

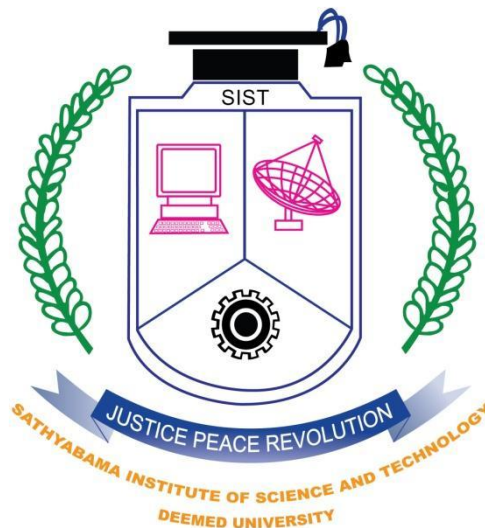
DRONESHIP (HYBRID AQUATIC- AERIAL QUADCOPTER)

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in
Electrical and Electronics Engineering

by

DIVAGAR .M (Register No. 37140028)

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS
ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119
APRIL 2021**



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **DIVAGAR .M** (Reg. No. 37140028) and **HARI HARAN** (Reg. No. 37140033) who carried out the project entitled "**DRONESHIP(HYBRID AQUATIC-AERIAL QUADCOPTER)**" under our supervision from December 2020 to April 2021.

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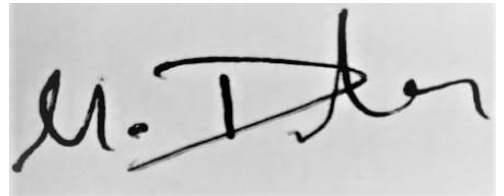
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DECLARATION

We **DIVAGAR.M** (Reg. No. 37140028) and **HARI HARAN** (Reg. No. 37140033) hereby declare that the Project Report entitled “**DRONESHIP AQUATIC-AERIAL QUADCOPTER**” done by us under the guidance of **Dr. V. SIVACHIDAMBARANTHAN** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

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ABSTRACT

Aquatic-aerial unmanned vehicles have recently become the focus of many researchers due to their various possible applications. Achieving a totally operational vehicle that is capable of aerial, water-surface, and underwater operations may be a significant challenge considering the vehicle's air–water–air transition, system, and stability underwater. We present in this paper a conceptual prototype for hybrid aerial-aquatic quadcopter which is multi-rotor type that is capable of aerial flight and water-surface operation, as well as sub-aquatic diving. The Drone uses two sets of propellers: one for air and one for underwater maneuvering. The usage of separate propellers for water medium makes the drone capable for high-speed maneuvering during underwater operations. It utilizes a hydraulic based ballast system to control vehicle buoyancy and depth underwater, as well as to perform seamless air-to-water and water-to-air transitions. Hybrid aerial-aquatic quadcopter are radio control quadcopter driven by an individual on the surface and can be tethered by a series of wires that send signals between the operator and the quadcopter when controlling underwater.

In this project we are using Bluetooth wireless technology to control our drone which is a quite simple communication system. The remote in this project is an android device which has Bluetooth feature inbuilt. The user has got to install an application on his/her mobile and switch on the Bluetooth within the mobile. Users can perform various actions using commands that are sent from the android mobile. The task of controlling the drone is done by the Arduino UNO which houses the micro- controller. It also gives us the advantage of adjusting the remote anytime, meaning that we will use any android devices including phones, tablets, computers. Physical barriers like walls, doors, etc. do not affect in controlling the drone.

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LIST OF ABBREVIATIONS

S.NO	ABBREVIATION	EXPLANATIONS
1	UAV	Unmanned Aerial Vehicles
2	UUV	Unmanned Underwater Vehicles
3	UAUV	Unmanned Aerial-Underwater Vehicles
4	CRACUNS	Corrosion Resistant Aerial Covert Unmanned Nautical System
5	ESC	Electronic Speed Controller
6	DC	Direct current
7	Mhz	Mega Hertz
8	I/O	Input / Output
9	USB	Universal Serial Bus
10	IDE	Integrated Development Environment
11	GND	Ground
12	PWM	Pulse-Width Modulation
13	AREF	Analog Reference
14	LED	Light Emitting Diode
15	TX	Transmit
16	RX	Receive
17	SPP	Serial Port Protocol
18	EDR	Enhanced Data Rate
19	PAN	Personal Area Network

20	FHSS	Frequency-Hopping Spread Spectrum
21	USART	Universal Synchronous and Asynchronous Receiver-Transmitter
22	VCC	Voltage Common Collector
23	IC	Integrated Circuit
24	VSS	Voltage Source Supply
25	BLDC	Brushless Dc Motor
26	FPV	First Person View
27	CNC	Computer Numerical Control
28	BEC	Battery Elimination Circuit
29	PCB	Printed Circuit Board
30	MOSFET	Metal Oxide Semiconductor Field Effect Transistor
31	RC	Remote / Radio Control
32	LiPo	Lithium Polymer
33	ADC	Analog to Digital Converter
34	NO	Normally Open
35	NC	Normally Closed
36	COM	Common
37	RAM	Random Access Memory
38	ROM	Read Only Memory

CHAPTER 1

INTRODUCTION

General Introduction

The development of a vehicle capable of both flight and underwater navigation has been of great interest for several years. The interest has additionally developed as automated vehicles have seen a sensational expansion in their utilization for common and military applications. Additionally, it does not leave all the while assessment of both the submersed and consequently the non-submersed parts of the construction. Civil applications include search and rescue, inspection, repairs and survey missions, reconnaissance tool for oil spill incidents. The applications for performing inspection of structures like ships hulls, underwater pier structures, oil platforms, and bridge pylons are innumerable. Additionally, beaches, rivers and lakes might be quickly surveyed and mapped for underwater erosion, oil spills, and pollution dispersion. Even lifeguard operation could be enhanced by having a vehicle which can operate in air and underwater when attempting rescues and reaching remote areas, as they could be used for rapid air or water deployment or as a buoyant or a towing platform. This vehicle could even be utilized in extreme weather (air and water) conditions where other vehicles cannot operate. Among the various military applications are launch and recovery from a submarine, rapid response to research a threat or a neighborhood of interest, delivering payloads to divers, rapid deployment to eliminate mines, smart/self-deploying buoy sensors, ships/ports inspections, or maybe stealth air/underwater missions.

The popularity of Unmanned Aerial Vehicles (UAVs) and Unmanned Underwater Vehicles (UUVs) will continuously increase due to their expanding availability and the cost efficiency of their production. These two kinds of vehicles were designed to perform well in their own specific environments. Nonetheless, a few circumstances require a vehicle to work well in both elevated and submerged conditions, like mapping of remote regions, and investigation of submerge structures, similar to petroleum platforms, gas pipelines, and ship hulls, similarly as a couple of military applications. To satisfy this sort of mission, the conventional UAV or UUV needs multi-vehicle cooperation collaboration. An auxiliary vessel is

currently used to transport the underwater vehicle to the goal location so it may dive to perform the inspection. However, this type of operation is extremely expensive and inefficient. Also, it does not leave simultaneous inspection of both the submersed and non-submersed portions of the structure. A hybrid vehicle would be able to accomplish both more efficiently and at a lower cost.

Need for UAUV's [unmanned aerial-Underwater vehicles]

- ☐ Some situations require a vehicle to operate well in both aerial and underwater environments such as, inspection of half-submerged structures [like offshore oil platforms, oil ships and gas pipelines as well as are several military applications].
- ☐ Simultaneously inspection of both the submerged and the half-submerged portions of the structure without any time interval.
- ☐ A hybrid vehicle would be able to accomplish both more efficiently and at lower cost.

Advantages over single Domain vehicle

- ☐ Dual aerial and aquatic capability
- ☐ Cost effective for the consumer who requires both aerial and aquatic operational vehicles.
- ☐ It provides the potential for working in a complex multi-domain environment.

SCOPE OF THE PROJECT:

A multi domain drone has a wide range of scope and as a key feature in rescue operational teams and search teams in militant services; the drone can be used as a research equipment for underwater marine research. And it has a huge engineering part to play in inspection and building of submarines which as half submerged inside the water, they can be inspected without loading into the dockyards. The developments of fully functional aquatic UAVs are promising and achievable. Many partially functional aquatic UAVs have proved the feasibility of a real one. We believe a fully featured aquatic UAV will be designed in the future.

CHAPTER 2

LITERATURE SURVEY

There is currently some active research on hybrid aquatic-aerial vehicles, such as the,

- 1) **A. Fabian, Yifei Feng, Erika Swartz, Derek Thurmer, R. Wang - 2012 Hybrid Aerial Underwater Vehicle, designed by the MIT Lincoln Lab.** The team was entrusted with identifying an opportunity in the field of robotics for a novel and unique system, then building a proof-of-concept prototype for that system. The team was motivated by gannet birds, *Morus bassanus*, which are equipped for a rapid, powerful, and streamlined transition from air to water and identified Project Gannet as the robot to be constructed. This design includes a fixed wing automated vehicle capable of flying, plunge diving into water, and exploring underwater by folding its wings. The vehicle can only transition from air to water, not from water to air.
- 2) **Flimmer (Flying Swimmer) Program at the Naval Research Laboratory (NRL) - (Edwards, 2014).** They built a flying submarine, which also featured a fixed wing airplane. It has four side-mounted fins, two aft and two forward. The team provide all the propulsion and control necessary for the vehicle and is combining two separate research areas: unmanned undersea vehicles (UUVs) and unmanned air vehicles (UAVs) to essentially improve strategic accessibility of UUVs in time basic circumstances. Autonomous vehicles are being an effective projection of force, both above and below the water's surface. NRL has built up an effectively controlled curvature robotic fin based on the pectoral fin of a coral reef fish, the bird wrasse (*Gomphosus varius*). In the latest fin iteration, four rib spars associated by a flexible synthetic membrane define the fin geometry, and control of each rib deflection angle enables the shape deformation needed to generate 3-D vectored thrust. Both vehicles lack the ability to transition smoothly between air and water, as the transition at high speed creates a high impact on the vehicle's frame. This increases the

complexity and cost of designing the vehicle's structure so that it can handle the impact force. On the other hand, the Droneship utilizes a ballast system to perform a seamless transition between the two media with simple airframe design.

3) Lock et al. (2013) and Izraelevitz et al. (2014)) studied a bio-inspired flapping foil with in-line motion to ensure efficient thrust production in different media. Both showed the success of this strategy in tunnel tests. Tan et al. investigated a single propeller with a gear box for both media; however, this increases the mechanical complexity, and it risks power losses penalty due to the gearbox friction. In contrast, the Droneship is a hybrid multi-rotor platform that uses a two set of propellers with direct drive-in air and underwater, thereby reducing the vehicle's mechanical complexity and extra weight penalty.

4) The “Naviator” Drone (Maia, Soni, & Diez-Garcias, 2015) is an octa-coaxial multi- rotor hybrid aquatic-aerial vehicle. The design makes use of four coaxial rotors with fixed pitch propellers. It is designed to be naturally buoyant, and uses the rotors to go underwater and to control the depth. All 8 propellers are used to maintain or change depth as well as to maneuver underwater. One disadvantage of this approach is that it consumes significant power to maintain the vehicle's stability and depth underwater and to stay on the surface of turbulent water due to its static neutral buoyancy. The Droneship is different in that it is capable of actively controlling its buoyancy using a ballast system. This allows it to naturally loiter on the surface of water and then allows for submersion without the need for propellers to pull the vehicle underwater.

Interest in operating drones in and around water is also exemplified through the Corrosion Resistant Aerial Covert Unmanned Nautical System (CRACUNS) project. CRACUNS' vehicle is built to be an unmanned underwater vehicle, diver, or a fixed position underwater and to fly like an autonomous unmanned aerial vehicle (Hopkins University Applied Physics Laboratory, 2016). The project is focused on the construction and testing of corrosion resistant drones. The designers fabricated a lightweight, submersible, composite airframe able to withstand the water pressure experienced while submerged. The vehicle's

airframe is designed to sink in water, and it uses the propellers to control depth and maintain stability underwater, which would add power penalty on the rotors similar to other vehicles previously discussed. Additionally, it does not have the ability to loiter on the surface of water. On the other hand, the Droneship is designed with active buoyancy control, and it can control its buoyancy and maintain its stability without the need for the rotors.

CHAPTER 3

PRODUCT DESCRIPTION

EXISTING SYSTEM

Unmanned aerial vehicles (UAVs) and unmanned underwater vehicles (UUVs) are two separate kinds of vehicles that are well adapted to work in their own environment (air and water, respectively), but a few circumstances may require a solitary vehicle fit for working in both environments. There have been only a few proposed models for Hybrid Aerial-Aquatic drones. Some models can only transition from air to water and not from water to air. A redesign is required to allow it take off from water to air. And an installation of ballast system to obtain neutral buoyancy is needed. Some above discussed models use the same set of propellers for both air and water platforms where air propellers will not work efficiently well in water medium or vice versa. So separate propellers need to be implemented which would give it much more high-speed maneuvering capability.

PROPOSED SYSTEM

- ☐ A multi-rotor type drone that uses two sets of propellers: one set for aerial flight and another set for underwater maneuver.
- ☐ Actively controlling its buoyancy using a ballast system which allows it to go underwater without the use of a rotor.
- ☐ The drone should be tethered by a wire to transmit data between the drone and the operator when underwater maneuvering.
- ☐ We are using Bluetooth wireless technology to control our drone during aerial flight which is a quite simple communication system.

ADVANTAGES

- ☐ By the usage of separate propellers, the drone is able to perform equally well in both mediums (air and water).
- ☐ The ballast system allows it to naturally loiter on the surface of water and then allows for submersion without the need for propellers.
- ☐ Some situations require a vehicle to operate well in both aerial and underwater environments such as, inspection of half-submerged structures [like offshore oil platforms, oil ships and gas pipelines as well as are several military applications].
- ☐ A hybrid vehicle would be able to accomplish both more efficiently and at lower cost.

APPLICATION

- ☐ Search and rescue operations.
- ☐ Inspection of half-submerged infrastructures [floating wind turbine, offshore oil platforms, etc].
- ☐ Marine research.
- ☐ Surveillance and military applications.
- ☐ Reconnaissance tool for oil spill incidents.
- ☐ Surveying and mapping.

BLOCK DIAGRAM

CONCEPT EXPLANATION

In our project, we are proposing a conceptual prototype for hybrid aerial-aquatic quadcopter which is capable of aerial flight and water surface operations as well as subaquatic diving. Our prototype is a multi-rotor type drone that uses two sets of propellers: one set for aerial flight and another set for underwater maneuvering. Air propeller is 10"x4.5" inch and the water propeller is 2- blade (2 cm). These propellers are ideal to work in their own environment. For aerial flight, we are using powerful brushless DC motors with air propellers which generate enough thrust to fly. By the installation of a ballast tank in the prototype, the vehicle is capable of diving into the water. Initially the ballast tank is filled with air. When the prototype lands on the water, the ballast tank is flooded with water using a hydraulic pump to gain negative buoyancy and the prototype sinks into the water. Then the ballast

tank is utilized to control the depth of the prototype by taking or ejecting more water into the ballast tank during underwater maneuvering. The water is ejected from the ballast tank and the prototype gains positive buoyancy and it reaches the surface. Then the water to air transition occurs by turning on air propellers and it lifts into the air. For controlling the prototype during underwater operations requires tether connection or using low frequency radio signals like 72Mhz transmitter and receiver or even lower signals which can be able to penetrate water.

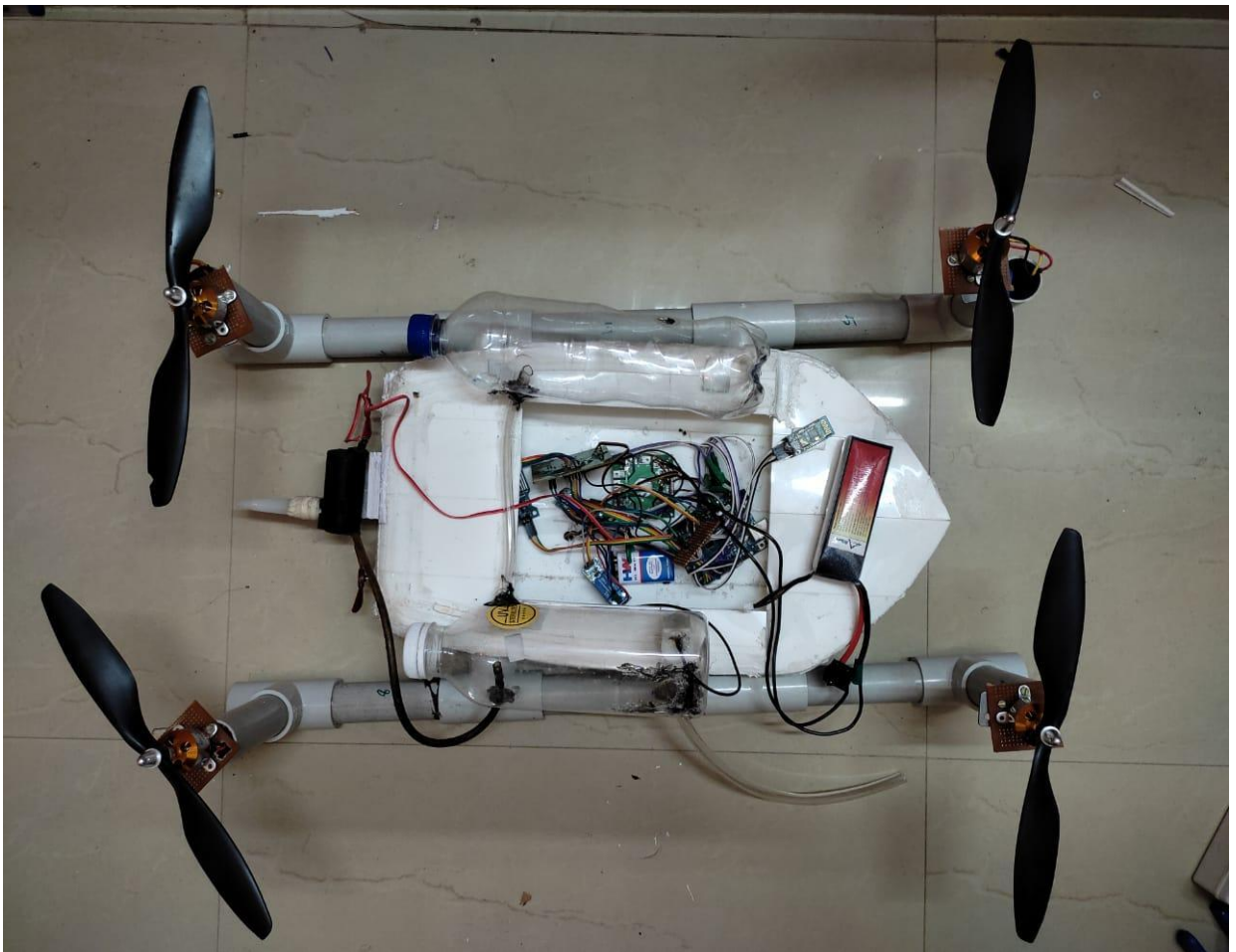


Fig 3.1 Prototype design

CHAPTER 4

HARDWARE DESCRIPTION

HARDWARE REQUIREMENTS

- ☐ Arduino UNO
- ☐ DC motor
- ☐ L293D motor driver
- ☐ Brushless DC motor
- ☐ Electronic Speed Controller
- ☐ Air and water propeller
- ☐ Lithium polymer Battery
- ☐ Bluetooth
- ☐ Relay
- ☐ Water pump
- ☐ Solenoid valve
- ☐ Water level depth sensor

Arduino uno

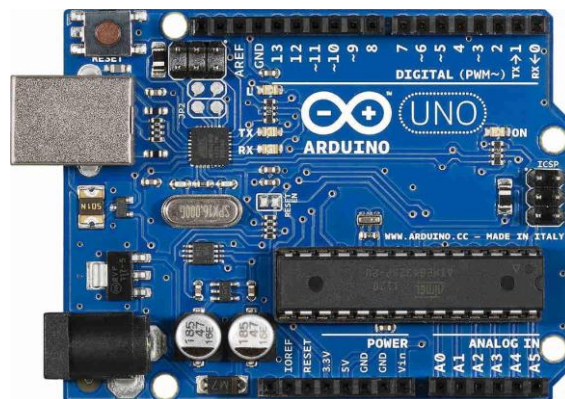


Fig 4.1 Arduino Uno Board

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller which is developed by Arduino.cc. The board is provided with sets of digital and analog input/output (I/O) pins which will be interfaced to various expansion boards (shields) and other circuits. The board

has 14 Digital pins, 6 Analog pins, and is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The user can control the board by sending a set of instructions to the microcontroller on the board. The user must use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)

The pins on the Arduino board are the places where to connect wires to construct a circuit. They usually have black plastic 'headers' that allow you to just plug a wire right into the board. The Arduino has several different types of pins, each of which is labeled on the board and used for various functions.

- **GND (3):** Short for 'Ground'. There are several GND pins on the Arduino, any of which may be used to ground your circuit.
- **5V (4) & 3.3V (5):** The 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.
- **Analog (6):** The area of pins under the 'Analog In' label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.
- **Digital (7):** Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input and digital output (like powering an LED).
- **PWM (8):** The tilde (~) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM). These pins are able to simulate analog output (like fading an LED in and out).
- **AREF (9):** Stands for Analog Reference. This pin is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

Reset Button

The Arduino has a reset button (10th pin). Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This should be very useful if your code doesn't repeat, but you want to test it more than once.

Power LED Indicator

Just beneath and to the right of the word "UNO" on your circuit board, there is a small LED next to the word 'ON'. This LED will light up whenever you plug your Arduino into a power source. If this light doesn't turn on, there is a good chance something is wrong and should re-check your circuit.

TX RX LEDs

TX is short for transmit, RX is short for receive. These pins are responsible for serial communication. There are two places on the Arduino UNO where TX and RX appear -- once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs. These LEDs will give us visual indications whenever our Arduino is receiving or transmitting data like when we're loading a new program onto the board.

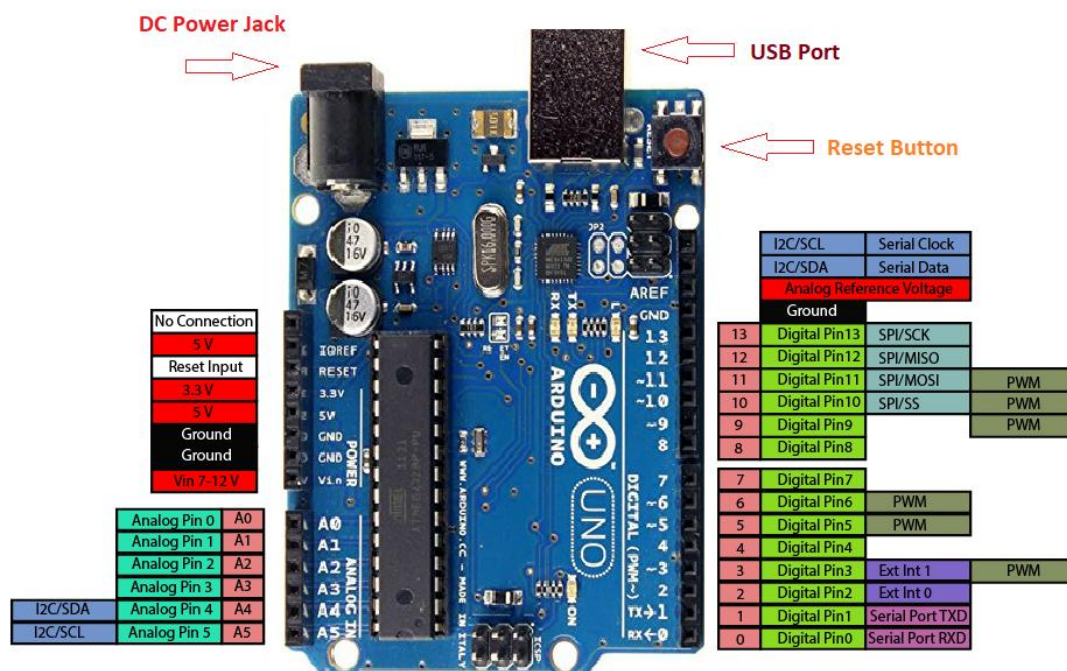


Fig 4.2 Pin Diagram of Arduino uno

HC-05 Bluetooth Module

HC-05 is a Bluetooth module for wireless communication. This module is often utilized in a master or slave configuration.

The HC-05 module is an easy to utilize Bluetooth SPP - (Serial Port Protocol) module, intended for wireless serial connection setup.

Serial port Bluetooth module is completely qualified Bluetooth V2.0 and (Enhanced Data Rate) EDR 3Mbps Modulation with additional 2.4GHz radio transceiver and baseband.

Through which one can construct a remote Personal Area Network (PAN) and it uses frequency-hopping spread spectrum (FHSS) radio technology to send information over air.

It uses serial communication to communicate with devices. It communicates with a microcontroller using an interface (USART).



Fig 4.3 HC-05 Bluetooth Module

Pin Description

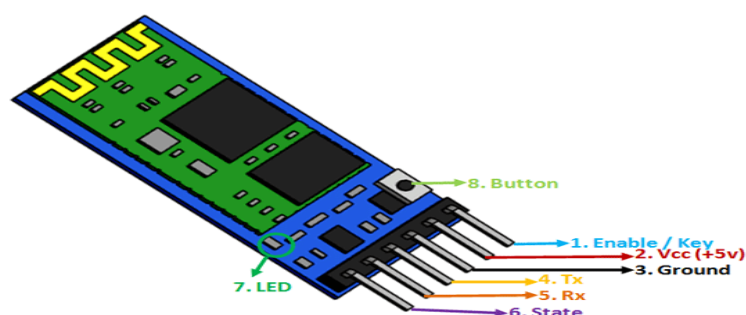


Fig 4.4 Pin diagram of HC-05 Bluetooth Module

Table:4.1: HC-05 Bluetooth Module Pins

Pin No	Pin Name	Description
1	Enable/ Key	Used to toggle between Data Mode (set low) and AT command mode (set high). It is in Data mode, by default.
2	Vcc	Powers the module. +5V Supply voltage should be connected.
3	Ground	Ground pin of module, connect with system ground.
4	TX- Transmitter	Transmits Serial Data. Everything received via Bluetooth is going to be given out by this pin as serial data.
5	RX – Receiver	Receive Serial Data. Every serial data given to this pin is going to be broadcasted via Bluetooth.
6	State	The state pin is connected to on board LED, it is frequently utilized as an input to check whether Bluetooth is working appropriately.

7	LED	Indicates the status of Module. • Blink once in 2 sec: Module has entered Command Mode • Repeated Blinking: Waiting for connection in Data Mode • Blink twice in 1 sec: Connection successful in Data Mode
8	Button	Used to regulate the Key/Enable pin to toggle between Data and command Mode

HC-05 module Information

- The HC-05 module has a red LED indicator which shows connection status, whether the Bluetooth is connected or not. When it gets connected to the other Bluetooth device, its blinking slows right down to two seconds.
- This module works on 3.3 V. We can connect 5V supply voltage as well since the module has on board 5 to 3.3 V regulator.
- As HC-05 Bluetooth module has 3.3 V level for RX/TX and microcontroller can detect 3.3 V level, so, no need to shift transmit level of HC-05 module. But we need to shift the transmit voltage level from microcontroller to RX of HC-05 module.

Bluetooth communication between Devices

- E.g Send data from the Smartphone terminal to HC-05 Bluetooth module and see this data on the PC serial terminal and the other way around.
- To communicate with smartphones with HC-05 Bluetooth module, smartphones need application for transmitting and receiving data. Terminal applications for android and windows can be found in respective apps store.

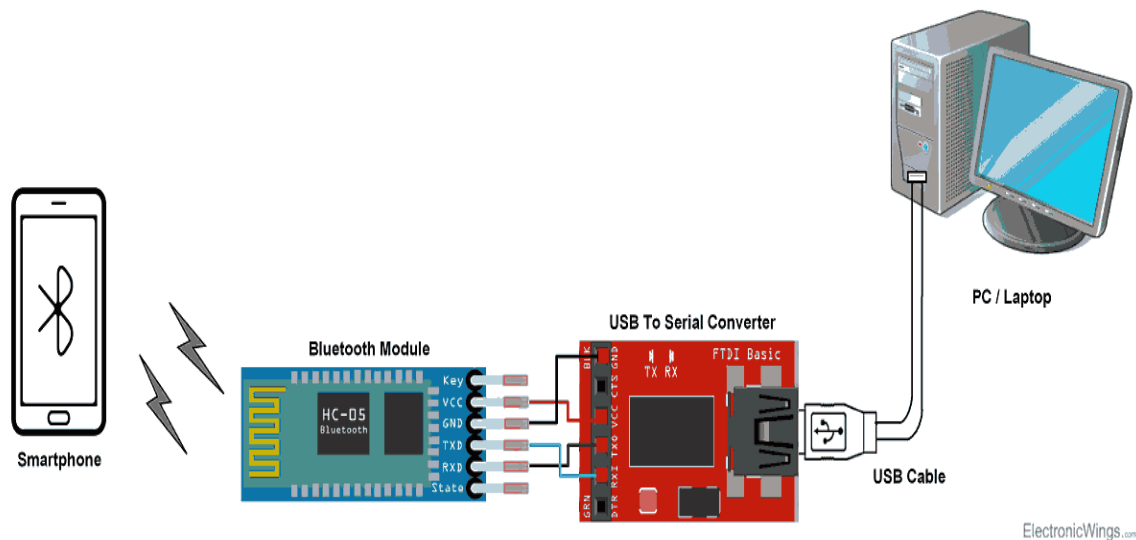


Fig 4.5 Bluetooth Module Serial Interface

So, once we want to communicate through mobile phone with HC-05 Bluetooth module, connect HC-05 module to the PC via serial to USB converter.

Before establishing communication between two Bluetooth devices, first we need to pair HC-05 module to mobile phone for communication.

HC-05 Default Settings

- Default Bluetooth Name: "HC-05"
- Default Password: 1234 or 0000
- Default Communication: Slave
- Default Mode: Data Mode
- Data Mode Baud Rate: 9600, 8, N, 1
- Command Mode Baud Rate: 38400, 8, N, 1
- Default firmware: LINVOR

Pair HC-05 and smartphone:

1. Look for a new Bluetooth device from your phone. You will find a Bluetooth device with the "HC-05" name.
2. Click on connect/pair device option; default pin for HC-05 is 1234 or 0000.

Open terminal software (e.g., Teraterm, Realterm etc.) in PC, after pairing two Bluetooth devices and choose the port where we have connected a USB to serial module. Also select default baud rate of 9600 bps.

In the smartphone, open the Bluetooth terminal application and connect to paired device HC-05.

To communicate, we have to type in the Bluetooth terminal application of our smartphone. Characters will get sent wirelessly to Bluetooth module HC-05. HC-05 will automatically transmit it serially to the PC, which will appear on the terminal. Same way we can send data from PC to smartphone.

Command Mode

- When we want to vary settings of HC-05 Bluetooth module like change password for connection, baud rate, Bluetooth device's name etc.
- To do that, HC-05 has AT commands.
- To use HC-05 Bluetooth module in AT command mode, connect "Key" pin to High (VCC).
- Default Baud rate of HC-05 in command mode is 38400bps.
- Following are some AT commands generally to vary the setting of Bluetooth modules.
- To send these commands, we must connect the HC-05 module to the PC via serial to USB converter and transmit these commands through the serial terminal of the PC.

Table:4.2: Command Mode of HC-05 Bluetooth Module

Command	Description	Response
AT	Checking communication	OK
AT+PSWD=XXXX	Set Password e.g. AT+PSWD=4567	OK

AT+NAME=XXXX	Set Bluetooth Device Name e.g. AT+NAME=MyHC-05	OK
AT+UART=Baud rate, stop bit, parity bit	Change Baud rate e.g. AT+UART=9600,1,0	OK
AT+VERSION?	Respond version no. of Bluetooth module	+Version: XX OK e.g. +Version: 2.0 20130107 OK
AT+ORGL	Send detail of setting done by manufacturer	Parameters: device type, module mode, serial parameter, passkey,etc.

How to Use the HC-05 Bluetooth module

The HC-05 has two working modes, one is that the Data mode during which it can send and get information from other Bluetooth devices and along these lines the other is that the AT Command mode where the default device settings are frequently changed. we will work the gadget in both of those two modes by utilizing the vital pin as clarified inside the pin description.

It is extremely simple to combine the HC-05 module with microcontrollers since it works utilizing the interface Protocol (SPP). Essentially power the module with +5V and interface the Rx pin of the module to the Tx of MCU and Tx pin of module to Rx of MCU as demonstrated inside the figure underneath.

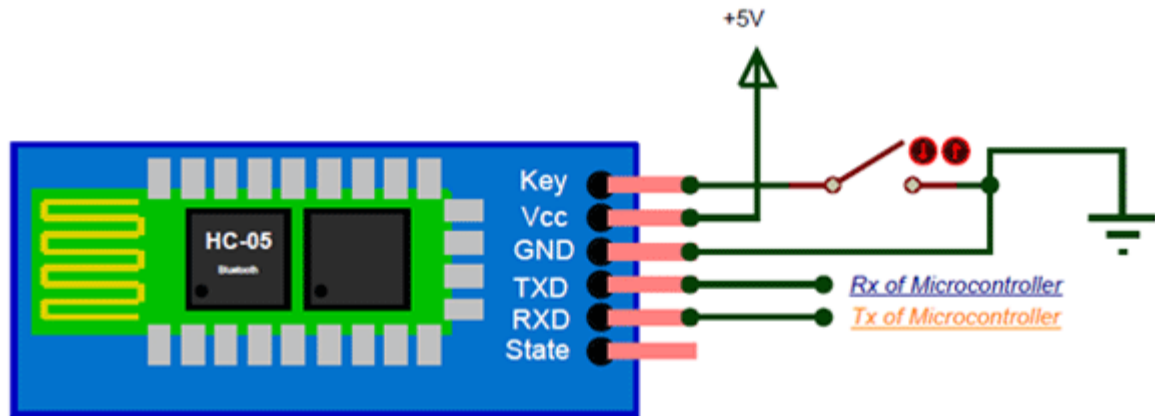


Fig 4.6 Bluetooth module connection

During power up the key pins are often grounded to enter into Command mode, if left free it will enter into the data mode by default. As soon as the module is powered you must be able to discover the Bluetooth device as “HC-05” then connect with it using the default password 1234 and begin communicating with it.

Specifications

- Serial Bluetooth module for microcontrollers
- Operating Voltage: 4V to 6V (Typically +5V)
- Operating Current: 30mA
- Range: <100m
- Works with Serial communication (USART) and TTL compatible
- Follows IEEE 802.15.1 standardized protocol
- Uses Frequency-Hopping Spread spectrum (FHSS)
- Can operate in Master, Slave or Master/Slave mode
- Can be easily interfaced with Laptop or Mobile phones with Bluetooth
- Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.

Applications

1. Wireless communication between two microcontrollers
2. Communicate with Laptop, Desktops and mobile phones

3. Data Logging application
4. Consumer applications
5. Wireless Robots
6. Home Automation

DC motor and L293d driver

A machine that converts DC electrical power into mechanical power is known as a Direct Current motor. DC motor working is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force.



Fig 4.7 DC Motor

Working principle of a DC motor

An electric motor is an electrical machine which converts electrical energy into mechanical energy. The basic working principle of a DC motor is: "whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force".

Here two dc motors are used for underwater operations as well as surface operation. Both motors are kept at constant speed to move forward and reduce the speed of one motor to turn into respective directions(left or right). The motor is controlled by an arduino through L293D driver (motor speed controller). The driver

helps to vary the power given to the motor which makes the motor to change speed and directions.

Applications of a DC Motor

It depends on the type of DC motor, which applications are ideal. The following applications are common:

- Cranes
- Conveyors
- Pumps
- Fans
- Machine tools
- Air compressors
- Toys
- Motor starters in cars

L293D

L293D is a typical Motor driver or Motor Driver IC which allows DC motors to drive in either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motors with a single L293D IC Dual H-bridge Motor Driver integrated circuit.

The L293d can drive small and quiet big motors as well, check the Voltage Specification at the end.

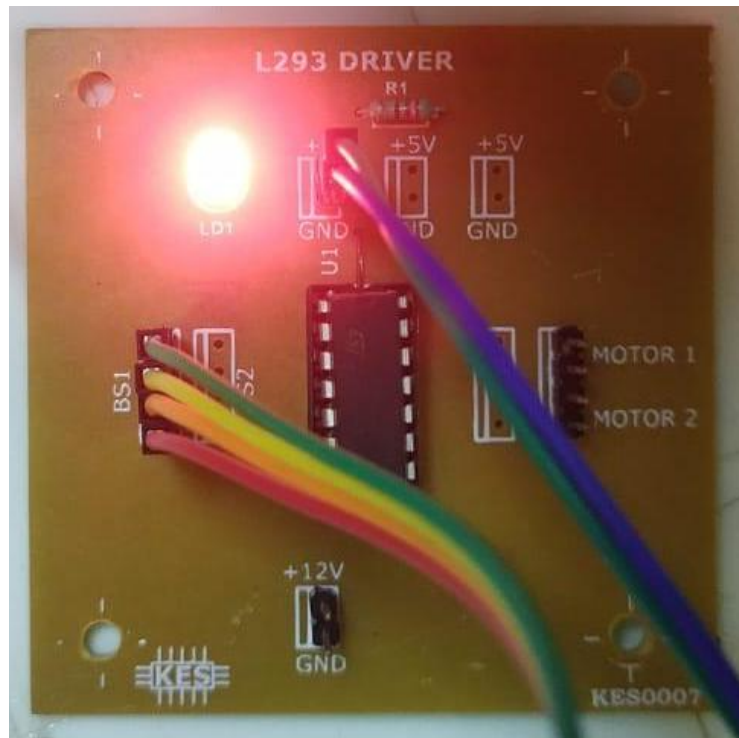


Fig 4.8 L293 Driver Circuit

Concept of H-bridge

It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. Voltage needs to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor.

In a single L293D chip there are two h-Bridge circuits inside the IC which can rotate two dc motors independently. Due to its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a L293D motor controller.

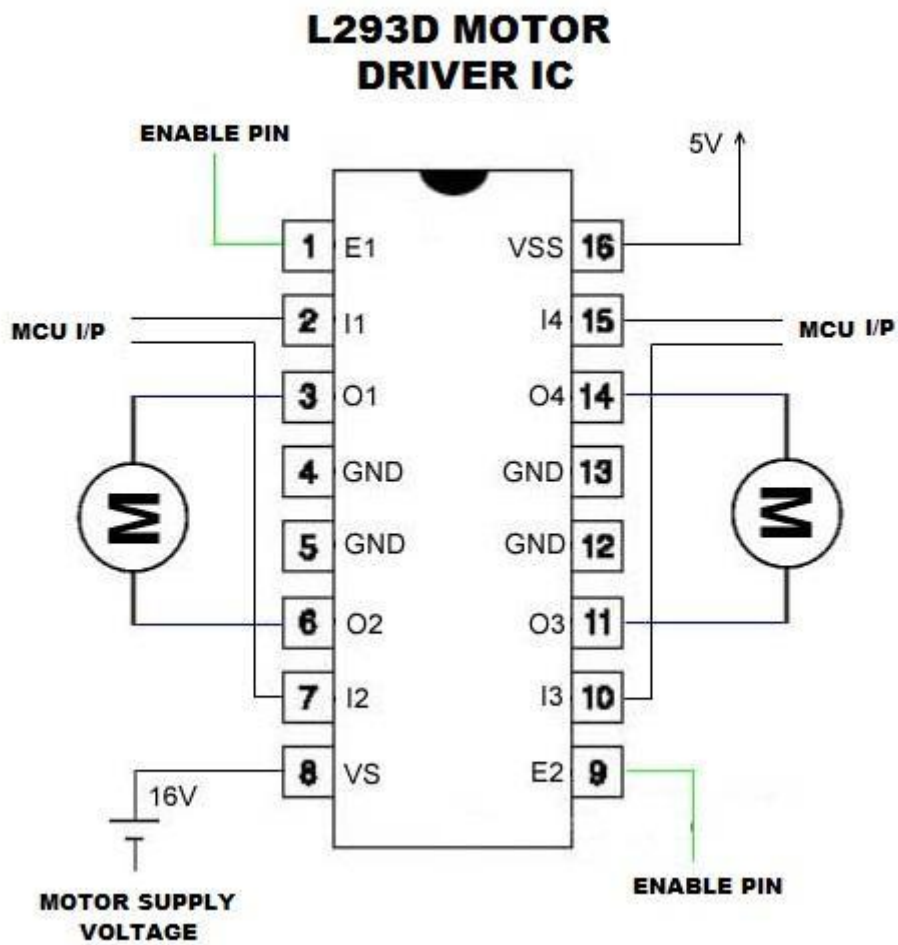
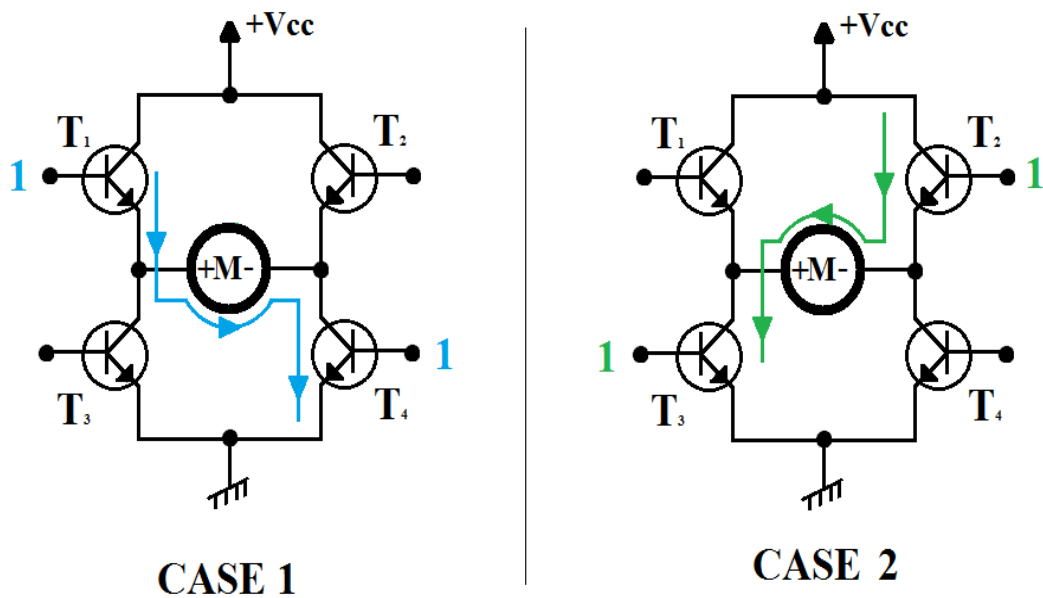


Fig 4.9 Pin diagram of L293 Driver

How L293D IC works



- L293D motor driver IC contains two H-bridge circuits inside it, which may also use darlington transistors some times for current amplification.
- Let us understand this H-bridge circuit, in case 1, when logic '1' applies to transistors T1 and T4, the motor starts rotating in clockwise direction due to circuit complete current and current flows through it as shown by blue indication.
- In case 2, we apply logic '1' to transistors T2 and T3, so the motor starts rotating in anti-clockwise direction due to circuit complete and direction of current flows through it is shown by green indication.

How simple or geared DC motor work with microcontroller?

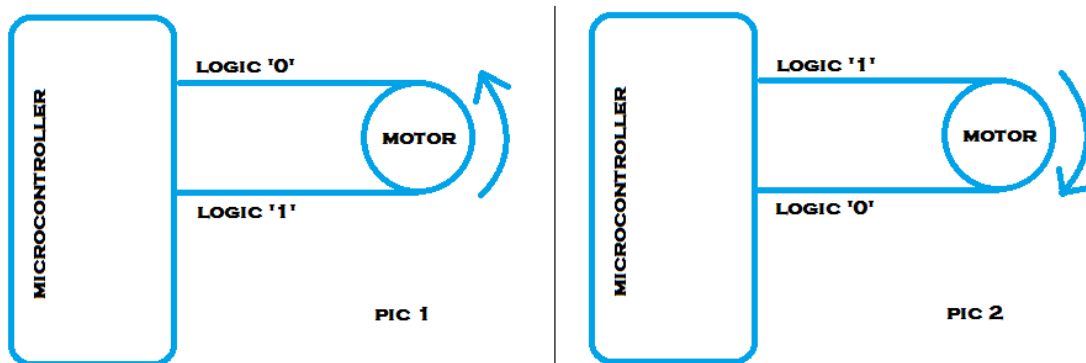


Fig 4.11 DC motor logic in microcontroller

- As you can see in the above figure, understanding the motor is simple as seen.
- Motor rotates in the direction of higher potential to lower potential.
- Here we make this diagram as simple as we can, cause easy understanding (not use L293D IC).

Voltage Specification

VCC is the voltage that it needs for its own internal operation 5v; L293D will not use this voltage for driving the motor. For driving the motors it has a separate provision to provide motor supply VSS (V supply). L293d will use this to drive the motor. The maximum voltage for VSS motor supply is 36V. It can supply a max current of 600mA per channel. VCC pin 16 is the voltage for its own internal Operation. The maximum voltage ranges from 5v and upto 36v.

BRUSHLESS DC MOTOR

A brushless DC motor (also known as a BLDC motor or BL motor) is an electronically commuted DC motor which does not have brushes. The controller provides pulses of current to the motor windings which control the speed and torque of the synchronous motor.

Working Principle of Brushless DC motor

BLDC motor works on the principle like that of a Brushed DC motor. The Lorentz force law states that whenever a current carrying conductor is placed in a magnetic field it experiences a force. Because of reaction force, the magnet will experience an equal and opposite force. In the BLDC motor, the current carrying conductor is stationary and the permanent magnet is moving.

When the stator coils get a supply from source, it becomes electromagnet and starts producing the uniform field in the air gap. Though the source of supply is DC, switching makes to generate an AC voltage waveform with trapezoidal shape. Due to the force of interaction between electromagnet stator and permanent

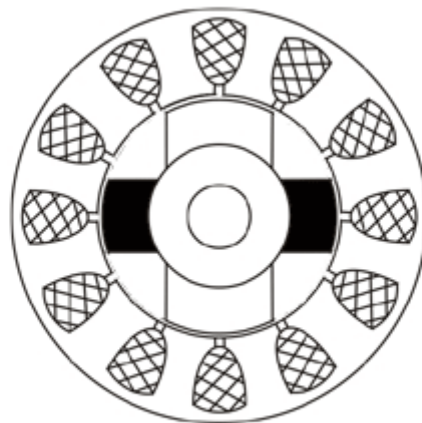
magnet rotor, the rotor continues to rotate. With the switching of windings as High and Low signals, corresponding windings are energized as North and South poles. The permanent magnet rotor with North and South poles align with stator poles which causes the motor to rotate.

Types of Brushless DC Motors

Basically, BLDC are of two types, one is outer rotor motor and other is inner rotor motor. The basic difference between the two is only in designing, their working principles are the same.

Inner Rotor Design

In an inner rotor design, the rotor is in the centre of the motor and the stator winding surrounds the rotor. As the rotor is in the core, rotor magnets do not insulate heat inside and heat gets dissipated easily. Due to this reason, an inner rotor designed motor produces a large amount of torque and is validly used.



Inner Motor

Fig 4.12 Inner Rotor Design

Outer Rotor Design

In outer rotor design, the rotor surrounds the winding which is in the core of the motor. The magnets in the rotor trap the heat of the motor inside and do not allow it to

dissipate from the motor. Such type of designed motor operates at lower rated current and has low cogging torque.



Outer Motor

Fig 4.13 Outer Motor Design

A2212/13T (BLDC) BRUSHLESS DC MOTOR

It is an outer motor design high speed brushless motor designed specifically for Quadcopters, Drones, or toy planes. The motor is OUTRUNNER type where the outside case rotates while inside stays fixed. It is one of the popular models in the market because it's low cost. It is preferred for small drones and planes. The model is available at different speeds and should be chosen appropriately.



Fig 4.14 A2212/13T (BLDC) MOTOR

Brushless Motor Pin Configuration

The motor has three pins as shown in figure. The internal connection between three of them is shown below.

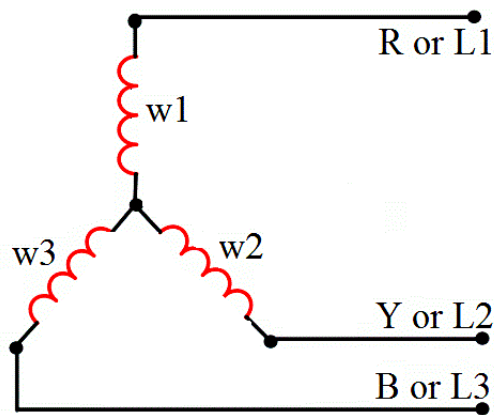


Fig 4.15 Pin Diagram Of BLDC Motor

Table:4.3: Brushless Motor Pin Connections

Pin Name	Description
R or L1	Connected to winding1 or phase1
Y or L2	Connected to winding2 or phase2
B or L3	Connected to winding3 or phase3

Features and Specifications

- Operating voltage: 7.2V to 12V (2 to 3Li-poly or 6to10 NiCad)
- No load current:0.5Amp
- Maximum current:13Amp for 60Sec
- Maximum Watts:150 Watt
- Weight of motor:50-60 grams
- Maximum operating temperature: + 80°C
- Complete speed control because of three phase connection.
- Long life as there are no moving contacts.

Propeller

This 10"x4.5" propeller can be used with brushless motors with a 800-2200 kV rating. With a low kV motor (800 - 1400 kV), this propeller offers smooth flights with longer flight times perfect for FPV and aerial photography. With a high kV motor (more than 1200 kV) this propeller offers fast flights perfect for acrobatic flights.

- Diameter: 10" (25.4 cm)
- Pitch: 4.5" (11.43 cm)



fig 4. 16 Air Propeller

Advantages of Brushless DC Motor

The advantages of a BLDC motor are:

- ☐ Brushless motors are more efficient as its velocity is determined by the frequency at which current is supplied, not the voltage.
- ☐ As brushes are absent, the mechanical energy loss due to friction is less which enhances efficiency.
- ☐ BLDC motors can operate at high-speed under any condition.
- ☐ There is no sparking and much less noise during operation.
- ☐ More electromagnets could be used on the stator for more precise control.

- ❑ BLDC motors accelerate and decelerate easily as they are having low rotor inertia.
- ❑ It is a high performance motor that provides large torque per cubic inch over a vast speed range.
- ❑ BLDC motors do not have brushes which make it more reliable, high life expectancies, and maintenance free operation.
- ❑ There are no ionizing sparks from the commutator, and electromagnetic interference is also reduced.
- ❑ Such motors cooled by conduction and no air flow are required for inside cooling.

Applications of Brushless DC motor

Brushless DC motors (BLDC) are used for a wide variety of application requirements such as varying loads, constant loads and positioning applications in the fields of industrial control, automotive, aviation, automation systems, health care equipment etc.

- ❑ Computer hard drives and DVD/CD players
- ❑ Electric vehicles, hybrid vehicles, and electric bicycles
- ❑ Industrial robots, CNC machine tools, and simple belt driven systems
- ❑ Washing machines, compressors and dryers
- ❑ Fans, pumps and blowers.

Electronic speed controllers (ESCs):

Electronic speed controllers (ESCs) are devices that allow drone flight controllers to control and adjust the speed of the aircraft's electric motors. A signal from the flight controller causes the ESC to raise or lower the voltage to the motor as required, thus changing the speed of the propeller.

30A BLDC ESC

This is fully programmable 30A BLDC ESC with 5V, 3A BEC. Can drive motors with continuous 30Amp load current. It has sturdy construction with 2 separate PCBs for Controller and ESC power MOSFETs. It can be powered with 2-4 lithium Polymer batteries or 5-12 NiMH / NiCd batteries. It has a separate voltage regulator for the microcontroller for providing good anti-jamming capability. It is most suitable for UAVs, Aircrafts and Helicopters.

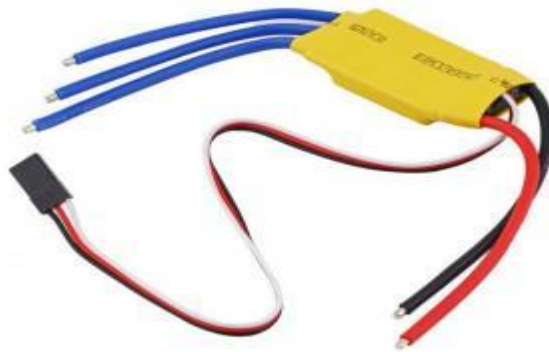


Fig 4.17 30A BLDC Electronic speed controller

Specifications

- ☐ Output: 30A continuous; 40Amps for 10 seconds
- ☐ Input voltage: 2-4 cells Lithium Polymer
- ☐ BEC: 5V, 3Amp for external receiver and servos
- ☐ Max Speed: 2 Pole: 210,000rpm; 6 Pole: 70,000rpm; 12 Pole: 35,000rpm
- ☐ Weight: 32gms • Size: 55mm x 26mm x 13mm

Features:

- ❑ High quality MOSFETs for BLDC motor drive
- ❑ High performance microcontroller for best compatibility with all types of motors at greater efficiency
- ❑ Fully programmable with any standard RC remote control
- ❑ Heat sink with high performance heat transmission membrane for better thermal management
- ❑ start modes: Normal / Soft / Super-Soft, compatible with fixed wing aircrafts and helicopters.
- ❑ Throttle range can be configured to be compatible with any remote control available in the market.
- ❑ Smooth, Linear and Precise throttle response
- ❑ Low-Voltage cut-off protection
- ❑ Overheat protection

Connections:

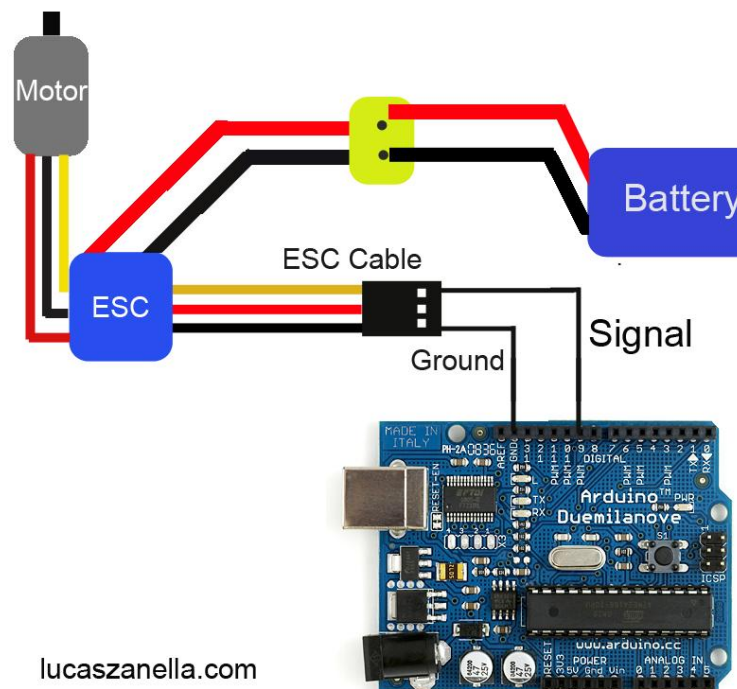


Fig 4.18 Interfacing BLDC to MICROCONTROLLER

BLDC ESC has three Blue wires coming out from the one end which are to be connected to the BLDC motor. On the other end, it has red and black wires which are to be connected to the battery. It also has a 3-pin servo connector which is used for receiving the throttle command and for giving out regulated 5V, 3Amp supply for the remote receiver and the servo motors. Both ESC and LiPo specifications are directly related to the max amount of current a motor pull. So, the mAh and C ratings of the battery are to be chosen according to the maximum motor current draw. The ESC just controls the amount of power going to the motor.

Table:4.4: BLDC pinout connection

Connection type	Wire Colour	Function
	Black	7.4 to 14.8V
	Black	Ground
BLDC Motor Connections	Three Blue Wires	BLDC ESC connections
Servo Connector	White	Throttle Input
	Red	5V, 2Amp Out
	Black	Ground

Control Signal:

30A BLDC ESC requires standard 50-60Hz PWM signal from any remote control as throttle input. You can also generate similar input signal from the microcontroller for making your own customized flying platform. Throttle speed is proportional to the width of the pulse. Maximum throttle position is user programmable. In general throttle is set at zero for 1mS pulse width and full at the 2mS pulse width.

Interfacing BLDC ESC with a microcontroller:

Connect the signal of the BLDC ESC to the microcontroller. Make sure that you make the ground common between microcontroller board and the BLDC ESC. You can also set the throttle range as mentioned in the section Throttle Range Setting. Now you are ready to drive a BLDC motor using this BLDC ESC with a microcontroller.

WATER LEVEL DEPTH SENSOR:

Water level sensors are used to detect the level of substances that can flow. Such substances include liquids. In this project, it is used to determine the amount of materials within a closed container. Here it relays information back to an Arduino board to indicate whether the ballast tank has a high or low water level.

This water level sensor module has a series of parallel exposed traces to measure droplets/water volume to determine the water level. Very Easy to monitor water level as the output to analog signal is directly proportional to the water level. This output analog values can be directly read via ADC and can also be connected directly to Arduino's analog input pins.



Fig 4.19 Water Level Depth Sensor

Working of water level sensor

The series of exposed parallel conductors together acts as a variable resistor (just like a potentiometer) whose resistance varies according to the water level.

The resistance is inversely proportional to the height of the water:

- ❑ The more water the sensor is immersed in, results in better conductivity and will result in a lower resistance.
- ❑ The less water the sensor is immersed in, results in poor conductivity and will result in a higher resistance.

The sensor produces an output voltage according to the resistance, which by measuring we can determine the water level.

Specifications of Water Level Depth Detection Sensor Module

- ❑ Working Voltage : DC 3-5V
- ❑ Working Current : <20mA
- ❑ Sensor Type : Analog
- ❑ Detection Area : 40 mm x 16 mm
- ❑ Size : 65 mm x 20 mm x 8 mm
- ❑ Humidity: 10% -90% non-condensing

Water Level Sensor Pin diagram

The water level sensor only has 3 pins to connect.

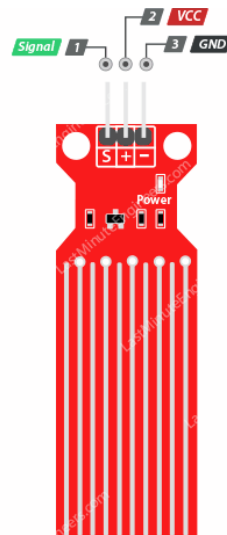


Fig 4.20 Pin diagram of Water Sensor

S (Signal) - pin is an analog output that will be connected to one of the analog inputs on your Arduino.

+ (VCC) - pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V – 5V. Please note that the analog output will vary depending on what voltage is provided for the sensor.

– (GND) - is a ground connection.

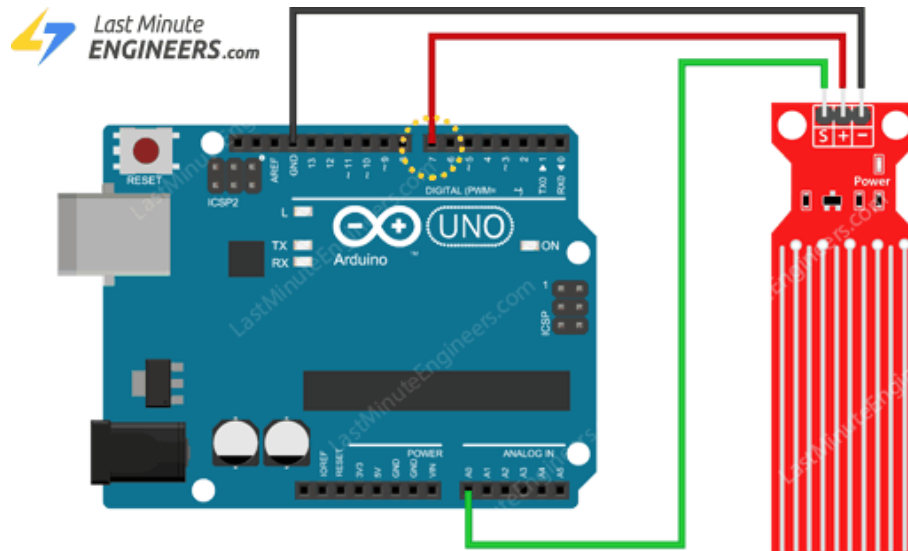


Fig 4.21 Connection diagram of water sensor

BALLAST SYSTEM

The ballast system is a complicated part of the design. The 12DC water pump is connected to an external hose that's capable of pumping water into the tank. The hose would then be connected to a solenoid valve that is normally open. Once the valve receives an electrical signal it will open up and will allow the water into the ballast tank.

The valve needs to be normally open as a safety measure. If the prototype ever loses power or signal, the valve will open and the compressed air inside the ballast tank will dispel the water inside and will make the prototype rise to the water surface.

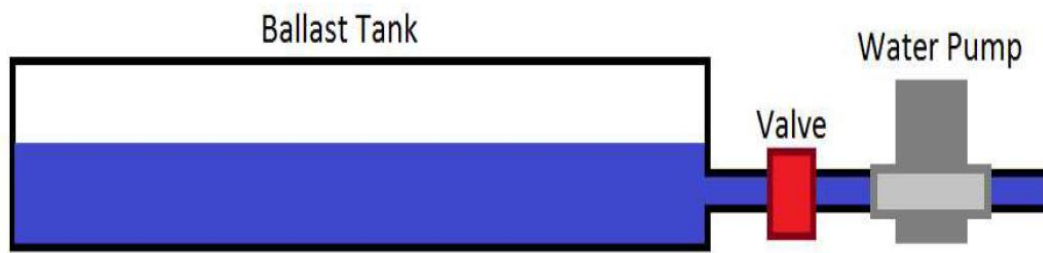


Fig 4.22 Schematic diagram of Ballast Tank

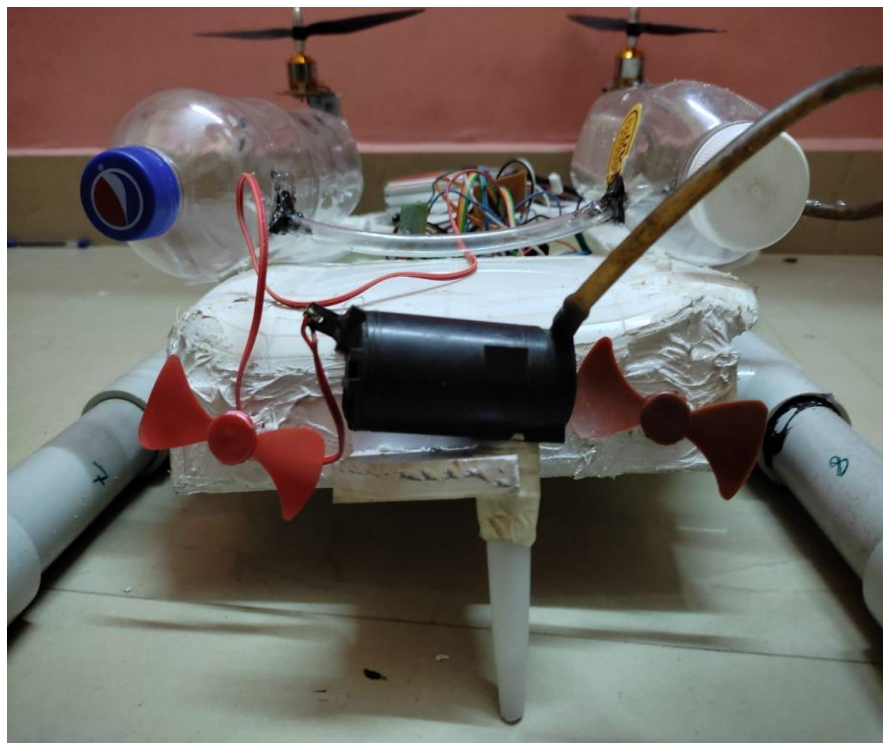


Fig 4.23 Ballast tank

Relay

A Relay is an electromechanical device that can be used to make or break an electrical connection. It consists of a flexible moving mechanical part which can be controlled electronically through an electromagnet, basically, a relay is just like a mechanical switch, but you can control it with an electronic signal instead of manually turning it on or off. Again, this working principle of relay fits only for the electromechanical relay.

Relay controls the opening and closing of the circuit contacts of an electronic circuit. When the relay contact is open (NO), the relay isn't energizing with the open contact. However, if it is closed (NC), the relay isn't energized given the closed contact. However, when energy (electricity or charge) is supplied, the states are prone to change.

RELAY CONNECTION



Fig 4.24 Relay connection

The relay's switch connections are usually labelled COM, NC and NO:

- **COM** = Common, always connect to this, it is the moving part of the switch.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.

Connect to **COM and NO** if you want the switched circuit to be **on when the relay coil is on**.

Connect to **COM and NC** if you want the switched circuit to be **on when the relay coil is off**.

CHAPTER 5

SOFTWARE REQUIREMENT

- ☐ Arduino IDE
- ☐ Embedded C

SOFTWARE DESCRIPTION

Arduino Software (IDE)

Arduino IDE where IDE stands for Integrated Development Environment - An official software introduced by Arduino.cc, that is mainly used for writing, compiling, and uploading the code in the Arduino Device. Almost all Arduino modules are compatible with this software that is open source and is readily available to install and start compiling the code on the go. It is an open source software that is mainly used for writing and compiling the code into the Arduino Module. A range of Arduino modules available including Arduino Uno, ArduinoMega, Arduino Leonardo, Arduino Micro and many more. Here we are using Arduino uno.

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards can read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. The user can tell your board what to do by sending a set of instructions to the microcontroller on the board.

Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code. The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board. The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.



The IDE environment is mainly distributed into three sections: menu bar, text editor, output pane. The top menu bar has the standard options, including “File” (new, load save, etc.), “Edit” (Used for copying and pasting the code with further modification for font), “Sketch” (Used for compiling and programming), “Tools” (options for testing projects), and “Help”. The Serial Monitor will actually help to debug the written Sketches where you can get a hold of how your program is operating. Your Arduino Module should be connected to your computer by USB cable in order to activate the Serial Monitor. The bottom of the main screen is described as an Output Pane that mainly highlights the compilation status of the running code: the memory used by the code, and errors occurred in the program. There is a list of libraries you can add by clicking the Sketch button in the menu bar and going to Include Library.

Embedded C

The Arduino Programming Language is basically a framework built on top of C++. Arduino boards are programmed in “C.” C is a popular system programming language that has minimal execution time on hardware in comparison to other high-level programming languages. Much like other microcontrollers, the AVR microcontrollers housed in Arduino boards are programmed in a subset of C. A general term for such subsets is “Embedded C” because they apply to programming embedded controllers. The language in which Arduino is programmed is a subset of C and it includes only those features of standard C that are supported by the Arduino IDE.

Embedded C programming language is an extension to the traditional C programming language, that is used in embedded systems. The embedded C programming language uses the same syntax and semantics as the C programming language. Smart phones, RAM and ROM are embedded C programming we use on a daily basis. Embedded software used in the processor and embedded C language often are used to program microcontrollers.

Embedded C programming solutions are widely used in applications that are based on the microprocessor and microcontroller. Embedded C is used in multiple industries with many uses. In addition, embedded C programming has some real time applications. Embedded C uses in devices and applications include highway speed checker, street light control, traffic signal control, vehicle tracking software, auto intensity control, home automation and artificial intelligence.

STIMULATION RESULT

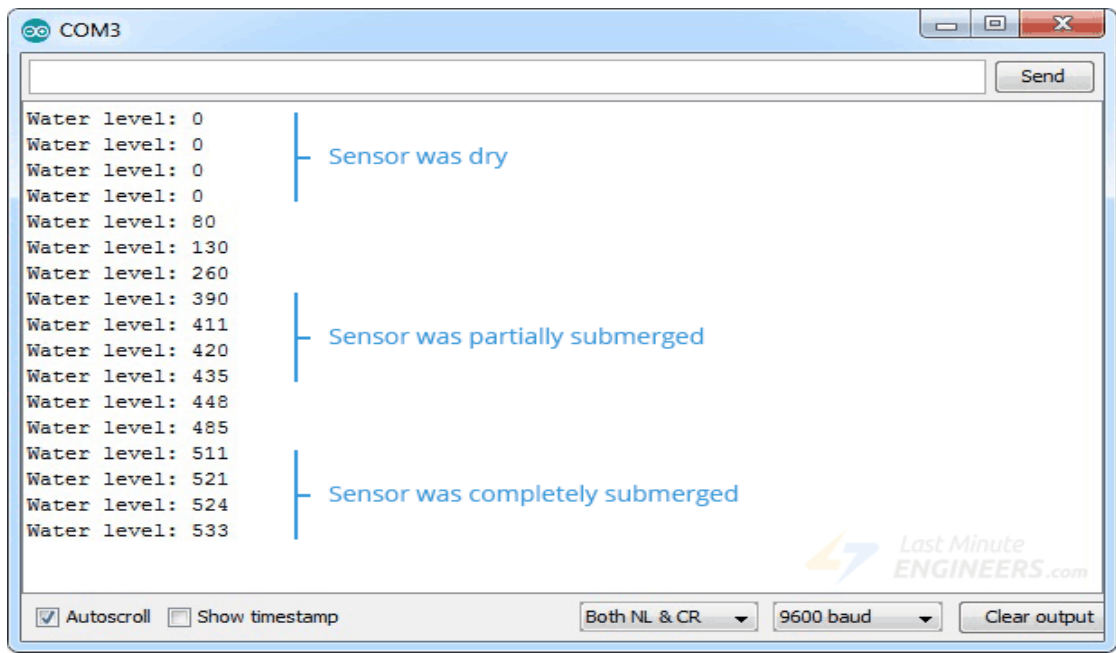


Fig 5.1 Stimulation result of water sensor

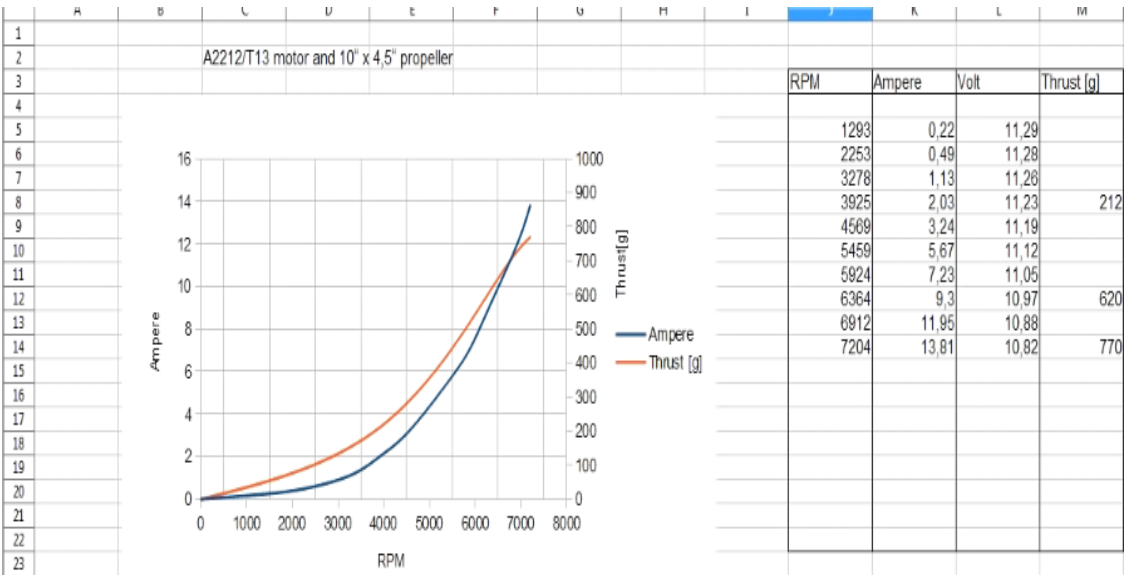


Fig 5.2 Stimulation result of generated thrust with 10"x4.5" propeller

CHAPTER 6

Conclusion

In this project, we proposed a conceptual prototype of Hybrid aerial-aquatic quadcopter by combining the functionalities of unmanned aerial vehicles (UAVs) and unmanned underwater vehicles (UUVs) in terms of reducing the cost and increasing the flexibility of working in different environments. And High speed maneuverability is achieved by introducing separate propellers for underwater operations. The hydraulic based ballast tank is utilised to control the depth of the drone and can dive into the water without any motor rotation just like submarines. The prototype designed to achieve air-water and water-air transition using a static hydraulic based ballast system.

FUTURE SCOPE

The Droneship (hybrid aquatic aerial quadcopter) is a successful concept vehicle that highlighted multiple possible areas of future work. The range of wireless communication underwater is an obvious challenge. This may be addressed by investigating acoustic or optical communication techniques, or alternatively, by outfitting the drone with sensors such as sonar, magnetometer and pressure sensors, and control algorithms to make it autonomous for inspection of submerge structures, such as petroleum platforms, ship hulls, and gas pipelines. The current shape of the vehicle can be improved as well. The vehicle's frame is constructed from off-the-shelf components which added some penalty to the vehicle's weight, and as a result, increased the vehicle drag. Making the vehicle waterproof is the most significant challenge to be achieved. Therefore, there is the opportunity to redesign the vehicle's structure to reduce its weight and drag in air and underwater, which could potentially reduce the vehicle's power consumption and thus increase operation time.

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