Chapter 1

Introduction

1.1 Basic Introduction

Over the last few years we have seen a massive growth in the manufacture and sales of remote control airborne vehicles known as Quadcopters. These Unmanned Aerial Vehicles have four arms and fixed pitch propellers which are set in an X or + configuration with X being the preferred configuration.

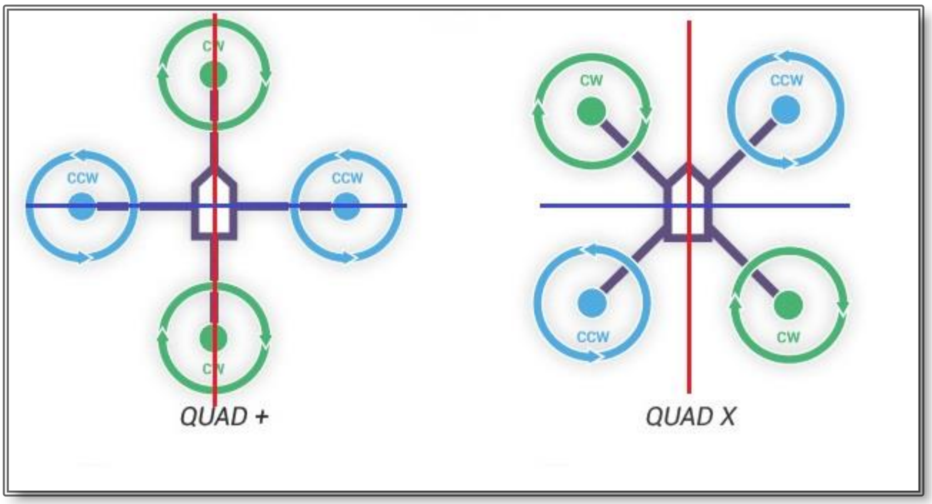


Figure 1.1 Quadcopter Configurations

They are sometimes referred to as Drones, Quadrotors or Quadcopters. In the standard format two propellers will spin in a clockwise direction with the other two spinning in an anticlockwise direction allowing the craft to vertically ascend, hover in the air and fly in a designated direction. The Quadcopter is a simple format with very few moving parts and has rapidly become a favourite vehicle for remote control enthusiasts and is widely being used as an effective Aerial photographic platform. A large majority of the Quadcopters were originally built by hobbyists who understood the simplicity of the vehicle. By adding four motors and four propellers to a lightweight frame constructed of light wood, carbon fiber, or fiber glass then connecting it to a remote control transmitter via a small control board fitted with a gyroscopic stabilization system and connected to a Lipo battery these craft were relatively simple to construct. Experimentation has led to the configuration of variations of the Quadcopter by using different amounts of arms we have seen Tricopters, Hex copters and Octocopters (with eight arms). Other configurations include a Vtail and an H frame variation.

The rapid advances in computing power, the efficiency of the coreless or brushless motors, smaller microprocessors the development of batteries and gyroscopic and accelerometer technology has all led to a proliferation of Quadcopter designs. The first Quadcopters were not designed for acrobatic flight as the development was concentrated on simple stable flight patterns but now this has all changed. Micro and even Nano Quadcopters are being produced mainly in China that can perform intricate aerobatic moves, flips and barrel rolls that years ago would have been unthinkable. Chinese companies like Hubsan have made tiny Nano Quadcopters. Quadcopters differ from conventional helicopters which use rotors which 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 as 'quadrotors') 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.

1.2 About the Project

Quadcopter, also known as quadrotor helicopter or quadrotor, is a 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. In a quadcopter, two of the propellers spin in one direction (clockwise) and the other two spin the opposite direction (counter clockwise) and this enables the machine to hover in a stable formation.

Firstly the motors which we used have an obvious purpose: to spin the propellers. Motors are rated by kilovolts, the higher the kV rating, the faster the motor spins at a constant voltage. Next the Electric Speed controller or ESC, is what tells the motors how fast to spin at any given time. We need four ESCs for a quadcopter, one connected to each motor. The ESCs are then connected directly to the battery through either a wiring harness or power distribution board. Many ESC1s come with a built in battery eliminator circuit (BEC), which allows you to power things like your flight control board and radio receiver without connecting them directly to the battery. Because the motors on a quadcopter must all spin at precise speeds to achieve accurate flight, the ESC is very important.

Our Quadcopter uses four propellers, each controlled by its own motor and electronic speed controller. Using accelerometers we are able to measure the angle of the Quadcopter in terms of X<Y and Z and accordingly adjust the RPM of each motor in order to self-stabilize itself. the Quadcopter platform provides stability as a result of the counter rotating motors. For Hovering over the skies the flight controller which is used is the ‘brain’ of the quadcopter. It houses the sensors such as gyroscopes and accelerometers that determine how fast each of the quadcopter’s motors spin. 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 Atmel644PA processor, which in-turn processes signals according the users selected firmware (e.g. Quadcopter) and passes the control signals to the installed Electronic Speed Controllers (ESCs) and the combination of these signals instructs the ESCs to make fine adjustments to the motors rotational speeds which in-turn stabilizes the craft.

1.3 Block Diagram

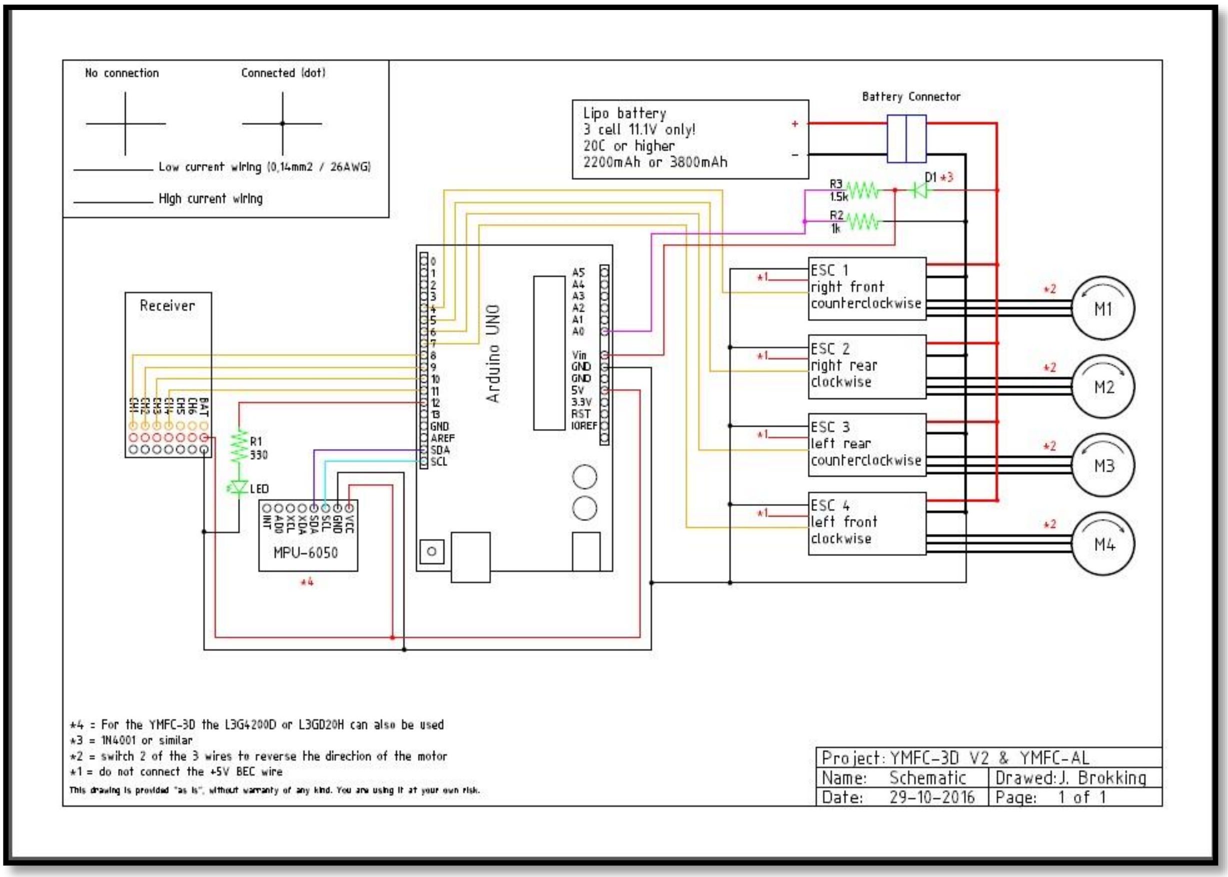


Figure 1.2 Block Diagram

1.4 Components Used

1.	Quadcopter HJ450 Frame	1
2.	ESC-30A	4
3.	Brushless motor-1200kv	4
4.	Propeller	4
5.	Fly sky transmitter and Receiver-CT6B	1
6.	Arduino Uno	1
7.	Battery and charger	1
8.	Connectors	As per required

Table 1.1: Components

1.5 Literature review

The quad rotor project required extensive research into similar systems. By reviewing others work, we used this insight to develop our system. To this end, research papers from various quadrotor groups were used as guides in the early development of the dynamics and control theory.

Quad rotor platforms used in research remain somewhat the same, having four electric motors pointed vertically upwards and equally spaced in a square fashion. However, there were some groups whom designed their own platforms, whereas commercial models available to the consumer were the Dragan Flyer, the X-UFO and the MD4-200.

1.6 Motivation

This project created a platform to learn about the unmanned aerial vehicles such as a Quadcopter. This expands the scope of the electrical engineering education to include the control and the understanding of the mechanical components. The Quadcopter has many applications that we are interested to develop like mapping and video streaming especially in a disaster and dangerous area. It also open up the possibilities to broaden the understanding and applications of control systems, stabilization, artificial intelligence and GPS navigation as it applies to the Quadcopter.

Quadcopter unmanned aerial vehicles are used for surveillance and reconnaissance by military and law enforcement agencies, as well as search and rescue missions in urban environments. The military use of unmanned aerial vehicles (UAVs) has grown because of their ability to operate in dangerous locations while keeping their human operators at a safe distance. The larger UAVs also provide a reliable long duration, cost effective, platform for reconnaissance as well as weapons. They have grown to become an indispensable tool for the military. One such example is the Aeron Scout, created by Canadian company Aeron Labs which is a small UAV that can quietly hover in place and use a camera to observe people and objects on the ground.

In addition to the military uses of the small UAV, we were interested in evaluating applications in the commercial and industrial sector. Our premise was that if smaller and cheaper UAVs become readily available, new markets and uses will emerge. Potential new markets in commercial and industrial applications include inspecting pipelines or even inspecting dangerous areas like a meltdown site at a nuclear power plant. Disaster relief or crop assessment seems also to be likely areas where small UAVs could be useful. We were also motivated by on-campus uses such as monitoring parking or quick-look video of an incident, or monitoring hard to reach locations, or exploration of a collapsed building or other dangerous location.

1.7 Objective

The goal of our project is to design, implement, and test a stable flying Quadcopter that can be used to collect and save Carbon dioxide gas sensing data along with the location using GSM module. Our plan was to choose an existing Quadcopter kit and add the required components to give the Quadcopter the capabilities to gather and log data autonomously. A GSM module will be used to determine the current position and an SIM card will be used to track location. If this goal is accomplished, our team would also like to design and implement some autonomous commands that may help aid a user in collecting the data. These commands include the auto-landing command, auto-move command, auto-homing command, and hold position command.

The final Quadcopter design had to meet the following specifications:

1. The Quadcopter must be capable of flying and landing in stable manner.

2. The Quadcopter must be capable of determining its current location using GSM data.
3. The Quadcopter must be capable to storing and logging data.
4. The Quadcopter must be able to perform the following commands:
   - Auto-landing
   - Auto-move
   - Auto-homing
   - Hold position

1.8 Need of Project

Personal Drones have been all the rage for the past few years, as toys, and primarily as new devices for capturing amazing aerial photography. As the technology has matured and become more mainstream, a number of practical and very interesting uses of Drone technology have emerged. In the past few months we have seen some amazing developments in the flying drone industry. Amazon has announced a service, which will deliver your orders right to your door, and 3D Robotics, a commercial drone maker, has received $36 million in funding. The future of drones flying around everywhere is coming closer and closer to us.

1.9 Project Plan

The project plan was divided into five major milestones each spaced approximately Ten days apart.

1. Project Description and Plan of Work
2. System Model
3. Components Purchasing
4. Implementation / Hardware / Software
5. Project Demonstrations

The sequence that we met these milestones was out of sequence with the required milestones. Experience told us to get the hardware done as soon as possible as this is often requires a lot of time. By doing so, and because of unforeseen difficulties, we fell behind slightly with the System Modelling and flight Controller. After working closely we were able to complete the milestones only slightly behind schedule.

1.10 SYSTEM OVERVIEW

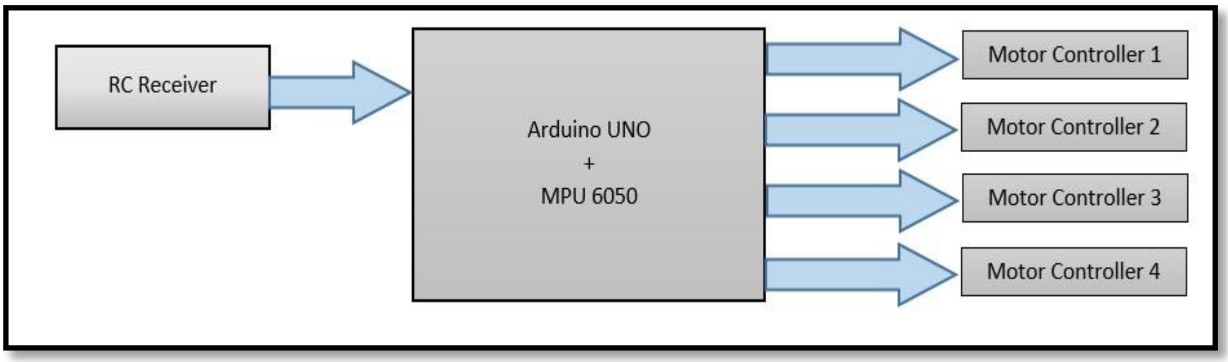


Figure 1.3 Arduino Setup

1.11 Controls

Roll – Done by pushing the right stick to the left or right. Literally rolls the quadcopter, which manoeuvres the quadcopter left or right.

Pitch – Done by pushing the right stick forwards or backwards. Tilts the quadcopter, which manoeuvres the quadcopter forwards or backwards.

Yaw – Done by pushing the left stick to the left or to the right. Rotates the quadcopter left or right. Points the front of the copter different directions and helps with changing directions while flying.

Throttle – Engaged by pushing the left stick forwards. Disengaged by pulling the left stick backwards. This adjusts the altitude, or height, of the quadcopter.

Trim – Buttons on the remote control that help you adjust roll, pitch, yaw, and throttle if they are off balance.

The Rudder – You might hear this term thrown around, but it's the same as the left stick. However, it relates directly to controlling yaw (as opposed to the throttle).

Aileron – Same as the right stick. However, it relates directly to controlling roll (left and right movement).

The Elevator – Same as the right stick. However, it relates directly to controlling pitch (forwards and backwards movement).

Manoeuvring:

Bank turn – A consistent circular turn in either the clockwise or counter clockwise direction.

Hovering – Staying in the same position while airborne. Done by controlling the throttle.

Roll

Roll moves your quadcopter left or right. It's done by pushing the right stick on your transmitter to the left or to the right.

It's called "roll" because it literally rolls the quadcopter. For example, as you push the right stick to the right, the quadcopter will angle diagonally downwards to the right.

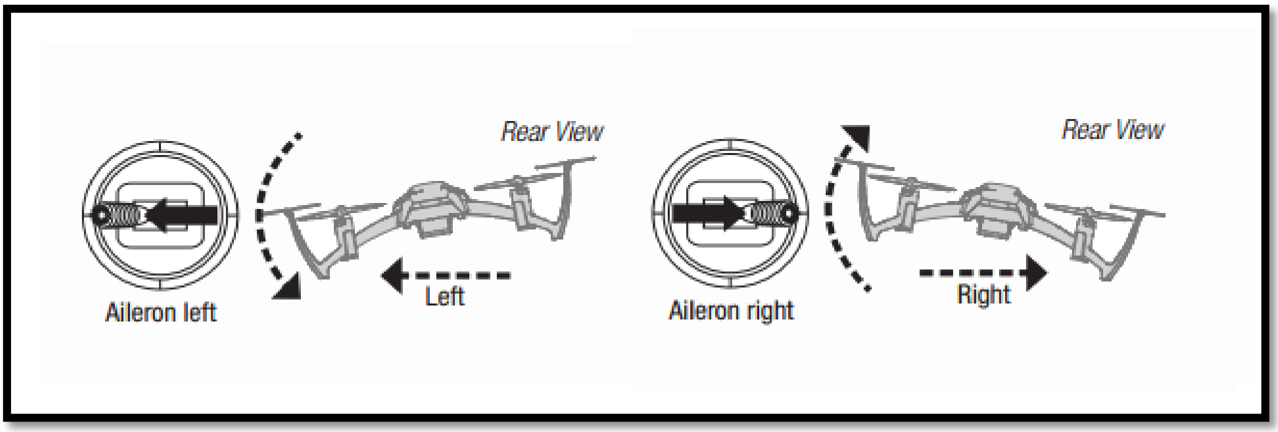


Figure 1.4 Example of a quadcopter rolling left and right. Notice the tilt of the quadcopter

Pitch

Pitch is done by pushing the right stick on your transmitter forwards or backwards. This will tilt the quadcopter, resulting in forwards or backwards movement.

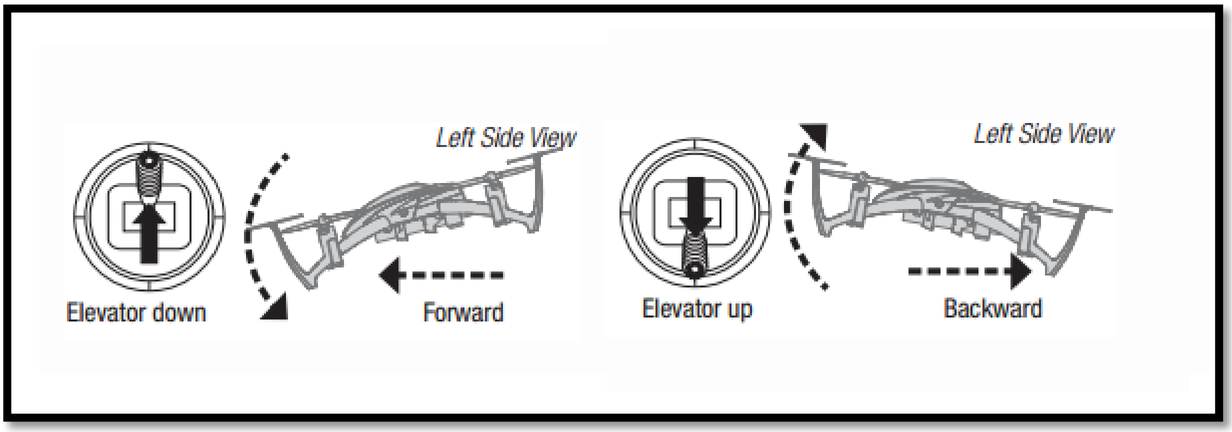


Figure 1.5 Example of a quadcopter pitching forwards and backwards

Yaw

This is done by pushing the left stick to left or to the right.

Throttle

Throttle gives the propellers on your quadcopter enough power to get airborne. When flying,you will have the throttle engaged constantly. To engage the throttle, push the left stick forwards. To disengage, pull it backwards.

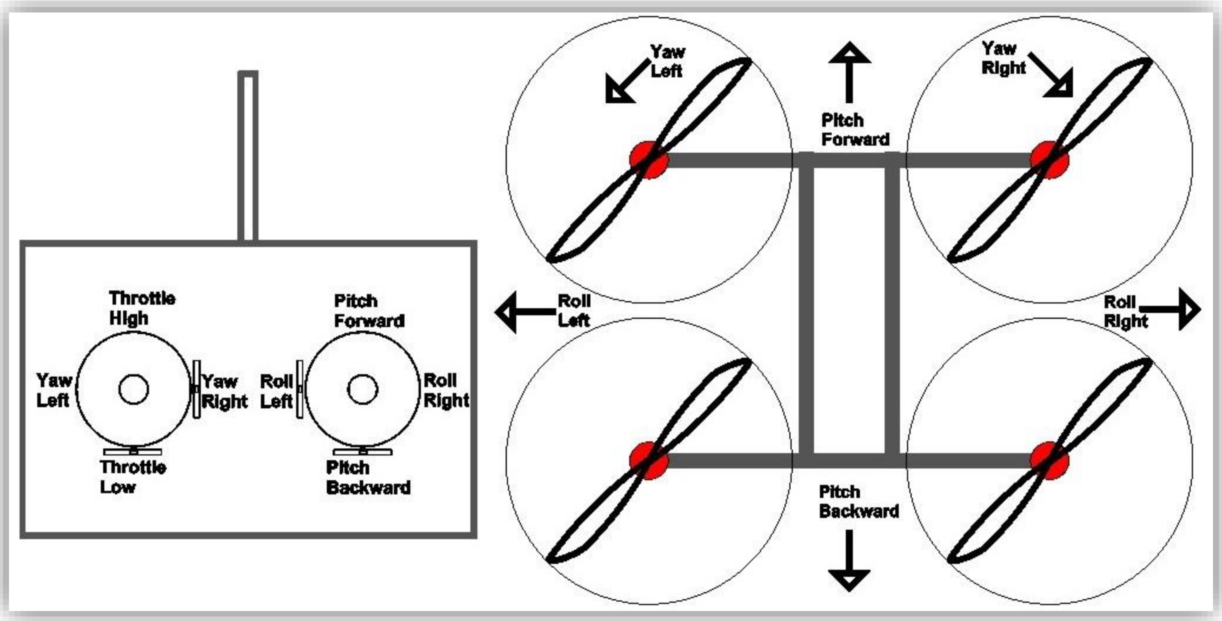


Figure 1.6: Simple sketch of roll, pitch, yaw, and throttle on a transmitter (left image) and quadcopter (right image).

Chapter 2

HISTORY

2.1 History

2.1.1 Oehmichen (1920)

Etienne Oehmichen experimented with rotorcraft designs in the 1920s. (Fig.2.1) among the six designs he tried, his helicopter No.2 had four rotors and eight propellers, all driven by a single engine. The Oehmichen No.2 used a steel-tube frame, with two-bladed rotors at the ends of the four arms. The angle of these blades could be varied by warping. Five of the propellers, spinning in the horizontal plane, stabilized the machine laterally. Another propeller was mounted at the nose for steering. The remaining pair of propellers were for forward propulsion.

The aircraft exhibited a considerable degree of stability and controllability for its time, and made more than a thousand test flights during the middle 1920s. By 1923 it was able to remain airborne for several minutes at a time, and on April 14, 1924 it established the first-ever FAI distance record for helicopters of 360 m (390 yd). It demonstrated the ability to complete a circular course and later, it completed the first 1 kilometer (0.62 mi) closed-circuit flight by a rotorcraft.

2.1.2 De Bothezat helicopter (1922)

Dr. George de Bothezat and Ivan Jerome developed this aircraft, (Fig. 2.2) with six bladed rotors at the end of an X-shaped structure. Two small propellers with variable pitch were used for thrust and yaw control. The vehicle used collective pitch control. Built by the US Air Service, it made its first flight in October 1922. About 100 flights were made by the end of 1923. The highest it ever reached was about 5 m (16 ft 5 in). Although demonstrating feasibility, it was underpowered, unresponsive, mechanically complex and susceptible to reliability problems. Pilot workload was too high during hover to attempt lateral motion. (4)

2.1.3 Convertawings Model A Quadrotor (1956)

This unique helicopter was intended to be the prototype for a line of much larger civil and military quadrotor helicopters. The design featured two engines driving four rotors through a system of v belts. (Fig. 2.3) No tail rotor was needed and control was obtained by varying the thrust between rotors.[5] Flown successfully many times in the mid-1950s, this helicopter proved the quadrotor design and it was also the first four-rotor helicopter to demonstrate successful forward flight. Due to a lack of orders for commercial or military versions however, the project was terminated. Convert a wings proposed a Model E that would have a maximum weight of 42,000 lb (19 t) with a payload of 10,900 lb (4.9 t) over 300 miles and at up to 173 mph (278 km/h).

2.1.4 Curtiss-Wright VZ-7 (1958)

The Curtiss-Wright VZ-7 was a VTOL aircraft designed by the Curtiss-Wright company for the US Army. The VZ-7 was controlled by changing the thrust of each of the four propellers. (Fig.2.4) AR.Drone is a small radio controlled quadcopter with cameras attached to it built by Parrot SA, designed to be controllable with by smartphones or tablet devices. Nixie is a small camera-equipped drone that can be worn as a wrist band.(6)

- Had 4 rotors and 8 propellers all driven by one motor

- Over 1000 Successful flights
- First recorded FAI distance record of 360m in 1924 for a helicopter
- Very Stable for the Time
- Designed by Etienne Oemichen

2.2 Current Developments

In the past 10 years many small quadcopters have entered the market that include the DJI Phantom and Parrot AR Drone. This new breed of quadcopters are cheap, lightweight. In the 20th Century, military research precipitated many widely used technological innovations. Surveillance satellites enabled the GPS-system, and defence researchers developed the information swapping protocols that are fundamental to the Internet. Drone fall into a similar category. Designed initially for reconnaissance purposes, their para-military and commercial development was often out of sight of the public. (7)

Military UAVs - from the Civil War to the Middle East conflicts:

The Oxford English Dictionary describes drones as **'*a remote-less controlled piloted aircraft or missile*'.**

Understood in such sense, drones came into first use after World War II when unmanned jets, such as the Ryan Firebee (a documentary about the Firebee and the use of early drones in the Vietnam War), started field operation. (8) Since then, the number of drones in military use increased substantially enough that the New York Time decided to refer to it as a new paradigm for warfare.

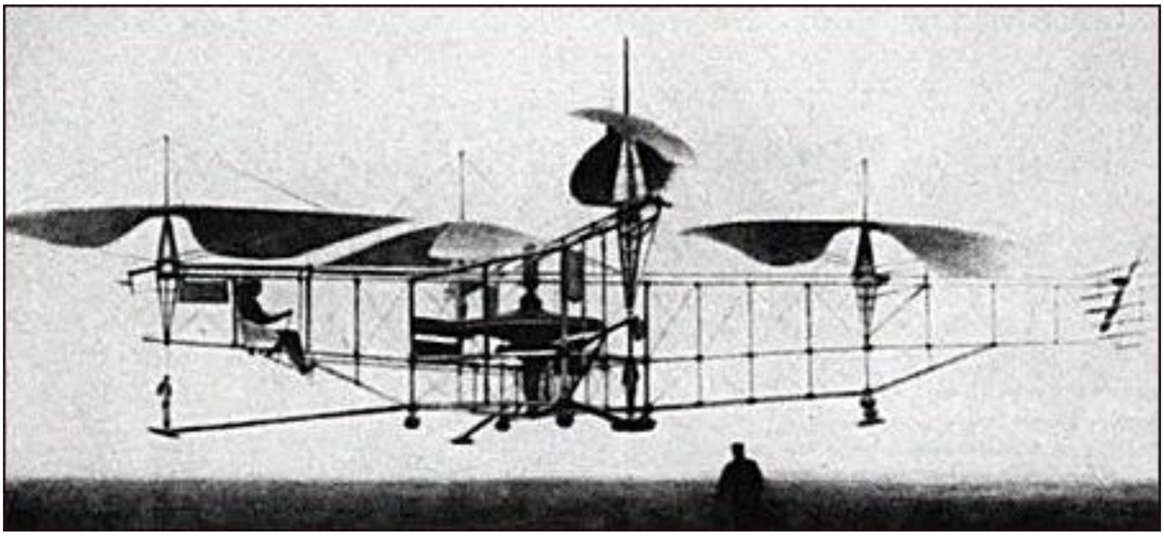


Fig. 2.1: 1920 – Oemichen

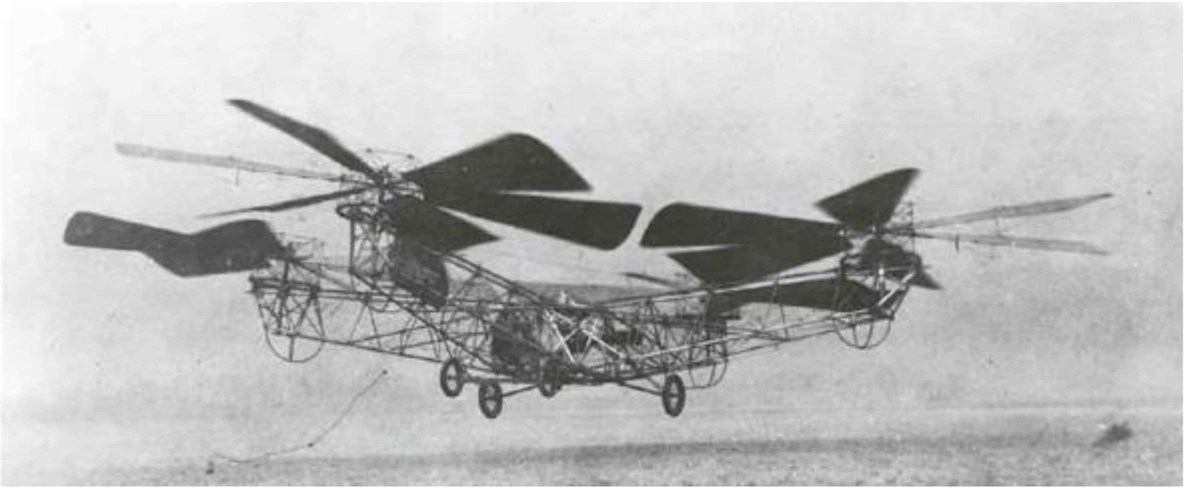


Fig. 2.2: De Bothezat helicopter, 1923 photo

Fig. 2.3: 1956 – Convert a wings Model a Quadcopter

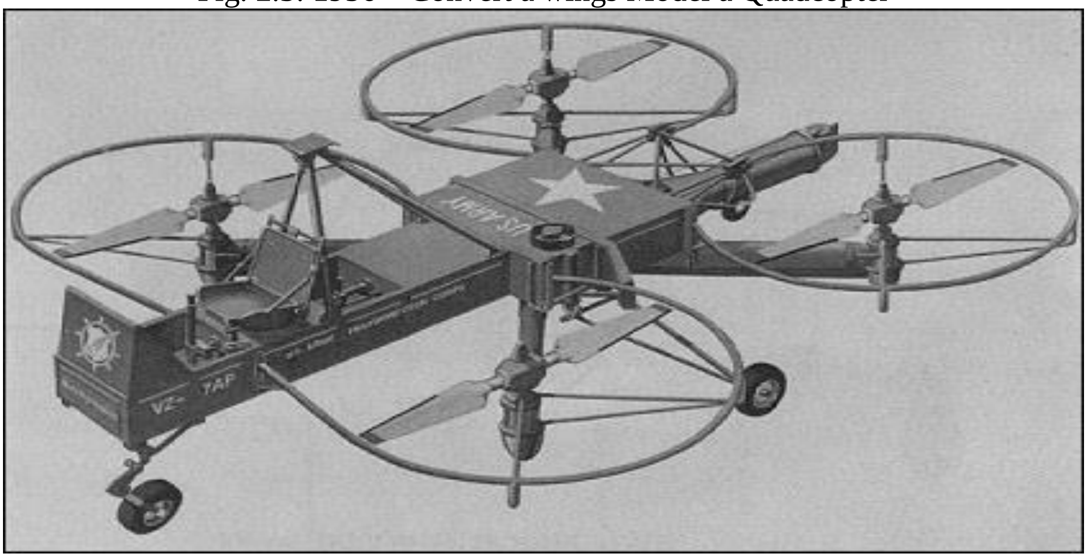


Fig. 2.4: 1958 - Curtis Wright VZ-

Chapter 3

MATERIALS & METHODS

3.1. HJ450 Frame

This is the glass fibre quadcopter frame which is very simple and easy to build frame this flame wheel is one of the most popular frames out there for a number of good reasons:

1. it's relatively inexpensive
2. It is famously durable
3. The centre plate doubles as a power distribution board which tidies things up quite a bit and allowed me to get rid of my ugly DIY wiring harness.
4. The design is really well thought out – it's a compact frame. Plenty of room for receiver, control board, ESCs, and battery, with mounting options and room to spare for a GoPro or other camera setup.
5. As one of the most popular quadcopter frames on the market, there is a wide variety of spare parts and accessories to choose from such as landing gears, gimbals, etc.

Figure 3.1 HJ-450

Every quadcopter or other multirotor aircraft needs a frame to house all the other components.
Things to consider here are weight, size, and materials. They're strong, light, and have a sensible configuration including a built-in power distribution board (PDB) that allows for a clean and easy build. There are also a ton of spare parts and accessories available from many different websites. There are also a ton of clones out there, most of which include the same built-in PDB and durable construction as the original. Parts and accessories are 100% compatible and interchangeable.
Frames can also be built at home using aluminium or balsa sheet. But results will vary from manufactured frames, both aesthetically and in terms of flight attributes.

3.1.1. Types of Frame

1. Aerial cinematograph:

Big enough to lift a specific camera with tall landing gear.

Figure 3.2 Aerial Quadcopter

2. Sport:

Super light-weight and extremely stiff for crisp and responsive control.

Figure 3.3 Sport Quadcopter

3. Sport FPV:

Lots of mounting surfaces for extra electronics and action cameras.

Figure 3.4 Sport FPV Quadcopter

4. Mini: Very small and virtually indestructible

Figure 3.5 Mini Quadcopter

3.2. Electronic Speed Controller

The electronic speed control, or ESC, is what tells the motors how fast to spin at any given time. You need four ESCs for a quadcopter, one connected to each motor. The ESCs are then connected directly to the battery through either a wiring harness or power distribution board. Many ESCs come with a built in battery eliminator circuit (BEC), which allows you to power things like your flight control board and radio receiver without connecting them directly to the battery. Because the motors on a quadcopter must all spin at precise speeds to achieve accurate flight, the ESC is very important. These days if you are building a quadcopter or other multirotor, it is pretty much standard to use ESCs that have the SimonK firmware on them. This firmware changes the refresh rate of the ESC so the motors get many more instructions per second from the ESC, thus have greater control over the quadcopter's behaviour.

ESCs are normally rated according to maximum current. We are using 30 A.Generally the higher the rating, the larger and heavier the ESC tends to be which a factor when calculating mass is and balance in airplanes. Many modern ESCs support nickel metal hydride, lithium ion polymer and lithium iron phosphate batteries with a range of input and cut-off voltages. The type of battery and number of cells connected is an important consideration when choosing a Battery eliminator circuit (BEC), whether built into the controller or as a stand-alone unit. A higher number of cells connected will result in a reduced power rating and therefore a lower number of servos supported by an integrated BEC, if it uses a linear voltage regulator. A well designed BEC using a switching regulator should not have a similar limitation.

Working:

The ESC controls the speed of an AC motor with frequency, not voltage. If you plug an 11.1 volt battery into your power system, you have 11.1 volts going to the motor with the full amperage potential of the battery backing that voltage. The AC brushless motors we use are true 3-phase AC motors. The motors DO run on AC current. The ESC is a trapezoidal wave generator. It produces 3 separate waves (one for each wire to the motor). The speed of the motor has nothing to do with voltage or amps, but instead the timing of the current fed into it. By increasing and decreasing the wave length (frequency) of the trapezoidal wave on the 3 phases, the ESC causes the motor to spin faster and slower. The ESC switches the polarity of the phases to create the waves. This means that the voltage through any given winding flows 'Alternately' one direction then the other. This creates a push-pull effect in the magnetic field of each winding, making the motor more powerful for its size and weight. The motor and the load that is placed on it, is what determines the amp draw from the ESC and the battery.

In the below picture, we have 2 motors with 3 poles each. Their winding are labelled as poles "A", "B", and "C". The graph (under the 2 motors) shows the 3 separate waves that the ESC generates to drive a motor. The graph shows the signals time to voltage relationships. The black wave on the graph is the signal that is sent to winding "A". The red signal goes to winding "B", and the blue signal goes to winding "C". If you look at "AC Motor 1" and "AC Motor 2", and the signals shown on the graph that are sent to the windings; it is easy to see that when we swop any two motor connections, we change the order that the waves hit the windings, and that changes the direction of the motor.

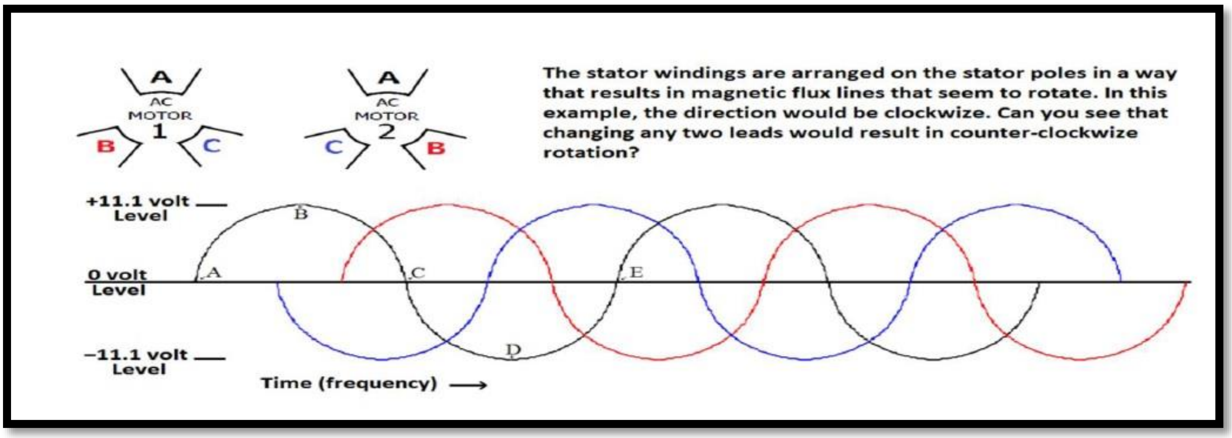


Figure 3.6 Frequency in variation Motors

Specifications

Current Draw: 30A Continuous/35A Burst

•Voltage Range: 2-4s Li poly

•BEC: 5V3A Linear

•Weight: 35g

Figure 3.7 ESC-30A

3.3. Brushless DC Motor

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors) are synchronous motors that are powered by a DC electric source via an integrated inverter/switching power supply, which produces an AC electric signal to drive the motor. In this context, AC, alternating current, does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. Additional sensors and electronics control the inverter output amplitude and waveform (and therefore percent of DC bus usage/efficiency) and frequency (i.e. rotor speed).The rotor part of a brushless motor is often a permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor.

Brushless motors may be described as stepper motors; however, the term stepper motor tends to be used for motors that are designed specifically to be operated in a mode where they are frequently stopped with the rotor in a defined angular position. This page describes more general brushless motor principles, though there is overlap. Two key performance parameters of brushless DC motors are the motor constants KV and Km.

Working:

In a **brushless DC motor** (BLDC), you put the permanent magnets on the rotor and you move the electromagnets to the stator. Then you use a computer (connected to high-power transistors) to charge up the electromagnets as the shaft turns. This system has all sorts of advantages:

- Because a computer controls the motor instead of mechanical brushes, it's more precise. The computer can also factor the speed of the motor into the equation. This makes brushless motors more efficient.
- There is no sparking and much less electrical noise.
- There are no brushes to wear out.
- With the electromagnets on the stator, they are very easy to cool.
- You can have a lot of electromagnets on the stator for more precise control.

The only disadvantage of a brushless motor is its higher initial cost, but you can often recover that cost through the greater efficiency over the life of the motor. The poles on the stator of a two-phase BLDC motor used to power a computer cooling fan.

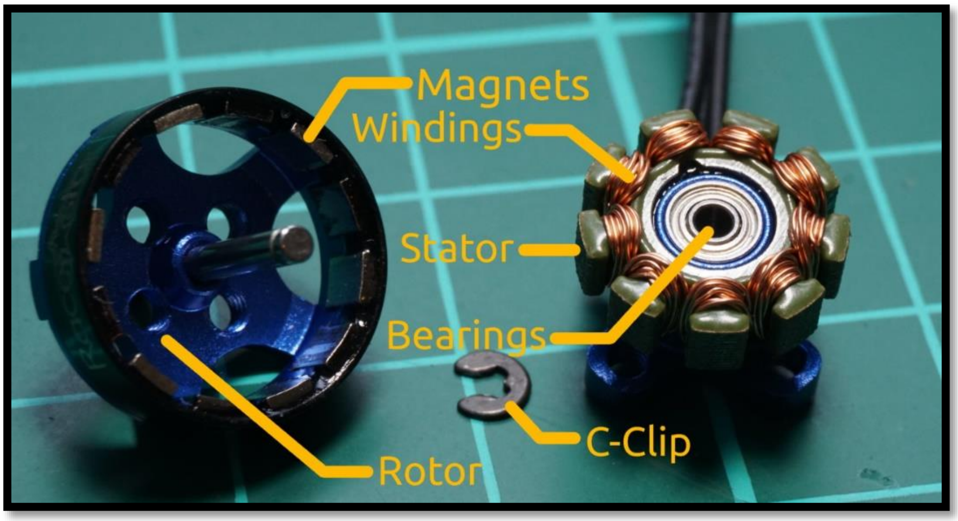


Figure 3.8 Brushless motor winding

Specifications:

- KV: 1300KV/1000KV/850KV/750KV
- Pull: 930g/890g/875g/866g
- Motor size(mm): Φ28*30
- Battery: 2-4s Li po

Figure 3.9 Brushless Dc motor 1200 kv

3.3.1. Types of Motors

 Brushed DC Motor

Since this type of motor is driven by a DC power supply, it is also called simply a DC motor. To distinguish it from a permanent magnet synchronous motor (brushless DC motor), here we will call it a brushed DC motor. Since it is comparatively economical and easy to drive, the brushed DC motor is used for a broad range of applications.

A brushed DC motor generates torque by mechanically switching the direction of current in coordination with rotation using a commutator and brushes. Shortcomings of a brushed DC motor include the need for maintenance due to wear down of the brushes and the production of electrical and mechanical noise. The PWM duty ratio can by adjusted using a microcontroller, etc. to change the applied voltage, thus allowing the speed of rotation and position to be controlled.

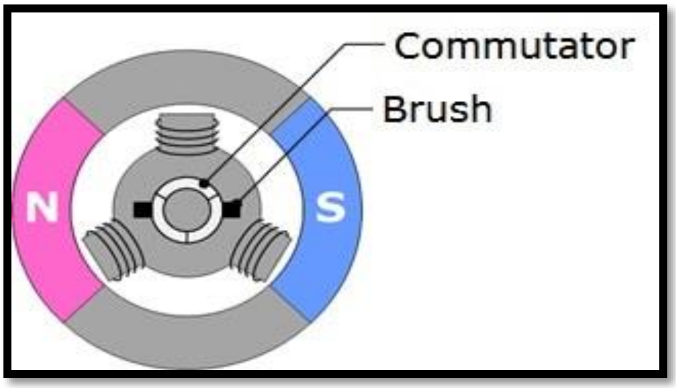


Figure 3.10 Brushed Dc Motor

 Permanent Magnet Synchronous Motor (Brushless DC Motor)

Take away the commutator and brushes that are the shortcomings of the brushed DC motor and you have a permanent magnet synchronous motor (brushless DC motor). Due to the lack of brushes, a brushless DC motor has excellent device life and low-noise characteristics. Also, it can achieve great efficiency, so it is used in a broad range of applications including energy saving home appliances and long-running industrial applications.

There are two major types of structure, differing by how the magnet is equipped on the rotor. Surface Permanent Magnet (SPM): This type has a permanent magnet affixed to the outside of the rotor, and magnetic permeability is constant through all positions.

Interior Permanent Magnet (IPM):
This type has a permanent magnet embedded inside the rotor, and since the magnetic permeability varies with position, reluctance torque can be used. Since there is no structure for mechanically switching the direction of current, this needs to be performed electronically using an inverter circuit. By driving an inverter circuit using a microcontroller, etc., a three-phase alternating-current voltage is applied to the stator, generating a rotating magnetic field.
Driving waveforms can be divided into the following two main types.
Trapezoidal wave drive:
Drives by applying trapezoidal (rectangular) wave voltage.
Sinusoidal wave drive:
Drives by applying sinusoidal wave voltage in order to suppress the vibration, noise, and torque ripple which are issues encountered with trapezoidal wave drive. In many cases, vector control (fields oriented control) is use to control torque and phase in a linearly independent manner. Since torque is proportional to drive current, high-speed and high precision position and speed control is possible by adding position and speed sensors. In order to drive efficiently, it is necessary to detect the rotor (magnet) position. Hall sensors, encoders, and resolvers are used for detecting position. Due to temperature limitations of sensors and cost considerations, there are cases where rotor (magnet) position is estimated from three-phase current or induced voltage without using sensors (sensor less position estimation).
In general, industrial systems mainly use a sensor method and home appliance systems use a sensor less position estimation method.

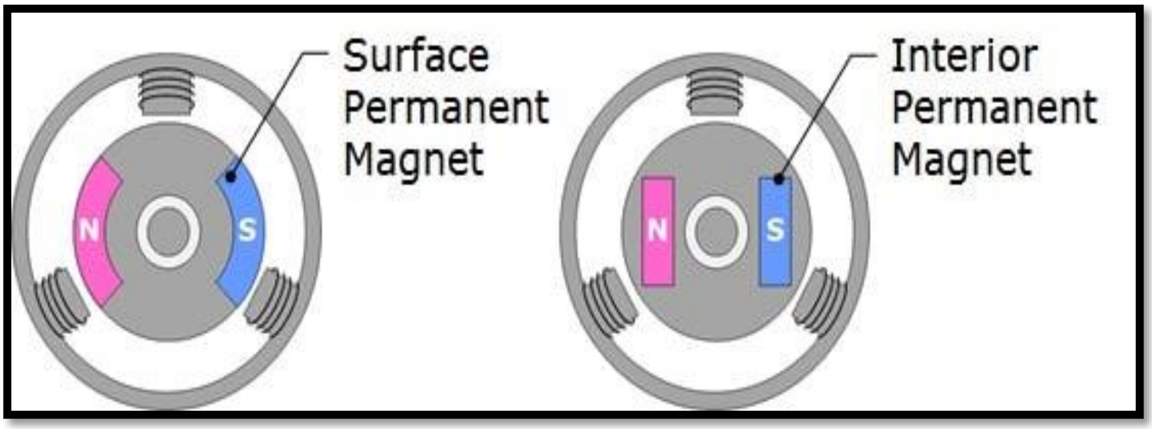


Figure 3.11 Brushless Dc motor-Permanent Magnet

 Three-Phase Induction Motor

A three-phase induction motor is an induction motor driven on a three-phase alternating current power source. A rotating magnetic field is produced by passing a three-phase alternating current through a stator, and an induced current is generated in the rotor by electromagnetic induction. This rotating magnetic field and induced current generate an electromagnetic force, which causes the rotor to rotate. Since the magnetic field needs to move in respect to the rotor in order to generate an induced current, the speed of rotation of the rotor is always slower than the synchronous speed of the rotating magnetic field. The difference between the frequency of the rotating magnetic field and the frequency equivalent to the speed of rotation is called the slip frequency. The generated torque is proportional to the slip frequency.
The structure of a three-phase induction motor is simple and sturdy. Because it is easy to use for large power motors and has relatively good efficiency, it is often used in industrial segments. However, due to the aforementioned slip frequency, it is unsuitable for position control. In many cases, the three-phase alternating-current used at factories and so on is input directly to drive the motor at a constant

speed. For adjustable-speed energy-saving applications which value efficiency, the motor can be inverter driven to control torque.

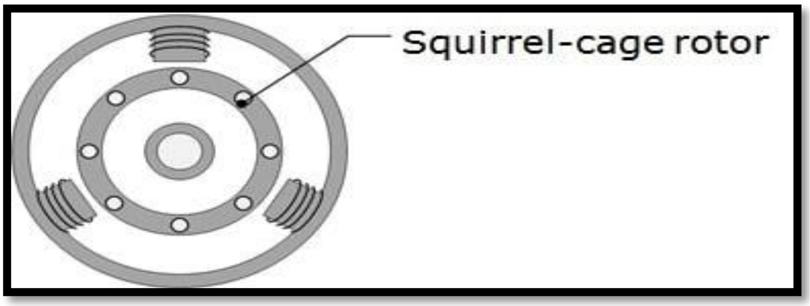


Figure 3.12 These-Phase Induction Motor

□ **Single-Phase Induction Motor (Universal Motor)**

Single-phase induction motors are a type of induction motor which as the name implies operate on a single-phase alternating-current power source. Since self-starting is not possible with single-phase alternating current, the motor needs a way to start.

Single-phase induction motors can be divided into the following three main types, depending on the way they start.

Capacitor: A capacitor splits phases to produce a two-phase alternating current to obtain a starting torque.

Split Phase: A starter coil with low inductance is used to obtain a starting torque.

Shaded Pole: A shaded pole produces an induced current, which is used to obtain a starting torque.

In many cases, the single-phase alternating-current used in homes and so on is input directly to drive the motor at a constant speed. The AC voltage phase can be controlled using a triac to control the speed of rotation.

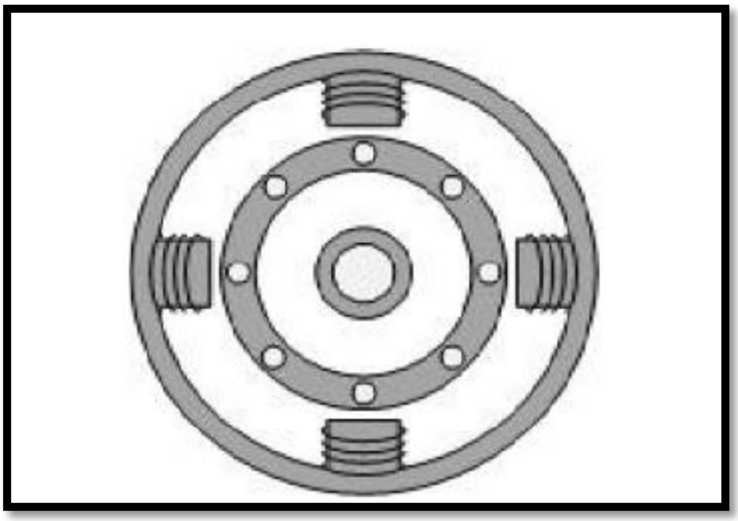


Figure 3.13 Single Phase Induction Motor

3.4. Propellers

Here in this project quadcopter there arises the need of two types of propellers to need the purpose of flight. A pair of clockwise (CW) and anticlockwise (ACW) propellers are needed.

The care should be taken in finalizing the dimensions of the propellers.

A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the air foil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade. Propeller dynamics can be modelled by both Bernoulli's principle and Newton's third law. A marine propeller is sometimes colloquially known as pitch of the screw. Generally, increased propeller pitch and length will draw more current. Also the pitch can be defined as the travel distance of one single prop rotation. In a nutshell, higher pitch means slower rotation, but will increase your vehicle speed which also use more power.

When deciding on length and pitch, you need to find a good balance. Generally a prop with low pitch numbers can generate more torque. The motors don't need to work as hard so it pulls less current with this type of prop. If you want to do acrobatics, you will need torque propellers which provide more acceleration and it puts less pressure on the power system.
Lower pitch propellers will also improve stability.

A higher pitch propeller moves greater amount of air, which could create turbulence and cause the aircraft to wobble during hovering. If you notice this with your quadcopter, try to choosing a lower pitched propeller.

When it comes to the length, propeller efficiency is closely related to the contact area of a prop with air, so a small increase in prop length will increase the propeller efficiency. (Pretty much like swimmers with larger hands and feet can swim faster, but also more tiring for them)

Figure 3.14 Propellers

3.5. Fly sky Transmitter and Receiver

Fly sky Transmitter and Receiver which we are using is CT6B which has 6 channels. It Requires a PC to change the channel variables, mixing and servo reversing. The radio transmitter and receiver allow you to control the quadcopter. There are many suitable models available, but you will need at least four channels for a basic quadcopter with the KK2.1.5 control board. In electronics and telecommunications a radio transmitter is an electronic device which, with the aid of an antenna, produces radio waves.

Transmitter

The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves. The term transmitter is usually limited to equipment that generates radio waves for communication purposes; or radiolocation, such as radar and navigational transmitters. A transmitter can be a separate piece of electronic equipment, or an electrical circuit within another electronic device. A transmitter and receiver combined in one unit is called a transceiver.

The purpose of most transmitters is radio communication of information over a distance. The information is provided to the transmitter in the form of an electronic signal, such as an audio (sound) signal from a microphone, a video (TV) signal from a TV camera, or in wireless networking devices a digital signal from a computer. The transmitter combines the information signal to be carried with the radio frequency signal which generates the radio waves, which is often called the carrier. This process is called modulation. A radio transmitter is an electronic circuit, which transforms electric power from a battery or electrical mains into a radio frequency alternating current, which reverses direction millions to billions of times per second. The energy in such a rapidly reversing current can radiate off a conductor (the antenna) as electromagnetic waves (radio waves).

Receiver:

A radio receiver is an electronic circuit that receives its input from an antenna, uses electronic filters to separate a wanted radio signal from all other signals picked up by this antenna, amplifies it to a level suitable for further processing, and finally converts through demodulation and decoding the signal into a form usable for the consumer, such as sound, pictures, digital data, measurement values, navigational positions, etc. The receiver is the receiving end of a communication channel. It receives decoded messages/information from the sender, who first encoded them. Sometimes the receiver is modelled so as to include the decoder. Real-world receivers like radio receivers cannot be expected to receive as much information as predicted by the noisy channel coding theorem.

In the given figure below

Right Stick:

The right stick controls roll and pitch. In other words, it moves your quadcopter left/right and backwards/forwards.

Left Stick:

The left stick controls yaw and throttle. In other words, it rotates your quadcopter clockwise or counter clockwise, and it adjusts the height at which you are flying

Figure 3.15 Fly transmitter and receiver –CT6B

When you first push your throttle to get your quadcopter off the ground, you may notice that the UAV automatically tilts and flies to one direction (or multiple). This happens when the controls are unbalanced. To balance them out, certain controls need to be trimmed.

Specifications

- Channels: 6channels
- Model type: Heli, Airplane, Glider
- RF power: less than 20db
- Modulation: GFSK
- Code type: PCM
- Sensitivity: 1024
- Low voltage warning: LED warning
- DSC port: yes
- Charger port: yes
- Power: 12V DC(1.5AAA*8)
- Weight:680g
- ANT length:26mm

3.6. Arduino Uno

Arduino is a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller based kits for building digital devices and interactive objects that can sense and control physical devices.

These systems provide sets of digital and analog I/O pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++.

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, 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.

Types of Arduino Boards:

1. Arduino Uno
2. Arduino Mega
3. Arduino Mega ADK
4. Arduino Pro
5. Arduino Ethernet
6. Arduino Zero
7. Arduino Due
8. Arduino Genuino
9. Arduino Yun
10. Arduino Leonardo

11. Arduino Fio

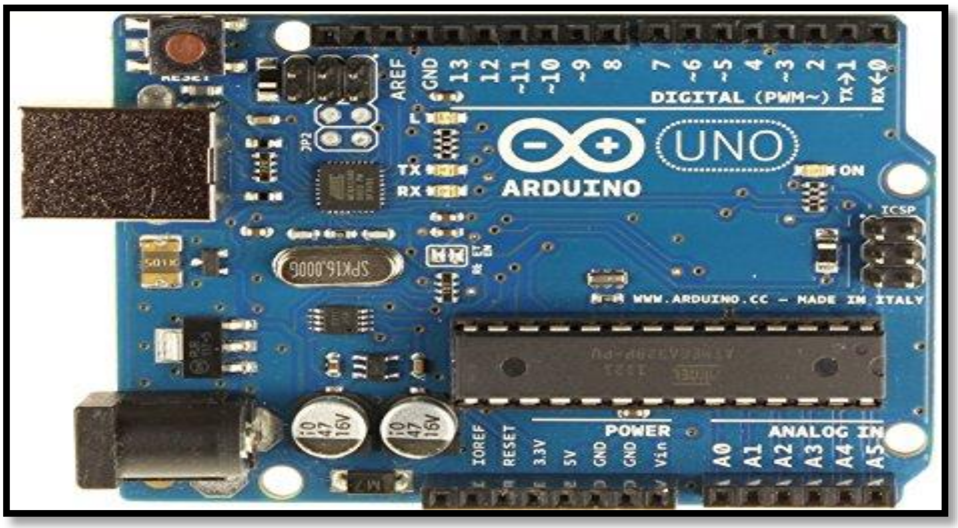


Figure 3.16: Arduino Uno

3.7. LIPO Battery

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated variously as LiPo, LIP, Li-poly and others), is a rechargeable battery of lithium-ion technology in a pouch format. Unlike cylindrical and prismatic cells, LiPos come in a soft package or pouch, which makes them lighter but also less rigid.

Quadcopters typically use LiPo batteries which come in a variety of sizes and configurations. We typically use 3S1P batteries, which indicates 3 cells in parallel. Each cell is 3.7 volts, so this battery is rated at 11.1 volts. LiPo batteries also have a C rating and a power rating in mAh (which stands for milliamps per hour). The C rating describes the rate at which power can be drawn from the battery, and the power rating describes how much power the battery can supply. Larger batteries weigh more so there is always a trade-off between flight duration and total weight. A general rule of thumb is that doubling the battery power will get you 50% more flight time, assuming your quadcopter can lift the additional weight.

Li Po batteries have three main things going for them that make them the perfect battery choice for RC planes and even more so for RC helicopters over conventional rechargeable battery types such as NiCad, or NiMH.

- Li Po batteries are light weight and can be made in almost any shape and size.
- Li Po batteries have high discharge rates to power the most demanding electric motors.
- Li Po batteries hold lots of power in a small package

Just as with other lithium-ion cells, LiPos 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.

Unlike lithium-ion cylindrical and prismatic cells, which have a rigid metal case, LiPo cells have a flexible, foil-type (polymer laminate) case, so they are relatively unconstrained. By themselves the cells are over 20% lighter than equivalent cylindrical cells of the same capacity.

Being lightweight is an advantage when the application requires minimum weight, such as in the case of radio controlled models. However, it has been investigated that moderate pressure on the stack of layers that compose the cell results in increased capacity retention, because the contact between the components is maximized and delamination and deformation is prevented, which is associated with increase of cell impedance and degradation.

Figure 3.17: Lipo Battery 3000 mAh 11.1 v

Chapter 4

Project Description

4.1 Principle of Operation

Frame principle: Frame is the structure that holds all the components together. The Frame should be rigid, and be able to minimize the vibrations coming from the motors. Quadcopter frame consists of two to three parts which don’t necessarily have to be of the same material:

- The centre plate where the electronics are mounted
- Four arms mounted to the canter plate
- Four motor brackets connecting the motors to the end of the arms

Most available materials for the frame are:

- Carbon Fibre
- Aluminium
- Wood, such as Plywood or MDF (Medium-density fibre board)

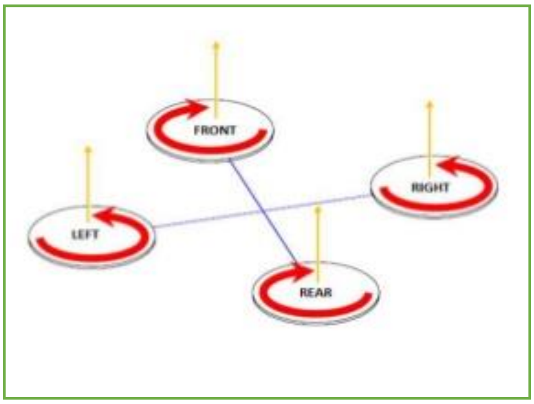
Carbon fibre is most rigid and vibration absorbent out of the three materials but also the most expensive.

Hollow aluminium square rails are the most popular for the Quadcopters’ arms due to its relatively light weight, rigidness and affordability. However aluminium could suffer from motor vibrations, as the damping effect is not as good as carbon fibre. In cases of severe vibration problem, it could mess up sensor readings.

Wood board such as MDF plates could be cut out for the arms as they are better at absorbing the vibrations than aluminium. Unfortunately the wood is not a very rigid material and can break easily in Quadcopter crashes.

As for arm length, the term “motor-to-motor distance” is sometimes used, meaning the distance between the centres of one motor to that of another motor of the same arm in the

Quadcopter terminology. The motor to motor distance usually depends on the diameter of the propellers. To make you have enough space between the propellers and they don’t get caught by each other



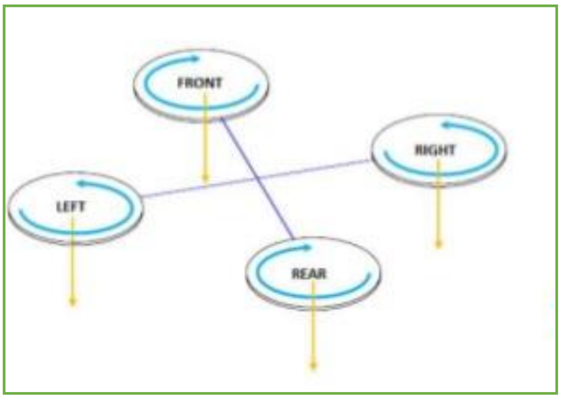


Figure 4.1: Take off Motion

Figure 4.2: Landing Motion

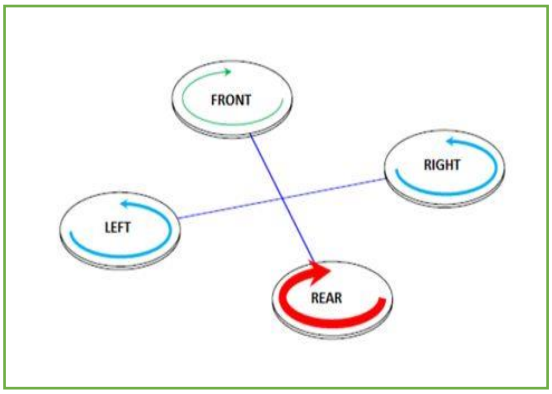


Figure 4.3: Forward Motion

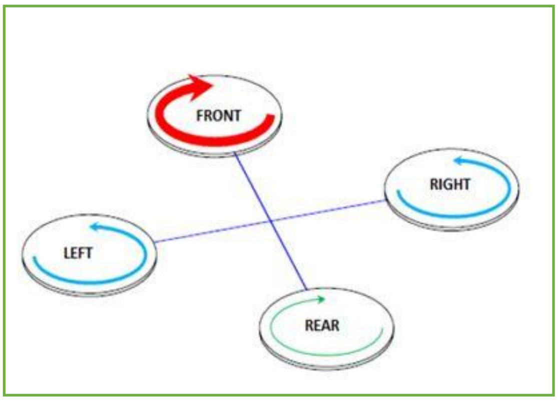


Figure 4.4: Back ward Motion

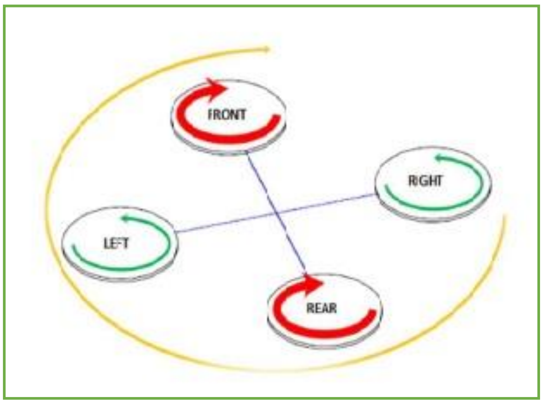


Figure 4.5: Right Motion

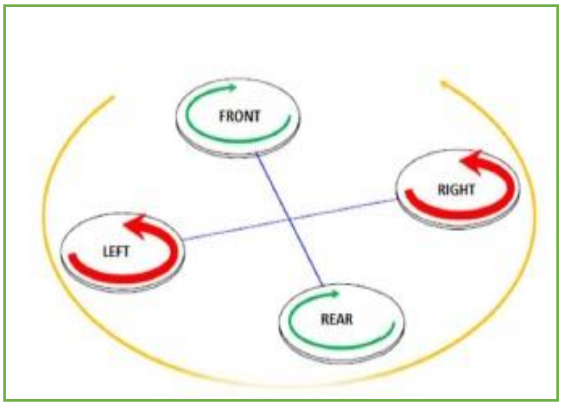


Figure 4.6: Left Motion

4.1.1 Flying Principle

A propeller is a type of fan that transmits power by converting motion into thrust. Propeller dynamics can be modelled by both Bernoulli's principle and Newton's third law. **Principle and Working**

The principle and working of a propeller is based on Bernoulli's Principle and Newton's Third Law Bernoulli's principle states that for an inviscid flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. Newton's third law states that every action has an equal and opposite reaction.

An aero foil of a propeller is shaped so that air flows faster over the top than under the bottom. There is, therefore, a greater pressure below the aero foil than above it. This difference in pressure produces the lift. Lift coefficient is a dimensionless coefficient that relates the lift generated by an aerodynamic body such as a wing or complete aircraft, the dynamic pressure of the fluid flow around the body, and a reference area associated with

4.1.2 Mechanism

Quadcopter can be described as a small vehicle with four propellers attached to the root located at the cross frame. This aim for fixed rotors is used to control the vehicle motion. The speeds of these four rotors are independent. By independent pitch, roll and yaw attitude of the vehicle can be controlled easily. Pitch, roll and yaw attitude of Quadcopter.

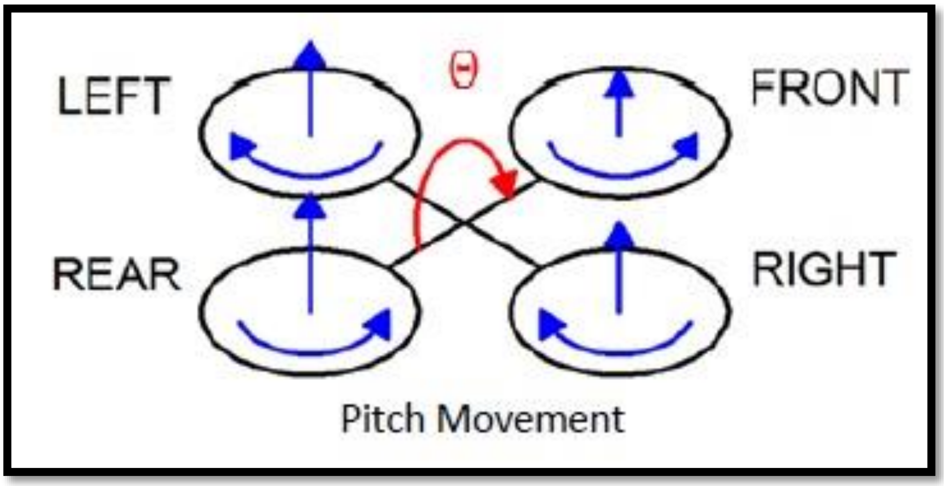


Figure 4.7: pitch direction

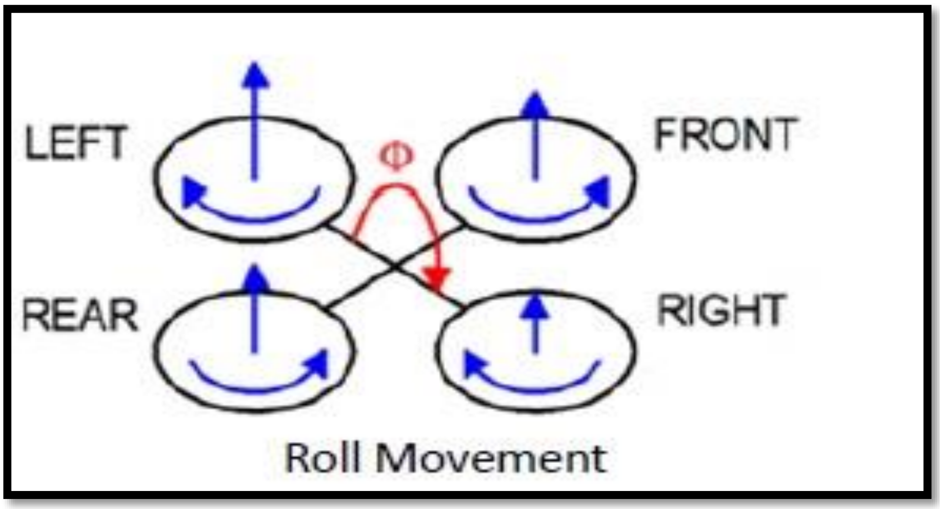


Figure 4.8: Roll direction

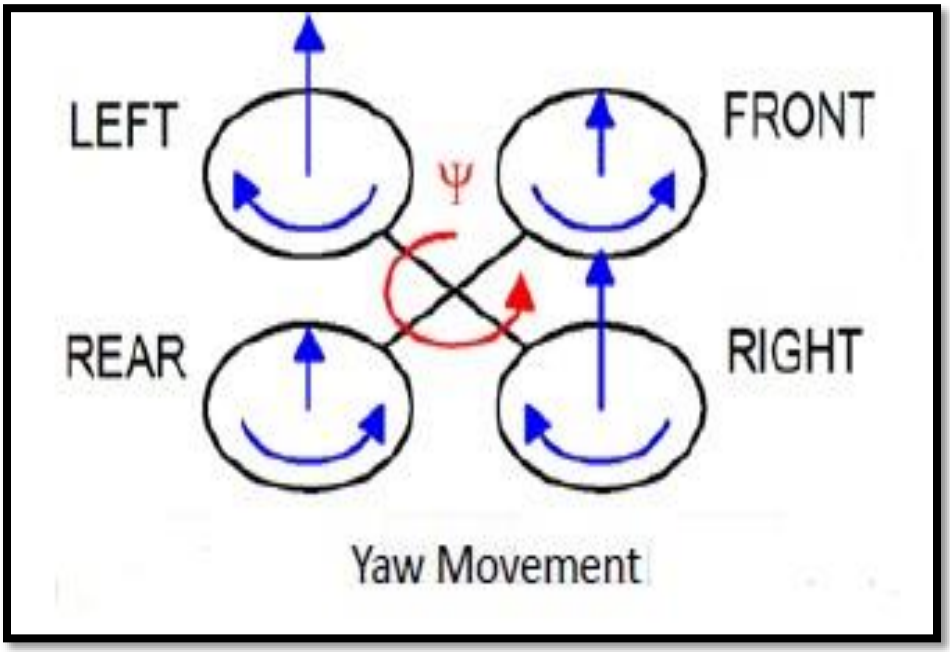


Figure 4.9: Yaw direction

4.1.3 Taking-off and landing motion mechanism

Quadcopter can be described as a small vehicle with four propellers attached to the root located at the cross frame. This aim for fixed rotors is used to control the vehicle motion.

The speeds of these four rotors are independent. By independent pitch, roll and yaw attitude of the vehicle can be controlled easily. Pitch, roll and yaw attitude of Quadcopter.

Hovering or static position. The hovering or static position of the Quadcopter is done by two pairs of rotors, by rotating in clockwise or counter-clockwise respectively with the same speed. By two rotors rotating in clockwise and counter-clockwise position, the total sum of reaction torque is zero and this allows the Quadcopter to be in a hovering position.

Forward and backward motion

Forward (backward) motion is controlled by increasing (decreasing) speed of rear (front) rotor. Decreasing (increasing) rear (front) rotor's speed simultaneously will affect the pitch angle of the Quadcopter.

Left and right motion

For left and right motion, it can be controlled by changing the yaw angle of the Quadcopter.

Yaw angle can be controlled by increasing (decreasing) counter-clockwise rotors speed while decreasing (increasing) clockwise rotor speed.

4.1.4 Processing of Receiving Signal

Modulation Technique in Quadcopter:

Pulse Width Modulation

Pulse width modulation is a way of simulating an analog output by varying HIGH and LOW signals at intervals proportional to the value. Width of each pulse varies according to the amplitude of the analog signal.

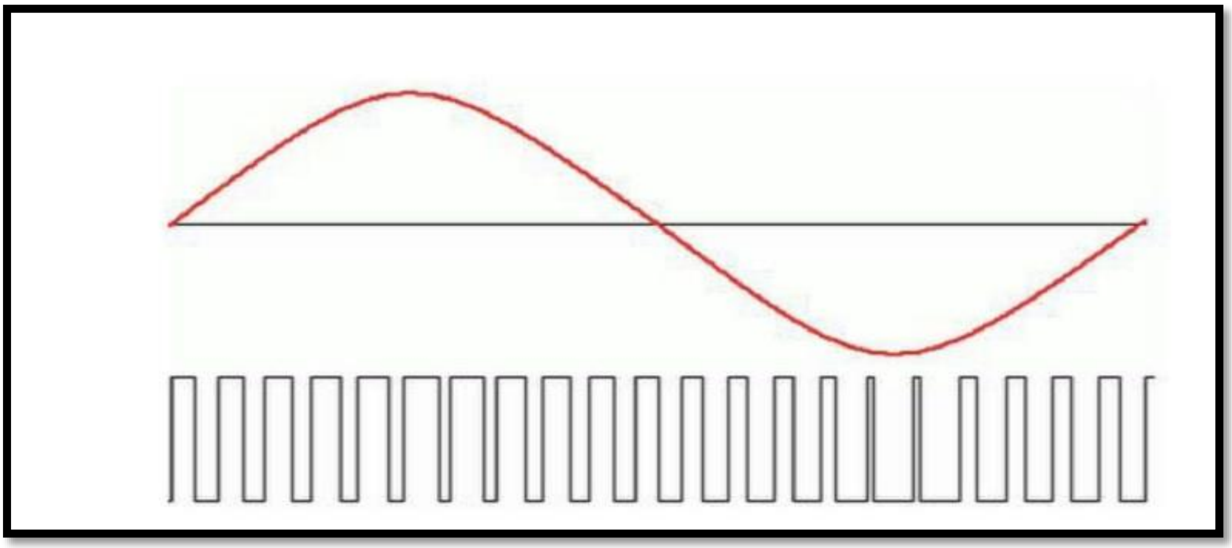


Figure 4.10: Pulse width Modulation

Pulse Position Modulation

Pulse-position modulation is a form of signal modulation in which M message bits are encoded by transmitting a single pulse in one of 2M possible time-shifts. This is repeated every T seconds, such that the transmitted bit rate is M/T bits per second.

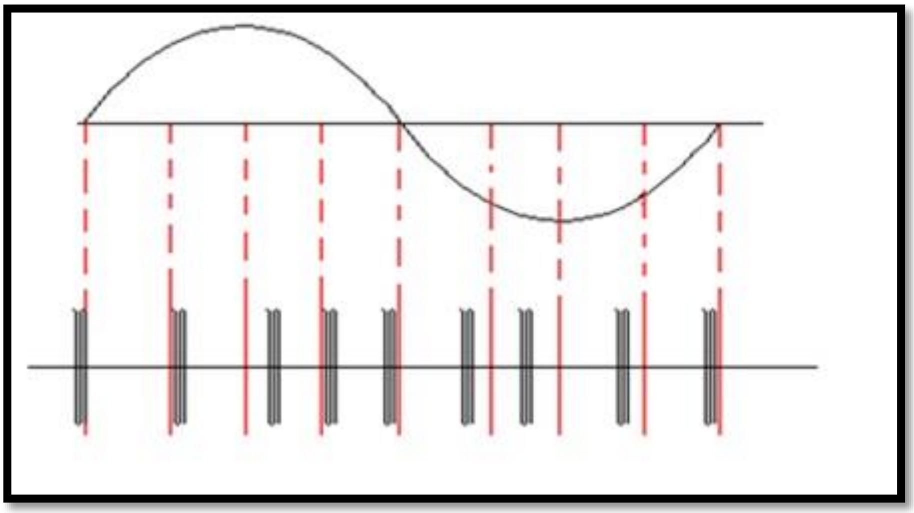


Figure 4.11: Pulse Position Modulation

PWM to PPM conversion

Pulse position modulation (PPM) is a pulse modulation technique that uses pulses that are of uniform height and width but displaced in time from some base position according to the amplitude of the signal at the instant of sampling. PWM refers to a pulse width modulation signal, where the width of each pulse changes according to the amplitude of an analog signal. PPM on the other hand refers to a pulse position modulation signal, where the width of each pulse remains the same, but each pulse is displaced by a certain position based on the analog signal amplitude. The basic need for conversion of a PWM signal received from a transmitter into a PPM signal arises due to the fact that the main controller board used (Arduino) on a Quadcopter can't process a PWM signal and hence a converter is required to convert a PWM signal to a PPM signal.

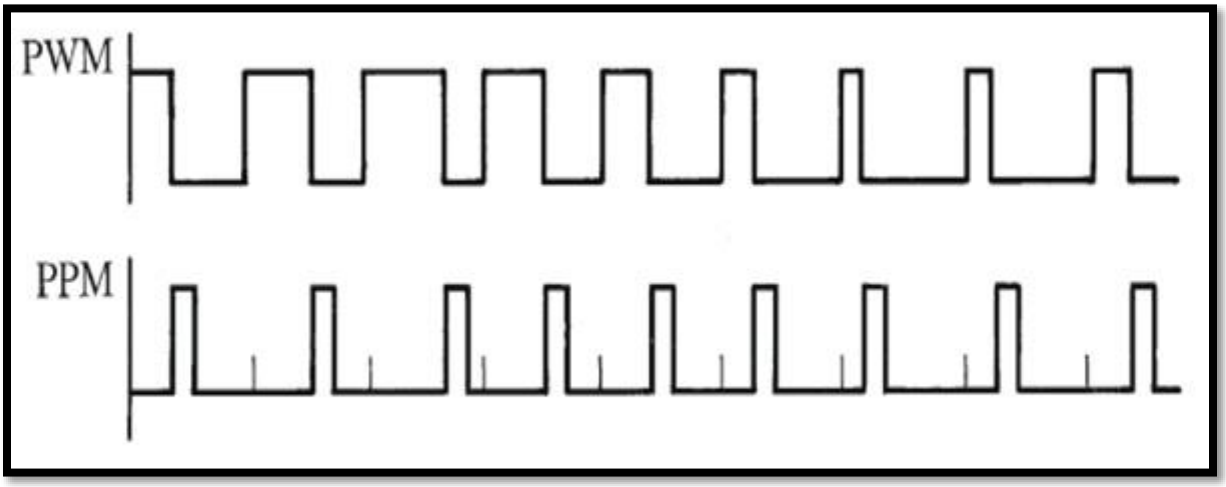


Figure 4.12: PWM to PPM conversion

4.2 Software Analysis

In this project we are using Arduino and Digital Radio Software

4.2.1 Arduino Analysis

In the project the program is dumped to the controller through Arduino. Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

4.2.2 Digital Radio Software

This is the software which is used to set PID Control Settings. Here we can set the different channels to be used for Radio transmitter and Receiver. Model that is used is MODEL-2. Different types of settings are available as:

1. ACRO
2. HELI-120
3. HELI-90
4. HELI-140

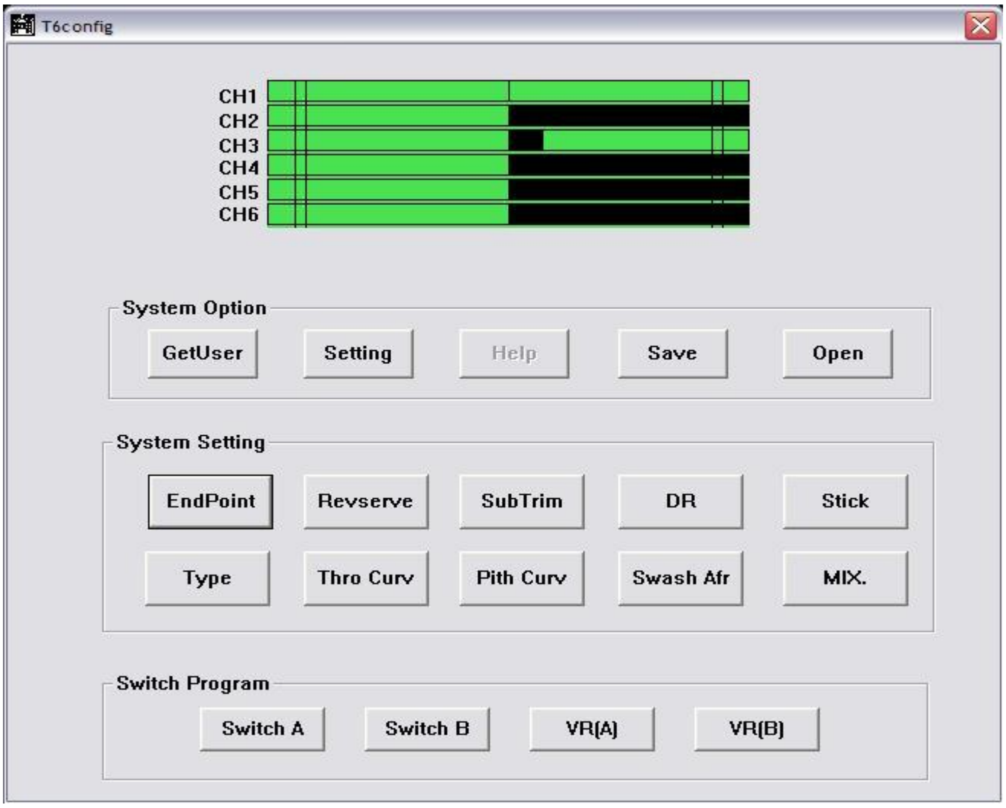


Figure 4.13: Digital Radio Software

4.3 Hardware Analysis

There are different steps to be followed in this analysis.

1. Assembling of Frame
2. Soldering for Chassis
3. Connection of ESC'S
4. Fixing of Brushless motors
5. Propellers fixing
6. Attachment of Flight controller KK2.1.5
7. Synchronization of Transmitter and Receiver
8. Checking receiver test and calibration
9. Adjusting the receiver parameters to IDLE
10. Testing the Quadcopter
11. Arduino with CO2 Sensor and GSM-900A module

4.3.1 Frame

Quadcopter frame can be called as the chassis of the quadcopter. The frame can be achieved in different configurations such as +, X, H, etc.…the selection of the frame is totally a user defined choice based on his own purposes.

We used HJ 450 Frame. FlameWheel450 (F450) is a multi-rotor designed for all pilots for fun. It can achieve hovering, cruising, even rolling and other flight elements. It can be applied for entertainment, aerial photography, FPV and other aero-modelling activities.

When flying, the fast rotating propellers of FlameWheel450 will cause serious damage.

Safety precautions to be taken are:

1. Keep flying multi-rotor away from objects, such as obstacles, human beings.
2. Do not get close to or even touch the working motors and propellers, which will cause
1. Serious injury.
2. Do not over load the multi-rotor.
3. Check that the propellers and the motors are installed correctly and firmly before flight.
4. Make sure the rotation direction of each propeller is correct
5. Check whether all parts of multi-rotor are in good condition before flight. Do not fly with old or broken parts.
6. Use DJI parts as much as possible.

Figure 4.14: HJ-450 4 axis Frame

4.3.2 Soldering

Chassis which is inbuilt with HJ-450 frame has to be soldered for connecting ESC’S. Chassis works as a PCB printed Board for power supply.

We have used Insulating material for soldering. While soldering we must make sure that there is no open or close circuit.

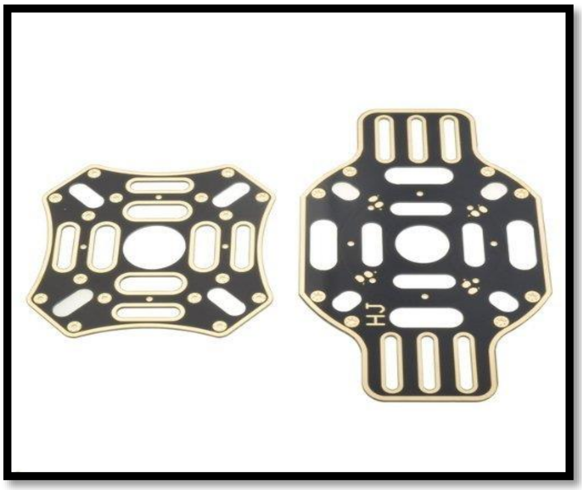


Figure 4.15: Chassis

4.3.3 Connection of ESC'S

After Soldering is done 4 ESC'S has to be connected to Chassis of HJ-450 frame. Proper Care should be taken so as not to get short circuit.

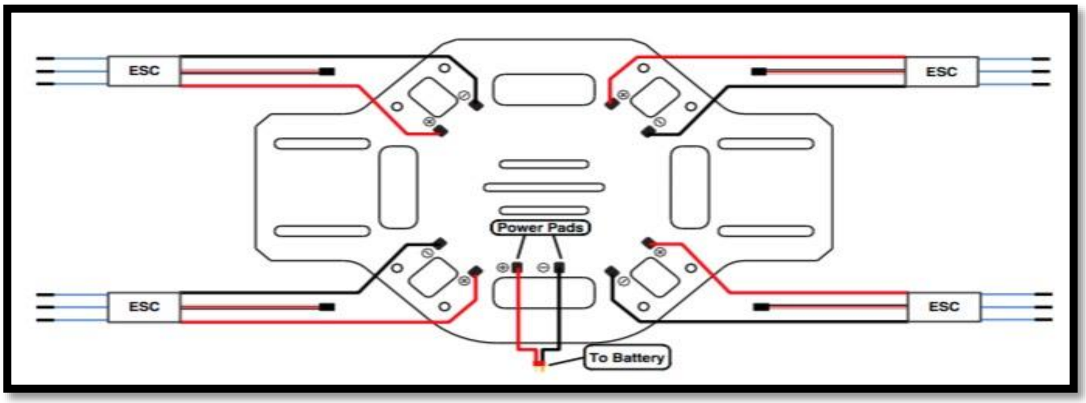


Figure 4.16: ESC Wiring

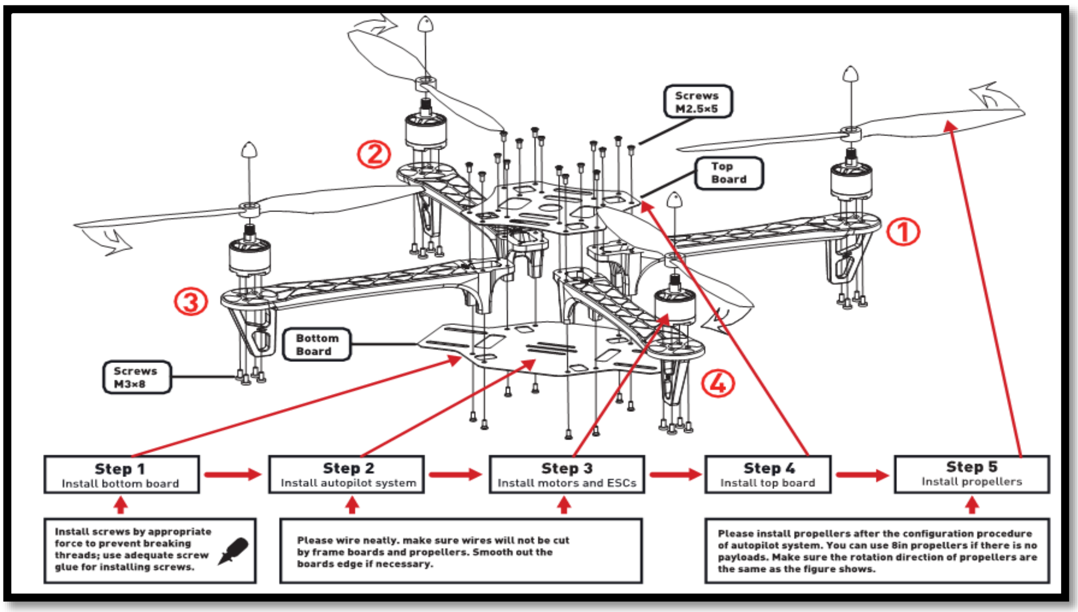


Figure 4.17: over View of HJ 450

4.3.4 Fixing of Brushless motors

After fixing of ESC'S we need to attach 4 brushless motors of 1200 kv each. Attachment of Brushless motor to ESC'S is to be done carefully so as not to get burst of winding. The three bullets which are attached to brushless motor is to be connected with ESC'S.

Figure 4.18: Brushless DC motor 1200 kv

4.3.5 Fixing of Propellers

After attaching brushless DC motors we need to 4 propellers. Two of them in clockwise and two of them in counter clock wise direction.

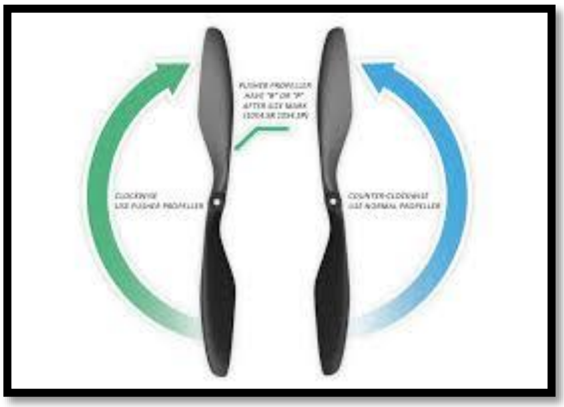


Figure 4.19: Propellers

4.3.6 Synchronization of Transmitter and Receiver

Receiver which is connected to Flight controller has to be synchronized with transmitter fly sky-CT6B.

Receiver has six channels and BAT. Each has three pins as:

1. Signal
2. Ground
3. Supply

Dummy Wire has to be connected to BAT Of Signal and Supply. After connecting it has to be synchronized with transmitter by pressing the BEEP button present. Along with it any one of the four ESC'S has to be connected to any of the channel present in the receiver.

4.3.7 Receiver Test

Once it is synchronized, in the flight control board the receiver parameters will start changing according to adjustment in the fly sky transmitter-CT6B.

- Aileron
- Elevator
- Throttle
- Rudder
- AUX

4.3.8 Receiver Parameters Set to IDLE

Once receiver test is performed, all the receiver parameters has to be set to IDLE for proper configuration. That means all parameters must be set to Zero.

4.3.9 Testing

after all the operations are performed, transmitter should be on and then moving the throttle up and down for about 3 times and then moving left to right, will make the flight controller to change to ARMED state and hence quadcopter hover the skies.

4.4 Static 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 Quadcopter are more likely to perform at low speeds relative to the earth. 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. To calculate power, 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:

$$Power = 0.015 \times 10^{3.2} = 24\ W.$$

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

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

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.

$$T = \frac{\pi}{4} D^2 p v (\Delta v)^2 \qquad (3)$$

Equation 4 gives the power that is absorbed by the propeller fr om 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.

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

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

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

$$where\ \mathcal{G} = 9.81\, m/s^2$$

Solving for mass is useful for Quadcopter 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.

4.5 Trouble shooting of the project and Difficulties Faced

We faces several problems through the journey of making this project which demanded our proper attention towards the project. Some of them are discussed in this section.

- Arming the motors
- Building the frame
- Interfacing of the board
- Achieving the stability

Arming the motors:

We are not aware of arming the motors and how to do it at the initial stage of the project and for this reason we ended up with an ideal copter without any response on throttle. So we went looking back on our work and found no troubles. After watching several videos from internet we came to learn about the process of arming and the problem is solved.

Building the frame:

Several hurdles are passed in building the frame for achieving the center of gravity, center of mass at the desired positions designed. The problem faced even in selecting the material for building the frame. When we went on building the frame using balsa wood we ended up with a hung frame on mounting the frames. So made some research and finally decided to build frame using Al foils.

Interfacing the board:

To program the board as per our purpose we need to interface it to the PC which needs a cable and a burner. In the beginning we were in search of board drivers and ended up with an error message on PC. After looking through the manual properly we understood about looking for the drivers of burner instead of board, problem solved.

Achieving the stability:

Once we were ready with our drone we started to take trials and we ended up with unstable flight which kept went around without giving any directional inputs other than throttle this is the major problem that we were stuck with. So we looked back on shifting the weights on frame and taking trial and from each trial we used to take feedback of the performance and after such several trials we were able to achieve up to the mark.

4.6 Disadvantages

1. **Limited Abilities:** Drones have obvious limitations. For example, they cannot communicate with civilians for more detailed intelligence. Drones cannot capture surrendering military personnel, abandoned hardware, or military bases. Drones cannot go from door to door, at least, not yet.
2. **Civilian Losses:** Drone warfare often causes collateral damages in civilian lives and property, as well as traditional warfare too.
3. **Counterproductive and Destabilizing:** Civilian opinions about drones are typically negative, since they are viewed as an invasion force. The mere presence of drones has been known to convert civilians into military combats. Furthermore, when drones cause collateral damage, such as killing civilians and damaging civilian property, the opinions of civilians decrease even more so. Additionally, some cultures believe the use of drones as not brave and cold hearted. As a result, drones are sometimes counterproductive by more destabilizing some regions.
4. **Too Easy:** By making drone warfare very similar to video games, drone warfare makes combat too easy by diminishing ethical decisions.
5. **Work and Personal Life Balance:** Some drone pilots or operators have difficulty switching between combat mode at work and civilian mode while not working. This is especially difficulty when drone pilots have minimal transition periods between work and personal, if any at all.
6. **Take Over:** Finally, the worst case scenario is when drones or a fleet of drones have been commandeered or taken control by the enemy. While security measures help make this possibility more difficult, it will never be impossible.

Chapter 5

Project Overview

5.1 Software Used

Many companies provide the Arduino, some of them provide shareware version of their product on the Web. We can download them from their Websites. However, the size of code for these shareware versions is limited and we have to consider which assembler is suitable for our application.

5.2 Arduino

The Arduino Integrated Development Environment - or Arduino Software (IDE)- contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

5.2.1 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 right-hand 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.

5.2.2 Sketch Book

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog.

5.2.3 Tabs, Multiple Files, and Compilation

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

5.2.4 Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Key span USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the File menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino bootloader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The bootloader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

5.2.5 Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu.
This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager.
Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch.

5.2.6 Boards

The board selection has two effects: it sets the parameters (e.g. CPU speed and baud rate) used when compiling and uploading sketches; and sets and the file and fuse settings used by the burn bootloader command. Some of the board definitions differ only in the latter, so even if you've been uploading successfully with a particular selection you'll want to check it before burning the bootloader.

5.2.7 Steps for Writing Program Code

STEP 1

Arduino microcontrollers come in a variety of types. The most common is the Arduino UNO, but there are specialized variations. Before you begin building, do a little research to figure out which version will be the most appropriate for your project.

STEP 2

To begin, you'll need to install the Arduino Programmer, aka the integrated development environment (IDE).

STEP 3

Connect your Arduino to the USB port of your computer. This may require a specific USB cable. Every Arduino has a different virtual serial-port address, so you'll need to reconfigure the port if you're using different Arduinos.

STEP 4

Set the board type and the serial port in the Arduino Programmer.

STEP 5

Test the microcontroller by using one of the preloaded programs, called sketches, in the Arduino Programmer. Open one of the example sketches, and press the upload button to load it. The Arduino should begin responding to the program: If you've set it to blink an LED light, for example, the light should start blinking.

STEP 6

To upload new code to the Arduino, either you'll need to have access to code you can paste into the programmer, or you'll have to write it yourself, using the Arduino programming language to create your own sketch. An Arduino sketch usually has five parts: a header describing the sketch and its author; a section defining variables; a setup routine that sets the initial conditions of variables and runs preliminary code; a loop routine, which is where you add the main code that will execute repeatedly until you stop running the sketch; and a section where you can list other functions that activate during the setup and loop routines. All sketches must include the setup and loop routines.

STEP 7

Once you've uploaded the new sketch to your Arduino, disconnect it from your computer and integrate it into your project as directed.

5.3 Applications

5.3.1. Civil and commercial applications

- **Pick and drop**

This is the modern era application of drones, they can carry weights up to certain limit and delivery them to the destination. Best example amazon and DHL are considering drone based delivery services for their products

Figure 5.1 Pick and drop Quadcopter

- **Toys for children**

Micro or mini drones are specially designed for kids that are easy to control and use.

- **Air inspection**

Drones are used in aircraft companies in inspecting the aircraft before takeoff & landing

Figure 5.2 Air Inspection Quadcopter

- **Communication Purpose**

Now a days drones are used for Telecom relay and signal coverage survey.

- **Aerial Photography**

This application is widely used now a days. Music concerts or any functions where there is a large gathering of people, they can be photographed using aerial only.

Figure 5.3 Aerial Quadcopter

- **Ambulance Drone**

Ambulance drones was implemented successfully in Finland, these drones carry the equipment necessary for emergency condition. The basic fir aid kit will also be present in this drone.

Figure 5.4 Ambulance Quadcopter

5.3.2. Military Applications

- Tracking
- Drones with the help of gps can track particular person or vehicle movement.
- Identifying enemy movements
- In search and rescue operations
- Many military operations uses drones for live coverage of the mission .Rescuing hostages and civilians is the main objectives of these operations. Drones are used to check the condition of the hostages
- Video surveillance

5.3.3. Environmental Applications

- Fire Control

Figure 5.5 Fire Control Quadcopter

Fires caused in forests due to various reasons are very difficult to control. These can be controlled effectively by means of drone. Drones will carry water of some sort of solutions. Drone installed with gas sensors helps to detect the amount of gases present in the particular area in the atmosphere. These figures can be stored in the memory card or send to us by using gsm module. For using gas sensors we need to use Arduino for interfacing.

- wild life surveillance

Many wild life species are going to extinct now a days due to radiation, hunters etc. .this can be prevented by tracking and surveillance of wild life animals.

5.3.4. Industrial Applications

- Inspection in areas where humans can't go
- Spotting leakages
- Construction/Surveying

5.3.5. Agriculture Applications

- Pesticide springer

The revolutionising concept of drone farming was being developed in many countries in which drones with the help of sprinklers sprinkle the pesticide in the fields and also used for video surveillance of the fields.

Figure 5.6 Agriculture Quadcopter

5.3.6. Recent Real time Applications

- Indian army develops 'Netra' UAV against terrorists

The 1.5 kg UAV, called 'Netra', is a collaborative development project between idea Forge, a company formed by a group of Indian Institute of Technology, Powai, alumni and one of Defence Research and Development Organization’s Pune-based labs, Research and Development Establishment (Engineers) (R&DE) Pune.

- An EYE in the sky during the Jharkhand flood

An ultrasonic human detection camera was used to find the bodies of the people under the buildings and mud

5.4 Limitations

They do however, have a few disadvantages. Not having a pilot on board means that human intuition is lost which can sometimes be a helpful tool in a number of the UAVs uses.

Also in warfare, not being on the aircraft and seeing the destruction and killing first hand has been argued to desensitize the UAV operators as they see people only as a blip on a screen and therefore can become ‘trigger happy’ and not worry so much about the civilian casualties. ‘Analysis by an American think tank The Brookings Institution on drone attacks in Pakistan has shown that for every militant leader killed, 10 civilians also have died. Keith Shurtleff, an army chaplain and ethics instructor at Fort Jackson, South Carolina worries “that as war becomes safer and easier, as soldiers are removed from the horrors of war and see the enemy not as humans but as blips on a screen, there is very real danger of losing the deterrent that such horrors provide.”

5.5 Modifications

Other plans in the future include adding a sonic sensor for more accurate altitude determination.
Currently the only methods to determine altitude is by using the barometric pressure sensor and the GPS receiver. There is no actual way to safely determine the quadcopters altitude relative to its landing surface. A sonic sensor could solve this problem, and be used to help aid the auto landing command. Another modification can be done by adding more methods of collecting data. Many ports still remain unused on the control board. Adding a camera could allow for digital photo or video to be taken. Adding some way to stream data from the quadcopter to the controller could be another great feature to add to our quadcopter, this would allow for even easier access to the data collected by the quadcopter. Smart phone capabilities could be another feature our group may want to add in the future.

Chapter 6

Result and Conclusion

6.1 Result Analysis

After configuring all the parts, assembling as required, configuring Software, finally we obtained our quadcopter which is shown below. We need to test the Acceleration Calibration every time when we change the ground surface area.

Figure 6.1: Quadcopter

Figure 6.2: Quadcopter

Figure 6.3: Quadcopter along with transmitter

6.2 System Verification and Testing

In this section of the document we will be discussing the methods we used to test each component of our quadcopter, the problems we faced, and how we solved them.

Testing

6.3 Conclusion

As per the design specifications, the quad copter self stabilizes using the array of sensors integrated on it. It attains an appropriate lift and provides surveillance of the terrain through the camera mounted on it. It acts appropriately to the user specified commands given via a remote controller .Its purpose is to provide real time audio/video transmission from areas which are physically in-accessible by humans. Thus, its functionality is monitored under human supervision, henceforth being beneficial towards military applications. It is easy to manoeuvre, thereby providing flexibility in its movement. It can be used to provide surveillance at night through the usage of infrared cameras. The system can further be enhanced for future prospects. The GPS data logger on the quadcopter stores its current latitude, longitude, and altitude in a comma separated value file format and can be used for mapping purposes. This project required members not only to interface and program the components of the quadcopter, but also exposed them to mechanical components and reality of project management to accomplish the project objectives.

6.4 Future Scope

Future of a quad-copter is quite vast based on various application fields it can be applied to. Quad-copter can be used for conducting rescue operations where it's humanly impossible to reach. In terms of its military applications it can be more widely used for surveillance purposes, without risking a human life. As more automated quad-copters are being developed, there range of applications increases and hence we can ensure there commercialization. Thus quad-copter can be used in day to day working of a human life, ensuring their well-being.

References