CARIBBEAN

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Abstract:

For the first time, Caribbean team decided to make their own ROV this year. We are a team of ten members all of us are students in the first year at the faculty of Engineering, Alexandria University, Electrical Department. Caribbean ROV was designed to help to do several tasks as investigation of shipwrecks & do several tasks relevant to this issue, investigation of oil pipelines underwater & fix some parts of it, monitoring under water life as fish and corals exploring submerged monuments & carry small parts of it.

Our ROV is made of PVC tubes connected together. It contains one well isolated tube including all our electrical system (Data transmission, Data processing, Motor driving system). Our ROV is equipped with 4 thrusters in different directions to enable the ROV to move in all direction with good manoeuvring.

The ROV also has a Camera equipped with night vision system in addition to high intensity light torch. The ROV is operated by normal Lead Acid Battery (12V - 12Ah). The pilot controls the ROV with a joystick, which is a part of our Driving station, which also include a screen viewing the camera. During this process, team members learned essential technical skills and utilized “outside-the-box” brainstorming techniques to ensure a quality product. The design and fabrication of the ROV cost approximately 2400 LE.

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I. What is ROV?

An underwater remotely operated vehicle (ROV) is a mobile robot designed for aquatic work environments. Remote control is usually carried out through copper or fibre optic cables. A human operator sits in a shore-based station, boat or submarine bubble while watching a display that shows what the robot "sees." The operator can also manoeuvre the robot.

It is used in many fields and has various applications as Petroleum, Construction Ocean observation, shipwreck exploration, Marine Life observation. There are basically three main classes of ROV:

- Small observation class ROV.
- Work class ROV
- Tracked ROV

II. Our vision:

As being Egyptian youth we care very much about our country and seek to make it the best. We know that the only way to achieve is by science and work, so we are working day and night to learn and apply in order to solve problems concerning marine, petroleum and robotics industry to improve Egypt rank between nations.

III. Our goals:

- Build nearly 100% Egyptian made ROVs using local raw material and tools.
- Use latest control and power systems in our ROVs.
- Found and lead the research in the field of the underwater robotics science and applications.

IV. Mechanical system:

1. Body structure:

We constructed our ROV body from PVC tubes. Since PVC tubes are cheap and can be easily connected together and body can be constructed in a very short time. In addition to that, we used these tubes in order to be ready to make any further modifications in the structure.

2. Propulsion system:

We armed our ROV with four bilge bumps of pumping power 1100 gallon per hour, after converting them to thrusters to act DC motors of where they provide a strong thrust for fast underwater manoeuvring and to carry missions efficiently. The motor is operated by 12 volt and has a max current 5A.This motor is well isolated from water, as shown in fig (1)

Figure 1: Bilge pump

Second stage of this system is the propellers which are responsible for converting the rotating motion of the motor rotor to a linear thrusting motion in the perpendicular plane. We have chosen a propeller with 3 blades having diameter of 2" (50mm) and a Pitch of 42, as shown in fig(2)

Figure 2: Propller

Third stage, motor housing which is installed in order to avoid eddy currents as and to avoid the mechanical vibration of the motor axis, as shown in fig(3)

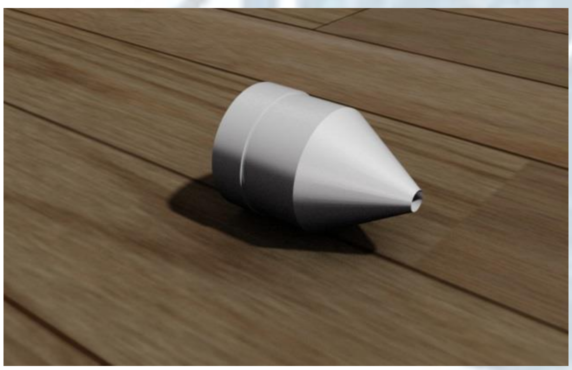


Figure 3: Motor housing

Last stage is the kort nozzle which is add as protection for the propeller from being broken or smashed while carrying missions and to protect users from touching this part of the system and also to provide a good distribution of the thrust around the thrusters and enhance the flow of water over the blades as shown in fig(4)

Figure 4: Kort Nozzle

The structure of the propulsion system is illustrated in figure 5.

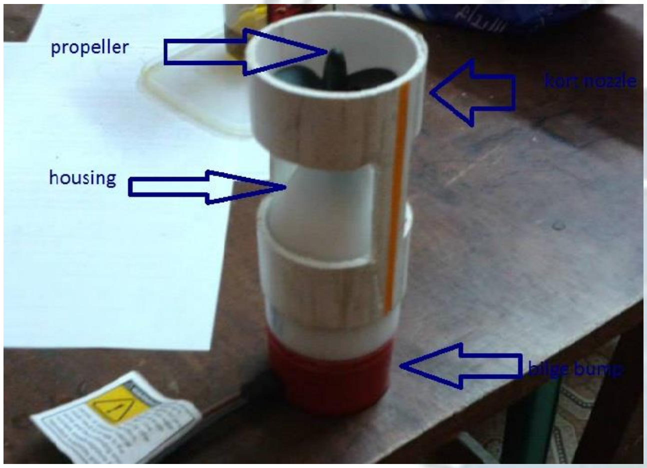


Figure 5: Thruster structure

3. Electrical system isolation

We have searched a lot till we reached a very effective solution where we didn't use any chemicals to isolate but we used a mechanical way where we used a 5'' PVC tube to put all our circuits inside then we closed the two ends of the tube with a two well fitted end cap, one for each side. We also used two O-ring in each end cap as sealing, where it's a rubber ring has O shape when force is applied on it the contact area between the tube and the cap increases so no water leakage, we have also placed a strong rubber disk (thickness 10 mm) of the same shape of the end cap and make a holes in it to pass wires through it, in order to be well isolated as shown in figure 6.

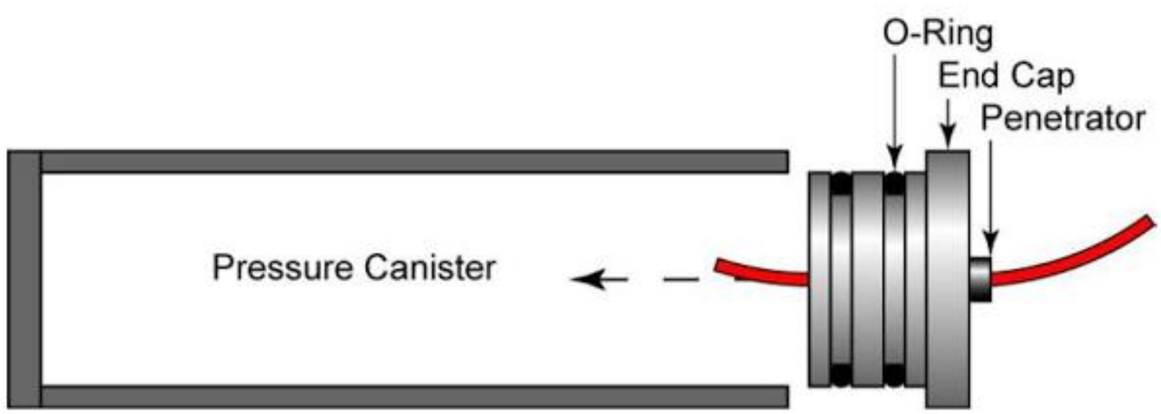


Figure 6: Electrical system isolation

V. Electrical system:

1. *Power management:*

We are operating our product on a DC system using a battery of 12 V and 12A.

2. *Control system:*

The control system is used to manage the motion of the ROV in all directions, and to control other features. It consists of multiple stages: as shown if Fig [7]

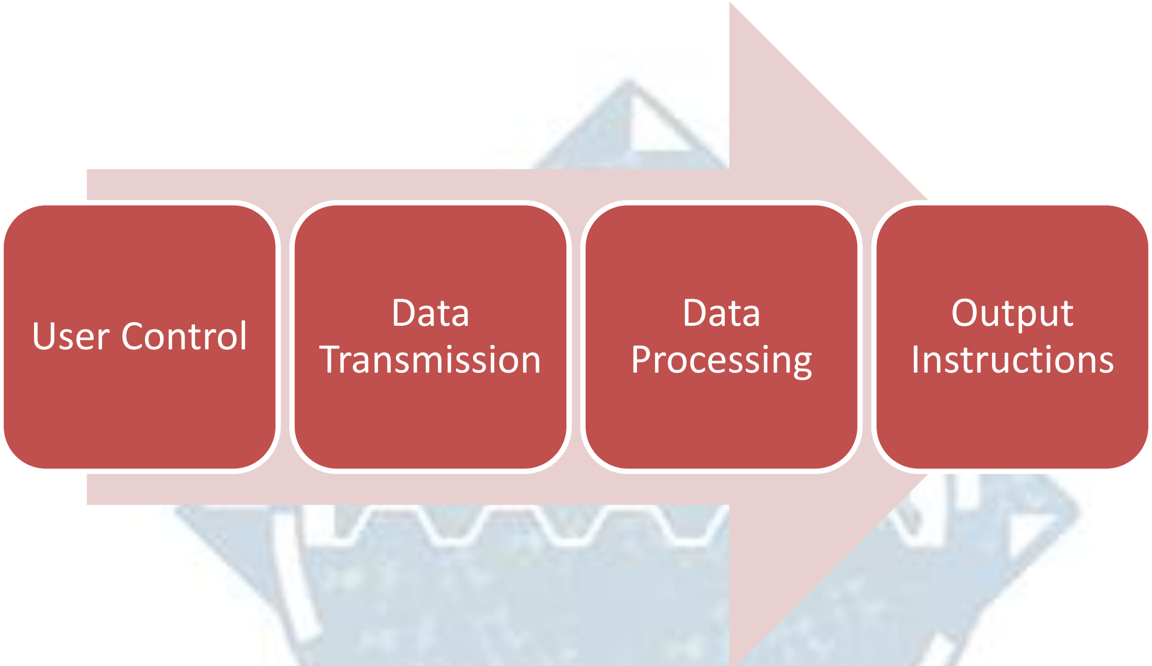


Figure 7: Stages of Control system

a) The user remote control:

The user will be controlling the motion of the ROV through the controller in order to move the ROV in all directions, for example if the user presses the forward button the ROV receives the command and manage to move forward ,i.e. the motors tend to move the ROV forward, as shown in fig(8).

Figure 8: user remote control

b) Data transmission (Encoder & Decoder):

The used method is to use an 8 to 3 priority encoder and 3 to 8 decoder, the 0 pin in the encoder is to grounded, so that the least priority level is for the no-motion state, where In the encoder the EI pin should be grounded in order to work properly and In the decoder the E2 pin and the LE pin should be grounded as well. The schematic of this system is shown in fig (9) .

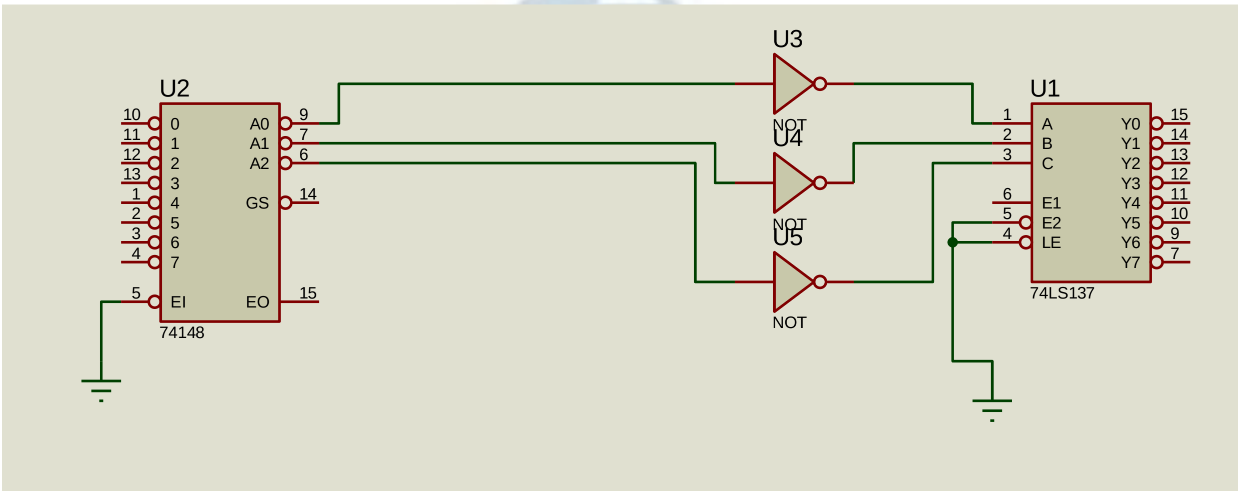


Figure 9: The Schematic of the data trasmission system.

c) Data processing:

After the data is transmitted from the control system to the ROV underwater, the data transmitted will be encoded the order that the user has entered, but it doesn't explain which motor will be used and will that motor move forward or backward, so data processing section is needed

- Motion enable:

The no-motion state which is used in order to enable all the motion, i.e. if the no-motion is activated all the motors are disabled, preventing the motion of the ROV

- Choosing the motor motion

The motors will be controlled as to move either in forward or backward each, and by combining the motion caused by them the ROV tends to move as the user pleases. Logic gates used to operate motors is shown in Fig [10] and truth table is shown in Table [1]

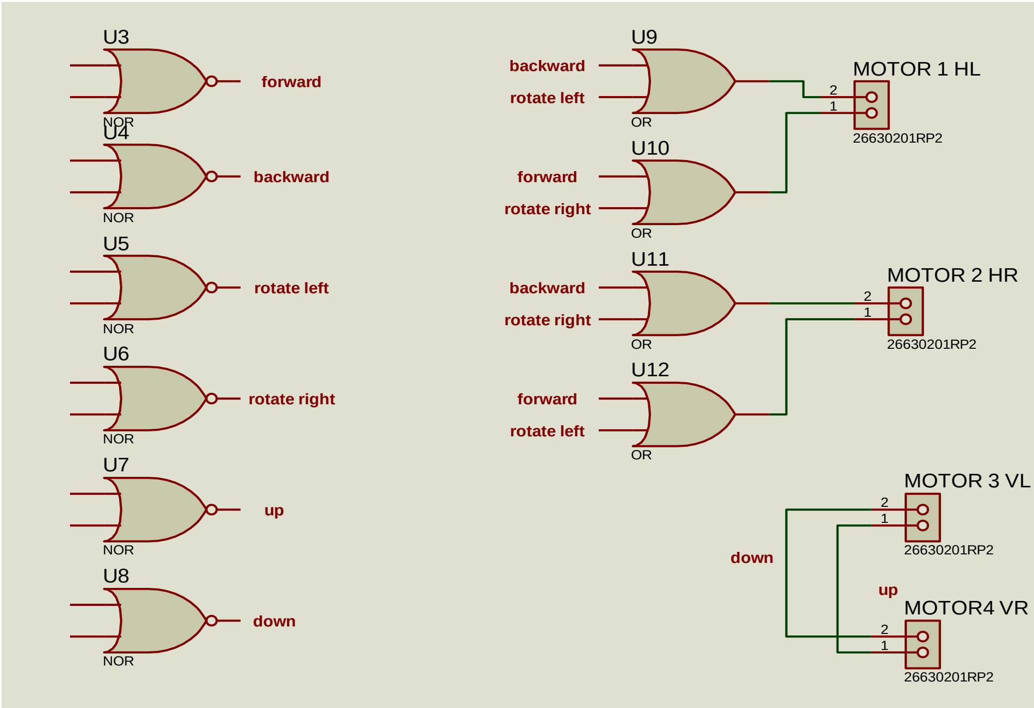


Figure 10: Logic gates used to drive motors

Table 1: Motor Motion

	Motor 1 HL*		Motor 2 HR*		Motor 3 VL*		Motor 4 VR*	
	For.	Back.	For.	Back.	For.	Back.	For.	Back.
Forward	1	0	1	0	0	0	0	0
Back	0	1	0	1	0	0	0	0
Left	0	1	1	0	0	0	0	0
Right	1	0	0	1	0	0	0	0
Up	0	0	0	0	1	0	1	0
Down	0	0	0	0	0	1	0	1

*H=horizontal, V=vertical, L=left, R=Right

3. *Motor driving system:*

- **Method one (Relay Board).**

We used mechanical switches (relays) as controlling elements for the motors motion where we used two relays for every motor, a relay for clockwise rotation(forward direction) and another relay for anticlockwise rotation (backward direction).we used this type of switching in order to sustain the high current surge of the motors (5A).

To avoid electromagnetic interference with the control system (electronic) problem, we used an non-electrical isolation method to isolate the control system from the motor driving system, where we used a 4n25 phototransistor optoislotaor where the signal is transmitted from the logic gate then to the diode of the isolator to the light sensitive base of the PNP transistor By an IR pulse. The schematic of this system is shown in fig (11)

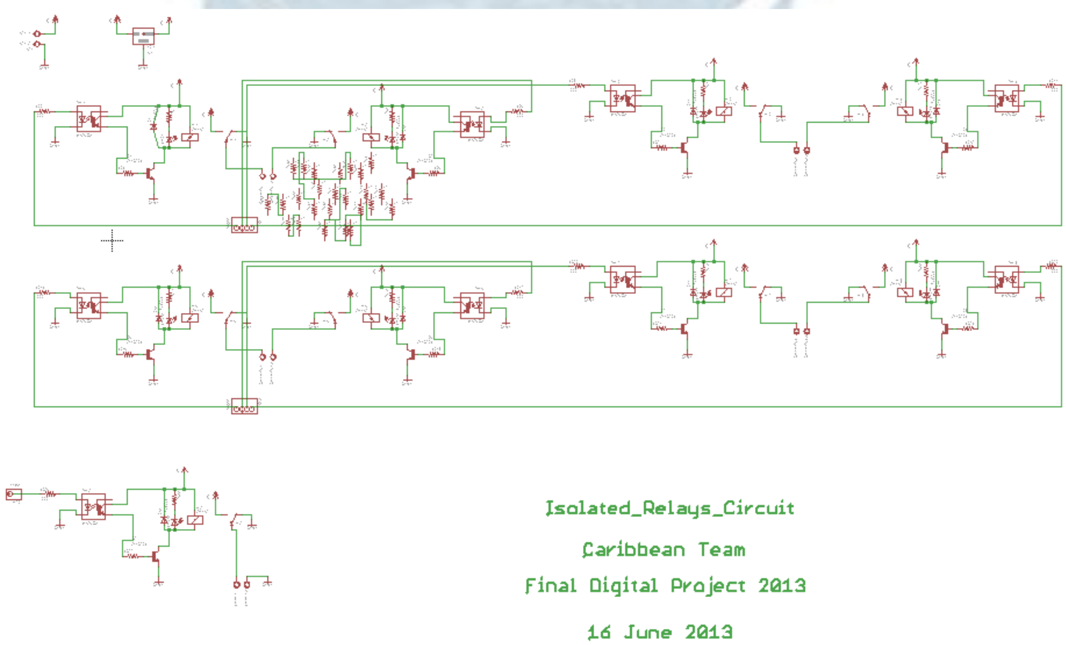
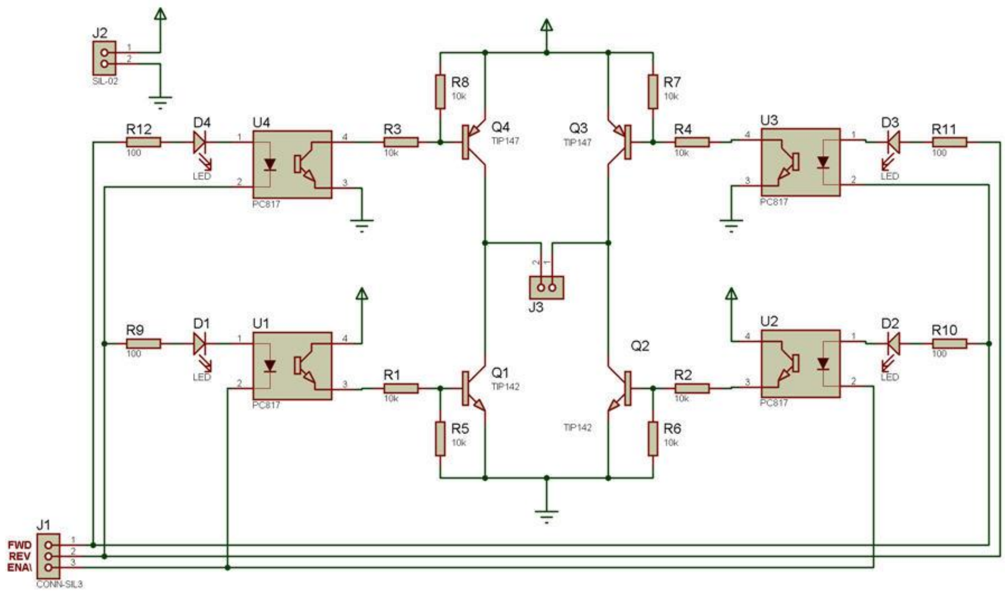


Figure 11: The schematic of motor driving system

- **<u>Method two (H-Bridge equivalent Circuit)</u>**



Schematic:

Advantages:

- Full electrical Isolation
- Speed control
- Maximum current flow of 10 A (regular H-Bridge has 3A limit)

Components:

1. TIP 147 transistor
   - Equivalent circuit

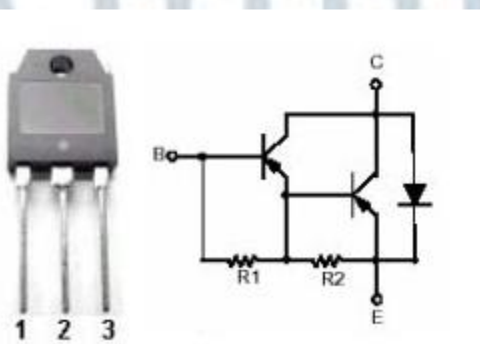


Fig.1 simplified outline (TO-3PN) and symbol

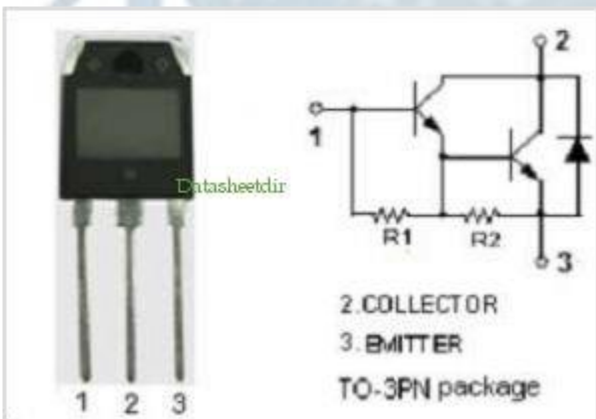
Consist of 2 pnp transistors and a diode
R1=8 KΩ
R2=0.12 KΩ

- Ratings:

Maximum collector emitter voltage: -100V
Maximum collector current: -10A DC / -15A pulse
Maximum base current: -0.5 A
Storage temperature: -65 to 150 degree Celsius

2. TIP 142 Transistor

- Equivalent circuit

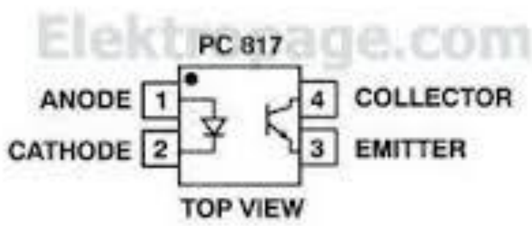


Consists of 2 npn transistors and a diode
R1=8KΩ
R2=40Ω

- Ratings:

Maximum collector emitter voltage: 100V
Maximum collector current: 10A DC / 15A pulse
Maximum base current: -0.5A
Storage temperature: -65 to 150 degree Celsius

3. PC 817 single channel optoisolator:



- Ratings:

  Forward current: 50mA DC/ 1A peak
  Reverse voltage: 6v
  Maximum Power dissipation: 70mW
  Collector emitter voltage: 35V
  Maximum collector current: 50mA

Operation:

When a signal is applied to forward input pin the transistors Q4 and Q2 one of them is TIP147 connected to the 12 volt input and the other is TIP142 and connected to the ground, so the output is 12 volt

4. Navigation system:

a) Imaging system:

We used a camera after being waterproofed in order to be aware of what going underwater. It can be interfaced with the TV so it`s user friendly, also it has high resolution in order to carry out missions obviously. The system is also equipped with a night vision system using Infrared to able to see at dark, as shown in fig (12)

Figure 12: Imaging system

b) Lighting system:

An ultra-bright light system is used in the ROV to ensure clear image to the ROV pilot even at deeper water or at night.

The System consists of 8 Ultra Bright LED each 4 are connected in series and both groups are connected in parallel. Each LED consume 3 volt. The system is well sealed form water in a water proof torch we manufactured, as shown in fig (13)

Figure 13: lighting system

VI. Challenges:

1. Choosing the data transmission method:

There are several ways in order to send the command data to the ROV, on the other hand most of these ways have proven they are not capable of working perfectly and may cause some problems with the user

a) MUX & De-MUX

An 8 to 1 MUX is used on the controller side and the 1 to 8 De-MUX is used on the other, also each one of them requires a counter and a source of very high frequency clock, like 555 timer or crystal oscillator

The selection pins are attached to the first 3 outputs of the counter, they will act as if the counter is a 0-7 binary and the final output is ignored. The schematic is shown in fig (14)

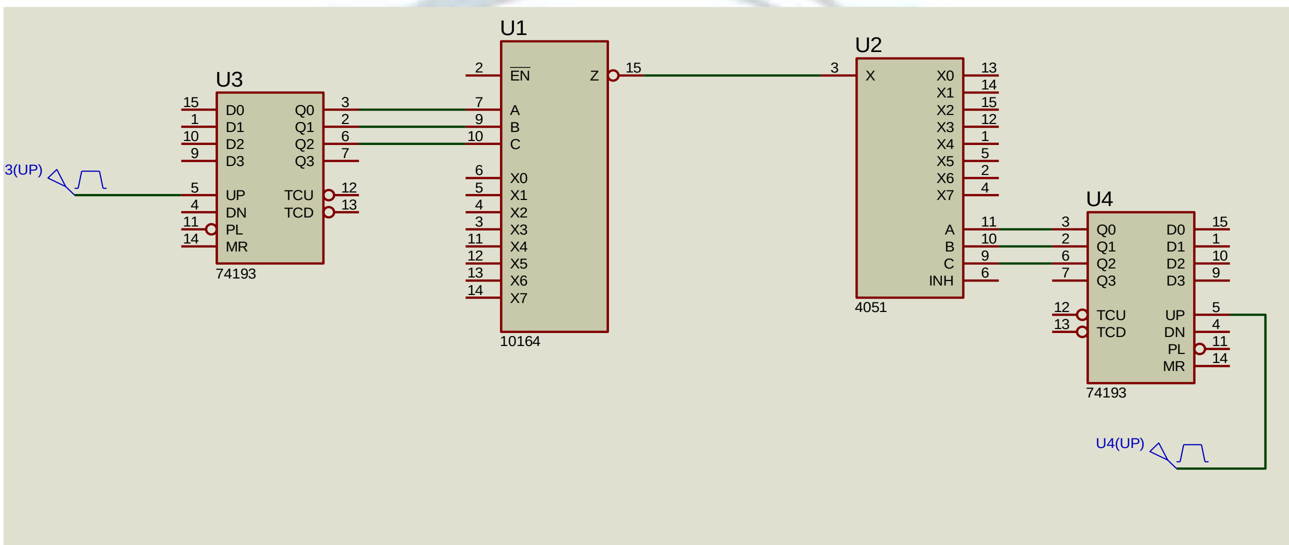


Figure 54: The schematic of the 8 to 1 MUX

Advantages:

- Uses only 1 wire
- May control multiple operations at a time

Disadvantages:

- The control signal is read in the inner system in 1/8 of the operation time this might cause several breaks of the operation
- The 555 timer is not very reliable on serving with 100% accuracy, so there might be a delay between the MUX and the De-MUX this delay in selection will lead to wrong control, for example when the user pushed the forward button the ROV rotates left

- A medium level complicated way of data transmission that needs a lot of preparations

b) **Encoder & Decoder**

Advantages:

- The priority encoder chooses the higher priority and send its signal, so if the user misused the controller by pressing multiple buttons, only one will respond, so no problems happen with the operation, it also provides an easy way to send the no-motion state
- No preparations or outer circuits are needed, only needs an inverter between them as the encoder is an active low o/p and the encoder is active high i/p
- Full operation time occurs, as the signal doesn't oscillates

Disadvantages:

- Uses 3 wires instead of one to send the data from one side to the other "non-economic"
- Doesn't offer the ability to use multiple options at the same time, just one operation at a time

c) **Shifting registers**

By using one parallel in serial out register on one side and another serial in parallel out on the other we could establish a way of single wire data transmission. The schematic is shown in fig (15)

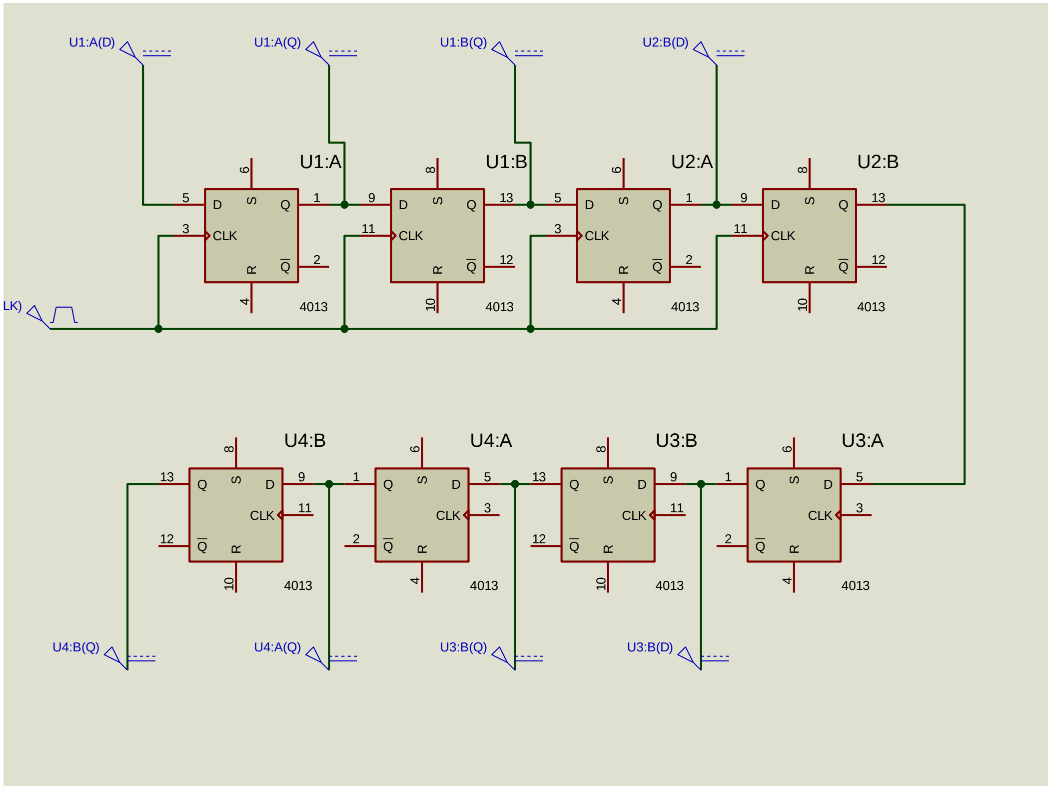


Figure 15: The schematic of shifting registers

Advantages:

- single wire transmission
- transmits up to 4 bit instruction
- delay time between the 2 clocks will not affect the data, it will only affect the time between starting a process and observing its effect

Disadvantages:

- uses multiple flip-flops and also needs a timer and a counter to work properly, so it needs a lot of preparations in order to establish a transmission system depends on registers
- in order to receive data correctly the output of the serial in parallel out register the reading time should be after the fourth clock so that each bit should be in the right flip-flop

Example to show the transmission of 1010 data

Clock	Q0	Q1	Q2	Q3
1	1	-	-	-
2	0	1	-	-
3	1	0	1	-
4	0	1	0	1

d) 8-wire RJ connector

this method uses 2 RJ connectors on both sides of the data transmission system, 8 data wire in a cable is capable of sending up to 8 bit instruction and the delay time is certainly zero because no gates or controllers are used in the transmission.

From all the previous types of transmission, the easier and most reliable way was the encoder-decoder type, because it contains an easy way to develop the zero state "no-motion" and doesn't have time delay or process defects

2. Electromagnetic interference isolation:

a) Opto isolator method

By using 4n25 phototransistor Opto isolator, where the signal is transmitted from the logic gate then to the diode of the isolator to the light sensitive base of the PNP transistor By an IR pulse, this will isolate completely as it is an IR pulse.

b) ULN 2803:

ULN2803 is an IC that is made of pairs of Darlington transistors and reversed diodes but it doesn't provide a complete isolation since the common ground of the chip is connected to the common of the relay so the driving system is partially isolated from the control system

3. Body material selection:

We have variety of materials that we can choose between them as artellone, acrylic, PVC tubes and aluminium.

a) Artellone (Nylon 101):

Artellone (Nylon 101) is relatively expensive but it can overcome crashes and is ductile. But it requires very clever machining and no further modifications can be done also it Offers less buoyancy.

b) Aluminium:

It`s the most expensive material. But it offers the least density so buoyancy can be easily modified but it requires machining and casting so it will be an expensive choice.

c) Acrylic:

It can be easily shaped but it is sensitive to collisions but it is relatively cheap.

d) PVC tubes

They are cheap and can be easily connected together and body can be constructed in a very short time. In addition to that, we used these tubes in order to be ready to make any further modifications in the structure.

From all the previous types of materials, the best one was the PVC tubes

4. *Water proofing:*

We faced great problem in waterproofing our circuits the problems was not in having a water proof container which include all our electrical system, the problems was how to put wires passing from the water proof container to outside the container without permitting any drop of water to enter. We tried many methods.

a) Silicon:

Where we make holes in the end cap and place the wires, then put silicon, the problem was that silicon was not liquid enough to enter all the small holes between the wire and the hole of the end cap, that's why it didn't succeed.

b) Epoxy compound

Where we make holes in the end cap and place the wires, then put Epoxy compound, the epoxy is more liquid than silicon so it solves the previous problem but a new problem appeared, that it takes long time to be completely dry (about 3-4 hours) and the wires couldn't be stable without vibration all this time so when the wire vibrates, it may move from its place about 1 mm or less, this movement leaves a small gap behind it so water enters from this place.

c) <u>Wax</u>

Where we make holes in the end cap and place the wires, then put melted wax, in order to ensure that the wax was completely liquid we didn't use the known wax gun, instead we put the wax into a cooking pan and exposed it to direct fire, so it becomes completely liquid. The wax here solved both problems mentioned before as it is completely liquid and it doesn't take long time to be solid but unfortunately this also didn't succeed, as the material of wax is a little bit flexible, so the wires are a little bit free to move in the direction parallel to the end cap, and this allow small droplets of water to enter.

d) <u>Rubber disk</u>

We searched after that for a solution which solves all these problems till we reached a very effective solution where we didn’t use any chemicals, but we used a mechanical way where we used a strong rubber disk of the same shape of the end cap and make a holes in it to pass wires through it, in order to be well isolating we have made the holes with a diameter less that the diameter of the wire, then we apply a strong force on the wire in order to force it to go through the rubber, so it become very tight and prevent any drop water from passing.

VII. Budget:

Item	Price (LE)
Motors	1200
Propellers	180
Battery	170
PVC tubes & connectors	160
Camera	160
Components	100
Cables	100
End Cap	60
Pipe collar	60
Motor housing	50
Axes	50
PCB	20
O-ring	20
Cork	15
Rubber (End Cap)	14
Ball Bearings	12
Gaskets	10
Acrylic	10
Rivets	6
Sum	**2397**