Project report submitted in partial fulfillment for the Degree of B. Tech in Applied Electronics & Instrumentation Engineering under Maulana Abul Kalam Azad University of Technology

AERIAL MONITORING SYSTEM

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CERTIFICATE OF APPROVAL

The project report titled "**AERIAL MONITORING SYSTEM**" prepared by **Tapadyuti Baral**, Roll No: 11705515051, **Debanjan Mandal**, Roll No: 11705515013, **Chirodeep Sinha**, Roll No: 11705515011, and **Avish Karmkar**, Roll No: 11705515008; is hereby approved and certified as a creditable study in technological subjects performed in a way sufficient for its acceptance for partial fulfilment of the degree for which it is submitted.

It is to be understood that by this approval, the undersigned do not, necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the project only for the purpose for which it is submitted.

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RECOMMENDATION

I hereby recommend that the project report titled "**Aerial Monitoring System**" prepared by **Tapadyuti Baral**, Roll No:11705515051, **Debanjan Mandal**, Roll No:11705515013, **Chirodeep Sinha**, Roll No:11705515011,and **Avish Karmkar**, Roll No:11705515008; be accepted in partial fulfillment of the requirement for the Degree of Bachelor of Technology in Applied Electronics & Instrumentation Engineering, RCC Institute of Information Technology.

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ABSTRACT

Technological advancements in fields of rescue operations as well as in remote package delivering systems have led us to the development of a quad copter. The quad copter's flight controller is an Arduino based microcontroller whose flight movements can be controlled using a transmitter-receiver setup. The quad copter is designed mainly for the purpose of search & rescue operations.

Here an accelerometer and a gyroscope is attached to indicates the direction and angular position of the quad copter. These readings are sent from the quad copter to a base station using a server-client concept. A Wi-Fi module, namely ESP8266 has been used for this purpose. Also we use ultrasonoic sensors for collision detection.

A GPS module also being attached which would give the exact location of the place to where the quad copter is travelling. Also, a camera would be installed.

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LIST OF ABBREVIATIONS

UAV	Unmanned Aerial Vehicle
LiPo	Lithium Polymer
Tx	Transmitter
Rx	Receiver
CG	Centre of Gravity
ESC	Electronic Speed Control
RC	Remote Controlled
CW	Clockwise
CCW	Counter Clockwise
PI	Proportional Integral

CHAPTER 1

INTRODUCTION

In this modern age of technology, quad copter has become one of the most popular inventions in the field of science. A quad copter, also known as Unmanned Aerial Vehicle where four propellers are used for lifting and stabilization. The rotors are directed upwards and they are placed in a square formation with equal distance from the center of mass of the quadcopter. The quadcopter is controlled by adjusting the angular velocities of the rotors which are rotated by electricmotors.A quadcopter, alsocalleda quadrotor

helicopter or quadrotor,isa multirotor helicopter that is lifted and propelled by four rotors. Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers).

Quadcopters generally use two pairs of identical fixed pitched propellers; two clockwise (CW) and two counterclockwise (CCW). These use independent variation of the speed of each rotor to achieve control. By changing the speed of each rotor it is possible to specifically generate a desired total thrust; to locate for the centre of thrust both laterally and longitudinally; and to create a desired total torque, or turning force. Quadcopters differ from conventional helicopters, which use rotors that are able to vary the pitch of their blades dynamically as they move around the rotor hub. In the early days of flight, quadcopters (then referred to either as 'quadrotors' or simply as 'helicopters') were seen as possible solutions to some of the persistent problems in vertical flight. Torque-induced control issues (as well as efficiency issues originating from the tail rotor, which generates no useful lift) can be eliminated by counter-rotation, and the relatively short blades are much easier to construct. A number of manned designs appeared in the 1920s and 1930s. These vehicles were among the first successful heavier-than-air vertical takeoff and landing (VTOL)vehicles. However, early prototypes suffered from poor performance, and latter prototypes required too much pilot work load, due to poor stability augmentation and limited control authority.

CHAPTER 2

FLIGHT DYNAMICS AND DEVELOPMENTS

A quadcopter is operated by varying RPM of its four rotors for control the lifting and torque. The thrust is determined by using altitude, pitch, and roll angles which can be obtained from the ratio of the angles. The thrust plays a key role in maneuvering. To conduct such maneuvers precise angle handling is required. It serves as a solution to handle angular precision which illustrates how the spin of four rotors is varied to achieve angular orientation along with takeoff, landing and varying an altitude. [1]

•**YAW** (turning left and right) A yaw rotation is a movement around the yaw axis of a rigid body that changes the direction it is pointing, to the left or right of its direction of motion.

•**ROLL** (tilting left and right) is controlled by increasing speed on one motor and lowering the opposite one.

•**PITCH**(moving up and down, similar to nodding) is controlled the same way as roll but using the second set of motors. This may be confusing but roll and pitch are determined from where the "front" of the drone is. To roll or pitch, one rotor's thrust is decreased and the opposite rotor's thrust is increased by the same amount

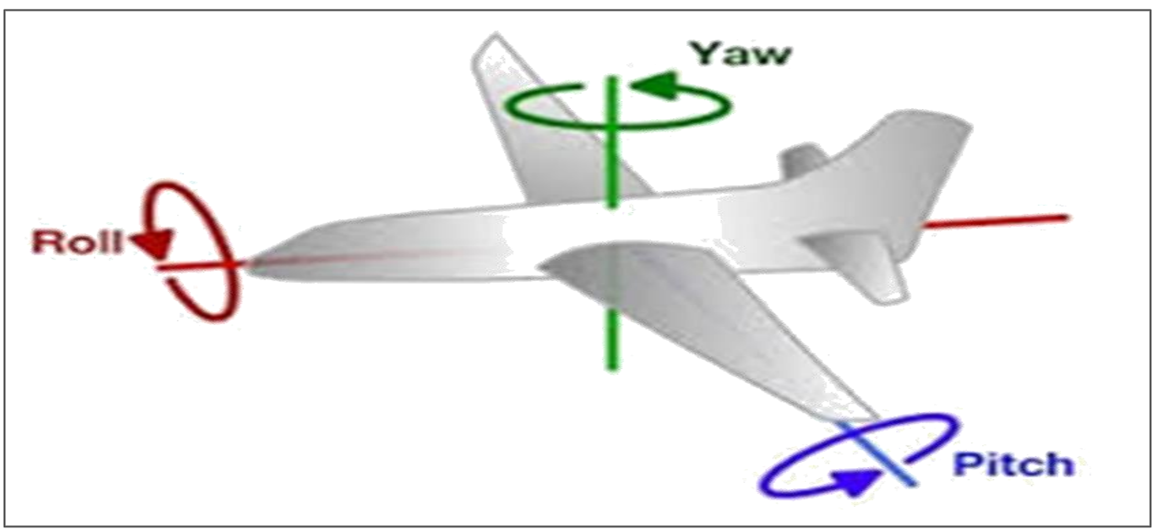


Figure 1.1: Roll, pitch, Yaw of a quadcopter

2.1 **Working Principle**

The Quadcopter or 4 Armed Drone works on the same principle of Aviation as a Helicopter does. It has 4 equally spaced motors arranged and placed at four corners of the structure forming a (X) like shape. Multirotor like Quadcopters are unstable without Electronic Assistance. Therefore to Balance it in the midair, a Microcontroller board or a Flight Control Unit (FCU) is required. It Takes the inputs from the Receiver Elevator, Rudder, Aileron and Throttle and Instructs the Electronic Speed Control Units to drive the motors accordingly. (2)

In this case we are using a Flight Control Unit called KK 2.1.5. This Flight Control Unit is powered by the Atmega 644PA 8-bit AVR RISC-based microcontroller with 64k of memory. The Flight Controller have Gyroscope and Accelerometer to compute the details at very high speed and perform with ease.

The ESCs have 3 output pins which connects the Brushless Motors. The Reversal of these pins are responsible for the Direction or change of direction of the motor's rotation.

The Battery Eliminator Circuit (BEC) is present inside the ESC and it is used to power other electronics present on board, such as The Flight Control Unit, receiver, camera etc.

The 5V output returning from BEC is fed to the FCU along the Signal Pins, for each motors and ESCs. This Powers the FCU and connects the signal pins on board.

The motors are out runner Brushless DC motors with 3 phase configuration which is rated 1000KVA. The motors are connected to their individual ESCs respectively.

Quadcopters can be programmed and controlled in totally different ways. However the most common ones are in either rate (acrobatic) or stable mode. In rate mode, only the gyroscope is used to control the quadcopter balanced, it does not self-level.

If switched to stable mode, the accelerometer gets activated, helping to stabilize the quadcopter. The speed of the 4 motors can be adjusted automatically and perpetually to keep the quadcopter balanced.

The radio Transmitter and Receiver is used to control the quadcopter. In order for a quadcopter to work, four channels (throttle, elevator, aileron rudder) are required. Getting a transmitter with 6 or 8 channels is recommended for additional functionalities.(3)

The Remote Control of transmitter has the Controls for Elevator / Rudder on the Left Side and Aileron / Throttle on the Right Side. (4)

Lithium Polymer (LiPo) batteries are the most famous power source for controlling quadcopters. LiPo batteries can have discharge rates sufficiently expansive to control even probably the most taxing multirotor. This settles on them the favored decision over different choices, for example, the Nickel Cadmium (NiCd) battery. This is likewise the essential reason they can be a genuine fuel source for multirotor.

To make anything fly, we have to balance its weight by generating an equivalent force (Lift) and balance moments about its Centre of Gravity (CG) by generating opposite moments. (5)

A quad-copter generates these required moments and lift force using its four rotors. To fly stable in a particular orientation, net moment about the cg should always be zero or resultant of all the forces acting on the system should pass through its CG. **If the resultant of the lift generated by all the rotors doesn't pass through CG, it creates a moment about the cg and tend to tilt the quad-copter until lift again passes through the CG.**

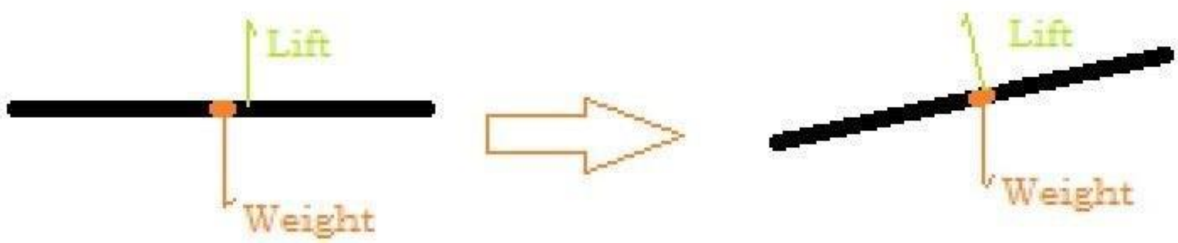


Fig. 1.2 Lift & Weight

Also to balance the angular momentum about the CG, two rotors are made to rotate clockwise and other two anti-clockwise.

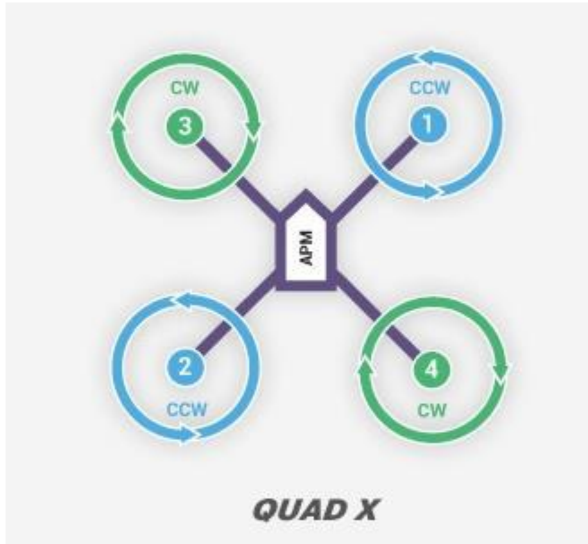


Fig. 1.3 Rotating Directions of the Propellers

In order for the quadcopter to hover in place, all the motors rotate at the same speed (or RPM). The rotation speed must be sufficient enough for the quadcopter to generate a ‘lift’, counteracting its own weight, but not so much that the quadcopterkeeps climbing in altitude. The torque effect acting on the body of the quadcopter by each of the motors should be cancelled out. Otherwise, expect the quadcopter to tend to want to yaw in a certain direction.

In order for the quadcopter to gain altitude, all four of the motors must increase the speed of rotation simultaneously. Conversely, to descend down, all four of the motors must decrease speed of its rotation simultaneously**. (6)**

The ‘pitch’ control tells the quadcopter whether to fly forward or backward. In order to pitch forward for example, the speed of the motors at the rear of the quadcopter must increase, relative to the speed of the motors on the front. This ‘pitches’ the nose (front) of the quadcopter down, resulting in the forward movement. This is achieved by either increasing the speed of the rear motors or decreasing the speed of the front motors. Conversely, in order to ‘pitch’ backwards, the speed of the motors at the front of the quadcopter must increase relative to the speed of the motors at the back.

The ‘roll’ control tells the quadcopter to move side to side. In order to ‘roll’ to the right for example, the speed of the motor at the left of the quadcopters must increase, relative to the speed of the motors on the right. This 'rolls down' the right side of the quadcopter, resulting in a sideways swaying movement.

This is achieved by either increasing the speed of the left motors or decreasing the speed of the right motors. Conversely, in order to 'roll' left, the speed of the motors of the right of the quadcopter should increase relative to the speed of the motors at the left.

The 'yaw' or 'rudder' is a rotation movement of the quadcopter. In this case, the rotation speed of diametrically opposing pairs of motors are increased or decreased, varying the torque in the direction of rotation of that pair causing the quadcopter to rotate in the direction of the increased torque.

All these factors are together responsible for the flight of the Quadcopter.

2.2STATIC THRUST CALCULATION

Calculations of static thrust are needed in order to ensure that the proper propellers and motors have been selected. Static thrust is defined as the amount of thrust produced by a propeller which is located stationary to the earth. This calculation is particularly important for this project because quadrotor helicopters are more likely to perform at low speeds relative to the earth(7).

This low-speed performance ensures that the calculations of static thrust can be applied to a wide range of flight conditions. Also, it is important to note that the final calculations of static thrust are estimates and not actual values.

The first step in calculating static thrust is determining the power transmitted by the motors to the propellers in terms of rpm. Aircraft-world.com has compiled empirical data used to calculate power , and the formula used for their datasheet is given in Equation 1.

$$Power = Prop\ Const * rpm^{Power\ factor} \qquad (1)$$

Where power is in watts and rpm is in thousands. For example, a 6X4 APC propeller has a propeller constant of 0.015 and a power factor of 3.2. Given a rotational speed of 10,000 rpm, the calculation goes as follows: $Power=0.015X10^{3.2}=24\ W$.

The next step is to determine the thrust produced by a propeller. Equation 2 gives thrust based on the Momentum Theory.

$$T = \frac{\pi}{4} D^2 \rho v \Delta v \qquad (2)$$

T=thrust [N]
D=propeller diameter [m]
v=velocity of air at the propeller [m/s]
Δv=velocity of air accelerated by propeller [m/s]
ρ = density of air [1.225 kg/m³]

A commonly used rule is that velocity of the air at the propeller is v=½Δv of the total change in air velocity: Therefore, and equation 3 is derived.

$$T = \frac{\pi}{8} D^2 \rho (\Delta v)^2 \qquad (3)$$

Equation 4 gives the power that is absorbed by the propeller from the motor. Equation 5 shows the result of solving equation 4 for Δv and substituting it into equation 3. In doing so, Δv is eliminated and torque can be calculated.

$$P = \frac{T \Delta v}{2} \Rightarrow \Delta v = \frac{2P}{T} \qquad (4) \qquad T = \left[\frac{\pi}{2} D^2 \rho P^2\right]^{1/3} \qquad (5)$$

Finally, it is advantageous to express the results of equation 5 in terms of mass. Newton's Law, F=ma, is used to obtain equation 6.

$$m = \frac{\left[\frac{\pi}{2} D^2 \rho P^2\right]^{1/3}}{g} \qquad (6)$$

Where g=9.81m/s^2.

Solving for mass is useful for quadrotor helicopters because it can be directly related to the mass of the aircraft. In particular, a thrust (mass) that equals the mass of the aircraft is needed for hovering. The importance of hovering will be addressed in the following section (DC Motors).

2. DEVELOPMENTS

2.3EARLYDEVELOPMENTS

The earliest invention of the quadcopter dates back to 1907 when Louis Breguet invented and flew the first quad rotor helicopter. The drones were then used mainly by the US army for military purposes. The literal introduction of quadcopter was in the late 2000s where advances in electronics allowed the production of cheap lightweight flight controllers which had the capability of flying an Unmanned Aerial Vehicle. Furthermore, a number of sensors were incorporated into the flight controller in order to increase the stability of thequadcopter. These sensors were accelerometers, gyroscope and magnetometer.This resulted in the quadcopterbecoming popular for small unmanned aerialvehicles. With their small size and maneuverability, these quad copters can be flown indoors as well as outdoors. But these quadcopters at the initial stages lacked in basic stability and controllability. Thus, new designs were incorporated in the quadcopters using more stable sensors. These sensors increased the stability of the quadcopter and also allowed it to hover at a predefined altitude. At this stage, the microcontrollers used were complex in nature and flight control was difficult as well due to errors from the controller output.

2.4SUBSEQUENT DEVELOPMENTS

The introduction of the advanced and stable sensors helped in increasing the stability of the drone. The control can be achieved by the PID controller. This led to the increase the demand of the drones in the field of agriculture. But still the drones were not upgraded enough to perform some specific tasks. There are several scopes for further development in drone technology. Thus, scientists introduced few other sensors like tilt sensors, infrared sensors etc. to make the drones more efficient in their tasks. The tilt sensor monitors the pitch, and the infrared sensor separates the subject of interest from other objects by the different radiation emitted from the system. (8)

The drones at this stage are still less efficient because it had no sensors to monitor and locate the present location of it. Later by the addition of GPS (Global Positioning System) module, helped to locate the exact location of the system. At present, the quadcopter is being controlled by a radio frequency transmitter. To make the flight more stable, the sensors were made more efficient. But the advanced sensors were not compatible with the old microcontrollers used. Thus, new microcontrollers are being introduced which provides the required output to the sensors and stabilize the flight control. The most popular microcontrollers used till date are the FY80, GY80, ARDUINO, X-BEE, because they are easy to program. (9)

2.5RECENT DEVELOPMENTS

Great advancements in the field of quadcopters has been achieved over the last decade as the quadcopters have evolved in designs as well as in flightcontrollability. This is due to the fact that better microcontrollers are being used along with better sensors attached. Introduction of BMP085 (pressure+altitude) sensor along with the gyroscope helped the drone in altitude hold control pre-determined by the microcontroller. At this stage, the GUI at the remote station was improved to give the user a nice flight experience. The drones proved useful in the Military in remote package delivering missions.

With the passage of time, ARDUINO became a popular microcontroller in making the drones because of its flexibility in the programming. Besides that, additional sensors like a camera; an ultrasonic sensor was attached to the drones. This helped the drones in calculating distance from the ground which previously the drones were unable to do (10). This revolutionary addition increased its popularity several times. The drones could now be used in way point navigation systems. The coordinates of the waypoints for predetermined flight is fed to the microcontroller. The algorithm calculates the distance between the current positions obtained from GPS to the first waypoint and the heading angle of the current position with respect to geographical north. Similarly succeeding waypoints are calculated. From these calculated values, the pulse width modulated signal is generated by controller which controls the quadrotor altitude. It is useful in applications such as autonomous security surveillance, fire suppression system, and a terrain mapping vehicle.

2.6LATEST DEVELOPMENTS

In latest there are huge developments. Previously, the drones follow pre-determined paths which cause collision. But now a day the drone can able to avoid obstacle collisions during travelling on determined path, here it uses a number of ultrasonic sensors to detect and avoid them. The signals of the sensors are controlled by an Arduino based microcontroller. But the quadcopter could not provide the exact location to where it is present. This can be eliminated in the future by using a gps module. This development created the system for applying in the application of package delivering, traffic control unit, etc. Latest developments have been made where the quadcopters are being controlled by voice commands and by simple hand gesture. These developments are still in the development stages but soon will become a reality.

COMPONENTS DIAGRAM

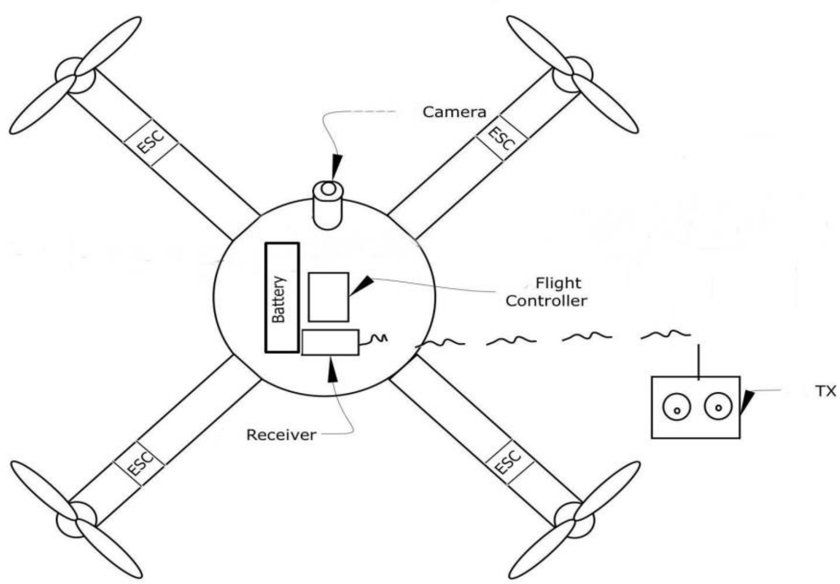


Fig. 1.4components placement

CHAPTER 3

OVERVIEW OF THE PROJECT

3.1 BLOCK DIAGRAM

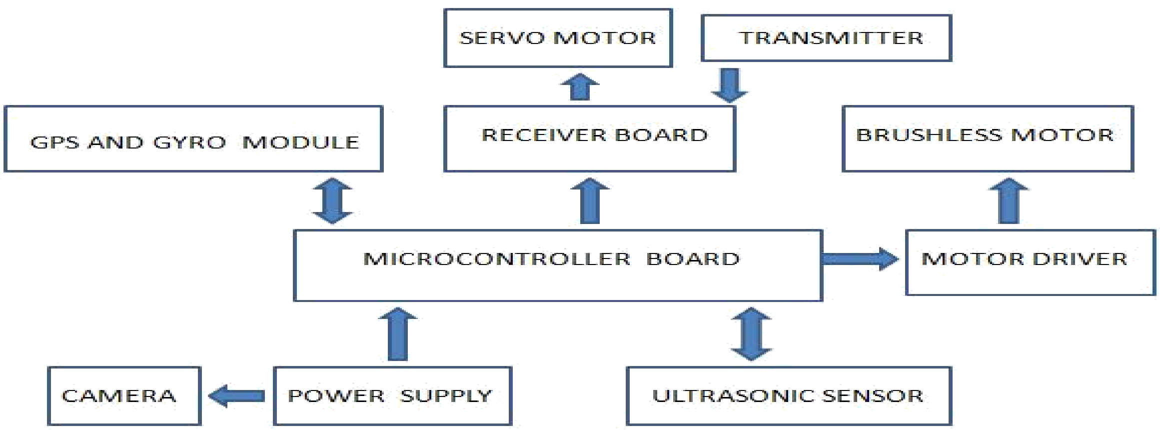


Figure 2.1 Block diagram of quadcopter

3.2 SCHEMATIC DIAGRAM

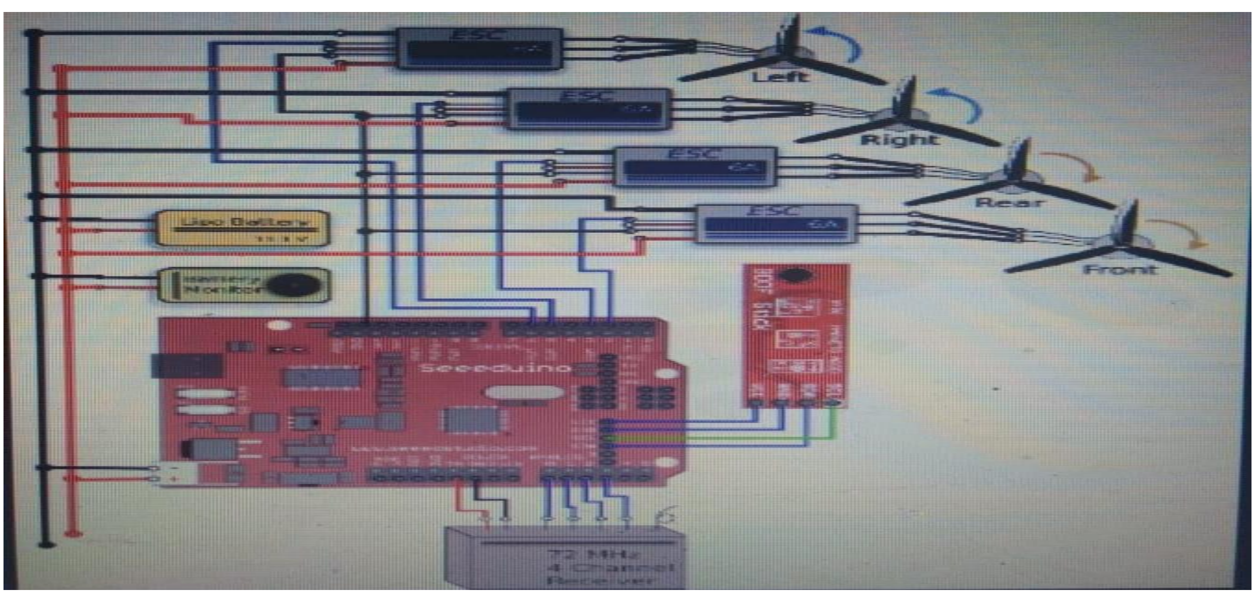


Figure 2.2 Schematic diagram of quadcopter

3.3.1 HARDWARE REQUIREMENTS

- ARDUINO UNO Board microcontroller
- KK 2.1.5 Flight controller board
- MPU-6050 (3-axis Accelerometer & Gyroscope)
- 4 no's of BLDC motors(1000kv) and ESC'S
- GPS module
- Node MCU / ESP8266 (Wi-Fi module)
- Mobile Application
- Ultra sonic sensor
- HC05
- LiPo Cell (2200mAh, 12v)
- 6 channel Transmitter & Receiver 2.4Ghz
- Propeller
- Frame (quad arm)

3.3.2 SOFTWERE REQUIRMENT

- Multiwii
- Arduino IDE

3.3.3 THIRD PARTY MOBILE APPLICATION

- EZ-GUI

3.4 HARDWARE COMPONENTS DESCRIPTION& DATASHEET

ARDUINO MICROCONTROLLER

In our project, an Arduino UNO microcontroller is used to control the quadcopter flight dynamics.Arduino refers to an open-source electronics platform or board as a controlling unit. Arduino is designed to make electronics automonoussytem by some pre-defined algorithm.Designers, hobbyists and anyone interest increating interactive objects or environments. In our project, an Arduino mega microcontroller is used to control the quadcopter flight dynamics. [11]

The Arduino UNO 2560 is a microcontroller board based on the It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the ArduinoDuemilanove or Diecimila.

TECHNICAL SPECIFICATIONS

Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	Depends per load
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

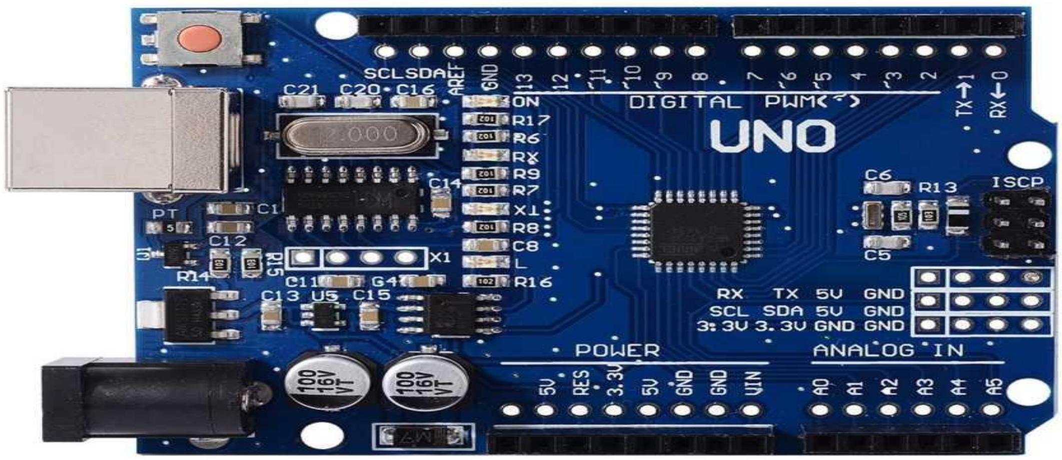


Figure 3.1:Arduino Uno microcontroller

MPU-6050 (3-AXIS ACCELEROMETER & GYROSCOPE)

The MPU6050 contains, a 3-Axis Gyroscope and a 3Axis accelerometer by measuring independently, but all are basedaround the same axes, this eliminates the problems of cross-axis errors when using separate devices.In our project, we have used the MPU-6050 to help in balancing the flight of the quadcopter and maintain its flight dynamics. (12)

TECHNICAL SPECIFICATION:

The MPU-60X0 is the world’s first integrated 6-axis Motion Tracking device that combines a 3-axis gyroscope, 3-axis accelerometer, and a Digital Motion Processor™ (DMP) all in a small 4x4x0.9mm package. With its dedicated I2C sensor bus, it directly accepts inputs from an external 3-axis compass to provide a complete 9-axis Motion Fusion™ output. The MPU-60X0 Motion Tracking device, with its 6-axis integration, on-board Motion Fusion™, and run-time calibration firmware, enables manufacturers to eliminate the costly and complex selection, qualification, and system level integration of discrete devices, guaranteeing optimal motion performance for consumers. The MPU-60X0 is also designed to interface with multiple non-inertial digital sensors, such as pressure sensors, on its auxiliary I2C port. The MPU-60X0 is footprint compatible with the MPU-30X0 family.

The MPU-60X0 features three 16-bit analog-to-digital converters (ADCs) for digitizing the gyroscope outputs and three 16-bit ADCs for digitizing the accelerometer outputs. For precision tracking of both fast and slow motions, the parts feature a user-programmable gyroscope full-scale range of ±250, ±500, ±1000, and ±2000°/sec (dps) and a user-programmable accelerometer full-scale range of ±2*g*, ±4*g*, ±8*g*, and ±16.

The MPU-6050 module has 8 pins:-

INT: Interrupt digital output pin.

AD0: I2C Slave Address LSB pin. This is 0th bit in 7-bit slave address of device. If connected to VCC then it is read as logic one and slave address changes.

XCL: Auxiliary Serial Clock pin. This pin is used to connect other I2C interface enabled sensors SCL pin to MPU-6050.

XDA: Auxiliary Serial Data pin. This pin is used to connect other I2C interface enabled sensors SDA pin to MPU-6050.

SCL: Serial Clock pin. Connect this pin to microcontrollers SCL pin.

SDA: Serial Data pin. Connect this pin to microcontrollers SDA pin.

GND: Ground pin. Connect this pin to ground connection.

VCC: Power supply pin. Connect this pin to +5V DC supply.

MPU-6050 module has Slave address (When AD0 = 0, i.e. it is not connected to Vcc) as,

Slave Write address(SLA+W): 0xD0 **Slave Read address(SLA+R)**: 0xD1

Figure 3.2: MPU-6050 (gyroscope &accelerometer)

BLDC motors

Brushless DC motors use electric switches to realize current commutation, and thus continuously rotate the motor. These electric switches are usually connected in an H-bridge structure for a single-phase BLDC motor, and a three-phase bridge structure for a three-phase BLDC motor shown in Figure. Usually the high-side switches are controlled using pulse-width modulation (PWM), which converts a DC voltage into a modulated voltage, which easily and efficiently limits the startup current, control speed and torque. Generally, raising the switching frequency increases PWM losses, though lowering the switching frequency limits the system's bandwidth and can raise the ripple current pulses to the points where they become destructive or shut down the BLDC motor driver. 3-phase motors are the most popular and widely used. (13)

BLDC motors have many advantages over brushed DC motors and induction motors. A few of these are:

• Better speed versus torque characteristics

• Faster dynamic response

• High efficiency

• Long operating life

• Noiseless operation

• Higher speed ranges

Features and Specifications:

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

Figure3.3:.BLDS motors

ESCS

Full-size electric vehicles also have systems to controlthe speed. An electronic speed control or ESC is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor and dynamic braking. Miniature electronic speed controls are used in electrically powered radio controlledmodels of their drive motors.

Specifications

• BEC: 5V, 3Amp for external receiver and servos

• Max Speed: 2 Pole: 210,000rpm; 6 Pole: 70,000rpm; 12 Pole: 35,000rpm

• Weight: 32gms

• Size: 55mm x 26mm x 13mm

Features:

• High quality MOSFETs for BLDC motor drive

• High performance microcontroller for best compatibility with all types of motors at greater efficiency

• Fully programmable with any standard RC remote control

• Heat sink with high performance heat transmission membrane for better thermal management

• 3 start modes: Normal / Soft / Super-Soft, compatible with fixed wing aircrafts and helicopters

• Throttle range can be configured to be compatible with any remote control available in the market 30A BLDC ESC

• Output: 30A continuous; 40Amps for 10 seconds

• Input voltage: 2-4 cells Lithium Polymer / Lithium Ion battery or 5-12 cells NiMH / 30A ESC

• Smooth, Linear and Precise throttle response

• Low-Voltage cut-off protection

• Over-heat protection

• Separate voltage regulator IC for the microcontroller to provide anti-jamming capability

• Supported Motor Speed (Maximum): 210000RPM (2 poles), 70000RPM (6poles), 35000RPM (12 poles)

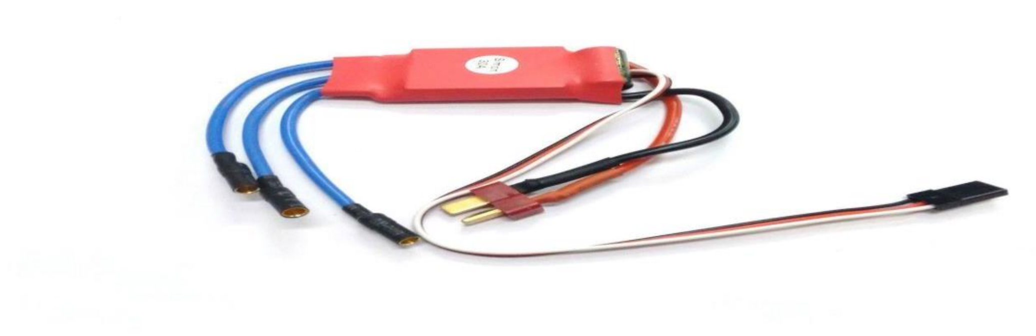


Figure 3.4: ESCs

Transmitter and Receiver

The transmitter enables the user to control the aircraft from a distance, using 2.4 gigahertz spread spectrum radio signals.

Receivers are electric devices with built in antennas that intercept the radio signals from the transmitters, and convert them into alternating current pulses. The receiver then produces information and sends it to the Flight Control Board.

The T6 channel receiver arrangement is:

CH 1 Aileron

CH 2 Elevator

CH 3 Throttle

CH 4 Rudder

CH 5 Aux

CH 6 Aux

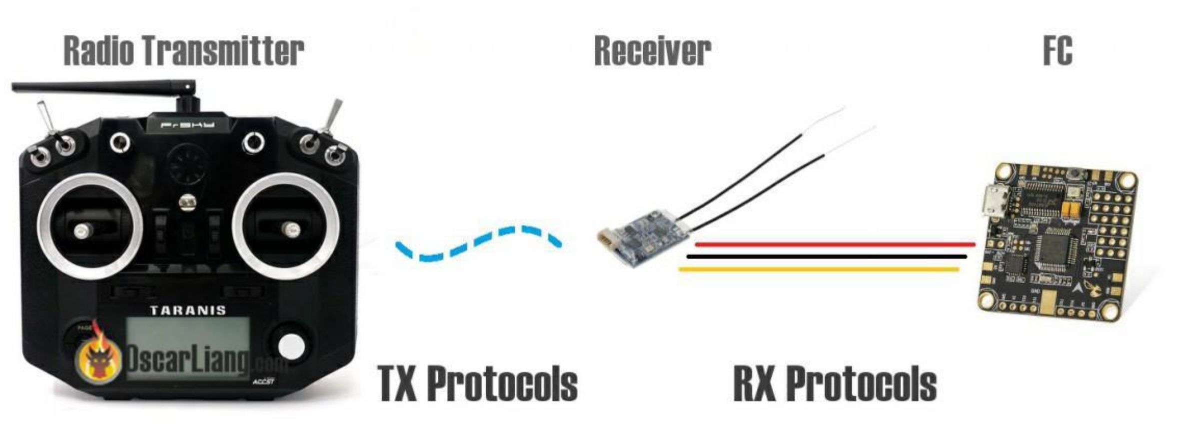


Fig. 3.5: A Tx& Rx Module

LiPo Cell

Lithium Polymer batteries (henceforth referred to as "LiPo" batteries), are a newer type of batteries used nowadays in many consumer electronic devices. They have been gaining in popularity in the radio control industry over the last few years, and are now the most popular choice for anyone looking for long run times and high power.

Just as with other lithium-ion cells, LiPo work on the principle of intercalation and de-intercalation of lithium ions from a positive electrode material and a negative electrode material, with the liquid electrolyte providing a conductive medium. To prevent the electrodes from touching each other directly, a microporous separator is in between which allows only the ions and not the electrode particles to migrate from one side to the other. (14)

Li Po batteries offer three main advantages over the common Nickel-Metal Hydride (NiMH) or Nickel Cadmium (NiCd) batteries:

1. LiPo batteries are much lighter weight, and can be made in almost any size or shape.
2. LiPo batteries offer much higher capacities, allowing them to hold much more power.
3. LiPo batteries offer much higher discharge rates, meaning they pack more punch.

Fig.3.6: A LiPo Battery

ULTRASONIC SENSOR

As the name indicates, ultrasonic sensors measures distance using ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic sensors measure the distance to the target by measuring the time between emission and reception (15). The process by which this sensor measures the distance are as follows:

$D = 0.5 * T * C$

Technical Specification:

Working voltage: DC 5v

Working current: 15mA

Working frequency: 40Hz

Maximum Range: 4m

Minimum Range: 2m

Measure angle 15 degree

Figure 3.7: ultrasonic sensor

ESP 8266

The ESP 8266 is low costWifi module. This small module allows to connect to a Wi-Fi network for any wireless connection. It is manufactured by Espessif system, a Chinese manufacturer.

In our project we have used this Wi-Fi module for wireless communication between the quadcopter and the ground station.

Espressif’s ESP8266EX delivers highly integrated Wi-Fi SoC solution to meet users’ continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry.

With the complete and self-contained Wi-Fi networking capabilities, ESP8266EX can perform either as a standalone application or as the slave to a host MCU. When

ESP8266EX hosts the application, it promptly boots up from the flash. The integrated highspeed cache helps to increase the system performance and optimize the system memory.

Wi-Fi Protocols (16)

• 802.11 b/g/n/e/i support.

• Wi-Fi Direct (P2P) support.

• P2P Discovery, P2P GO (Group Owner) mode, GC(Group Client) mode and P2P Power Management.

• Infrastructure BSS Station mode / P2P mode / SoftAP mode support.

• Hardware accelerators for CCMP (CBC-MAC, counter mode), TKIP (MIC, RC4), WAPI (SMS4), WEP (RC4), CRC.

• WPA/WPA2 PSK, and WPS driver.

• Additional 802.11i security features such as pre-authentication, and TSN.

• Open Interface for various upper layer authentication schemes over EAP such as TLS, PEAP, LEAP, SIM, AKA, or customer specific.

• 802.11n support (2.4 GHz).

• Supports MIMO 1×1 and 2×1, STBC, A-MPDU and A-MSDU frame aggregation and 0.4 μs guard interval

• WMM power low U-APSD.

• Multiple queue management to fully utilize traffic prioritization defined by 802.11e standard.

• UMA compliant and certified.

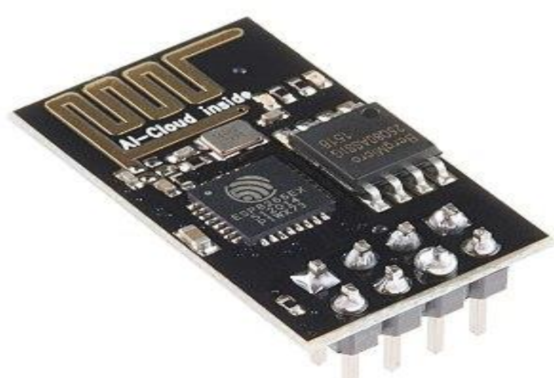


Figure 3.8: Esp8266 Wi-Fi module

HC- 05

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module,designed for transparent wireless serial connection setup.The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication.This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate)3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. The Bluetooth module HC-05 is a MASTER/SLAVE module.By default the factory setting is SLAVE.The Role of the module (Master or Slave) can be configured only by AT COMMANDS.The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections.Master module can initiate a connection to other devices.The user can use it simply for a serial port replacement to establish connection between MCU and GPS. (17)

Figure 3.9: HC- 05

KK 2.1.5 Flight controller board

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, whichin-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 signals instructs 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 your radio system via a receiver (Rx) and passes these signals together with stabilization 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 each motor to control flight orientation (up, down, backwards, forwards, left, right, yaw) (18)

TECHNICAL SPECIFICATION

- Size: 50.5mm x 50.5mm x 12mm
- Weight: 21 gram (Inc. Piezo buzzer)
- IC: Atmega644 PA
- Gyro/Acc: 6050MPU
- Auto-level: Yes
- Input Voltage: 4.8-6.0V
- AVR interface: standard 6 pin.
- Signal from Receiver: 1520us (5 channels)
- Signal to ESC: 1520us Firmware Version 1.6

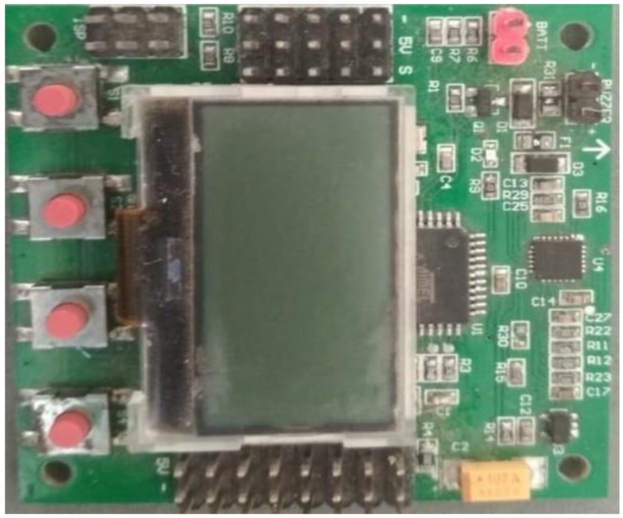


Figure 3.10: kk 2.1.5

3.5SOFTWAREREQUIREMENT DESCRIPTION

ARDRINO IDE

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiringproject, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that isloaded into the Arduino board by a loader program in the board's firmware.

Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

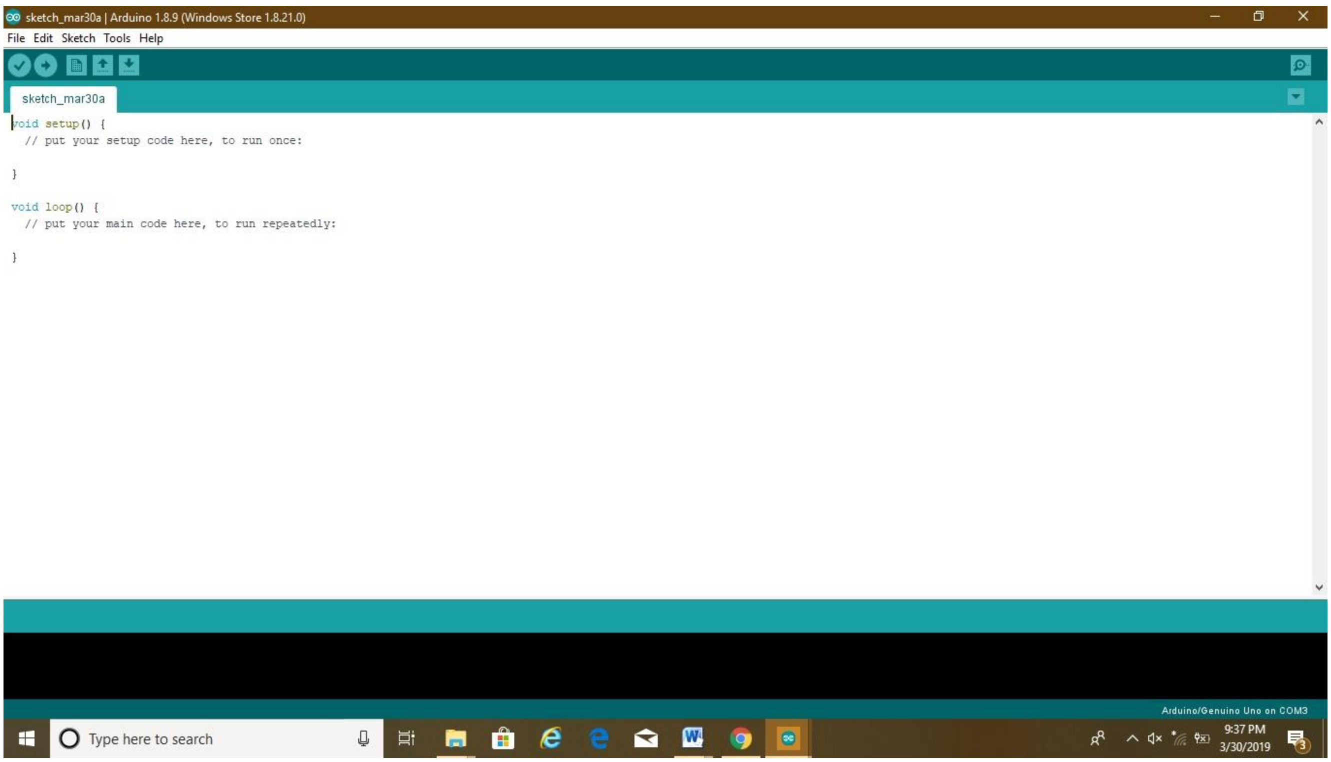
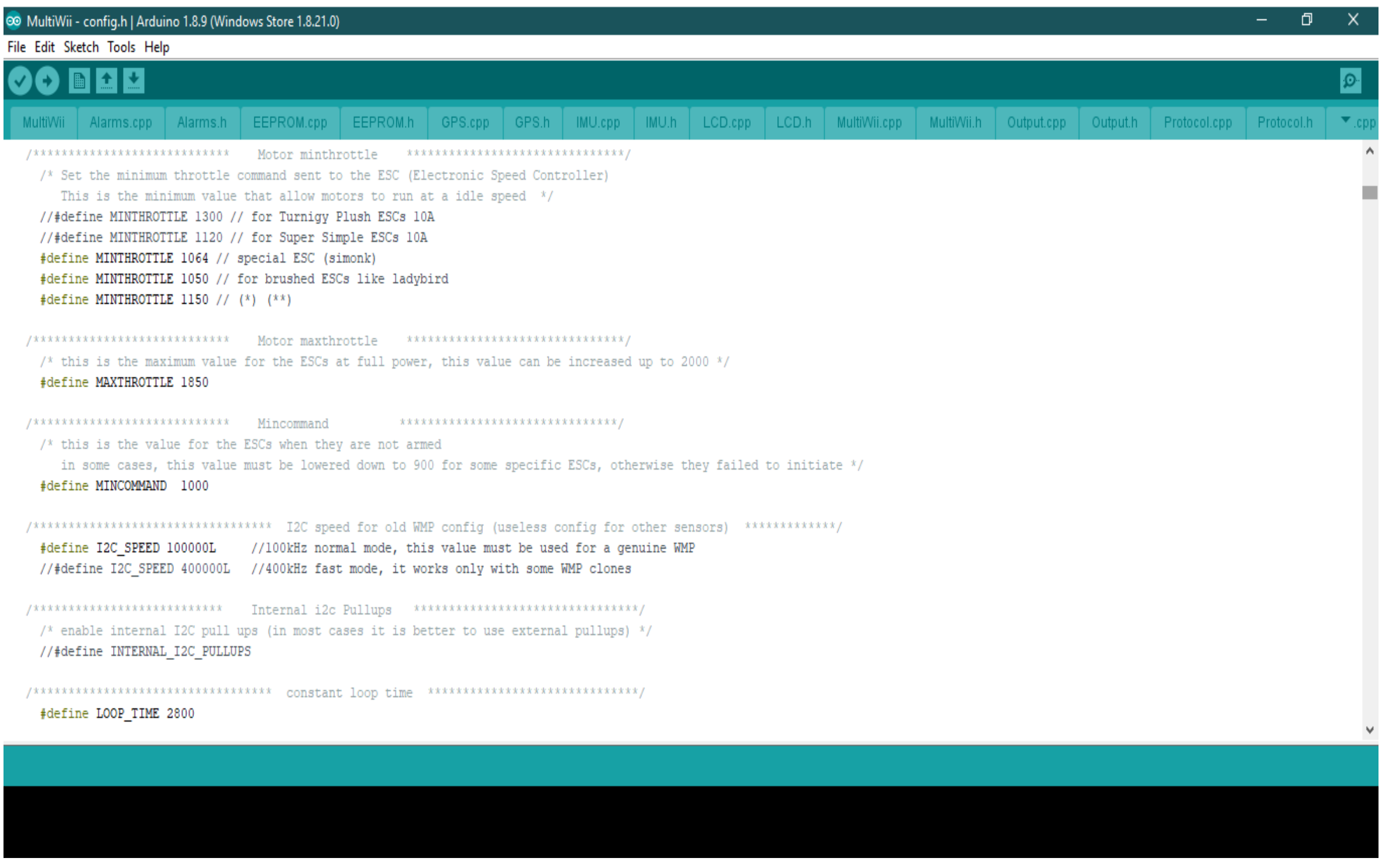
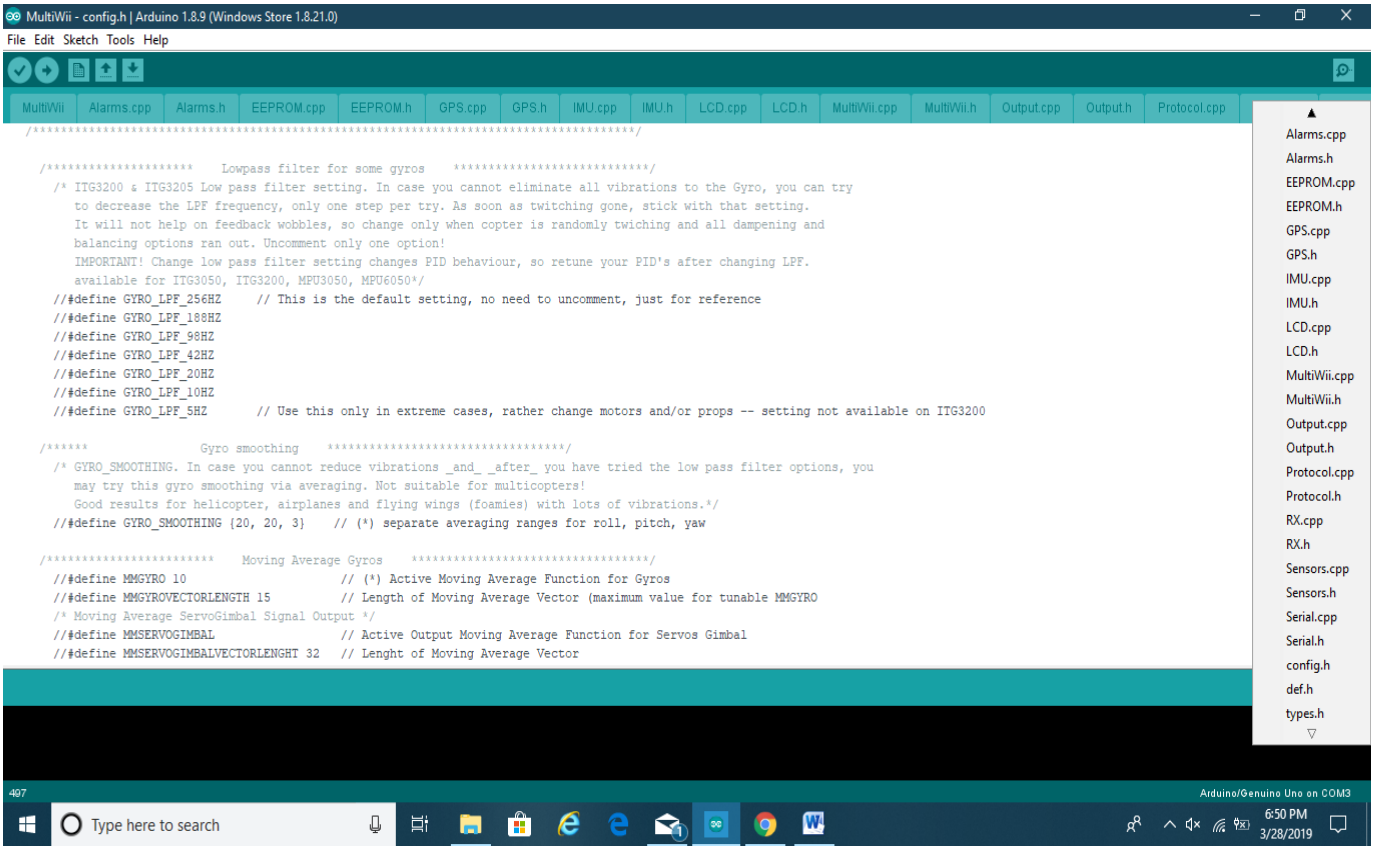


Figure 3.11: Auduino blank sketch

Multiwii

MultiWii is general purpose software to control a multirotor RC model. It can now use various sensors but was initially developed to support Nintendo Wii console gyroscopes and accelerometers. We can find these sensors in the extensions of the Nintendo Wii Mote: Wii Motion Plus and Wii Nunchuk..This project was an opportunity to develop my own software on an Arduino platform. The software is for the moment able to control a tricopter, a quadricopter.




MultiWii - config.h | Arduino 1.8.9 (Windows Store 1.8.21.0)
File Edit Sketch Tools Help
MultiWii Alarms.cpp Alarms.h EEPROM.cpp EEPROM.h GPS.cpp GPS.h IMU.cpp IMU.h LCD.cpp LCD.h MultiWii.cpp MultiWii.h Output.cpp Output.h Protocol.cpp
/******************** Lowpass filter for some gyros ****************************/
/* ITG3200 & ITG3205 Low pass filter setting. In case you cannot eliminate all vibrations to the Gyro, you can try
to decrease the LPF frequency, only one step per try. As soon as twitching gone, stick with that setting.
It will not help on feedback wobbles, so change only when copter is randomly twiching and all dampening and
balancing options ran out. Uncomment only one option!
IMPORTANT! Change low pass filter setting changes PID behaviour, so retune your PID's after changing LPF.
available for ITG3050, ITG3200, MPU3050, MPU6050*/
//#define GYRO_LPF_256HZ // This is the default setting, no need to uncomment, just for reference
//#define GYRO_LPF_188HZ
//#define GYRO_LPF_98HZ
//#define GYRO_LPF_42HZ
//#define GYRO_LPF_20HZ
//#define GYRO_LPF_10HZ
//#define GYRO_LPF_5HZ // Use this only in extreme cases, rather change motors and/or props -- setting not available on ITG3200
/****** Gyro smoothing **********************************/
/* GYRO_SMOOTHING. In case you cannot reduce vibrations _and_ _after_ you have tried the low pass filter options, you
may try this gyro smoothing via averaging. Not suitable for multicopters!
Good results for helicopter, airplanes and flying wings (foamies) with lots of vibrations.*/
//#define GYRO_SMOOTHING {20, 20, 3} // (*) separate averaging ranges for roll, pitch, yaw
/************************ Moving Average Gyros **********************************/
//#define MMGYRO 10 // (*) Active Moving Average Function for Gyros
//#define MMGYROVECTORLENGTH 15 // Length of Moving Average Vector (maximum value for tunable MMGYRO
/* Moving Average ServoGimbal Signal Output */
//#define MMSERVOGIMBAL // Active Output Moving Average Function for Servos Gimbal
//#define MMSERVOGIMBALVECTORLENGHT 32 // Lenght of Moving Average Vector
Alarms.cpp
Alarms.h
EEPROM.cpp
EEPROM.h
GPS.cpp
GPS.h
IMU.cpp
IMU.h
LCD.cpp
LCD.h
MultiWii.cpp
MultiWii.h
Output.cpp
Output.h
Protocol.cpp
Protocol.h
RX.cpp
RX.h
Sensors.cpp
Sensors.h
Serial.cpp
Serial.h
config.h
def.h
types.h
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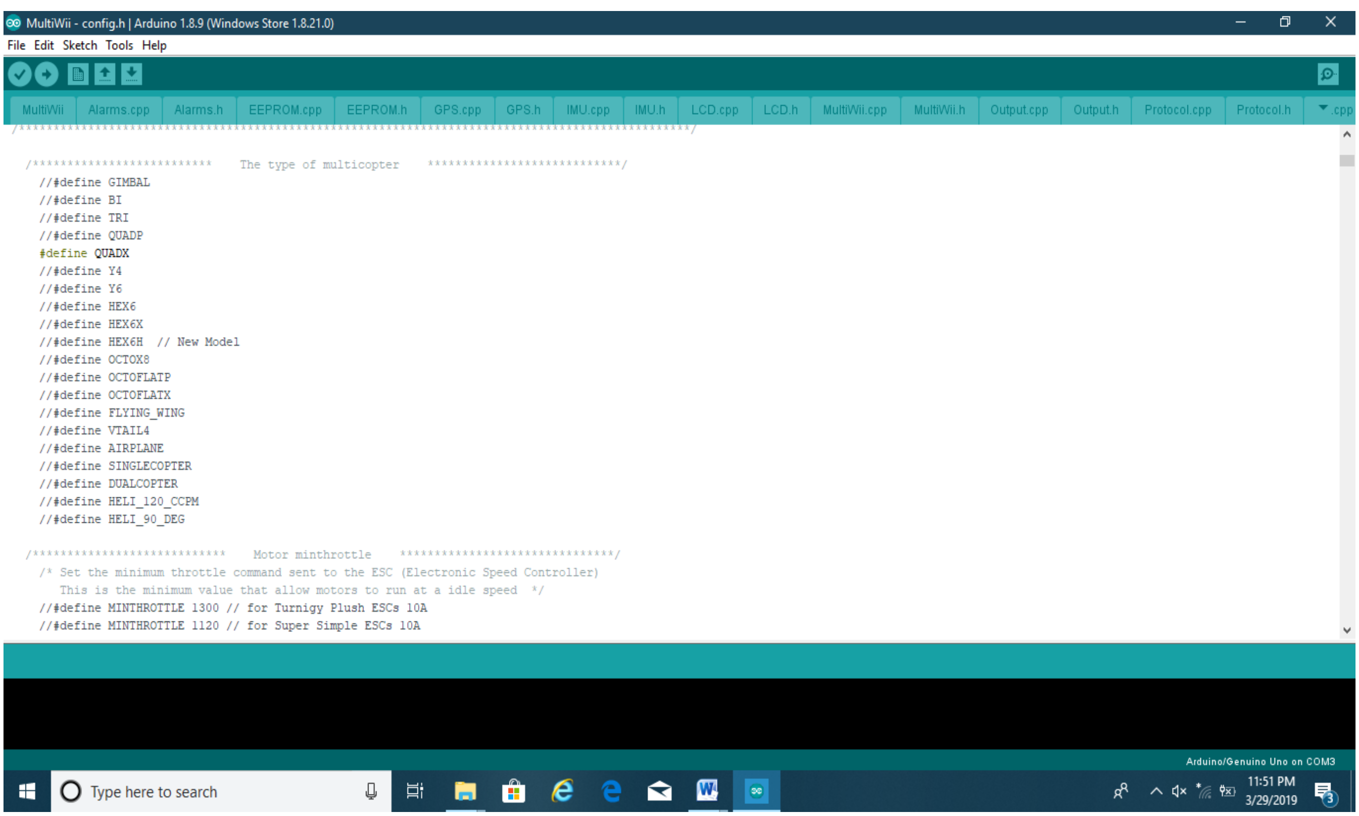
MultiWii - config.h | Arduino 1.8.9 (Windows Store 1.8.21.0)
File Edit Sketch Tools Help
MultiWii Alarms.cpp Alarms.h EEPROM.cpp EEPROM.h GPS.cpp GPS.h IMU.cpp IMU.h LCD.cpp LCD.h MultiWii.cpp MultiWii.h Output.cpp Output.h Protocol.cpp Protocol.h
/************************ The type of multicopter ****************************/
//#define GIMBAL
//#define BI
//#define TRI
//#define QUADP
#define QUADX
//#define Y4
//#define Y6
//#define HEX6
//#define HEX6X
//#define HEX6H // New Model
//#define OCTOX8
//#define OCTOFLATP
//#define OCTOFLATX
//#define FLYING_WING
//#define VTAIL4
//#define AIRPLANE
//#define SINGLECOPTER
//#define DUALCOPTER
//#define HELI_120_CCPM
//#define HELI_90_DEG
/**************************** Motor minthrottle *******************************/
/* Set the minimum throttle command sent to the ESC (Electronic Speed Controller)
This is the minimum value that allow motors to run at a idle speed */
//#define MINTHROTTLE 1300 // for Turnigy Plush ESCs 10A
//#define MINTHROTTLE 1120 // for Super Simple ESCs 10A
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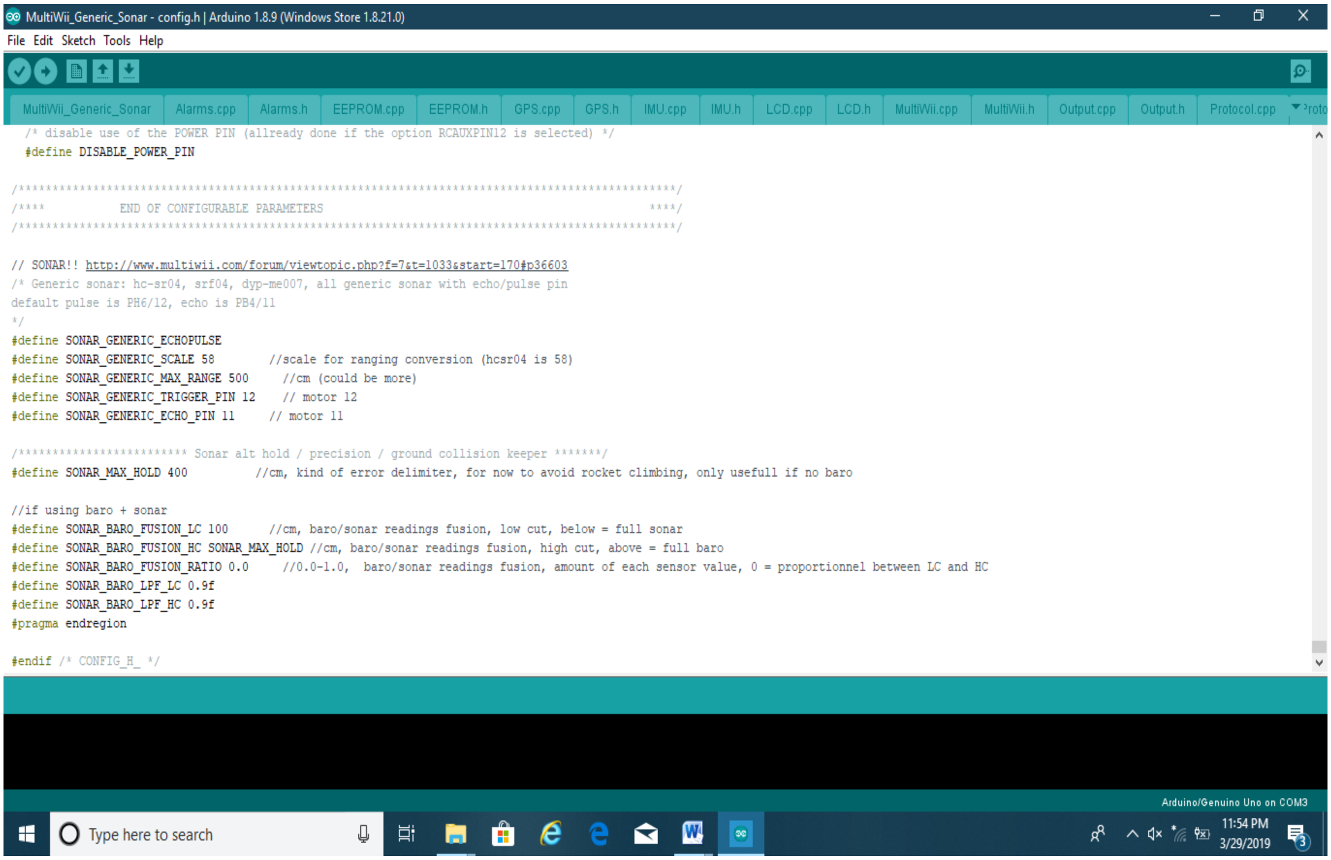
MultiWii_Generic_Sonar - config.h | Arduino 1.8.9 (Windows Store 1.8.21.0)
File Edit Sketch Tools Help
MultiWii_Generic_Sonar Alarms.cpp Alarms.h EEPROM.cpp EEPROM.h GPS.cpp GPS.h IMU.cpp IMU.h LCD.cpp LCD.h MultiWii.cpp MultiWii.h Output.cpp Output.h Protocol.cpp
/* disable use of the POWER PIN (allready done if the option RCAUXPIN12 is selected) */
#define DISABLE_POWER_PIN
/**** END OF CONFIGURABLE PARAMETERS ****/
// SONAR!! http://www.multiwii.com/forum/viewtopic.php?f=7&t=1033&start=170#p36603
/* Generic sonar: hc-sr04, srf04, dyp-me007, all generic sonar with echo/pulse pin
default pulse is PH6/12, echo is PB4/11
*/
#define SONAR_GENERIC_ECHOPULSE
#define SONAR_GENERIC_SCALE 58 //scale for ranging conversion (hcsr04 is 58)
#define SONAR_GENERIC_MAX_RANGE 500 //cm (could be more)
#define SONAR_GENERIC_TRIGGER_PIN 12 // motor 12
#define SONAR_GENERIC_ECHO_PIN 11 // motor 11
/************************ Sonar alt hold / precision / ground collision keeper *******/
#define SONAR_MAX_HOLD 400 //cm, kind of error delimiter, for now to avoid rocket climbing, only usefull if no baro
//if using baro + sonar
#define SONAR_BARO_FUSION_LC 100 //cm, baro/sonar readings fusion, low cut, below = full sonar
#define SONAR_BARO_FUSION_HC SONAR_MAX_HOLD //cm, baro/sonar readings fusion, high cut, above = full baro
#define SONAR_BARO_FUSION_RATIO 0.0 //0.0-1.0, baro/sonar readings fusion, amount of each sensor value, 0 = proportionnel between LC and HC
#define SONAR_BARO_LPF_LC 0.9f
#define SONAR_BARO_LPF_HC 0.9f
#pragma endregion
#endif /* CONFIG_H_ */
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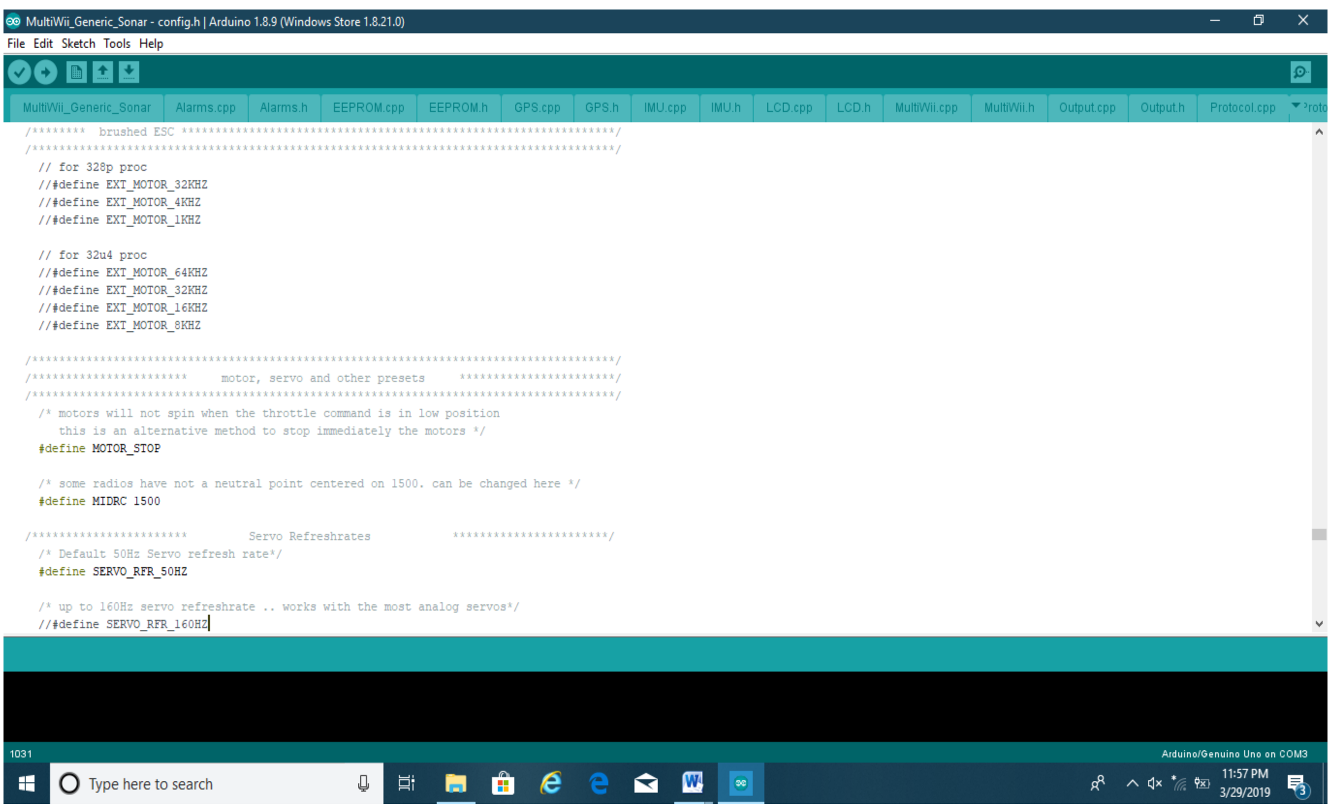
MultiWii_Generic_Sonar - config.h | Arduino 1.8.9 (Windows Store 1.8.21.0)
File Edit Sketch Tools Help
MultiWii_Generic_Sonar Alarms.cpp Alarms.h EEPROM.cpp EEPROM.h GPS.cpp GPS.h IMU.cpp IMU.h LCD.cpp LCD.h MultiWii.cpp MultiWii.h Output.cpp Output.h Protocol.cpp
/******** brushed ESC ****/
// for 328p proc
//#define EXT_MOTOR_32KHZ
//#define EXT_MOTOR_4KHZ
//#define EXT_MOTOR_1KHZ
// for 32u4 proc
//#define EXT_MOTOR_64KHZ
//#define EXT_MOTOR_32KHZ
//#define EXT_MOTOR_16KHZ
//#define EXT_MOTOR_8KHZ
/*********************** motor, servo and other presets ***********************/
/* motors will not spin when the throttle command is in low position
this is an alternative method to stop immediately the motors */
#define MOTOR_STOP
/* some radios have not a neutral point centered on 1500. can be changed here */
#define MIDRC 1500
/*********************** Servo Refreshrates ***********************/
/* Default 50Hz Servo refresh rate*/
#define SERVO_RFR_50HZ
/* up to 160Hz servo refreshrate .. works with the most analog servos*/
//#define SERVO_RFR_160HZ
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3.6EZ-GUI

EZ-GUI is an Android based Ground Control Station (GCS) for UAVs based on MultiWii and Cleanflight.

It displays all available data from a flight controller in a convenient way.

It allows you to easily configure and tune your model from Android device, so you don't have to take your laptop to the flying field.

It supports direct USB connection (Android >3.1) as well as Bluetooth, WiFi and 3DR Radio.

Works with:

CleanFlight

Betaflight

iNav

Multiwii 2.4

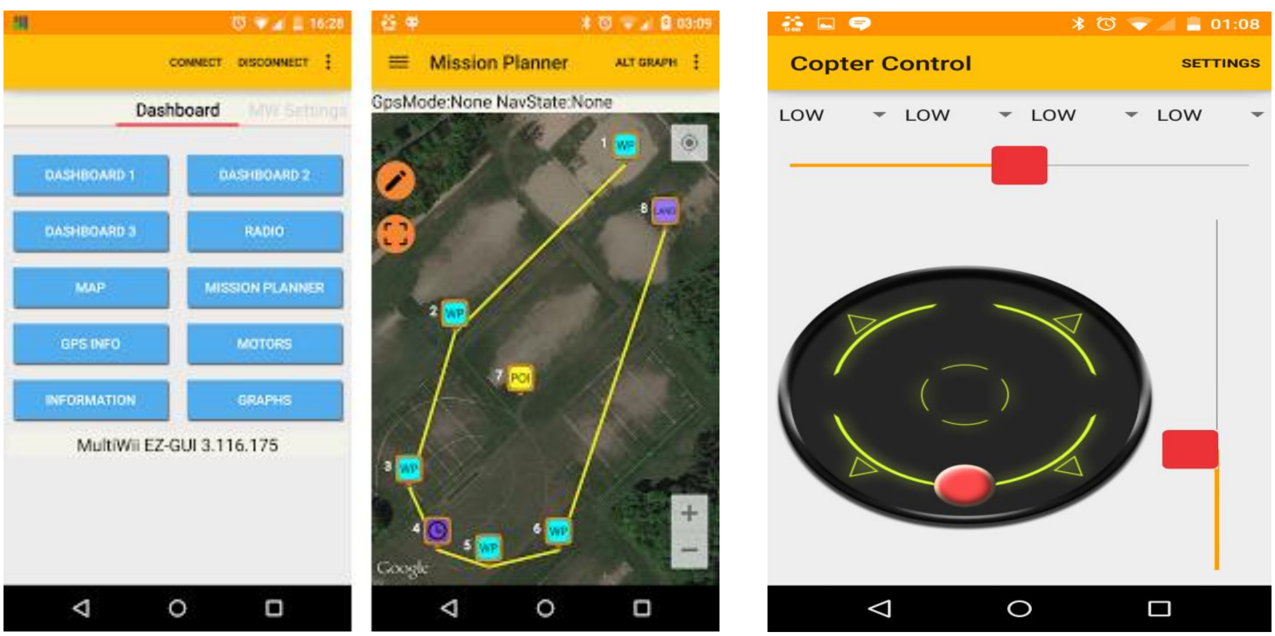


Figure 3.12: screenshot of ez-gui

CHAPTER 4

DESCRIPTION OF PROJECT & WORK PLAN

4.1 DESCRIPTION OF THE PROJECT

In this project, we as a group have decided to make a quadcopter which would be used in remote package delivering systems and rescue operations.

Firstly, we have studied the associated works related to the quadcopter developments over the last few decades. Then we have compiled the reviews of the individual papers and made a single literature review out of the individual papers. Next, we have bought the individual components of the quadcopter.

After that, we have done the interfacing of individual sensors i.e. accelerometer, gyroscope etc. along with the ultrasonic sensor which is used for the obstacle avoidance, with the Arduino as a microcontroller, then we have assembled all the sensors together to achieve interfacing with Arduino and also to calibrate it. Next, we have used the ESP8266 MOD as the server client concept to send some data over a Wi-Fi network. Here we have used server to send some data over the network by generating an IP address and the client is being used here to receive those data which is being sent. For this we have done the interfacing of all the sensors individually with the ESP8266 MOD and later we have combined all the sensors together to achieve interfacing with this Wi-Fi module.

Next, we have made all the required connections of Arduino with different sensors to make the quadcopter fly. Hence, we have done the quadcopter setup with the transmitter, along with the electronic speed controller (ESC) which are connected for controlling the speed of 4 respective motors. Moreover, we have upload the flight controller program on Arduino platform and the controlling of the quadcopter is achieved through transmitter. The only thing which needs to be done is to make it fly by controlling the transmitter.

Figure 4: complete setup of our drone

4.2 OBJECTIVE

- Make a low cost effective flight controller board with the help of arduino.
- To control the drone by a mobile app with the use of Esp8266 or Hc-05.
- The drone is inbuilt as self-automated collision detector by the use of ultrasonic sensor.

4.3 WORK PLAN

Table 1. Work plan structure

SL NO	DURATION	PROGRESS
1	August-September (2018)	Selection of project topic and study of the project topic.
2	October- (2018)	Study of previous work done related to our project and preparing a literature review of our topic.
3	November -December (2018)	Purchase of required components and assembling them.
4	January-February-March (2018)	Operation of the components in coordination to make the quadcopter fly.
5	April- May (2019)	Perform various tasks with the quadcopter and error detection & correction.

4.4 COST ESTIMATION STRUCTURE

Table 2. Cost Estimation Table

Sl no.	Components name	Quantity	Description	Price (Rs)
1	Arduinouno board	1	Used as the main flight controller	400
2	MPU-6050	1	3-axis gyroscope & accelerometer. Used to balance flight.	180
3	BLDC motors	4	Used as the rotors to lift the quadcopter and fly	1800
4	ESCs	4	Used to provide proper current to the motors	1400
5	HC 05	1		300
6	Propellers	4	Used to provide the thrust and lift to the quadcopter.	300
7	NodeMCU / Esp8266 (wifi module)	1	Used in communication between the quadcopter and the transmitter	250
8	Ultra sonic sensor	1	To avoid collision	100
9	Li-Po battery	1	Used to power the whole quadcopter	1500
10	Connecting Wires		Used in connections	170
		TOTAL	6400	

CHAPTER 5

RESULT, DISCUSSION AND CONCLUSION

Table 3. Values of Sensors

SENSORS	PARAMETERS	DISPLAYED VALUE
MPU 6050	Gyro (X axis)	4.519 (degree)
	Gyro (Y axis)	10.710 (degree)
	Gyro (Z axis)	14.702 (degree)
	Acc (X axis)	9.077g
	Acc (X axis)	0.028g
	Acc (X axis)	1.054g

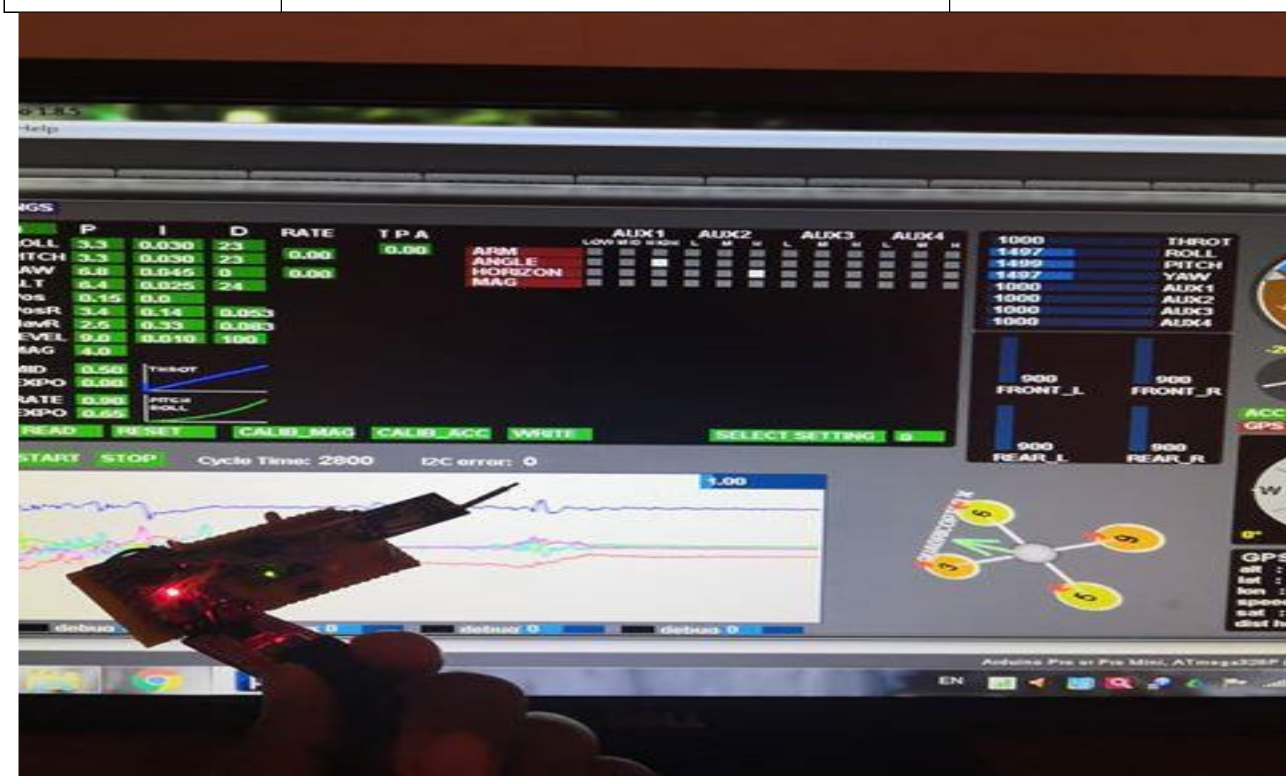
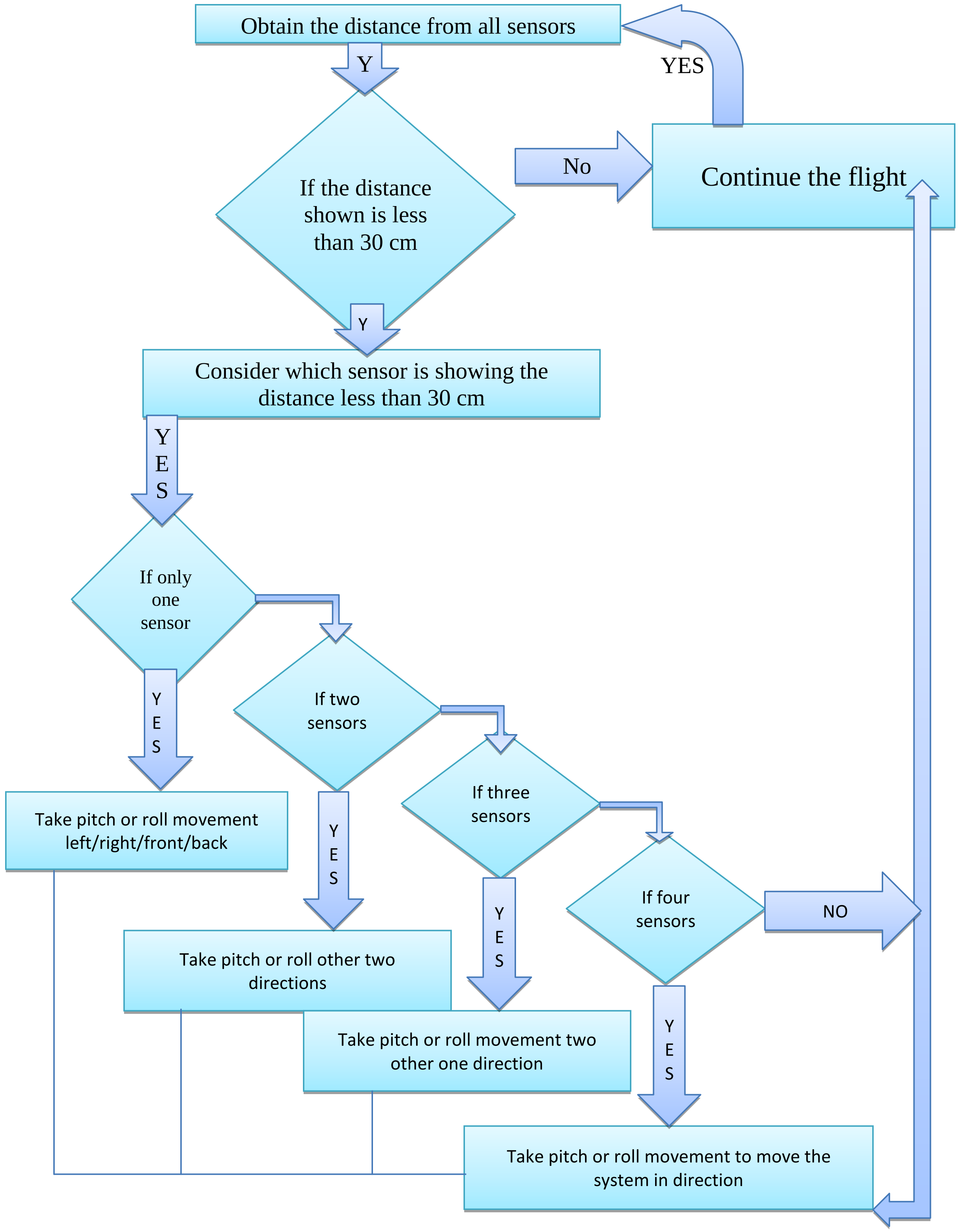


Figure 5: MPU 6050 graph

Algorithm for Obstacle Detection using ultrasonic sensor



Comparison between auduino and kk2.1.5.:

(Also reason of choosing auduino as flight controller).

SL NO	**Arduino Flight Controller Board**	**KK 215 Flight Controller**
1	It is a most recognized & trustworthy student's project testing board in the world	It is a most available & cheapest flight controller board till now
2	It is a developing testing board. As per requirement and additional features, lots of components or set up modules can interface with it	It is a compact system for both hardware and software part. Additional components or modules cannot be interfacing with it directly.
3	Overall low cost & easily available in the market.	High price & not so much available than the arduino.
4	Open source IDE software is used for programming the board.	The software for this flight controller board is not open to all.
5	Arduino flight controller board is still in the developing process. More study and research is required in this area for making cost effective, stable FC Board.	KK215 is fully developed flight controller board. It is not possible for developing more in this version of board.

Figure 6: Arduino as flight controller

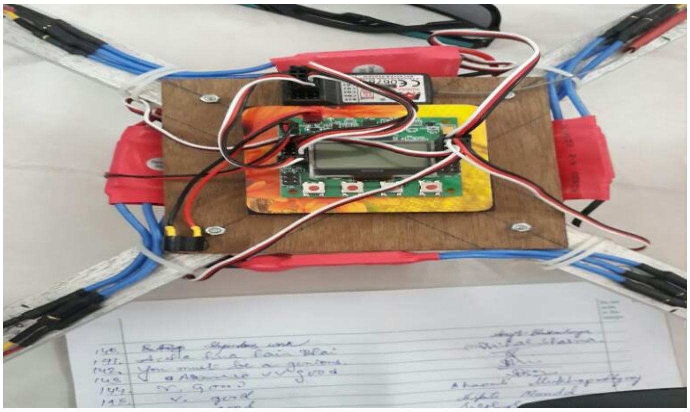


Figure 7: kk2.1.5 as flight controller

Outcome

As the Stability has been tested and calibrated, the Quadcopter successfully took off.

Figure 8: The Quadcopter Flies in the sky at same place but different altitude

The Quadcopter can fly in the sky up to a permissible height. It can be used for Remote Reaching, Aerial Photography, Security, etc.

The ability to shoot higher perspectives with drones is also a great way to shoot landscapes that don’t have foreground elements.

Safety measures have been taken while flying this drone, and maximum stability is aimed for the same.

Conclusion:

In this project we concluded how to design a unmanned aerial vehicle. While the initial goal of creating an IOT based quadcopter but at the end we are not able to reach our goal. But our group still learned a substantial amount about robot design, fabrication, implementation & control of various sensors & modules, also auduino programming.

We used the spring test to determine the motor and propeller thrust for various PWM signals. We used this information for quadcopter frame down section and control. We learned important soldering and electric system fabrication skills including digital to analog motor control. In this project we able to stabilize the quadcopterin XYZ axes by calibration. Also we were able to control the quadcopter by mobile application using Bluetooth or wifi. We also implement the ultrasonic sensors for obstacle detection and avoidance.

CHAPTER 6

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Gurkan Tuna, Tarik Veli, Mumcu Kayhan Gulez, Vehbi Cagri Gungor, Hayrettin Erturk

2. "Dynamics modelling and linear control of quadcopter"
Pengcheng Wang ; Zhihong Man ; Zhenwei Cao ; Jinchuan Zheng ; Yong Zhao

https://ieeexplore.ieee.org/abstract/document/7813499

3. "Hybrid parallel neuro-controller for multirotor unmanned aerial vehicle"
Alexey Bobtsov ; Alexei Guirik ; Marina Budko ; Mikhail Budko
https://ieeexplore.ieee.org/document/7765223

4. "Development of a single axis tilting quadcopter"
Russell Oliver ; Sui Yang Khoo ; Michael Norton ; Scott Adams ; Abbas Kouzani
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5. "Thin, Flexible Secondary Li-Ion Paper Batteries"
Liangbing Hu†, Hui Wu†, Fabio La Mantia, Yuan Yang, and Yi Cui*
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6. "A method for the correlation dimension estimation for on-line condition monitoring of large rotating machinery".
AlbertoRolo-NaranjoMaría-ElenaMontesino-Otero

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