Rowboatics Abstract

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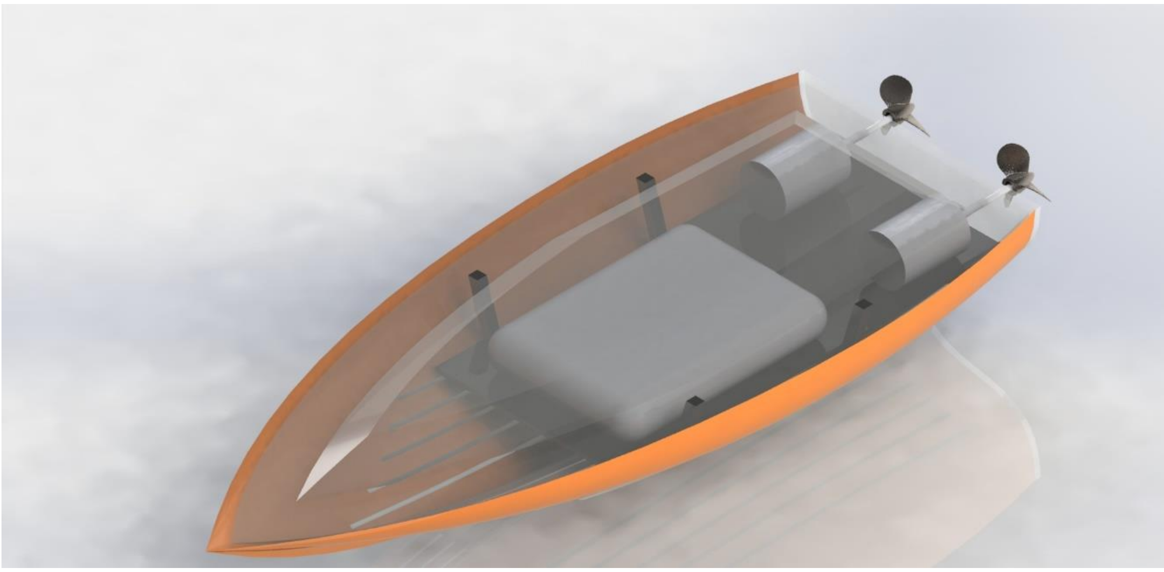
Team Code - RB-225396

NOTE –
The abstract aims to present all that we have researched from the internet and present it . However , our actual design may or may not contain all the features described here , i.e. the actual design would be inspired from this abstract but there may be slight differences as we wanted to present this abstract in form of research .

List of Contents –

Design –

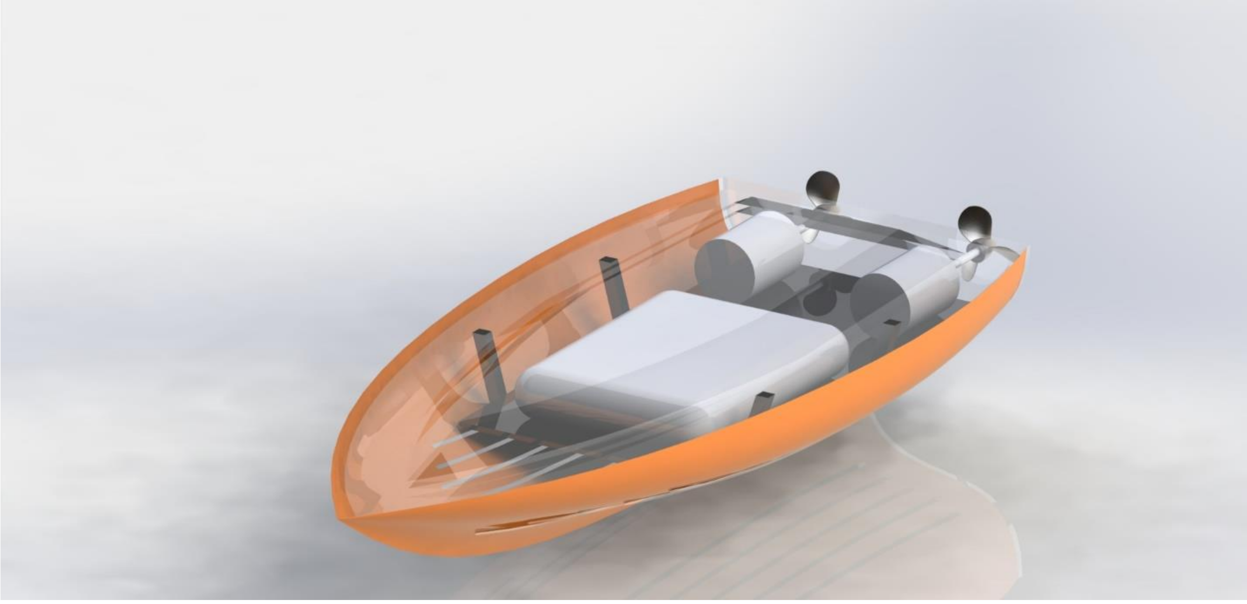
Hull Choice - We have chosen a Deep V Planing Hull for our boat . It has the following characteristics as mentioned below .



[Image of CAD model of Deep V Planing Hull type boat with differential drive control system]

Deep V Hull

The deep V Hull is a very popular type of planing hull . (There are 3 types of hulls majorly , displacement hull , planing hull and semi displacement hull) . The deep V hull is the boat with a deadrise running from 21 to 26 degrees for the entire length. That gives these vessels a wedge shape. It is a popular choice for sport fishing boats, especially those used in big waters or oceans. The reason is that the design allows the vessels to travel through the water smoothly—as long as you're going fast , due to its planing structure .



[More detailed view of our CAD model]

Braking System –

There are 2 types of braking systems used in boats , reverse thrusting and rudder based braking .
Rudder based brakes are used in large ships generally , where a rudder based steering mechanism is also present . Whenever the rudder is turned more than a certain critical angle , the rudder instead of steering action performs braking action only , hence used in braking in ships . This could be easily modified to suit our needs in RC boats , where we can have a control surface attached to a servo connected to the esc controller . Whenever a braking signal is given , the surface would straighten up , thus barricading the flow of water and stopping the RC boat .

Other mechanism which is more popular among RC boats is reverse thrusting mechanism , in which the main engine motors (which are responsible for forward thrusting) are made to rotate in the opposite direction , hence stopping the RC boat

We would be using reverse thrusting mechanism for braking in our boat .

Aerodynamics design part –

There are 2 things to consider while considering the aerodynamics of the boat : The body and the propellor . We have considered both of them separately , and have studied on what can be improved .

Body Design part -

Hydrofoils -

Hydrofoils can increase the speed of your vessel drastically. With the lift that occurs once your hydrofoils are operating, you're dealt with less drag and resistance that's caused by the water. It is not only more fuel-efficient, but it brings a whole new level of eco-consciousness.

Vortex Generators :

Vortices generators are small devices which help to delay the flow separation by working as a small wingtip and creating small wing tip vortices which simply pull in the high Energy flowing above the boundary layer into it to regnergise the flow and keep it attached to the surface.
Its length of the Vortex Generator should be around 5-8% of the chord length of the wing and placed just in front of the laminar to turbulent boundary layer transition with an angle of 15° to the flow over the wing.
According to our analysis, the Delta wing Shape vortex generator gives a minimum amount of drag force and also delays flow separation through increasing velocity near the surface.

Bubble Generator :

A small device attached to the hull of the boat to generate bubbles which would act as a lubricating layer and reduce drag and fuel consumption significantly . We can use the negative pressure generated by the forward movement of the boat to push air through a tube to the bottom of the hull on the vortex generators to create micro bubbles

Guides –

Guides can be used under the hull, to provide directional stability.

They must be precisely align to be parallel, otherwise the boat may lose control and move in chaotic manner, losing speed efficiency as well.

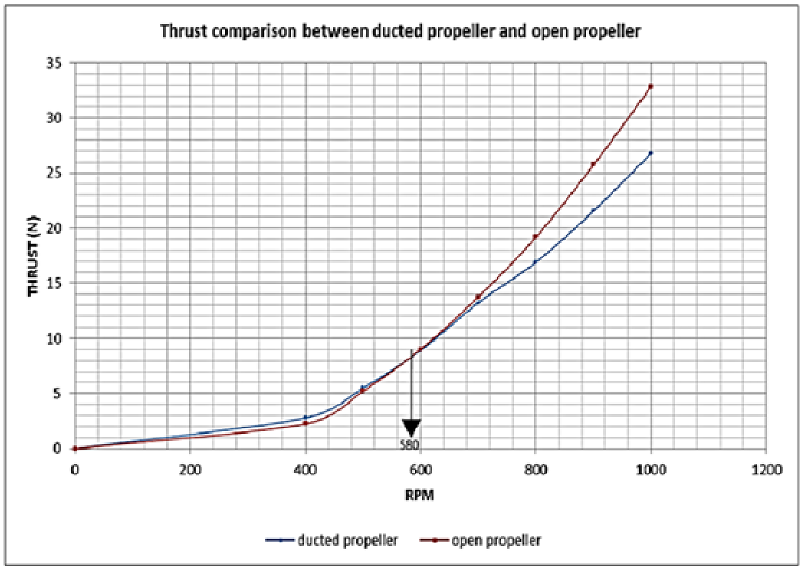
Propeller Design part –

Effect of Ducted Propellor -

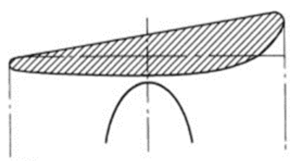
In our research, we have found that duct showed two-fold effects on the propeller:

1. Inducing an increment of velocity through the propeller in forward motion, and

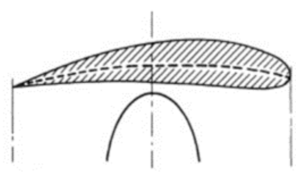
2. Negating tip effects if the gap between the inner wall and the propeller tip is very small (i.e., 0.03 in.)



There are two nominal types of duct form:



1)Accelerating duct



2) Decelerating duct

The velocity induced by the duct in forward flight can be expressed as:

$$\delta_d = 1 - \left(\frac{R_e}{R}\right)^{\frac{1}{2}} \left(\frac{0.458 + 4.431s}{1 + 1.089s} z + \frac{2.033 + 4.88s}{1 + 0.893s} s z^2\right)$$

Where, R_e, is the duct exit radius

s , is the length to exit radius ratio, between 0.5 and 2.0

z, a camber ratio (the ratio of the maximum difference between the duct mean camber line and the chord line to the duct chord length), between 0.05 and 0.1

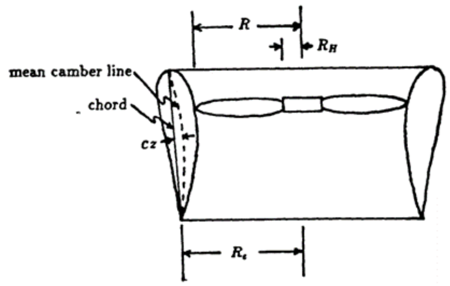
The propeller induced velocity can be expressed as:

$$\delta_i = K\left(\sqrt{1 + C_{T_P}} - 1\right)$$

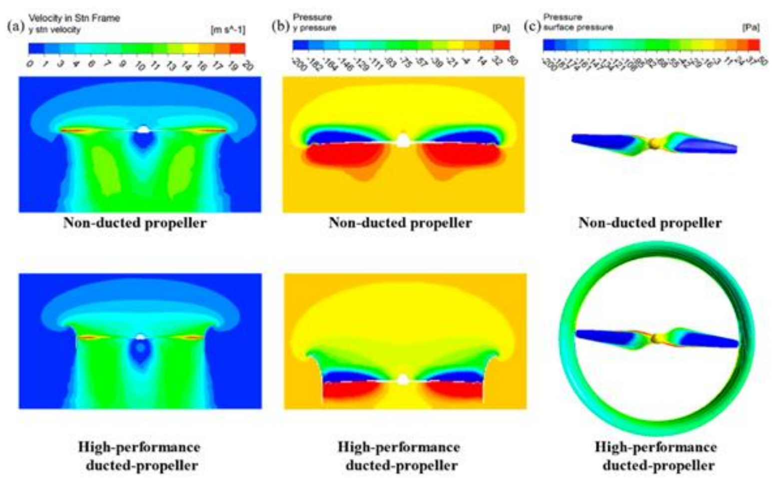
Where,

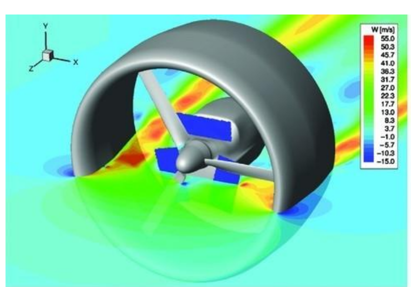
1. The value of K depends on the geometry of the shroud and the position of the propeller in the duct

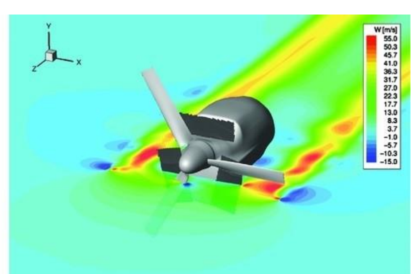
2. C_{T_P} is the propeller thrust coefficient



Ducted Propeller Geometry







Axial velocity in a slice of the flow field- ducted propeller (left) and

free propeller (right).

Blade size and shape -

Propeller diameter calculation (considering 100% engine horsepower and RPMs):

Three Bladed Propeller Diameter in Inches = (632.7 x (Propeller Shaft Horsepower)^0.2) / Propeller Shaft Revolutions Per Minute (RPM)^0.6

Two-Bladed Propeller Diameter = Three-Bladed Propeller Diameter x Two-Bladed Propeller Diameter Conversion Factor

Two-Bladed Propeller Diameter Conversion Factor is 1.05

Four-Bladed Propeller Diameter Conversion Factor is 0.94

The higher the pitch, the higher the speed of the boat and greater the efficiency of the propeller

90% Engine Horsepower = 0.90 x (Fuel Stop Power Brake Horsepower – Total Horsepower Losses)

90% Maximum Propeller Drive Shaft RPM = 0.90 x Maximum Propeller Drive Shaft RPM

Knots @ 90% = (10.665 / (Displacement in Pounds / (90% Engine Horsepower)) ^1/3) x (Loaded Waterline Length in Feet)^0.5

Propeller Slip = 1.4 / (Knots @ 90%)^0.57

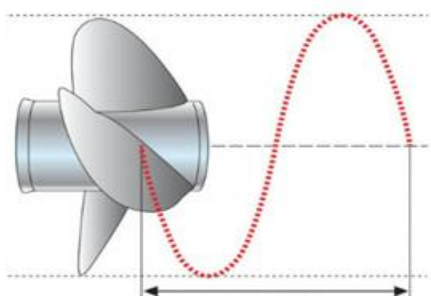
Three Bladed Propeller Pitch in Inches = (12 in/ft x (Knots @ 90%) x 101.3 kts/ft/min) / 90% Maximum Propeller Drive Shaft RPM) x (1.0 + Propeller Slip)

Pitch values should be rounded down unless the decimal is 0.7 or greater.

Two-Bladed Propeller Pitch Conversion Factor is 1.01

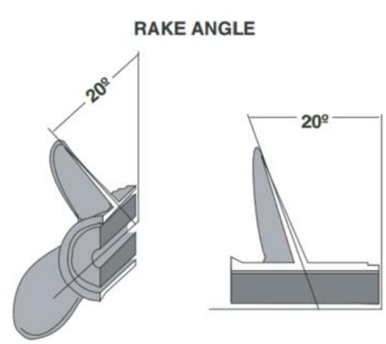
Four-Bladed Propeller Pitch Conversion Factor is 0.98

This methodology favours a slightly over pitched propeller



Pitch

Rake: Rake is the angle between the blade and the hub. Propellers can have between 0- and 20-degrees rake. It determines how much the bow lifts out of the water. High rake propellers are ideal for light-weight and high speed boats.



Optimization of the number of blades –

Theoretically, a single-blade propeller would be the most efficient - if the vibration could be tolerated. To achieve an acceptable level of balance with much less vibration, a two-bladed propeller is the most efficient, practically speaking. With more blades, efficiency decreases, but so does the vibration level. Most propellers are made with three blades as a compromise for vibration, convenient size, efficiency, and cost. The efficiency difference between a two- and a three-bladed propeller is considered less significant than the vibrational difference. Nearly all racing propellers are presently either three- or four-bladed.

With the growing frequency of propellers being run at an increased height (surfaced), four- and five- bladed props have become more popular. They suppress the higher level of vibration and improve acceleration by putting more blade area into the water. They can also help to make the rake more effective in lifting the bow of the boat for added speed.

Material design part -

Most of the RC boats are made up of balsa wood or fibreglass like materials .

Mechanical Part -

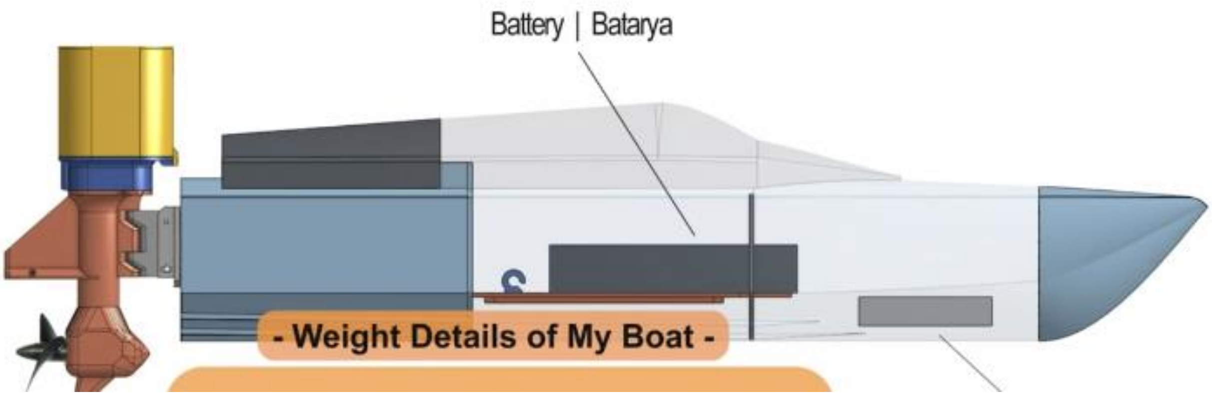
Weight and Torque Balancing –

Weight distribution is very important in a boat because we need to balance the boat on the water (i.e., a bit of the front part should be slightly lifted from the surface so that we can reduce the drag force due to water) .There are many chances of flipping and jumping of boats so we have to take into account the following.
Mainly we are concentrating on four following factors:
(1).Position of Motor.

(2).Balancing the torque produced due to the propeller.
(3).Position of Battery.
(4).Thrust Line

Position of Motor

We have to adjust the motor at the back of the boat so as to reduce the distance between propeller and motor thus avoiding the need for long transmission systems , thus avoiding losses .



Balancing the torque produced due to the propeller.

There are two types of situations in which we have to balance the torque. One is with a single motor and servo and the other one is dual motor situation.

As per our research in single motor case there will be a torque acting on the boat due to rotation of the motor .To prevent the flipping over of boat we place the place battery away from the centerline of the boat. So that weight of battery will balance the torque and if it is not enough, we place the extra weight at front portion of the boat.

In a dual motor mechanism when we use the two motors, net torque on the boat is zero , irrespective of the direction of the motion of motors , since the torque about the centre of buoyancy would be 0 . Hence there is no need to change the position of the battery.

Position of Battery

Position of the battery is at the centre generally but due to the torque applied by the propeller we have to move it a bit ahead so that the weight of the battery will balance the torque applied by the propeller. Also , as explained in the torque balancing section , we need to keep the battery a bit away from the centreline.

Thrust Line

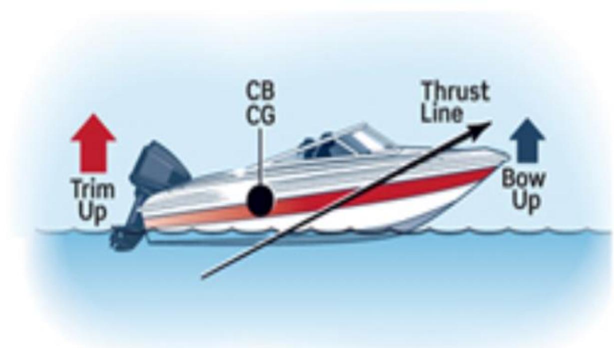


Figure-1

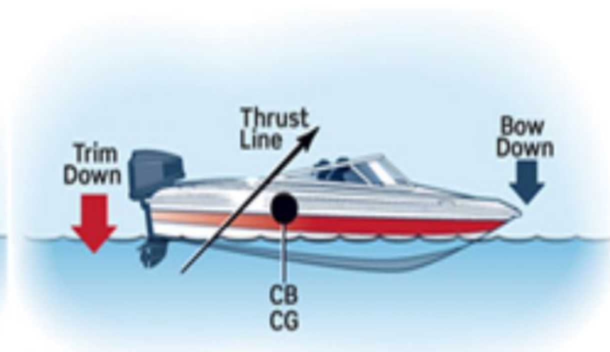


Figure-2

(**Thrust line:** Thrust line is a theoretical line that through the structure represents the path of the resultants of the compressive forces. And also for a structure to be stable, the line of thrust must lie entirely inside the structure.)

In figure-1 the propellor is kept at an angle to the vertical, so the thrust line will be ahead of centre of buoyancy/centre of gravity and hence due to this The bow will rise and reduce the viscous force which helps the boat to go with a greater speed.

In figure-2 the propellor is kept vertically so the thrust line will be behind the centre of buoyancy/centre of gravity and hence the bow goes down and will increase the viscous force which slows down the boat.

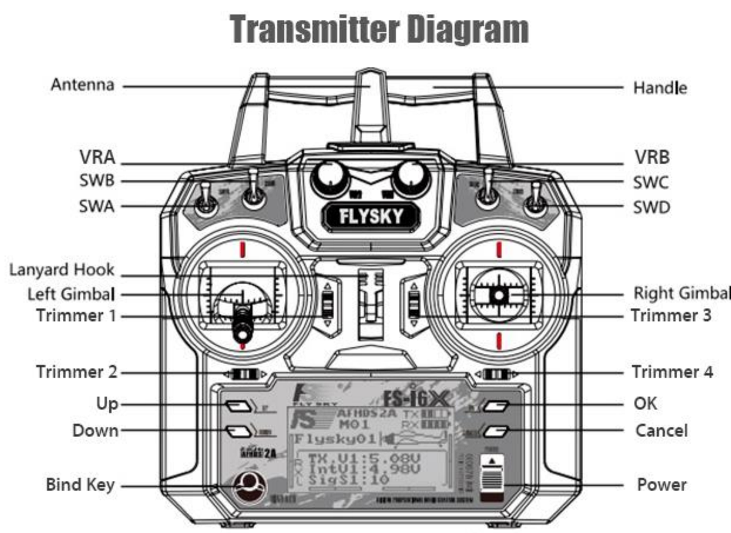
Electronics part –

We did find a few parts , however , these are only for discussion purposes and we may or may not use these exact parts depending upon the availability of the parts around us .

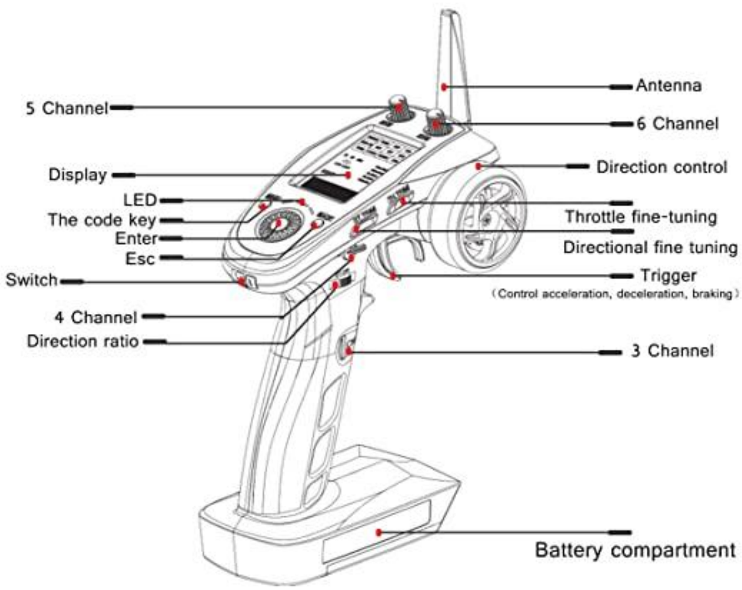
As per the problem statement given to us , we cannot make a Bluetooth or wifi based boat . Hence we had to make a radio controlled RC boat .

After a bit of searching , it was clear to us that flysky transmitter and receiver sets are the most popular among engineers who are already making RC automobiles .

Hence we decided to use it .



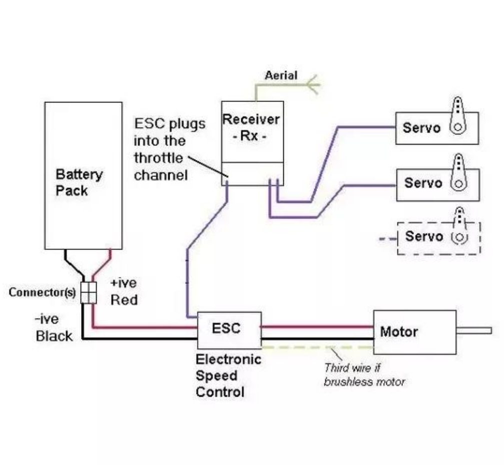
GT5 Transmitter

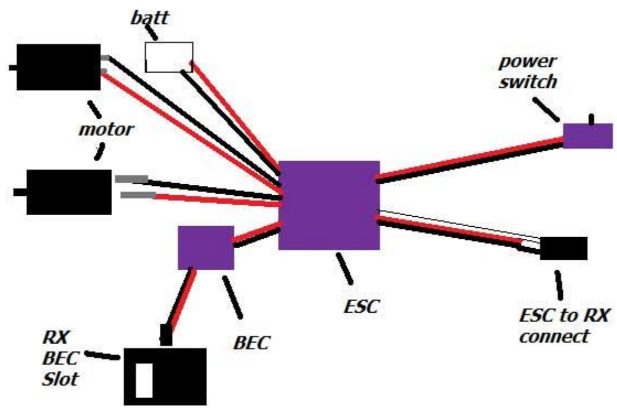


Brushless motors (also called BLDC motors) have significantly more lifetime as compared to the brushed DC motors , hence we decided to use it .


We also need an Electronic Speed Control unit (also known as ESC) in order to be able to control the motors speed and direction of motion . Different ESC's are available in the market depending on the amperage requirements of the device .

Here is a rough circuit diagram of what we are going to make , although the exact circuit diagram would depend on the exact parts we would choose later .





Thanks for reading !! 😊