

 **DRONE**
TEAM

Drone It Yourself!

MAKING AND DESIGNING A TOY DRONE
THROUGH MULTIDISCIPLINARY
COLLABORATIVE WORK
Project no. 2015-1-ES01-KA202-015925

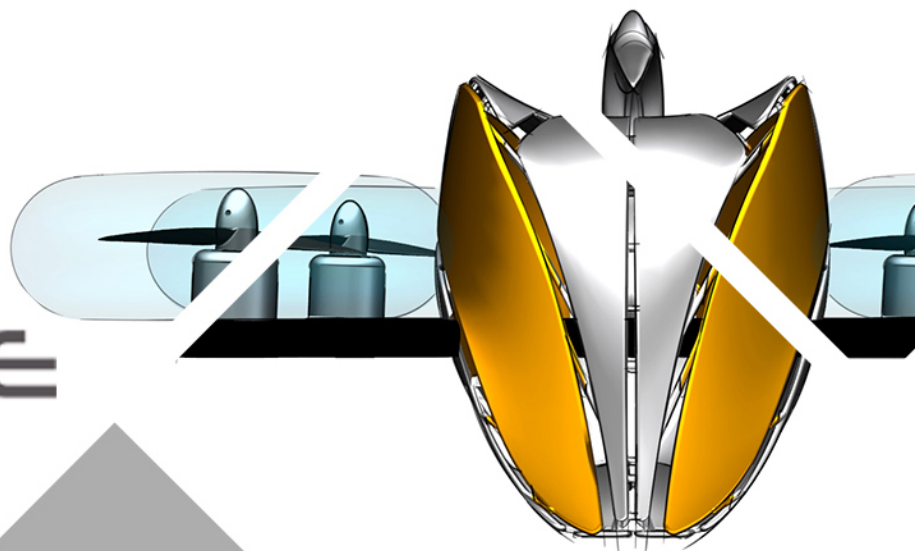


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Drone It Yourself! consists of the following modules:

0. INTRODUCTION TO THE DRONETEAM PROJECT
1. BASIC TOY DRONE FRAME
2. MODULE OF FLIGHT CONTROL
3. MODULE OF COMMUNICATION CONTROL
4. MODULE OF ADVANCED FRAME
5. MODULE OF GPS-COMPASS CONTROL
6. MODULE OF PROBLEM MANAGEMENT
7. MODULE OF FLIGHT STABILIZATION SYSTEM
8. MODULE OF FIRST PERSON VIEW
9. DRONETEAM E-LEARNING PLATFORM
10. OTHER DEVELOPMENTS
11. GLOSSARY



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MODULE OF FLIGHT CONTROL

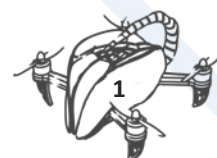
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1. CHOOSING THE FLIGHT CONTROLLER

The flight controller is the part of drone what is like a brain. To maintain the quadcopter balance, must be continuously taking measurements from the sensors, and making adjustments to the speed of each rotor to keep the body level. These adjustments are calculated using some very complicated algorithm in order to keep the quadcopter perfectly balanced.

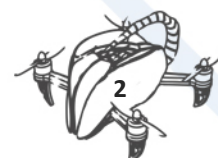
Before choosing the flight controller let's see few flying capabilities:

- Gyro Stabilization – the ability to easily keep the copter stable and level under the pilot's control. This is a standard feature of all flight control boards.
- Self-Levelling – the ability to let go of the pitch and roll stick on the transmitter and have the copter stay level.
- Care Free– The pilot can control the copter as if it is pointing in its original direction as the orientation of the copter changes.
- Altitude Hold – the ability to hover a certain distance from the ground without having to manually adjust the throttle.
- Position Hold – the ability to hover at a specific location.
- Return Home – the ability to automatically return to the point where the copter initially took off.
- Waypoint Navigation – the ability to set specific points on a map that copter will follow as part of a flight plan.
- GPS – the ability to record the data of flying,

Open source is quite popular. Flight controller is no exception. It is a very flexible method and you can always modify any of it to suit your own needs.

The table below shows open source boards and some of the features each of them.

Board	Gyro Stabilization	Self-Levelling	Care Free	Altitude Hold	Position Hold	Return Home	Waypoint Navigation	Pricing
AeroQuad 32	Yes	Yes		Yes	Add-on	Add-on	Add-on	Medium
ArduCopter (APM 2.5)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Medium
AutoQuad v6.6	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Crius All In One PRO	Yes	Yes	Yes	Yes	Add-on	Add-on	Add-on	Low
Crius MultiWii Lite	Yes	Yes						Low
Crius MultiWii SE	Yes	Yes	Yes	Yes				Low
Hobbyking KK2.0	Yes	Yes						Low
KKMulticopter	Yes							Low
MultiWii PRO / MTK GPS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low



Board	Gyro Stabilization	Self-Levelling	Care Free	Altitude Hold	Position Hold	Return Home	Waypoint Navigation	Pricing
MultiWii PRO 2.0 / MTK GPS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
OpenPilot CC3D	Yes	Yes						Low
Paris MultiwiiCopter	Yes	Yes	Yes	Yes	Add-on	Add-on	Add-on	Medium
Quadrino ZoomFlight	Yes	Yes	Yes	Yes				Medium
UAVP/UAVX	Yes	Yes	Yes	Yes	Yes	Add-on	Add-on	Low

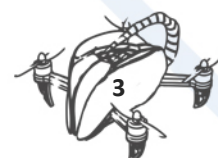
The quality of the software, components, and build must be taken into consideration during the process of choosing the flight controller.

The second point to consider is flying style. Before looking at flight controllers we should know that there are three different type of flying styles and most flight controllers are only really good at one specific style.

The first and most common flying style nowadays is called “cinema flying”. Cinema flying is when you fly specifically to produce the smoothest video possible. This type of flying usually requires a flight controller with very dampened flight characteristics and small control stick rates (slow manoeuvrability).

The second flying style is called “autonomous flying”. Autonomous flying is obviously when you fly a model without having to touch any of the controls. It’s important to have a flight controller that has features like auto take-off and landing, waypoint flying and data telemetry. It should also have open-source firmware so that you can later on add or improve features.

The third and most fun style of flying is called “sport flying”. Sport flying is when you fly very fast and do aggressive/precise manoeuvres for fun or to race another pilot. Any good flight controller for sport flying should be able to recover from very fast roll rates, hold any angle you put it in (regardless of how fast or what direction it’s going) and should be fully tuneable. It also shouldn’t cost a lot of money, since it’s possible that it could break from crashing often.



2. THE DESCRIPTION OF SELECTED FLIGHT CONTROLLERS

2.1. 3DR PIXHAWK

Pixhawk is an advanced autopilot system designed by the PX4 open-hardware project and manufactured by 3D Robotics. It features advanced processor and sensor technology from ST Microelectronics® and a NuttX real-time operating system, delivering incredible performance, flexibility, and reliability for controlling any autonomous vehicle.

The benefits of the Pixhawk system include integrated multithreading, a Unix/Linux-like programming environment, completely new autopilot functions such as sophisticated scripting of missions and flight behaviour, and a custom PX4 driver layer ensuring tight timing across all processes. These advanced capabilities ensure that there are no limitations to your autonomous vehicle. Pixhawk allows existing APM and PX4 operators to seamlessly transition to this system and lowers the barriers to entry for new users to participate in the exciting world of autonomous vehicles.

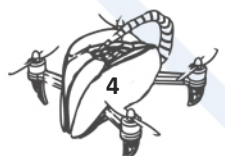
The flagship Pixhawk module will be accompanied by new peripheral options, including a digital airspeed sensor, support for an external multi-colour LED indicator and an external magnetometer. All peripherals are automatically detected and configured.

Pixhawk includes:

- Pixhawk autopilot
- Buzzer
- Safety switch button
- 3DR power module with XT60 connectors and 6-position connector cable
- Extra 6-position cable to connect a 3DR GPS+Compass module
- Micro USB cable
- SD card and adapter
- Mounting foam
- 3-wire servo cable
- I2C splitter module with cable

Features

- Advanced 32-bit ARM Cortex® M4 Processor running NuttX RTOS
- 14 PWM/servo outputs (8 with failsafe and manual override, 6 auxiliaries, high-power compatible)
- Abundant connectivity options for additional peripherals (UART, I2C, CAN)
- Integrated backup system for in-flight recovery and manual override with dedicated processor and stand-alone power supply
- Backup system integrates mixing, providing consistent autopilot and manual override mixing modes
- Redundant power supply inputs and automatic failover
- External safety button for easy motor activation



- Multicolour LED indicator
- High-power, multi-tone piezo audio indicator
- micro SD card for long-time high-rate logging

Options:

- PPM encoder for RC receivers that do not provide PPM output.
- External USB and LED module for convenient status indicator and micro-USB port on your vehicle
- Digital airspeed sensor for fixed-wing aircraft
- Telemetry radios with one-mile range for two-way control, telemetry and data logging via free mobile apps or PC/Mac/Linux ground station
- u-blox GPS with compass (required for autonomous flight)

Specifications:

Microprocessor:

- 32-bit STM32F427 Cortex M4 core with FPU
- 168 MHz/256 KB RAM/2 MB Flash
- 32 bit STM32F103 failsafe co-processor

Sensors:

- ST Micro L3GD20 3-axis 16-bit gyroscope
- ST Micro LSM303D 3-axis 14-bit accelerometer / magnetometer
- Invensense MPU 6000 3-axis accelerometer/gyroscope
- MEAS MS5611 barometer

Interfaces:

- 5x UART (serial ports), one high-power capable, 2x with HW flow control
- 2x CAN
- Spektrum DSM / DSM2 / DSM-X® Satellite compatible input up to DX8 (DX9 and above not supported)
- Futaba S.BUS® compatible input and output
- PPM sum signal
- RSSI (PWM or voltage) input
- I2C®
- SPI
- 3.3 and 6.6V ADC inputs
- External microUSB port

Power System:

- 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



Weight and Dimensions:

- Weight: 38g (1.31oz)
- Width: 50mm (1.96")
- Thickness: 15.5mm (.613")
- Length: 81.5mm (3.21")

The cost of Pixhawk is \$200

2.2. CC3D

The CopterControl & CC3D boards are an all-in-one stabilization hardware which runs the OpenPilot firmware. It can fly any airframe from fixed wing to an octocopter and is configured and monitored using the OpenPilot Ground Control Station (GCS) software. The retail CC3D board comes with everything pictured above.

In 2012 the Original CopterControl boards were discontinued due to lack of available gyro sensors, the board was slightly revised and released with a new gyro sensor that is less effected by temperature changes. The new revision is called CC3D, other than the single sensor it is identical to the original CopterControl. Both CopterControl & CC3D boards are 100% compatible when updated to the v3 bootloader. Any documentation pertaining to the original CopterControl board also applies to the new CC3D.

The board shares a lot with the Revolution platform, including the powerful OpenPilot architecture and the cross-platform Ground Control Station (GCS).

CopterControl from the OpenPilot project introduces a new generation of multi-purpose aircraft stabilization platforms. The CopterControl platform has been designed from the ground up to perform the following functions:

- a Multirotor controller with auto-level, including TriCopters, QuadCopters and HexaCopters
- a Flybarless Helicopter controller with auto-level
- a Fixed Wing UAV controller

The CopterControl hardware has the following features:

- Powerful STM32 32-bit microcontroller running at 90MIPs with 128KB Flash and 20KB RAM
- 3-axis high-performance MEMs gyros and 3-axis high-performance MEMs accelerometer
- Tiny 36mmx36mm 4-layer PCB for superior electrical noise reduction and flight performance.
- Software support for Windows, Mac and Linux
- Direct high speed USB support with no drivers required, a truly plug and play device.
- Spektrum satellite receiver support
- Futaba S-BUS hardware support
- Innovative Flexi-port technology for superior port flexibility
- 4Mbits on-board EEPROM for configuration storage



HARDWARE

The tiny CC3D board, just 36x36mm, installs easily on just about any craft. Designed to be vibration-resistant, the board can be mounted at any angle. Supplied with the board is a Receiver Cable Set (which also supplies power to the board).

There's an on-board mini-USB connector for easy, quick connection to the Ground Control Station (GCS) for configuration and calibration of the CopterControl.

Sensors and Components

- 3-axis Gyroscope array: IDG-500 and ISZ-500
- 3-axis Accelerometer: ADXL345
- Supports several common RC inputs: 6 PWM channels, combined PPM, Spektrum/JR DSM2, DSMJ, DSMX satellites, and Futaba S. Bus receivers
- Simultaneous support for multiple receivers
- Receiver Port functions (configurable): 6 PWM input channels or combined PPM stream, 4 PWM output channels
- Main Port functions (configurable): serial telemetry (default), GPS, S. Bus, Spektrum/JR satellites
- Flexi Port (configurable): serial telemetry, GPS, Spektrum/JR satellites, or I2C peripherals (under development)
- 10 PWM outputs to servos or ESC's, or for camera stabilization
- Camera stabilization: supports up to 3-axis camera mounts with stabilization and manual control from any of configured receivers
- On-board USB connectivity for easy configuration
- USB and serial telemetry and configuration (including wireless with optional radio modules)
- Supported by powerful OpenPilot GCS
- 4 Mbit on-board memory
- 3C Quaternion based complementary filter running at 500Hz

The cost is about \$20

2.3. ARDUPILOT APM 2.6

The ArduPilot 2.6 Flight Controller is the master piece of the ArduPilot autopilot system.

Based on the Arduino technology, ArduPilot has the power and stability of an open source system that is supported all around the world.

Thanks to ArduPilot, you'll be able to transform any vehicle to an autonomous unmanned machine.

ArduPilot is able to perform programmed GPS missions with waypoints, return to home, mission following via a ground computer with telemetry (additional hardware is needed for these functionalities).



In ArduCopter configuration (for Multirotors and for Helicopters) a gyro stabilization is foreseen for your camera.

Unlike other “black box” type solutions, ArduPilot leaves you the full control of your system and you benefit of quality code that is controlled by hundreds of professionals, that use it and work on it, all around the world.

Features:

- Arduino Compatible
- Can be ordered with top entry pins for attaching connectors vertically, or as side entry pins to slide your connectors in to either end horizontally
- Includes 3-axis gyro, accelerometer and magnetometer, along with a high-performance barometer
- On-board 4 Megabyte Data flash chip for automatic data logging
- Optional off-board GPS, uBlox LEA-6H module with Compass.
- One of the first open source autopilot systems to use Invensense's 6 DoF Accelerometer/Gyro MPU-6000.
- Barometric pressure sensor upgraded to MS5611-01BA03, from Measurement Specialties.
- Atmel's ATMEGA2560 and ATMEGA32U-2 chips for processing and usb functions respectively.

Data Sheet:

- 3-Axis Gyro
- 3-Axis Accelerometer
- High Resolution Altimeter
- 5Hz GPS Module
- Dimension: Approx. 70.5x45x13.5mm
- Weight: 31g

The cost is about \$80

2.4. SUMMARY

There is a wide choice of flight controllers on the market, most of them have similar features, but our choice is Ardupilot APM 2.6. For us a big advantage is that Ardupilot is compatible with Arduino which is very well documented platform and our student use it at school. This flight controller is recommended for students who start working with multicopters.

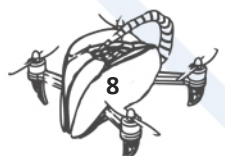
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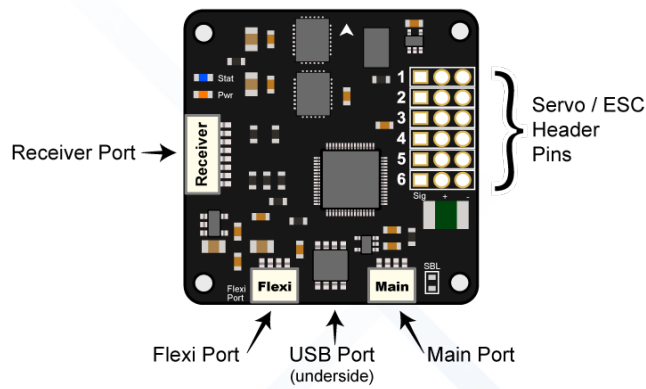
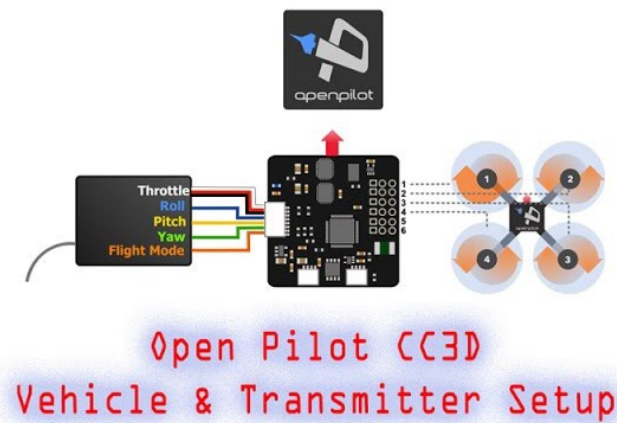
3. ASSEMBLING

3.1. MECHANICAL

Follow the instructions in the assembling manual that comes with the package.

3.2. ELECTRICAL

General connection diagram for CC3D:



We'll focus on the two main ports in the CC3D:

1. Output to the ESC controllers (Servo/ESC Header Pins, signal yellow wire in the top pin):

<u>Receiver module</u>	<u>ESC/Motor wires</u>
CH1	North West
CH2	NE
CH3	SE
CH4	SW

2. Input from the radio receiver (receiver port):

Reference (CC3D receiver port front view):

<u>Receiver module</u>	<u>CC3D cables</u>
RX 1	Blue 5
RX 2	Black 4
RX 3	Red/White/Black 1
RX 4	Red 3
RX 5	Free
RX 6	White 2
RX 7	Blue 1



4. RC TRANSMITTER-RECEIVER

4.1. TRANSMITTER-RECEIVER BINDING:

Binding is necessary to teach the receiver the code of the specific transmitter so that they can talk to each other.

NOTE: This would be not necessary if you are using the Transmitter--Receiver that are packed in the same box.

1. Connect the Turnigy 2.2 battery into the Transmitter (Don't turn on the transmitter).
2. Connect the binding wire (Jumper) in the bind port of the Receiver.
3. Power up the Receiver, using the 3 wire cable connector and plug it into the Receiver power port. It will blink fast a red led.
4. Using the Transmitter (power off) hold the button (Bind range test) and switch on the power.
5. If this step has been made properly the Led in the receiver should not blink anymore but steady red light, now the Transmitter--Receiver are binded together.

4.2. TRANSMITTER CONFIGURATION:

In our case we needed to change some parameters in the RC control transmitter.

1. Press key [MENU].
2. Move the cursor to Settings and press [MENU] key.
3. Move the cursor to REVERSE and press [MENU] key.
4. For the ELE and THR options set it reversed (REV).
5. Press the [MENU] key to accept the changes.

4.3. CC3D CONFIGURATION

Download the CC3D software for: Windows; Mac; Linux 32; Linux 64.

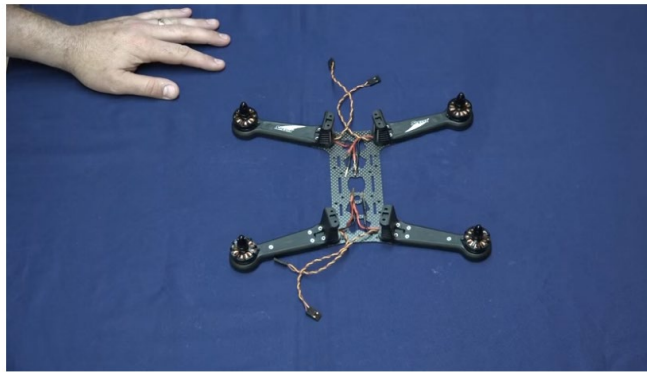
Launch the application and you should see a similar start screen, select the Vehicle Setup Wizard and follow the instructions.

WARNING: Some firmware versions are not compatible with the CC3D board, we recommend for now to don't upgrade the firmware and just skip that step in the Wizard.

Once you have finished the wizard you should add the following for the PID settings.



4.4. REFERENCES



https://www.youtube.com/watch?v=JxfYvqrXA_g

5. DRON FLIGHT CONTROLLER

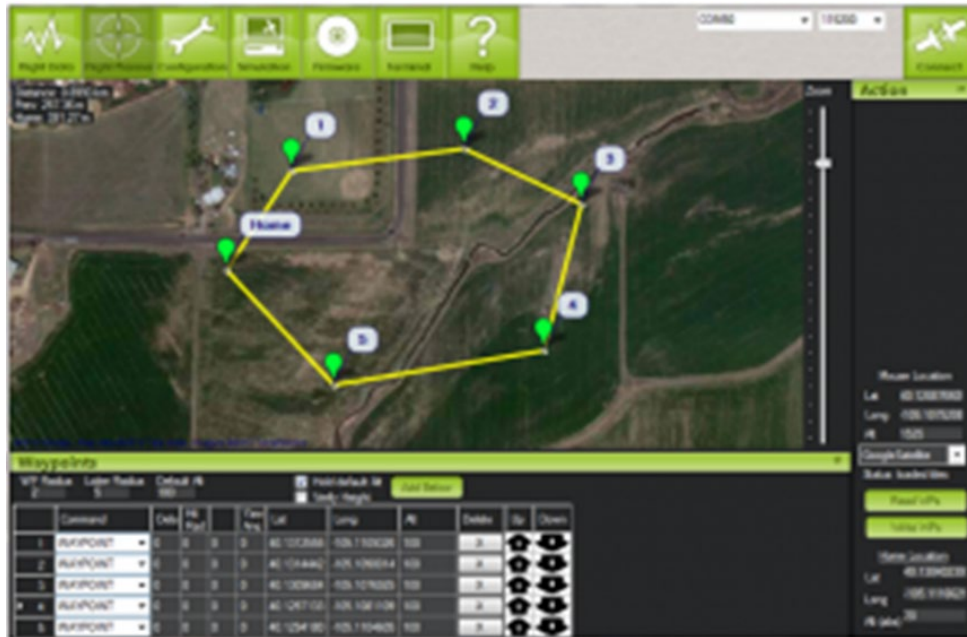
The flight controller that we have chosen is ArduPilot APM 2.6.



5.1. ARDUPILOT APM 2.6

- The APM 2.6 is a complete open source autopilot system
- Arduino Compatible
- Includes 3-axis gyro, accelerometer and magnetometer, along with a high-performance barometer
- On-board 4 Megabyte Data flash chip for automatic data logging
- Atmel's ATMEGA2560 and ATMEGA32U-2 chips for processing and usb functions respectively.
- Dimensions of main board: 70x44x14mm
- Weight: 30g

- This revision of the board has no on-board compass, which is designed for vehicles (especially multicopters and rovers) where the compass should be placed as far from power and motor sources as possible to avoid magnetic interference.
- This is designed to be used with the 3DR uBlox GPS with Compass so that the GPS/Compass unit can be mounted further from noise sources than APM itself.
- Powerful Ground Control Software



The downloadable mission planner software is what you use to configure and control your Ardupilot board, features include:

- Point-and-click waypoint entry, using Google Maps.
- Select mission commands from drop-down menus.
- Download mission log files and analyse them.
- Configure APM settings for your airframe.
- Interface with a PC flight simulator to create a full hardware-in-the-loop UAV simulator.
- See the output from APM's serial terminal.

