# Design and Implementation of Black Box Detection using Deep-water Remotely Operated Vehicle (ROV)

Ms. P M Kalpana
*Assistant Professor, Department of Electrical and Electronics Engineering, Velammal Institute of Technology, Chennai-601204, India*

*Abstract-* **Remotely operated underwater vehicles (ROVs) are remotely controlled underwater robots controlled by an individual on the surface (ship). These robots are tethered by a series of wires that send signals between the operator and the ROV. All ROVs are equipped with propulsion system and lights. The objective of our project is to design a remotely operated vehicle (ROV) which will assist in locating the black box by using a RF signal receiver and transmitter set. It consists of an underwater vehicle with thrusters for horizontal and vertical positioning, a DPDT-based connection for operating the thrusters, the transmitter and receiver module for signal transmission and reception.**

## INTRODUCTION

In recent times, the instances of plane crashes and missing planes are alarming and a cause for concern. The reason and cause for these events may be speculated, but there are devices which are capable to narrow down the probable cause of the event. Hence, it is essential that we know the cause for the crash in an effort to prevent any future disasters.

The Black box data recorders are capable of storing all data involving the plane till the moment of crash. This information can be vital and can help minimize future disasters. The main challenge is to locate the black box after a crash as it is difficult to do it manually.

## DESCRIPTION

ROV has several sizes from small vehicles equipped with a tiny water proof camera which is used for observation, and mechanical tools like robotic arm for complex job requirement. Generally they are the freest flying in underwater.

The ROV vehicle class includes the majority of low cost vehicles, mostly are electrically controlled. The next step in advancing the technology is performed by commercial firms that saw the future in ROV support of offshore oil operations and the transition from military use to the commercial world was rather rapid. ROV had gained popularity with the military, oil and gas operations, and science markets due primarily to their quiet operation. In the case of ROV technology the answer is quite simple. There is no other practical, safe and economically feasible way to perform deep underwater intervention.

Due to its potential contributions and high benefit in many fields, a lot of researcher does research on ROV, but most of them are not design for small scale of inspection or recreational needs. Most of the ROV are large size, high deployment weight and expensive ownership.

Existing systems

Manned vehicles:

Submarine

Atmospheric diving suit:

Drawbacks in the existing system: High in cost, Heavy in weight, Always a human should accompany with it, Transportation is also a very difficult process.

## PROPOSED METHOD

A remotely-operated underwater vehicle is controlled by an operator who remains out of the water. The operator typically uses a joystick or controller to manipulate the position of the vehicle in the water, and a video display to see the environment it is operating in. Basically remotely operated underwater vehicle is controlled by a user on the boat and the ROV is used for research in undersea location where human cannot be able to reached. Remotely Operated Underwater Vehicle is designed based on low cost material and low electricity consumption.

The objective of our paper is to design a low cost remotely operated vehicle (ROV) which will assist in locating the black box.

Underwater vehicles can be broadly classified as either:

Manned

Remotely-operated

Autonomously-operated

A remotely-operated underwater vehicle is controlled by an operator who remains out of the water. The operator typically uses a joystick to manipulate the position of the vehicle in the water, and a video display to see the environment it is operating in. This paper focuses solely on this unmanned remotely-operated class of vehicle.

*Rov classification*

The commercial sub-sea industry applies some broad categorization to ROV's.

These can be summarized as:

Micro Observational Class

Mini Observational Class

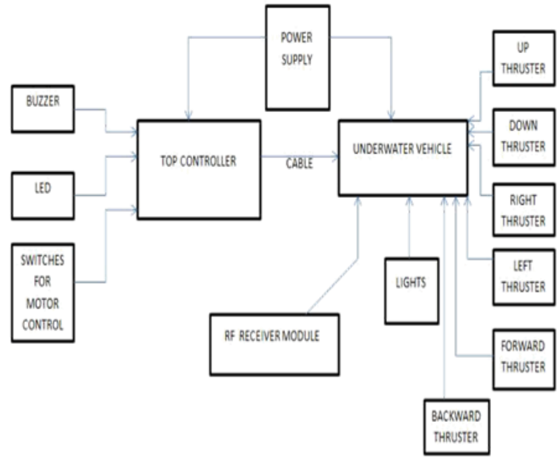
Light & Medium Work Class

Heavy Work Class

Seabed Working Class

*Commercial rov use*

As can be seen by the large variety of ROV's available, there are an accordingly large number of applications they are used for. Here is a selection:Port and pier inspection, Trenching and ploughing, Cable laying & maintenance, Pipe laying & maintenance, Nuclear plant inspection, Water tank inspection, Environmental monitoring, Sea floor surveying, Wreck discovery, Archaeology, Acoustic positioning, Harbour and coastal defence, Mine counter-measures, Sub-sea construction, Well-head maintenance, Mining, Search-and-rescue and Biological research.




Use cases

Major events where ROV's have been used extensively include:

Japanese tsunami search-and-recue

BP Macon do well-head repair

The search for the Titanic

The investigation into the sinking of the Costa Concordia cruise ship

## SYSTEM REQUIREMENTS AND ARCHITECTURE

From an analysis of commercial ROV's that can be found operating in the field, and with consideration to the ROV's applications and operating environments, the design of this ROV system has closely followed these primary design guidelines: ease-of-use, portability and cost effective construction methods and materials

Working from these guidelines, the following requirements were specified:operator controller with switches, buzzer and LED's, 4 thrusters for horizontal positioning, 2 thrusters for vertical positioning, Surface power, 30 m tether for data transfer between operator controller and ROV Lightweight frame construction.

Frame design:

The purpose of the frame is to support the water-proof enclosure, the thruster motors, and any trimming weights. Ideas for the frame design were initially considered and assessed using pencil and paper. The principle design goal for the frame, taking into account thruster and enclosure positioning and support, was to ensure there was maximum water flow through the open frame, to therefore minimize drag.

The chosen design consists of 3 sections placed horizontally perpendicular to the forward direction of travel, two along the bottom to support the enclosure, and a single upper section towards the rear. They are used for cross bracing and vertical thruster support, and join the two rectangular side sub-frames that support the horizontal thrusters.

The hollow frame is designed to fill with water during operation to assist with buoyancy and ballast trimming, and has a number of holes drilled for this purpose. In addition, there is a mesh attached to the bottom of the frame which serves as a surface on which to mount the trimming weights.

Frame construction:

The frame is constructed of plastic tubing, and the associated connecting elements, with a nominal 32 mm outer diameter. This material is lightweight yet rigid and strong, readily available, easy to work, and cost effective. All the wiring to and from the motors, and the tether to the surface controller, have been routed through the inside of the plastic tubing to minimize drag, to avoid damage to wiring, and to avoid fouling of the propellers.

Water-proof enclosure design and construction:

The water-proof enclosure is where all the underwater electronics are located.

Due to the high cost of these components keeping water out of this area is absolutely essential, so given the limited budget available, considerable research was done into finding suitable low-cost off-the-shelf components that would meet the requirements of: water-proof, accessible, readily available, usable, modifiable, uncompressible

It should be noted that the components are actually designed to keep water in, rather than water out, so it was initially unclear whether this system will prove to be completely waterproof.

In order to find out, a T-section with two screw end-caps, and a single push-fit end-cap were trialed in a local swimming pool down to a maximum depth of 5 meters for 30 minutes. This testing met with success as no water was detected inside the enclosure, so it was decided to proceed with using these components.

COMPONENTS USED

Propellers:

A number of different propellers have been tested to ascertain the relative thrust measurements and the current draw by the thruster motors, to find the most suitable propeller:Unmodified bilge pump with impeller, 3-blade 35 mm propeller, 3-blade 50 mm propeller and 3-blade 60 mm propeller

When power is applied to the thruster, the structure pivots and applies a downward force to the scales. That force, measured as weight by the scales, is directly proportional to the thruster force output. Due to the nature of the testing apparatus, the measurements taken are not considered highly accurate but serve to provide relative indications of the differences between the propellers. Table 5.1 shows the current draw and the thrust values of the various propellers that were taken into consideration.

| Propeller | Current draw(a) | Thrust (g) | (g/A) |
|---|---|---|---|
| Bilgepump impeller | 1.60 | 75 | 46.88 |
| 3-blade 35 mm | 2.05 | 125 | 60.98 |
| 3-blade 50 mm | 2.80 | 190 | 67.86 |
| 3-blade 60 mm | 3.50 | 190 | 54.29 |

TABLE 5.1 Thrust and current draw values

On a gram per Amp basis, it was noted during testing that the 3bladed 50 mm propellers generated significantly less turbulence. It also had a much higher reverse thrust compared to any of the 3-blade propellers. Minimizing turbulence is important for good visibility during operation of the ROV and though reverse thrust is not important for the horizontal thrusters, it is critical for the vertical thrusters. For these reasons, 3-blade 50 mm propellers were chosen for all six thrusters.

Propeller rotation:

As a single propeller rotates, it imparts a rotational force to the vehicle, and this hasthe effect of steering the vehicle to the right or left. To minimize this force, two thrusters are used simultaneously, with each thruster having a propeller that rotatesin the opposite direction to the other. Table 5.1.1 shows the allocation of rotation direction to the individual thrusters.

| THRUSTER | ROTATION DIRECTION |
|---|---|
| Horizontal front right | Counter clockwise |
| Horizontal front left | Clockwise |

| | |
|---|---|
| Horizontal rear right | Clockwise |
| Horizontal rear left | Counter clockwise |
| Vertical right | Clockwise |
| Vertical left | Clockwise |

TABLE 5.1.1 Thruster propeller rotation direction

To ensure an equivalent level of thrust from each of the two thrusters, propellers designed for opposite rotation are used.

TETHER

The tether is the physical and communications link between the top controller, located out of the water, and the ROV in the water.

The tether in this case consists of a single 30 m Ethernet cable with 16 in one special combination. This length will give a maximum depth of 30 Meters straight down and 21 meters out at a 45° angle. 30 meters is the typical maximum depth of recreational scuba divers, and therefore the maximum depth for easily testing the ROV, allowing for an emergency recovery.

The primary physical requirements for the tether are that it must be as light and smallas possible to minimize drag through the water, and ideally should be neutrally buoyant. The Ethernet cable is not neutrally buoyant so a number of floatation devices are attached to the tether at regular intervals to ensure neutral buoyancy. To avoid fouling of the tether with the thrusters, the tether is made positively buoyant for the meter closest to the ROV.

For physical protection, at the ROV end a cable strain relief grommet is used, and the first 5 meters of the tether are enclosed in a black braided sheath.

MOTORS

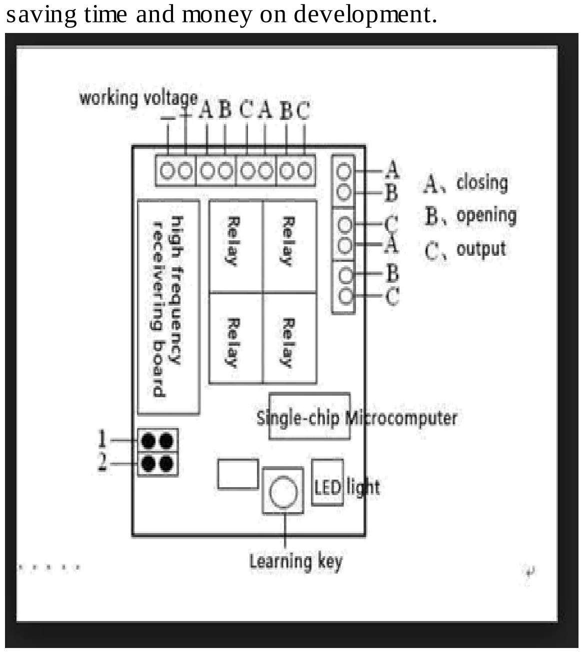
High Torque 22000 RPM Robo War Motor:

This is a 22000 RPM Central shaft DC motor. It is most suitable for light weight robot requiring small power. This motor can be used with 50 mm Diameter Wheel and 87mm Diameter Multipurpose Wheel. A DC motor is a mechanically commutated electric motor powered from direct current (DC). The stator is stationary in space by definition and therefore it's current. The current in the rotor is switched by the commutator to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 900.

RF MODULE

An RF module (radio frequency module) is a (usually) small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through Radio Frequency (RF) communication. For many applications the medium of choice is RF since it does not require line of sight. RF communications incorporate a transmitter and/or receiver.

RF modules are widely used in electronic design owing to the difficulty of designing radio circuitry. Good electronic radio design is notoriously complex because of the sensitivity of radio circuits and the accuracy of components and layouts required achieving operation on a specific frequency. In addition, reliable RF communication circuit requires careful monitoring of the manufacturing process to ensure that the RF performance is not adversely affected. Finally, radio circuits are usually subject to limits on radiated emissions, and require Conformance testing and certification by a standardization organization such as ETSI or the FCC. For these reasons, design engineers will often design a circuit for an application which requires radio communication and then "drop in" a pre-made radio module rather than attempt a discrete design, saving time and money on development.



## SPECIFICATIONS OF THE MODULE USED

- Power: 4.5~7V
- Quiescent Current (mA): 4.5 mA
- Modulation: AM (OOK)
- Operating Temperature: -10°C to +70°C
- Receiver sensitivity (dB):-105 DB
- Operating range: up to 300m (984ft)
- RF radio: 433MHz
- Channels: 4
- Dimensions: 4.5 x 2cm
- Weight: 37g

many unnecessary headaches, and wasted a considerable amount of time and money. It can be simply summarized as: on a limited budget, waterproofing is difficult. However the water proofing for the motors have been successfully done.

## CONCLUSION

This paper started with the overall goal of combining personal interests and newly developed skills, to produce a potentially useful and interesting device, whilst presenting as many realistic challenges as possible.
The paper has now ended with that goal completely satisfied: an extremely interesting, fully working underwater vehicle has been designed and constructed, from scratch, utilizing and learning many new skills, and overcoming many, many challenges along the way.

## REFERENCES

[1] A. M. Plotnik and S. M. Rock (2007), "A multi-sensor approach to automatic tracking of midwater targets by an ROV," in Proceedings of the AIAA, 2007.
[2] Autonomous Underwater Vehicle— "Camera" Stephen Hsu, Chris Mailey, Chris Montgomery, Ryan Moody, duke & NC state university, 2006.
[3] Design, Modelling and Control of an Autonomous Underwater Vehicle Louis Andrew Gonzalez Master Thesis 2007, University of Western Australia.
[4] Gianluca Antonelli, Underwater Robots: Motion and Force Control of Vehicle-Manipulator Systems, Springer, Cassino Italy, Second Edition, 2006.
[5] K.R. Goheen and E.R. Jefferys, "The application of alternative modelling techniques to ROV dynamics", in Proceedings of IEEE International Conference Robotics and Automation, vol. 2, pp. 1302-1309, May 1990. .
[6] Robert D. Christ and Robert L. Wernli Sr., The ROV Manual: A User Guide for Observation-Class Remotely Operated Vehicles, Elsevier Ltd., Oxford UK, First edition, 2007.
[7] Roy Kim Lea, Control of a Tethered Underwater Flight Vehicle, PhD thesis, University of Southampton, May 1998.
[8] The Remotely Operated Vehicles Committee of the Marine Technology Society (MTS ROV), http://www.rov.org/rov.