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WEEK 1: INTRODUCTION TO DRONES

NON-COMMISSIONED OFFICERS

DRONE HISTORY [1]

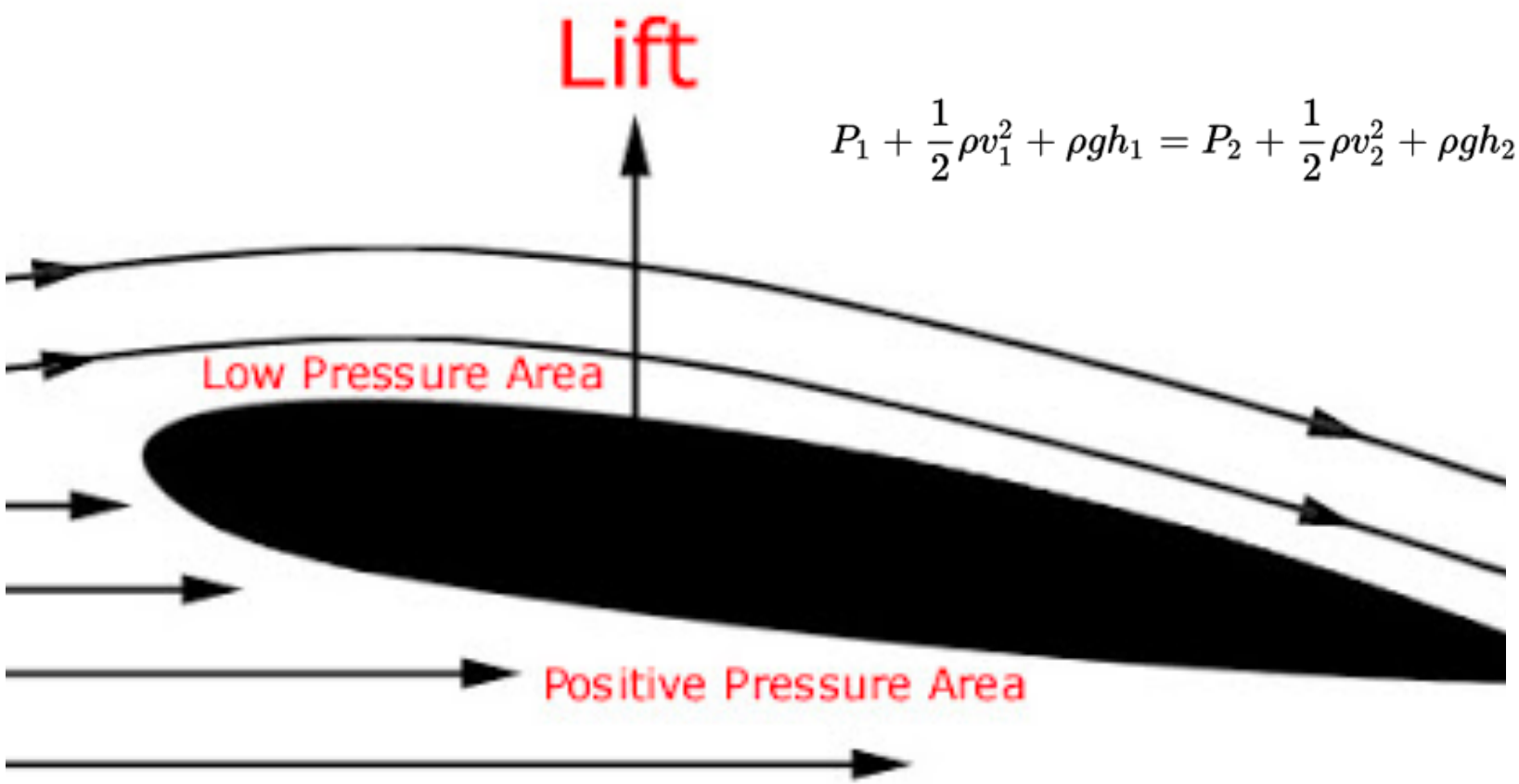
- 1849 – Austria attacked Venice using unmanned explosive balloons
- 1907 – Development of an early gyroplane which reached only 0.6 meters
- 1916 – First pilotless aircraft was developed in which they used radio guidance system to control it
- 1918 – Kettering Bug used gyroscopic controls and was used like a torpedo
- 1935 – Radio-controlled target drone, RP-1
- 1960s - Hobbyist pick up RC aircrafts
- 1986 – RQ2 Pioneer reconnaissance aircraft developed by the U.S. and Israel
- 2000 – Introduction of the Predator Drone
- 2006 – FAA issued first commercial drone permit

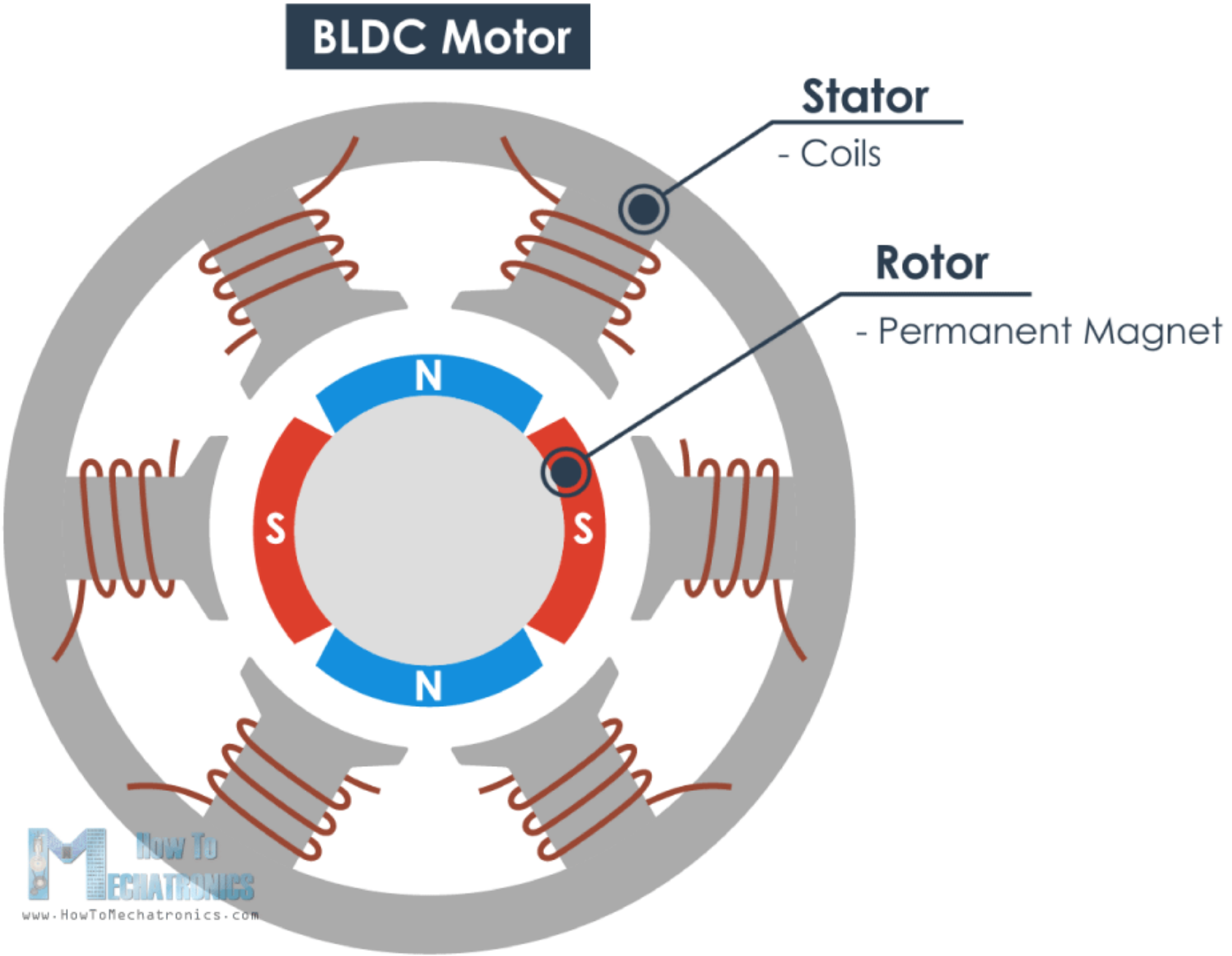
DRONE SAFETY AND LAWS

- Safety is the #1 goal of every pilot!!!
- Follow community guidelines: faa.gov/uas/
- Fly no higher than 400 feet and stay away from obstacles
- Always keep drone in sight
- Do not interfere with manned aircrafts and always avoid them
- Contact the airport to fly 5 miles within the airport
- Do not fly over unprotected persons or moving vehicles, and remain at least 25 feet away from individuals and property
- Do not fly in adverse weather conditions
- Do not fly under the influence of alcohol or drugs
- Do not fly near or over sensitive infrastructure or property such as power stations, correctional facilities, government facilities, etcetera
- Do not conduct surveillance or photograph persons without the individual's permissions
- Always check local laws and ordinances!
    - https://www.911security.com/learn/airspace-security/drone-laws-rules-and-regulations/nevada

HOW DOES AN AIRFOIL WORK? [2]

- Bernoulli's Equation states that if there is an increase in the velocity of the fluid, there is a decrease in static pressure
- For an aircraft to fly, the force upwards (lift) must be greater than the force of the gravity
- Surface area is greater on the top than on the bottom of airfoil
- According to the continuity equation, a higher area equals a higher velocity too as it must displace more air
- A higher velocity results in decrease in pressure. The pressure over the wing is lower than the pressure under the wing which results in lift



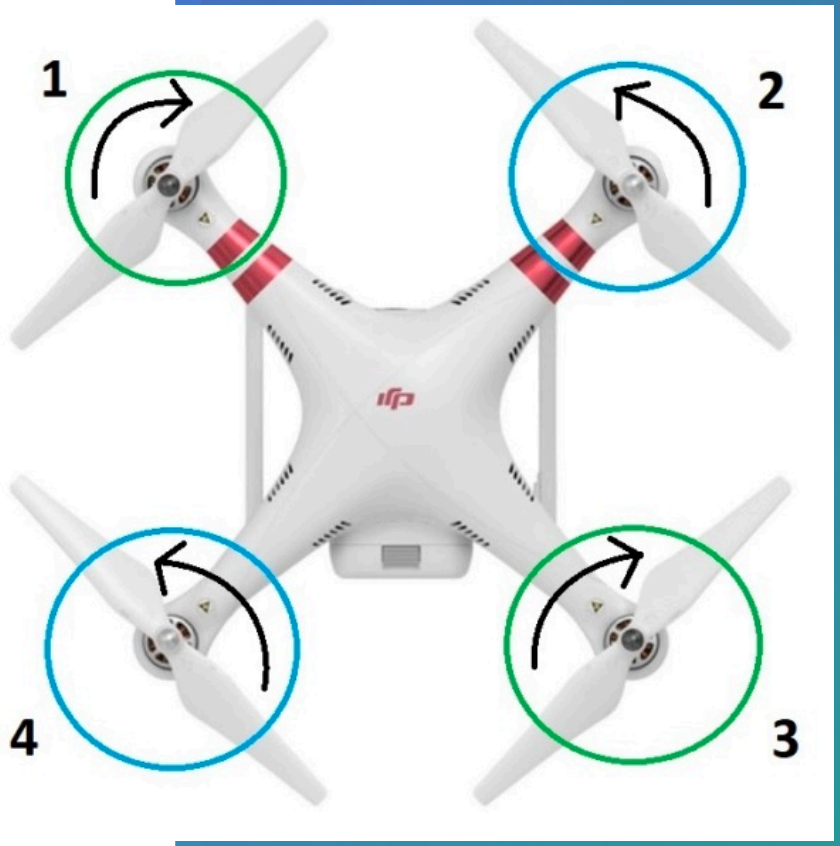


HOW DOES A BRUSHLESS MOTOR WORK? [3]

- Current through a coil generates a magnetic field
- Applying current, the coil will attract the magnet on the rotors. This is done by activating each coil one after another
- In a brushless motor, one coil will attract the magnet and one coil will repel. For a full 360, it needs six steps

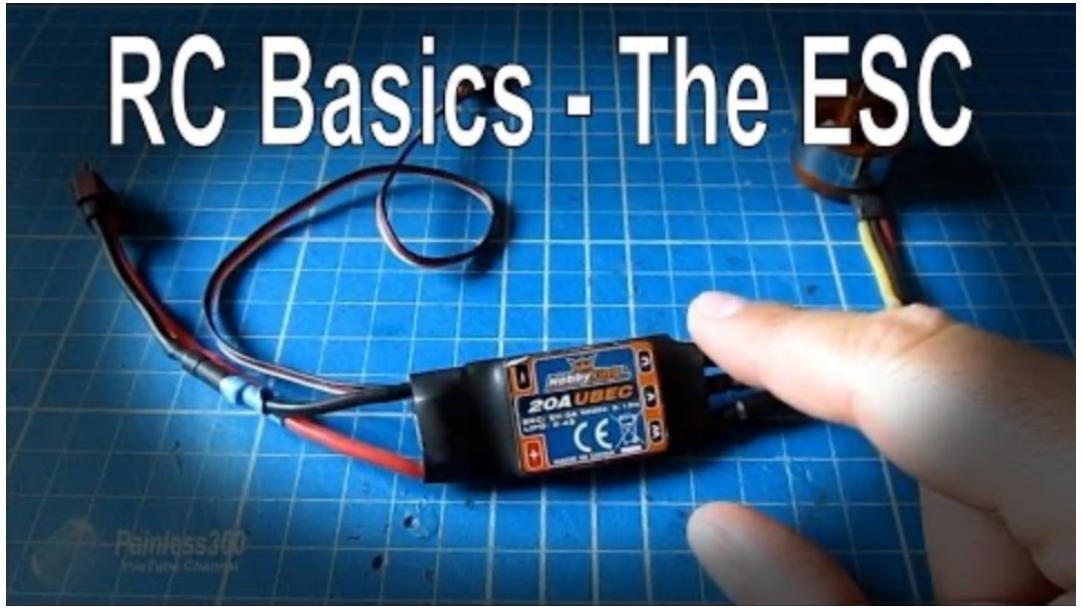
DRONE MOTORS [4]

- Size listing is four numbers, where the first two numbers represents the diameter, and the last two numbers represent the height
  - 2212 has a 22mm diameter and a 12mm bell height
- KV is the rated RPM of the motor per applied volt
  - 1000kv motor connected to a 10V power source produces 10,000RPM
- Required that two opposite motors spin in clockwise rotation and the other two spin counter-clockwise



WHAT IS AN ESC?

- Electronic Speed Controller are switches that turns the current on and off to regulate the speed
- Takes signal from flight controller and power and controls the acceleration and deceleration of the motor
- Switches frequency of the transistors which controls the speed
- Back EMF from the motor is used to detect the rotation
- Swapping two of the three wires reverses the motor
- ESCs must be calibrated to set the high and low throttle signal
- Please watch video on the right from 3:15 to 6:10

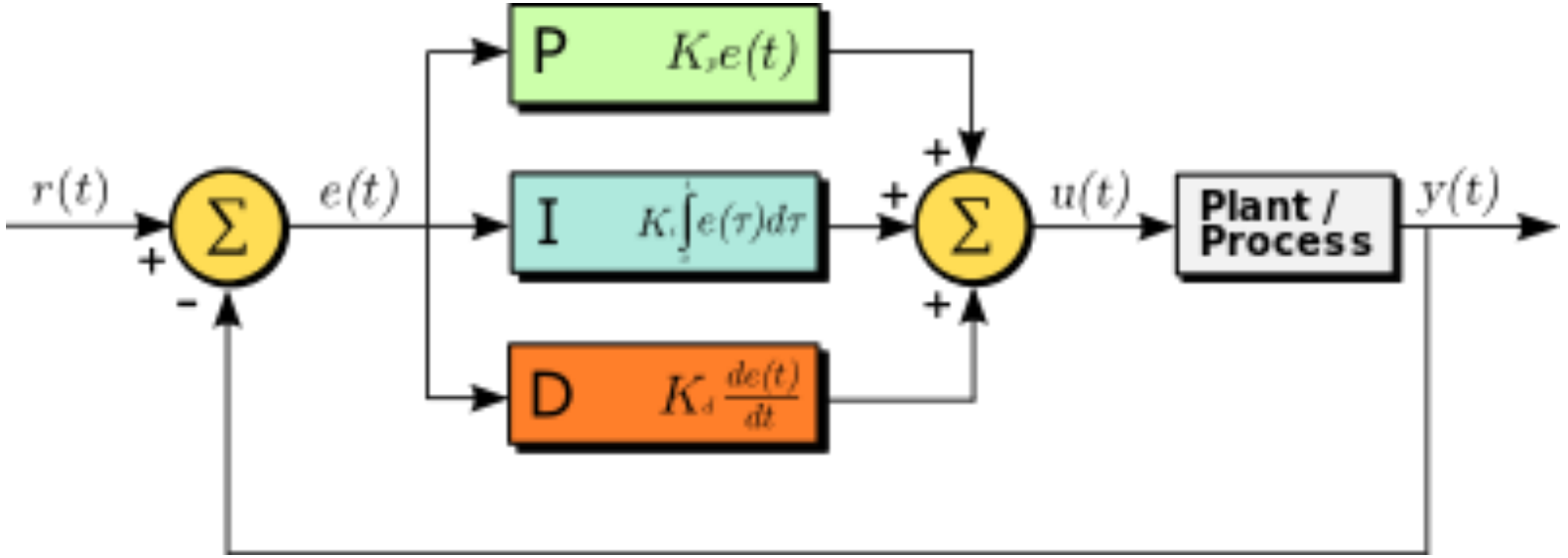


BATTERY

- Lithium based with the Lithium Polymer (LiPo)
- Max voltage per cell is 4.2V while the minimum is 3.3V
- 2S 3000mAh battery is two 3000mAh cells in series
- W = V * I → Watts equals voltage times current
- Higher voltage battery may provide more power and longer flight time, but it's not a linear increase. The extra weight of the battery may also draw more power
- Charging
  - Set to battery's actual cell count (1S, 2S, 3S)
  - CAREFUL! A 2S battery set for 3S will result in the charger trying to put 12.4V in the battery which is only rated for 8.4V. The battery will puff up and could burst into flames
  - Set the charge rate to 1C which is the best for increasing the longevity of the battery, but it will also result in a longer charge
  - The battery's balancing lead is connected to charge all the cells equally

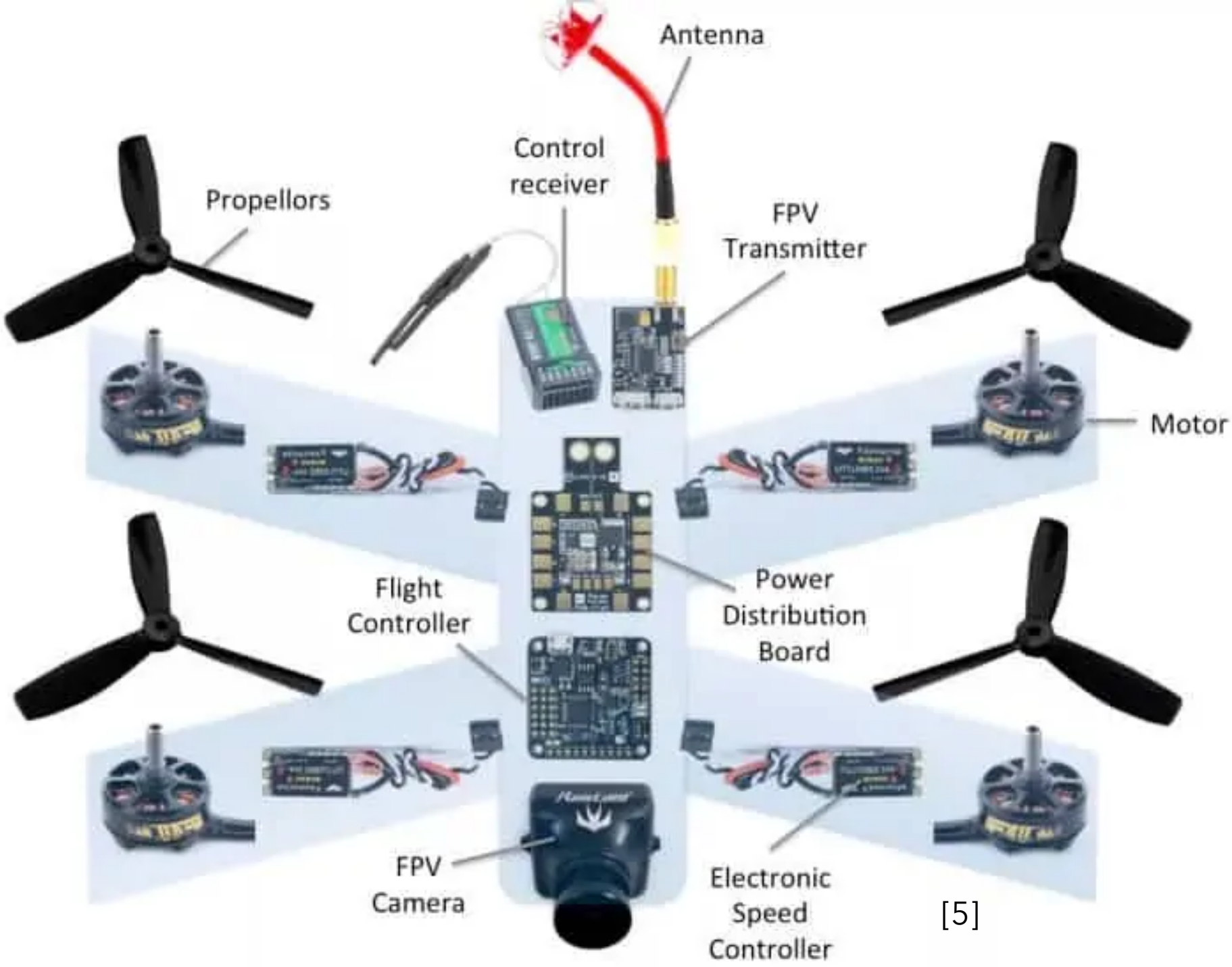
FLIGHT CONTROLLER

- The computer of the drone which receives command signals from the pilot, determines the current operating conditions and sends the appropriate signals to the ESCs
- Gyro is used to hold the current altitude of the multirotor
- Accelerometers is used to sense a change of force and return the multirotor to level from any given attitude
- Magnetic sensor is used to determine the magnetic heading
- GPS allows the drone to know where it is



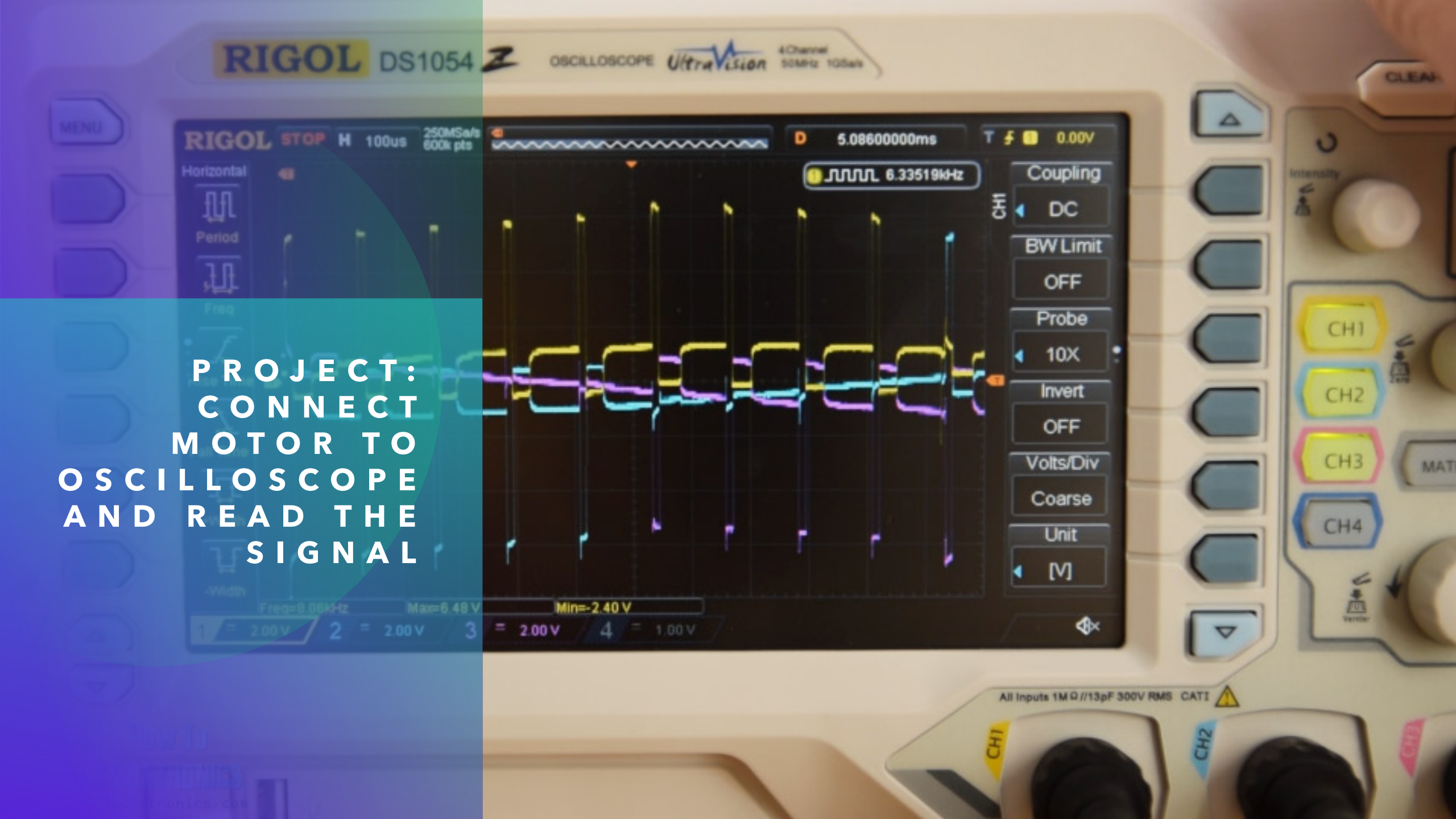
- Proportional Gain
  - Responsible for quick response which can cause oscillations. A high P value will react quickly but will result in high oscillation. A low P value will cause the drone to be slow to respond
- Integral Gain
  - Eliminates the long-term error. High values can cause overshoot and lead to oscillations. A low value will make it more difficult for the controller to respond to the changes
- Derivative Gain
  - The goal of the derivative gain is to reduce the overshoot. A high derivative gain will slow the response of the system. It will compensate for the overshoot. On the contrary, a low value causes the system to overshoot the set value

DRONE PID CONTROL (PROPORTIONAL, INTEGRAL, DERIVATIVE) [6]


Antenna
Control receiver
Propellors
FPV Transmitter
Motor
Flight Controller
Power Distribution Board
FPV Camera
Electronic Speed Controller

[5]

PROJECT: CONNECT MOTOR TO OSCILLOSCOPE AND READ THE SIGNAL



REFERENCES

- [1] - https://interestingengineering.com/a-brief-history-of-drones-the-remote-controlled-unmanned-aerial-vehicles-uavs#:~:text=Some%20of%20the%20earliest%20military%20drones%20appeared%20in%20the%20mid%2D1850s&text=The%20concept%20of%20drones%20may,incendiary%20balloons%20over%20the%20city.
- [2] - http://www.aviation-history.com/theory/airfoil.htm
- [3] - https://howtomechatronics.com/how-it-works/how-brushless-motor-and-esc-work/
- [4] - https://www.dronezon.com/learn-about-drones-quadcopters/how-a-quadcopter-works-with-propellers-and-motors-direction-design-explained/
- [5] - https://bestdroneforthejob.com/blog/three-great-fpv-racing-drone-kits-assembly-required/
- [6] - https://en.wikipedia.org/wiki/PID_controller