QUADCOPTER DRONE KIT



F120 Brushless Version

Basic Theoretical Knowledge

CONTENTS

1 The Development of Aircraft

2 The Flying Principle

3 Hardware Configuration

01

The Development of Aircraft

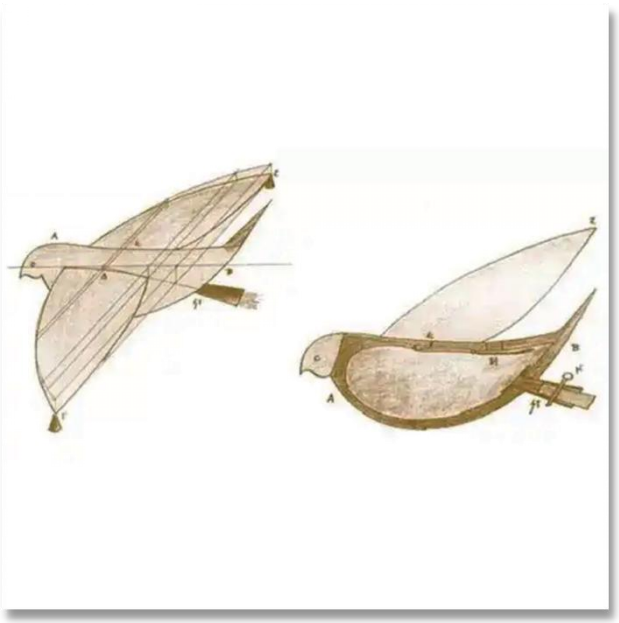
The Birth of Aircraft

Ancient innovations



Kongming lantern

(Zhuge Liang, China)



Mechanical pigeon

(Archytas, Greece)

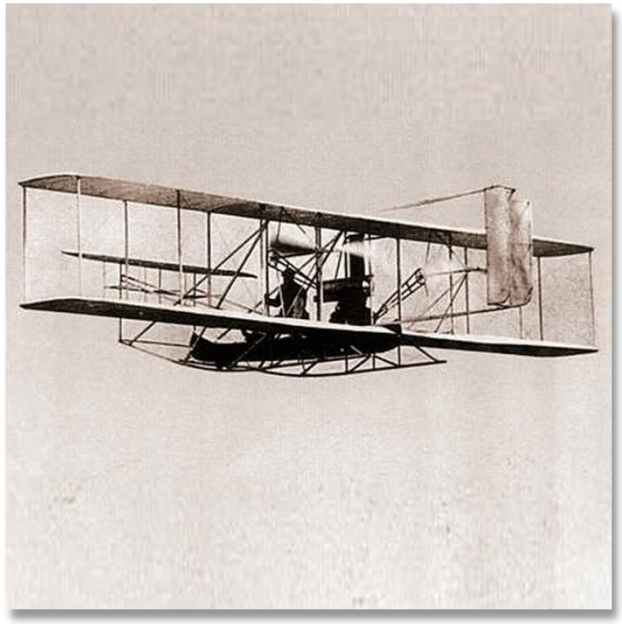


Boomerangs

(Australia)

The Birth of Aircraft

Industrial Revolution Breakthroughs



The Wright Brothers' Flyer I



Northrop XB-35



Space X Crew Dragon



The Definition of Aircraft

Aircraft = Mechanically-powered artificial object capable

√ Controlled takeoff & flight within/outside atmosphere

√ Human-operated or autonomous navigation

The Classification of Aircraft



Fixed-wing Aircraft



Spacecraft



Rocket



Missile

The Current Development of Aircraft



2000s

2010s

2020s

Dominance of Military Drones



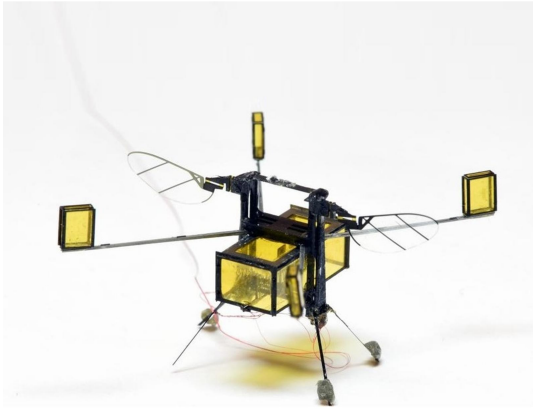
Predator Drone

Explosion of Consumer Quadcopters



DJI Phantom

Biological Bionic Miniaturization



Harvard's RoboBee Project

The Current Development of Aircraft



Film Aerial Photography

8K Gimbal + Intelligent Tracking

Film Aerial Photography in "The Revenant"

Precision Agriculture

Multispectral Crop Health Analysis

Agricultural UAV Spraying Operations



The Current Development of Aircraft



Power Inspection

Infrared Thermal Imaging Defect Detection

Power Grid Inspection with UAVs

Ecological Protection

Anti-Poaching Sonic Repelling System

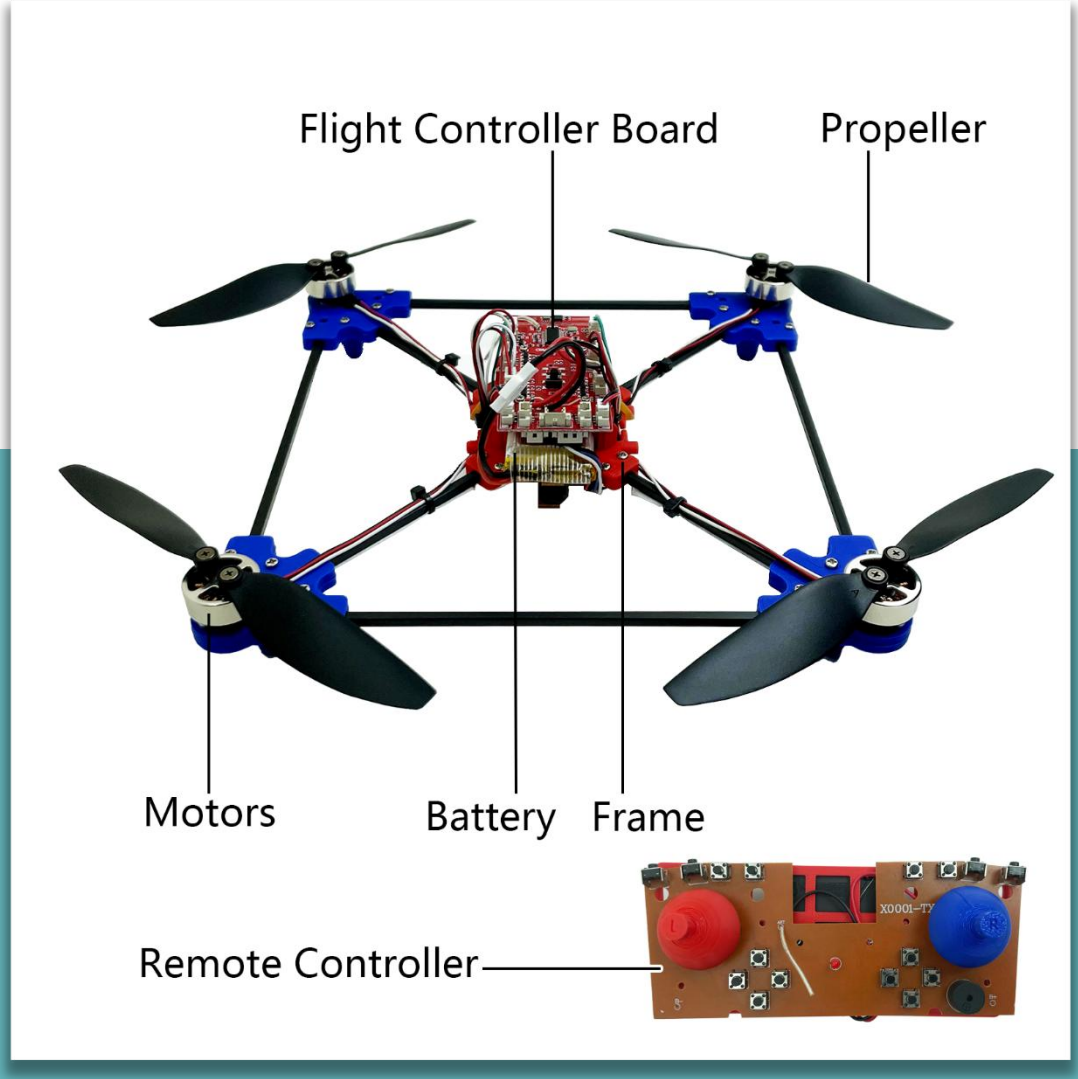
UAV Patrols in African Rhino Sanctuaries



02

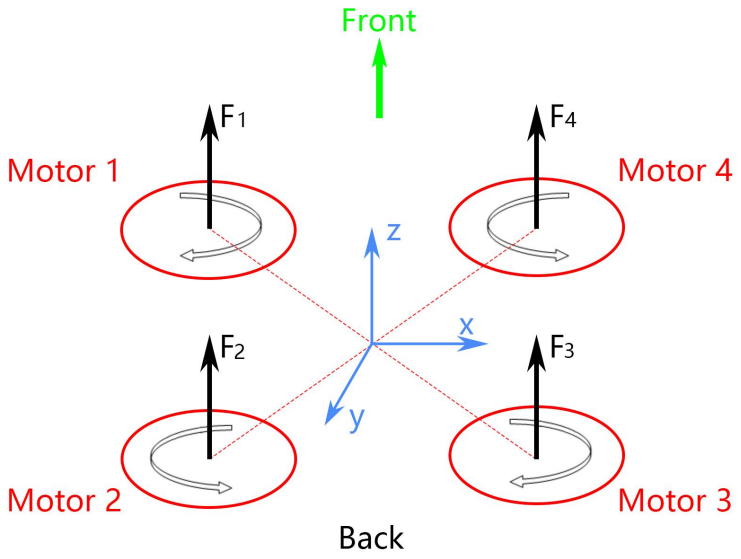
The Flying Principle

The main components of a Quadcopter Drone



The Principle of Flight Attitude Control



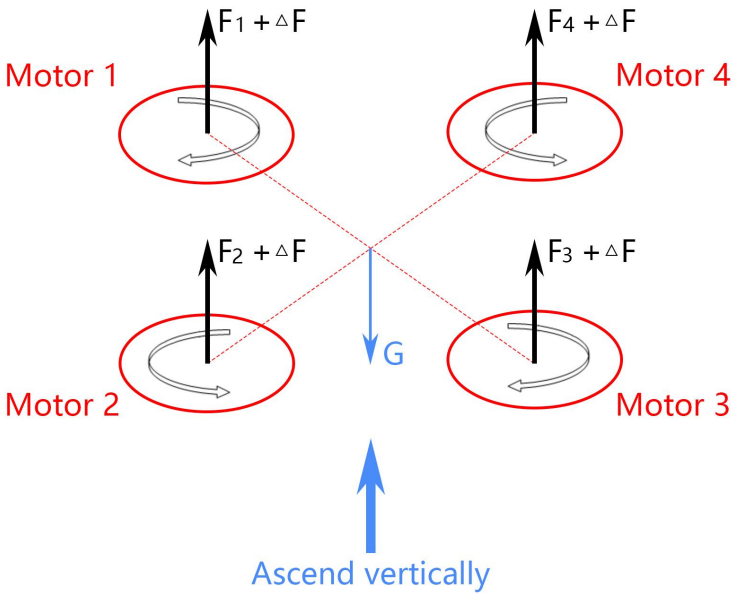


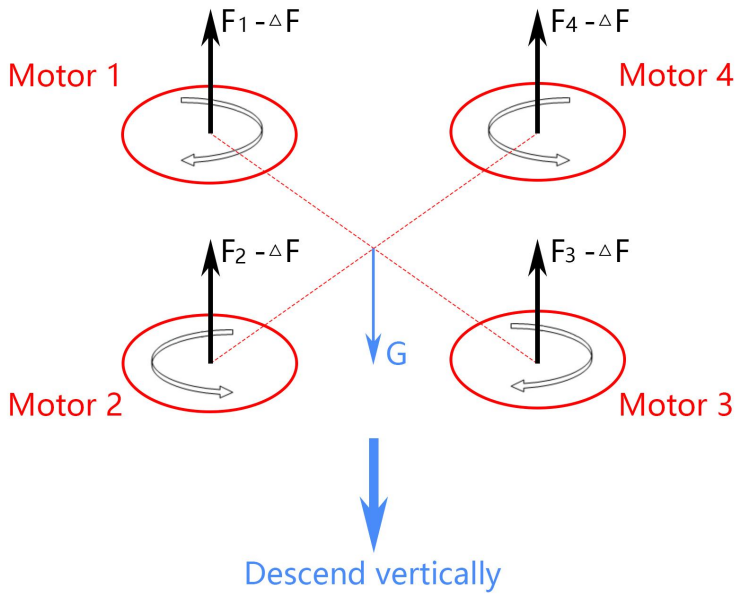
In a quadcopter drone, the rotation directions of adjacent rotors are opposite.

The rotors M1 and M3 rotate clockwise, while the rotors M2 and M4 rotate counterclock-wise. During flight, the clockwise reaction force (counter-torque) generated by M2 and M4 cancels out the counterclockwise reaction force (counter-torque) generated by M1 and M3, allowing the drone's body to remain stable.

When ensuring that each rotor of the quadcopter drone rotates at the same speed
(resulting in a total torque of zero), various movements can be achieved by adjusting.

A. Ertical movement (vertical ascent, vertical descent).



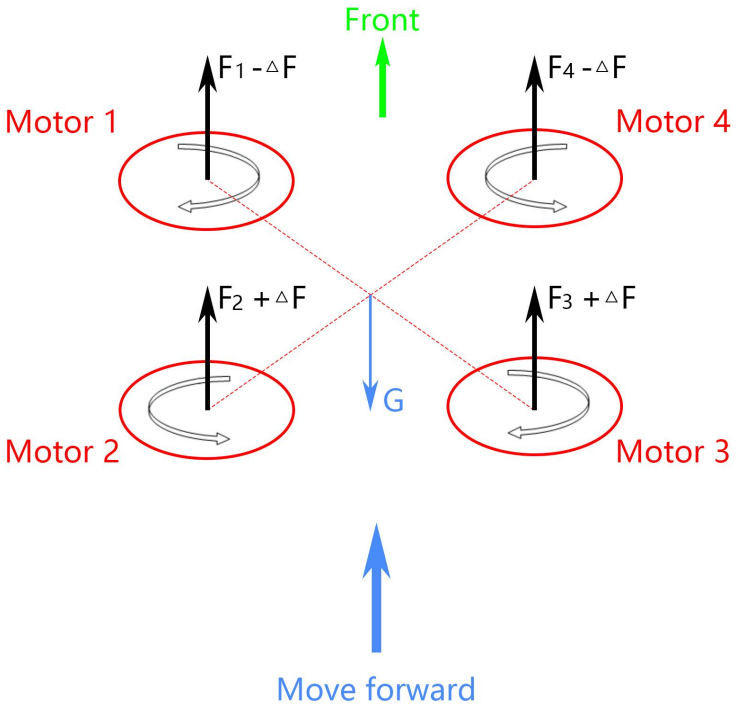


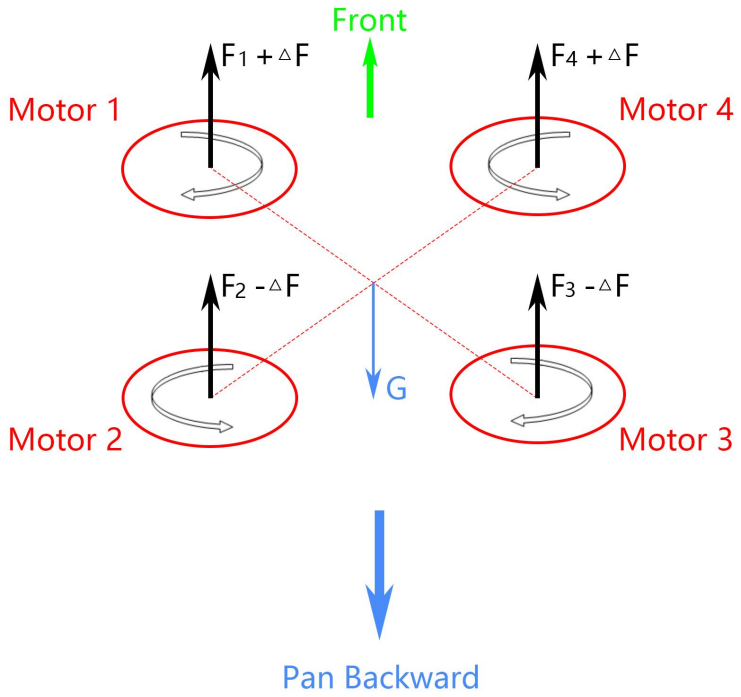
Ignoring external factors, when the total lift force “F” of the drone is equal to its gravity, the drone will hover.

If each rotor increases its rotation speed by the same amount, the total lift force “F” will increase and become greater than gravity, resulting in vertical ascent.

Conversely, if each rotor decreases its rotation speed by the same amount, the total lift force “F” will decrease and become less than gravity, resulting in vertical descent.

B. Pitch movement, roll movement (flying forwards, backwards, leftwards, or rightwards horizontally)

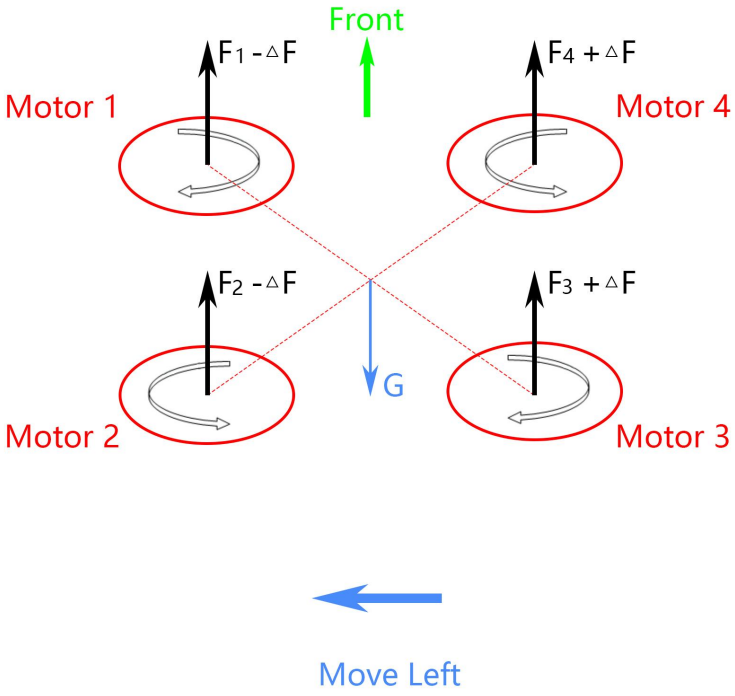


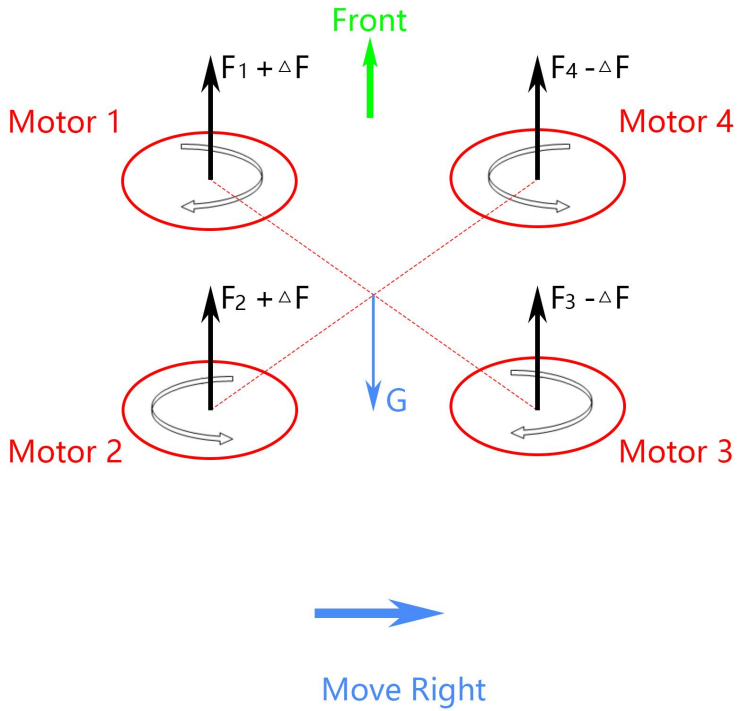


Disregarding external factors, when the rotational speeds of the front rotors M1 and M4 decrease while those of the rear rotors M2 and M3 increase, the lift generated by the rear rotors M2 and M3 exceeds that of the front rotors M1 and M4, causing the quadrotor aircraft to move forward.

Conversely, if the rotational speeds of the front rotors increase while those of the rear rotors decrease, it will move backward. This is also known as pitch motion.



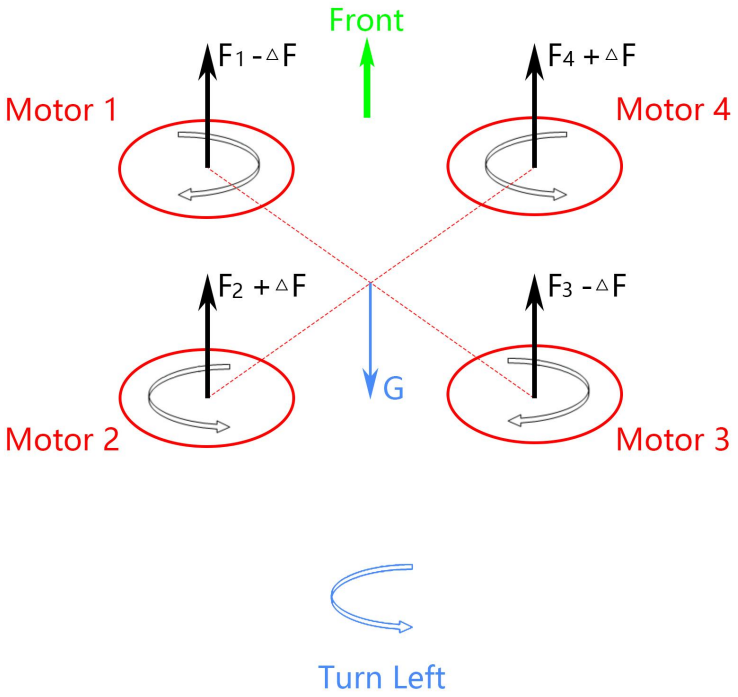


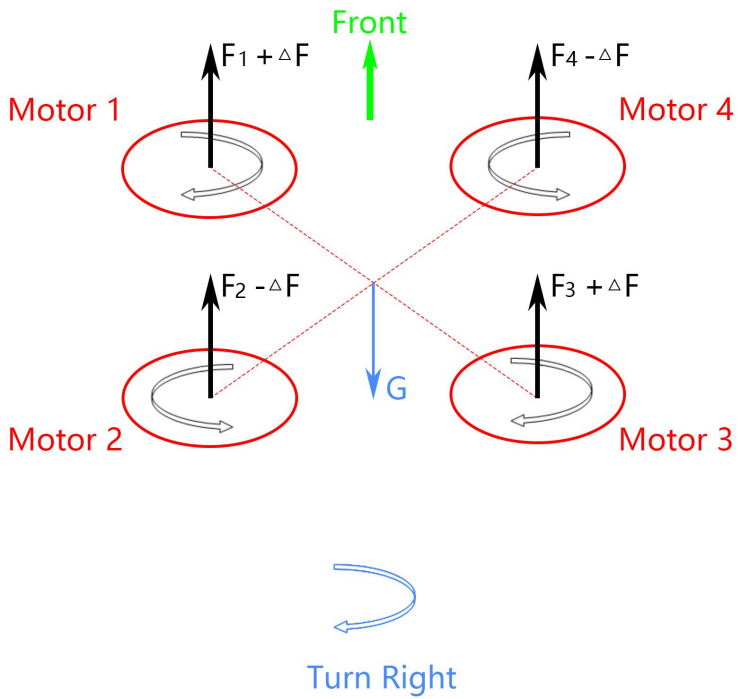


Similar to the principle of pitch motion, when the rotational speeds of the right rotors M3 and M4 increase while those of the left rotors M1 and M2 decrease, the lift generated by the right rotors M3 and M4 exceeds that of the left rotors M1 and M2, causing the quadrotor aircraft to move to the left.

Conversely, if the rotational speeds of the left rotors increase while those of the right rotors decrease, it will move to the right. This is also known as roll motion.

C. Yaw movement (rotating horizontally to the left, rotating horizontally to the right)





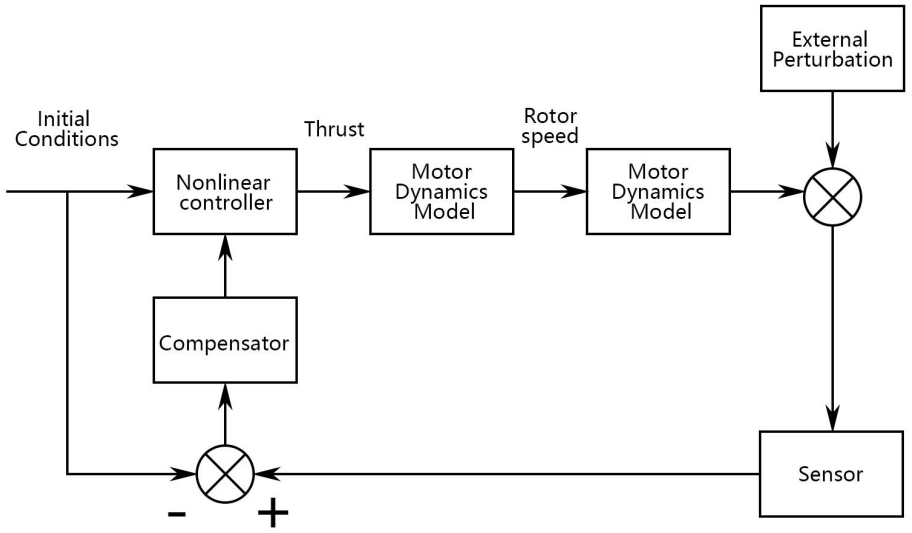
Ignoring external factors, when the rotation speeds of rotors M2 and M4 increase while the rotation speeds of rotors M1 and M3 decrease, the lift generated by M2 and M4 increases while the lift generated by M1 and M3 decreases. At this point, the total lift force F becomes zero, but the counterclockwise rotation speed is greater than the clockwise rotation speed, generating a counterclockwise torque that causes the drone to rotate to the left, also known as yawing to the left.

Conversely, the drone will rotate to the right, also known as yawing to the right.

Signal Control Logic for Flight Attitude



Core objectives of the stabilization management position



Basic function:

As a prerequisite for the autonomous flight of quadrocopter drones, the attitude stabilization controller controls the three orientation angles (pitch angle, roll angle, yaw angle) to stably track target signals and ensure the dynamic characteristics of the system according to expectations (e.g. response speed, overshoot, steady-state deviation).

Closed-loop performance requirements:

Dynamic response (fast convergence)

Robustness (disturbance rejection)

Stability (without persistent oscillations)

03

Hardware Configuration

1. Frame and Mechanical Design



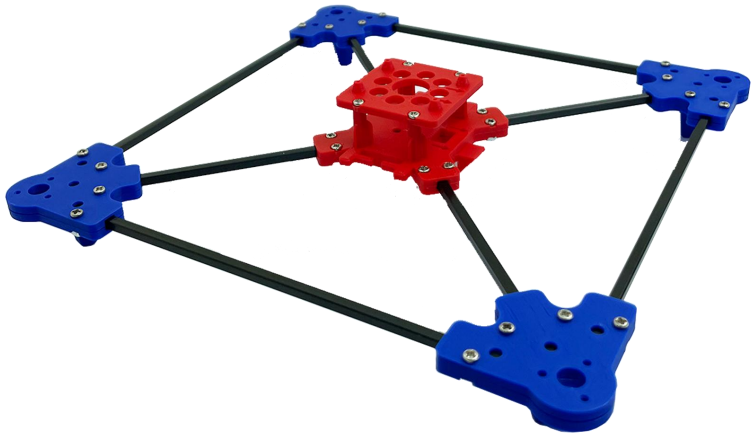
Core Functions of Frame

Primary Roles

Structural Support and System Integration

Key Challenges

Lightweight Design, Deformation Resistance, Vibration Damping, and Modular Configuration



F120 Design Highlights

Carbon Fiber + 3D Printing

Lightweight design (PLA—BASIC airframe) + strength optimization (carbon fiber rods).

Triangular Stability Structure

Reduces deformation risks and enhances flight stability.

220mm Wheelbase

Compatible with 64mm propellers, balancing size and power efficiency.

2. Power System



Commonly Used Motors for Drones

Brushed Motors (Core-type)

Low cost, used in toy drones (low efficiency, short lifespan).

Brushless Motors (Outer-rotor design)

High efficiency, low energy consumption, extended lifespan, and high reliability, ideal for professional drones.

KV Rating

Definition

The increase in no-load RPM per 1V increase in voltage (unit: RPM/V).

Low KV (more winding turns)

High torque, matched with large propellers (e.g., long-range cruising).

High KV (fewer winding turns)

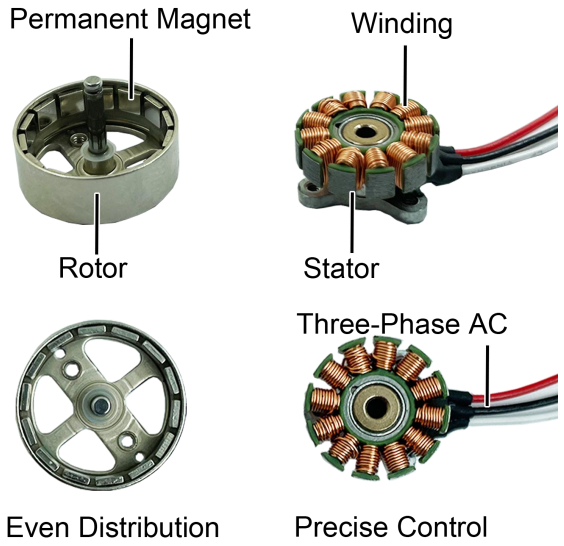
High RPM, suited for small propellers (e.g., racing drones).

Components of a Brushless Motor

Stator: Laminated silicon steel structure with three-phase windings to generate a rotating magnetic field.

Rotor: Outer-rotor design with permanent magnet direct-drive configuration for propellers.

ESC (Electronic Speed Controller): Regulates current frequency and phase to control motor speed and torque.



2. Power System



Motor for F120

Specifications

16mm diameter × 6mm height, high-torque output with dynamic balance.

KV Design

Mid-low KV range optimized for large propellers, balancing RPM and torque (ideal for hovering and agile maneuvers).

Innovative Feature

Generates startup tones via precise motor vibration control (via ESC), demonstrating ultra-fine commutation accuracy.

Battery for F120

Endurance Calculation

8A hover current → theoretical 15-minute flight time (reduced during maneuvers).

Protection System

Combines hardware (high/low-voltage protection circuit) and software (flight controller integration) to prevent overcharge/over-discharge.

3. Flight Control Module



Flight Control Board (FCB)

Signal Processing

Receives remote control commands or autonomous control signals and converts them into flight control instructions.

Motor Speed Control

Adjusts motor RPM via ESCs (Electronic Speed Controllers) to enable hovering and maneuvers (e.g., ascent, lateral movement, roll).

Peripheral Control

Supports synchronized operation of external devices like gimbals, ultrasonic sensors, and servos.

Optical Flow Module

Function

Enables assisted positioning in GPS-denied environments (e.g., indoors, tunnels), stable hovering, and obstacle-avoidance navigation.

Principle

Combines camera and rangefinder data to calculate pixel-to-physical displacement ratios, enabling real-time adjustments to flight attitude.

F120 Design

Integrated Design

ESC (Electronic Speed Controller) embedded into the flight control board, reducing wiring complexity and improving reliability.

Rapid Response

Optimized signal processing algorithms minimize command latency (<10 ms), enhancing flight stability and maneuverability.

4.Communication & Interaction



Wi-Fi Video Transmission Module

Advantages: Low cost, real-time transmission (direct smartphone connectivity).

Limitations: Short range (<500 meters), susceptible to interference (avoid crowded signal environments).

Remote Controller (2.4 GHz)

4-channel design: Basic flight controls (throttle, pitch, roll, yaw), with receiver integrated into the flight control board.


Thank You