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- **BENDJEMAA Radouan**
- **DJELLOUL Abd el Aziz**

Theme

Conception and realization of a drone quad copter

Dr. BEDHIAF Yassin	MCA to University of Khenchela	President
Mr. SAIDI Abdelkader	MAA to University of Khenchela	Framed
Dr. LAABDANI Rafik	MAA to University of Khenchela	Examiner

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Thanks and gratitude

Praise be to god who enables us to accomplish this humble work.

All thanks and gratitude to the family, which was a source of continuous Strength and Energy and was the first supporter in all circumstances and adversity.

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Dedication

I dedicate this humble work to ***my father*** *Ali (Othman) who left us on 22 April 2020, my hero you held my hand when I was small, you caught me when I fell, you're the hero of my childhood and my later years as well an every time think of you my heart still fills with pride though I'll always miss you dad, I know you're by my side in laughter and in sorrow in sunshine and though rain I know you're watching over me until we meet again in heaven with the prophets and the righteous .*

My mother *is a woman like no other, she gave me life, taught me, dressed me, kissed me, but most importantly loved me unconditionally There are not enough words to describe my mom, I hope that ALLAH will make her lofty like mountains, pure in soul, and ALLAH will grant her everything that her heart desires, and my mother will always and forever remain a crown over my head, and my life will be for her as long as I live.*

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To my loyal friend Cherif Brahimi, the owner of the big skull who has always accompanied me since we studied in high school until today

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With God's help, this dissertation was completed and this humble work was given to my Father and my Mother God and was preserved from all things hated.

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Djelloul abd elazize

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ABSTRACT

This thesis is a complete study of the installation of a quad rotor drone for fire detection. We reached the final model after passing several theoretical and applied experiments. It is a solid carbon fiber structure that is resistant to shocks and high heat. We have also supplied the aircraft with specially designed engines for this type of aircraft as well as a lithium battery that guarantees the maximum flight time required of 15 minutes and after ensuring the perfect flight of the aircraft.

We have added a fire detector and camera to ensure that fires are detected and that real information is transmitted in record time from where the fire occurred.

Résumé

Cette thèse est une étude complète de l’installation d’un drone quadri rotor pour la détection des incendies. Nous avons atteint le modèle final après avoir passé plusieurs expériences théoriques et appliquées. C’est une structure solide en fibre de carbone qui est résistant aux chocs et à la chaleur élevée. Nous avons également fourni à l’avion des moteurs spécialement conçus pour ce type d’avion ainsi qu’une batterie au lithium qui garantit le plus grand temps de vol nécessaire de 15 minutes et après avoir assuré le vol parfait de l’avion.

Nous avons ajouté un détecteur d’incendie et une caméra afin de nous assurer que les incendies sont détectés et que l’information réelle est transmise en un temps record à partir de l’endroit où l’incendie s’est produit.

الملخص

هذه الاطروحة عبارة عن دراسة كاملة لتركيب طائرة مسيرة رباعية مراوح لاستشعار الحرائق وقد توصلنا للنموذج النهائي بعد المرور على عدة تجارب نظرية وتطبيقية وهي طائرة ذات هيكل صلب صنع من الياف الكربون مقاوم للصدمات والحرارة العالية كما زودنا الطائرة بمحركات ذات قوة مصممة خصيصا لهذا النوع من الطائرات إضافة الى بطارية ليثيوم تضمن اكبر وقت لازم من التحليق يبلغ 15 دقيقة وبعد التأكد من الطيران المثالي للطائرة اضفنا حساس حرائق وكاميرا وذلك لضمان استشعار الحرائق وارسال المعلومات الحقيقية في وقت قياسي من مكان وقوع الحريق .

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ABBREVIATIONS

U.A.V	Unmanned Aerial Vehicle
VTOL	Vertical take-off and landing
HALE	height altitude long endurance
MALE	medium altitude long endurance
US	United States
PID	Proportional Integral Derive
RF	Radio Frequency
PWM	Pulse with Modulation
ESC	Electronic Speed Control
PA	Power Amplification
SPI	Serial Peripheral Interface
GFSK	Gaussian frequency Shift Keying
DMP	Digital Motion Processor
Li-Po	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
CC	Constant Curent
CV	Constant Voltage
CW	Clockwise
CCW	Counter clock wise
USB	Universal Serial Bus

SYMBOLES

F	thrust force orce
Ω	Rotation speed in fixed landmark
v	Linear Velocity in Fixed Landmark
R	rotation matrix
T	transformation matrix
ξ	Position vector
ϕ	roll angle
θ	pitch angle
ψ	yaw angle
ω	engine rotation speed
$d\ \omega$	Desired engine speed
ω	error between ω and $d\ \omega$
τ	Engine input torque
u	La control
x	state variable
$d\ x$	desired state
e	tracking error
s	sliding surface
t	time variable
$i\ \lambda$	Sliding surface parameters
V	Function of Lyapunov
$i\ k$	Backstepping design parameters
y	output variable
$r\ y$	desired trajectory
f	default
$a\ f$	Failure of actuator
$s\ f$	Failure of sensor

General Introduction

General Introduction

UAV have taken a great deal of interest in these recent years, and have even polarized major developers and investors. That is because they have become available for civilian use, including in the peasant area, as well as in the insecticide spray, as well as economic uses, such as the transport of Purchases, As far as investment is concerned, it has reserved a leading position to compete with large industrial companies and the market for these aircraft has become a world open to billions of dollars. [1]

Drones are flying robots which incorporate unmanned aerial vehicles (UAVs) that fly thousands of kilometers and little drones that fly in limited spaces Ethereal vehicles that don't carry a human administrator, fly remotely or independently, and carry deadly or nonlethal payloads are considered as drones A ballistic or semi-ballistic vehicle, journey rockets, gunnery shots, torpedoes, mines, and satellites cannot be considered as drones. Propels in manufacture, route, inaccessible control capabilities, and control capacity frameworks have made conceivable the improvement of a wide extend of drones which can be utilized in different circumstances where the nearness of people is troublesome, outlandish, or unsafe [2]. Flying robots for military reconnaissance, planetary investigation, and search-and-rescue have received most consideration within the past few a long time. Depending on the flight missions of the drifts, the degree and sort of presented adapt are diverse. Impressive central focuses of the Depending on the flight missions of the drones, the estimate and sort of introduced gear are different. Considerable preferences of the drones have driven to a bunch of considers to center on the optimization and improvement of the exhibitions of these drones. Agreeing to the said characteristics, drones advantage from the potential to carry out a assortment of operations counting surveillance, watching, security, transportation of loads, and aerology [3]. Drones generally shift regularly in their arrangements by stage and by mission. There are various drone classifications based on distinct parameters, such as a modular and controlled set of stages. They recognized points of interest of each as important to the requests of clients within the logical investigate division. They classified the drones' stages for gracious logical and military employments based upon characteristics, such as estimate, flight continuance, and capabilities. In their drones' classifications, they classified them as MAVs (Small scale or Smaller than expected Discuss Vehicles), NAVs (Nano Discuss Vehicles), VTOL (Vertical Take-Off & Landing), LASE (Moo Height, Short-Endurance), LASE Near, LALE (Moo Elevation, Long Perseverance), MALE (Medium Elevation, Long Perseverance), and Solidness (Tall Elevation, Long Continuance). In an outline of military rambles utilized by the UK outfitted powers, Brooke-Holland classified drones into three classes. Course I is subdivided into four categories (a, b, c, d). They classified drones as super-heavy with weights more than 2000 kg, overwhelming with weights between 200 kg and 2000 kg, medium with weights between 50 kg and 200 kg, light/mini with weights between 5 kg and 50 kg, and at long last small scale drones with weights less than 5 kg . This classification which is characterized based on drones' weight is appeared in Gupta et al classified drones as Solidness, MALE, TUAV (medium run or strategic UAV), MUAV or Smaller than expected UAV, MAV, and NAV. categorized drones as three fundamental sorts, to be specific, miniaturized scale and scaled down UAVs, strategic UAVs, and key UAVs. He isolated the strategic UAVs into six subcategories: near run, brief run, medium run, long extend, perseverance, and medium height long endurance [4].

In our project, we're going to have to do with arsonists, and before we talk about this, we're going to see the losses caused by the fires in many Algerian states, in particular (Khenchela). Northern Algeria is facing extremely intense fires. Since the fires began, dozens of people have lost their lives. National mourning of three days was decreed by the authorities. And to deal with emergencies, Algerians are organizing. The land is burned as far as the eye can see. In northern Algeria, (Amazigh) is particularly affected by a series of fires. Rescue operations take place day and night in this region located 100 kilometers east of Algiers In just a few days, 42 civilians and 28 soldiers lost their lives according to the government. The region around Tizi-Ouzou paid the highest price. In this territory, the villagers were evacuated in haste, so they did not have time to take away the essentials. To help them, a wave of solidarity was created between Algerians. Water, clothing but also food are collected and distributed by the population. Throughout Algeria, there is great emotion and solidarity. Both collection and distribution videos are broadcast on social networks. For example, in Algiers, young people prepared a truck full of water.

While the country is facing a heat wave, fighting fires is proving difficult because high winds fan the flames. On the investigation side, the authorities say that four "arsonists" were arrested, without further details. And the tension is strong; a young man accused of pyromania was beaten to death. And on the front of the fires, the country has just received the reinforcement of two water bombers rented from the European Union. [5]

The fires that broke out the day before yesterday Sunday, in the forests of Ain Mimoun in Tamza in state of Khenchela, spreading in the forests bordering the Municipality of Chélia and Bouhmama, destroyed nearly 1,500 hectares of plant cover consisting mainly of Aleppo pines, said Tuesday, July 6, the director general of forests, Ali Mahmoudi, quoted this by the official agency APS.

The DGF added that the conservation of the forests of Khenchela is strengthened by five mobile columns of the neighboring states with a total of more than 200 officers equipped with 90 vehicles and tankers, and who contribute alongside the officers of the Emergency Preparedness, workers of the Regional Rural Engineering Company and volunteer citizens to contain the flames in order to control the situation and prevent the spread of the fire to other areas [6]

And as a result of the significant loss of our nation from the fires, we decided to make a drone a quad rotor with a fire sensor and a camera to convey the real picture of where it happened fire plus GPS system to accurately identify site coordinates the drone aircraft will have a light hull and a carbon fibre-manufactured solid as well as powerful speed assurance engines And the persistence and load of the added components is comfortable, as well as a design that's tailored to the conditions you can encounter at a location The accident also has to supply the drone with lithium batteries to ensure longer flight Periodic drone charging stations for permanent search and sensor They may be power plants Solar, wind, or even steam.

We hope that this project will support the State's efforts to protect natural resources and promote programmes to promote forest tourism in our country.

This project is divided into three chapters

First chapter: We know the most important historical stations that drone development has experienced from their use in war to their present form. The most important categories are divided into three sections, in terms of the nature of the wings, in terms of control and vision, as well as in the different uses of military and civilian aircraft. And then we'll get to know the main producers of the most important drones in 2022.

Second chapter: We will see in this section an introduction on Drone quad rotor, then a detailed definition of it, then we will study in detail the movement of Drone in three axes (pitch ,roll ,yaw) We then mathematically model the drone's motion and stability at the base of the Euler and Newton equations. Then we will model the drone on MATLAB and analyze the results.

Third chapter: We make the drone based on careful study to acquire the necessary parts, such as carbon fiber structure and high-performance motors, then we will equip this drone with a highly advanced lithium battery, then we will equip it with a remote control unit by radio control, and after the success in flying the drone, we will provide it with a modern camera that sends video clips in time The real one, in addition to the infrared sensor and the smoke sensor, for the drone can independently and accurately identify fires.

Chapter I

Generalities on drones

I.1 Introduction

The development of drones has gone through several stages throughout history, in line with the objectives laid down, and at the beginning of their manufacture they were intended solely for military use, but over time they have become available in many areas and effectively, and they have been widely deployed in our world today and are even available for personal use.

In this chapter we will present general information about drones which initially include the definition and evolution history of drones over time and wars. Second, we will list the different classifications of drones and their advantages and disadvantages. Finally, we will mention the different areas of use and the laws concerning their civil use.

I.2 Definition of a drone

A drone or U.A.V (Unmanned Aerial Vehicle) is a human unmanned aircraft that can be operated remotely, autonomously or semi-autonomously. It is likely to carry various payloads, making it capable of performing specific tasks, for a flight time that may vary depending on its capabilities. The use of drones was first known in military applications, such as surveillance and reconnaissance and as a target identification platform or weapon. Then, several civil applications became competing, notably in the observation of natural phenomena (Avalanches, volcanoes, etc.), the spraying of pesticides on agricultural surfaces, environmental monitoring (example pollution measurements) and road networks, infrastructure maintenance [7].

I.3 The history of drone development

Prior to the early twenty-first century, it was only utilized for military objectives. This review gathered historical details regarding how the drone industry was developed.

1849. The rebellion in Venice was declared in the wake of the bourgeois revolutions in Austria then they declared independence, the city was besieged from all sides. Artillery was not effective because of good terrain and fortifications. On the gun approach

The concept was proposed by Franz von Eukhatek, an Austrian artillery lieutenant. Balloons are raining down on the city. Bombs were dropped on the besieged city on July 12, 1849. There were shrapnel bombs on board, as well as mechanisms for dropping them in time. The bombardment did not bring \important consequences, but they produced terror among the gun. [8] This is considered the first documented case in history drone strikes

Figure I.1: Bombing by Balloon, 1848

In1910.Inspired by the success of the Wright Brothers, Charles Kettering, an American military engineer from Ohio, proposes the concept of an unmanned aerial vehicle. In reality, it's a bomb with wings. Aviation has advanced by clearing the ground for the development of a drone strike. According to the inventor, an aircraft filled with explosives was capable of flying over. Straight, drone for a while. Then the drone dropped its wings. It is known that in 1914, Kettering obtained a United States Army order to make these drones. It was adopted at no time.

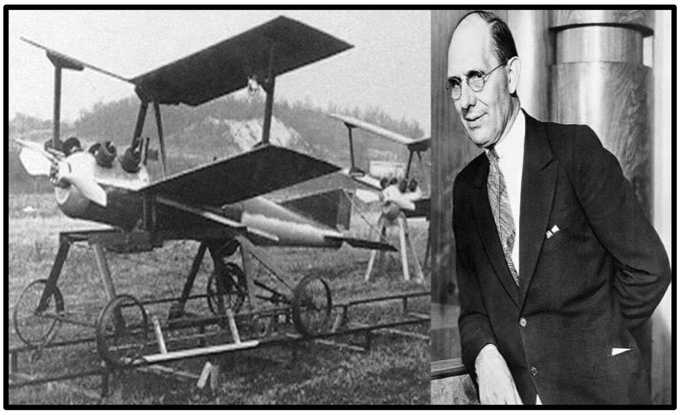


Figure I.2: One of the world's first drones was built in Dayton

The First World War accelerated the development of many fundamental technologies. Unmanned aerial vehicles (UAVs) that are radio-controlled are examples of modern technology. The drone experiment began after it had become widespread and nearly uncontrollable. Using radio transmitters at the same time, traditional airplane re-engineering experiments began using a remote control.

Prior to the First World War, several innovators were drawn to the possibility of using radio to operate a distant aircraft. One of them, Elmer Ambrose Sperry, was successful in drawing the attention of the United States Navy. Since 1896, Sperry had been refining the functioning of naval gyroscopes, and the Sperry Gyroscope Company was created in 1910. In 1911, when planes had barely been flying for eight years, Sperry got intrigued in the notion of introducing radio control to them. He realized at the time that in order for the radio control to work properly, the equipment required to be furnished with an autonomous stabilizing mechanism. He therefore decided to alter his naval gyroscopic stabilizers. He then decided to adapt his naval gyroscopic stabilizers initially used on destroyers to aircraft.

One day they managed to interest the command and they started to develop his drone. It was basically a winged bomb on Radio control. The first successful test flight took place in September 1917. [9]

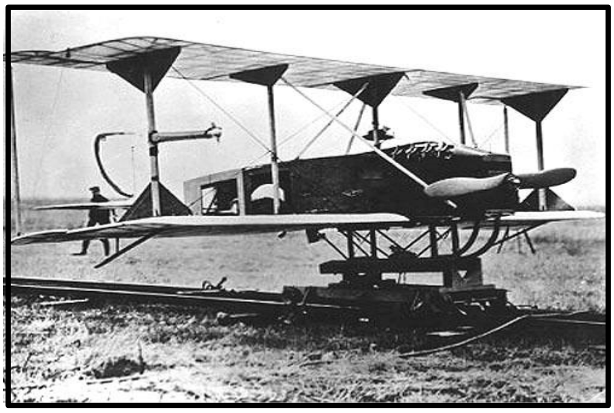


Figure I.3: Hewitt-Sperry /an Automatic Airplane,

Photographed, On a launch trolley in 1918.

1935 is the year. A reusable unmanned aerial vehicle has been built by engineers in the United Kingdom. The name "QueenBee" was given to it. As a starting point, the Fairy Queen Airplane model was employed. The drone might be flown remotely from a sea vessel at a distance of up to 5 kilometers after rebuilding and modification. Radio-controlled drones were already creating their own precision navigation feature before the start of World War II. The legendary QQ-2 radio was one of these drones. The aircraft made its debut flight in 1939, and it was the most widely produced QQ-2, with 14 0000 examples manufactured. [10]

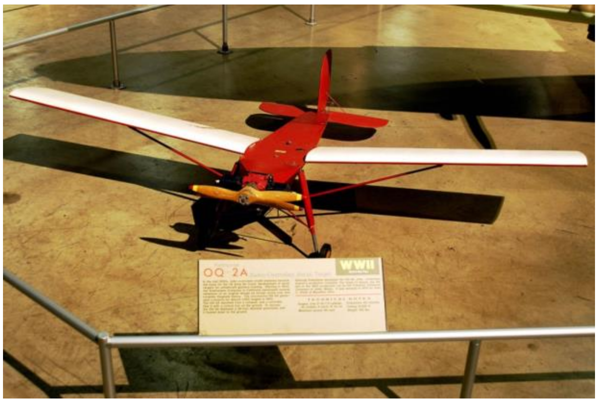


Figure I.4: The **OQ-2 Radio plane** was the first mass-

Produced UAV or drone in the United States, In 1907, the Breguet business produced the first quad rotor, the Breguet-Richet gyroplane. It couldn't take off since it was just 60 cm above the ground, and it had to be held in place by four people. [11]

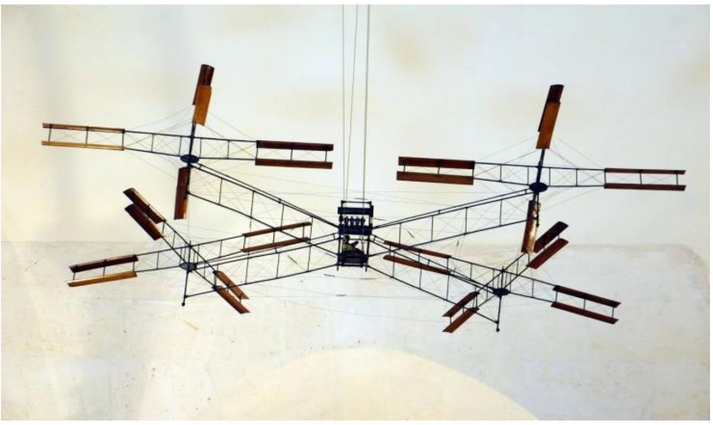


Figure I. 5: Gyroplane Breguet-Richet, luise Breguet 1907/ photo Michèle Favareille

In January 1921, George de Bothezat, the Russian-American, was the first person to fly a quad rotor. In December 1922, he successfully flew from 1:42 to 1.8 m from the ground. On January 19, 1923, the aircraft took two people 1.2 m from the ground.

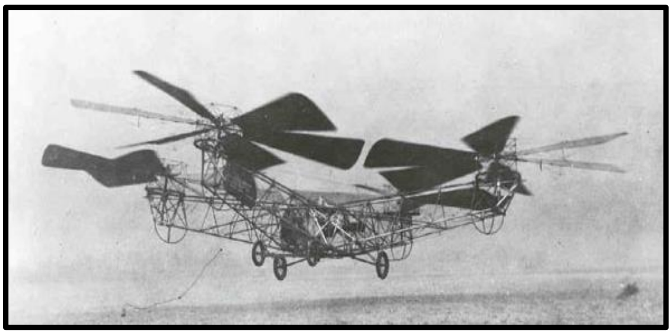


Figure I.6: Flying Octopus" U.S. Army Air Service

In 1924, the Frenchman Étienne Oehmichen presents a quad rotor rises an altitude of more than ten meters and makes a complete loop over one kilometer in 7 minutes and 40 seconds. The Oehmichen quad rotor type 2 is equipped with eight steering propellers. [12]

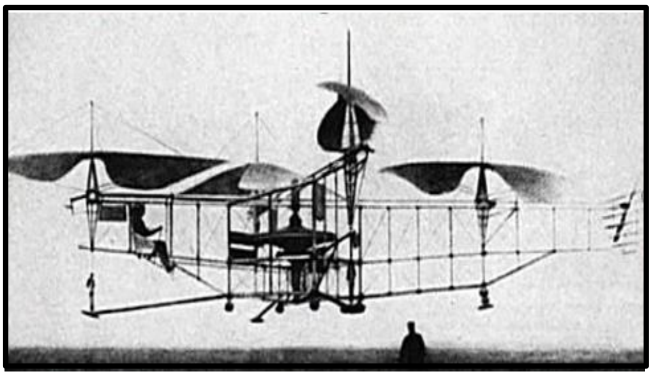


Figure I .7: first helicopter to fly on the distance of one

1 kilometer (0.6 mile)

Over the years, developers have tried to develop drones in terms of remote control, and in terms of toughness, they have also developed engines to make them carry weights.

In January 2016, the Chinese company Ehlang presents a quad rotor that can carry a person and fly up to 3,500 meters and peak at nearly 100 km/h.

Figure I .8 : Le Ehang 184 a été dévoilé mercredi au CES de Las Vegas 2016

Over the years, researchers have sought to develop and use marching aircraft in several fields. Scientists today have achieved good results in terms of rigidity, performance, speed and also smooth use. The inclusion of marching aircraft more extensively in everyday life has also been studied, opening up new urban horizons with the rule of technology.

I.4 drones classifications

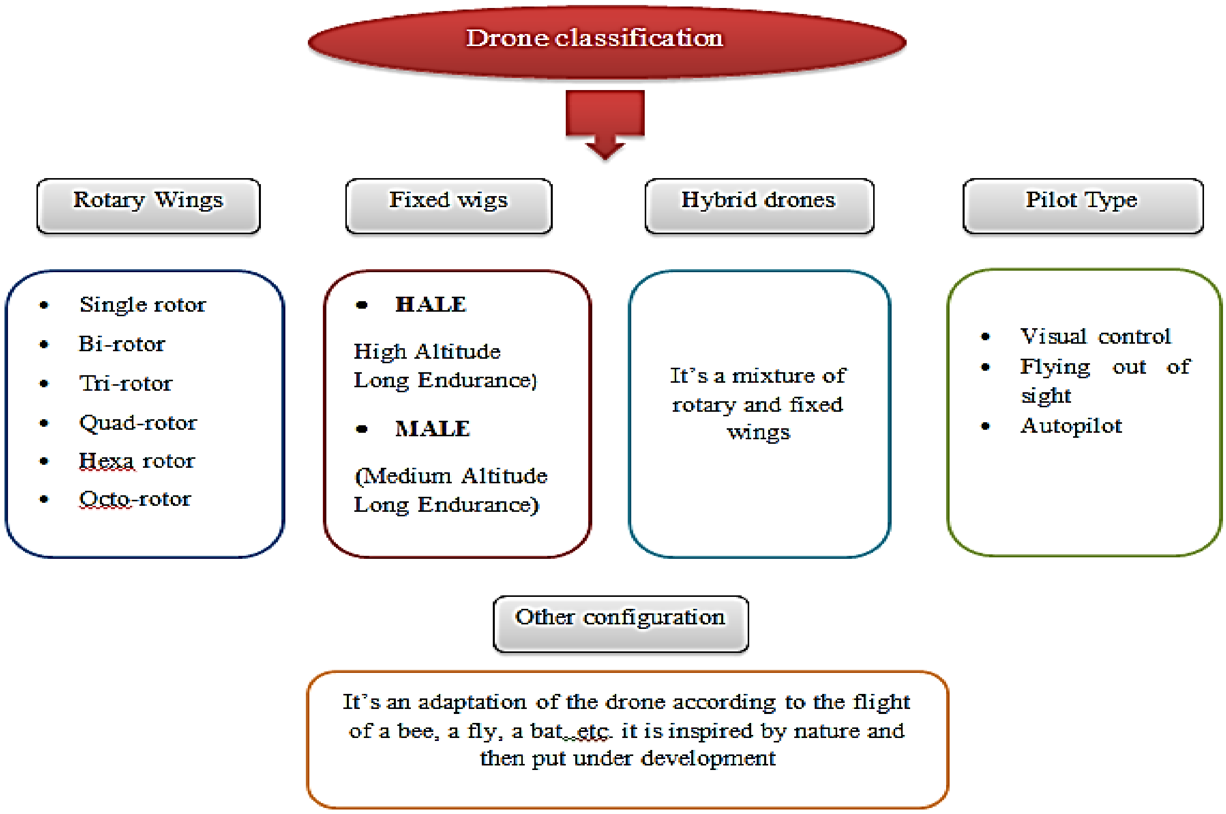


Figure I .9 : drone classification

I.4.1. Mode of Propulsion Classification

A) rotary-wing VTOL

- **Single rotor drone - unmanned helicopter**

Single rotor drones are very similar in design and to real helicopters. Unlike a multi-rotor drone, a single-rotor drone has one large lead rotor plus a small rotor on the tail to control the course. Single rotor drones are much more efficient than multi-rotor versions. They have a longer flight time and can even be powered by internal combustion engines.

- **Bi-Copter Drone**

A biplane marching plane is an aircraft with a good cruise design for small, energy-economical defectors. There are several types of this aircraft with a good historical extension Their faults are perfectly unstable when flying

- **Tri rotor**

A three-fan marching aircraft is an aircraft with three poles each with an engine that is suitable for reconnaissance within medium distances but is less constant when flying at high altitudes.

Figure I .10: drone (single rotor ,bi-copter, tri-copter)

- **Drones quad copter**

It's an ideal airplane in terms of energy consumption and in-flight stability that spreads fans around four consistent poles with a thoughtful construction.

- **Drones Hexa copter**

Its fans are distributed around six poles with a special design that allows it By flying stable with significant weights and effective delivery One of its drawbacks is the consumption of a lot of energy.

- **Drones Octo-copter**

Its fans are distributed around eight poles with a special design that allows it to fly high and stable

With heavy weights one of its drawbacks is the consumption of a lot of energy. [13]



Figure I .11: drone (quad copter, Hexa-copter, Octo-Copter)

B) Fixed-wing drones

- **HALE (High Altitude Long Endurance)**

A new form of aircraft that offers lower-cost telecommunications for under developed areas of the world, as well as commercial and government surveillance and monitoring capabilities. It is capable of reaching the stratosphere

- **MALE (Medium Altitude Long Endurance)**

They are flying drones at a medium height and with a high degree of autonomy. [14]


Figure I .12: (HALE and **MALE)**

I.4.2 Hybrids drones

The hybrid models combine the benefits of fixed-wing models, such as longer flying periods, with the benefits of propeller-based models, such as the ability to fly. Since the 1960s, hybrid aircraft concepts have been under development with limited success. However, with the introduction of a new generation of sensors (gyroscopes and accelerometers), hybrid design has been given fresh life and development direction. [15]

Figure I.13: UAV Airbus "Zelator-28"

I.4.3 Classification According to the Pilot Type

Drones generally fly remotely in three different ways:

- **Visual control:**

horizontal distance of aircraft less than 100 meters from the pilot, who maintains a direct view of the aircraft's is smaller than the size of the palm of your hand It flies up to 100 meters in the visual range, and that's parallel to remote manual control This type of drone is specifically intended for children and is also considered the best option for beginners in the drone field because of its cheap price.

- **Flying out of sight:**

Distance greater than 100 meters puts aircraft guidance by video feedback drone which is controlled remotely equipped with a camera, this device allows in particular the discovery of areas inaccessible by man or the best surveillance of a territory more or less wide by the sky

- **Autopilot**:

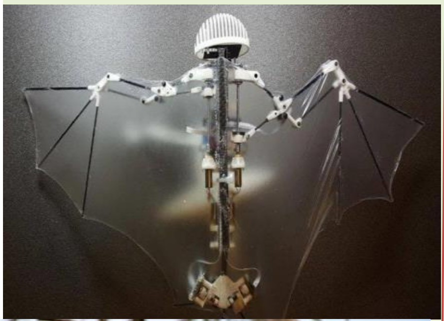
This is a flight that has already been recorded using pre-configured parameters that allow flight within a specified range and in a previously specified manner Swiss air rescue services have developed an autonomous drone to help them in their search for injured and missing persons. Capable of detecting the heat and signals of telephones over a distance of several hundred meters, [16]

Figure I .14: Classification According to the Pilot Type

Note:

There are many kinds of marching aircraft that vary in shape, where we sometimes see very different shapes from the standard, and also different in size, there are very small fly-sized marching aircraft, and there are also aircraft that fly with one wing flying around the axis. [17]

Table I.1: Other drone configuration

Drones	**inventors**	**properties**
	Designed by experts at a university of Harvard They called it **beebot**.	Is an amphibious robot weighing 175 mg that flies with its wings and flies that can swim, dive and move directly from water to air.
	devised by experts at Brown University of America who called it a **batbot**	The flying bat flies this drone as fast as 10 times a second and has wings that have a thin membrane about a foot and a half that can actually fly like a bat for high robot resilience.
	Adapted by robotics and mechanical engineering researchers from Stanford University and the University of Groningen, Netherlands (**clawed drone)**	Is a very common four-fan, except for the two flexible legs, which end up with bird clawing.

I.5 Uses of drones

There are several uses of the entire drone, divided into two sections**.**

I.5.1 Civilian uses of the drone

Nowadays, there are many Drones in our daily lives, including personal uses, including those associated with partnerships in various areas.

- Study of the atmosphere, soils (geology) and oceans.
- Forest fires, avalanches.
- Crop monitoring and agricultural application.
- Search and rescue (sea, mountains, desert, etc.).
- Delivery of food and rescue equipment in hostile areas.
- Traffic and Transportation of Dangerous Goods Surveillance [18]

Figure I.15: Some areas of civilian use of drones

I.5.2 Military uses of drones

The aircraft took a wide range of military use to speed up and perform various tasks that were previously difficult and complex

- Search and Reconnaissance
- Espionage on a nearby scale
- Intense shelling of closed areas
- Jamming radars to pass other aircraft
- Delivery of supplies and ammunition in mountain areas

- Sensing the minefields with close flip-flops from the questionable area [19]

Figure I .16:UAV "Orion", manufactured by JSC "Kronshtadt"

Figure I.17: defence news in mena (Eljazair 54)

I.6 the Advantages of Drones

- They are cheap and affordable
- They are easy and fun to use
- Drones can enforce security and surveillance
- Drones can be used in agriculture
- Possibility to deliver packages
- They can make 3D maps
- Drones can Survey dangerous places
- They can save lives
- Possibility to take aerial view photography
- Drones can capture incredible sport moments [20]

I.7 Disadvantages That Are Associated With Drones

After several years of practice using drones, a list of typical hazards accompanying their use can be formed:

- Short flight time
- Statistics of the dangerous or criminal use of drones
- They are easily affected by the weather

- Drone collisions with people. Risk of injury
- Flights over areas where flights are prohibited or inappropriate
- Dangerous proximity to aircraft, including helicopters, etc.
- Collisions with buildings, structures, monuments
- The use of drones for the transport of criminal goods, primarily drugs
- Voyeurisms
- Hooliganism, terrorists acts
- The use of commercial drones for military purposes
- The dangers of using data collected by commercial UAVs [21]

I.8 best commercial and professional drones in 2022

Here is our list of the top seven commercial and professional drones on the market, with specs and details included.

❖ **DJI MATRICE 300 RTK**

DJI's new M300 RTK was designed specifically with inspections and public safety applications in mind, That being said, we've decided to focus on its outdoor inspection capabilities because of its long transmission range, high-tech obstacle avoidance, the high quality camera DJI has paired with it, and its long flight time.

❖ **Key specs**

- Max Flight Time 55 minutes
- Obstacle Avoidance Six obstacle avoidance sensors for improved safety while flying
- Transmission Range 9.3 miles
- Rain and dust proof The M300 has a weather sealing rating of IP45, which means it can sustain rain and dust while in the air (the M200 V2 is rated at IP43)

❖ **Fly ability ELIOS 2**

The Elios 2 is Fly ability's flagship professional grade drone designed specifically for flying in confined spaces. The drone sits in a cage, allowing it to collide and continue flying, making it the best option on the market for indoor inspections because it can safely fly in spaces that almost no other drone can safely enter.

❖ **Key specs**

- Collision resilience reliable operations in any situation
- Confined space accessibility fly where no other drone can
- Robust transmission inspect beyond line of sight
- Intuitive to fly the Elios 2 was made to be easy to fly, and new drone pilots have reported learning how to use it for basic missions in just a few hours
- Inspection features GPS-free stabilization, distance lock, and full HD all combine to make the Elios 2 a powerful tool for collecting visual data for inspection purposes
- Robust inspection lighting with 10K of lumens and both oblique and dustproof lighting, the Elios 2 was designed to provide the lighting you need for challenging indoor inspection scenarios

❖ **DJI MAVIC 3**

The DJI Mavic 3 came out in late 2021, after years and years of anticipation, Since launching, the Mavic 3 has quickly become one of the top drone models used by professional drone photographers and videographers, as well as for presumes (amateurs who want to work with professional equipment), The Mavic 3 comes in two models—the standard and the Cine. In the specs below we only cover the standard version but you can learn more about both on the DJI website.

❖ **Key specs**

- Cameras the Mavic 3 have two cameras: a Hasselblad camera with a 4/3″ sensor and a Tele camera with a 1/2″ sensor.
- Max flight time 46 minutes.
- Max speed 47 mph (75 kph).
- Range 9.3 miles (15km).

❖ **the Freefly Alta 8**

The Freefly Alta 8 represents a big step up from the Mavic 2 Pro, and is a professional grade drone made primarily for high-end cinematography. To clarify the distinction between the Alta 8 and the Mavic 2, the Alta 8 would be ideal for work on movies while the Mavic 2 would be suitable for non-movie related professional photo/video work.

❖ **Key specs**

- Dual camera mounting options—allows for a different perspective
- Weather-resistant drone has plastic enclosures to protect sensitive components and two fully enclosed weather resistant receiver compartments
- Carbon fiber airframe and propellers
- Built-in supports for both First-Person-View (FPV) and Radio Tx/Rx systems
- Other features precise positioning, height hold, vertical and ground velocity limits, Return-to-Home

❖ **XAG V40 2021**

XAG is a drone company that only makes drones for work in agriculture, and the XAG V40 is the flagship professional drone of XAG's V Series lines of drones.

The XAG V40 came out in late 2021 and it's one of the best drones for agriculture on the market. The V40 can conduct fully autonomous drones that can conduct mapping, spraying, and surveying on farms.

Agriculture has been one of the fastest-growing sectors for drone adoption over the last few years, and XAG has helped push that adoption even further. Its drones let farmers collect high quality data on the status of their crops, and also enables remote crop care with its ability to spray pesticides and other materials.

❖ **Key specs**

- Payload 4 gallon (16 liter) liquid tank and 6.5 gallon (25 liter) granular container
- Sprayers equipped with XAG Revo Spray and Revo Cast
- 3D mapping XAG's Real Terra system supports rapid agricultural mapping.
- Ingress protection P67 rating protection

❖ **Parrot ANAFI USA**

Parrot's ANAFI USA is a tough professional grade drone that comes with both a visual and thermal sensor, making it a good tool for both law enforcement, fire departments, and search and rescue. With a long flight time, one of the highest IP ratings* of any drone on the market, and an easy to use platform, the ANAFI USA is a powerful tool for public safety agencies.

Note: IP stands for Ingress Protection and rates how strongly protected an item are from dust and water.

❖ **Key specs**

- Flight time 32 minutes
- High quality visual camera 4K HDR / 21 MP camera with 32X zoom
- Thermal camera FLIR BOSON thermal sensor
- GPS-less environments works indoors without GPS
- Made for harsh conditions protected from dust and rain, with an impressive IP53 qualification
- Ease of use can launch

❖ **the Wingtra One Gen II**

The Wingtra One Gen II might well be the best drone for mapping yet.

Wingtra worked on its Wingtra One Gen II for six years before launching it in 2021. The Gen II is an updated version of Wingtra's first professional grade drone for mapping and surveying and it is a robust system made specifically for large-scale city mapping. If you're looking for the best professional drone for surveying, this model is definitely worth considering.

❖ **Key specs**

- Weight 8 pounds (3.7 kilo grams)
- Max payload weight 1.8 pounds (800 grams)
- Max flight speed 35.8 mph (16 m/s)
- Max flight time 59 minutes
- Minimum space for take-off 6.6 ft x 6.6 ft (2m x 2m) [22]

I.9 Conclusion

In this chapter we talked about drones in detail, beginning with the history of their development and then their classification. We also talked about the areas in which drones are used, and we also talked about the seven most important seven professional drones. This field made us knows a lot of other accurate information regarding drones.

According to our research, we found that drones have become very popular in recent years and the development has been very rapid at all levels, experts are now working to improve flight time and are in recent experiments to achieve this by due to the remarkable development of the field of high performance solid batteries.

In addition, the exterior designs have taken the lion's share, each time we see new more suitable designs in terms of uses, drones have become available even for people's daily use which shows their rapid integration into society.

Chapter II

Modelling and simulation of drone quad copter

II.1. Introduction

Modeling is the application of tools to produce a mathematical model of a system; the more complex the presentation, the more accurately it matches the real behavior of the system. The control of dynamic systems is essentially based on the modeling, identification, and analysis of physical processes operating on the system.

In this chapter, we will first see a broad description of the quad rotor and its probable movements, followed by the dynamic modeling of the quad rotor system using the Newton-approach. Euler takes into consideration the physical effects that affect its dynamics, such as aerodynamic effects, gravity, gyroscopic effects, friction, and moment of inertia. Finally, it describes the operating principle of the PID corrector by defining the control equations and the angles of orientation

II.2. General Description of the quad rotor

A quad rotor is a mobile aerial robot with four rotors defined in space by six DDL. These four rotors are often situated at the ends of a cross, with the control electronics in the center of the cross. To prevent the airplane from spinning on its yaw axis, two propellers must turn in one direction and the other two in the opposite. To guide the airplane, each propeller torque rotating in the same direction must be set at the opposite ends of a cross branch. [23]

II.2.2 Quad copter operation

The quad rotor is made up of four (04) rotors with six (06) degrees of freedom (DDL), three rotational motions, and three translational motions defined in space. The four rotors are usually placed at the cross's extremities, with the control electronics in the center. The opposing propellers rotate in one direction while the other two rotate in the opposite direction to keep the device from spinning on itself. The quad rotor is a low-powered system with a very distinctive function (the number of actuators is less than the number of DLDs that can be done). By carefully modifying engine speeds, it may be pushed up/down, tilted left/right (roll), forward/backward (pitch), or rotated over itself (yaw). [24]

II.3 Quad copter Movements

When a standard helicopter's main rotor rotates, it generates reactive torque, which causes the helicopter body to rotate in the opposite direction if the torque is not disturbed. Installing a tail rotor that provides lateral thrust is a typical way to do this. This rotor, together with its associated power supply, does not contribute to thrust. Quad rotors, on the other hand, feature two rotors that rotate clockwise and two rotors that rotate counter clock wise, thereby lowering reactive torque and allowing the vehicle to glide without losing control. In fact, unlike traditional helicopters, all of the energy needed to fight spin is also used to create thrust

The fundamental motions of a quad rotor are accomplished by adjusting the speed of each rotor and hence the thrust produced. The quad rotor tilts towards the direction of the slower rotor, which accounts for the translation along this axis. As a result, the movements are linked, which implies that the quad rotor cannot complete the translation without rolling or pitching. This means that a change in rotor speed translates into a movement in at least three degrees of freedom. A roll motion (the quad rotor tilts towards the slower rotor, to the right) and a yaw motion (the balance between the rotors spins in the direction of a yaw) will come from raising the speed of the left thruster (the quad rotor tilts towards the slower rotor, to the left).

a yaw movement (the equilibrium between clockwise rotating rotors and counterclockwise rotating rotors is disrupted, resulting in a horizontal rotation motion), and a translation (the roll motion tilts the armature and with it, the thrust force orientation). We can control the six degrees of quad rotor freedom with only four controllers because of this connection (the torque applied by the engines on each thruster). There are five primary motions in the quad rotor [24]

- ✓ Vertical movement.
- ✓ Movement of the roll.
- ✓ Pitch movement.
- ✓ Yaw motion.
- ✓ Horizontal translations

II.3.1 Vertical movement

The quad rotors rise and fall are simply reflected in the vertical movement. The increase is accomplished by elevating the four engines' speeds to the same level, canceling the rotational torques caused. The engines are slowed to allow for the fall.

Figure II.1: Illustration of vertical

II.3.2 Movement of the roll

The method for calculating roll is shown in Figure II.3. A torque is applied around the x-axis in this example, i.e., a thrust differential between rotor 2 and rotor 4 is applied. This movement (rotation around the x-axis) is accompanied by a y-axis translation movement.

Figure II.2: Illustration of the roll

II.3.3 pitch movement

Figure (II.4) shows how pitch is obtained. In this case, a torque is applied around the y-axis, that is to say by applying a thrust difference between rotor 1 and rotor 3. This movement (rotation around y) is coupled with a translation movement according to the x-axis.

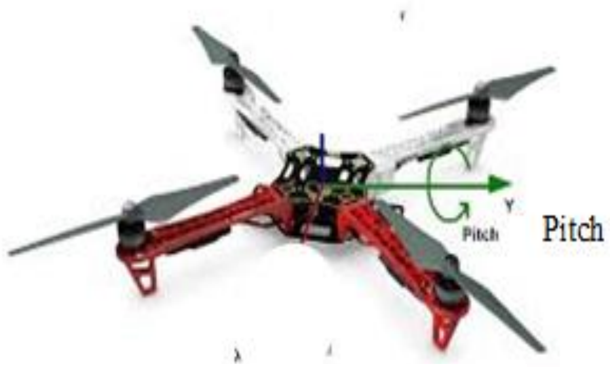


Figure II.3: Illustration of the pitch

II.3.4 yaw movement

Figure (II.5) shows how yaw is obtained. In this case, we want to apply a torque around the z-axis, which is done by applying a velocity difference between the rotors {1, 3} and {2, 4}. This movement is not a direct result of the thrust produced by the thrusters but by the reactive torques produced by the rotation of the rotors. The direction of the thrust force does not shift during movement, but the increase in lift force in one pair of rotors must be equal to the decrease in the other pairs to ensure that all the thrust force remains the same.

Figure II.4: Illustration of yaw

II.3.5 Horizontal translations

Figure (II.6) shows how horizontal translation is achieved. In this case, we want to apply a force along x or y that is done by tilting the body (by pitch or roll) and increasing all the thrust produced to keep the importance of the push z component equal to the gravity force.

Figure II.5: Illustration of the translation

II.4 Quad copter Dynamic Model

Quad rotors are fairly complex mechanical systems. Their movements are governed by several mechanical and aerodynamic effects. The quad rotor model must take into account all the effects that affect its movement, including gyroscopic effects.

The method for calculating roll is shown in Figure II.3. A torque is applied around the x-axis in this example, i.e., a thrust differential between rotor 2 and rotor 4 is applied. This movement (rotation around the x-axis) is accompanied by a y-axis translation movement.

- The structure of the quad rotor is assumed to be rigid and symmetrical, which implies that the inertia matrix will be assumed diagonal.
- Propellers are assumed to be rigid in order to be able to ignore the effect of their deformation during rotation.

- The mass center and the origin of the landmark linked to the structure coincide
- The lift and drag forces are proportional to the squares of the rotor rotation speed, which is a near approximation to the aerodynamic behavior.

To evaluate the quad rotor's mathematical model, we use two markers: a fixed marker connected to the earth Rb and a moveable marker connected to the quad rotor's mass center and positioned at the intersection of the two bars. The transit between the moving and fixed markings is determined by the transformation matrix T, which holds the direction and location of the moving mark in relation to the fixed mark. The following axis convention was used [25]

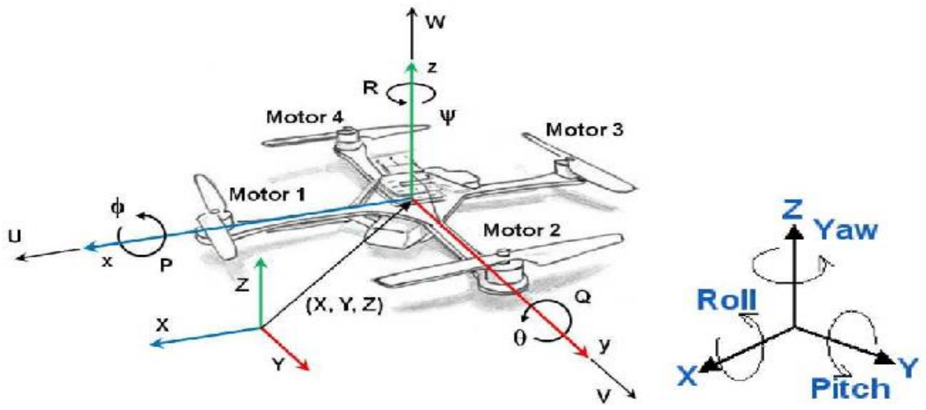


Figure II.6: The structure of the quad rotor and relative coordinate systems

$$T = \begin{bmatrix} R & \xi \\ 0 & 1 \end{bmatrix} \quad (II.1)$$

With R the rotation matrix (describes the orientation of the moving object), ξ = $[x\ y\ z]^T$ is the position vector,to determine the elements of the rotation matrix R, we use the angles of Euler

II.4.1. Euler's Angles

At the beginning the moving mark coincides with the fixed mark, after the moving mark makes a rotation motion around the x-axis of a roll angle ,Followed by a rotation around the y-axis of a pitch angle followed by rotation around the yaw angle z-axis ($\pi < \psi < \pi$). So we have the formula of the rotation matrix R:

$$R = Rot_z(\psi) * Rot_y(\theta) * Rot_x(\phi)$$

$$R = \begin{bmatrix} c\psi & -s\psi & 0 \\ s\psi & c\psi & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c\theta & 0 & s\theta \\ 0 & 1 & 0 \\ -s\theta & 0 & c\theta \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & c\phi & -s\phi \\ 0 & s\phi & c\phi \end{bmatrix} \quad (II.2)$$

$$R=\begin{bmatrix} c\psi c\theta & s\phi s\theta c\psi - s\psi c\phi & c\phi s\theta c\psi + s\psi s\phi \\ s\psi c\theta & s\phi s\theta s\psi + c\psi c\theta & c\phi s\theta c\psi - s\phi c\psi \\ -s\theta & s\phi c\theta & c\phi c\theta \end{bmatrix} \quad (II.3)$$

And : $s \equiv sin$ and $c \equiv cos$.

The rotational speeds Ω1; Ω2; Ω3 in the fixed marker are expressed as a function rotational speeds $\dot{\phi}$ $\dot{\theta}$ $\dot{\psi}$ in the moving marker, we have:

$$\Omega=\begin{bmatrix}\Omega_1\\\Omega_2\\\Omega_3\end{bmatrix}=\begin{bmatrix}\dot{\phi}\\0\\0\end{bmatrix}+Rot_x(\phi)^{-1}\begin{bmatrix}0\\\dot{\theta}\\0\end{bmatrix}+\left(Rot_y(\theta)Rot_x(\phi)^{-1}\right)\begin{bmatrix}0\\0\\\dot{\psi}\end{bmatrix} \quad (II.4)$$

In fact, roll rotation occurs when the reference marks are still confused. Then, in for pitch, the vector representing rotation must be expressed in the fixed marker: it is therefore multiplied by Rot x $(\phi)^{-1}$. Similarly, the vector representing the yaw rotation must be expressed in the fixed marker which has already undergone two rotations. Thus we arrive at:

$$\Omega=\begin{bmatrix}\Omega_1\\\Omega_2\\\Omega_3\end{bmatrix}=\begin{bmatrix}\dot{\phi}\\0\\0\end{bmatrix}+\begin{bmatrix}0\\\dot{\theta}c\phi\\\dot{\theta}s\theta\end{bmatrix}+\begin{bmatrix}-\dot{\psi}s\theta\\\dot{\psi}s\phi c\theta\\\dot{\psi}s\phi c\theta\end{bmatrix}=\begin{bmatrix}\dot{\phi}-\dot{\psi}s\theta\\\dot{\theta}c\phi+\dot{\psi}s\phi c\theta\\\dot{\psi}s\phi c\theta-\dot{\theta}c\phi\end{bmatrix} \quad (II.5)$$

$$\Omega=\begin{bmatrix}1&0&-s\theta\\0&c\phi&s\phi c\theta\\0&-s\phi&s\phi c\theta\end{bmatrix}\begin{bmatrix}\dot{\phi}\\\dot{\theta}\\\dot{\psi}\end{bmatrix} \quad (II.6)$$

When the quad copter makes small rotations, the following approximations can be made:

$c\phi = c\theta = c\psi = 1$ Et $s\phi = s\theta = s\psi = 0$

So the angular velocity will be

$$\Omega=\begin{bmatrix}\dot{\phi}&\dot{\theta}&\dot{\psi}\end{bmatrix}^T \quad (II.7)$$

The linear speeds v_x^b v_y^b v_z^b in the fixed landmark as a function of linear velocities the moving markers are given by:

$$v = \begin{bmatrix} v_x^b \\ v_y^b \\ v_z^b \end{bmatrix} = R * \begin{bmatrix} v_x^m \\ v_y^m \\ v_z^m \end{bmatrix} \qquad (II.8)$$

I.5 Physical effects on the quad rotor

For our case, we will consider only the forces and moments applied to the quad rotor generated by aerodynamic effects, propeller rotation and precession gyroscopic.

II.5.1. Forces

The forces acting on the quad rotor system are:

II.5.1.1. the weight of the quad rotor

This force is due to the mass of the object. It is always perpendicular to the surface earth. It is given in the inertial referential by:

$$P = m.g.\vec{k} \qquad (II.9)$$

II.5.1.2. Thrust forces

The forces that are forces caused by the rotation of motors, they are perpendicular to the plane of the propellers. These forces are proportional to the square of the engine speed:

$$F_i = b\omega_i^2 \qquad (II.10)$$

With i = 1 : 4, b: is the lift coefficient, it depends on the shape and number of blades and the density of the air.

II.5.1.3. Drag Forces

The drag force is the coupling between a pressure force and the friction force viscous, in this case we have two drag forces acting on the system they are:

The drag in the propellers: it acts on the blades, it is proportional to the density of the air, the shape of the blades and the square of the speed of rotation of the propeller, it is given by the following relation:

$$T_h = d.\omega_i^2 \qquad (II.11)$$

Is the drag coefficient it depends on the manufacturing of the propeller, Drag according to axes (x, y, z): it is due to the movement of the body of the quad rotor

$$F_{tT} = K_{ftT} \cdot v \quad (II.12)$$

$$F_{tR} = K_{ftR} \cdot \Omega \quad (II.13)$$

$KftT$ Translation drag coefficient and v: linear velocity.

$KftR \cdot$ The coefficient of drag of rotation and Ω: the angular velocity

II.5.2. Moments

There are several moments acting on the quad rotor, these moments are due to the forces of thrust and drag and gyroscopic effects

II.5.2.1. Moments due to thrust forces

The rotation around the x-axis

it is due to the moment shouted by the difference between the lift forces of rotors 2 and 4; this moment is given by the following relation:

$$M_x = l(F_4 - F_2) = lb(\omega_4^2 - \omega_2^2) \quad (II.14)$$

The rotation around the y axis

It is due to the moment shouted by the difference between the lift forces of rotors 1 and 3, this moment is given by the following relation:

$$M_y = l(F_3 - F_1) = lb(\omega_3^2 - \omega_1^2) \quad (II.15)$$

II.5.2.2. Moments due to drag forces

Rotation around the z axis: it is due to a reactive torque caused by the drag in each propeller; this moment is given by the following relationship:

$$M_z = ld(\omega_4^2 - \omega_2^2 + \omega_3^2 - \omega_1^2) \quad (II.16)$$

$$M_a = K_{fa}.\Omega^2 \quad (II.17)$$

Moment resulting from aerodynamic friction is given by:

With Kf: The coefficient of aerodynamic friction and Ω is the angular velocity.

II.5.3. Gyroscopic effect

The gyroscopic effect is defined as the difficulty of changing the position or the orientation of the plane of rotation of a rotating mass. The gyroscopic effect is thus named in reference to the operating mode of the gyroscope, motion control device used in aviation (Greek gyro meaning rotation and scope, observe). In our case there are two gyroscopic moments, the first is the gyroscopic moment of the propellers, the other is the gyroscopic moment due to quad copter movements, gyroscopic moment of the propellers: it is given by the following relation:

$$M_h^g = \sum_1^4 \Omega \wedge J \begin{bmatrix} 0 & 0 & (-1)^{i+1}\omega_i \end{bmatrix}^T \qquad (II.18)$$

With Jr is the inertia of the rotors, Gyroscopic moment due to quad rotor movements it is given by the relation following:

$$M_{gm} = \Omega \wedge J\Omega \qquad (II.19)$$

II.6 Development of the Mathematical Model according to Newton-Euler

The Quad rotor is displayed as a inflexible body subjected to the driving forces and outside strengths. a well-known result of mechanics is that the flow of bodies rigid can be portrayed utilizing the Newton-Euler approach (based on strengths and moments acting on the body) and the Euler-Lagrange approach (based on hypotheses energy). With the Newton-Euler approach the flow are at first defined in terms coordinates of the moving marker (connected to the unbending body), at that point communicated in terms of coordinates of the inertial marker utilizing kinematic changes. The Lagrange, on the opposite, needs specifically the utilize of generalized coordinates (coordinates of the inertial marker) and this requires a much heavier imagery. Thus, the last result is the same, but gotten with diverse evaluations. In this section, a Newton-Euler approach is embraced to infer the inflexible body flow of the Quad rotor, because it speaks to the only approach to modelling Based on the past conditions of powers connected to the quad rotor the equations (II.9…II.12), and the minutes acting on the quad rotor equations (II.14, .II.18). And to summarize the set of conditions portraying the total show of the quad rotor, utilizing the detailing of Newton-Euler and the energetic framework model is show within the taking after shape.

$$\begin{cases} \dot{\zeta} = v \\ m\ddot{\zeta} = F_f + F_t + F_g \\ \dot{R} = RS(\Omega) \\ J\dot{\Omega} = -\Omega \wedge J\Omega + M_f - M_a - M_{gh} \end{cases} \qquad (II.20)$$

With

ζ: is the position vector of the quad rotor.

m: The total mass of the quad rotor.

Ω: The angular velocity expressed in the fixed marker

A: The rotation matrix.

J: Symmetric inertia matrix of dimension (3x3), it is given by:

$$J = \begin{bmatrix} I_x & 0 & 0 \\ 0 & I_y & 0 \\ 0 & 0 & I_z \end{bmatrix} \quad (II.21)$$

S (Ω): is the ant symmetric matrix; for a velocity vector Ω = [Ω1; Ω2; Ω3], it is given by:

$$S(\Omega) = \begin{bmatrix} 0 & -\Omega_3 & \Omega_2 \\ \Omega_3 & 0 & -\Omega_1 \\ -\Omega_2 & \Omega_1 & 0 \end{bmatrix} \quad (II.22)$$

$\boldsymbol{F_f}$ is the total force generated by the four rotors, it is given by:

$$F_t = R * \begin{bmatrix} 0 & 0 & \sum_1^4 F_i \end{bmatrix}^T \quad (II.23)$$

$$Fi = [b \bullet \omega i]^2 \quad (II.24)$$

Ft: The drag force according to the axes(x, y, z), it is given by:

$$F_t = \begin{bmatrix} -K_{ftTx} & 0 & 0 \\ 0 & -K_{ftTy} & 0 \\ 0 & 0 & -K_{ftTz} \end{bmatrix} \quad (II.25)$$

$KftTz$: translation drags coefficients.

Fg: Force of gravity, it is given by:

$$F_g = \begin{bmatrix} 0 \\ 0 \\ -mg \end{bmatrix} \quad (II.26)$$

Mf: The moment caused by thrust and drag forces. It is given by:

$$M_f = \begin{bmatrix} l(F_4 - F_2) \\ l(F_3 - F_1) \\ ld(\omega_1^2 - \omega_2^2 + \omega_3^2 - \omega_4^2) \end{bmatrix} \quad (II.27)$$

Ma: Moment resulting from aerodynamic friction, it is given by:

$$M_a = \begin{bmatrix} K_{fax}\phi^2 \\ K_{fay}\phi^2 \\ K_{faz}\phi^2 \end{bmatrix} \qquad (II.28)$$

$Kfaz$: The coefficients of aerodynamic friction.

II.6.1. Translation motion equations

After presenting the equations of forces in the previous sections, we can currently switch to the full model of the quad rotor; we using the second law of Newton in the case of linear motion we have the following formula:

$$m\zeta^{\cdot\cdot} = Ff + Ft + Fg \qquad (II.29)$$

We replace each force with its formula, we find:

$$m\begin{bmatrix} \ddot{x} \\ \ddot{y} \\ \ddot{z} \end{bmatrix} = \begin{bmatrix} c\phi c\psi s\theta + s\phi s\psi \\ c\phi s\psi s\theta + s\phi c\psi \\ c\phi c\theta \end{bmatrix}\sum_1^4 F_i - \begin{bmatrix} K_{ftTx}\dot{x} \\ K_{ftTy}\dot{y} \\ K_{ftTz}\dot{z} \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ -mg \end{bmatrix} \qquad (II.30)$$

We then obtain the differential equations that define the translation motion

$$\begin{cases} \ddot{x} = \dfrac{1}{m}(c\phi c\psi s\theta + s\phi s\psi)(\sum_1^4 F_i) - \dfrac{K_{ftTx}}{m}\dot{x} \\ \ddot{y} = \dfrac{1}{m}(c\phi s\psi s\theta + s\phi c\psi)(\sum_1^4 F_i) - \dfrac{K_{ftTy}}{m}\dot{y} \\ \ddot{z} = \dfrac{1}{m}(c\phi c\theta)(\sum_1^4 F_i) - \dfrac{K_{ftTz}}{m}\dot{z}\_g \end{cases} \qquad (II.31)$$

II.6.2. Rotational motion equations

We apply the same Newton principle for the case of rotation we find the formula following:

$$J\Omega = -\Omega \wedge J\Omega + Mf - Ma - Mgh \qquad (II.32)$$

.

Replaces each moment with the corresponding expression, we find

$$\begin{bmatrix} I_x & 0 & 0 \\ 0 & I_y & 0 \\ 0 & 0 & I_z \end{bmatrix}\begin{bmatrix} \ddot{\phi} \\ \ddot{\theta} \\ \ddot{\psi} \end{bmatrix} = -\begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix} \wedge \left(\begin{bmatrix} I_x & 0 & 0 \\ 0 & I_y & 0 \\ 0 & 0 & I_z \end{bmatrix}\begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix}\right) - \begin{bmatrix} J_r\bar{\Omega}_r\dot{\theta} \\ -J_r\bar{\Omega}_r\theta \\ 0 \end{bmatrix} - \begin{bmatrix} K_{fax}\dot{\phi}^2 \\ K_{fax}\dot{\theta}^2 \\ K_{fax}\dot{\psi}^2 \end{bmatrix} + \begin{bmatrix} lb(\omega_4^2 - \omega_2^2) \\ lb(\omega_3^2 - \omega_1^2) \\ ld(\omega_1^2 - \omega_2^2 + \omega_3^2 - \omega_4^2) \end{bmatrix} \qquad (II.33)$$

We then obtain the differential equations defining the rotation motion:

$$\begin{cases} I_x\ddot{\phi} = -\dot{\theta}\dot{\psi}(I_z - I_y) - J_r\overline{\Omega_r}\,\dot{\theta} - K_{fax}\dot{\phi}^2 + J_r\overline{\Omega_r}\,\dot{\theta} + lb(\omega_4^2 - \omega_2^2) \\ I_y\ddot{\theta} = -\dot{\phi}\dot{\psi}(I_z - I_x) + J_r\overline{\Omega_r}\,\dot{\theta} - K_{fay}\dot{\theta}^2 + J_r\overline{\Omega_r}\,\dot{\theta} + lb(\omega_3^2 - \omega_1^2) \\ I_z\ddot{\psi} = \dot{\phi}\dot{\theta}(I_y - I_x) - K_{faz}\dot{\psi}^2 + lb(\omega_1^2 - \omega_2^2 + \omega_3^2 - \omega_4^2) \end{cases} \quad (II.34)$$

With:

$$\overline{\Omega_r} = \omega_1 - \omega_2 + \omega_3 - \omega_4 \quad (II.35)$$

As a result, the complete dynamic model governing the quad copter is given by the system equations according to:

$$\begin{cases} \ddot{\phi} = -\dot{\theta}\dot{\psi}\dfrac{(I_z - I_y)}{I_x} - \dfrac{J_r}{I_x}\overline{\Omega_r}\,\dot{\theta} - \dfrac{K_{fax}}{I_x}\dot{\phi}^2 + \dfrac{lb}{I_x}lb(\omega_4^2 - \omega_2^2) \\ \ddot{\theta} = -\dot{\phi}\dot{\psi}\dfrac{(I_z - I_x)}{I_y} + \dfrac{J_r}{I_y}\overline{\Omega_r}\,\dot{\theta} - \dfrac{K_{fay}}{I_y}\dot{\phi}^2 + \dfrac{lb}{I_y}lb(\omega_3^2 - \omega_1^2) \\ \ddot{\psi} = -\dot{\phi}\dot{\theta}\dfrac{(I_y - I_x)}{I_z} - \dfrac{K_{faz}}{I_z}\dot{\psi}^2 + \dfrac{lb}{I_z}lb(\omega_1^2 - \omega_2^2 + \omega_3^2 - \omega_4^2) \\ \ddot{x} = \dfrac{1}{m}(c\phi c\psi s\theta + s\phi s\psi)(\sum_1^4 F_i) - \dfrac{K_{ftTx}}{m}\dot{x} \\ \ddot{y} = \dfrac{1}{m}(c\phi s\psi s\theta + s\phi c\psi)(\sum_1^4 F_i) - \dfrac{K_{ftTy}}{m}\dot{y} \\ \ddot{z} = \dfrac{1}{m}(c\phi c\theta)(\sum_1^4 F_i) - \dfrac{K_{ftTz}}{m}\dot{z}\_g \end{cases} \quad (II.36)$$

II.6.3. Relation of forces/moment and speed of engines

From the equations mentioned above (II.10, II.14, II.15, II.16), we can calculate the speed of the engines from the forces and moments applied to the quad rotor. This relationship is very important for controller implementation. So we can rewrite the equations in matrix form such as:

$$\begin{bmatrix} F_i \\ M_x \\ M_y \\ M_z \end{bmatrix} = \begin{bmatrix} b & b & b & b \\ 0 & -bl & 0 & bl \\ \_bl & 0 & bl & 0 \\ d & \_d & d & -d \end{bmatrix} \begin{bmatrix} \omega_1^2 \\ \omega^2 \\ \omega_3^2 \\ \omega_4^2 \end{bmatrix} \quad (II.37)$$

By inverting the matrix, we obtain the relationship between the speeds of the engines:

$$\begin{bmatrix}\omega_1^2\\ \omega^2\\ \omega_3^2\\ \omega_4^2\end{bmatrix}=\begin{bmatrix}\frac{1}{4b} & 0 & \frac{1}{2b} & -\frac{1}{4b}\\ \frac{1}{4b} & -\frac{1}{2b} & 0 & \frac{1}{4b}\\ \frac{1}{4b} & 0 & -\frac{1}{2b} & -\frac{1}{4b}\\ \frac{1}{4b} & \frac{1}{2b} & 0 & \frac{1}{4b}\end{bmatrix}\begin{bmatrix}F_i\\ M_x\\ M_y\\ M_z\end{bmatrix} \qquad (II.38)$$

II.7 Dynamic study of a DC engine (motor)

II.7.1 the equations of a DC engine

A DC motor is simply an actuator that converts electrical energy into mechanical energy, it consists of two interactive electromagnetic circuits the first (called the rotor) is free to rotate around the second (called the stator) which is attached instead. [26]

In the rotor, several copper winding groups are connected in series and are accessible from the outside thanks to a device called manifold in the stator two or more permanent magnets impose a magnetic field that affects the rotor.

The stator is the inductor: its current is noted «i»

Note that the inductor current = excitation current

The rotor is the armature: its current is marked "I"

The electrical equation:

$$u = Ri + L\frac{di}{dt} + E$$

By taking the Laplace transform of the previous equation, we can form the transfer function of this system:

$$H(p)=\frac{K}{K^2+RF+(Rj+Lf)p+LJp^2}$$

K: Engine gain in V.s/rad

R: internal resistance of the motor in

L: inductance in H

f: friction

J: rotor inertia in $g.cm^2$

We deduce that this system is of order 2, and in the case of a quad copter the inductance on mH and the resistance on Ohm, so it is negligible and also neglects the friction (in front of the inertia of the rotor). So we get the following form:

$$H(p) = \frac{K}{K^2 + RJp}$$

The fact that it is a system of order 1 will be easily identified, the time constant makes a sound recording of the motor response to a voltage step

$$\tau = RJ = 0.1s$$

Et le gain statique K =1500 tr/min/volt

1500/9.55=157.08 rad/s/volt

So:

$$H(p) = \frac{K}{1+\tau p} \equiv \frac{157.08}{1+0.1p}$$

K: Motor gain in rad/s/volt

τ: engine time constant in seconds.

II.8 Simulink Model of a Quad copter

Starting with the expression of angular accelerations (9.5) uses the Matlab/simulink formalism to carry out the following simulation:

- Modelling of thrust and drag with gyroscopic effect and inertia effect

```
clc; clear;
close all;
%% constant parameters of quad copter
Ix = 7.5*10^(-3);   %the moment of inertia according to the X axis
Iy = 7.5*10^(-3);   % the moment of inertia along the Y axis
Iz = 1.3*10^(-2);   % the moment of inertia along the Z axis
Ir = 6*10^(-5);     % the moment of inertia of the motor in kg.m²
d = 7.5*10^(-7);    % trainee coefficient (kg.m.rad -2)
b = 3.13*10^(-5);   % thrust coefficient (kg.m.rad^-2)
l = 0.23;           % half-envirgure of the quad copter (en m)
m = 0.65;           % the mass of the quad copter in kg
g = 9.81;          % gravity
%% the PID parameters:
%% PID1 :( phi; roll angle)
   kpr=0.7;
```

```
    kir=0.7;
    kdr=0.7;
%% PID2 :(teta;pitch angle)
    kpt=0.7;
    kit=0.7;
    kdt=0.7;
%% PID3 :( psi;yaw angle)
    kpl=0.7;
    kil=0.7;
    kdl=0.7;
%% PID4:(Z;power)
    kpz=0.7;
    kiz=0.7;
    kdz=0.7;
```

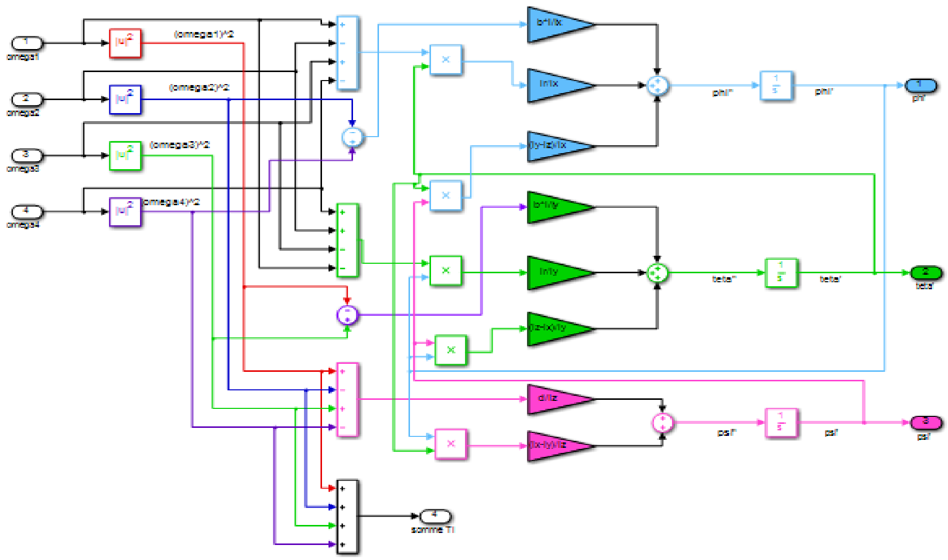


Figure II.7: complete simulation of angular acceleration modelling

And from the expression of the accelerations following the axes (X, Y) and the position (Z) we perform the following displacement simulation:

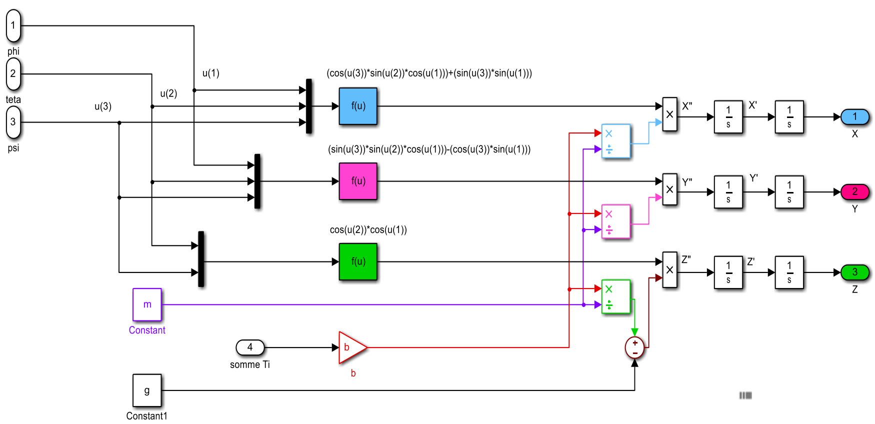


Figure II.8: displacement simulation

And in an open loop the mathematical relationship between angular accelerations and displacements after the use of motors equations is like the following simulation:

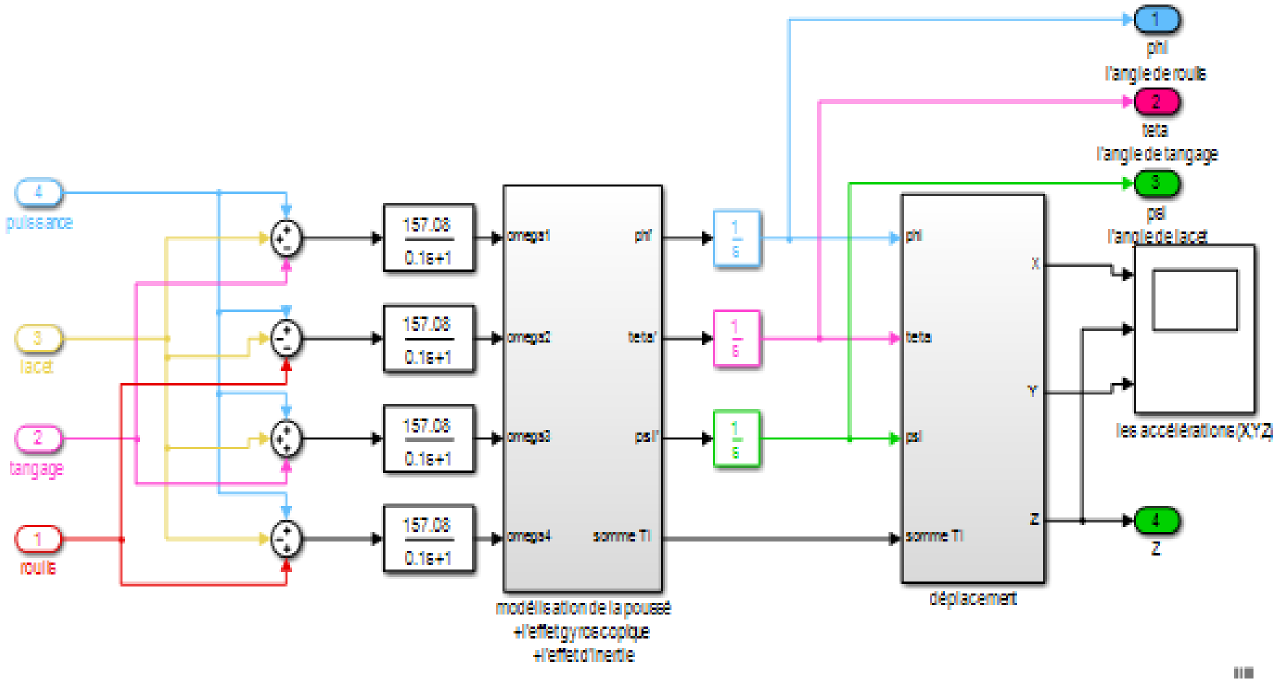


Figure II.9: the model of a quad copter

In this simulation, the dynamic quad copter constants were chosen equal to the coefficients of a typical real quad copter as Table (II. 1), the initial conditions of Tableau (I I.2) to use the angles in two cases is the same for all controls:

Table II.1: the constant parameters of the quad copter

Quadcopterr constant	
Ix	**7.5*10^ (-3)**
Iy	**7.5*10^ (-3)**
Iz	**1.3*10^ (-2)**
Ir	**6.0*10^ (-6)**
d	**7.5*10^ (-7)**
b	**3.3*10^ (-5)**
l	**0.23**
m	**0.65**
g	**9.81**

Table II.2: initial conditions for angles and step bloc

Case / angle	Case1	Case 2	Step block
phi	0.4	-0.1	1, 0, 0 0.01s
teta	0.5	0.3	1, 0, 0 0.01s
psi	0.6	-0.2	1, 0, 0 0.01s
z	0.8	0.6	1, 5, 5 0.01s

II.9 The stability of quad copter

Stability is the ability of a drone to return to a given state of flight balance when it has been discarded, without the pilot having to intervene.

- ✓ When it comes to movements around the pitch axis, we are talking about stability or longitudinal maneuverability.
- ✓ When it comes to movements around the roll axis, we are talking about stability or lateral maneuverability.
- ✓ When it comes to movements around the yaw axis, we are talking about stability or road maneuverability.

A servo system is a system called a tracker, it is the instruction that varies and in the case of a regulator, the instruction is fixed and the system must compensate for the effect of disturbances we apply linear controllers to stabilize the four-rotor and between these controllers we choose the PID, LQR,… etc.

II.9.1 quad copter stability with PID Control

The PID regulator or PID corrector (proportional, integral, derived) is an algorithm control system that improves the performance of a control system that is closed-loop system or process. It is the most used regulator in many fields where its correction qualities apply to multiple physical quantities. Among the advantages of this regulator we quote:

- Simple structure.
- Good performance in several processes.
- Reliable, even without a specific model of the control system.

The correction is based on the observed error which is the difference between the set (value desired) and measurement (real value).

e = set point – measurement

The PID allows three actions based on this error:

- ✓ **A Proportional action:** the error is multiplied by a gain Kp to improve the speed of the system, the greater the Kp, the shorter the response time increased exceedance and system stability is deteriorated.
- ✓ **An Integral action:** the error is integrated over a time interval t, then multiplied by a **Ki** gain to eliminate residual error in steady state (static error) and improves accuracy but, this causes the phase shift.
- ✓ **Une action Dérivée :** l'erreur est dérivée suivant un temps t, puis multipliée par un gain **Kd** ce qui accélère la réponse du système et améliore la stabilité de la boucle.

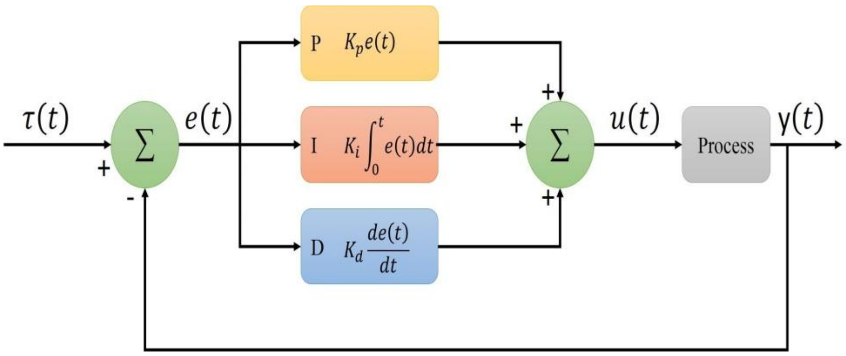


Figure II.10: Parallel structure of a PID regulator

The general expression of the proofreader is written in the following form:

$$U(t) = K_p e(t) + K_i e(\tau)d\tau + K_d \frac{de(t)}{dt} \qquad (II.39)$$

At the beginning of this chapter we mentioned that the quad rotor is a subset system to 6 DDL; the translation movements are occupied 3 DDL according to the axes (x, y,z), other DDLs are occupied by the rotation movements according to the axes (x, y, z) roll, pitch and yaw respectively. Our quad rotor is a quad rotor radio controlled by a controller of two joysticks balls, when we don't need to correct translation errors that will manually correct. Regarding the error that enters the roll, pitch and yaw motion will be corrected using the corrector PID through a gyroscope.

The orientation angles are checked as described in the following equations:

$$u_{\phi} = K_{pa}\left(\phi_d - \phi\right) + K_{ia}\int_0^t \left(\phi_d - \phi\right) + K_{da}\frac{d\left(\phi_d - \phi\right)}{dt} \qquad (II.40)$$

$$u_{\theta} = K_{pa}\left(\theta_d - \theta\right) + K_{ia}\int_0^t \left(\theta_d - \theta\right) + K_{da}\frac{d\left(\theta_d - \theta\right)}{dt} \qquad (II.41)$$

$$u_{\psi} = K_{pa}\left(\psi_d - \psi\right) + K_{ia}\int_0^t \left(\psi_d - \psi\right) + K_{da}\frac{d\left(\psi_d - \psi\right)}{dt} \qquad (II.42)$$

Where Kpa , Kia and Kda are parameters of the PID controller for controlling the roll, pitch and yaw.

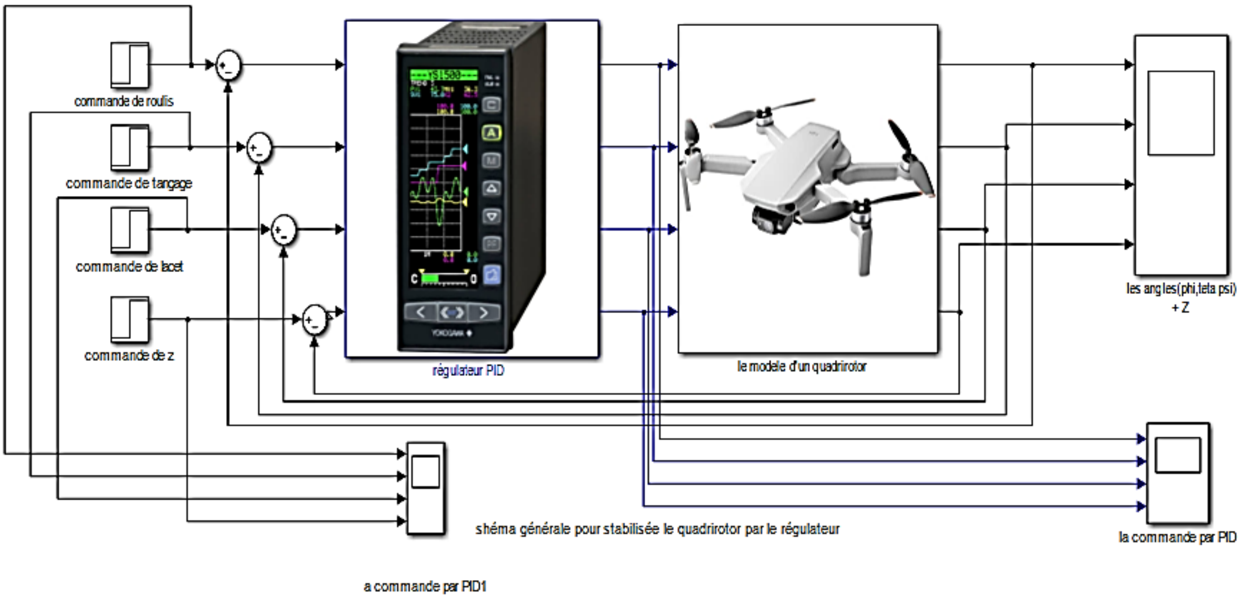


Figure II.11: Simulink diagram of the PID regulator

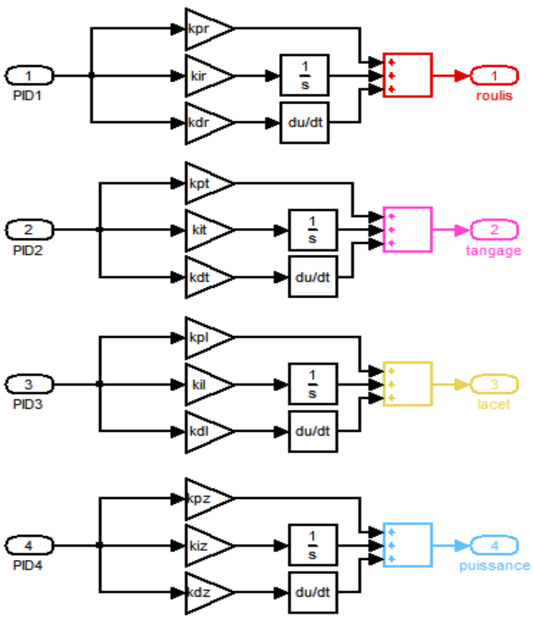


Figure II.12: the PID block

Table II.3: PID regulator parameters

Angle / PID	roll	pitch	yaw	power
kp	0.7	0.7	0.7	0.7
ki	0.7	0.7	0.7	0.7
kd	0.7	0.7	0.7	0.7

II.9.2 the results of the PID command

- The output of the control by PID

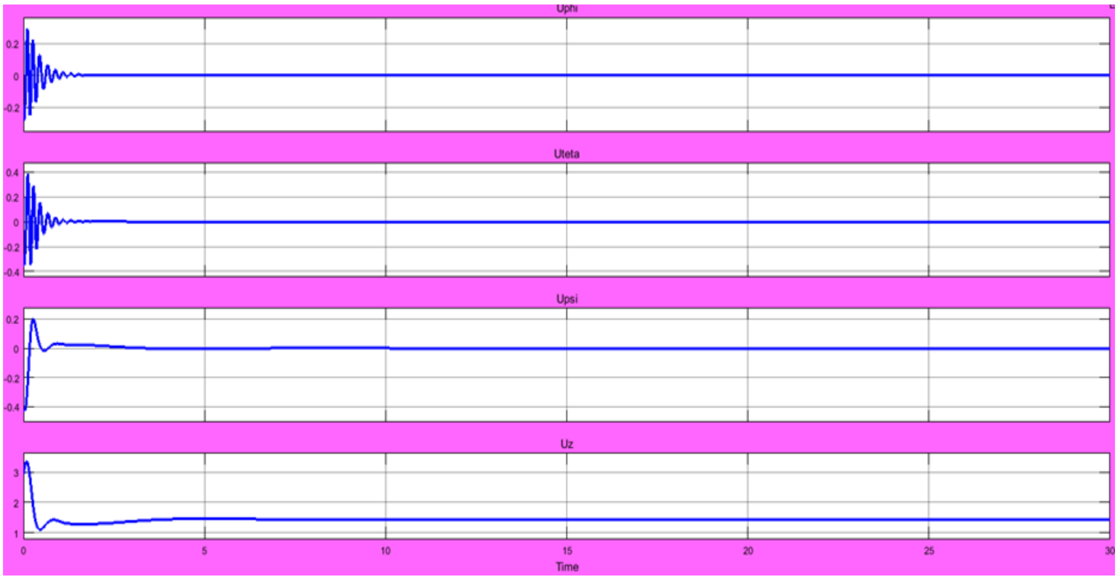


Figure II.13: the output of the PID control (case1)

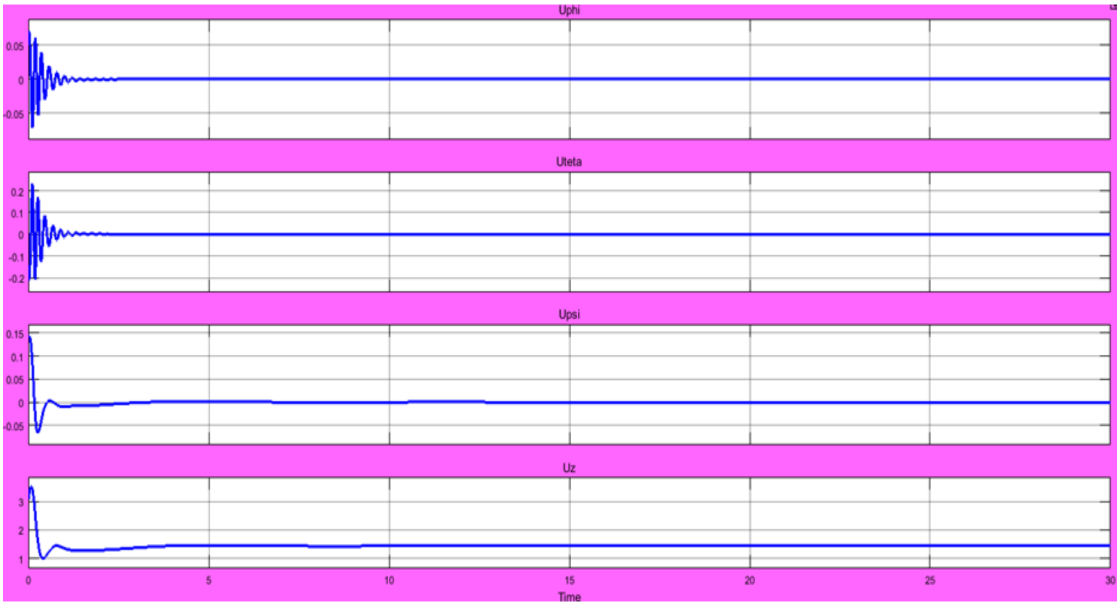


Figure II.14: the output of the PID control (case2)

- **The results according to the angles (phi, teta ,psi and Z)**

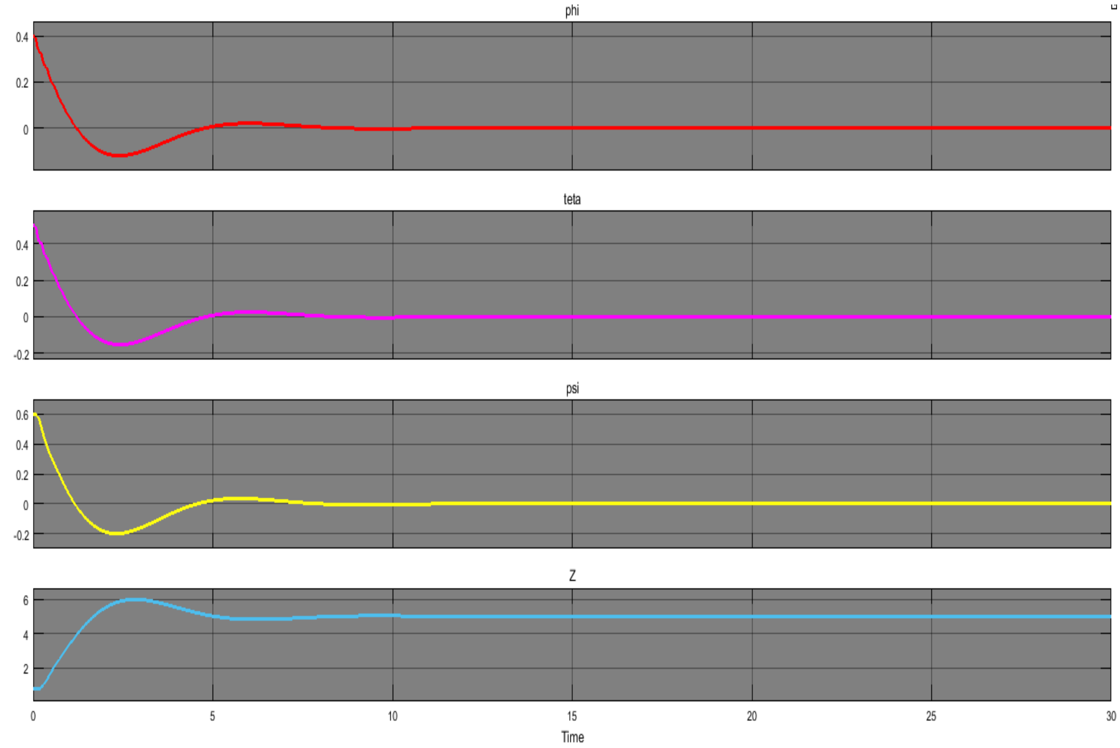


Figure II.15: the output of the PID control (case1)

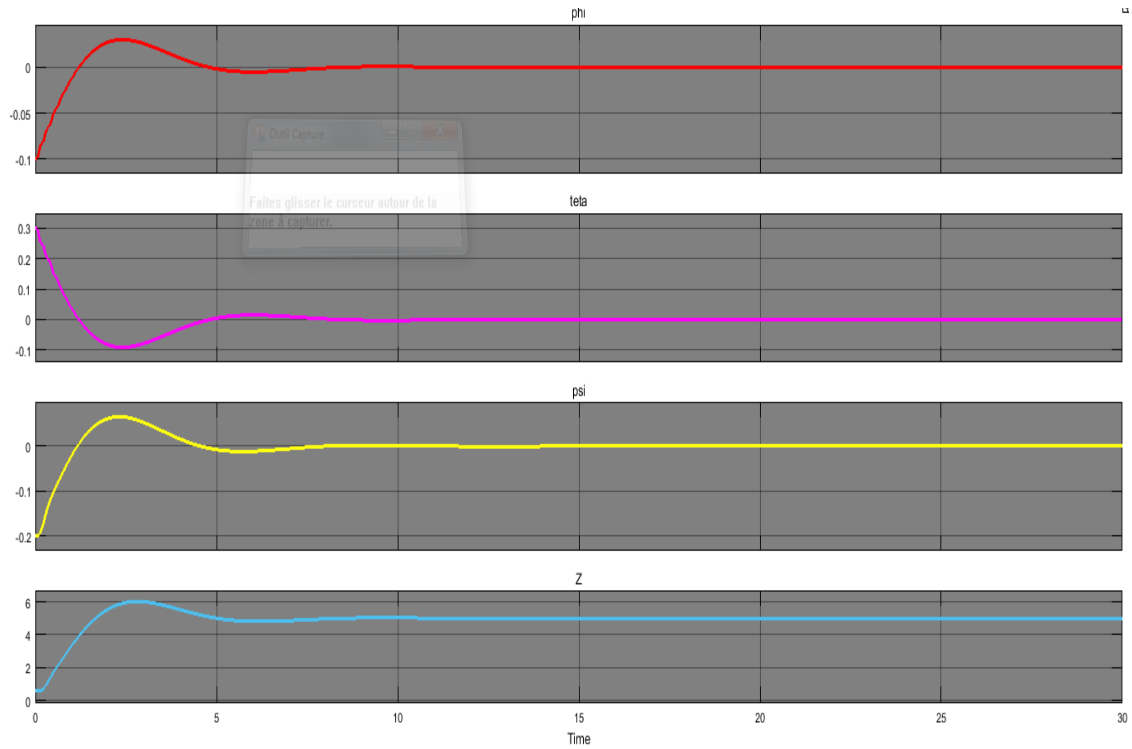


Figure II.16: the output of the PID control (case2)

- **Interpretation**

That the system consisting of the process and the control loop is said to be stable, since it has a set point variation, the measurement returns to a stable state.

Is the system is stable, because the elapsed time to regain stability constitutes the transient regime. (We see that stabilization on the three angles is quite fast)

II.9.3 Results obtained without PID regulator

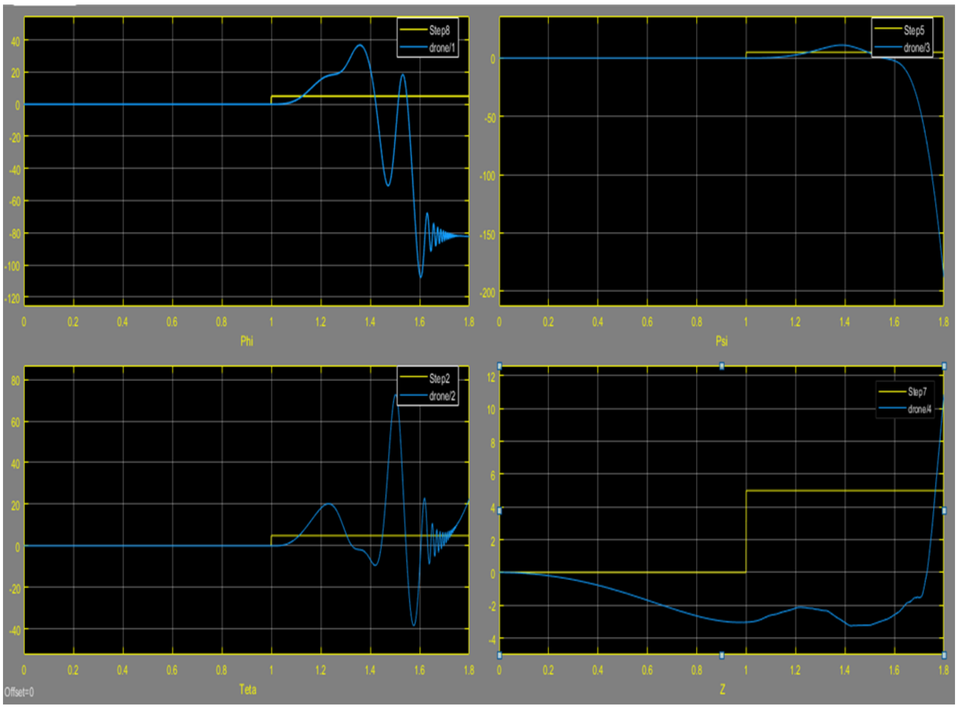


Figure II.17: Results at output of system

- **Interpretation**

Based on the results presented above, we can notice that the system is unstable and there is a divergence as time passes.

II.9.4 Quad copter control and stability

After the modelling of the quad copter and its physical behaviour, the objective of the «Simulink Controller» part is to develop an algorithm that allows calculating the four voltages of the motors from the two main inputs. These are the user-given yaw path and spatial position.

There are several ways to regulate the system around the balance point (yaw, roll and pitch equal to zero).

❖ **Quad copter regulation with PID**

The general approach to adjusting and stabilizing a system is as follows**:** Calculate the difference between the set point and the actual value at the output of the system and use a PID controller to minimize this error. For our case,

it is a question of checking the angles (phi, theta, psi) as well as the position (z) (Figure IV.6) the regulation.

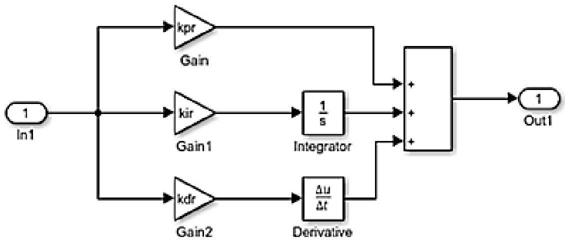


Figure II.18: PID corrector

The following diagram shows the regulated quad copter model with a closed-loop PID controller

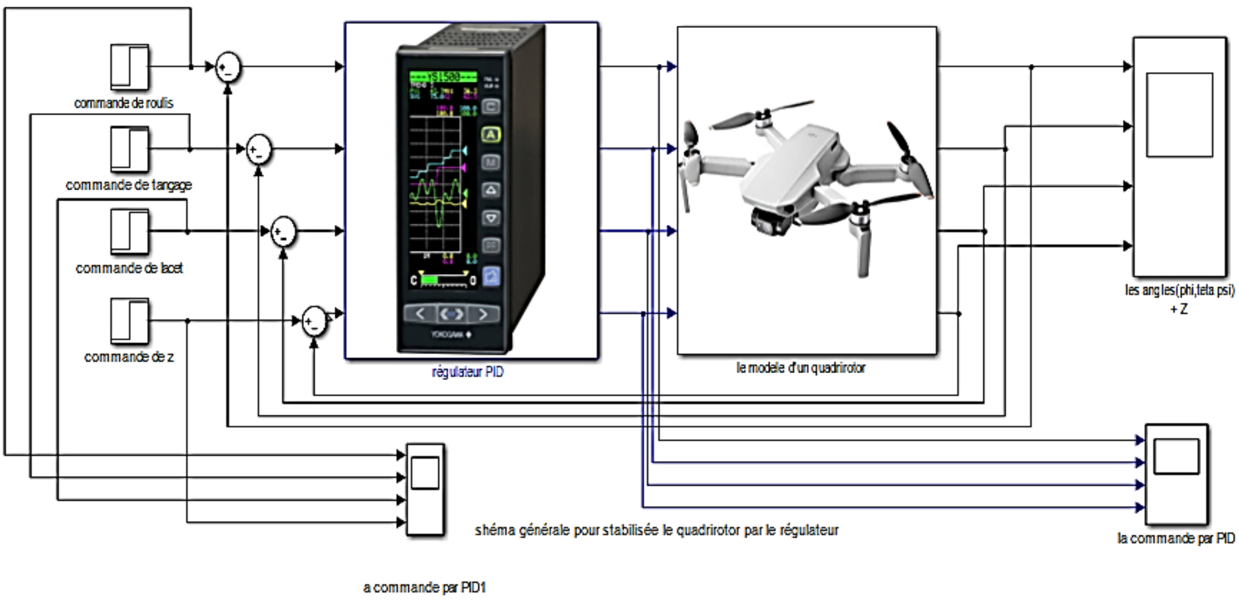


Figure II.19: PID Regulator Simulink Diagram

The following table shows the values of the three parameters P, I, D of the four movements obtained after several tests.

Table II.4: Settings of the PIDs used

PID1 (phi; roll angle)	PID2 (teta; pitch angle)	PID3 (psi; pitch angle)	PID4 (Z; the power)
kpr=0.5	kpt=0.5	kpl=0.4	kpz=0.5
kir=0.3	kit=0.2	kil=0.25	kiz=0.25
kdr=0.45	kdt=0.3	kdl=0.35	kdz=0.75

❖ **The results of the PID command**

The following Figures shows the simulation results using a PID controller

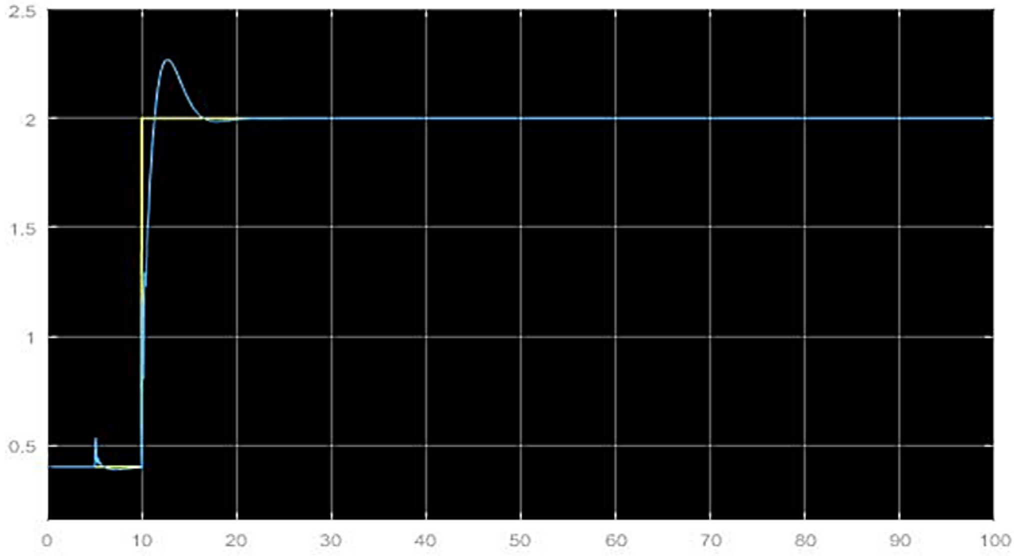


Figure II.20: roll angle (phi)

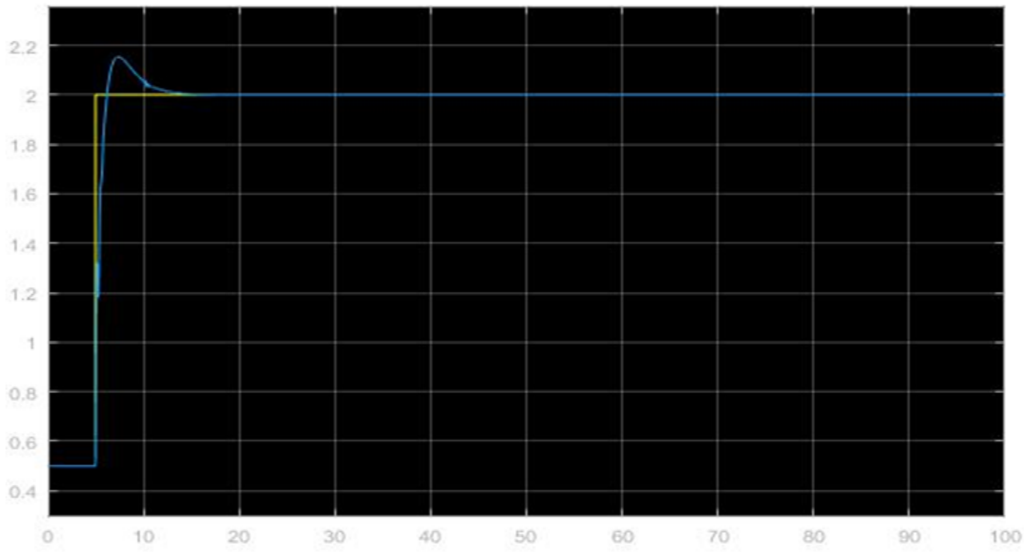


Figure II.21: pitch angle (teta)

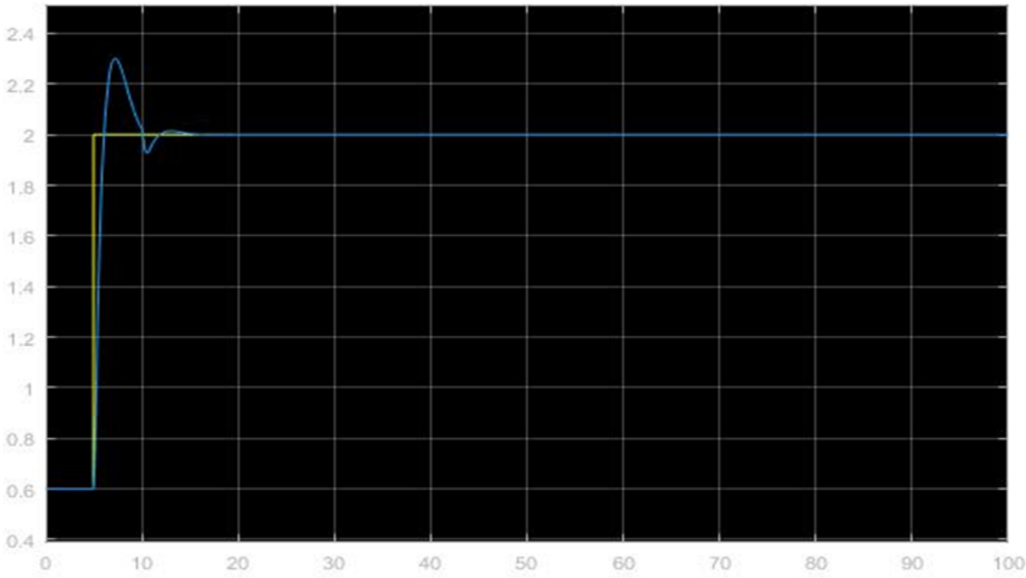


Figure II.22: yaw angle (psi)

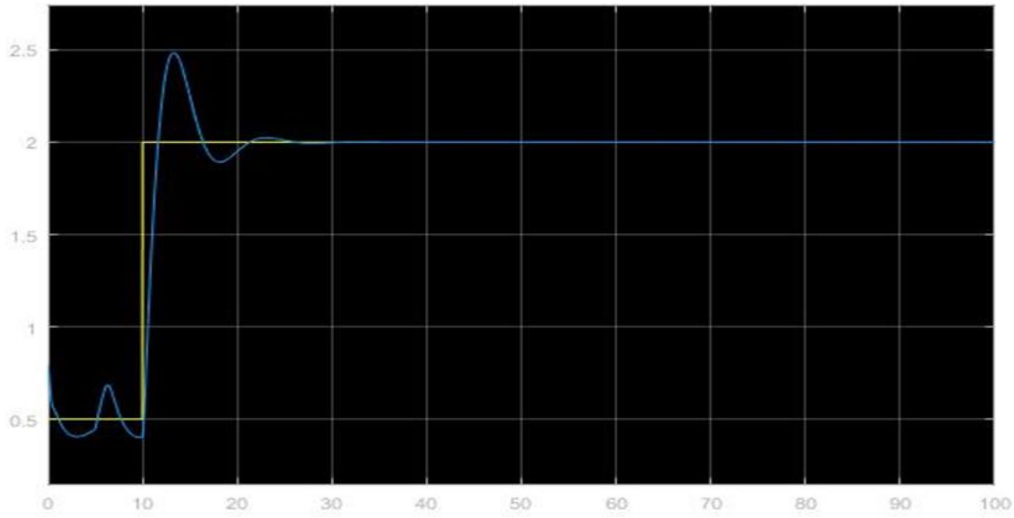


Figure II.23: the power (Z)

❖ **Note**

Figures (II.11, II.12, II.13 and II.14) show the roll angle tracking errors, pitch angle, yaw angle (θ, ψ), and Z motion relative to the desired trajectories θd, ϕd, ψd, Zd generated by the quad copter position control, We can thus see that there is good tracking of the trajectory for the entire mission despite some error observed between t=5 s and t=20 s.

The maximum exceedance is of the order of 0.5 which represents 20% of the desired value. These results are considered acceptable and therefore we can see that PID regulation has given satisfactory results for system stabilization.

II.10 Conclusion

This chapter allows the reader to have preliminary concepts about flying robots and their principle of operation. The quad rotor is one of the flying robots that have been under investigation in recent years. This system consists of four rotors, two of which rotate in one direction and the other two in the opposite direction. by varying the rotation speeds of these rotors, the quad rotor can make different movements both in translation and in rotation.

Concerning the modelling we used the Newton-Euler formalism where we established the dynamic model of the quad rotor to get as close as possible to the real dynamics of the quad rotor. The latter is subjected to disturbances of the external environment which influence the rotating behaviour of the quad rotor to which we have used the classic linear corrector PID. In the next chapter, we will see the simulation.

Chapter III

Realization of drone quad copter

III.1 Introduction

In this chapter, we will look at the phases of drone construction in how to search and coordinate parts in a precise way, subject to a study with scientific bases. We will also describe precisely the parts selected in the choice of the structure in terms of hardness, size and then the engines, which are of a special type and then lithium fans and batteries which are the most important parts that we will talk about the controller and which is the beating heart of the drone.

After the necessary steps to choose the parts, we assemble them one by one, starting with the flesh of the power, then assembling the motors, then placing the controller and adjusting the necessary adjustments.

III.2 Charge book

- ✓ Drone with solid structure, smooth and resistant to natural effects
- ✓ Be very effective in flight and turn
- ✓ Fly for 15 to 20 minutes
- ✓ It can carry a weight of at least 500 grams
- ✓ Distance control for a distance from 500m to 1000m
- ✓ Flying at an altitude of 30 metres or more

III.3Theoretical Study to Choose Drone component

Our theoretical study is based on an earlier expert study, as well as on the experiences of the manufacturers and each part has a compatible link with the other parts, according to the information presented.

III.3.1 frame

The frame is the main body of quad copter there are three types of quad copters Plus shape (+), Cross shape(X), and H shape The characteristics to be taken into account for the chassis are the weight, which will be linked to the Materials used and its impact resistance, the lighter the chassis, the more power you retain and the more flight time you gain.

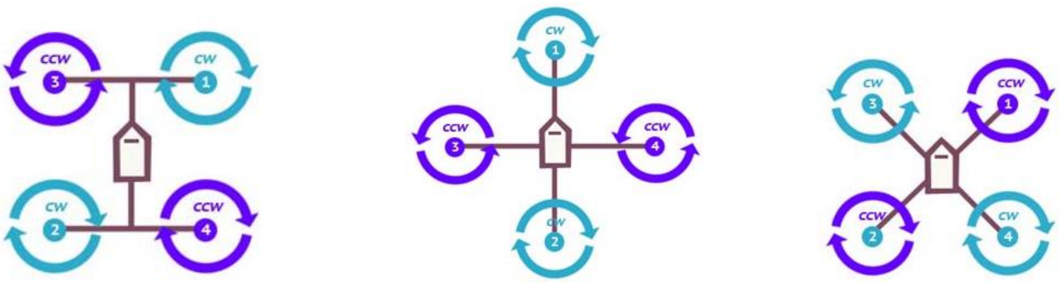


Figure III.1 : shap (H .+.X)

❖ **Top materials used in drones**

- ✓ Carbon fiber-reinforced composites
- ✓ Thermo plastics such as polyester, nylon, polystyrene, etc.
- ✓ Aluminum

The frame gives a drone its shape and holds all of the subsystems in place. Because it serves a mechanical function, the most important material property for the frame is strength. For commercial drones, thermoplastics such as variants of nylon, polyester, and polystyrene, are popular choices because they are inexpensive to make into complex parts using injection molding processes.[26]

Each material has its properties in terms of hardness, cost and weight, but in our project we want a light and solid structure that is capable of carrying the added parts with wind and shock-proof, so we found these specifications in carbon fiber structures.

Figure III.2: Frame (carbon fibre)

❖ **Properties**

- ✓ Light (246 g)
- ✓ Factory of solid and very light (carbon fiber materials)
- ✓ Medium size meets the needs (380 mm)
- ✓ Well designed and modern and helps integrate parts

III.3.2 Brushless motors

Â Brushless DC motors are synchronous motors, consisting of permanent magnets on the rotor, and a three-phase winding on the stator a controller (ESC), powered by a continuous current source, transforms this current into a three-phase alternating signal. Since the coils do not move, this means that the wires can go directly to them so no need for brushes and a collector.

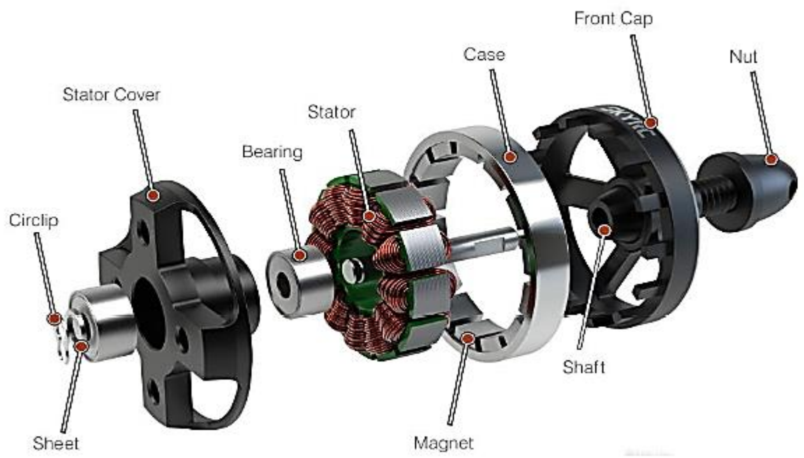


Figure III.3: Description of a BLDC engine

❖ **Functioning**

The brushless motor works from three sources of variable voltages and three groups of coils retries between them. Just run a current through part of the winding to create a magnetic field that will attract the magnets in the simple case of the BLDC motor, at each switch, two phases are connected respectively to the voltage supply and to the ground, and one phase is not connected. For example, in Figure 3, phase A is not connected, phase **B** is connected to the supply voltage and phase **C** is connected to the ground. A current runs through the coils from **B** to **C** and generates a statoric magnetic field $\vec{B}$ in the motor directed following ys The rotor supports a magnet whose magnetic moment **m** oriented from south to north, tends to align with the stator magnetic field by rotating in the trigonometric direction.

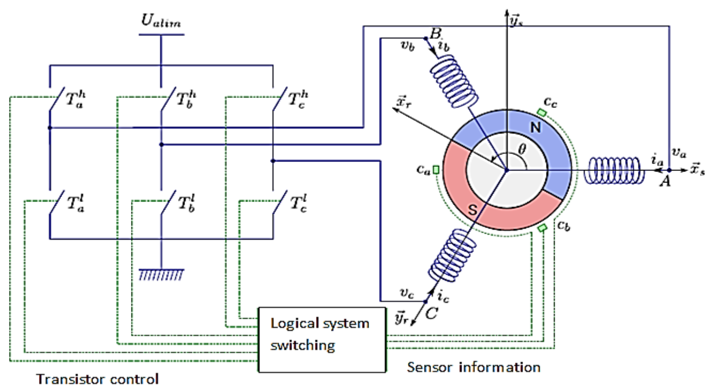


Figure III.4: Operation of the brushless inverter and motor

As soon as the rotor approaches ys, the switch will be modified to circulate the current from B to A, the stator magnetic field $\vec{B}$ rotates by $\frac{\pi}{6}$, so as to attract the rotor and continue the rotation in the trigonometric direction.

The angle between m and B leads to a magnetic torque $\vec{C}_m = \vec{m} \wedge \vec{B}$

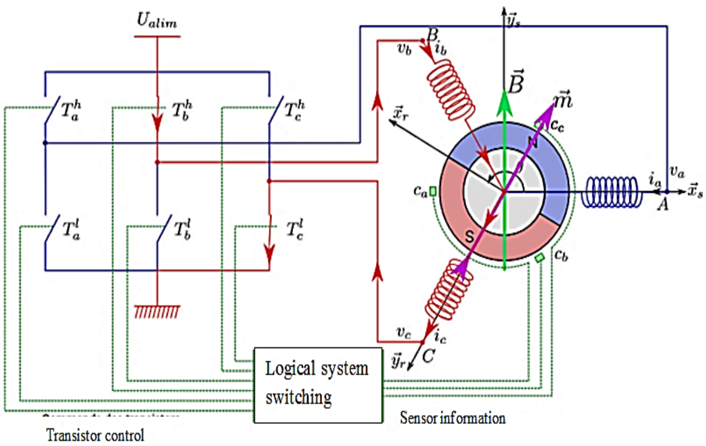


Figure III.5 : Exemple de situation de commutation

The rotor supports a magnet oriented from south to north, tends to align with the magnetic field by turning clockwise, by successively feeding coil groups A, B and C, the rotor will each time align to the fields and rotate.

The speed of this rotation is controlled by an electronic chip present in the tool. The latter detects the power required by the user through the Electronic controller. If a power loss is detected, this controller compensates by sending more current to the engine, in order to maintain a steady speed of rotation 7). [27]

- **Brushless motors (2212/920 KV)**

The 2212 Brushless DC Motor (BLDC) is a high-speed three-phase brushless motor designed specifically for quad copter, drones or toy aircraft. The engine is of the out runner type where the outer housing rotates while the interior remains fixed. It’s one of the most popular models on the market because it’s inexpensive. It’s better for small drones and airplanes. The model is available in different speeds and must be selected in a suitable way. {A}

Figure III.6: brushless motor 2212/920 KV

III.3.2.1 Criterion of choice

This engine was selected based on the following table

Table III.1: Quad copter frame, li-po battery, motor and propeller size matching table

Frame size	Prop size	Motor size	Motor kv	Li-Po battery
120 mm or smaller	3 Inch	1104-1105	4000KV+	80-800 mAh
150 mm-160 mm	3-4 Inch	1306-1407	3000 KV+	600-900 mAh 2s/3s
180 mm	4 Inch	1806-2204	2600 KV+	1000-1300 mAh 3s/4s
210 mm	5 Inch	2204-2206	2300 KV-2700KV	1000-1300 mAh 3s/4s
250 mm	6 Inch	2206-2208	2000KV-2300 KV	1300-1800 mAh 3s/4s
330 mm-350 mm	7-8 Inch	2208-2212	1500 KV-1600KV	2200-3200 mAh 3s/4s
350 mm-500 mm	9-10 Inch	2212-2216	800 KV-1000 KV	3300 mAh 3s/4s

- **Properties**
  - ✓ Long running time.
  - ✓ High dynamic response.
  - ✓ High efficiency.
  - ✓ Characteristic speed as a function of the more favourable torque.
  - ✓ Interference-free operation.
  - ✓ Can reach high speeds.
  - ✓ High torque to mass ratio.

III.3.3 Propellers

In aeronautics, a propeller is a means of propulsion that converts the rotary motion of an engine and generates a force propelling the aircraft forward a propeller in a drone for propulsion functions and stabilize the flight. It and mounted on an engine and usually has two blades. The rotation acts on the mass of air that passes through the propeller and propels it towards the rear towards an accelerated speed.

A pressure difference produces a thrust that is transmitted to the aircraft.

- **Propeller Characteristics**

The main characteristics of a propeller are:

- ✓ Number of blades
- ✓ Material and weight

- ✓ Diameter
- ✓ The pitch
- ✓ Direction of rotation

Most drone propellers have two or three blades, but the most common version being two. Thus, a three-blade propeller will not perform as well as another two-blade propeller, but it will provide more thrust with a little more power.

Figure III.7: Propeller with two and three blades

❖ **The manufacturing material**

Many materials are used in the manufacture of propellers for example, carbon, wood, plastic, resin but the propellers most used and very resistant. Because they are lighter, they consume less energy.

❖ **Diameter**

There are small or large propellers. For the quad copter, we use propellers from 8" (20/32 cm) to 13" (33.02 cm), and this size varies according to the size of the chassis. A 30 cm frame supports only 9" (22.86 cm) max propellers, while 450 cm frames can support 12" (30.48 cm) max propellers [28].

Figure III.8: diameter of propeller

❖ **The Pitch**

Pitch is the distance that the propeller travels vertically (linear trajectory) in a full turn. The pitch of a propeller can vary according to the number and form of the blades, the weight of the machine and the atmospheric pressure. The large steps have much more lift, allowing a more stable flight provided that the engine is powerful enough. On the contrary, small steps have less lift and its flight is quite stable, so they do not need much power and are indicated for weak engines.

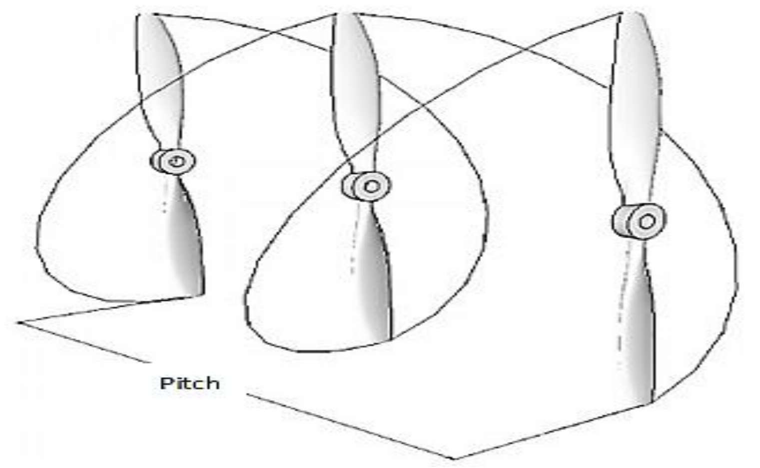


Figure III.9: Pitch of a propeller for one turn

- **Direction of rotation**

A propeller is called right pitch if it rotates clockwise (CW), and left pitch in the case of counter-clockwise (CCW). [29]

III.3.3.1 Criterion of choice

Propellers selected in this project based on datasheet motor

Table III.2: Motors datasheet

Item NO	Volts (v)	Prop	Throttle	Amps (A)	Watts (W)	Thrust (g)	Efficiency (g/w)	Operating temperature (c)
ML 2212 920KV	11.1 V	DJI9.4*4.3	50%	1.8	20	230	11.5	37 C
			65%	2.8	31.1	310	10	
			75%	3.9	43.3	410	9.5	
			85%	5.5	61.1	480	7.9	
			100%	7.6	84.4	610	7.2	
		APC10*4.5	50%	2.6	28.9	290	10.0	55 C
			65%	5.1	56.6	460	8.1	
			75%	7.4	82.1	590	7.2	
			85%	10.1	112.1	730	6.5	
			100%	13.4	148.7	860	5.8	
	14.8V	DJI9.4*4.3	50%	2.7	40.0	350	8.8	52 C
			65%	4.4	65.1	490	7.5	
			75%	6.3	93.2	640	6.9	
			85%	8.3	122.8	790	6.4	
			100%	11.5	170.2	990	5.8	

III.3.4 Electrical Speed Controllers (ESC)

The Electronic ESC (Electrical Speed Controler) speed controllers are essential electronic circuits to control the speed of the motors. Each engine must be controlled separately by a speed controller. [30]

Figure III.10: Electrical Speed Controllers (ESC)

On input, we find a classic positive and negative wiring, to be connected to a power supply generally a battery:

- ✓ red wire to power the engine, positive.
- ✓ black ground wire, negative.
- ✓ brown wire connected to the GND of arduino
- ✓ yellow wire corresponds to the signal (PWM) generated by the board

In output, there are 3 wires connected to the brushless motor, they are used to turn the motors.

Figure III.11 : Electrical Speed Controllers (ESC) scheme

❖ **Functioning of ESC**

The ESC controller receives the battery power and sends it to the motor coils without a brush connected in such a way that it operates at the specified speed. The output voltage of the receiver (link between the drone and the pilot) is too low to drive an engine. It is therefore used to trigger an ESC that manages the full battery voltage.

❖ **voltage variation**

The voltage at the input of the brushless motor controls the number of revolutions, so one must control the voltage to vary the RPM (revolution/minute or revolutions/minute), it is used as a measure of the revolution of the motor, which means ñ how fast the motor will run.

$$RPM = KV.U$$

❖ **Engine Position Detection**

The controller needs to know the position of the magnet to switch the current in the coils. Typically, it uses the induced current in the unbilled coil.

❖ **current switching**

The ESC controller is composed of MOS transistors controlled by a microcontroller, It takes at least six (two per coil) to form six switches (6). By adjusting the transistor switching frequency, the motor speed is changed. Here is a diagram showing the stator coil switching system:

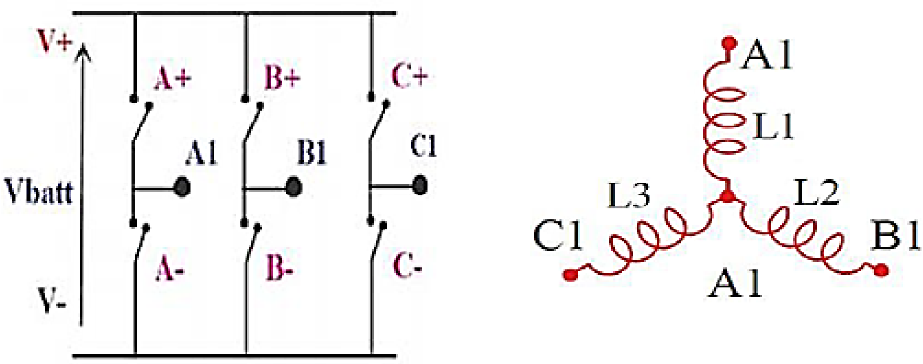


Figure III.12: coil switching

A+ closed A- open ⟶ A1 connected V+

A+ open A- closed ⟶ A1 connected V-

A+ open A- open ⟶ A1 open circuit

A+ closed A- closed ⟶ short circuit

III.3.4.1 Criterion of choice

The choice of ESC depends on the highest value absorbed by the engine, we recognize it through the motor datascheeet published by the factory

Table III.2: highest value absorbed by the ML2212

Item NO	Volts (v)	Prop	Throttle	Amps (A)	Watts (W)	Thrust (g)	Efficiency (g/w)	Operating temperature (c)
ML 2212 920KV	11.1 V	DJI9.4*4.3	50%	1.8	20	230	11.5	37 C
			65%	2.8	31.1	310	10	
			75%	3.9	43.3	410	9.5	
			85%	5.5	61.1	480	7.9	
			100%	7.6	84.4	610	7.2	
		APC10*4.5	50%	2.6	28.9	290	10.0	55 C
			65%	5.1	56.6	460	8.1	
			75%	7.4	82.1	590	7.2	
			85%	10.1	112.1	730	6.5	
			100%	13.4	148.7	860	5.8	
	14.8V	DJI9.4*4.3	50%	2.7	40.0	350	8.8	52 C
			65%	4.4	65.1	490	7.5	
			75%	6.3	93.2	640	6.9	
			85%	8.3	122.8	790	6.4	
			100%	11.5	170.2	990	5.8	

III.3.5 Batteries

There are two main types of batteries: Ni-Mh (Nickel—Metal hydride) and Li-Po. Ni-Mh is an evolution of Ni-Cd batteries (Nickel—Cadmium) in order to suppress the memory effect. Li-Po is a different technology where the memory effect does not exist but has other constraints. This second type of battery is now the most popular choice for those looking for long times and high power. The vast majority of drones are powered by LiPo 3S rechargeable batteries, of much better quality in terms of energy storage. Drones weighing less than 2 kg very often use 11.1V LiPo 3S batteries.

❖ **Battery characteristics**

There are three main characteristics of a LiPo battery:

- ✓ Voltage
- ✓ capacity
- ✓ discharge rate

Figure III.13 : Batterie Li-Po 11.1V

❖ Voltage

La tension exprimée en Volts de la batterie influe directement sur la vitesse de rotation des moteurs électriques. Elle dépend du nombre de cellules

Of which they are composted. Generally, the amount of cells in a quadrotor battery varies from 1 â 3A LiPo cell â a standard voltage of 3.7 V. The above battery of 11.1 V is â three times 3.7V, so it is a battery â three cells in series (3S).

❖ Capacity

This is the amount of energy a battery can provide when fully charged. It is usually expressed in milli amperes hours (mAh): for example, a 5000 mAh battery will return 5A for one hour, conversely if we charge the same battery â 5A, it will be fully charged in about one hour. The higher the value, the greater the autonomy.

Drone battery capacities most often vary between 1000 and 8000 mAh, but can reach â more than 2000 mAh for models requiring high autonomy for professional drones for example, and stays around 550 mAh for a mini drone, or even down to 80 mAh.

❖ discharge rate

In addition to the capacity of the battery, it is essential to look at its discharge rate, noted "C". It corresponds to the maximum battery capacity â to discharge continuously without risk. In other words, on the above battery, 30C means that the battery can be discharged with a power of up to 30 times the capacity of the battery in a continuous way, that is 2200mAh 30 C = 2.2A x 30 = 66 A in a continuous max. This rate will notably have an impact on drone performance and especially on the battery's ability to deliver a certain amount of energy at a precise moment, to make the drone operate to the maximum of its possibilities.

❖ The advantages

Li-Po batteries offer three main advantages over NiMH (Nickel-Metal Hydride) or Ni-Cd (Nickel Cadmium) batteries:

- ✓ Lightweight and high performance.
- ✓ High capacity, allowing them to retain much more power.
- ✓ Offers a better power/weight ratio than any other Batteries.

❖ The disadvantages

Allows the disadvantages of Li-Po batteries

- ✓ They have a shorter lifespan than Ni batteries.
- ✓ Battery chemistry can cause a fire if the battery is punctured and vented into the air.
- ✓ They require specialized care in how they are loaded, unloaded or stored.

III.3.6 Balanced Charger

In a multiple-celled battery pack, it is possible for the individual cells to develop differences in their charge levels. Since Lithium Polymer (LiPo) batteries are very sensitive to overcharging, it's important that their cells be kept at or very near equal levels when charging. A balanced charger (or balancer) does this by monitoring the individual cell voltages in a pack through a connector on the pack (called a balance connector) and adjusting their rate of charge accordingly. When such a balancer is built into a charger, the charger is known as a Balance Charger.

Figure III.14 : Balanced Charger

III.3.7 Flight controller

The flight controller is the brain of a drone. A small box filled with intelligent electronics and software, which monitors and controls everything the drone does. And just like the brains of different organisms, flight controllers also vary in sizes and complexity,allows control of motor speed and general movement of Drone with other features that allow good stability and performance of Drone.

III.3.7.1 kk 2.1.5

The KK2.1 Multi-Rotor controller manages the flight of (mostly) multi-rotor Aircraft (Tricopters, Quadcopters, Hexcopters etc). {B}

Its purpose is to stabilize the aircraft during flight and to do this, it takes signals from on-board gyroscopes (roll, pitch and yaw) and passes these signals to the Atmega324PA processor, which in-turn processes signals according the users selected firmware (e.g. Quadcopter) and passes the control signals to the installed Electronic Speed Controllers (ESCs) and the combination of these signals instructs the ESCs to make fine adjustments to the motors rotational speeds which in-turn stabilizes the craft.[31]

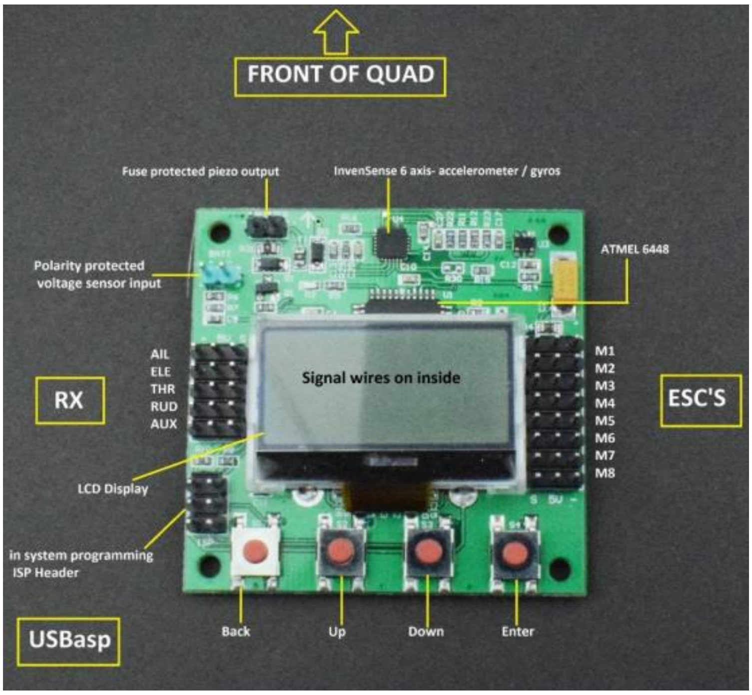


Figure III.15: KK 2.1.5 Multi rotor Flight Control Board

❖ **K.K 2.1.5 Configuration**

For better stability of the quadcopter we put certain values to the settings menu.

Figure III.16: Main Screen of the FCU KK 2.1.5

❖ **PI Editor**

It enables us to adjust the control loop feedback parameters for Roll, Pitch and Yaw. The proportional term (P) produces an output value that is proportional to the current error value. A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the quad copter will overshoot and start to oscillate. Since the control loop compensates for errors 400 times a second too high a P gain will result in a high frequency oscillation. If the proportional gain is too low, the control action will be too slow to react on the quad copter and it will be difficult to control. The contribution from the integral term

(I) is proportional to both the magnitude of the error and the duration of the error. The integral in a PI controller is the sum of the instantaneous error over time and gives the accumulated offset that should have been corrected previously. If the integral term is too high, the quad copter will start to oscillate. Since the 'I' term is related to the duration of the error over time, too high as I gain will result in a low frequency oscillation. Too low as I gain will result in a less "locked in" feeling.

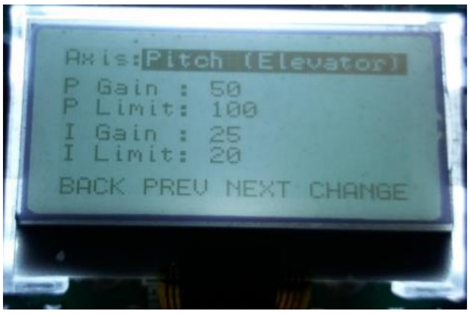


Figure III.17: Inside the PI Editor Menu and adjusting the Pitch Axis PI values for Stable Flight

Channel : 1

P gain: 50 **P limit:** 100 **I gain:** 25 **I limit:** 20

Figure III.18: Inside the PI Editor Menu and adjusting the Pitch Axis PI values for Stable Flight

Channel : 2

P gain: 50 **P limit:** 100 **I gain:** 25 **I limit:** 20

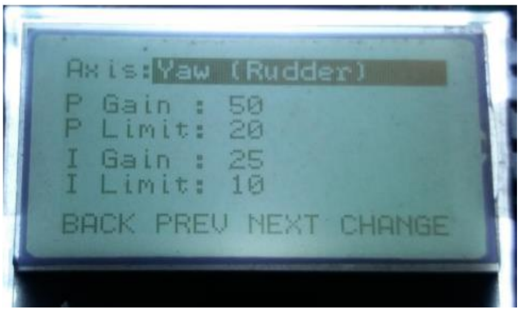


Figure III.19: Inside the PI Editor Menu and adjusting the Yaw Axis PI values for Stable Flight

Channel : 4

P gain: 50 **P limit:** 20 **I gain:** 25 **I limit:** 10

❖ **Show Motor Layout**

Displays a graphical representation of the motors and servos

- ✓ Can be used to check the Motor direction and which outputs to connect the ESCs and Servos to. Note that this does not set the motor direction. That is set by the wires connected between your motor and ESC. If needed to reverse the motor, reverse two of the three motor wires.
- ✓ Enables us to see which Motor Layout we have selected and any changes we make in the Mixer Editor.

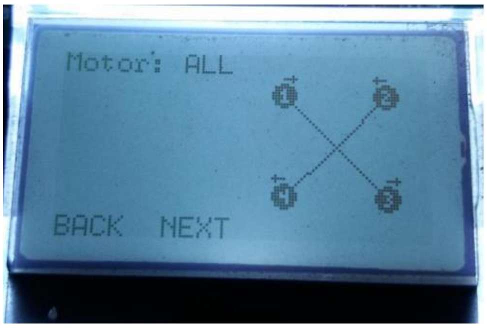


Figure III.20: Motor Layout

Not

The third channel for uploading remains the same

III.3.7.2 QQ thunder super

Multi-Rotor Controller have a built-in precise digital gyroscope. It is with an acceleration sensor which able to provide excellent self-leveling. Besides all standard PCM and 2,4G digital receivers. It is also compatible with S.BUS, DSM2 and DSMX , satellite. They have the most convenient way to bind the model and adjust the sensor that makes you have more time enjoy the flight. [32],{C}

Table III.3 : Product Specifications

Processor	32 BIT ARM
Voltage	**3.6-5.4V**
Current	**60mA**
Output rate	**360Hz**
Dimension (L-W-H	**43x29x13 mm**
Weight	**13 g**

Figure III.21 : QQ thunder super

❖ Hardware Connecting

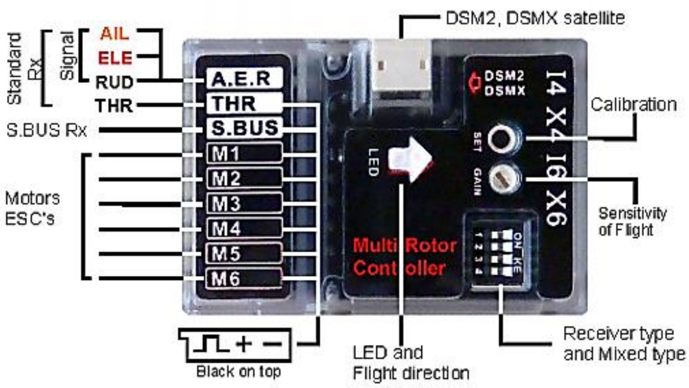


Figure III.22 : Hardware Connecting

❖ Status LED

It has different lights color to show different status when power on, please refer to as shown belo

Table III.4: Status LED

Power on ⟶		from left to right ⟶		Ready
LED on 1 second [Receiver type]	LED off 0.5 second	LED on 1 second [Mixed type]	LED off 0.5 second	Constant on [Ready]
White: Standard receiver		White : I-4		Green light constant on means lock
Blue : S.BUS	LED off	Blue : X-4	LED off	
Yellow : DSM2		Yellow : I-6		
Purple : DSMX		Purple : X-6		

❖ DIP Switch

There is a 4 bits DIP switch for setting receiver type and mixed type. Once you changed the switch position, you have to re-power on! Please contrast as shown below:

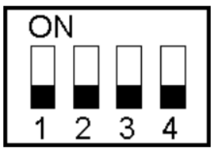


Figure III.23 : Switch schematic diagram

The 1–2 bits of DIP Switch for Multi-Rotor mode define, the 3–4 bits for receiver type define, refer to as shown below:

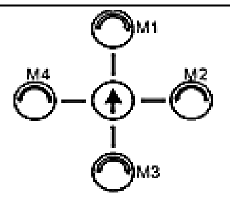
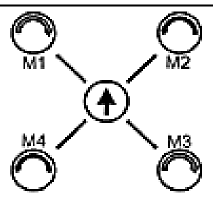
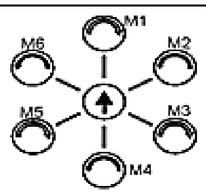
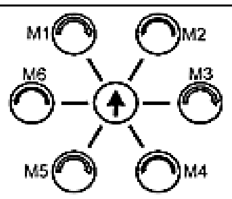
Table III.5: switch diagram

Mixed type	Switch schematic diagram	Receiver type	Switch schematic diagram	LED light color
I-4	ON 1 2	Standard receiver	3 4	white
X-4	ON 1 2	S.BUS	3 4	blue
I-6	ON 1 2	DSM2	3 4	yellow
X-6	ON 1 2	DSMX	3 4	purple

❖ Installation Instruction

It has different kinds of Multi-Copter mode. refer to as shown below, different mode has different direction and position:

Table III.6: different kinds of Multi-Copter mode

Mixed type	Installation Instruction
I–4	
X–4	
I–6	
X–6	

Notes

1) Remove propellers during installing, to avoid any injury from motor accidental start!

2) Support all standard receivers, S.BUS, DSM2 and DSMX satellite, but you can only use one of these. Absolutely for bidden to install receiver together or mix!

3) Controller must be securely mounted in as close as the barycentre of the multi-rotor. In order to provide better flight performance, we suggest taking some measures to avoid vibrations.

4) The ESC's travel midpoint is at 1520us, DO NOT use 700us travel midpoint ESC, as it may lead aircraft to fly away or cause injury and damage.

III.3.7.3 PIXHAWK

It is a flight controller that contains several inputs and outputs that allow it to direct the drone according to certain parameters entered by the factory, and it is able to add other equipment like a camera, and it is specially designed for the general class of hobbyists and students and anything that spins in drone orbit, there are several version of this controller, and each new version is more advanced that the other. [33]

❖ **Connectors**

Like all distribution boards, it has multiple inputs and outputs that ensure total control over the circuit breakers and the professional touch to this board and its elements are defined in the following schema.

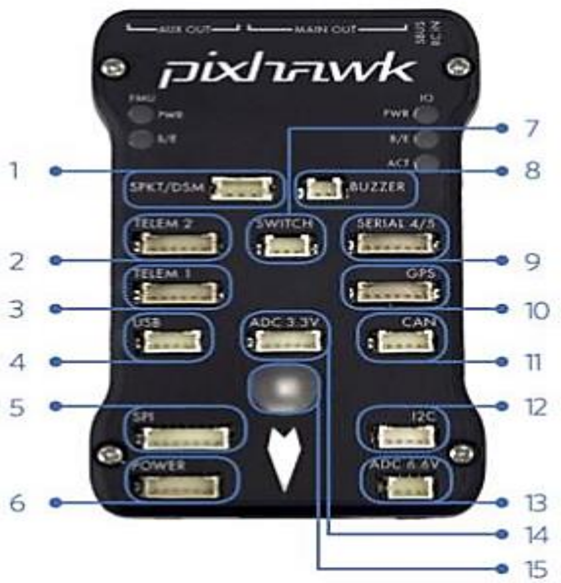


Figure III.24 : Pixhawk2.8 schematic diagram

1 Spektrum DSM receiver

2 Telemetry (on-screen display)

3 Telemetry (radio telemetry)

4 USB

5 SPI (serial peripheral interface) bus

6 Power module

7 Safety switch button

8 Buzzer

9 Serial

10 GPS module

11 CAN (controller area network) bus

12 PC splitter or compass module

13 Analog to digital converter 6.6 V

14 Analog to digital converter 3.3 V

15 LED indicator

❖ **Assembly of the drone components with (2.8 pixhawk)**

The assembly of components with the distribution board has precise steps including the assembly of the motors, then immediately after assembly, it is connected via the USB port with PC to be programmed according to certain parameters.

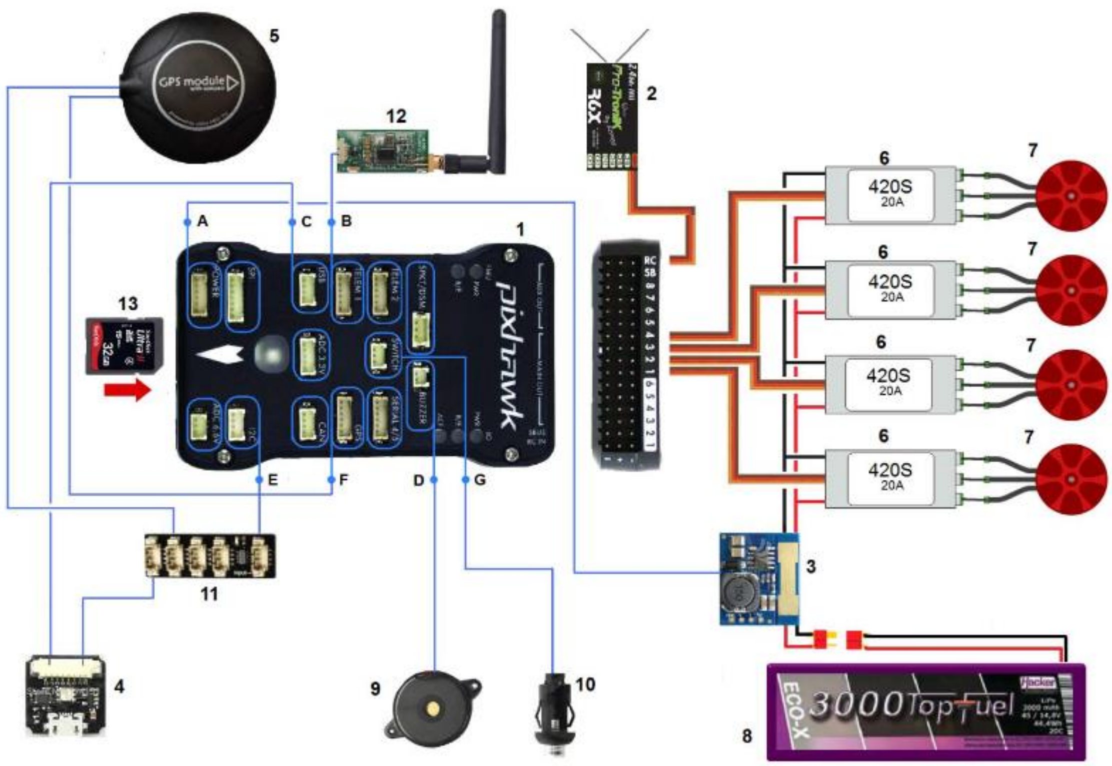


Figure III.25: assembly diagram

Table III.7: Assembly of the drone components with (pixhawk2.8)

Number	Part
1	Board distribution (pixhawk2.8)
2	Receiver FS-IA6B
3	Power distribution
4	ring of gps
5	GPS
6	ESC 20A
7	Brushless motor
8	Lithium battery 3000 mah
9	Sonnerie piézo-éléctrique
10	Switch button
11	Entrances to other additions
12	CC2531 ZigBee USB Dongle
13	SD card

- **Setup program (Mission Planner)**

It is program designed for the purpose of setup boards distribution, especially PIXHAWK, and it can allow the user to adjust the balance and control pints according to the type of drone and according to the structure, it’s easy to use for beginner and professionals.

- **Mission Planner**

Once installation is complete, open Mission Planner by clicking on its system icon Once the installation of Mission Planner and driver is done, there will several pop-ups when you open the MP at the first time The first pop-up clicks Yes and the others click NO There are six menu button in main menu.

Flight DATA: flight attitude and data will show in real time on MP

Flight plan : planning the flight mission

Initial setup : for firmware installation and update, Mandatory Hardware and Optional Hardware setup

Config/ tuning : including detailed PID setup and parameters changeSimulation **:** make PIXHAWK work as a simulator after upgrade a special simulation firmware

Helpe: you can get help when you have questions about MP

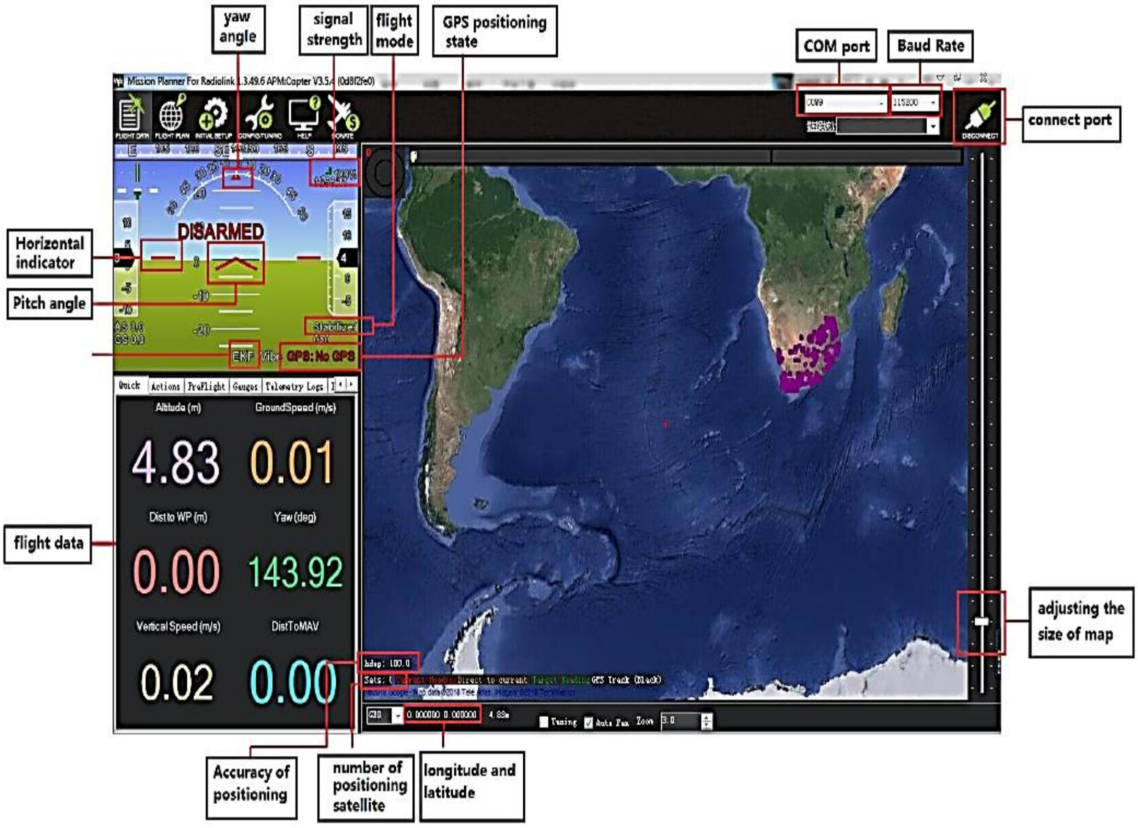


Figure III.26: Mission Planner

❖ **Characteristics of pixhawk2.8**

- **Processor**
  - ✓ 32-bit ARM Cortex M4 core with FPU
  - ✓ 168 Mhz/256 KB RAM/2 MB Flash
  - ✓ 32-bit failsafe co-processor
- **Sensors**
  - ✓ MPU6000 as main accel and gyro
  - ✓ ST Micro 16-bit gyroscope
  - ✓ ST Micro 14-bit accelerometer/compass (magnetometer)
  - ✓ MEAS barometer
- **Power**
  - ✓ Ideal diode controller with automatic failover
  - ✓ Servo rail high-power (7 V) and high-current ready
  - ✓ All peripheral outputs over-current protected, all inputs ESD protected
- **Interfaces**

- ✓ 5x UART serial ports, 1 high-power capable, 2 with HW flow control
- ✓ Spectrum DSM/DSM2/DSM-X Satellite input
- ✓ Futaba S.BUS input (output not yet implemented)
- ✓ PPM sum signal
- ✓ RSSI (PWM or voltage) input
- ✓ I2C, SPI, 2x CAN, USB
- ✓ 3.3V and 6.6V ADC inputs

- **Dimensions**
  - ✓ Weight 38 g (1.3 oz)
  - ✓ Width 50 mm (2.0")
  - ✓ Height 15.5 mm (.6")
  - ✓ Length 81.5 mm (3.2")

III.2.8 Remot control

A radio control communication usually involves a transmitter and a portable receiver. For UAV, we need a minimum of four channels These channels are typically associated with:

• **Pitch:** which results in a forward-backward motion.

• **Altitude (throtel):** Move closer or further away from the ground.

• **Yaw:** clockwise or counter-clockwise.

• **Roll:** lateral motion left and right.

❖ **Description:**

FlySky FS-i6 2.4G 6CH RC Transmitter With FS-iA6 Receiver

- **Brand Name:** Flysky;FS-i6

❖ **Specifications:**

- ✓ **Channels:** 6 Channels
- ✓ **Model Type:** Glider/Heli/Airplane;RF
- ✓ **Range:** 2.40-2.48GHz
- ✓ **Bandwidth:** 500KHz
- ✓ **Power:** Less Than 20dBm
- ✓ **Code Type:** GFSK

- ✓ **Sensitivity:** 1024
- ✓ **Low Voltage Warning:** less than 4.2V
- ✓ **DSC Port:** PS2
- ✓ **Output:** PPM
- ✓ **Charger Port:** No
- ✓ **ANT length:** 26mm*2(dual antenna)
- ✓ **Weight:** 392g
- ✓ **Power:** 6V 1.5AA*4
- ✓ **Display mode:** Transflective STN positive type, 128*64 dot matrix VA73*39mm,white backlight.
- ✓ **Size:** 174x89x190mm;On-line
- ✓ **Color:** Black;
- ✓ **Certificate:** CE0678,FCC;
- ✓ **Channel Order:** Aileron-CH1, Elevator-CH2, Throttle-CH3, Rudder-CH4,Ch 5 & 6 open to assignment to other functions.

❖ **Reciver FS-iA6**

Specifications:

- ✓ **Channels:** 6 Channels
- ✓ **Model Type:** Fixed wing/Glider/Airplane
- ✓ **RF Range:** 2.40-2.48GHz
- ✓ **Bandwidth:** 500KHz;

Figure III.27: remot control flysky fs-i6

Figure III.28 : reciver FS-IA6B

III.3.8.1 Criterion of choice

The FlySky FS-i6 basic RC set is an economic solution for beginners, that still provides good set of features, telemetry and broad programming capabilities. For a very reasonable price you get a programmable RC set with basic telemetry, more than sufficient for hobby flying. The set includes iA6 receiver that supports PWM, PPM and iBUS output formats. The smaller size factor is excellent for child's hand. It is available in both Mode 1 (right hand throttle) and Mode 2 (left hand throttle), with easy way to select Modes 3 and 4 directly in the transmitter. The transmitter can be easily upgraded to a different, open source firmware featuring 10 channels and some other improvements.

III.3.9 Flight time

Pilot time that commences when an aircraft moves under its own power for the purpose of flight and ends when the aircraft comes to rest after landing [34]

$$t = \mu * \frac{60}{1000} * \frac{c * v}{n * pm + pe}$$

C: battery capacitance (mh)

V: nominale voltage (volt)

n: number of motors

Pm: motors consumed power (watt)

Pe : components consumed power (watt)

μ : battery constant (0.8)

- **All up weight**

  is the total weight of the combined drone cutting

  - ✓ Battery (3s) 377 g
  - ✓ Frame 246g
  - ✓ Motors 53g x 4 = 212 g
  - ✓ ESC 4 x 25g = 100 g
  - ✓ Flight controller 13g

All up weight =948g

- **battery power**
  - ✓ battery capacitance

C= 5000 mh

- ✓ nominale voltage

V=11.1

- **consumed power**

- ✓ motors

948 / 4 = 237

1motor ⟶ 237 (in datascheet of motor 290 g ⟶ 28.9 w)

- ✓ motors consumed 28.9 W
- ✓ another components 50 W

$$t = 0.8 * \frac{60}{1000} * \frac{5000*11.1}{4*29.8+50} = 15.74\,\text{min}$$

III.4 Building and Preparing to Fly a Quad copter

In this part we will see the construction of the drone phase and we will show how it was assembled from the construction of the structure to the flight.

- **Not**

In this part we relied on:

- ✓ Experts who have done previous experiments in YouTube
- ✓ Data attached with pieces
- ✓ Our Theoretical Study

III.4.1 Acquisition of Drone component

The purchase of drone pieces was made after the theoretical study through several stages and the pieces were purchased from several points of sale, which are fully imported

Figure III.29: Drone component

III.4.2 Building the Frame and power distribution

In this part, we build a piece with a piece according to the scheme, and then we flesh the electric wire into the power distribution panel and motors

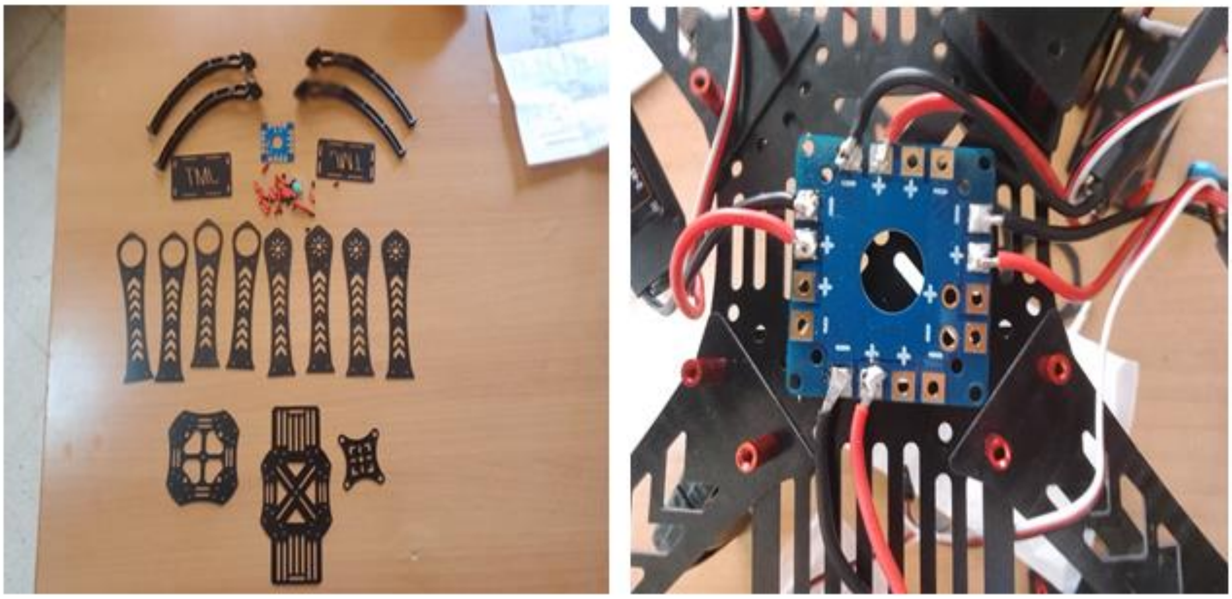


Figure III.30: Frame and power distribution

III.4.3 installation of motors and ESC

The installation of motors and ESC according to the form of the frame (x) as indicated in the theoretical study

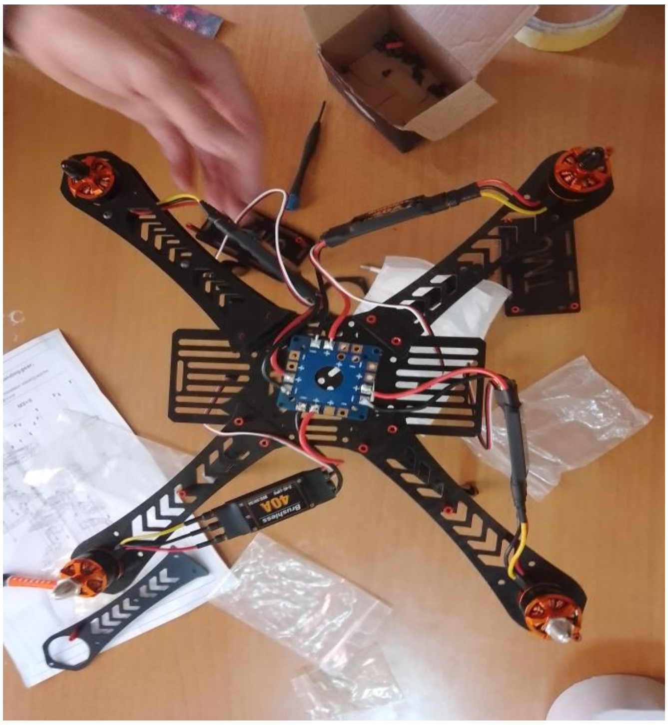


Figure III.31: The installation of engines and ESC

III.4.4 flight control

We connect it with the engines according to the document attached to it in the case it is considered the most important stage where it is subjected to precise steps

Figure III.32: flight controller associate with motors

III.4.5 Test Motors without propeller

Motors without propellers determine the direction of engine rotation as well as to prevent the drone from random collisions as well as protect

III.4.6 Quad copter Flies

After we did all the steps of assembling and adjusting the settings, we tried the drone which flew well with a remarkable balance and that's our goal

Figure III.33: Quad copter Flies

III.5 Additions

We added a fire sensor and a camera to this drone via their arduino software.

Figure III.34: Smoke Sensor m-Q135 with camera esp 32

III.5.1 camera esp 32

The esp32 cam is a low-cost module that has Wi-Fi and bluetooth capabilities. It also supports TF cards or micro SD cards [35]

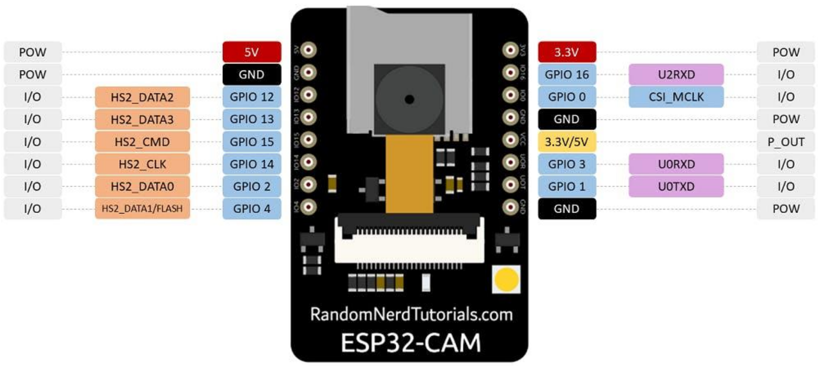


Figure III.35: The esp32 cam pinout

III.5.1.1 Programming

To program this module follow the diagram and inject the program with arduino

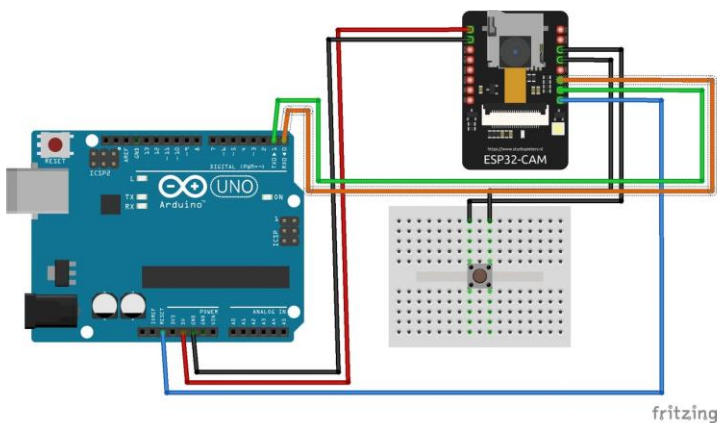


Figure III.36: wiring diagram

III.5.2 Smoke Sensor m-Q135

The sensor is enclosed in two layers of steel. The output is taken as the voltage which depends on the concentration of the gases. In other words, voltage is proportional to the gas concentration. The higher the concentration, the higher would be the voltage. Similarly, when the concentration is lower, the voltage would be lower.

III.5.2.1 Circuit Diagram

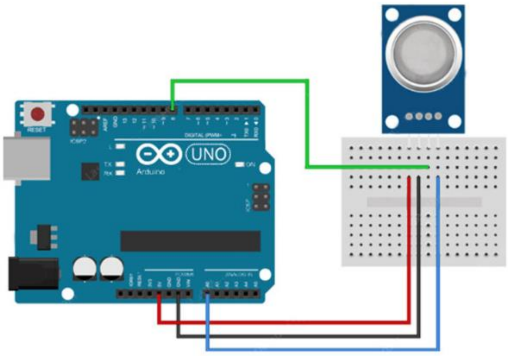


Figure III.37: MQ135 sensor with arduino UNO

❖ **Connection Table**

Table III.9: Connection sensor with arduino UNO

Arduino	MQ135 Smoke Sensor
5V	VCC
GND	GND
D8	D0

❖ **Not**

The camera and fire sensor will be combined into one program and then the merger will be done with the drone and so we get a fire sensor drone with accurate fire image sent to the data station

III.6 Conclusion

In this chapter, we presented the theoretical study of the drone parts collection, based on a database created by experts following repeated experiments and in-depth studies. The aim is to coordinate the various parts on the market and to observe the conditions of force and impact resistance, as well as the flight time, because our drums are designed to detect fires and this makes us eager to observe the conditions strictly and disciplined.

In the second part, we acquired the parts of the drone and we made the installation on the basis of video clips made by experts as well as on the basis of our own skills and like any scientific experience, we encountered technical problems, but we solved them, then added a fire sensor and a camera by programming them with arduino and finally came out with a final design of the without fire sensor.

General conclusion

General conclusion

The work presented in this brief was devoted to the study and realization of a quad copter drone our work began with generalities about drones. We then presented the mathematical model of quad copter. Our study continued with the realization of our own quad copter drone. A detailed description of the components used in the montage is presented. The operations of assembly of components and calibration of sensors and electronic speed controllers are explained. The stabilization of the drone was ensured by implementing a PID type control law

The creation of Drone is an accurate compilation of pieces with programming-based additives as for Flight Control and Remote Control. It is an integrated study in all respects as all systems in our project, Drone has a corrector PID from which we can balance the Drone and return the speed of the engines to its stable position every time you ask this corrector is combined with Flight control kk2.1.5

The purpose of the first chapter was given a general explanation about the drones available and used in the world, which allows the reader to take an idea before starting in the theoretical and practical phase of the quad copter.

In the second chapter the objective was modelling and then simulation on matlab in order to study behaviour and stabilization of the quad copter system, to achieve to create a dynamic model that describe the dynamics of translation and rotation of the quad copter system through studies the effects acting equations and to Newton-Euler's equations, and to deduce the correction equations the rotating errors.

Concerning the practical part, the last chapter explains everything that to create a quad copter from design flight control to quad copter flight.

The quad copter that we will want to carry out in the future makes it possible to:

Programming Drone to fly at certain distances and between certain points with the completion of solar or air power plants to power Drone without human intervention and the completion of the receiving station of information transmitted via camera and sensors.

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