FABRICATION OF UNDERWATER SURVEILLANCE DRONE

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Abstract- **Highly developed drone technology enables the use of drones in a wide variety of areas. However, those drones are mainly used in the unmanned aerial vehicles. We believe that underwater drones will become a big research topic and find a market in the near future. We developed an underwater drone with a wide-angle camera acting as the "eye" of the drone. And also an arm which acts as a helping hand of the drone. The designs are based on the open source hardware and will be shared as an open-source for contributing to the innovation of manufacturing including drone. The function of the wide-angle camera is to update the live video footage to the surface control unit. The underwater drone was designed by extending the Cam module, arm, frame, and the printed circuit board designed by own team. As for the application of the underwater drone, we focused on to perform the Rescue Operation to save the person who is shrinking under the water, investigating Damages under the Ship Bottom, searching Loosed items.**

CHAPTER-1: INTRODUCTION

1.1 WHAT IS AN EMBEDDED SYSTEM?

A combination of computer hardware and software, and perhaps additional mechanicalor other parts, designed to perform a dedicated function. Most of the controlling systems, today, are embedded systems. The complexity of the systems may differ from to the other.

1.2 IMPORTANCE OF EMBEDDED SYSTEMS

Embedded systems have become an integral part of our daily lives, from the smartphones we use to the cars we drive. They play a crucial role in controlling and monitoring various systems, such as medical equipment, home automation systems, industrial automation systems, and transportation systems.An embedded system is a combination of hardware and software designed to perform a specific task, with varying levels of complexity. The first modern embedded system was the Apollo Guidance Computer, and the first mass-produced embedded system was the autonetics D-17 guidance computer. Embedded systems are characterized by their specific functionality and may have real-time performance constraints. The software used for embedded systems is often called firmware and is stored in read-only memory or flash memory chips. There are several types of software architecture in common use, such as simple control loops and interrupt-controlled systems. Peripherals, such as serial communication interfaces, timers, and discrete I/O, are used to enable the embedded system to interact with the outside world. Processors are key elements.

1.3 BRIEF HISTORY

The first recognizably modern embedded system was the Apollo Guidance Computer, developed by Charles Stark Draper at the MIT instrumentation Laboratory. The first mass- produced embedded system was the autonetics D-17 guidance Computer for the Minuteman (missile), released in 1961. It was built from transistor logic and had a hard disk for main memory. Since these early applications in the 1960s, embedded systems have come down in price. There has also been an enormous rise in processing power and functionality.

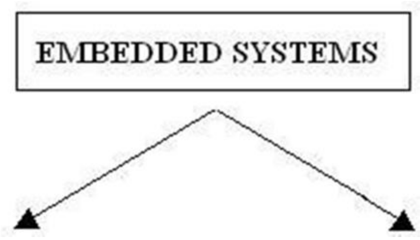
In 1978 National Engineering Manufacturers Association released the standard for a programmable microcontroller. The definition was an almost any Computer –based controller. They included single board Computers, numerical controllers and sequential controllers in order to perform event-based instructions. By the mid-1980s, many of the previously external system components had been integrated into the same chip as the processor, resulting in integrated circuits called microcontrollers, and wide spread use of embedded systems became feasible. Presently, a lot of varieties of embedded systems are available at very lowcosts.

1.3.1 CHARACTERSTICS

Embedded systems are designed to do some specific task. Some also have real time performance constraints that must be met, for reason such as safety and usability; others may have low or no performance requirements, allowing the system hardware to be simplified to reduce cost.

The software written for embedded systems is often called **firmware,** and is stored in read-only memory or flash memory chips rather than a disk drive. It often runs with limited computer hardware resources: small or no keyboard, screen, and little memory.

Embedded system consists of two parts:



HARDWARE	SOFTWARE
Peripherals	1. ALP
Processors	2. C
Memory	3. VB, etc...

Fig 1.1: Embedded System Classification

1.4 EMBEDDED SOFTWARE

Various software‘s can be for various purposes. ALP i.e. Assembly Language Programcan be used as the back end and other software like C, VB, etc.can be used in front end.

1.4.1 EMBEDDED SOFTWARE ARCHITECTURES

There are several different types of software architecture in common use.

a. Simple Control Loop:

In this design, the software has a loop. The loop calls the subroutines, each of whichmanages a part of the hardware or software.

b. Interrupt Controlled System:

Some embedded systems are predominantly interrupt controlled. This means that tasks performed by the system are triggered by different kinds of events. An interruptcould be generated for example by a timer in a pre-defined frequency, or by a serial port controller receiving a byte.

These kinds of systems run a simple task in a main loop also, but this task is not sensitive to expected delays. The tasks performed in the interrupt handlers should be kept short the interrupt latency to a minimum. Some times longer tasks are added to a queue structure in the interrupt handlers to be processed in the main loop later.

1.4.2 PERIPHERALS

Peripherals are the various devices that are connected to the CPU, for performingvarious functions. Embedded systems talk with the outside world via peripherals, such as:

1.4.2.1 Serial communication interfaces (SCI): RS-232, RS-422, RS-458 etc.

1.4.2.2 Synchronous Serial communication interfaces (SSCI): I2C, JTAG,SPI,SSC and ESSI

1.4.2.3 Universal Serial Bus (USB)

1.4.2.4 Timers: PLL(s), Capture/Compare and Time Processing units.

1.4.2.5 Discrete I/O: General Purpose Input/output (GPIO).

1.4.3 PROCCESORS

Processors are the key elements in any embedded system. They interact with thememory, where the various instructions of useful functions into a single IC package.

These functions are:

- The ability to execute a stored set of instructions to carry out user definedtasks.
- The ability to be able to access external memory chips to both read andwrites datafrom and to the memory.

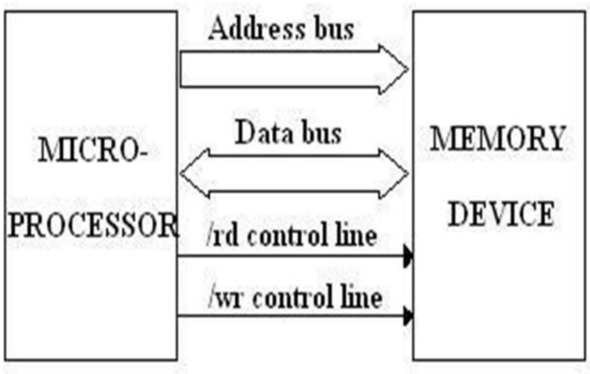


Fig 1.2: Microprocessor accessing memory

1.4.4 MICROCONTROLLER

Basically, a microcontroller is a device which integrates a number of thecomponentsof a microprocessor system on to a single chip.

So a microcontroller combines onto the same microchip:

- The CPU core
- Memory(both ROM and RAM)
- Most microcontrollers will also combine other devices such as:
- A Timer module to allow the microcontroller to perform tasks for certainperiods.
- A serial I/O port to allow data to flow between the microcontroller and other devices such as a PC or another microcontroller.
- An ADC to allow the microcontroller to accept analogue input data forprocessing.

DSP:

It is the study of signals in digital representation and processing methods of thesesignals. It is used where large mathematical and scientific calculations arerequired.

ASIC:

It is an IC designed for a specific application. This IC designed for specificapplication can‘t be used for other applications.

1.5 FEATURES:

The main features of an embedded system are its reliability and the scope for debugging.

1.5.1 DEBUGGING:

Debugging may be performed at different levels, depending on the facilities available, ranging from assembly or source-level Debugging with an in- circuit emulator or in circuit Debugger, to outputs from serial debug ports to an emulated environment running on a PC. As the complexity of embedded systems grows, higher level tools and Operating systems ormigrating into machinerywhere it makes sense.

1.5.2 RELIABILITY:

Embedded systems often reside in machines that are expected to run continuously for years without errors and in some cases recover by themselves if any error occurs. Therefore thesoftware is usually developed and tested more carefully than that for PC, and unreliable mechanical moving parts such as Disk drives, switches or buttons are avoided.

Specific reliability issues may include:

The system cannot safely be shut down for repair, or it is too inaccessible to repair. Solutions may involve subsystems with redundant spares that can be switched over to, or software ―limp modes‖ that provide partial function. Examples include space systems, undersea cables, navigational beacons, bore-holesystems and automobiles.

The system must be kept running for safety reasons. –Limp modes‖ are less tolerable.
Often backups are selected by an operator.
Examples include Aircraft, Navigation, Reactor control systems, safety-critical Chemical factory controls,Train signals and engines on single-engine Aircraft.
The system will lose large amounts of money when shutdown: Telephone switches, Factory controls, Bridge and elevator controls, funds transfer and market making, automated sales and service.
Physically, embedded systems ranged from portable devices such as MP3 players, to large stationary installations like traffic lights, Factory controllers. In terms of complexity embedded systems can range from very simple with a single microcontroller chip to very complex with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

1.6 KEY IMPORTANCE OF EMBEDED SYSTEMS

1.6.1 INCREASED EFFICIENCY

Embedded systems are designed to perform specific tasks, and they are optimized for efficiency. They can perform tasks faster and with greater accuracy than humans, reducing the chances of errors and increasing productivity. This efficiency can help save time and resources, making operations more cost-effective.

1.6.2 ENHANCED FUNCTIONALITY

Embedded systems can add new features and functionalities to existing systems, improving their performance and capabilities. For example, embedded systems can be used to add new sensors to a car that can detect and alert drivers of potential dangers, such as lane departure or collision. This enhances the safety of the vehicle, and the driver's experience.

1.6.3 IMPROVED RELIABILITY

Embedded systems are designed to operate reliably in harsh environments, such as extreme temperatures, humidity, or vibrations. They are also designed to operate for extended periods withoutrequiring maintenance. This reliability is critical in systems where safety is paramount, such as medical equipment or aerospace systems.

1.6.4 COST-EFFECTIVENESS

Embedded systems can be designed to be highly cost-effective, as they are often optimized for a specific task. They can reduce the need for additional hardware or personnel, and they can be produced in large quantities, reduce the cost per unit. This makes them ideal for use in mass- produced products such as consumer electronics, automotive, and industrial automation systems.

1.6.5 REMOTE MONITORING AND CONTROL

Embedded systems can be connected to the internet, allowing them to be monitored and controlled remotely. This is particularly useful in industrial automation systems, where operators can monitor and control machines from a central location, reducing the need for on-site personnel. This also allows for predictive maintenance, where systems can be maintained before they fail, reducing downtime and repair costs.

1.6.6 ENERGY EFFICIENCY

Embedded systems can be designed to consume very little power, making them ideal for use in battery-powered devices such as smartphones, wearable devices, and sensors. They can also be used to optimize energy usage in buildings, reducing energy costs and carbon footprint.
In summary, embedded systems are crucial for enhancing the performance, reliability, and functionality of various systems. They play a vital role in improving our daily lives, making them more efficient, cost-effective, and convenient.

CHAPTER 2 OVERVIEW OF THE PROJECT

2.1 ABOUT THE ROBOT

ROBOT is a mobility device designed for shifting Objects, moving Objectspeople from one place to another with the help of self-propelling. Product design is the concept of systematic approach in understanding the user requirement, existing deficits, possible improvement and inventing new designs through idea generation, concept development, and concept realization thereby bringing newer products and solutions for the better quality of life**.** The Robot is divided into two different types based on the power used for mobility.
We developed an underwater drone that combines the hottest keywords in today‘s drone technology: Wide angle camera, underwater drone", Surveillance", Inspection", deep learning". Our model is designed based on open-source hardware, is equipped with a function of wide angle camera, and has the ability of transmitting live video footage. The body was designed using a free software application for creating solid 3D computer-aided design objects (Open CAD). The printed-circuit board was designed with frizzing. The underwater drone was equipped with wide angle camera lenses.The goal of this research was to use the underwater drone for investigating and observing the lakes, seas, and so on.

2.2 INTRODUCTION

An underwater remotely operated vehicle (Underwater Drone) is a mobile robot design for aquatic work environment.This remote control vehicle operates in lake, ponds, well, etc. It is constructed basically by leak proof material like carbon fiber, thin aluminum sheet. It contains one camera with two LED lamp for better visualization .It contain different brushless D.C motor according to power required to move the Underwater Drone inside the water.
During deep water the pressure get increases continuously so the design of Underwater Drone is based on submarinewhich help to distribute pressure on a whole body of Underwater Drone.

The propellers are used to move the Underwater Drone inside the water. The design of propeller is constructed with specific angle and the propeller is fitted in round cylinder with brushless motor shaft Thecylinder use the specific amount of water to the propeller because of this maximum energy is use to move the drone. It contains GPS to track the location of drone

The material well be used in the Underwater Drone are made up from aluminum and using some electronic components. The propeller are made from alloy copper material.
The use of this project based on small robotic vehicles is now widespread in engineering curricula. In contrast, the underwater environment presents unique design challenges and opportunities. The wire guidedUnderwater Drone project describe a below relatively in expensive to implement. The built controller for the LEGO motors and evolves their design In to Underwater Drone, Underwater vehicles controlledremotely by a human operator via connecting wire.
The Underwater Drone can reach areas out of diver's range, while the computerized graphic controller allows theoperator, By means of video camera within Underwater Drone.

The Underwater Drone is design to develop three main submarine tasks inspection, repair and maintenance.

2.3 PROBLEM STATEMENT

- We select this project for ease in underwater operation to find out some accidental object like partsof vehicle, crash aero planes, and ships inside the water during any natural disaster.
- To study aquatic environment like different species of aquatic animal and plant.
- For inspection of hull to reduce the effort of divers.
- For surveillance to keep eye on terrorist activity.

2.4 OBJECTIVE

Rescue Operation -underwater drone introduced to rescue operation to find out misplace bodiesduring floods alsoused to search destroyed accidental part such as aero plane, ships, etc.
Infrastructure maintenance, Municipalities and service companies use the ROV's underwaterremote camera toperform frequent inspections of storm water/drain pipes, water tank, sewer pipes.
To perform underwater operation and inspection in crucial area with the help of underwater drone.

The primary objective of an underwater surveillance drone is to gather data and images fromunderwater environments for a variety of purposes. This data can be used to monitor and protect underwater assets and infrastructure, support scientific research, and provide insights into the health and condition of aquatic ecosystems.

More specifically, the objectives of an underwater surveillance drone may include:Security surveillance:
Underwater surveillance drones may be used to monitor and protect critical infrastructure, such as underwater pipelines, cables, and other assets. They can be used to detect and identify potential threats, such as underwater mines, and provide early warning of security breaches or other unauthorized activities.
Environmental monitoring:

Underwater surveillance drones can be used to monitor the health and condition of aquatic ecosystems, including water quality, temperature, and the presence of pollutants. They can also be used to monitor marine wildlife populations and habitats.

Scientific research:
Underwater surveillance drones can be used to support scientific research in a variety of fields, such as oceanography, marine biology, and geology. They can be used to collect samples and data from underwater environments, and to provide detailed images and footage of underwater landscapes.

Search and rescue:
Underwater surveillance drones can be used to assist in search and rescue operations, such as locating and retrieving lost or stranded divers or swimmers.
Overall, the objective of an underwater surveillance drone is to provide valuable data and insights from underwater environments that can be used to support a variety of applications and industries.

2.5 GOAL OF THIS PROJECT

- This concept of the robot helps to inspect or view the missing things or persons under the water Withoutany human interference except controlling.
- This project is less expensive and can be implemented easily at a less cost. The Government of India can take measures to fund this project as to provide the same to the people at a subsidized cost.
- Research and case study can be done so as to renovate the project and bring about enhancements in thesame

2.6 METHODOLOGY

The hardware of the drone involves Wide angle camera which will be responsible to transmitting live video feed to the base station and also Arduino Nano which will be responsible for executing tasks like collecting the data from the signal decoder and controls the various coordination of motors with the help of mini microcontroller. In the frame design of the drone, the main cylinder and propeller casings will be made using PVC, since PVC is lighter in weight also cost-friendly. One side of the will be transparent to capture the video by the camera. These data will be transferred tothe base station without any delay. The power to the system will be given by Lithium-Polymer Battery because they are lightweight.

The methodology of underwater drones involves a series of steps and processes that are designed to ensure the successful deployment and operation of the vehicle. The specific methodologycan vary depending on the type of underwater drone and its intended application, but some general steps may include:

Design and construction:
The first step in the methodology is to design and construct the underwater drone. This involves selecting the appropriate materials, components, and systems to ensure the vehicle can perform its intended function.

Testing and calibration:
Once the drone is constructed, it must be tested and calibrated to ensure it is functioning properly. This may involve running tests on the vehicle's systems, such as its propulsion, navigation, and imaging systems.

Deployment and operation:
After the drone is tested and calibrated, it can be deployed in its intended environment. This may involve launching the drone from a boat or shore, or using a submersible to transport the vehicle to the deployment site. Once the drone is in the water, it can be operated using a remote control or autonomous software to carry out its mission.

Data collection and analysis:
As the drone operates in the water, it collects data and images that can be used for a variety ofpurposes, such as scientific research, environmental monitoring, or security surveillance. Once the data is collected, it must be analyzed and processed to extract meaningful insights.
Maintenance and repair:
Finally, the underwater drone must be maintained and repaired to ensure it remains in good working condition. This may involve routine maintenance tasks, such as cleaning and lubricating the vehicle's systems, as well as more significant repairs or component replacements if necessary.

Overall, the methodology of underwater drones is designed to ensure the successful deployment and operation of these vehicles, and to maximize their effectiveness in a variety of applications. It involves careful design and construction, rigorous testing and calibration, and ongoing maintenance and repair to ensure the vehicle remains in good working order.

2.7 PREVIOUS SYSTEM AND ITS DEMERITS

Now a day's, main problem in Seas and Lakes people are falling / grabbing in to water by the force generated by the water, Damages under the Ship Bottom generated by the sea, Loosed items Under Water, etc... They are many types of rescue systems are available in the world which are operated on the surface of the water areas only but not work under water perfectly. The professional divers also stay up to max 20Min under the water it is due to the lack of sufficient Oxygen levels under water.
The demerits due to above are as follows:

- More time is spent on searching of valuable things under the water.
- Usage of professional divers will be more in order to find the expected things in water

2.8 PROPOSED METHOD

Covering the demerits, the project will not only remove the above demerits but also increases the ease of workflow making fewer human efforts and complexity. The features of the proposed underwater device are as follows:

- Explore the world beneath the water with the help of a HD camera and lights.
- Locate and search the position of the expecting object using the camera.
- Grab any object from underwater with the robotic arm.
- Capturing real-time scenarios of underwater by employing an HD camera and its application.

CHAPTER-3 ABOUT THE COMPONENTS

Main Components

1. MOTOR
2. ELECTRONIC SPEED CONTROLLER(ESC)
3. HULLS
4. PROPULSION
5. ELECTRIC SUPPLY OR BATTERY

6. DPDT SWITCHES
7. CAMERA AND DISPLAY
8. CONTROL BOARD
9. TOOGLE SWITCH

3.1 MOTOR:

To assure the proper movement of the ROV inside the water powerful brushless motors were used.The main reason why brushless motors were used is that they can work inside the water without any problem and they do not have to be waterproofed. Brushless motors are suitable for working underwatersince they do not have contacts, and they are powered by the stationary coils. The stationary coils are powered by an AC signal to spin the casing containing the magnets.

BRUSHLESS DC MOTOR:

A brushless DC motor has a rotor with permanent magnets and a stator with windings. The rotor can be of ceramic permanent magnet type. The brushes and commutatorare eliminated and the windings are connected to the control electronics. The control electronics replace the commutator and brushes and
energize the stator sequentially. Here the conductor is fixed and the magnet moves. The current supplied to the stator is based on the position of rotor. It is switched in sequence using transistors.

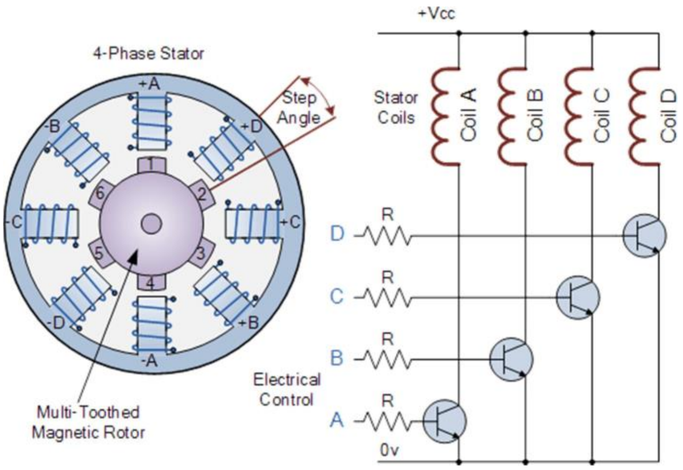


Fig.3.1 Brushless DC Motor

The position of the rotor is sensed by Hall Effectsensors. Thus acontinuous rotation is obtained.
Advantages of brushless DC motor:

- More precise due to computer control
- More efficient
- No sparking due to absence of brushes
- Less electrical noise
- No brushes to wear out
- Electromagnets are situated on the stator hence easy to cool
- Motor can operate at speeds above 10,000 rpm under loaded and unloadedconditions
- Responsiveness and quick acceleration due to low rotor inertia

Disadvantages of brushless DC motor:

- Higher initial cost
- Complex due to presence of computer controller
- Brushless DC motor also requires additional system wiring in order topower theelectronic commutation circuitry.

Fig.3.2 DC MOTOR WITHOUT GEAR

boxMotor Type : DC without gearBase Motor : DC 1200 RPM
Shaft type : Circular 6 mm dia with internal hole for coupling, 23 mmshaft length

Max Torque : 1.5 kg-cm at 12V, 500 RPM Max Load Current: ~350mA at 12V-500RPM

BRUSH TYPE DC MOTOR:

A typical brushed motor consists of an armature coil, slip rings divided intotwo parts, a pair of brushes and horse shoes electromagnet as shown in Fig. 4.1.4. A simple DC motor has two field poles namely a north pole and a south pole. The magnetic lines of force extend across the opening between the poles from north to south. The coil is wound around a soft iron core and is placed in between the magnet poles. These electromagnets receive electricity from an outside power source. The coil ends are connected to split rings. The carbon brushes are in contact with the split rings. The brushes are connected to a DC source. Here the split rings rotate with the coil while the brushes remain stationary.

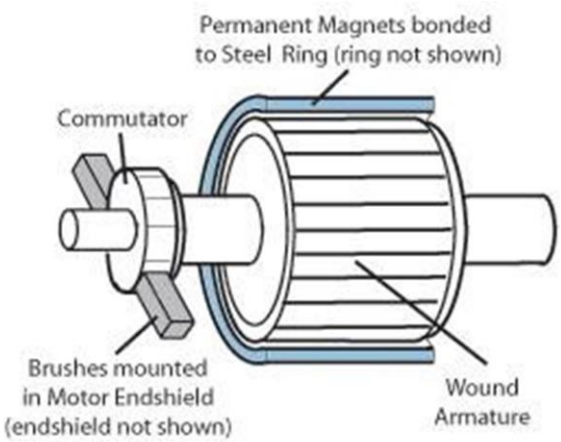


Fig 3.7: Brush type DC motor

The working is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's lefthand rule. The magnitude of the force is given by

$F = BIL \sin\Theta$

Where,

B is magnetic field density in weber/m^2**I**is thecurrent

L is the length of the conductor in meter

Θ is the angle between the direction of the current in the conductor and theelectric Field

If the current and filed are perpendicular then θ=90°. The above equationbecomes F =BIL

A direct current in a set of windings creates a magnetic field. This field produces a forcewhich turns the armature. This force is called torque. This torque will cause the armature to turn until its magnetic field is aligned with the external field. Once aligned the direction of the current in the windings on the armature reverses, thereby reversing the polarity of the rotor's electromagnetic field. A torque is once again exerted on the rotor, and it continues spinning. The change in direction of current is facilitated by the split ring commutator. The main purposeof the commutator is to overturn the direction of the electric current in the armature.

The commutator also aids in the transmission of current between the armature and the power source. The brushes remain stationary, but they are in contact with the armature at the commutator, which rotates with the armature such that at every 180° of rotation, the current in the armature is reversed.

Advantages of brushed DC motor:

- The design of the brushed DC motor is quite simple
- Controlling the speed of a Brush DC Motor is easy
- Very cost effective

Disadvantages of brushed DC motor:

- High maintenance
- Performance decreases with dust particles
- Less reliable in control at lower speeds
- The brushes wear off with usage

3.2 ESC (Electronic Speed Controller):

As per the name of this component it is used to control the speed of brushless dc motor. IN order to increase the speed of motor the ESC must provide more voltage than before. By increasing the output current of Esc user can achieve higher torque value. Esc have two cable for power (positive and negative). Another feature of ECs have is that user is able to change the direction of the motor by reversing the polarity.

PWM 3A DC 6V 12V 24V 28V MOTOR SPEED CONTROL SWITCH CONTROLLER QUALITYMODULE

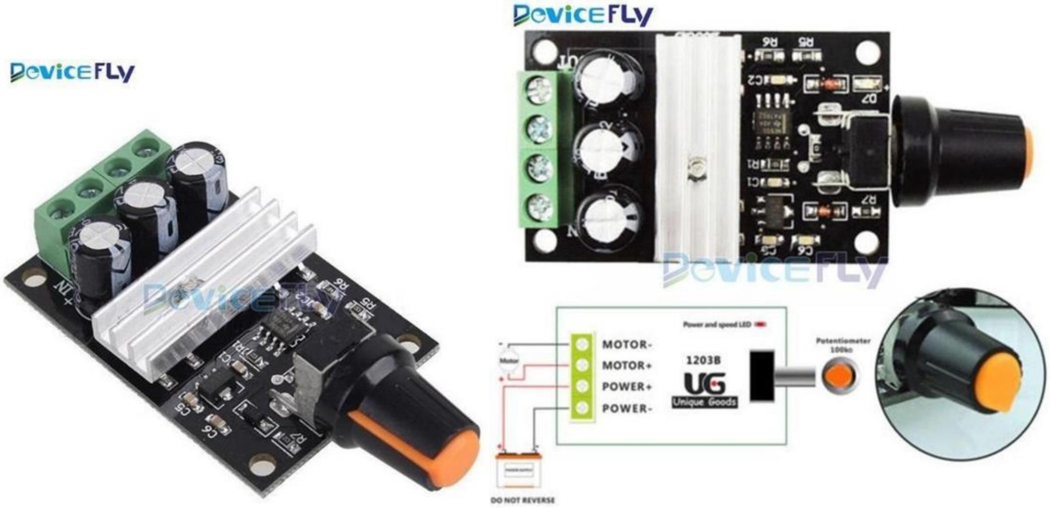


Fig 3.3 Electronic Speed Control

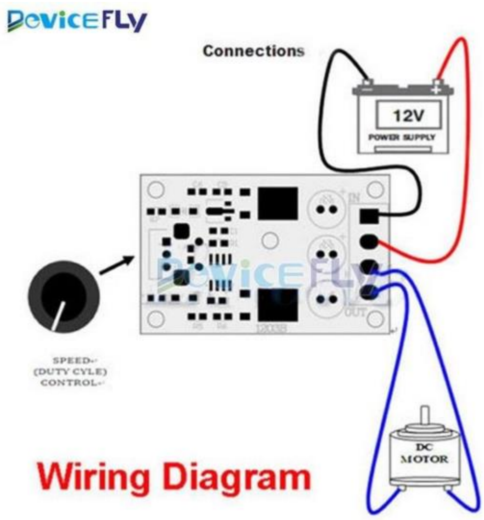


Fig 3.4 Wiring of ESCcurrent :3ADuty

Features:

This DC Motor Speed Controller allows controlling the direction of a DC motor using a Pulse-Width-Modulated (PWM) DC voltage with a Duty Cycle fully adjustable from 0%-100%.

The motor speed controller can easily provide a continuous current of3A to your DC motor or other DC load.

Main technical parameters:

Input supply voltage:6V-28VDC The maximum outputpower: 80W
The maximum continuous output
Cycle adjustable:5%-100%Quantity:1PC

Operating instruction:

1. Connect your DC motor (or DC load) to the motor terminals as indicated on the wiring diagram.
2. Connect a voltage of 10V-36V DC to the circuit making sure of the correct polarity of the connection. Note that thevoltage applied to the motor will be supply voltage applied to the circuit. It is recommendedto add an appropriately rated fuse inline with the positive supply in order to protect the circuit from any possible short circuits.
3. You can now control the speed of the motor through potentiometer.

Package Included:

1 x PWM 3A DC 6V 12V 24V 28V Motor Speed Control Switch Controller Quality Module

3.3 HULL:

The upper and lower hulls were made from PVC tubing utilizing threaded end caps with O-ring seals for easily opening and closing each end of the hull, but at the same time ensuring watertight integrity. To support the electronic components inside the upper hull, two Perspex boards were machinedto size and PVC supports were attached inside the tube to allow the boards to be properly placed and tobe easily slide in and out This Hull part account for the majority of the vehicle’s volume and thus selecting proper size was critical. Selection of diameter of the PVC tubes was calculated on the basis of sizes of the Controllers and battery to be housed inside the drone.

Fig 3.5 Hull Side view

Fig 3.6 HULL Front view

3.4 PROPULSION

The propulsion section of the drone includes motors or motor controllers. It controls the speed and position of the ROV. Motors were selected according to their inherent watertight integrity, size specifications and low cost. Since, motors are to be placed outside the main body of the drone; their volume must be taken into consideration for designing the overall structure of the volume. A propeller-to-hull and propeller-top propeller interaction was done with the help of Arduino Microcontroller. We have used a total3 brushless DC motor as thrusters. Out of which 1 motors is used for vertical movements and 2 motors for backward and forward movements. The speed of this motor will be controlled by the microcontroller to balance the movement of the drone in a particular plane

Fig.3.7 Propeller Side view

Fig 3.8 Propeller Top View

3.5 ELECTRIC SUPPLY OR BATTERY:

The Underwater surveillance drone uses the battery or eletric supply in the following components : 1.Propulsion: AUVs use electric motors to propel themselves through the water, and batteries are used topower these motors. The battery capacity must be sufficient to enable the AUV to travel long distances oroperate for extended periods of time.

2. Sensors: AUVs are often equipped with a variety of sensors to gather data about their environment. Thesesensors require power to operate, and batteries are used to provide this power.

3. Communication systems: AUVs may be equipped with acoustic modems or other communication systems to enable communication with a surface vessel or other underwater devices. These communication systems require power, which is provided by the AUV's batteries.

4. Control systems: The electronics and control systems in an AUV require a steady supply of power to function properly, and batteries are often used to power these components.

5. Emergency backup power: In some cases, AUVs may be equipped with backup batteries to provide powerin case of a power outage or other emergency.

The battery usage in an unarmed underwater drone is critical to its operation and must be carefully managedto ensure that the AUV can perform its mission effectively and safely.

The battery usage in an unarmed underwater drone is critical to its operation and must be carefully managedto ensure that the AUV can perform its mission effectively and safely.

Fig 3.9 12V BATTERY

3.6 DPDT SWITCHES

This is Robotics switch box enclosure with DPDT switches. The switch box is used to accommodate two DPDT Rocker Switches. It is a perfect makeshift remote for your robot. This isremote control box for wired hobby robot. To make the anticlockwise motion of the motor, the polarityof supply must be inverted in a clockwise motion. For "Polarity Reversal" DPDT switches are generally used. A Double Pole Double Throw (DPDT) switch is an electromechanical switch that has 2inputs and4 outputs and each input is connected to 2 corresponding outputs.

Fig.3.10 DPDT SWITCH

Fig 3.11DPDT SWITCH internal view

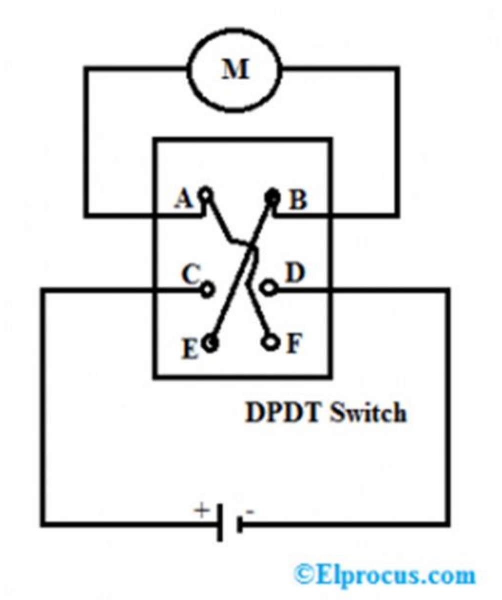
Features:
Homopolymer. Good Processability.
Good Impact Resistance.Good Stiffness.
Switched will directly snap fit into slots.
Switches are ROCKER TYPE (They will retain central Position once force is removed from them.Flush mounting DPDT rocker switch
For Linear Actuators and other DC Motors3 position switch

How does DPDT Switch Works?
DPDT or Double pole, double throw switches will break or make the two conductors connected to two separate circuits. In this switch, DP switches control two independent circuits whereas DT switches close a circuit in the up & down position. These switches have six terminals like two inputs and four outputs which are available in both momentary & maintained contact versions.

This is a dual ON-ON type of switch that is derived from the SPDT characteristics. Generally, thisswitch has 2 (ON-ON) positions or 3 (ON-OFF-ON) positions. The set of SPDT switches operates mutually 23 through four circuits with two independent circuit systems.

These circuits can be activated at the same time. So, in this condition, both appliances within similar circuits will be power-driven once the switch is ON. Meanwhile, for the four circuits within a DPDT switch, only two circuits can be energized simultaneously. This switch uses polarity reversal that permits it to switchtwo energized circuits simultaneously.

DC Motor Control using DPDT Switch
The DPDT switch circuit diagram is shown below which is used to control a DC motor. To control a DC motor, first, we need to connect the motor to a switch. Generally, DPDT has six terminals whereas DC motor has two terminals. Here, the switch terminals are represented with A, B, C, D, E, F &G. The connection of this circuit is as follows.

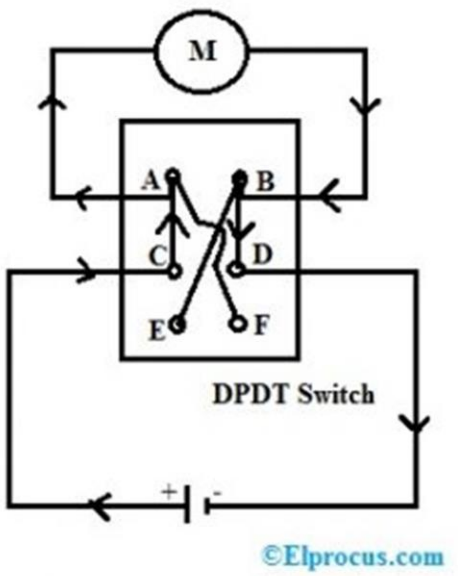


DPDT Switch to Motor Connection

First, we need to connect a wire in between two terminals like A & F through soldering as shown in the above circuit. Connect a wire between two terminals like B & E. The DC motor is connected in between A& B terminals whereas the battery is connected in between C & D terminals.

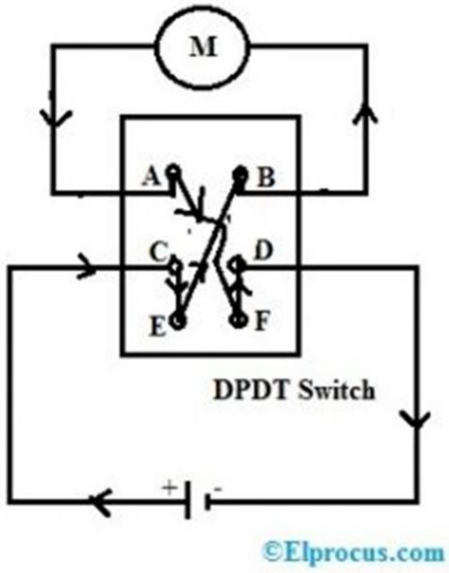
Working

The working of this motor can be done in two ways like forward rotation and reverse rotation. Once the switch is pressed in forward direction then terminal-A is connected to terminal C whereas terminal B is connected to terminal D. Therefore, the DC motor rotates in forward direction because the battery is allied inforward connection toward the motor.



Forward Rotation Connection

Once the switch is pressed in the reverse direction, terminal-C is connected to terminal-E & also terminal-Dis connected toward terminal-F. Therefore, the DC motor rotates in the reverse direction because the batteryis allied in reverse connection toward the motor.



Reverse Rotation Connection

DPDT Toggle Switch

This DPDT toggle switch is available in On-Off-On configuration which is rated at up to 6A & 125VAC. Byusing this switch, you can switch two different circuits or two loads simultaneously. The **dpdt on-off-on switch diagram** is shown below.

DPDT On Off On Switch

This switch is used in Jeeps, RV's & boats. This switch is a Marine-grade toggle switch and sealed with waterproof. The operation of the DPDT toggle switch is, it acts like two separate SPDT switches which are connected to a similar switch bat. This switch includes two separate ordinary terminals where each of these terminals can be connected to one or two terminals on a similar face of the switch. The dotted line within thetoggle switch illustrates that the switch includes two SPDT switches within one package through one switch bat.

Advantages & Disadvantages

The **advantages of the DPDT switch** include the following.

- It carries two independent signals
- They work with high voltages & currents
- Failover capabilities
- High switching current allows the device to drive motors, pumps, and control relays.
- This switch can be used in different applications
- By using this switch one can control an appliance at the same time through one flick.
- This switch is not expensive
- Less weight

The **disadvantages of the DPDT switch** include the following.

- As compared to bridges, these are expensive.
- Network connectivity issues cannot be traced using this switch.
- Broadcast traffic may be difficult on a switch

What is a DPDT Switch used for?

The applications of DPDT switch or DPDT switch **uses** include the following.

- A DPDT switch is used where an open and closed wiring system is used.
- This switch is frequently used for simultaneous switching of two independent signals that should work intandem.
- This switch is frequently used for switching mains' electricity as it can separate both the neutral & liveconnections.
- A DPDT switch can be connected like a reversing switch for an electric motor.
- By using the DPDT switch, reverse polarity can be achieved in a more controlled way.
- This switch is used to control the robot.

Thus, this is all about an overview of a DPDT switch and its working. Here is a question for you, what is the difference between DPDT & SPDT?

3.7 CAMERA AND DISPLAY:

Main Features:

Screen Size: 4.3 inch Screen Resolution: 800*480
Dimensions Size:240*108*16mm(W*H*T)OSD Languages: English
Pixels: 480 * RGB * 272(Analog Panel)
Video Input: When parking, Input from Camera RC Cable.
Black Screen: when no video signal input, black screen will be displayed.
The camera used is a sensor camera used in car back camera and display is a 5inch LCD screen display with 8 LED night vision rear camera. It has high definition LCD screen. HD 170 degree wide angle camera. We used this camera because of its water proof feature and its economical. We used 2 strips of LED instead of 8 LED night vision camera because vision is not proper in day time and LED strips are waterproof.

Fig.3.12 Camera and Display

3.8 CONTROL BOARD:

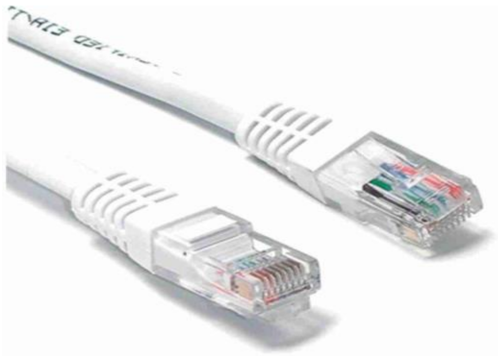
Controller is a main device that controls the drone. Robotic switches are used to operate the drone movements. DPDT switch is used to move the drone upward and downward and it is placed middle of control board.2 switches are used to give right and left motion, front and back motion.5 meters long RJ 45 cable is used to connect 3 motors and camera , light to the controller board. The display will show the output of camera.

RJ 45 cable has total 4 pairs of wires in which 3 pairs are used to connect with 3 motors and remaining pair (one wire acts as positive another negative) that is connected to camera and one signal jogwire is used to connect with camera to control board that will sends signal from camera to display.

Fig.3.13 CONTROL BOARD

RJ45 CABLE:

Rj 45 cable has total 4 pairs of wires in which 3 pairs are used to connect with 3 motors and remaining pair (one wire acts as positive another negative) that is connected to camera and one signal jog wire is used to connect with camera to control board that will sends signal from camera to display.



3.9 TOGGLE SWITCH:

Toggle Switches have an operating lever that can be pushed up and down or left and right to switchan electrical circuit. A toggle is a small wooden rod that is used as a clothing fastener in the place of buttons. The term toggle switch 31 was created because of the resemblance of the switch‘s lever to that ofthe toggle used in clothing.

Fig.3.14 TOOGLE SWITCH

The switch consists of a lever that is moved back and forth between two positions, which either opens orcloses the circuit.

When the lever is in the "on" position, the switch completes the circuit, allowing electricity to flow through the connected device or appliance. When the lever is in the "off" position, the circuit is broken, preventing electricity from flowing.

Toggle switches come in a variety of sizes and configurations, and can be used in a wide range of applications. They are commonly used in household and commercial settings to control lighting, fans, and other appliances, as well as in industrial and automotive applications to control machinery and equipment.

Toggle switches are often preferred over other types of switches because they are simple to use and reliable, and they can be easily installed in a variety of settings. They are also relatively inexpensive, makingthem a popular choice for many different types of applications.

CHAPTER 4 CONSTRUCTION AND ASSEMBLY

There are numerous variables that were looked into, for example safety factor, material, thickness, length, and diameter. Due to this there was a spreadsheet made with the capacity to enter all these parameters, and calculate the maximum depth with the corresponding cost. The unmanned submersible will make out of a barrel lodging all the wires, circuits, and cameras. The failure analysis will be dependent upon this cylinder's behavior as the depth increases. The joined spreadsheet utilizes the comparisons for hoop stress, longitudinal stress, and axial stress to verify the principle stresses.

The upcoming analysis depends on a couple of presumptions. For example, the cylinder will act as a pressurized vessel with a negative internal pressure value. An alternate assumption is that the atmospheric pressure will be 101.325 kilopascals. The water that the submersible will be worked in is ocean water, whichhas a thickness of 1027 kg/m3 . Some materials will be acknowledged for the submersible so correlations 10 could be made when referencing cost versus depth. The materials acknowledged are broadly accessible and cost anywhere from $11.27 to almost $4,000. The list below incorporates all the materials acknowledged.

- 316 Stainless Steel (36X96 Sheet - Unpolished)
- 7075 Aluminum (48x72 Sheet)
- Titanium Grade 2 (24X36 Sheets - Ground Finish)
- Titanium Grade 5 (24X36 Sheets - Ground Finish)
- PVC Schedule 40
- PVC Schedule 80

There are a considerable amount of parameters to these calculations, and some were made consistent for the simplicity of the material correlation. The variables that might be altered for optimization while staying inside a factor of safety are diameter, length, thickness, and depth. This permits the ability to observewhich of the six materials will withstand the desired depth while staying inside the factor of safety demands. This also allows the option to implement different size combinations to see how it affects the outcome.

The task was to determine how deep into ocean the Remotely Operated Underwater Vehicle (the pressure vessel) can dive while maintaining a safety factor of 1.5, and additionally figure out which material would allow us to achieve this goal with the best cost. The different materials will be tested according to the size of the pressure vessel. It is to be noted that this is a simplified version of the actual model, which will beused as a preliminary test in order to understand the effects of hydrostatic pressures on an 11 object under water. The model being tested has a cylindrical body that is hollow inside. This will assimilate the body of the actual ROV without the two wing-like components of the model.

The pressure vessel has a length of 0.4752 meters (1 foot and 5 inches) and a diameter of 0.1524 meters (6 inches) consistent with the real model. These measurements were kept the same for all the materials being tested and the only measurement that was changed was the thickness due to the fact that eachmaterial is sold with a certain thickness. The materials tested were PVC Schedule 40, PVC Schedule 80, Aluminum 7075, Stainless Steel 316, Titanium (Grade 2) and Titanium (Grade 5). The yield strength, tensile strength, and cost for each material were collected for the analysis. In order to measure the factor of safety ofthe pressure vessel to ensure that the material will not fail, the following values we calculated depending on the depth at which the pressure vessel is located: Tangential stresses, Axial stresses, Principles stresses and Von Misses stresses.

With the factor of safety calculations done, the attention was turned to the cost analysis. Due to the fact that each material is sold with a certain diameter, the cost of the material depends on solely its length. Keeping in mind that all models accounted for have the same length, it can be said that price will not change with the depth at which the specimen is sent. The prices were placed side by side with the maximum depth each material reached. In doing this, the material that went the deepest for the least amount of the cost wouldbe the one selected. Of course there are some obvious assumptions that could be made, for example Titanium (Grade 5) would go deeper than any other material but its cost would to be high and PVC Schedule40 is the cheapest but it will not go very deep. These assumptions cannot influence the selection of the material because the material of the lowest cost would prevail.

PVC Sch. 40		Stainless Steel316		Aluminum7075		PVC Sch. 80		Titanium(Grade 2)		Titanium(Grade 5)	
Depth	**FoS**	**Depth**	**FoS**	**Depth**	**FoS**	**Depth**	**FoS**	**Depth**	**FoS**	**Depth**	**FoS**
50m	15.817	50m	15.887	50m	17.634	50m	24.403	50m	33.093	50m	66.199
100m	8.636	100m	8.675	100m	9.628	100m	13.324	100m	18.069	100m	36.145
200m	4.526	200m	4.546	200m	5.046	200m	6.983	200m	9.47	200m	18.944
300m	3.067	300m	3.08	300m	3.419	300m	4.732	300m	6.416	300m	12.835
400m	2.319	400m	2.329	400m	2.586	400m	3.578	400m	4.852	400m	9.706
500m	1.864	500m	1.873	500m	2.079	500m	2.876	500m	3.901	500m	7.803
600m	1.559	600m	1.565	600m	1.738	600m	2.405	600m	3.261	600m	6.524
610m	1.534	610m	1.541	650m	1.606	770m	1.881	900m	2.186	1300m	3.038
620m	1.509	620m	1.516	690m	1.515	900m	1.612	1100m	1.793	2000m	1.98
624m	1.499	627m	1.499	697m	1.499	969m	1.499	1317m	1.499	2644m	1.499

Table 4.1 Ranges of different materials

The materials required for building an underwater drone will depend on design and specifications, but mayinclude PVC pipes, motors, propellers, batteries and sensors. In our project we included

The frame of the drone provides the structure and support for the various components. PVC pipes arecommon choice for the frame, as they are lightweight, durable, easy to work with. The pipes are cut to size and assembled using PVC joints.

.1 HULL

- Hull is made up of PVC pipes. Ten L-Shape joint pipes and Ten 'T' joint pipes are used to assemblethe hull body and before assembly.
- The hull body is main structure of body which is able to hold the remaining parts and somecomponents are to be placed inside the body.
- The hull should be made airtight as water may suspend into the drone and drown.
- As Hull is the main body of the drone it should balance all the weights corresponding to its structure.
- The weight should be balanced so it can float and submerged in water properly.
- There are 3 motors arranged in the drone in the pipes they are fixed so that the shaft must be projectedoutwards because the propeller is fitted to the shaft.
- The 2 motors are placed horizontally for the propulsion of the drone.
- The other motor is placed at the bottom of the drone for vertical movement of the drone.
- The motor must be water proof for this purpose we used glue gun the glue which is applied around the motor and between the pipe here glue acts as water resistant.
- Materials commonly used for underwater drone hulls include high-density polythene(HDPE), acrylonitrile butadiene styrene(ABS), and various types of composites. The choice of material dependson factors such as depth of drone will be operating at, the expected stress on the hull, and the desired weight and cost.
- Over all the design and construction of an underwater drone hull requires careful consideration of a range of factors including material, dimensions, weight, and functionality, to ensure the drone is capable of operating effectively and reliably in its intended environment.
- Water proofed camera is fitted in L joint pipe and its placed front middle of hull body.
- All wiring of 3motors and camera connected to RJ45 cable which has 8 wires i.e 4 pairs.
- The wires are connected inside the pipes and the output receiving signal wire which is connected tocamera and RJ45 cable are drawn outside from the backside middle of hull body.
- After the body is fitted tightly without any leaks or gaps with electric tape.

- The is total construction of hull body and emerged components in it.

4.2 PROPELLER CONSTRUCTION USING 3D PRINTER

- In this underwater drone project, we used two blade propellers , because it rotates with very high speedand it is very less weight compared to 3 blade propeller.
- The speed of motor depends upon the design of propeller blades.
- 2 blade propeller make more sense when speed and efficiency are important and they can becommonly employed in lightweight drones and less powerful motors.
- This 2blade propeller is made using 3D printer

4.3 STEPS FOR MAKING PROPELLER USING 3D PRINTER

1. Design the propeller

Use a 3D modelling software, such as blender solid works, to design the propeller.Consider the pitch, diameter, chord length, and blade twist.

It is important to optimize these parameters based on intended use and the motor size. Keep inmind that the propeller should be strong, balanced, and efficient.

2. Convert the design into printable file format

Save the design in file format that the 3D printer can read, such as STL, OBJ, or 3MF.Make sure the file is high-quality and dimensions are accurate.

3. Import the design into 3D printer software

Load the file into the 3D printer software, such as Cura or PrusaSlicer. The software will generate a G-code that tells the printer how to create the propeller layer by layer. Adjust the settings such as layer height, infill density, and print as needed.

4. Prepare the printer

Make sure that the 3D printer is clean and ready to use. Install the correct nozzle size and filament material, such as PLA or PETG. Level the build plate and calibrate printer as needed.

5. Print the Propeller

Start the printing process let the printer work. Depending on the size and complexity of the propeller, this may take several hours. Make sure to monitor the printer and check for any issues, such as wraping or under-extrusion.

6. Remove the Propeller form the Build plate

Once the printing is complete, remove the propeller from the build plate. Use a spatula or scrapper to carefully lift the propeller off the build plate. Be careful not to change the bulb or the hub.

7. Clean up the Propeller

Remove any supports or excess supports from the propeller. Use a hobby knife or sandpaper to smooth out any rough edges or imperfections. Check the balance of the propeller by placing it on a flat surface and spinning it. If it wobbles, trim the blades as needed.

8. Test the Propeller

Attach the propeller to a motor and test it in water. Make sure it spins smoothly and efficiently. Adjust the pitch or chord length as needed to optimize the performance.

Overall, making a 2-blade plastic propeller using a 3D printer requires patience, attention to detail, and a good understanding of propeller design and manufacturing. With practice and experimentation, you can create a propeller that is strong, balanced, and effective for your needs.

Propellers come in many sizes and shapes, but we require 2 blade propeller. Every propeller has two important things one is pitch and other is diameter. The units of both diameter and pitch is in inch. Propeller blades are described by

$$A*B$$

Where A is Diameter of BladeB is Diameter of Blade

Diameter is the distance across the circle made by the blade tips as the propeller rotates.

Pitch represents the twisted present on the propeller blade. It is the distance that a propeller would move in one revolution if it were moving through a soft solid like screw in wood. The two blade propeller is more durable than the blade propeller.

4.4 CONNECTIONS

Underwater surveillance drone typically require several different types of connections to functionproperly. Here some of the connections used in the project

- Power Connection:

The drone will need a power source to operate so it will need some sort of connection to a battery orpower supply.

- Communication connection:

The drone will need a way to communicate with its operator or other devices, so it will typically havea communication connection.

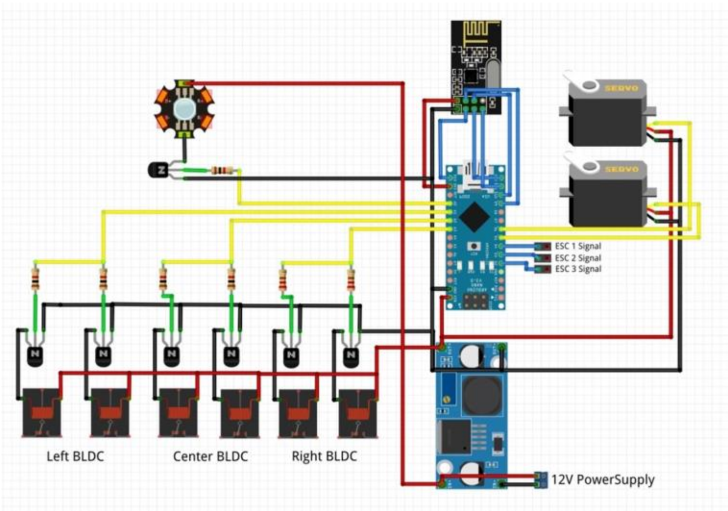
- Navigation Connection:

The drone will need to able to navigate underwater, so it may have a connection to navigationSwitches.

- Propulsion Connection:

The drone will need a way to move in through water so it will typically have a connection to itspropulsion system, such as motors and propellers

It's important for all these connections to be watertight and reliable in order to ensure that the droneoperates properly and doesn't suffer any damage.



Fig,4.1 Circuit Diagram

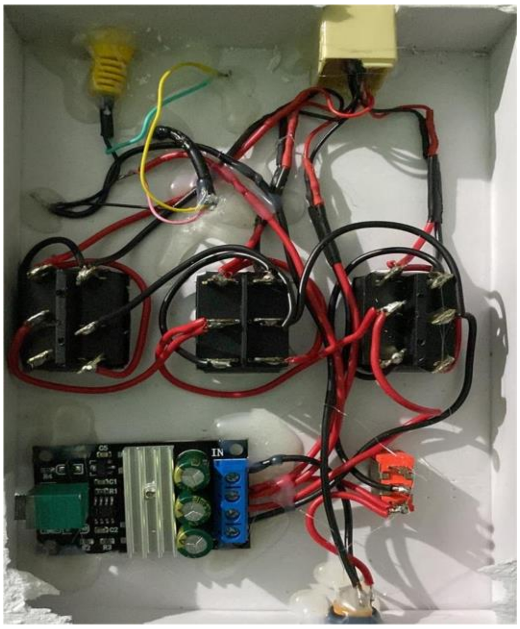


Fig4.2 Connections

4.5 CONTROLLER CONSTRUCTION

1. Controller is the main device that controls the every movement of drone and it positions the drone under waste properly.
2. First connections should be made properly from power supply i.e 12v battery to all three motors, LED light strips and camera and display.
3. Rj 45 cable is the main wire which has 4 pairs of wires(4 neutral and 4 phase wires) that connects all three motors, LED light strips and camera and display with 12v battery.In between this speed controller is placed to control the speed of the motors i.e it regulates the speed of the motor.
4. toggle switch is used to switch on/off the LED light strips and it is placed back of DPDT switches.
5. Three DPDT Switches are placed in middle of control board. They are used to switch the motors.Middle DPDT Switch has three modes front press of switch makes rotate the propeller clockwise direction that means the drone moves upwards middle press makes off position and back press of switch makes anti clockwise direction of propeller that makes downward motion of drone.
6. Left side placed DPDT switch has two presses front and back . It gives front and back motion of left side motor.
7. Right side placed DPDT switch has two presses front and back . It gives front and back motion of right side motor.And by pressing both left and right switches simultaneously i.e left side switch front press and right side switch back press gives right direction of drone and opposite press gives left direction of drone.
8. LCD display is placed front end of control board and total this connections are connected together. 12v battery is used to give power supply to control board.

- The drone hull and its components are fixed using PVC pipes and the connections are drawn from it and connected to control board.
- The video is transferred through signal cables which is also connected to control board.
- The battery is power supply for entire working of drone and it is connected to Control board from another side of board.
- The board is accommodated with a toggle switch which is used for power supply and DPDT switches for the moment of drone and a LCD screen for video display.
- The power supply is connected to Toggle switch and ESC and From ESC the power supply is given to the DPDT switches and the electric supply also transferred from control board to drone.
- The control signals are also connected along with power supply given to the drone.
- The video signals are received to the board and connected to LCD screen.
- The construction and assembly of the underwater surveillance drone is completed.

APPLICATION

Infrastructure maintenance:-
municipalities and service companies' can use the ROV's underwater remote camera to performfrequent inspections of storm water/drain pipes, water tank, sewer pipes.
Photography:-
It use for underwater photography. It is use to capture inner beauty of oceans, lakes, etc.Search and rescue:-
underwater drone introduced to rescue operation to find out misplace bodies during floods, also usedto search destroyed accidental parts of aero plane, ships, etc.
Aquaculture:-
To observe the health of aquatic animal by Inspection this is useful for fisherman.

Hull infection:-
Using the camera on our remote control LED underwater vehicles to perform hull inspectionprovides a cost effective preventive maintenance step can detect signs of minor hull damage before it become a serious issue.
Military missions: -
Underwater ROV can be used to keep an eye or spying work which can be useful for military purpose

CHAPTER 5BUDGET

MOTOR	1800
ELECTRONIC SPEED CONTROLLER(ESC)	750
PVC PIPES	800
PROPELLERS	2000
BATTERY	600
DPDT SWITCHES	200
CAMERA	1000
LCD SCREEN	1500
TOOGLE SWITCH	100
TOTAL	8650

Table 5.1 Budget

CHAPTER 6RESULT

The underwater surveillance drone is to provide enhanced security and monitoring capabilities in aquatic environments. Some of the potential results of using an underwater surveillance drone may include:

Improved situational awareness:
Underwater surveillance drones can provide real-time video and image feeds to operators, allowing them to monitor underwater areas and detect potential threats or hazards.

Enhanced security:
Underwater surveillance drones can be used to monitor critical infrastructure such as underwater pipelines, ports, and other facilities, helping to prevent theft, vandalism, and other security breaches.

Environmental monitoring:
Underwater surveillance drones can also be used to monitor water quality, temperature, and other environmental factors, helping to detect pollution and other hazards.

Search and rescue:
Underwater surveillance drones can be used to search for missing persons or lost objects in aquatic environments, and can assist with search and rescue operations in areas where it may be difficult or unsafe for human divers to operate.

Scientific research:
Underwater surveillance drones can be used to collect data on marine life and habitats, providing valuable information for marine biologists and other researchers.

Overall, the result of an underwater surveillance drone is to provide improved monitoring and security capabilities in aquatic environments, helping to ensure the safety of people and assets, and providingvaluable data for scientific research and environmental monitoring.

Fig6.1.Working of drone

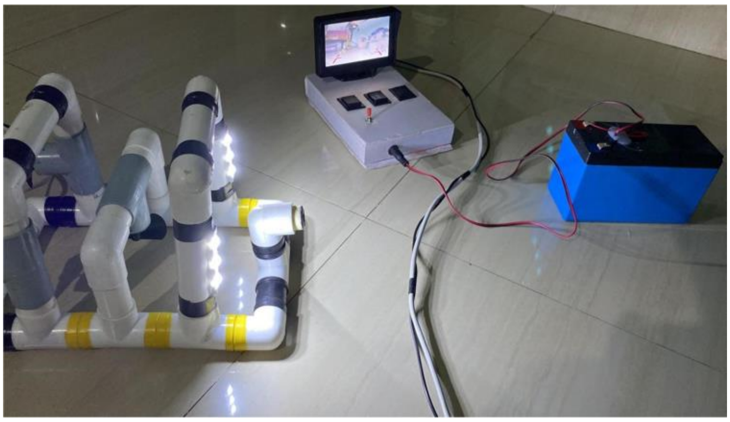


Fig 6.2 Monitoring of drone

Fig 6.3 OUTPUT VIEW IN AQUARIUM

Fig6.4 OUTPUT VIEW

CHAPTER 7 CONCLUSION

In conclusion, underwater surveillance drones are valuable tools that can provide enhanced monitoring and security capabilities in aquatic environments. These drones have the potential to improve situational awareness, enhance security, and provide valuable data for scientific research and environmental monitoring.

Underwater surveillance drones are capable of operating in difficult or dangerous underwater environments, and can collect data and images that would otherwise be difficult or impossible to obtain. They can be used to monitor critical infrastructure, detect potential threats or hazards, and assist with search and rescue operations.

As technology continues to improve, underwater surveillance drones are likely to become even more versatile and useful in a variety of fields, including security, environmental monitoring, scientific research, and more. It's important for these drones to be designed and built with high-quality materials and components, and to be operated safely and responsibly to ensure the best possible results.

7.1 FUTURE SCOPE

The future scope of underwater surveillance drones is significant, with many potential developments and applications on the horizon. Some of the possible future developments and applications for underwater surveillance drones may include:

Improved autonomy:
As artificial intelligence and machine learning technologies continue to advance, underwater surveillance drones may become increasingly autonomous, able to make decisions and take actions based on the data they collect.

Advanced sensing and imaging:
As sensor and imaging technologies improve, underwater surveillance drones may be able to provideeven more detailed and accurate data on underwater environments, enabling more effective monitoring and analysis.

Enhanced security features:
Underwater surveillance drones may be equipped with advanced security features, such as biometric sensors or facial recognition technology, to help identify potential security threats.

Integration with other systems:
Underwater surveillance drones may be integrated with other systems, such as underwater sonar or satellite networks, to provide more comprehensive monitoring and analysis.

Expanded applications:
Underwater surveillance drones may be used for a wide range of applications beyond traditional security and surveillance, such as scientific research, environmental monitoring, and marine biology.

Overall, the future scope of underwater surveillance drones is significant, with many potentialdevelopments and applications that could greatly enhance their effectiveness and usefulness. As technology continues to advance, these devices are likely to become even more versatile and valuable in a variety of fields.

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