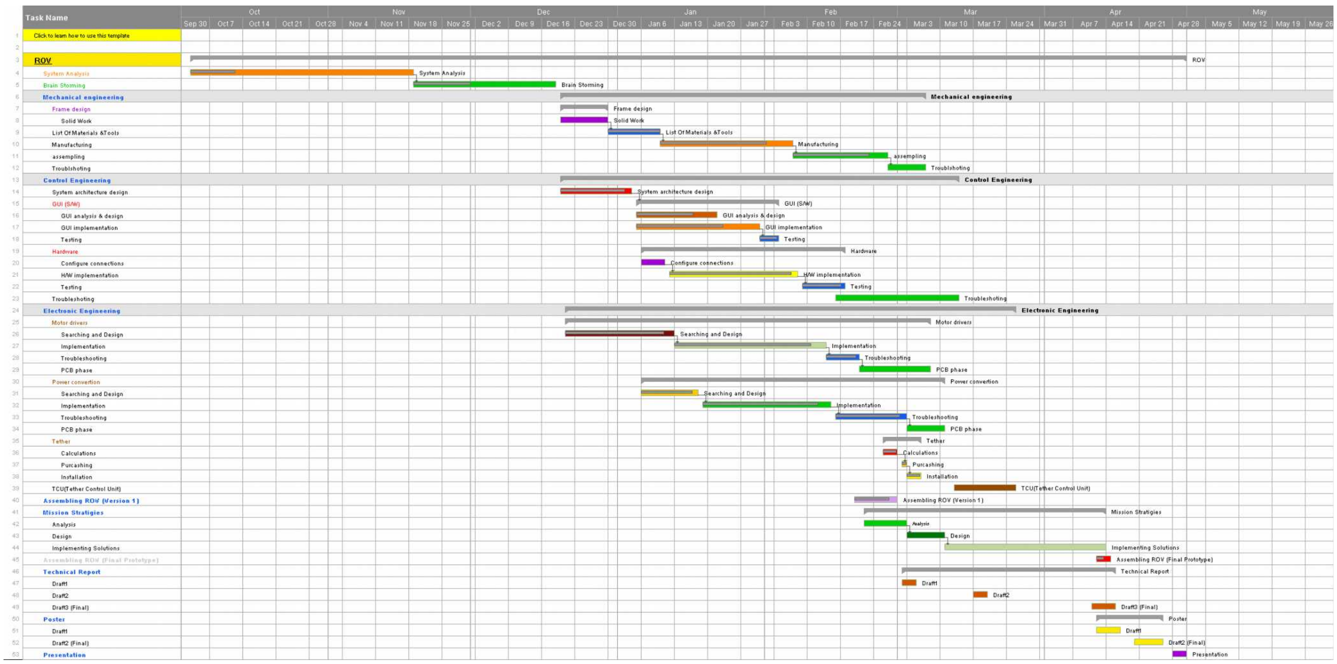

Fig.30: Gannt chart

References

- Competition Technical Manager and Head Rules Judge – ***Matthew Gardner.***
- The great sites http://www.wikipedia.org/ , http://www.howstuffworks.com/.
- Making a FET "H" bridge (revised) http://letsmakerobots.com/node/18633.
- Arduino http://www.arduino.cc/.
- Open ROV http://openrov.com/.
- MATE forum http://forums.marinetech2.org/.

Appendix A: Electrical block diagrams

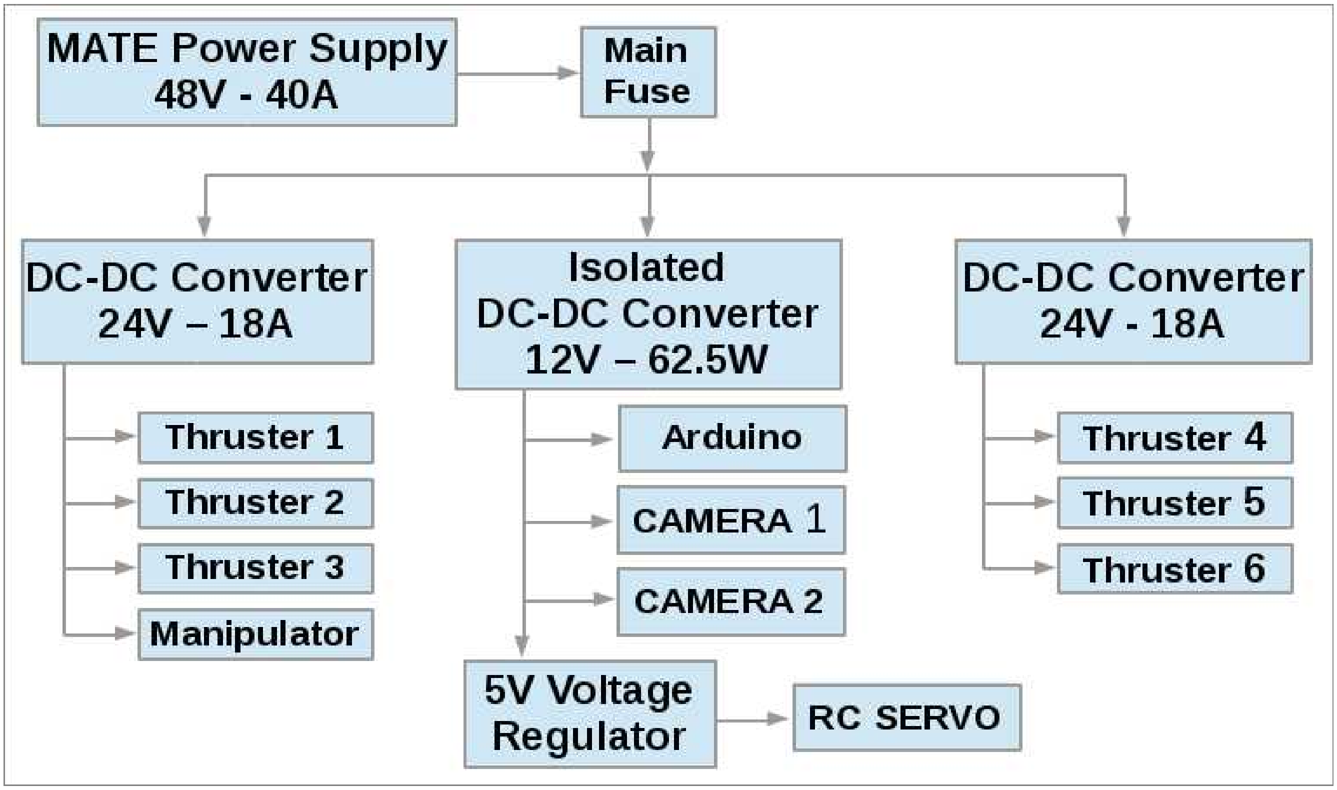

Fig.A1: Power distribution Block Diagram

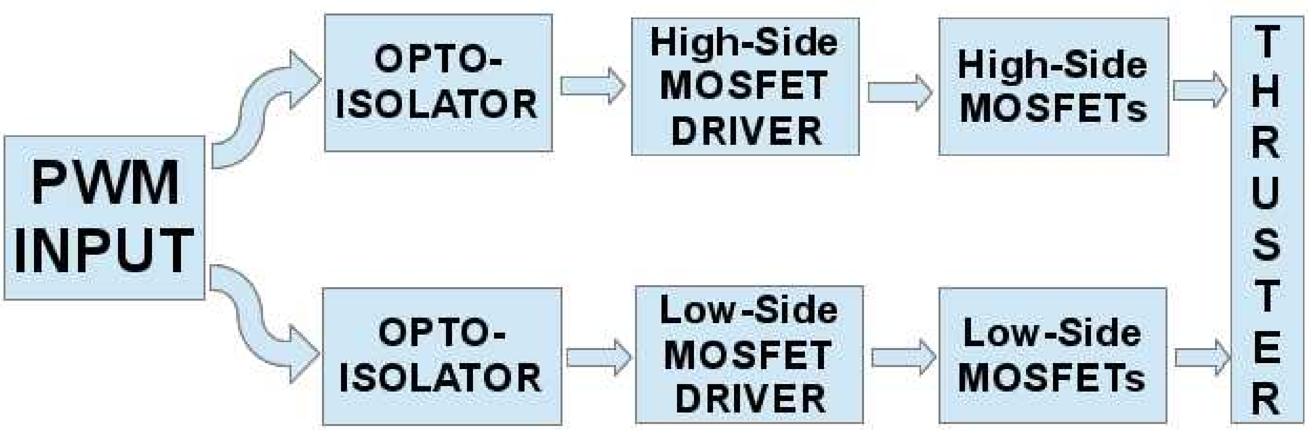

Fig.A2: Motor Driver Block Diagram

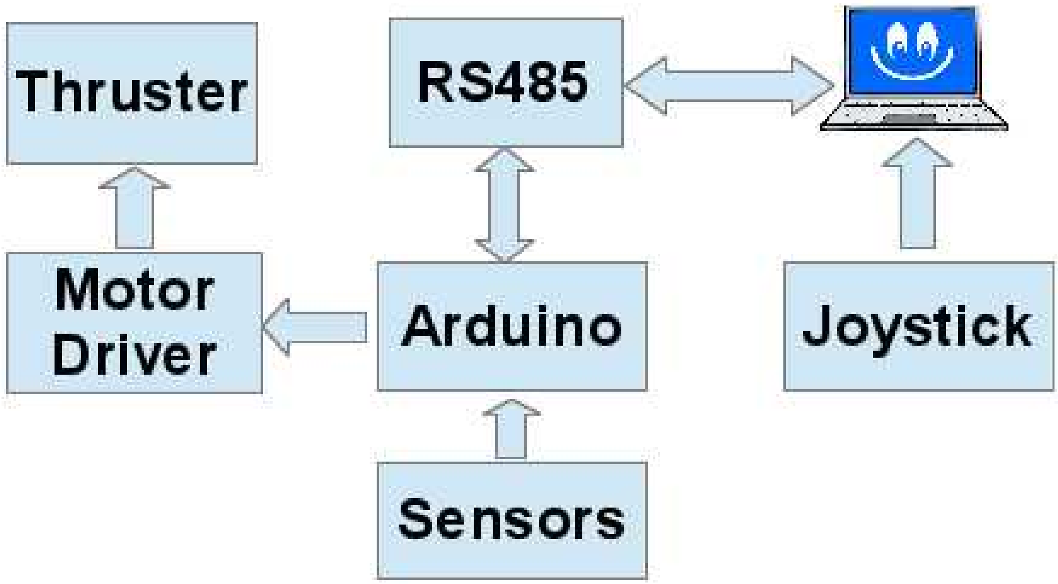

Fig.A3: Communication and Signals Block Diagram

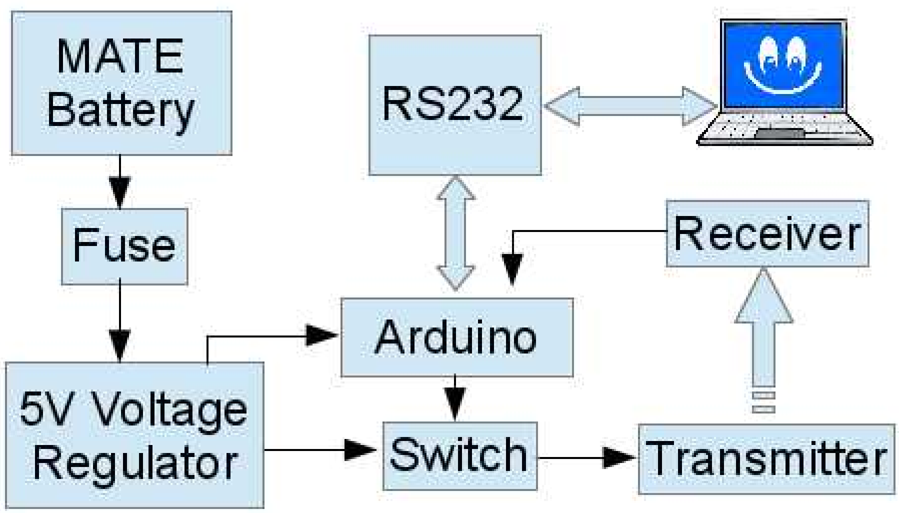

Fig.A4: Transmissometer Block Diagram

Appendix B: Circuit schematics

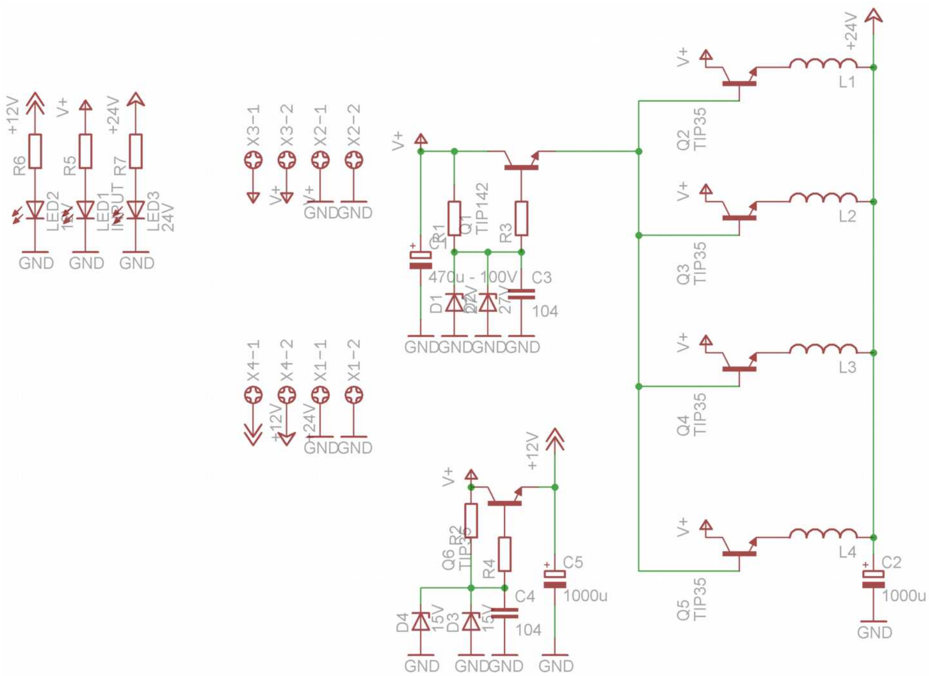

Fig.B1: Power converter schematic.

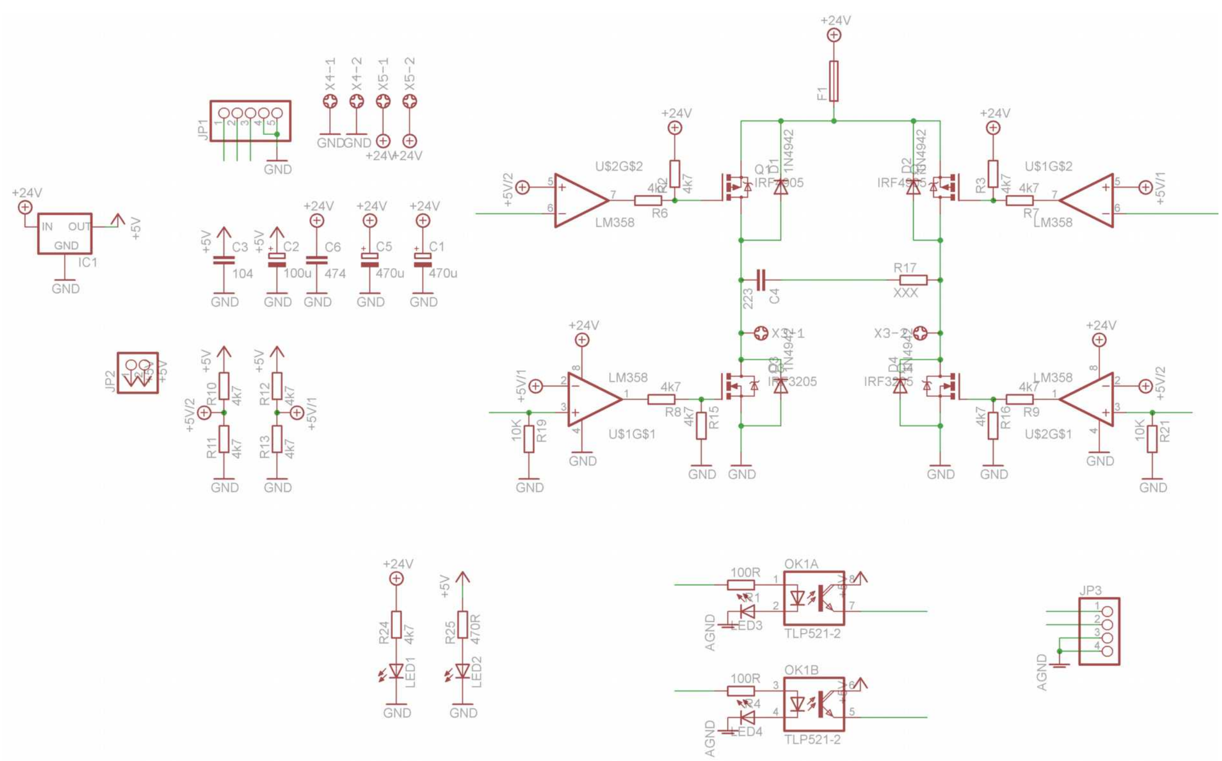

Fig.B2: Motor driver schematic.

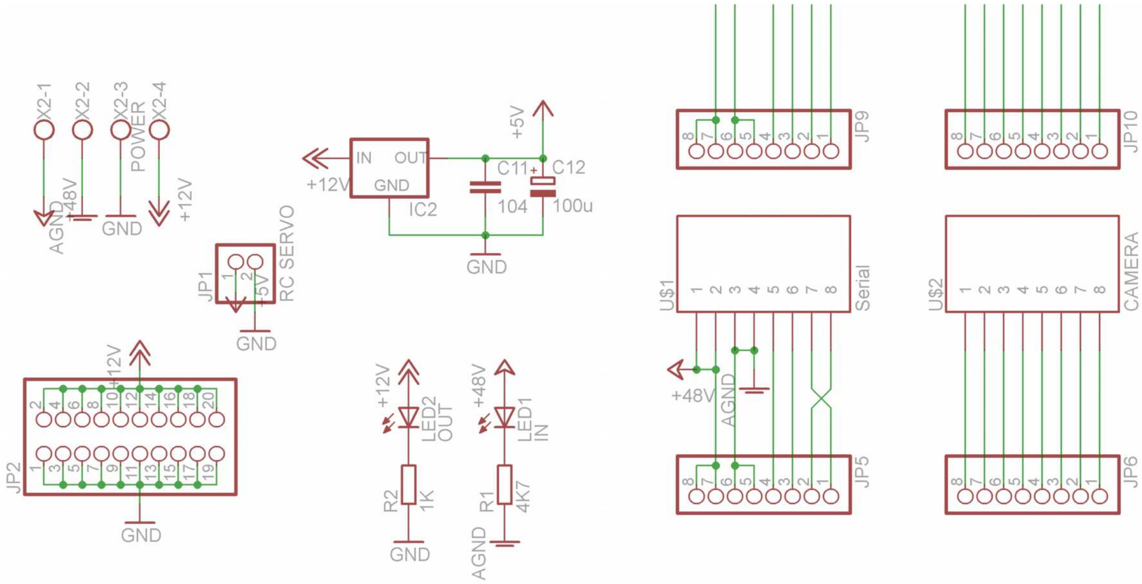

Fig.B3: Breakout board schematic.

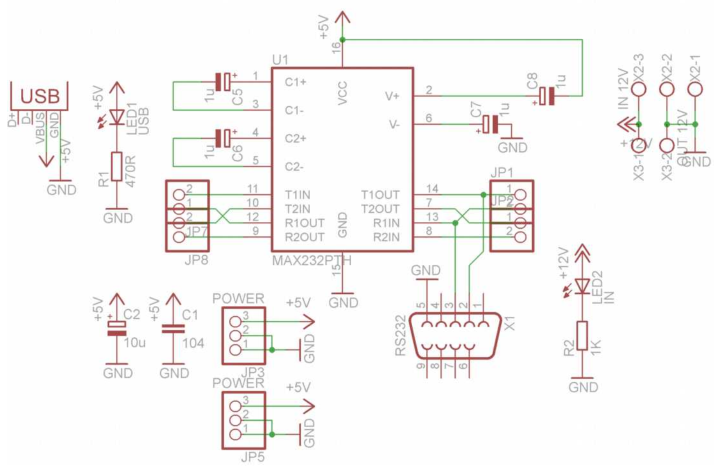

Fig.B4: Transmissometer communication circuit.

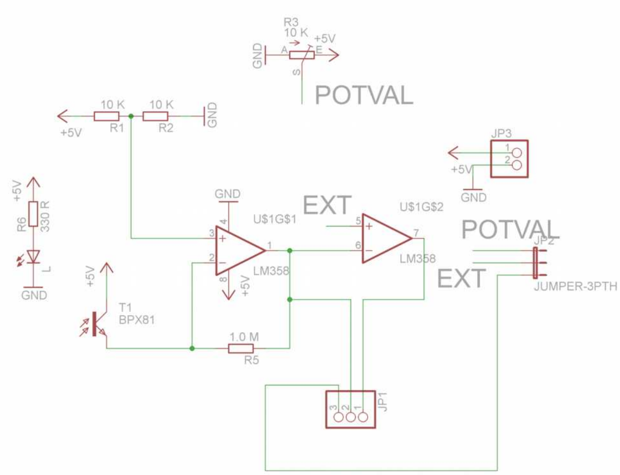

Fig.B5: Transmissometer detector circuit.

Appendix C: Programming flow chart

Fig.C: Programming flow chart.