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Design and Development of Fire Fighting Drone

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Abstract **- Drones are a promising technology with applications in industry, defense, and many other domains. Drone use is rapidly growing as a result of its remarkably broad use. The purpose of this project is to construct a hexacopter and create a personalized remote control that will allow the drone's functions to be controlled. Additionally, the drone has a fire extinguisher and a fire ball pickup device that can be operated via a wireless remote control that may be modified. The idea at hand concerns a fire-extinguishing firefighting drone that, should a house fire occur, a building or similar structure that can be quickly put out to put out a fire early on and that can be remotely controlled like an unmanned drone by connecting to a central control center. Pick and place is a widely utilized technique in contemporary manufacturing settings. Pick and place automation expedites the process of moving parts or things from one area to another. Drones can swiftly assess a conflagration's impacted region and provide vital information about the fire's intensity and extent back to a remote operator. Fire officials can then utilize this raw data to swiftly determine whether any buildings or people are in the route of the disaster and to develop a plan for limiting the fire. Drones are also capable of quickly compiling extremely detailed maps. Where Drone carries fire extinguisher ball, extinguisher mist spray injector.**

Keywords: Hexacopter drone, Fire extinguisher ball, Mono-ammonium phosphate Spray injector, High-definition camera.

I. INTRODUCTION

The frequency of fire-related incidents is rising. In all, 18,450 fire incidents were registered in India in 2015, resulting in 17,700 fatalities and 1,193 injuries, according to the NCRB. Twelve large fires in Mumbai over the past six months have claimed 22 lives. Reading through items such as “Fire outbreaks is the third biggest risk to business continuity and operations, according to India Risk Survey (IRS) 2018. In IRS 2016, fire outbreaks were ranked eighth biggest risk to business” only strengthen the veracity of the claim. Having firefighters lose their lives as a result of it “2 firemen who died in well tragedy were feted for work-TOI” makes us seriously doubt the system. Therefore, the goal of this project is to lessen the workload for firefighters by developing a drone that can act as a first responder in place of firefighters, potentially saving lives. With the aid of cameras and sensors, this IOT-Based drone system will offer insightful information about the surroundings. The suggested system will assist the firefighters in keeping an eye on the situation, such as determining whether a person is trapped inside or whether there are any explosives nearby the fire. It will also help them detect any dangerous gases and create an appropriate plan of action. It's a serious issue because of the sharp rise in the number of fire-related incidents. By enhancing the response to the disaster, the drone will help save lives. The firefighters will also benefit from the ability to control the fire by dropping a fire extinguisher ball.

The main purpose of this firefighting drone project is to overcome the fastest technology of fire extinguisher in crowded cities with tallest building, to avoid human casualties and property damages. As we know that on tallest side at the emergency situation the fire fighters cannot reach due to the height and depth of fire so at these critical situations to extinguish the era, the drones are the preferable action. Now a day’s technologies going far up, some actions cannot have done by human but technology can that’s one example is drone. In this drone we are putting best technologies to perform best action on any situations. Like, extinguishing agent uses, such as foam, powder, or specialty liquids. Mist distributors, which release a cooling mist to enable firefighters and drones to approach a fire, High-definition cameras with human detection capabilities to recognize products and codes on packaging to identify potentially hazardous and combustible materials.

The effectiveness of drones is quickly gaining traction as organizations all over the world start implementing this technology. This project describes the parts that go into building a drone, identifying the best material for thermal resistance, and assembling firefighting apparatus. This is made to operate in extremely cold temperatures, and it will all be manually operated at the ground station. Currently, firefighters risk their lives to crawl into buildings, look for survivors using a camera, and manually identify victims. The purpose of the drone is to locate hot-spots and victims in danger areas. This lessens the number of firefighters who lose their lives. This can be made possible by using the drone, which can move swiftly through the building without worrying about running into anything.

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II. LITERATURE SURVEY

1. Manuj etl (2019) (IOSR-JMCE); Created semi-autonomous drones for firefighting missions instead of putting firefighter lives in danger.

The existing hexacopter is enhanced in this study in order to achieve constant flying, gather and store Global Positioning System (GPS) data, and carry out auto-landing. The system was equipped with a fire extinguisher and other firefighting supplies. Two more models were developed, tested, and the outcomes were found to support the research.

2. Vimalkumar R and Karankumar Shaw from the SRM Institute of Science and Technology in Kattankulthur, Tamilnadu, India, in the year 2020.

This paper describes that drone carry a fire extinguisher ball for extinguish the fire, the drone designed carrying maximum 20k

3. Abinesh. D. V (2017) developed a quad-copter to explore affected areas.

After evaluating many drone designs, the author decided on the quadcopter with an arm length of 220 mm due to its affordability and intuitive simplicity in manufacture. The purpose of the 10 x 4 inch propeller is to improve stability. The components of the propeller are chosen taking into account the temperature that the drone would encounter when it is close to a fire.

4. Dr. Ronald T. examined the concept and issues surrounding the usage of unmanned aerial systems in the fire department in their 2018 research.

Priority is placed on drone airworthiness, command and control, and crash avoidance. UAS field testing should continue, and fire chief opinions on UAS use should be surveyed. Additionally, to establish regulations on the use of UAS technology in the fire service, the Federal Aviation Administration (FAA) and fire chiefs collaborated. payload with 14 minutes' battery endurance.

5. Burchan (2019) demonstrated the use of drone assisted wildfire fighting using fire extinguisher balls as a complement to traditional firefighting methods.

The recommended system consisted of six balls, each weighing 0.5 kg, and a hexacopter with a payload of 15 kg. It comprises scanning for spot fires with unmanned aircraft systems (UAS) and determining how likely it is that a wildfire will get close to the building. In order to help with situational control, it also sends vital information to the firefighting UAS. However, these balls were useless against class A and B flames.

6. To effectively monitor forest fires, Abdulla Al-Kaff (2019) developed an autonomous unmanned aerial vehicle.

The system includes algorithms for autonomous takeoff and landing, trajectory planning, fire monitoring, and surveillance operations inside a specified area. This design incorporates thermal cameras, temperature sensors, and communication modules to provide information about the fire to the Emergency Response Team (ERT).

III. PROBLEM STATEMENT

Both humans and human property can be harmed by fire. UAVs are the best option to fight the fire, save human lives, and prevent additional property damage. General fire accidents happen frequently in an unplanned and sudden manner, resulting in approximately 2.1 million injuries to humans and up to 50 billion dollars in property damage.

IV. OBJECTIVES

The hypothetical design relies on the deployment of fire extinguisher balls from an unmanned aircraft system (UAS) to reduce the threats that flames pose to manned vessels, the firefighter crew, and society as a whole.

- To create a hexacopter that can put out fires.
- To create a hexacopter that prevents severe accidents and property damage.
- To create a hexacopter with a lower price.

V. LIST OF COMPONENTS AND DETAILS

1) DJI NAZA M-LITE CONTROLLER
2) ELECTRONIC SPEED CONTROLLER
3) BRUSHLESS DC MOTORS
4) LIPO BATTERY
5) PROPELLERS
6) FRAME
7) TRANSMITTER -RECIEVER MODULE
8) SERVO MOTORS
9) PUSH AND POP BUTTONS
10) LANDING GEARS
11) CAMERA
12) FIREBALL

Details of All the Components

1) DJI NAZA M-LITE Controller

a) One-stop design

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b) Improved attitude stabilization Algorithm Intelligent switching between various flight control modes
c) Hold on to the GPS module's accurate position
d) Smart Orientation Control (IOC)
e) Failure mode
f) Low voltage defence
g) Motor Dis-arm and Arm
h) Support for Futaba S-Bus and PPM receiver
i) Support for various multi-rotor aircraft
j) An integrated Gimbal stabilization feature

Figure 1: DJI NAZA M-LITE Controller

2) Water Pump

The two types of pumps that are most frequently utilized are submersible and jet. As shown in Figure, Jet pumps pull fluid to the surface, whereas submersible pumps push it there fluid. Please make sure that your pump is only using pure water. There may be air in the pipes if the pump's sounds are unfamiliar or the water pressure is too low. The pump could become too hot if there is air in the pipes. Knowing the water's temperature will help prevent the motor from overheating.

Figure 2: Water Pump

3) DC Motor

A of a group of electrical devices known as DC motors transform direct current electrical power into mechanical power. The maximum types rely on the magnetic field's forces. Almost all DC motor types contain an internal mechanism—either electromechanical or electronic—that allows them to sporadically shift the direction of the motor's current flow.

Features

1) The steel construction can resist the demands of competition.
2) They are appropriate for a variety of Quadcopter and Hexacopter Frames due to their lightweight construction.
3) Small size.
4) Provides excellent performance and value.
5) For the optimum RC experience, use a smooth throttle response.

DC Motor Specification

- Motor KV (RPM/V) for Model 6T A2212: 2200
- Compatibility LiPO Batteries: 2S to 3S
- Maximum Efficiency: 80%
- Current Handling Capacity: 12
- Current without Load (mA): 500
- Maximum Efficiency Right now: 4–10
- Length: 27 millimeters
- Breadth (millimeters): 26
- 60 grams in weight
- Shipment Weight: 0.064 kg

Figure 3: DC Motor

4) LIPO Battery

A lithium polymer battery, or more precisely a lithium-ion polymer battery, is a rechargeable battery that uses a polymer electrolyte rather than a liquid electrolyte. It is made of lithium and other elements. This electrolyte is made up of high conductivity semisolid (gel) polymers. These batteries are employed in applications where weight is important, such as mobile gadgets, some electric cars, and radio-controlled aircraft. Compared to other lithium battery types, they offer a higher specific energy.

Figure 4: Li-PO Battery

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5) Propellers

Propellers are devices that transform rotational motion into linear propulsion. The drone propeller creates an airflow and spins, which causes a pressure differential between the aircraft's top and bottom surfaces, lifting the craft. There is a glass fiber propeller accessible. As much as three inches, three to seven inches, eight to ten inches, eleven inches and more, as well as propeller accessories. Carbon Fibre Propeller is an alternative if you prefer light weight and added strength.

Figure 5: Propellers

6) Frame

The 450mm Hex Frame constructed using premium materials. The Ultra Durable Poly-amide Nylon is used to build the Arms while Glass Fibre serves as the Main Frame. For direct soldering of your ESCs, this F450 model has integrated PCB connectors. This keeps your electronics layout very organised by doing away with the requirement for untidy multi- connectors or a power distribution board. Additionally, the F450 has stronger molded arms, so a hard landing won't result in arm breaking at the motor mount. All of the frame bolts have Pte-threaded brass sleeves, making assembly simple and negating the need for lock nuts. The hardware is incredibly simple to maintain organised and only needs one size of hex wrench to assemble because it only uses one size of bolt throughout the entire assembly.

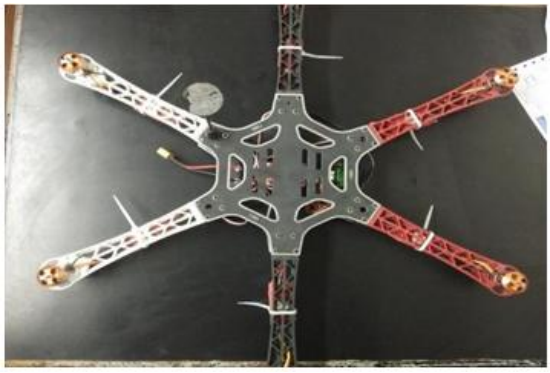

Figure 6: Frame

7) ESC (Electronic Speed Controller)

This 30A BLDC ESC has a 5V, 3A BEC and is fully programmable able to run motors on a constant 30 amp load current. It is well-built, with two independent PCBs housing the power MOSFETs for the controller and ESC. Five to twelve NiMH or Ni-Cd batteries or two to four lithium polymer batteries can power it. To effectively prevent jamming, a separate voltage regulator for the micro-controller is included. Helicopters, aircraft, and UAVs are the best applications for it.

Specifications:

- BEC: 3Amp, 5V for servos and an external receiver.
- Maximum Speed: 210,000 rpm for 2 poles, 70,000 rpm for 6 poles, and 35,000 rpm for 12 poles.
- Weight: 32 grams.
- Dimensions: 55 x 26 x 13 mm.

Features:

1) High performance micro-controller for optimal compatibility with all motor types at higher efficiency.
2) Premium MOSFETs for BLDC motor drive.
3) Completely programmable using any common RC remote control; enhanced thermal management through the use of a high-performance heat transmission membrane in the heat sink.
4) Three start modes that work with fixed-wing and helicopters: Normal, Soft, and Super-Soft.

Figure 7: ESC

8) Servo Motor

One type of motor with incredibly accurate rotational capabilities is a servo motor. Usually, this kind of motor has a control circuit that provides feedback on the current position of the motor shaft. The servo motors can rotate very precisely because of this feedback. You can rotate an object at predefined angles or distances with a servo motor. It is made up of a simple motor that powers a servo mechanism. If a motor is driven by an AC power source, it is referred to as an AC servo motor; otherwise, it is called a DC servo motor. In this lesson, we will only discuss how the DC servo motor operates. In addition to these main categories, there are many

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distinct types of servo motors depending on the kind of gear arrangement and operating characteristics. A servo motor's gear arrangement allows us to create very high torque servo motors in small, lightweight designs. Because of these qualities, it is used in many different applications, such as robotics, RC cars and helicopters, and toy cars.

Servo Motor Working Mechanism:

There are three components to it:

1) Managed device
2) Sensor output
3) Feedback mechanism

Figure 8: Servo Motor

9) Camera

Ultra HD Video Resolution: Shoot crystal- clear 4K/30FPS, 2.7K/30FPS, 1080P/60FPS, and 720P/120FPS videos with our 4K Action Camera. Perfect for vlogging, sports, and travel videos.

Wide Angle Lens: With a 170° super-wide-angle lens, capture more of your surroundings in every shot. Ideal for outdoor adventures, sports activities, and scenic shots.

Wifi & App Compatible: Connect to WiFi and download the Go-plus Cam Pro App to control your camera remotely, preview your shots, and share your footage instantly. Perfect for uploading to YouTube and other social media platforms.

Waterproof Up To 98FT: Take your camera underwater and capture stunning footage while swimming, diving, or surfing. The included waterproof case lets you shoot up to 98ft deep, making it ideal for aquatic sports.

Multiple Features: Our action camera comes with multiple features such as Loop Recording, Time Lapse, Slow Motion, Burst Photo, Exposure, Driving Mode, and Sound Record. This means you can capture your adventure just the way you want it, and with the best quality possible.

Figure 9: Camera

10) Landing Gears

Skidding universal landing gear.

White is the colour for the multi-rotor hexacopter for the DJI f450, f550, and SK480.

Robostall universal landing gear skid for multi-rotor, quad-copter dji f450, f550, and sk480 is included in the package

Figure 10: Landing Gears

- **Easy to use:** The feature that makes this pack of one fire extinguishing ball so easy to use is that, in an emergency, it can activate on its own when no one else is around. When placed in the right high-risk area, where most fires are likely to originate, it will extinguish the fire on its own in three to five seconds after reaching the proper temperature.
- **No Need for Special Maintenance:** This unit can function as a fire alarm for five years without the need for special maintenance. It is made of environmentally safe dry powder and is lightweight and portable, weighing only 1.5 kg. When activated, it can produce a loud noise of 101 decibels, keeping you safe.
- **Safe and Effective:** People no longer need to be in close proximity to the fire scene, and the surroundings are entirely safe for human health includes a wall mounting bracket and, in the event of a fire, can also be operated manually.
- **Coverage:** It covers an area of roughly 70 to 80 square feet at a 360-degree angle.It has the ability to put out three different types of fire: electrical, liquid, and solid.

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In its packaging, it weighs 1.5 kg.The 144 mm diameter ball is 100% eco-friendly and 100% biodegradable, making it convenient to carry and use. With a five-year shelf life and no wiring or ducting, even young children can operate this ball.

Figure 11: Fire Ball

11) Receiver Transmitter Module

2.4 GHz radio frequency transmitter and receiver Work voltage is 5 volts.

= 2.4 GHz working frequency Distance: 50 meters in a straight line.

Figure 12:Transmitter-Receiver Module

12) Switches and Push-buttons

Depending on the application, the purpose of a push-button switch is to enable or disable an electrical circuit. Push button switches are utilized in a wide range of products, including medical equipment, outdoor controls, mobile communication terminals, and industrial equipment control handles. In most cases, push button switches have a push button housed inside housing. Pushing the button may cause it to move in relation to the housing, modifying an electrical contact's state either directly or indirectly by opening or closing the contact. A push button switch may also have an actuator, driver, or plunger of some type placed inside switch housing with at least two contacts connected to an electrical circuit in which the switch is integrated.

Figure 13: Push-buttons

VI. PIN CONFIGURATION

Port description:

A: For left/right roll control
E: For front/back pitch control
T: To regulate the throttle
R: To regulate the rudder
U: For the Control Mode Turn on switch
X1 to adjust gain or to control the Gimbal pitch.
X2: Compatible with S-Bus and D-Bus or for IOC switch, or for gain tuning
X3: To monitor voltage (connect to the VU V-SEN port)
M1: To rotor #1
M2: To rotor #2
M3: To rotor #3
M4: To rotor #4
M5: To rotor #5
M6: To rotor #6
F1: To the roll servo Gimbal
F2: To use a pitch servo Gimbal
GPS port: GPS module wire connection.
LED: LED port, for LED wire connection from Versatile Unit EXP. (Signal pins are pins that are close to nicks in three-pin ports.)

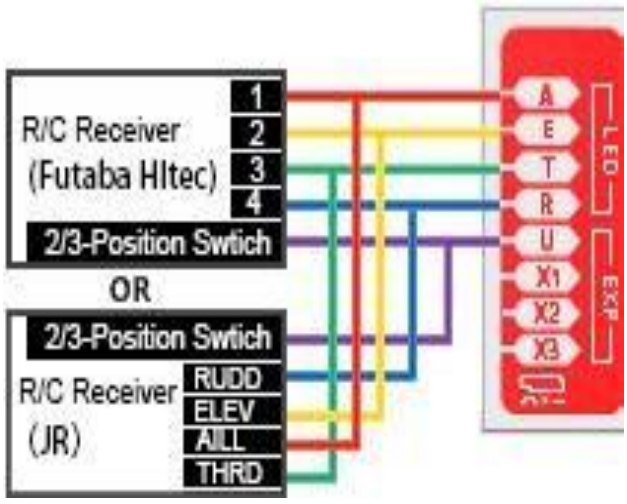

Figure 14: Pin Configuration

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VII. METHODOLOGY

The construction of a hexacopter involves putting together the necessary parts, such as the drone's frame or chassis, motors, motor drivers, propellers, battery, etc. The drone's control board serves as its primary control panel, and motor driver boards are used to connect the motors to it.

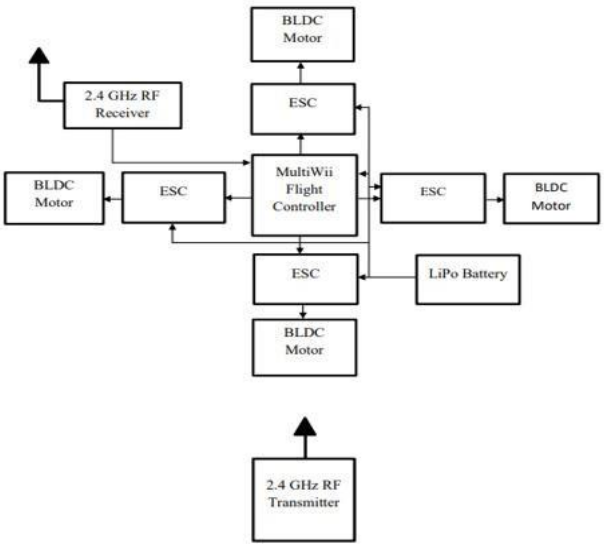

Figure 15: Block Diagram for Transmitter Section

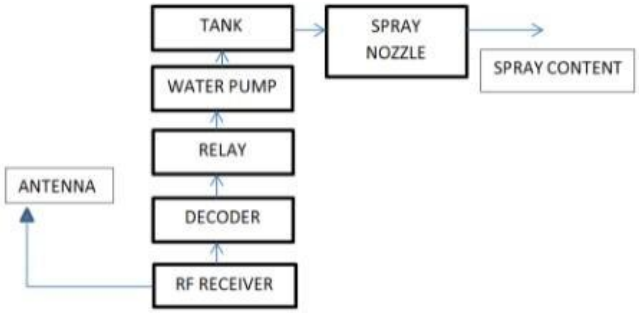

Figure 16: Block Diagram for Receiver Section

The drone control board has a wireless module attached to it that receives data transmitted by the remote control unit.

Using a tiny blast, the drone uses foam-encased PVC balls with dry chemical agents to put out fires instantly. Drones are used by the system to drop fire extinguisher balls into the fire. The balls explode when they come into contact with fire, and the fire can go out.

Using wireless technology and a specially designed remote unit, the dropping mechanism is controlled. When a fire is detected, the remote unit's LCD display receives an alert.

Also we are providing one tank on upside of drone (we can also use pipe which is connected to tank placed on ground to deliver large amount of water to extinguish fire because we cannot lift high weighted tank.) to extinguish the fire by using pressure vessel nozzle placed in front of pipe.

The goal of the current invention is to create a fire drone that can immediately respond to fire conditions, progress, and conditions. It also has a variety of functions that can be used to rescue various types of fire suppression and lifesaving.

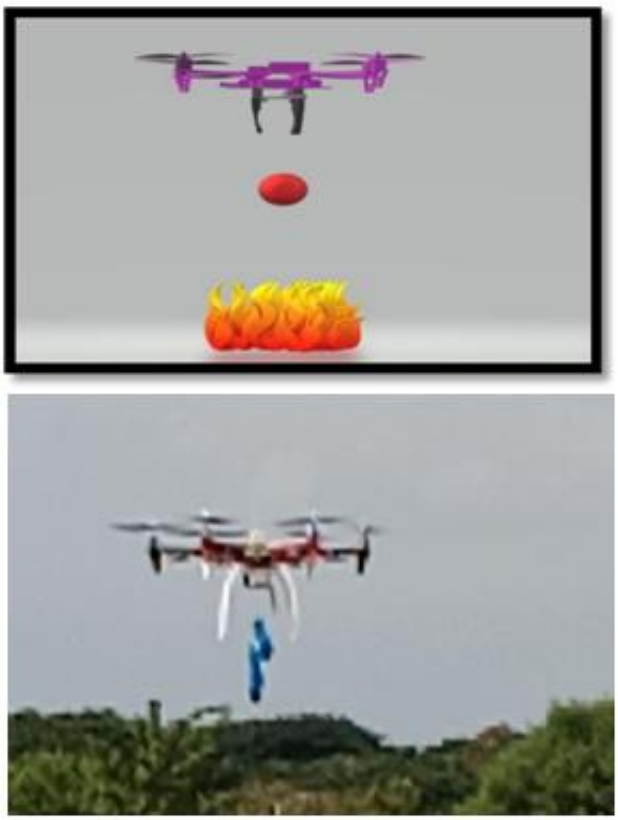

Figure 17: Droping Mechanism

Figure 18: Spraying Mechanism

Circuit Diagram

An electrical circuit is represented graphically in a circuit diagram, which is also referred to as an electrical diagram, elementary diagram, or electronic schematic.

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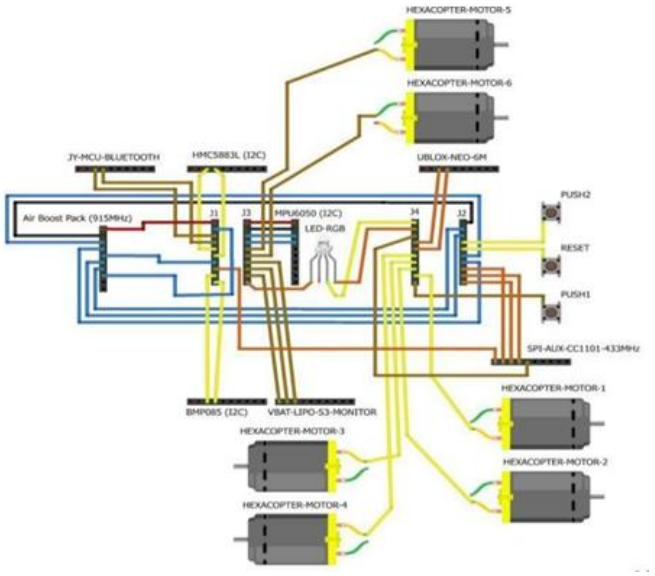

Figure 19: Circuit Diagram

Calculations

For designing the drone the imp factor to be calculated is motor for calculating the motor for drone involves considering several factors, including the drone's weight, desired thrust to weight ratio, propeller size, and battery voltage.

1) Motor Calculation

For choosing appropriate motor you have to know the various factors like

a) Determine total weight
b) Thrust to weight ratio
c) Calculate required thrust
d) Select propeller size
e) Determine voltage

So,

We are assuming 3kg total weight capacity and 500gm payload
Total weight =3.5kg
Thrust to weight ratio for hexacopter is 2:1 and 3:1 for this project we are choosing 2:1 ratio.
Total thrust= Total weight x Thrust to weight ratio Total thrust=3.5 x 2 kg
Total thrust= 7 kg
Thrust is measures in newton (N) So, convert kg to newton 1kg=9.81N

Therefore multiply total thrust by 9.81

7 x 9.81 = 68.67 N total thrust we want to generate here we are using hexacopter so we have 6 motors So, required thrust generated by single motor is Total thrust / total motors

7/6=1.16 kg

68.67/6 =11.445 N

For this thrust we are perform CFD Simulation by using appropriate propellers and motor specification to meet our criteria.

We are using 1045 propellers for generating maximum thrust. For 1000kv the thrust generated is 500 to 600 grams only

6 x 600 =3600 grams which not suitable for drone For 2200kv motor can generate 1200 grams thrust 1200 x 6 = 7200 grams = 7.2 kg

7.2 x 9.81 = 70.632 N thrust can be generated by this motor So, for single motor 7.2/6=1.2 kg =11.772 N

From above calculation and motor specification which meets our criteria so we are using this 2200kv motor for the drone

RPM=total kv x per volt

RPM=2200 x 1 =2200 =2200x11.1=24420 rpm

Advantages

- About streaming and live video footage from drones.
- On fire extinguisher for drones.
- Water sprayer.
- Powder sprayer.

Applications

- As a Fire Extinguisher Drone.
- Dropping mechanism.
- Sprayer mechanism.

VIII. CAD MODEL AND REAL IMAGES

Figure 20: CAD Model

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Figure 21: Real Image

IX. CONCLUSION

A fully-fledged drone designed for human safety, also to reduce property damage. Create an interdisciplinary platform to address the needs of society by developing and deploying autonomous drone systems across multiple societal sectors. The platform's goal is to link and integrate existing technological development, research application and applications in different societal sectors to make them inform of each other.

In order to facilitate the creation of knowledge and innovation aimed at both the public and private sectors, we also seek to incorporate and integrate user viewpoints. It is anticipated that the project will produce a broader network of cooperating partners, multidisciplinary research grants, and tangible applications for autonomous drone operations in the designated regions.

The concept of a firefighter drone will expedite the response time and enhance the ability to monitor a region and assist a citizen in need. The use of thermal and regular cameras to create a 3D area and heat model will offer insightful information that will make it easier for firefighters to create a suitable plan of action, which would otherwise be challenging. Cameras used for explosive and human detection can assist firefighters in locating distressed citizens. Moreover, speakers and microphones facilitate communication. Fire in a specific area can be decreased and an entry or exit route can be made with a fire extinguisher ball. The toxicity reports that the gas sensors produce can also aid in the firefighters' self-defense. The Fire-Fighter Department can afford the drone because of the cost-effective cameras, sensors, and other hardware used in its construction.

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