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DESIGN OF MULTIFUNCTIONAL QUADCOPTER

[1]Ayush Srivastav, [2]Aman Vaish, [3]Charu Srivastav, [4]Aman Gupta,
[5]Sheetal Khaitan, [6]Permendra Kumar Verma, [7]Sheshnath Yadav
[1,2,3,3,4,5,6,7]Deptt. of Electronics & Communication Engineering
Buddha Institute of Technology (India)

ABSTRACT

This paper presents a new design of quadcopter which can detect the amount of gas leakage in any circumstances, can jam the mobile signals and can also collect water sample from remotable areas. The quad copter has been designed in such a way that it can carry heavy loads. We have developed the drone by keeping the load carrying capacity in mind as the quadcopter has to carry all the setups including the water sample that will be collected in the quadcopter.

Keywords-Gas Sensor, Mobile Signal Jammer, Pitch, Roll, Thrust, UAV (Unmanned Aerial Vehicle), Water Sample Collector, Yaw.

I.INTRODUCTION

In this fast growing world in field of technology, the three basic things that we need to save is time, money and life. These days UAV is one of the most eyecatching and useful technology on which too much of research is being focused on. UAVs is a mechatronic system which combines elements of mechanical, electronic, electrical, software and control engineering. Quadrotor aerial robot is an automatic system which is an unmanned VTOL (vertical take-off and landing) helicopter. The quadcopter consist of four rotors constituted at the four end of the cross intersection.

LPG leakage sensor: We are familiar with the LPG gas that is used in almost every house in our country. A lot of cases related to accidents caused due to LPG gas leakage can be heard in news in every second day. This drone is designed in such a way that it can sense the amount of gas leakage in a particular house or building. This feature can be of great use for firefighters to know the exact situation of gas leakage by sending the drone in the building.

(Note: The same setup can be used by traffic police to detect the alcohol consumed by some driver and would make it easy to catch the individuals breaking the drink and drive rules)

Mobile signal jammer: The drone also contains a signal jammer circuit which can block all the mobile signals in 100m radius range. This will be of high benefit to the police and soldiers in riots for getting control over spreading of rumours.

Water sample collector: The speed of increase in technology is directly proportional to the growth of pollution in our environment. We need to keep a regular check on the pollution being spread in our environment. We have developed a drone which can collect the water sample from unremotable water bodies. The cost of collecting water sample from drone will be much faster and cheaper than a person going to the same place and bringing it to the laboratory for further water quality testing.

Quadcopter theory: The Quadcopter uses four propellers, each controlled by its own motor and electronic speed controller. Accelerometers will measure the angle of the Quadcopter in terms of X, Y, and Z axis and accordingly adjust the RPM of each motor in order to self-stabilize its self. The Quadcopter platform provides stability as a result of the counter rotating motors which result in a net moment of zero at the centre of the quadcopter.

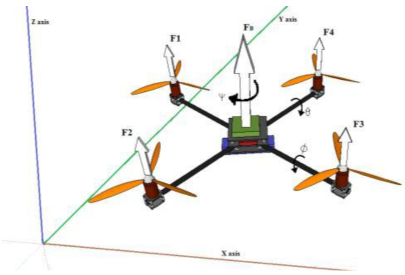


Fig.1 Net momentum

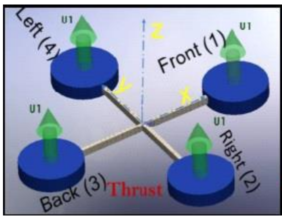
Using this principle we are able to adjust the speed (RPM as a function of the voltage provided to the motor) of each individual motor in order to correctly manipulate Quadcopter's yaw, tilt, and roll. Tilt and roll can be controlled by changing the speed of the appropriate motors, while yaw control involves delicate balancing of all four motor functions in order to change the moment force applied to the quad. Controlling the Quadrotor involves four different states [3]:

U1 - Upward motion z-direction: (figure 2) with respect to the body. This motion is provided by the thrust generated by all four motors rotating with the same angular velocity.

U2 - Roll motion Φ: (figure 3) this motion is attained by the force differential between the thrust generated by the right and the left propellers.

U3 - Pitch motion θ: (figure 4) this motion is attained by the force differential between the thrust generated by the front and the rear propellers.

U4 - Yaw motion ψ: (figure 5) this motion is attained by controlling two sets of flaps placed underneath the side propellers to redirect a small component of the normal-to-body thrust force in the horizontal plane. The force components act in opposite directions which create a moment-couple about the vertical axis of the body.



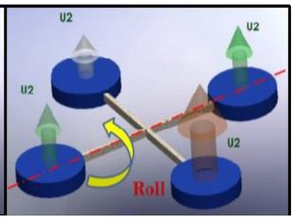
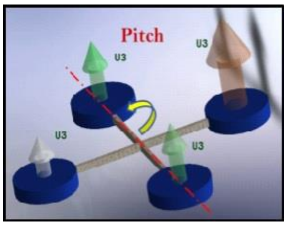


Fig.2 Thrust **Fig.3** Roll



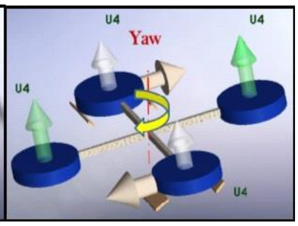


Fig.4 Pitch **Fig.5** Yaw

II. SYSTEM DESCRIPTION

The control signal generated by remote using FS-CT6B 2.4 GHz frequency transmitter and receiver. The microcontroller decodes the data frame sent and process it.It also has input signals from sensors in IMU board. The IMU board consists of 3-axis gyroscope and 3-axis accelerometer on it. Data from these sensors will be helpful in stabilizing and balancing the quadcopter. The microcontroller is governed by the programme written in its memory. According to the data received from the remote and from the sensors. The controller sends appropriate signals to the ESCs. This would be achieved by the PWM channels available in it.

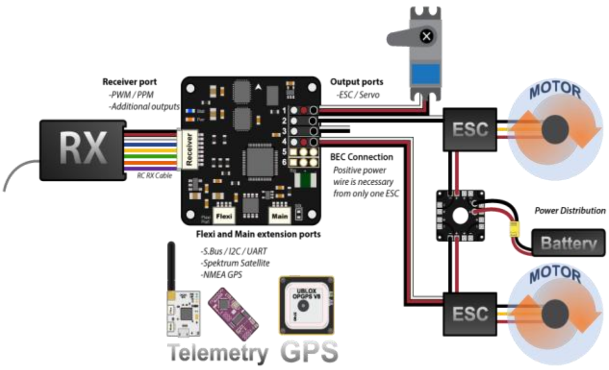


Fig.6 System Model

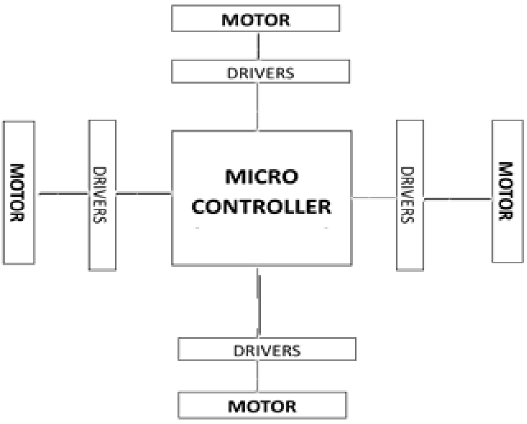


Fig.7 Block diagram

Yaw motion is achieved by supplying more voltage to M1 and M3 which moves the Quadcopter in left direction. Supplying more voltage to M2 and M4 which moves the Quadcopter in right direction.

Frame design and construction:

The components of our quadcopter are framed together on a frame. The main design consideration for the frame, as for most aircraft, is minimizing weight. Because this is a multi-rotor in which we have to set up some more devices, sensors and microcontrollers to make it multifunctional, we need to reduce the weight of the quadcopter as much as possible. For reducing the weight, light weight teak wood is being used. By surfing on internet, it was found that this wood was strong yet light in weight which was perfect as per our requirement.(fig.8).

Fig.8 Quadcopter Structure (working view)

Fig.9 Quadcopter structure (rest view)

III.ADDED FEATURES

1.Gas leakage sensor: We have fixed MQ7 gas sensor which can detect the amount of gas leakage. Sensitive material of MQ-7 gas sensor is SnO2, which with lower conductivity in clean air. It make detection by method of cycle high and low temperature. We took the value of conductivity of sensor in clean air. As the conductivity of the sensor changes the program on the microcontroller compares the present conductivity with that of the conductivity in fresh air and displays it through a graph or values on our device which can be connected to our drone through wifi, Bluetooth or internet. We have controlled the sensor through microcontroller and have designed the circuit in such a way that we can control the sensor and get its output directly on our mobile phones or laptop through our android application which we have developed through MIT app inventor or arduino software on our pc respectively.

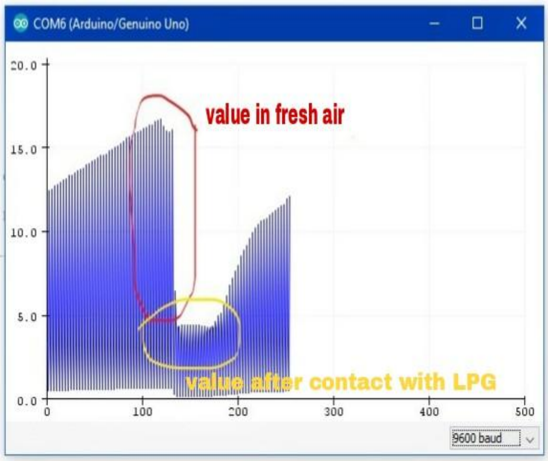


Fig.10 value before and after LPG leakage

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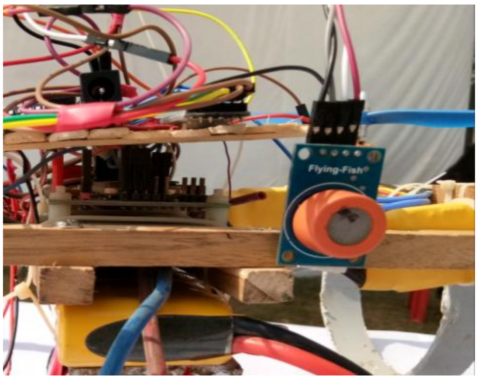

Fig.11 MQ7 sensor on our drone

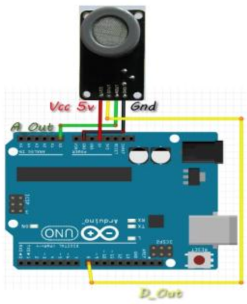

Fig.12 Connection with arduino

Table1:

Technical Data

Model No.			MQ-7
Sensor Type			Semiconductor
Standard Encapsulation			Plastic
Detection Gas			Carbon Monoxide
Concentration			10-10000ppm CO
Circuit	Loop Voltage	V_c	≤10V DC
	Heater Voltage	V_H	5.0V±0.2V ACorDC（High） 1.5V±0.1V ACorDC（Low）
	Heater Time	T_L	60±1S（High）90±1S（Low）
	Load Resistance	R_L	Adjustable
Character	Heater Resistance	R_H	31Ω±3Ω（Room Tem.）
	Heater consumption	P_H	≤350mW
	Sensing Resistance	R_s	2KΩ-20KΩ(in 100ppm CO)
	Sensitivity	S	Rs(in air)/Rs(100ppm CO)≥5
	Slope	α	≤0.6 (R_{300ppm}/R_{100ppm} CO)
Condition	Tem. Humidity		20℃±2℃；65%±5%RH
	Standard test circuit		Vc:5.0V±0.1V; V_H（High）：5.0V±0.1V; V_H（Low）：1.5V±0.1V
	Preheat time		Over 48 hours

2.Signal jammer: The drone comprises of a mobile signal jammer which can block all the signals in 100m radius range of the drone. Cell phone jammer is an electronic device that blocks transmission of signals between a cell phone and a base station. By using the same frequency as a mobile handset, the cell phone jammer creates strong interference for communication between the caller and receiver. It is efficient in blocking transmission of signals from networks including UMTS, 3G, CDMA, GSM and PHS.

Mobile phones operate at different frequency bands in different countries. In India it is around 900Mhz to 1800Mhz.

The below mentioned formula can be used to calculate the required values.

$$f = \frac{1}{2\pi\sqrt{L_1C_1}}$$

Depending on the frequencies you need to block, the values of inductor (L1) and capacitor (C1) can be altered.

For any jammer circuit, it's essential to have three important sub circuits.

- RF amplifier
- Voltage Controlled Oscillator
- Tuning circuit

These 3 circuits, when combined together form an efficient cell phone jammer circuit.

- RF amplifier circuit comprises of the transistor Q1, capacitors C4, C5 and resistor R1. This RF circuit amplifies the signal generated by the tuned circuit. The amplified signal is given to the antenna through capacitor C6. It blocks DC and allows only the AC component of the signal to be transmitted.
- When transistor Q1 is turned ON, the tuned circuit at the collector turns ON. The tuned circuit consists of capacitor C1 and inductor L1. This acts as an oscillator with zero resistance. It produces very high frequency with minimum damping.
- When the circuit is ON, voltage is stored in the capacitor. Once the capacitor is completely charged, it allows charge to flow through the inductor. When current flows through the inductor, it stores magnetic energy corresponding to the voltage across the capacitor. At a certain point, the inductor reaches its maximum and the charge or voltage across the capacitor turns to zero.
- Now the magnetic charge through the inductor decreases and the current charges the capacitor in opposite or reverse polarity. The process repeats and after a while, inductor charges the capacitor and becomes zero.
- This process runs till internal resistance is generated and the oscillations stop. RF amplifier feed is given through capacitor C5 to the collector terminal before C6. The capacitors C2 and C3 generate pulses in random fashion (noise) at the frequency generated by the tuned circuit.
- The RF amplifier boosts the frequency generated by the tuned circuit. The frequency generated by the tuned circuit and the noise signal generated by the capacitors C2 and C3 is combined, amplified and transmitted.

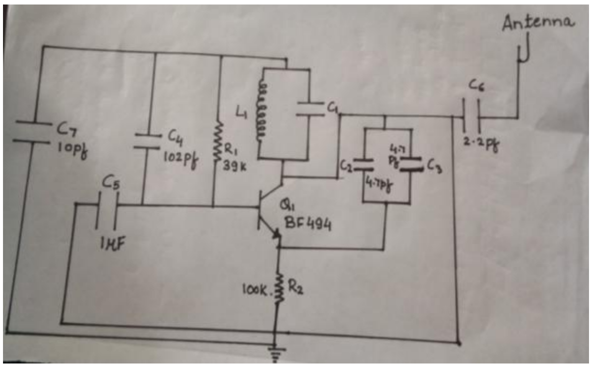

Fig.13 Circuit diagram of signal jammer

3.Water sample collector: The water sample collector works on the principle of hydraulics. The system contains a dc motor of 60 rpm as we wanted a higher torque to pull the piston of syringes as shown in the arrangement in fig.13.This is no rocket science in understanding this arrangement. As the motors rotate clockwise, the arrangement allows piston of the syringes to suck the water from some water source and when motors are rotated anticlockwise, the water is released.

The movement of motors are controlled by our device by internet, Bluetooth or wifi.

(NOTE: All the arrangements should be placed in such a manner that the center of gravity of the drone lies at the center of the drone)

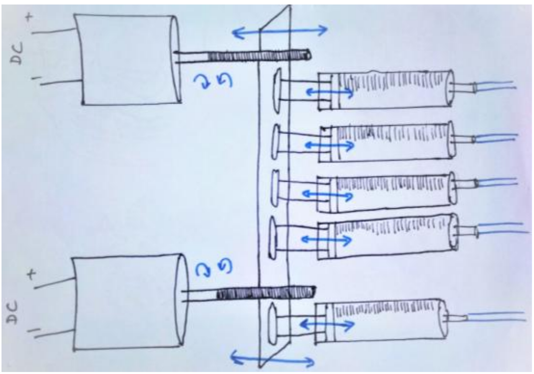

Fig.14 Arrangement for water sample collector

IV. DESIGN METHODOLOGY

Sensor selection:

The control and balancing of quadcopter is achieved by the use of sensors that communicate to the control system. The control system performs calculates to work out the outputs required to move the quadcopter to a desired position as well as maintain stability. In the UAV and the MAV project the size and the weight of the employed components play a dominant role, it would be preferable to develop still smaller and more lightweight attitude determination systems than the ones available on the market. Altitude determination systems normally consist of gyroscopes, accelerometers and magnetometers, whereat a device, containing gyroscopes and accelerometers, is commonly called Inertial Measurement Unit (IMU). We will be using MPU6050 breakout board, which has 3-axis accelerometer and 3-axis gyroscope. An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer.

Brushless DC motors:

Brushless motors are more advantageous to quadcopter over brushed DC motor. Brushless motors have more torque per weight, have more efficiency, reduced noise factor, reliability, elimination of ionizing sparks from commutator, longer life span, more power and overall reduction of electromagnetic interface.

Propellers:

Propellers transduce the rotary motion to aerodynamic lift force. Two pair of counter rotating propellers make the aerodynamic torque is zero. We will be using 11 inch diameter with a pitch of 4.7 inch/revolution.

Electronic speed control (ESC):

An ESC controls the brushless motor by converting the supplied DC from the battery into three phased AC. ESC is an electronic circuit with the purpose to vary an electric motor's speed, its direction and possibly also to act as a dynamic brake. We selected Turnigy Basic 25A v3.1 Brushless Speed Controller.

Battery (LiPo):

Lithium polymer batteries (LiPo) are increasingly popular for powering remote control aircraft; due to light weight, energy density, longer run times and the ability to be recharged. We selected Zippy 11.1V 25C 5000mah battery.

Microcontroller selection:

In order to gather information from the sensors, interpret the data and send the appropriate control signals to the actuators a microcontroller is needed. Searching for the right controller to be interfaced with other components, we came across STM32 32-bit microcontroller running at 72 MHz. It is based on 32 bit with 16M flash memory.

Receiver :

For radio controlled (RC) systems we need a transmitter and receiver. One or more output devices such as an ESC/motor combo or servos. These are plugged into the receiver and are usually used to spin wheels or move control surfaces such as a steering mechanism. We will be using 2.4GHz FHSS 6 channel transmitter and receiver.

Arduino board: We have used an arduino board to implement different advanced functions which our quadcopter can perform.

V. RESULT & CONCLUSION

The core intention of our project is to develop a drone which can be of great use to the government. We aim at making a design of a quadcopter which can be used in the market for both government and private use. We know that most of the drones we use are developed, designed and manufactured in other countries and are imported in our country. We want to empower our country by designing and manufacturing our own drones which can do a lot of more stuffs other than just flight and recording through camera. With the aid of our faculty advisor we have the resources and technical knowledge to successfully complete this project. We chose the quadcopter for our UAV design since it has interesting design elements and potential for marketable gains.

At this point, we have added this 3 features(gas leakage sensor, signal jammer, and the water sample collector) but the project could go in a variety of directions since the platform seems to be so light and flexible. This flexibility allows changing the functions it performs and also allows integration of any technology that would prove to be useful. This project will clearly demonstrated the goals of proving that small scale UAVs are useful across a broad range of applications.

Application of a our quadcopter other than these three features (gas leakage sensor, signal jammer, and the water sample collector) are listed below:

- Safety inspection tool in construction industry
- Traffic monitoring
- Locating forest fires or frost conditions in farmlands
- Visual tracking and control using camera system
- Object identification and avoiding using fuzzy control
- Temperature and altitude estimation
- Weather forecasting
- Scenic photography
- Post natural disasters
- Agriculture surveying
- Crowd management
- Perimeter surveillance
- Search and rescue operations

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