# Design and Development of Unmanned Aerial Vehicle for Extinguishing Fire

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**Abstract -** This study explores the potential application of fire extinguishing balls in a system that integrates drone and remote sensing technologies to augment conventional firefighting techniques. The proposed system consists of scouting unmanned aerial vehicle (UAV) to detect spot fires and monitor the risk of wildfire approaching a building, fence and/or firefighting crew via remote sensing, communication UAV to establish and extend the communication channel between scouting UAV and fire-fighting UAV, and a fire-fighting UAV autonomously travelling to the waypoints to drop fire extinguishing balls (environmental friendly, heat activated suppressants). Through a transdisciplinary, multi-institutional project, this idea is being developed. The experiments done thus far to evaluate fire extinguishing balls are included in the scope of this paper, along with a general illustration of this design. Unless there are already open windows in the buildings, the experiments' findings suggest that smaller fire extinguishing balls available on the global market attached to drones might not be helpful in putting out building fires. Results, however, suggest that even smaller fire extinguishing balls may be useful in putting out fires in short grass (a ball of about 0.5 kg size put out a fire in a circle of 1-meter-long short grass). This discovery led them to focus on fighting wildfires rather than putting out building fires. The project also demonstrates the construction of drones with heavy payloads (about 15 kg payload) and the advancement of a device that can carry fire-extinguishing balls and be mounted on drones.

**Index Terms** – Electronic Stability Control (ESC), Drone, Fire, Propeller, Transmitter, Receiver, Controller, Unmanned Aerial Vehicle (UAV), Water Pump, Radio Equipment.

## I. Introduction

It is possible to distinguish between various drone types based on their type (fixed-wing, multirotor, etc.), level of autonomy, size, weight, and power source. These details are crucial for things like the drone's cruising range, the longest flight time, and the carrying capacity. In addition to the drone itself, or the "platform," there are different kinds of payloads that can be distinguished, such as cargo (such as mail packages, medications, fire extinguishing materials, flyers, etc.) and various kinds of sensors (such as cameras, sniffers, meteorological sensors, etc.). We'll go over some of the uses for various payloads. Drones need to communicate wirelessly with a pilot on the ground in order to perform a flight, to a certain extent. Additionally, most of the time a payload like a camera or sensor needs to be in communication. Frequency spectrum is needed for this communication to function. Depending on the type of drone, the payload, and the flight characteristics will determine the frequency spectrum requirements. International coordination is necessary for frequency spectrum use because it transcends national boundaries. Discussion of frequency spectrum and vulnerability (an understanding of the available frequency spectrum and associated risks in using the frequency spectrum), surveillance and compliance, as well as national and international legal issues on frequency spectrum and equipment requirements (enforcement of frequency spectrum use, equipment requirements, and the need for international and European cooperation). Finally, the topic of drone technology's upcoming developments is covered. Drones are getting smaller, lighter, more effective, and more affordable. Drones will therefore be used for a wider variety of purposes and will be more widely available to the general public. In addition to becoming more autonomous, drones will also be able to operate in swarms.

The safety of bridge inspection is currently mired in numerous problems. A person must directly inspect a bridge in order to look for any indications of deterioration. This creates a safety risk because the draughts under bridges could cause platforms on which the inspector is standing to fail or even send the inspector falling off the inspection platform. Workers on platforms inspecting bridges may even be at risk from overhead power lines because electrical safety knowledge is required, which complicates an otherwise straightforward inspection when multiple crews are involved. Water below a bridge can present serious safety risks. In this situation, the conventional ground platforms used for inspections are useless, and suspended platforms can be very dangerous due to their instability. Nevertheless, it is crucial to continuously check bridges for potential dangers because failures do happen.

In some circumstances, extinguishing a fire can be even more dangerous. Due to smoke production, fires in enclosed spaces reduce visibility and have the potential to block any exits either immediately or later. When exits are blocked, there is a risk of injuries or fatalities. Fires in open areas, however, can be even more dangerous. Since wildfires are so heavily dependent on the wind, which is typically unpredictable, they tend to spread very quickly—sometimes at speeds of 16–20 kmph, or 9.9–12.2 mph (Cheney). Finding a safe substitute for direct fire extinguishing is crucial because of the frequent deaths and injuries caused by wildfires due to their unpredictable behavior that have affected both firefighters and civilians.

## II. Component study

2.1) Radio Equipment: A radio controller is a bare minimum requirement for operating any remote-control model. The majority of controllers are made up of a small receiver and a handheld transmitter. These can cost as little as $30 or as much as several thousand dollars. A lot of cheap radios can be found for less than $100, but to perform as intended, they occasionally need technical adjustments and upkeep. Even though they are not always as dependable as more expensive radios, these radios are excellent for low-cost multi-copters.

Radios are available in a wide range of channels and bandwidths. Because they are less expensive and don't need any crystals swapped when flying near other 2.4GHz radios, 2.4GHz radios are the most widely used. Most have a range of about 1000 metres, though some may have a shorter range than comparable radios of lower frequency. A radio for multi-copter aircraft must have at least four channels, though six channels are preferred. Pitch, roll, throttle, and yaw are controlled by the four primary channels; any additional channels can be used to switch between flight modes or activate electronics. Radios are also offered in a variety of modes based on the purpose of each gimbal axis.

2.2) Battery: The most common battery used for multicopters is the lithium polymer battery or LiPo. These batteries are preferred for their high energy density, allowing them to output large amounts of power while keeping very lightweight and compact. However, LiPo batteries can be extremely dangerous if not handled properly. It is also important to understand the ratings of a LiPo battery. LiPo batteries consist of cells, each with a nominal voltage of 3.7 volts, 4.2 volts when fully charged. These cells can be arranged in either series or parallel to form a LiPo battery pack. If flying a multi copter that consistently draws 25 amps, then a 2500mAh battery should last close to 6 minutes. Finally, the C rating of a battery determines it's discharge rate. LiPos are often given a rating for continuous discharge and maximum or burst discharge (for up to about 10 seconds). The current draw from a battery back can be calculated using the formula:

$$I = C * \text{Capacity (Ah)}$$

For example, a 2200mAh 25C LiPo would produce 55 amps (100A = 20C * 5Ah).

LiPo batteries greater then 1S require a balance charger. Balance chargers come in many variations; some are capable of rapid charging (if supported by the LiPo), charging multiple batteries, storing and discharging. A 50W balance charger is sufficient for charging most batteries one at a time within about an hour.

2.3) Motor and Speed Controllers: Selecting the correct motors and speed controllers can be quite complicated without knowledge of the rating systems assigned to each component. I will begin by introducing a few common motor ratings. These include power (watts), current draw (amps), speed (kv) and thrust. First, it must be decided what the multi copter's primary use will be, whether it is casual flying, aerobatics or heavy lifting. Start by estimating the amount of weight planned to lift including the airframe and any heavy components such as batteries or cameras and gimbals. Since it is required that multi copter to hover at 50% throttle, a good way to estimate the thrust for the propeller and motorcombination is to double the weight. For aerobatic multi copters it may be good idea to choose lightweight, yet overpowered components that can supply more than twice the weight in thrust. In order to determine the nominal rpm for the props, multiply the kv of the motor by the voltage of the battery. Without getting too technical with the reasons for different prop sizes and their rotational speeds, the bottom line is that it is required to use larger and slower props with heavy lift multi copters and smaller faster props for micros and aerobatic multi copters.

Table 1. Motor and controller specifications

| | **Micro** | **Standard & Aerobatic** | **Heavy Lift** |
|---|---|---|---|
| **Size** | 10 – 15" | 15-20" | 20-25" |
| **Weight** | 200-500 gms | 500-1200 gms | 1.2 Kg+ |
| **Thrust** | 0.5-1 Kg | 1-1.2 kg | 2.5 Kg+ |
| **Prop Size** | 5-7" | 8-10" | 11-15" |
| **Speed** | 1800kv | 1800-1000kv | 1000-500kv |
| **Current** | 5-10A | 10-20A | 20-60A |
| **Battery Size** | 2-3S(7.4-11.1V) | 3S(11.1V) | 4-6S(14.8-22.2V) |
| **Power** | 50-100W | 100-200W | 200-800W |

2.4) Multicopter Frames: There are many different frame designs and configurations to think about when designing a multi-copter, with some having advantages over others. The quadcopter is likely the most popular frame for multicopter aircraft. The tri-copter, hexa-copter, Y6, octo-copter, and X8 are other common configurations. These configurations are based on the quantity of motors, but with a number of configurations, the frame orientation can also be changed to +, X, spider, or V. The biggest and most noticeable difference between each configuration created by changing the number of motors is the rise in available thrust as the number of motors rises. While mounting powerful motors to a quadcopter might produce thrust comparable to that of an octocopter, doing so would necessitate large, slowly spinning props, which are likely to cause low frequency oscillations into the platform because of slower response times caused by the increased momentum of each prop. In addition to increased thrust, the Y6, octocopter, X8, and V8 configurations also frequently allow the aircraft to continue flying even with a damaged motor thanks to their motor redundancy. The stability of the aircraft in the wind will improve with more motors, but, the flight controller has a greater impact on overall stability than the number of motors. It is crucial to consult the flight controller's documentation when configuring the frame and electronics in order to determine the correct rotation of each rotor. Any two of the three leads from the esc can be switched in order to reverse the rotation of a brushless motor. Each motor should always have its props removed before testing its rotation.

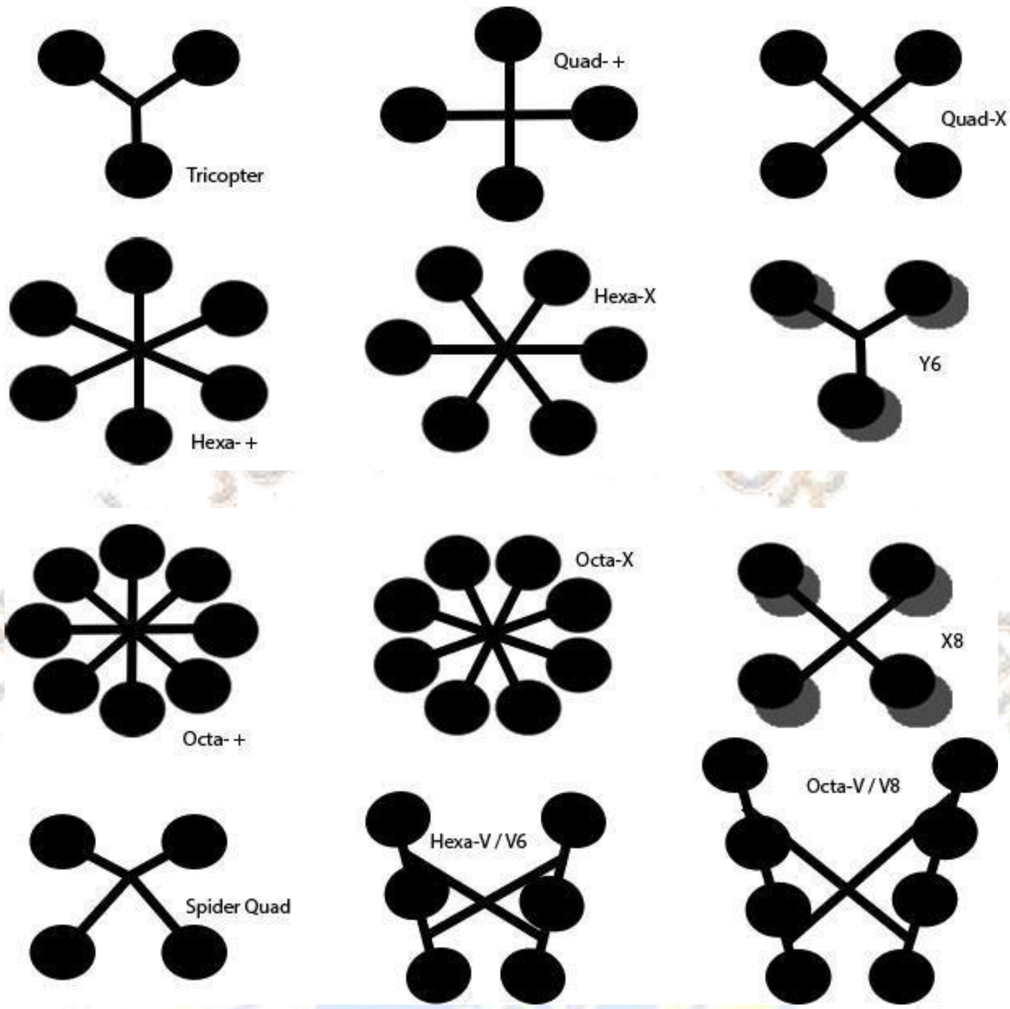


Figure 1. Multicopter Configurations

2.5) Flight Controllers: The flight controller is the most crucial component of the multicopter. To instruct each motor to carry out the desired action, the flight controller must combine the control inputs through a control system. Without having to manually change each motor's rpm, it allows the pilot to control the multicopter. From the most basic flight controller to GPS-navigated autopilot systems, there are many different configurations of flight controllers, each with their own benefits and drawbacks.

2.6) Common Sensors:

a) Gyroscope – Measures angular velocity allowing for relative angle holding. Accelerometer – Measures acceleration allowing for auto-leveling. Magnetometer – Measures magnetic heading allowing for orientation control. Barometric Pressure – Measures altitude for holding within approximately 1-2 m.

b) Ultrasonic – Measures altitude for object avoidance and holding within approximately 1-2cm. (Range = 4m)

c) Optical Flow – Measures optical displacement for position holding and optical navigation.

d) GPS – Receives and processes global positioning data for position holding and waypoint navigation.

## III. MULTICOPTER PAER LIST

1000kv BLDC motor

Propeller

ESC Simonk 30A

20 AWG Silicon Wire


Figure 2. Drone Parts

## IV. Wiring

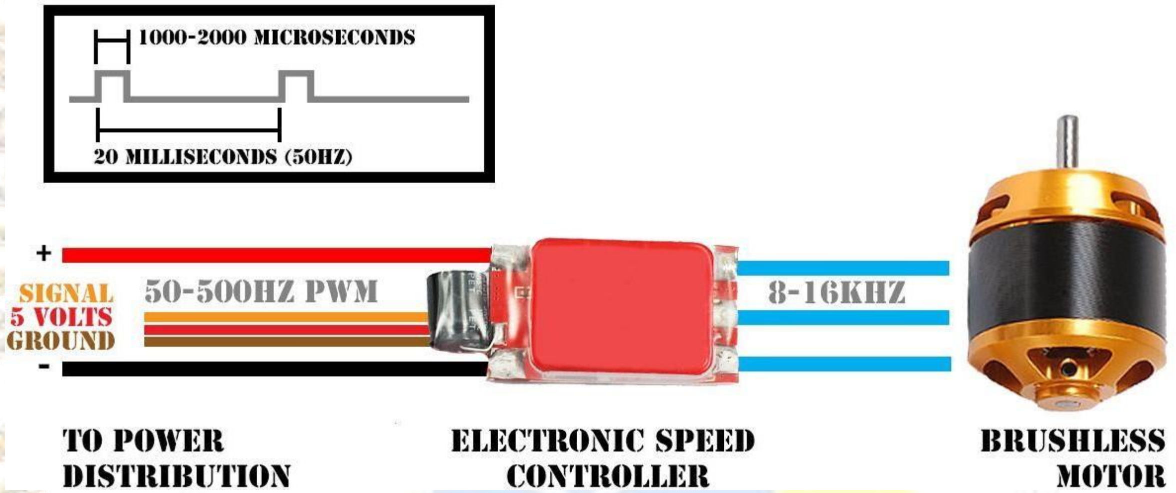


Figure 3. Wiring Schematic

a) Begin by flashing any custom firmware to each electronic speed controller

b) Using either bullet connectors or a direct solder connection, wire each motor to the proper speed controller. Ensure that the appropriate motors have been properly reversed; this can be done by switching any two of the three wires between the ESC and the motor.

c) If there is an ESC with a built in BEC (Battery Elimination Circuit)that uses a switching regulator, remove the red wire from the 3 wire signalcable on all but one ESC. Most flight controllers will support connection of all 5 volt lines of the three pin signal cable only if the ESC uses a linear regulator.

d) Solder all the primary positive and negative leads from the speedcontrollers to a power distribution board or power spider. Include a batteryconnection and any additional auxiliary power connections on the powerdistribution. Be sure to properly shield the connections from any shorts byusing electrical tape or heat shrink tubing.

e) Check for the correct polarity of all connections. Also check that there is no continuity or shorts between the positive and negative leads of the battery connector using a multi meter.

f) Secure all electronics to the airframe and properly connect each of the signal cables from the ESCs to the flight controller. Consult the flight controller's documentation for the proper placement of each cable.

f) Connect the radio receiver to the flight controller using a set of male to male 3 pin signal cables. Provided that one of the connections is powering the receiver, the remaining channels need only be wired with a single signal cable.

h) If the ESCs do not have a built in BEC, it is needed to wire an independent BEC from the power distribution to the flight controller. This will power the flight controller and receiver with the necessary 5 volts power. This can also be helpful for providing a cleaner, less noisy power supply to the electronics or video transmitter.

## V. Throttle Range Setting and Normal Working

First time to use ESC or to change the transmitter, it's necessary to calibrate the throttle. The procedure of throttle calibration:

a) Switch on transmitter, move the throttle stick to the top.

b) Connect receiver with power supply, to make surereceiver and transmitter connect well, then connect battery pack with ESC.

c) Motor emits continuous sound of "BEEPBEEP" and one short "BEEP" the highest point throttlecalibrated successfully.

d) Move the throttle stick to the bottom, motor emits continuous sound of "BEEP-BEEP" and one long "BEEP", the lowest point throttle calibrated successfully.

e) Throttle calibration finish, it's ready to go.

For Normal Working, follow the below steps:

a) Switch on transmitter, move the throttle stick to the top.

b) Connect the system with battery pack, motor emits continuous" BEEP,BEEP " and one long" BEEP", it shows ESC is ready to go.

## VI. Assembly

The assembly of the drone's frame is stated below. Along with the frame, motor placement and their connection with ESC will be completed. Follow the instructions given below to get the frame ready:-

a) In the frame accessories, two plates were received that are needed to connect in between the arms of the frame. Out of these two plates, grab the bigger one. It is observed that there are solder pads present on the plate with some positive and negative signs on them. This board is the power distribution board of the drone.

b) Take this power distribution board and attach the four legs ofthe frame to the plate and tighten them with screws. Now before placing the second plate, it is needed to complete some other things as well.

c) Take the ESC and remove the connector that is attached to the power wires of the ESC. It can be identified by observing the no of wires attached to that connector and also the size of the connector. Oncethe connector is removed, take the soldering iron and attach the redwire of the ESC to the pad with the "+" sign on it and the black wireto the pad with the "-" sign.

d) Repeat the process with all four of the ESCs and after that connectthe LiPo battery in a similar way but connect the battery through a switch which can be turned ON or OFF when required.

e) Now place the ESCs under the drone's arms with the help of cableties and place the top plate of the frame as well.

f) As the ESCs are connected, now it is required to take the motors and put them in place i.e. the end of the drone's arms, and tighten them with screws. Once that is done, it is observed that there are three wires coming out of the BLDC motor. It is now needed to connect those three wires to the three wires coming out of the ESC.

g) Take the middle wire of the motor i.e. the yellow-coloured wire and connect that to the middle wire of the ESC. Connect the rest of the two wires as required can be adjusted later on. Repeat the samestep for all four motors but remember not to attach the propellers now.

With this the frame assembly is complete. Now in the next step, it is required tocalibrate the ESCs and adjust the directions of the motor rotation as well. How to do that will be discussed in the next step.

Figure 4. Frame Assembly

## VII. UNDERSTANDING THE ROTATIONAL DIRECTION OF THE PROPELLERS

It only needs to be set up so that the motor directions at the ends of each rod are the same but different from one another. For example, if one rod has motors spinning in a clockwise direction, the motors at the ends of the complementary rod must be tuned to spin anticlockwise.

Yes, by simply applying different speeds (RPMs) to the relevant motors, the quadcopter's flying direction can adjusted and regulated according to the own preferences.

The following pictures demonstrate how the fundamental speed gearbox can be used with the appropriate motors to achieve and carry out any desired flying direction for the device:

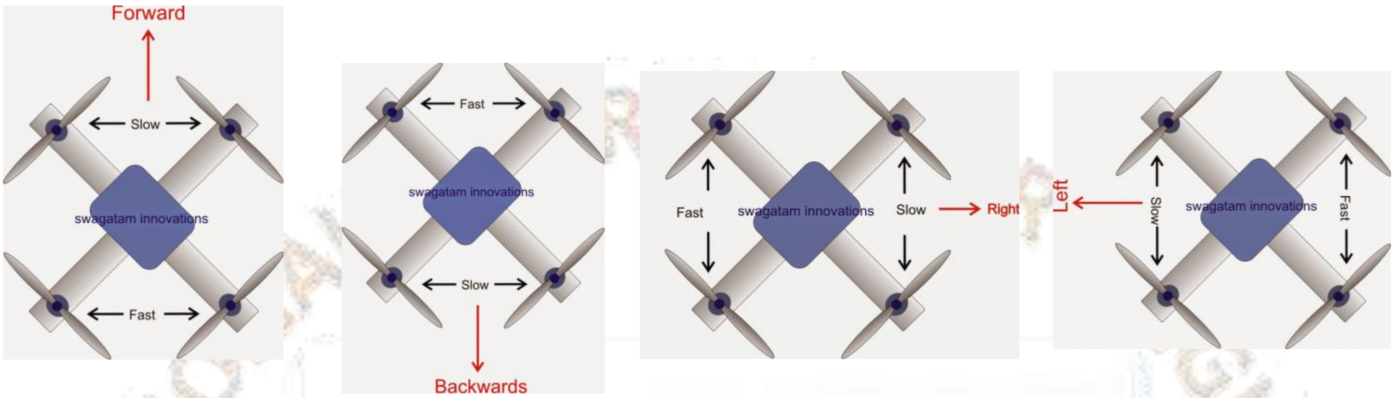


Figure 5. Rotational direction of Propellers

As shown in the diagrams, the quadcopter can be made to fly in any desired direction by appropriately reducing the speed of one set of motors, increasing the speed of the opposing set of motors, or adjusting the speeds to one's own preference.

The images show the basic directions, like forward, reverse, right, and left, but any other unusual direction can also be successfully implemented by appropriately adjusting the speeds of the appropriate motors, or even just one motor.

For instance, increasing the speed of only the S/E motor may cause the machine to fly in the N/W direction, while increasing the speed of the S/W motor may cause the machine to fly in the N/E direction, and so on. All that is required is practise until the user can fully control the quadcopter and has mastered it.

## VIII. ELECTRONIC CIRCUIT OF QUADCOPTER

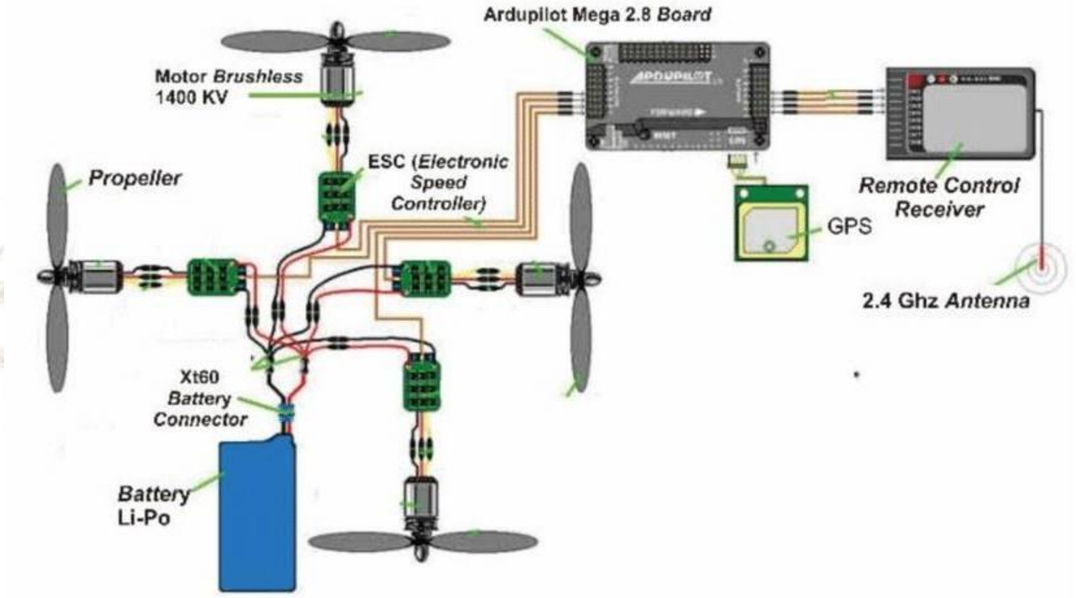


Figure 6. Circuit Diagram

8.1) KK2.1 Controller

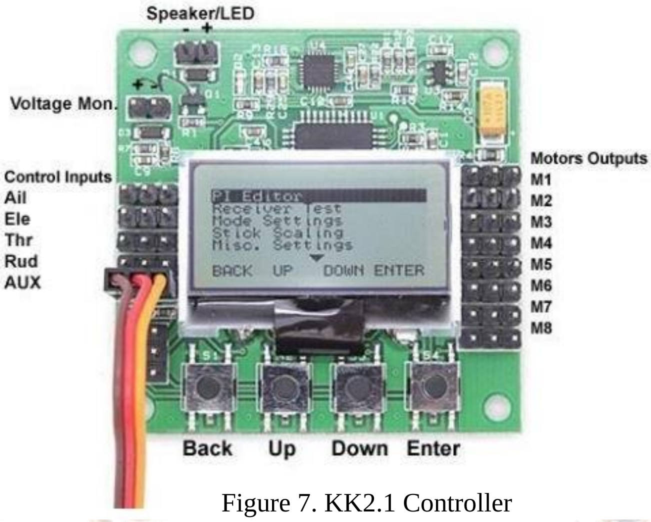


Figure 7. KK2.1 Controller

The KK2.1 Multi-Rotor controller manages the flight of (mostly) multi- rotor Aircraft (Tri-copters, Quadcopters, Hex-copters etc). Its purpose is to stabilize the aircraft during flight and to do this, it takes signals from on-board gyroscopes (roll, pitch and yaw) and passes these signals to the Atmega324PA processor, which in-turn processes signals according the users selected firmware (e.g. Quadcopter) and passes the control signals to the installed Electronic Speed Controllers (ESCs) and the combination of these signalsinstructs the ESCs to make fine adjustments to the motors rotational speeds which in-turn stabilizes the craft. The KK2.1 multi-Rotor control board also uses signals from the radio system via a receiver (Rx) and passes these signals together with stabilisation signals to the Atmega324PA IC via the aileron; elevator; throttle and rudder user demand inputs. Once processed, this information is sent to the ESCs which in turn adjust the rotational speed of eachmotor to control flight orientation (up, down, backwards, forwards, left, right, yaw).

8.2) Powering the KK2.1X Controller

The KK2.1.X has two 5V power busses.

The first 5V bus is common across the receiver inputs, output 1 (M1) and the programmer port. This bus powers the KK2.1.X processor and needs to be as clean as possible (i.e. no noise from servos).

The second 5V bus is common for outputs 2 to 8 (M2 to M8) only.

Prohibition of connection of the two 5V busses together as any noise on output 2 to 8 will then be present on the KK2.1.X CPU power supply.

ESCs don’t generally need a 5V power supply but servos do. Therefore, if a servo is connected to M2 to M8, it will also need a 5V power supply.

Usually, an ESC with a 5V BEC will be connected to M1 which will power the receiver and the KK2.1.X board. Servos on the M2 to M8 5V bus will need another ESC with a 5V BEC to be connected to M2 to M8. Note, the M2 to M8 power bus at 6V can be ran if needed to.

In general, only one BEC should be connected to M2 to M8. In the case of a quadcopter, the three ESCs connected to M2, M3 & M4. If they have switching BECs, their 5V wires should not be connected on the M2 to M8 power bus. Therefore, remove all 3 red wires from the servo connector and put some heat shrink over each one (leave one BEC on M2 to M4 if it is required to power a servo on M5, M6, M7 and/or M8). ESCs with linear BECs are ok to leave the 5V wire in the servo connector. If in doubt, remove the 5V wire.

Some ESCs don’t have an internal BEC so it is needed to use an external UBEC. If an ESC (without a BEC) is already plugged into M1, the following options are available to power the KK2.1.X and receiver.

a. Connect the UBEC to a spare receiver channel. This will power the receiver and the KK2.1.X via the cable that connects the receiver and KK2.1.X.

b. Use the Mixer Editor and copy the M1 settings to M5 (or any spare output). Connect the ESC for motor 1 that the would have connected to M1 (output 1) to the new motor output which is just configured. Now, the UBEC to M1 can be connected.

c. Use a servo Y lead to connect both the ESC and UBEC to M1.

Some ESCs have low current BECs which have been known to “brown out” when large motor currents are drawn. If this happens, the KK2.1.X will reboot and therefore results in a crash. Due to concern an external UBEC can be used and connect as above.

8.3) BLDC Motor


Figure 8. BLDC Motor

A compact but effective motor using 3 lithium-polymer batteries for aircraft weighing up to 800 grammes (28 oz). With brief bursts of up to 180 watts, propping is advised for roughly 140 watts of continuous power. A fantastic more powerful alternative to geared Speed 400-480 motors in slow-flying or 3D planes that need a larger 10" propeller. Use on sailplanes up to 28 oz, trainers up to 25 oz, aerobatic aircraft up to 18 oz, and 3D aircraft up to 15 oz. 10 x 5 on 3 lithium-polymer cells is the suggested prop. The chosen BLDC motor costs 350 per unit.

So, 350*4 =1400/- as four motors are used in Prototype.

a. KV (rpm/volt): 1000

b. No. of cells: 2-3 Li-Poly 6-3 NiCd/NiMH

c. Size: 28 mm dia *28 mm bell length

d. Shaft Dia: 3.2 mm

e. Poles: 14

f. Thrust: 900/4

g. Resistance: 0.090 ohms

h. Max efficiency : 80%

i. Max efficiency current: 4-10A (>75%)

j. Current capacity : 12A/60s

k. Weight: 64 g

l. Load current @10v: 0.5A

m. Working voltage: 7-12V

The motor features a 3.2mm hardened steel shaft, dual ball bearings, andhas 3.5mm gold spring male connectors already attached and includes 3 female connectors for the speed control. Now includes collet type prop adapter and radial motor mount. Mounting holes have 16mm and 19mm spacing on centers and are tapped for 3mm (M3) screws.

The four BLDC motors are connected and controlled through the SIMONK 30A ESC drone controller which receives signal from the FS-IA6B 2.4 Ghz 6 channel wirelessly controlled receiver which is signal operated bythe Remote.

8.4) FS-i6 Transmitter Remote

The main advantage of this transmitter is that it is not required to use any PC or laptop to set up this transmitter. It has one LCD display on it and can easily set up this transmitter by using the buttons given on it. It can operate up to 1500 meters. The range of transmitters depends on magnetic interference. If the magnetic interference is more at someplace, then the transmitter will have less range and if the magnetic interference is less, then the transmitter will operate at a higher range.

Now, the average range of this transmitter is 1500 meters.

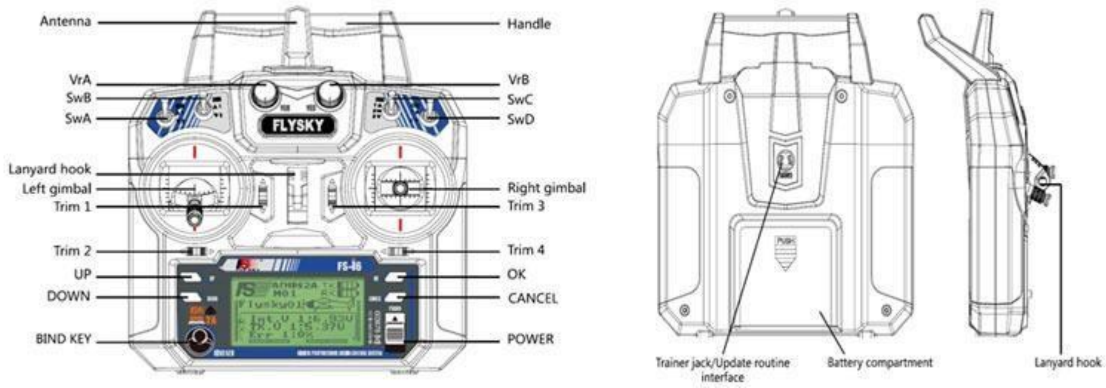


Figure 9. Transmitter Remote

8.5) FS-iA6B/FS-iA6 Receiver

This receiver has 2 antennas and 6 channels. For the best quality signal, thereceiver should be mounted away from the motors or metal parts. The connectors are used to connect the parts of the model and the receiver.


Figure 10. Receiver Schematic

CH1 to CH6: These channels are used to connect the ESCs (Electronic speed controller), VCC, or other parts.

B/VCC: It is used to connect the binding cable for the binding receiver and transmitter.

8.6) FS-IA6B/FS-iA6 Receiver Connections

Connection of motors with the receiver through ESCs (electronic speed controllers). The connection of the receiver is shown in the figure given below.

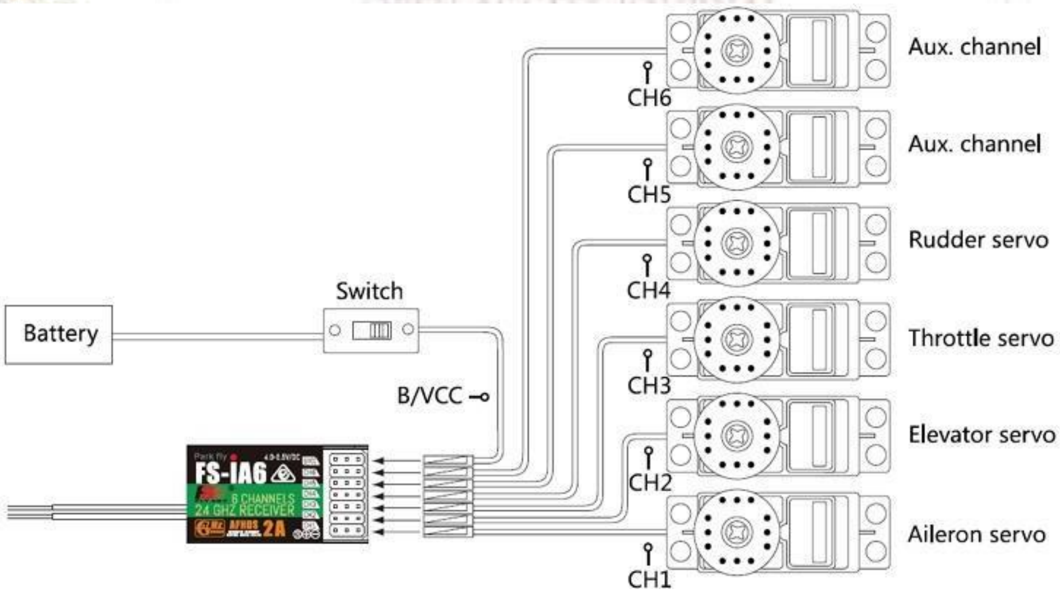


Figure 11. Receiver Connections

8.7) Mini Submerged Water Pump

Figure 12. Water Pump

A mini submersible water pump uses a motor to drive an impeller that rotates and forces water outwards, making it a centrifugal water pump. The water pump's body and the motor are both in close proximity and are enclosed in a waterproof seal.

Mini submersible pump motor hobby kit, 3v to 6vdc This small, inexpensive submersible pump motor can be powered by a power source ranging from 2.5 to 6 volts. With extremely low current consumption of 220ma, it can take up to 120 litres per hour.

It is just needed to attach a tube pipe to the motor outlet, submerge it in water, and then power it. Make sure the motor is never submerged beneath the water. Due to heating, the dry run may cause damage to the motor and make noise.

a) Cost: 50/- per unit

b.) Operating voltage: 2.5-6V

c) Maximum lift: 40-110cm / 15.75"-43.4"

d) Flow rate: 80-120L/H

e) Outside diameter: 7.5mm / 0.3"

f) Inside diameter: 5mm / 0.2"

g) Diameter: Approx. 24mm / 0.95"

h) Length: Approx. 45mm / 1.8"

i) Height: Approx. 30mm / 1.2"

j) Material: Engineering plastic

k) Driving mode: DC design, magnetic driving

Ontheprototype, the small submerged water pump is submerged in a water-filled container, and its purpose is to release the water upon signal reception.

The FS-IA6B 2.4Ghz 6 channel wireless receiver, which is signal operated by the Remote, provides connection to the pump through the SG90 servo motor.

8.8) Micro Servo Motor

High output power in a small, light package. Smaller versions of the standard types, servos can rotate about 180 degrees (90 in each direction). can be used to control these servos with any hardware, library, or servo code. It's beneficial to move objects without having to construct a motor controller with feedback and a gear box, especially because it can fit in tight spaces. It includes hardware and three horns (arms).


Figure 13. Servo Motor

In the protype, the copper cables that connect to the submerged water motor and drop mechanism motor are wound around the servo motor bush. For the submerged water pump and drop mechanism, it serves as an ON/OFF switch.

The FS-IA6B 2.4 GHz 6 channel wireless receiver, which is signal operated by the Remote, is used to transmit signals to control the SG90 Motor.

## IX. Working

a) When the rotation is increased of all four motors, the lift force will increase and drone will take off when the force exceeds the gravity that's pulling down the drone.

b) When the sticks are loosened the drone is airborne the motor speed are adjusted to the lift force is matching the force by gravity letting the hover in a fixed height with all four propellers rotating at the same speed.

c) The precision in the plane parallel to the ground is controlled by GPS and sensor include to the flight controller.

d) To keep the drone stable only pointing in one direction if all motor were spinning in the same direction the drone will turn around it's ownvertical axis due to Newton's third law of motion. Newton's third law ofmotion states that when two bodies interact they apply forces to one another that are equal in magnitude and opposite interaction.

e) This would mean if a motor is providing a certain amount of torque to the rotor when propeller is attached to the static path will receive an equal amount of torque in the opposite direction that means the net torque will be in the same direction and will make the drone turn in opposite direction of the propeller rotation.

f) This is prevented by spinning the propellers in pairs diagonally inopposite direction making the net reaction torque zero.

g) Preventing the drone from turning so now hovering position can move the drone on the plane parallel to the ground where pitch is forward and backward motion and roll is what makes the drone moves oversight.

h) These motions are also controlled by motor speed differences instead of diagonal motor pairs are now formed by the two motors on each side or front and back of the drone.

i) As an example to pitch the drone forward the front propellers are running slower and back propellers at higher speed this will make the drone till forward.

j) The tilt angle can be viewed as a combined angular lift force that can be split up into two components the vertical force that should be equal tothe gravity for the drone to keep its altitude and into the horizontal force which will make drone move forward.

k) This means with larger speed difference with unchanged gravity would lead to an increased tilt angle making the drone move faster.

l) The same techniques is used to roll the drone where one of the side pairsare spun faster and other one slower making the drone go into a roll motion.

m) This is where the quadcopter design really excels as the reaction torque produced by the motors become zero if everything is added up despite changing the speed on the propellers to pitch.

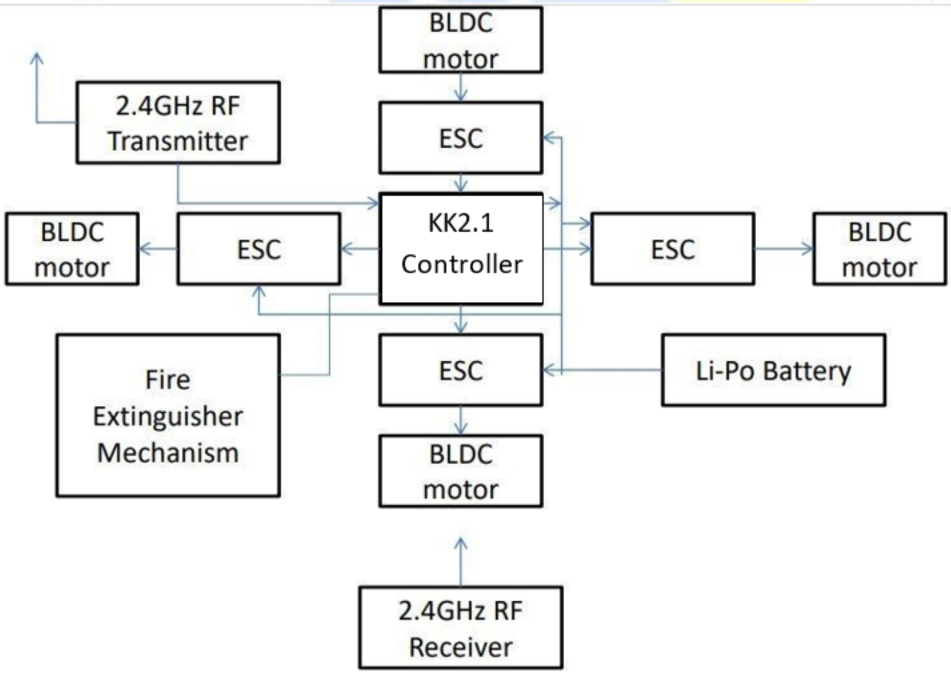


Figure 14. Flowchart of working

## X. Fire Extinguishing Mechanism

10.1) Drop Mechanism:

The balls of an mono ammonium phosphate are placed which has a mobility to vanish high calorific amounts of flame such as burning house, burning forest etc. Nowthedrone has capacity to store 8-9 balls in it's container, so such a generical amount of balls in it. Suppose when there is blastand to vanish such kind of flame so can fly the drone for that place and going to drop one of already placed balls so it will help to resolve such a matter

10.2). Water Spray Mechanism:

The tank filled with water which is situated at the top of drone will be throw water through nozzle. Intheprototype maximum capacity of water is about 660ml. The pipe connected to theoutlet of submerged motor will throw water in fire received from inlet. As it's a prototype it will definitely extinguish more fire when will make it's drone in real. This mechanism contain submerged motor which run on 9V battery. Submerged motor can run within the power supply of 3-6V so this battery is sufficient for run the motor.

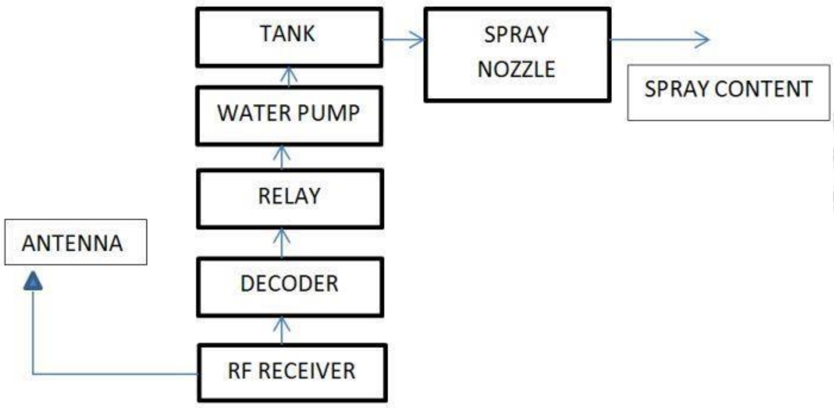


Figure 15. Flowchart of Fire extinguishing Mechanism

## XI. Calculations:

11.1) Thrust Calculations:

The Thrust to Weight Ratio can be between 2.5 to 3.5, for this type of application, because the Drone has to carry more payload and it should alsohave better maneuverability.

Specifications ofthePropeller

Diameter : 25.4cm

Pitch : 11.43cm

Weight : 14gm

Total Weight of Drone is approximately equal to 1000gm

By the experiment as mentioned below it is concluded that motor and propeller could take 770g max thrust at max RPM

Total thrust produced at 100 % RPM = 4 x 770

=3080grms

Therefore Thrust to Weight Ratio = Thrust Produced/Total Weight of Drone

= 3080/1000

= 3.08 : 1

Since the Thrust to Weight Ratio is 3.08, the Drone will have better maneuverability

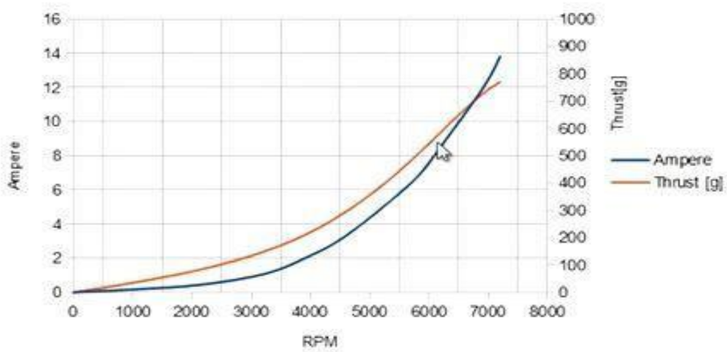


Figure 16. Ampere Vs. RPM Vs Thrust

11.2) Flight Time Calculation
3S 2200mahTherefore,
2200/1000 = 2.2 Amp
Maximum BLDC Motor Amp= 10 AmpSo,
Battery Amp/ Motor Amp * 60 = Flight duration
But, each cell should only discharged up-to 3 V to be safe.Therefore,
Effective capacity= 3/3.7 * 100
= 88%
Hence Effective Capacity= 1000*0.88
= 880 mAh
So, Now the new value is880/1000 = 0.88 amp
Now,
Battery Amp/ Motor Amp * 60 = Flight duration0.78/ 10 * 60 = 5.28 minutes (for full throttle)
Hence, actual flight time will be longer because the drone will not becontinuously running at full throttle.

## XII. CAD AND PROTOTYPE:

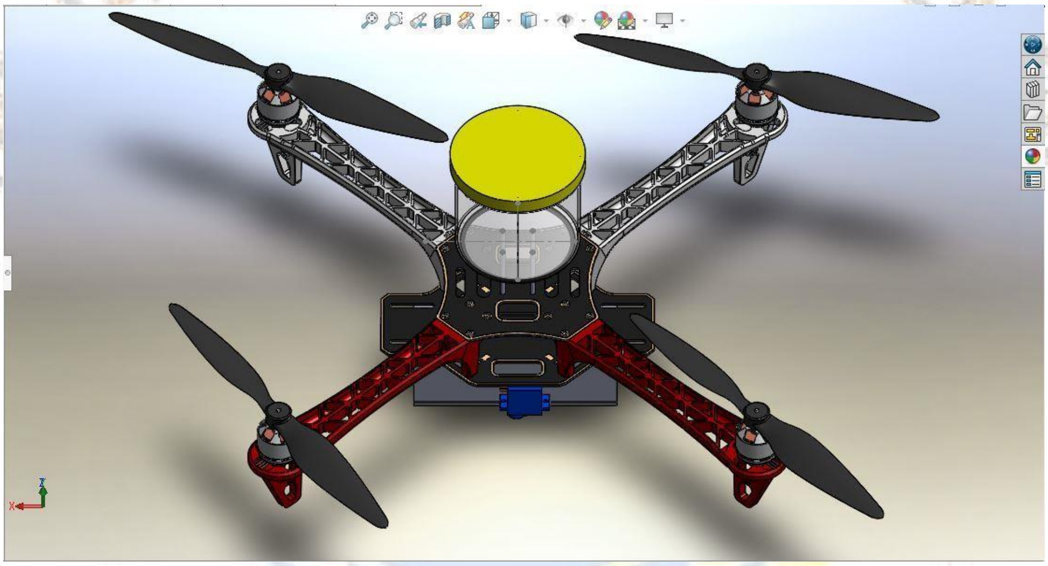

Figure 17. CAD Model

Figure 18. Final Prototype

## XIII. CONCLUSION:

We've calculated the effects of using a platform that can control a variable number of drones that can spray water or other extinguishing agents on a wildland fire. The impact has been calculated on the spread of a forest fire while taking into account a variety of variables, such as the intensity of the fire, the length of the flames, the vegetation, the moisture content, the wind's direction and speed, the payload that each drone carries, and the amount of time it takes for each drone to arrive at the fire front. It is determined how many linear metres of an active fire front can be put out as these factors change based on the critical water flow computed as a function of the key factors influencing how a fire evolves.

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