UM2512

User manual

How to build your own mini-drone with the STEVAL-DRONE01 reference kit

Introduction

The STEVAL-DRONE01 mini drone kit features the high performance STEVAL-FCU001V1 flight controller unit, as well as the motors, propellers, plastic frame and battery you need to assemble your own mini-drone.

The flight controller unit runs the firmware (STSW-FCU001) to control the speed of each connected motor and to stabilize the drone. To achieve this, the STM32F4 microcontroller hosted on the board analyses data from the accelerometer and gyroscope sensors (LSM6DSL and iNEMO 6DoF inertial measurement unit) to provide highly accurate stability and control.

The FCU board includes a Bluetooth Low Energy SPBTLE-RF module, so you can turn your smartphone running a dedicated App into a remote control unit.

Figure 1. STEVAL-DRONE01 reference design kit

1 Safety considerations

A drone presents safety hazards for the person piloting the drone and others in the vicinity of the drone, so due care and attention must be applied when operating the drone.

You must ensure the drone has sufficient clearance from all objects and persons to fly safely.

Check the rules and regulations specified by your country's Civil Aviation Authority or similar authority, and ensure that your drone does not enter "no-fly" zones.

2 Overview

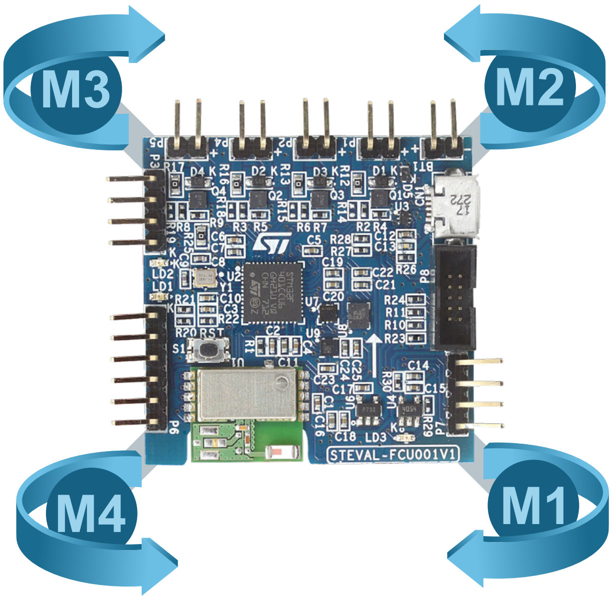
2.1 Features of the STEVAL-DRONE01 kit

- Drone Kit based on the STEVAL-FCU001V1 compact flight controller unit
- Four motors: 3.7 V, 85x20 mm coreless DC motors
- Two clockwise and two counterclockwise 65 mm propellers, plus a couple of spares
- LiPo 3.7 V / 600 mAh battery with a maximum discharge current of 30 C
- 3D plastic mechanical frame including propeller guards for safety
- WEEE and RoHS compliant
- Compliant with Directive 2006/66/EC

2.2 Flight control dynamics

In the quadcopter configuration shown below, each motor spins in the same direction as its diagonal counterpart, and in the opposite direction of its horizontal and vertical counterparts. The rotors on each motor produce a thrust and a torque around their center of rotation.

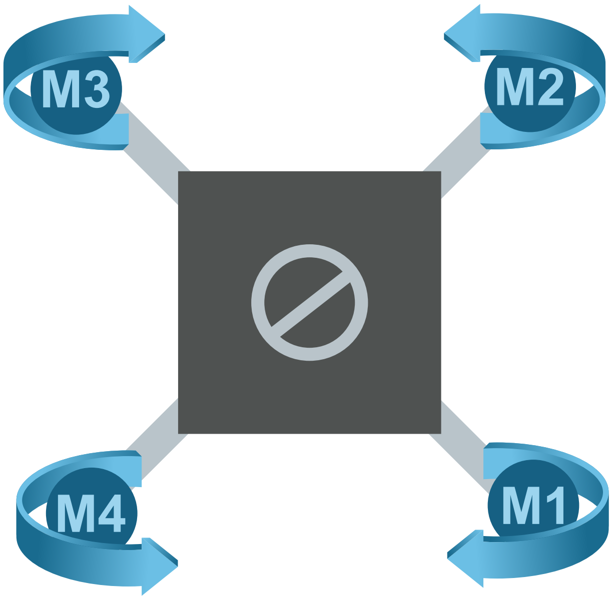
Figure 2. Motor rotation on a quadcopter



The direction (yaw), vertical inclination (pitch), horizontal inclination (roll), and altitude of the drone are all controlled by manipulating the velocity of the motors with respect to each other and to the force of gravity.

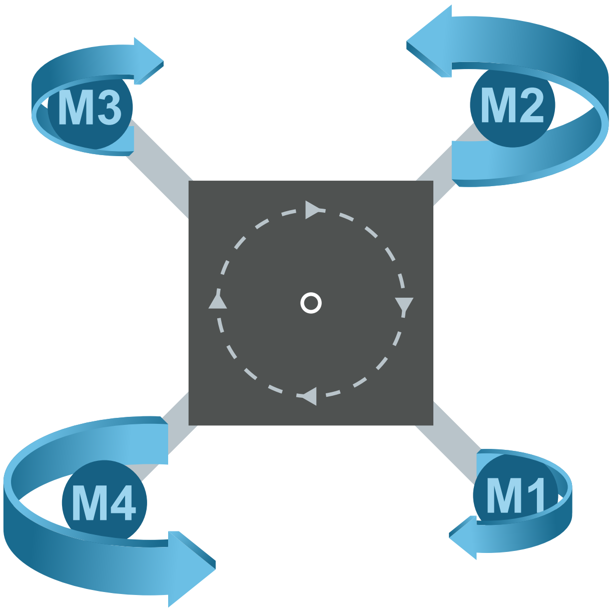
When all four motors rotate at the same speed, the drone can only move up or down, or simply hover.

Figure 3. **Four motors rotating at the same speed**



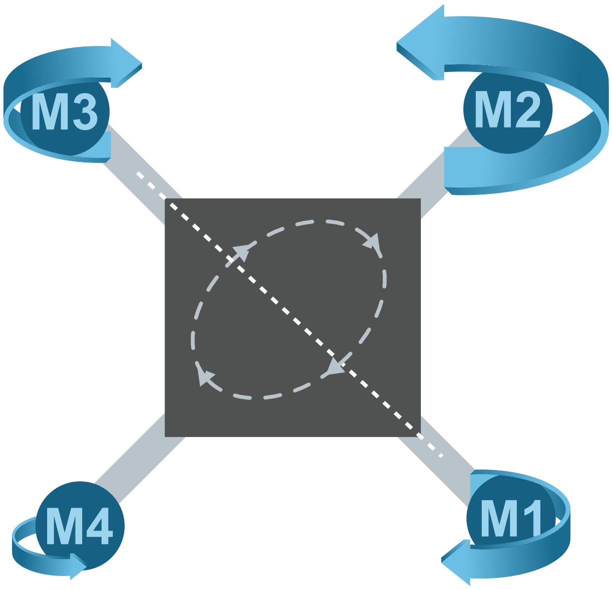
When two diagonal motors rotate more quickly than the other two motors, the drone rotates along its yaw axis. If the counterclockwise motors spin faster, the drone rotates in a clockwise direction, and vice versa.

Figure 4. **Anticlockwise motors cause clockwise rotation**



When a motor is accelerated and its diagonally opposite motor is slowed down, the drone rotates along the other diagonal axis. This will cause the drone to either pitch in order to move forwards or backwards, or roll in order to move sideways.

Figure 5. **Differentiating diagonal motor velocities adjust pitch and roll**

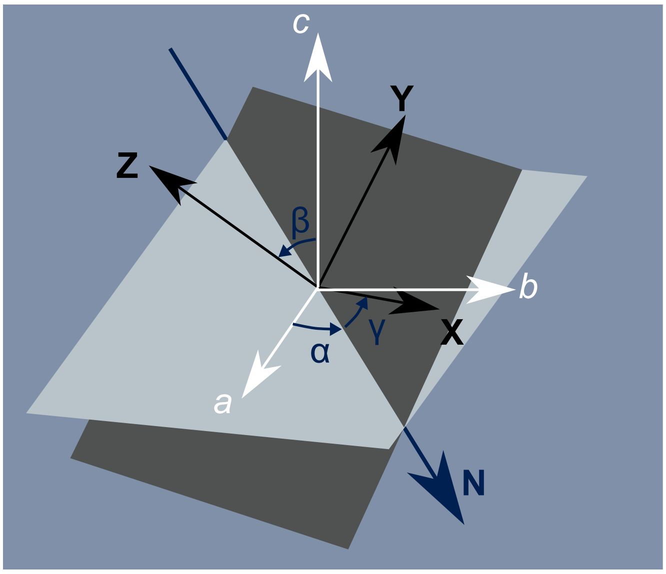


2.2.1 Euler angles

The flight control unit (FCU) uses Euler angles to determine the orientation of a drone and produce desired balance and movement. The FCU algorithm compares actual Euler alpha (α), beta (ß) and gamma (γ) angles with target angles to determine the necessary adjustments to the individual motor velocities.

Figure 6. **Reference axes for Euler angles**

abc: the fixed system
XYZ: the rotating system
N: the intersection line between the ab and XY planes
α: the angle between the x axis and N
ß: the angle between the z and Z axes
γ: the angle between N and the X axis



2.3 Frame of the drone kit

The frame included in the kit is built with a 3D printer, and you can download the STL file from the STEVAL-DRONE01 product folder to build your own frames starting from our basic design. If you develop a new design for your frame, it is important that it retains the necessary size, weight, strength and symmetry characteristics for the drone to be able to fly.

To promote the air flow for clockwise and counterclockwise rotors, the three arms that hold the motors have an airfoil shape.

Figure 7. STEVAL-DRONE01 frame

2.4 Flight control unit

The flight controller unit (FCU) is an STEVAL-FCU001V1 evaluation board with an STM32 microcontroller that determines flight parameters and controls the speed of each motor by regulating the input voltage from the 600 mAh LiPo (Lithium Polymer) batter.

To determine the current position and direction of the drone, the FCU uses data from the following set of micro electro-mechanical systems (MEMS) sensors:

- LSM6DSL iNEMO inertial module: 3D accelerometer and 3D gyroscope
- LIS2MDL high performance 3D Magnetometer
- LPS22HD MEMS pressure sensor: 260-1260hPa absolute digital output barometer

To receive commands, the FCU includes an SPBTLE-RF very low power module for Bluetooth Smart v4.1, so you can use a smartphone app to control the drone. Alternatively, you can use a remote controller if you attach an RX receiver (not included in the kit) to the drone.

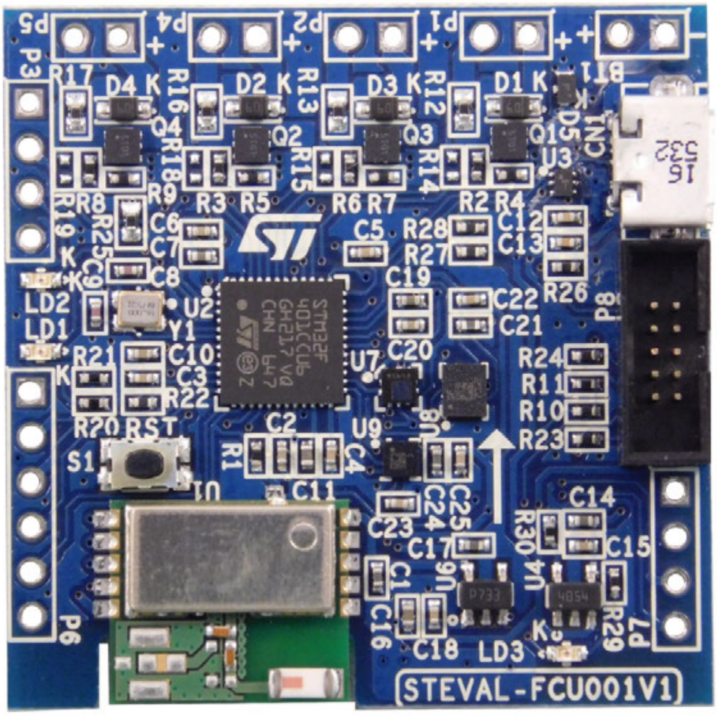


Figure 8. STEVAL-FCU001V1 flight control unit

3 How to update the firmware

To download the firmware onto the board, you need an ST-LINK/V2 connected to the JTAG to SWD adapter board included in the kit, or wire a connection between connector CN4 on an STM32 Nucleo board and the adapter board.

Note: The source FW code is intended for evaluation purposes only, and is not designed or tested for use in commercial products.

Follow the steps below to update the firmware on the STEVAL-FCU001V1 to the latest version available on the STSW-FCU001 product page:

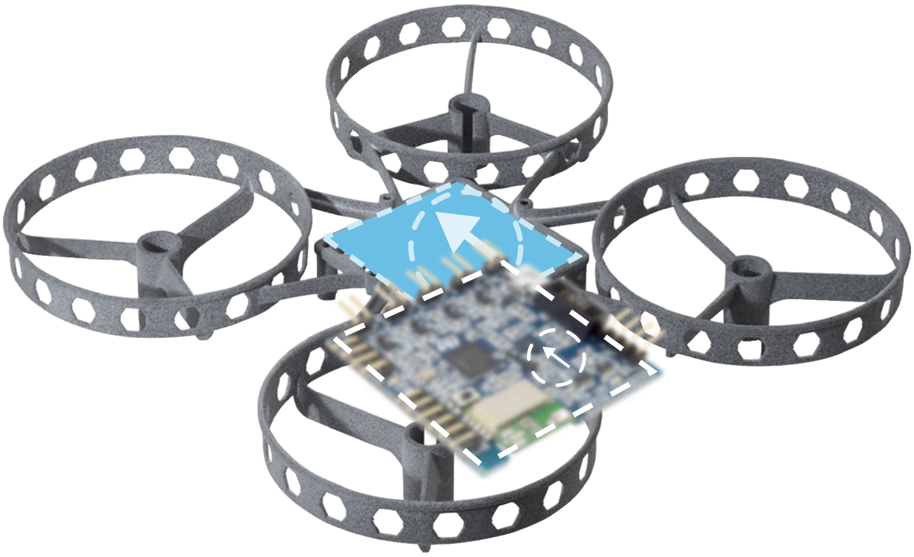
Step 1. Connect a single cell battery (or external 3.7 V voltage supply) to connector BT1.
Step 2. Connect the micro USB cable to avoid discharging the battery.
Step 3. Connect the ST-LINK/V2 cable to the SWD micro connector.
Step 4. Use preferred IDE to compile and update the downloaded FW.

4 How to mount the STEVAL-FCU001V1 board on the drone frame

Follow the instructions below to mount the STEVAL-FCU001V1 flight control unit on the drone frame:

Step 1. Align the STEVAL-FCU001V1 board on the square section at the center of the frame.

Figure 9. Alignment of the FCU board on drone frame



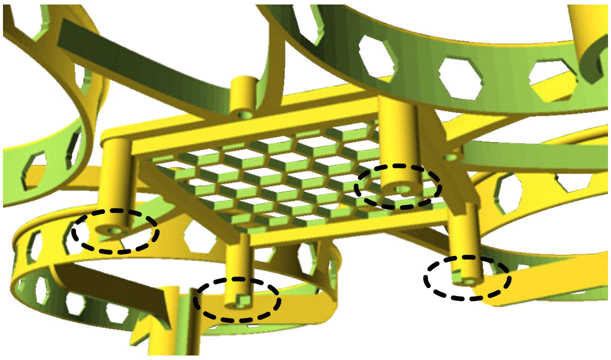
Step 2. Fasten the board to the frame with double-sided adhesive tape or the four nylon screws included in the package.

Ensure that the board lies as flat as possible on the frame.

You may want to glue an adhesive sponge between the frame and the board to minimize mechanical vibration from the motors.

You can mount the board on the top side or the bottom side of the frame, but it is easier to program the board microcontroller when the board is mounted on the top side.

Figure 10. Mounting holes for the FCU on the drone frame



Step 3. Insert the four motors in the sleeves.

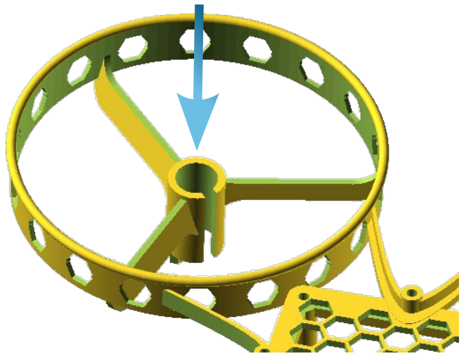
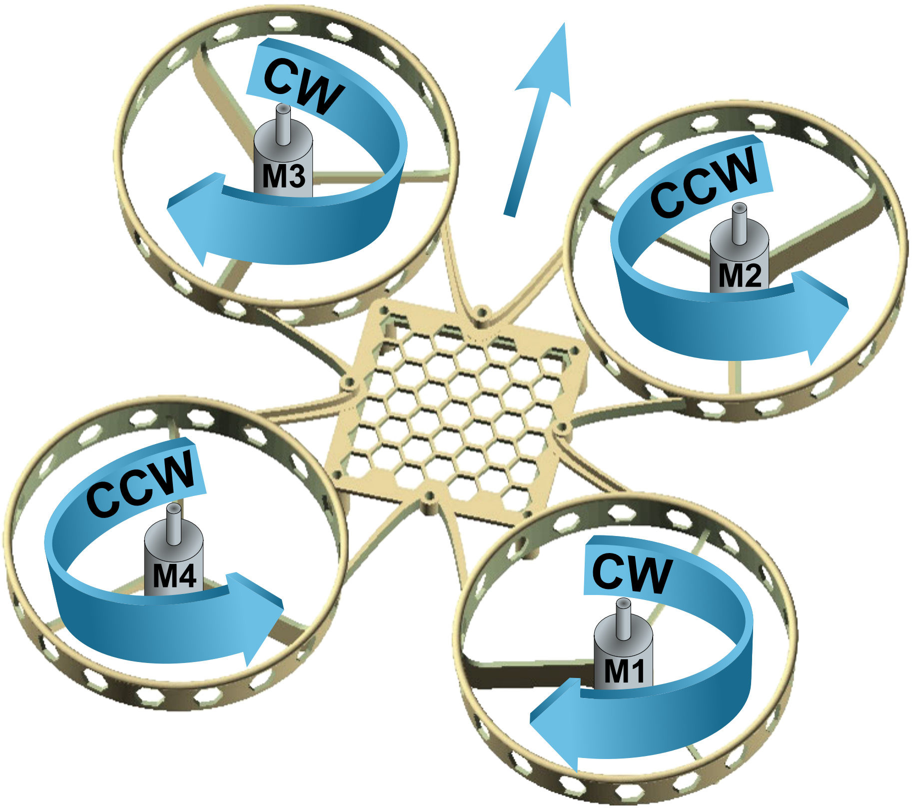


Figure 11. Motor housing sleeve

Step 4. Place the four motors in the correct configuration with respect to the facing direction of the board:

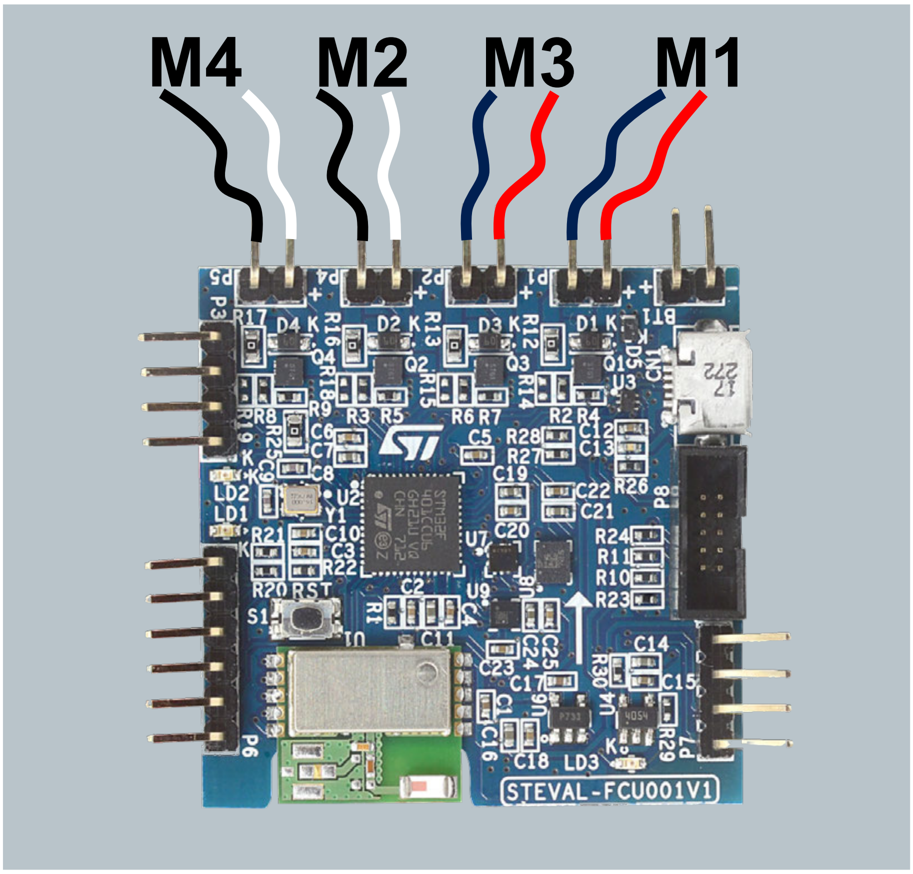
– The clockwise motors (M1 and M3) have the red (+) and blue (-) cables
– The counterclockwise motors (M2 and M4) have white (+) and black (-) cables.

Figure 12. Motor orientation with respect to facing direction



Step 5. Connect the motor cables to the supply pins on the FCU board

Figure 13. Motor supply connections on FCU board

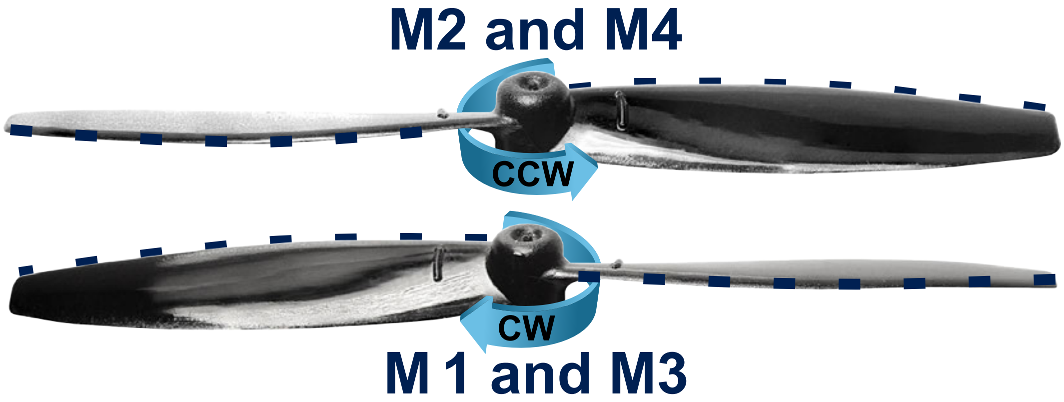


Step 6. Push fit the propellers onto the motors

The correct propeller for clockwise and counterclockwise rotation has the leading edge raised in the respective direction of rotation.

Note: For safety reasons, you should disconnect the battery before mounting the rotors.

Figure 14. Propeller rotation directions



Step 7. Fasten the battery to the frame.

The battery is LiPo single cell, 600 mAh and 30 C maximum discharge current.

Figure 15. Battery mounting

Step 8. Connect the battery to connector BT1 on the STEVAL-FCU001V1 board.
The battery is charged by the FCU board when connected via USB.

Step 9. Ensure correct polarity when you connect the battery.

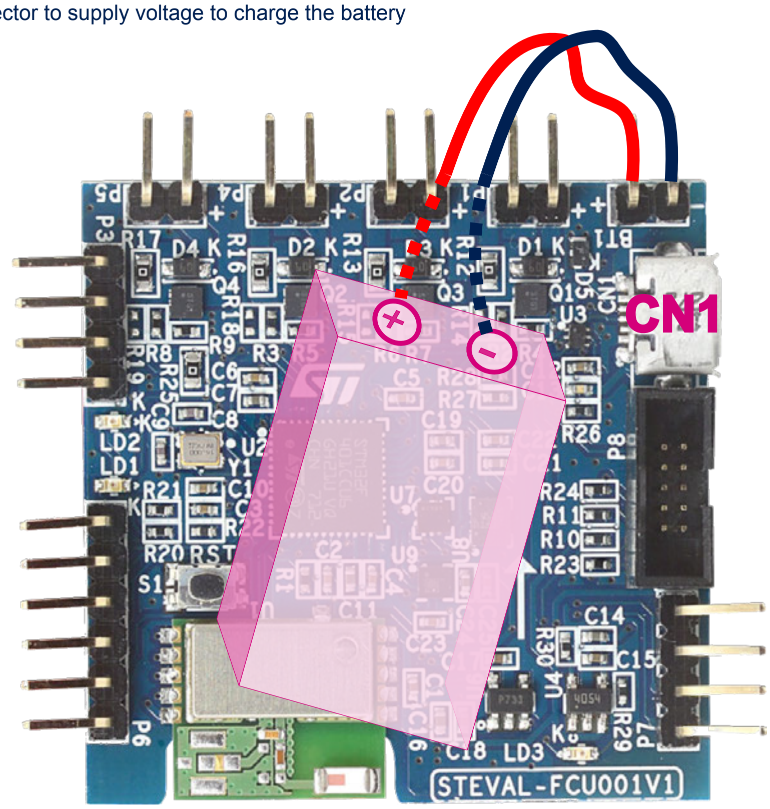
Danger:
LiPO batteries can be damaged and even explode if they are short-circuited or overcharged.

Note: Reverse battery protection is not implemented on the FCU board.
Carefully read the storage and handling recommendations provided by the battery manufacturer.
Do not leave the battery connected when the drone is not in use.

Warning:
Do not allow the battery to discharge completely or this may permanently damage it.

Figure 16. Battery connection

CN1: USB connector to supply voltage to charge the battery



5 How to fly the drone with the AppDrone app

Before you fly the drone, make sure that you have:

1. updated the latest version of the STSW-FCU001 firmware
2. assembled the STEVAL-DRONE01 kit
3. connected the battery

Step 1. Place the quadcopter on a flat surface and press the reset button on the board.

Step 2. Download and install the AppDrone app on your smartphone or tablet.

Step 3. Run the app.

Figure 17. **AppDrone app main screen**

Step 4. Click [**Start Connection**] in the main app screen.
You will be prompted to enable Bluetooth on your device, and to select your Drone from the list.

Step 5. Place your drone on a flat, horizontal surface.
The surface represents a reference plane to determine any offsets for the AHRS Euler angles.
Ensure the surface is reasonably horizontal or the offsets will be too high for reliable flight.

Step 6. Tap and hold the icon to perform sensor calibration.
Hold your finger on the icon for a few seconds until it turns green.

5.1 Arming procedure

For safety reasons, the drone is initially disarmed (red LED on the STEVAL-FCU001V1 blinks), and the motors will not respond to any commands issued by the remote controller.

5.1.1 Arming procedure with AppDrone

If you are using the AppDrone app:

Step 1. In the AppDrone app, tap on the icon.

5.1.2 Arming procedure with external remote control

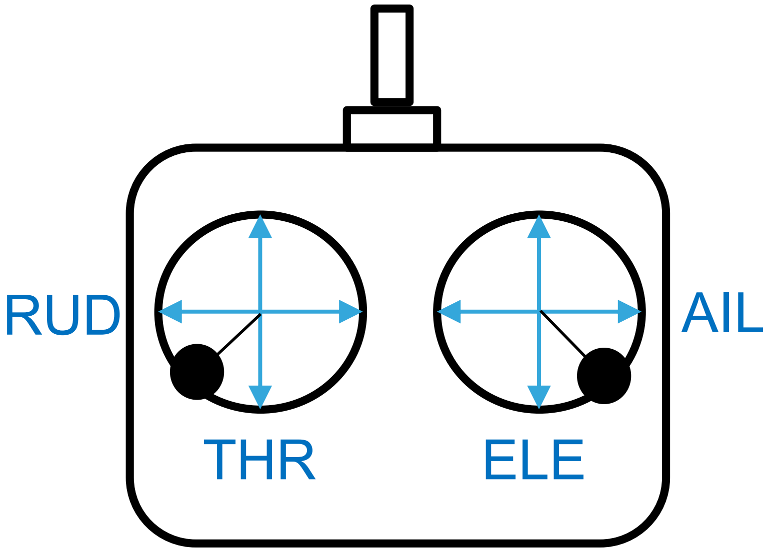
If you are using an external remote control unit:

Step 1. Connect a remote controller receiver to P6 of STEVAL-FCU001V1 (please refer to UM2311 for pinout details).

Step 2. Enable the Remote Controller in the firmware (refer to UM2329).

Step 3. On your remote control unit, move and hold the levers to the positions shown in the figure below:

Figure 18. Remote control lever positions to arm drone



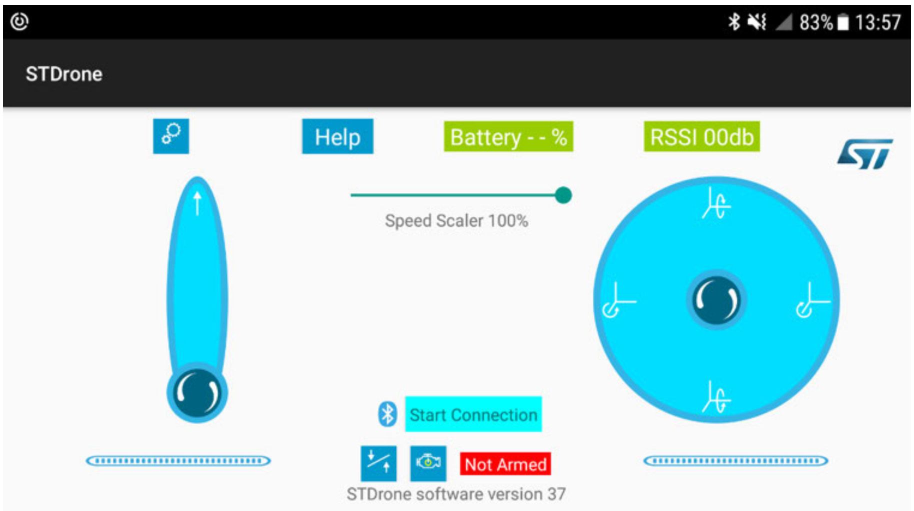
5.2 Test flight

Follow the procedure below to perform your first test flight.

Step 1. Slide the speed scaler down to 60%.

Step 2. Select the settings icon and set the left joystick capability to throttle only.

Figure 19. Left joystick reduced to throttle only



If the drone seems unstable and starts to oscillate, try reducing the PID proportional gain in the firmware. Look for PID tuning tutorials on the Internet to help you.

Revision history

Table 1. Document revision history

Date	Version	Changes
18-Dec-2018	1	Initial release.

Glossary

multicopter A rotorcraft with more than two rotors. Multicopters are less complex than two-rotor helicopters as they use fixed-pitch blades and are controlled by varying the relative speed of each rotor to change the thrust and torque they produce.

pitch The pitch axis is a horizontal axis through a body. Rotation along the pitch axis causes the body to change its NSEW compass bearings.

roll The roll axis is a horizontal axis through a body. Rotation along the roll axis causes the body to bank left or right.

unmanned aircraft system An aircraft without a human pilot on-board, but controlled by an operator on the ground.

yaw The yaw axis is the vertical, up-down axis that runs through a body. Rotation along the yaw axis causes the body to change its NESW compass bearings.

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