Falcon 2 Flight Controller

Set-Up Guide

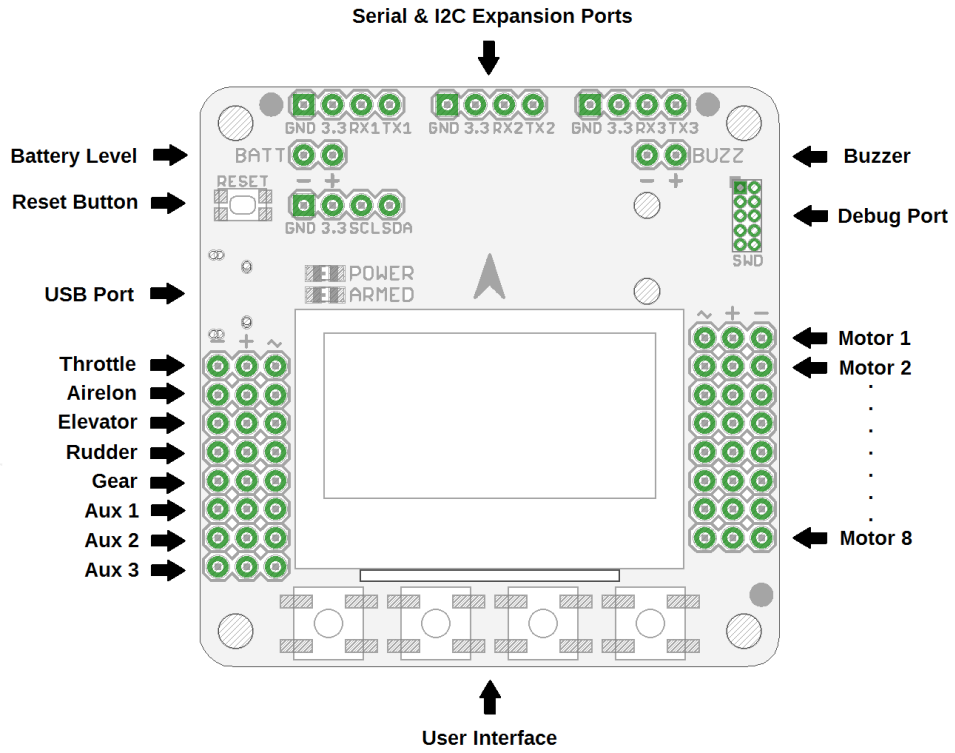
Thank you for choosing the Falcon 2 flight controller. Please take time to read this set-up guide. It has been written to provide all you need to know to get flying as quickly and as safely as possible.

WARNING: This flight controller operates high speed brushless motors that have the potential to cause serious injury if used incorrectly. Please ensure that you have carefully followed these instructions, and that the Falcon 2 is properly installed, calibrated and correctly set-up, before attempting to get airborne. Use the Falcon 2 at your own risk, no liability can be accepted for any loss or damage howsoever caused.

WARNING: Always turn on the transmitter before the receiver and turn off the receiver before the transmitter.

Falcon 2

The Falcon 2's layout is shown in the diagram below:



The Falcon 2 is a 32-bit, ARM Cortex M0+ based flight controller capable of both manual (rate, auto-level and heading free), as well as automated (altitude hold, loiter and return to home) modes. It connects to either a standard 8-channel, CPPM or DSM2/DSMX satellite receiver and combines this pilot input with gyroscope, accelerometer, magnetometer (compass) and barometer (altitude) sensors. These allow it to stabilise and fly any number of pre-set or custom multi-rotor (drone)

configurations through a motor mixer editor. The Falcon 2's various settings are also configurable “in the field” using its miniature user interface.

Falcon 2 Flight Modes

The Falcon 2 can operate in rate mode, auto-level, heading free, altitude hold, loiter and return to launch (RTL). The multi-rotor can be switched between modes during flight, by flipping an assigned switch on the transmitter. The Falcon 2 will acknowledge the change of flight mode with a fast double beep on the buzzer. The Falcon 2 can operate without a GPS, but one is required for loiter and RTL. If at any time the GPS connection is lost, the flight controller will enter auto-level and output a fast sequence of beeps on the buzzer. To deactivate the buzzer simply switch to a new flight mode.

Rate Mode

In rate mode (also known as gyro or acro mode), the input from the pilot is converted a “rate” of rotation in degrees per second. In this mode the multi-rotor rotates at a speed proportional to the stick input from the pilot. At high rate stick scaling and transmitter EXPO, it is possible to perform acrobatics such as flips and rolls.

Auto-Level

In auto-level, the input from the pilot is converted to degrees for the roll and pitch axes. In this mode the multi-rotor tilts at an angle proportional to the stick input from the pilot. Releasing the sticks brings the copter back to level flight. The yaw axis acts in the same way as rate mode, proportional to the rate of rotation (in degrees per second).

Heading Free

Heading free mode works in a similar way to auto-level, except that the multi-rotor's orientation is always with respect to its launch heading. So for example, if the pilot's transmitter is pointing the same direction as the aircraft at launch, pulling back on the pitch (elevator) stick will always pitch the aircraft back towards the pilot, irrespective of which way it happens to be pointing.

Altitude Hold (Auto Throttle)

Altitude hold is the same as auto-level, except the Falcon 2 takes control of the throttle. The throttle stick mid point (usually 50%) ±10% becomes a dead band. In this band the multi-rotor maintains is current altitude. Moving the throttle stick higher than the dead band, causes it to climb at a specified climb rate, while moving the stick lower causes it to descend a specified descent rate.

Loiter (requires an external GPS)

Loiter mode is the same as altitude hold, but additionally it causes the multi-rotor to automatically maintain its current position. Moving the transmitter roll, pitch or yaw sticks beyond their centre points results in the flight controller relinquishing control back to the pilot. Releasing the sticks returns control back to the Falcon 2. The throttle control works the same way as altitude hold.

RTL (requires an external GPS)

Return to launch causes the Falcon 2 to enter a predefined flight sequence:

1. Enter loiter mode at the current altitude.
2. Climb or descend to a specified return altitude.
3. Rotate the multi-rotor on to the return bearing.
4. Fly back to the launch location on that bearing.
5. On arrival at the launch location, enter loiter mode.
6. Rotate on to the launch bearing.
7. Descend down to the landing altitude.
8. Activate the warning buzzer and continue to descend at the landing descent rate.
9. Land.

During RTL the pilot may at any time switch to an alternative mode to deactivate the flight sequence.

Important: After acrobatic manoeuvres that include flips or rolls, please allow a number of seconds for the before switching back to auto-level or other flight modes. This allows time for the auto-level algorithm to settle.

Falcon 2 Installation

IMPORTANT: FIRST REMOVE THE PROPELLERS

Install the Falcon 2 in your multi-rotor frame either with M3 nylon pillars and nuts, or self adhesive gyro pads. The arrow on the Falcon 2 indicates the airframe's forward direction of travel.

RC Receivers

The receiver input connections currently accept either an 8 channel standard receiver, a single CPPM receiver, or a DSM2/DSMX satellite receiver (with a Tarot ZYX-S converter cable).

Standard Receivers

Connect the 8 standard receiver channels in the following order, top to bottom: Throttle, Airelon, Elevator, Rudder, Gear, Aux1, Aux2 and Aux3.

CPPM receivers

Connect the single CPPM receiver to the throttle channel. The Falcon 2 can read up to 6 channels.

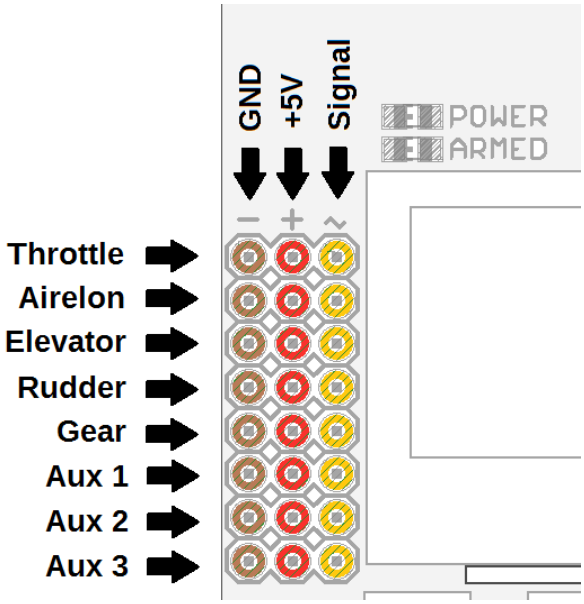
Satellite Receivers

Connect the DSM2/DSMX satellite receivers to the flight controller through a Tarot ZYX-S conversion cable. Connect the cable's standard 0.1” JWT (DuPont) header to the throttle channel. The Falcon 2 can read up to 7 channels.

Note that the satellite receiver must first be bound to the transmitter using a main

receiver prior to installation. During the bind process the transmitter must configure the satellite receiver to use a frame rate of 22ms. It is currently not possible to bind to the Falcon 2 directly, as its bootloader, (a small piece of code that allows firmware to be uploaded through the micro USB port), conflicts with the satellite receiver's bind procedure.

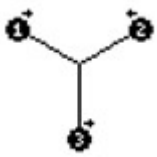
Important: Please ensure the polarity of the receiver connectors are correct: GND (ground) (-), +5V (+), signal (~), as there is no polarity protection. Also, never connect the +5V power line directly to the signals as the microcontroller is not +5V tolerant.

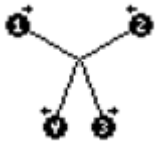
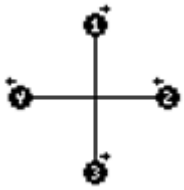
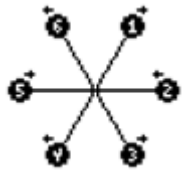
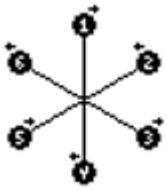
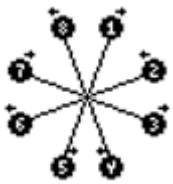


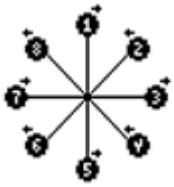
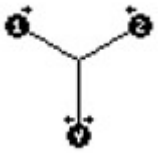
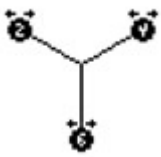
Motor Outputs

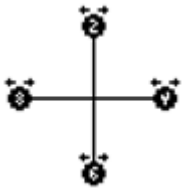
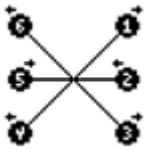
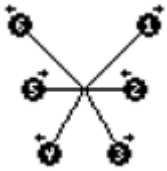
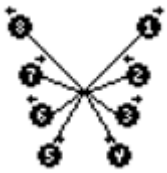
The Falcon 2 allows up to 8 brushless motor/servo channels. During normal operation Motor 1 (M1) is used to power the Falcon 2 board with a +5V BEC (Battery Eliminator Circuit) from an ESC (Electronic Speed Controller). Motor channels M2-M8 are on a separate +5V power bus that can be used to power any additional servos.

The table shows the connections required for each motor/servo configuration and the each motor's expected direction of rotation, either clockwise or counter clockwise.

Motor Layout	M1	M2	M3	M4	M5	M6	M7	M8
Tricopter 	M (c)	M (cc)	M (c)		S		G	G

Quadcopter V-Tail 	M (c)	M (cc)	M (c)	M (cc)			G	G
Quadcopter X Mode 	M (c)	M (cc)	M (c)	M (cc)			G	G
Quadcopter + Mode 	M (c)	M (cc)	M (c)	M (cc)			G	G
Hexacopter X Mode 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	G	G
Hexacopter + Mode 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	G	G
Octocopter X Mode 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)

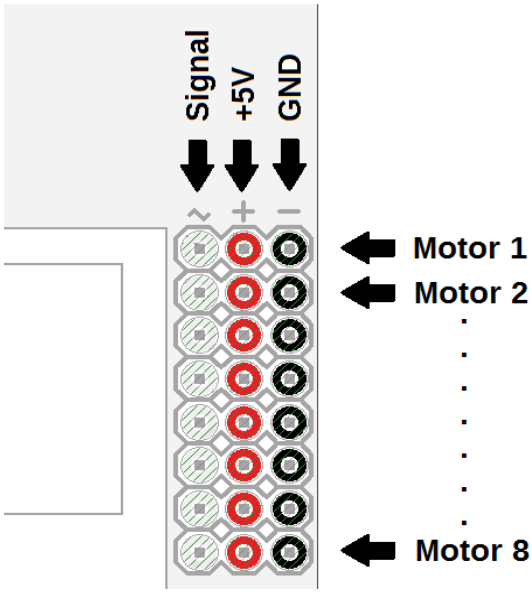
Octocopter + Mode 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)
Singlecopter 1M4S* 	M (c)				S	S	S	S
Singlecopter 2M2S* 	M (c)	M (cc)			S	S	G	G
Dualcopter* 	M (c)	M (cc)			S	S	G	G
Y4 	M (c)	M (cc)	M (c)	M (cc)			G	G
Y6 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	G	G

X8 X Mode 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)
X8 + Mode 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)
H6 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (c)	G	G
H8 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)
V6 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	G	G
V8 	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)	M (c)	M (cc)

M – Motor Connection
S – Servo Connection
G – Camera Gimbal (Optional)
c – Clockwise
cc – Counter Clockwise

* Singlecopter 1M4S, Singlecopter 2M2S and Dualcopter configurations may require an additional +5V BEC on the power bus, in order to drive their additional servos.

Important: Please ensure the polarity of the motor connectors are correct: GND (-), +5V (+), signal (~), as there is no polarity protection. Also, never connect the +5V power line directly to the output signals as the microcontroller is not +5V tolerant.



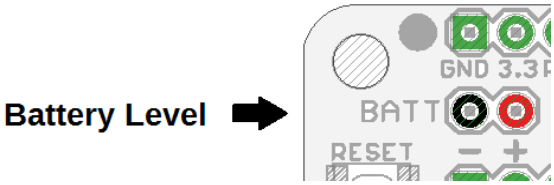
User Interface

Communication with the microcontroller is handled by 4 buttons and a micro OLED display.

Battery Level (BATT)

On the left is the battery monitor input (BATT) that can accept up to 6S (25.2V) LiPo (Lithium Polymer) batteries. Only the (+) connection is used, the (–) connection is just a dummy pin. Ground return is through the M1 connector or the USB port.

Important: Please do not connect batteries greater than 6S (25.2V) to the battery level port.



Buzzer (BUZZ)

On the right is the +5V buzzer (BUZZ) connection. Connect the supplied +5V buzzer to the BUZZ port: Red (+), Black (-).

Important: Please ensure that the buzzer polarity is correct before powering the board, as there is no reverse polarity protection.

USB Port

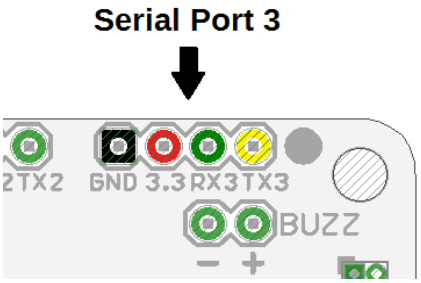
The micro USB port is used to provide auxiliary power and to upload future firmware (software) updates on to the Falcon 2's embedded microcontroller. The auxiliary power from the micro USB port is protected by a 500mA resettable fuse.

Serial Ports

The Falcon 2 has three external serial ports. Serial 1 and 2 are currently reserved for future use, Serial 3 can be (optionally) connected to a GPS.

The Falcon 2 is only compatible with uBlox GPS modules. It has been tested with NEO-6M and NEO-M8N, but should also be compatible with the NEO-7M.

Connect the GPS to Serial port 3 (TX3, RX3) on the top right of the Falcon 2 board:



Connect the corresponding GPS serial port pins:

Falcon 2	uBlox GPS
+3.3V	PWR (+3.3V)
GND	GND
RX3	TX
TX3	RX

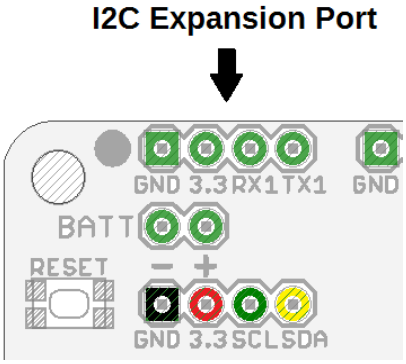
Important: Please ensure that the GPS module can operate at +3.3V. Only connect the GPS to +3.3V.

During installation the orientation of the GPS with respect to the flight controller is not important, so long as the antenna is pointing upwards and has an unobscured view of the sky.

The Falcon 2 will automatically configure the GPS boards for the correct baud rate and protocol. From a cold start it can take up to a minute to get a fix.

I2C Expansion Port

It is currently possible to (optionally) connect the either a HMC5883L or HMC5983 external magnetometer to the Falcon 2's I2C expansion port:

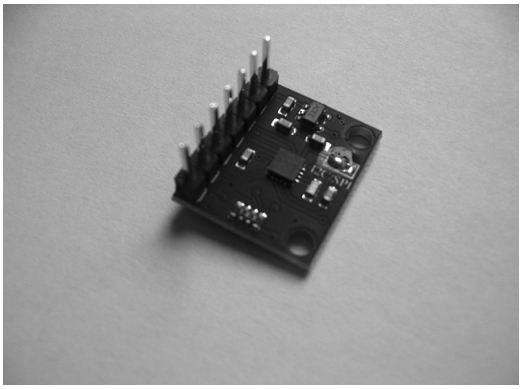


Connect the corresponding magnetometer pins:

Falcon 2	HMC5883L / HMC5983

+3.3V	PWR (+3.3V)
GND	GND
SCL	SCL
SDA	SDA

If the board provides a SPI / I2C solder bridge option, then solder the I2C option, (as shown in the diagram below). The purpose of connecting an external magnetometer is that it can be placed away from sources of electromagnetic interference that can affect the compass reading. The external compass may be part of a GPS unit or alternatively a standalone board. In either case, align the dot in the top left hand corner of the magnetometer chip and its text the same way as the flight controller.



Important: Please ensure that the compass is correctly calibrated and only connect it to +3.3V.

Debug (SWD) Port

The SWD port can be used by developers to debug the Falcon 2's firmware using an Atmel-ICE (In Circuit Emulator). It is not required for either normal operation or to upload new firmware.

Reset Button

The reset button can be used to reset the microcontroller. It is not used during normal operation. Double tapping the reset button will put the Falcon 2 into bootloader mode. The board's microcontroller will wait for new firmware to be uploaded, rather proceeding to the flight control code.

Power and Armed LEDs

The power LED (green) indicates that power is applied to the board, either through the USB port or the M1 motor connection. The armed LED (red) is illuminated when the board is in ARMED mode.

Powering The Board

Important: Before powering the board, please carefully check the connectors'

polarity and that they are inserted correctly, as an incorrect connection may damage the board.

1. Important: First turn on your transmitter and select the correct model.
2. Power the board, either with the micro USB cable from the PC or via the M1 (Motor 1) connector, by plugging in a LiPo battery into your multi-rotor's wiring harness or Power Distribution Board (PDB).

Important: Never power the M1 connector directly from a LiPo battery. The Falcon 2 is designed to be powered from a +5V BEC, (+6V maximum). Voltages higher than +6V may damage the board.

With the power applied, the Falcon 2 should display its splash screen and beep two times, before entering SAFE mode.

Falcon 2 Modes

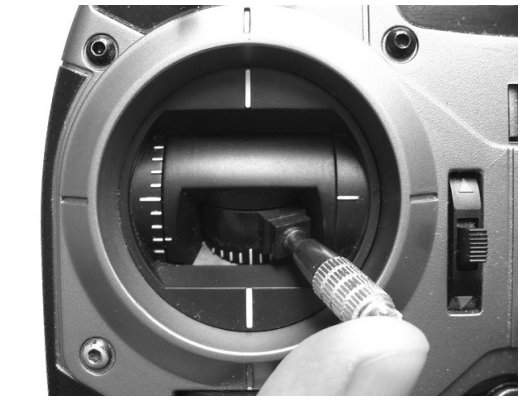
SAFE Mode

SAFE mode is the Falcon 2's central display. It details the receiver status, battery level and flight mode. It also provides the GPS Fix, number of satellites, GPS horizontal accuracy and aircraft heading. From SAFE mode it is possible to either enter ARMED mode, or alternatively enter the MENU system.

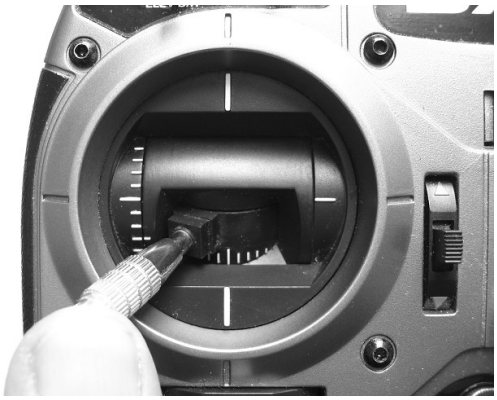
WARNING: Do not attempt to ARM the board and launch if the receiver status indicates an error. (In any case, the Falcon 2 will prevent the motors from being ARMED in the event of a receiver error).

ARMED Mode

Moving the transmitter's rudder stick to the right for 2 seconds with the throttle at idle (default < 10%) activates ARMED mode. In ARMED mode the motor outputs become active. While the throttle is at idle, the flight controller periodically beeps to indicate that ARMED mode is active. Above the throttle idle threshold (> 10%) the propellers will start to spool up and the beeps will cease. Note that it's only possible to ARM the board in the manual (rate, auto-level and heading free) modes.



Moving the transmitter's rudder stick to the left for 2 seconds with the throttle at idle, or leaving the throttle at idle for more that 20 seconds, will cause the Falcon 2 to return to SAFE mode. Note that it's possible to return to SAFE mode from any flight mode.



WARNING: Please ensure that the Falcon 2 is correctly calibrated before attempting to enter ARMED mode. See Calibrate Menu below.

MENU Mode

The MENU mode is entered from SAFE mode, (by pressing the right-hand MENU button). The Falcon cannot be ARMED in MENU Mode. The menu allows the flight controller's settings to be changed with the use of the 4 user interface buttons and OLED display.

Falcon 2 Menu System

The Falcon 2's menu system allows the flight controller's settings to be changed. Changes to the settings are persistent and stored in (EEPROM) memory. The settings remain after power is removed.

Radio Menu

Navigate: SAFE Mode – Main Menu – Radio Menu

Rate Stick Scaling

Rate Stick Scaling determines the minimum and maximum values for the throttle in percent (%) and roll, pitch and yaw rates in degrees/s that correspond to a full throw of the transmitter stick.

The default throttle value is set at 90%. This allows the Falcon 2 to the utilise the 10% "headroom" to maintain flight stability at full throttle.

High roll, pitch and yaw rate stick scaling values require positive EXPO to be added to the transmitter channels. The table gives an indication of the EXPO values to chose for Roll (Airelon) and Pitch (Elevator):

Rate Stick Scaling	Transmitter EXPO (Roll and Pitch)
±180º/s	+0%
±250º/s	+30%
±500º/s	+65%

A good starting point for the Yaw (Rudder) EXPO is around +30%. Later adjust the rate stick scaling and transmitter EXPO to suit your preference.

Leave the transmitter dual rate settings at 100%.

Important: Please ensure that rate stick scaling is less the gyroscope full scale range (±250°/s, ±500°/s, ±1000°/s and ±2000°/s). See Gyro/Accel Settings below.

Auto-Level Stick Scaling

Auto-level Stick Scaling determines the minimum and maximum roll and pitch values in degrees for a full throw of the transmitter stick. The default is ±45º.

A good starting point for Roll, Pitch and Yaw in auto-level is an EXPO of around +30%.

Radio Switch Selection

Radio switch selection allows the flight modes and gimbal activation to be assigned to the transmitter switches. It is possible to select one of 3 switch positions: low, middle or high.

1. Navigate: SAFE Mode – Main Menu – Radio Menu – Radio Switch Settings.
2. Press the DOWN button to move to the required flight mode or camera gimbal option.
3. Press the CHANGE button to cycle through to the desired transmitter switch setting that activates the selected option.

If Gimbal Ctrl (SAFE Mode – Main Menu – Settings Menu – Gimbal Settings) has been enabled, the transmitter switch will activate the 2-axis gimbal servos. In the inactive state the gimbal servos will remain centred.

Rx Channel Map

The Rx Channel Map determines the order of the incoming signals from the receiver, either for single channel CPPM receivers, or to swap channels on multi-channel standard receivers. The default channel order is: Airelon, Elevator, Throttle, Rudder, Gear, Aux1, Aux2 and Aux3.

PID Editor

Navigate: SAFE Mode – Main Menu – PID Editor

Rate Mode PI Editor

The Rate Mode PID Editor menu system allows the PID Gain and Limit settings for the roll, pitch and yaw “rate” (degrees/s) control loops to be adjusted. It is possible to cycle through the roll, pitch and yaw settings by pressing the CHANGE button.

P Gain is the proportional gain and determines the size of the instantaneous reaction (in the present) to the pilot's input and provides the multi-rotor's basic response. I Gain is the integral gain and determines the size of the response from readings taken over a period of time (in the past). It re-enforces the P response, providing solidity to the flying characteristics. The I gain is also useful for correcting asymmetric configurations such as the tricopter. D Gain is the derivative gain that acts to provide a predictive response (in the future). It acts like a shock absorber that dampens motion towards the pilot's input, but on the other hand provides an opposite reactive response to any motion away from it, for example unwanted rotational motion caused by a sudden gust of wind.

The PID Limit should remain unchanged for motors (at 1000µs), but can be used to limit the full range travel of servos. The I Limit prevents the integral value from becoming too large, a process know as integral wind-up. Integral wind-up affects both motors and servos.

In terms of units the PID Gain is a simple multiplier, while the PID Limits represent the minimum and maximum pulse width output values in microseconds (µs). The control signals for ESCs are between around 1100µs minimum and 1900µs maximum, while servos are centred around 1500µs and vary between roughly 1000µs to 2000µs. By reducing the PID limits it is possible to reduce the full range travel of a servo.

In general the larger the air frame the larger the P and I gains. Here are basic set-up recommendations to get you flying:

Roll and Pitch Table

Air Frame Size	P Gain	I Gain	D Gain	I Limit	PID Limit
250mm	0.80	0.50	0.0000	500µs	1000µs
450mm	1.50	0.60	0.0000	500µs	1000µs

Yaw Table

Airframe Size	P Gain	I Gain	D Gain	I Limit	PID Limit
250mm	1.60	0.20	0.0000	100µs	300µs
450mm	2.00	0.20	0.0000	100µs	300µs

Note: In the case of the tricopter yaw servo, reduce the P Limit to around 300µs to limit its travel.

These settings are provisional and will require further experimentation to perfectly tune them for your specific multi-rotor configuration.

Auto-Level PID Editor

Important: Auto-Level is still dependant on the Rate PI Gain and Limits for aircraft stabilisation, therefore it is necessary to first set-up the correct PI Gain and Limit values for your airframe and get stable flight in rate mode, before switching to auto-level.

The Auto-Level PID Editor menu system allows the PID Gain and Limit settings for the roll and pitch “angle” (degrees) control loops to be adjusted. These additional control loops accept the pilot's input in degrees, the output of which is used to drive (in degrees/s) the corresponding inner “rate” control loops (mentioned above) that provide basic flight stabilisation.

There is no auto-level control loop for yaw. Yaw just uses the “rate” control loop settings in the Rate Mode PID Editor (see above).

The initial suggested settings for the PID Gains and Limits are:

Airframe Size	P Gain	I Gain	D Gain	I Limit	PID Limit
All	3.0	0.0	0.0000	100°/s	200°/s

The size of the P Gain determines how quickly the multi-rotor returns to reaches the angle commanded by the pilot.

Auto-Level Trim

Auto-Level Trim allows small adjustments to be made to the roll and pitch angle. Positive roll trim tilts the multi-rotor further to the right, positive pitch trim tilts the multi-rotor further back (nose up). Correct accelerometer calibration should remove the need to adjust the Auto-Level Trim.

Heading PID Editor

The Heading PID Editor allows the PID Gain and Limit settings for the yaw heading (in degrees). This sets the strength of yaw hold/response both for loiter and RTL modes.

Altitude Hold PID Editor

The Altitude Hold PID Editor menu system allows the PID Gain and Limit settings for the strength of both “Position” and “Rate” of climb / descent response. They are used in conjunction with the “Altitude Hold Settings”, (see Settings Menu section below), that sets the actual desired climb and decent rate (in metres per second).

Loiter PID Editor

The Loiter PID Editor menu system allows the PID Gain and Limit settings for the strength of both GPS “Position” and “Speed” response. During loiter the aircraft tries to maintain its current position and zero speed.

Gimbal P Editor

The Gimbal P Editor allows the P (proportional) Gain and Limits to be set for a servo operated 2-axis gimbal on motor outputs M7 (roll) and M8 (pitch). Adjust the P Gain and Limits until the gimbal servos are stable and within bounds.

Settings Menu

Navigate: SAFE Mode – Main Menu – Settings Menu

Mode Settings

- **Link Roll Pitch:** Sets whether changes to the roll settings in the Rate Mode PI Editor are automatically copied over to the pitch and vice-versa.
- **Auto Disarm:** Automatically disarms the board after 20 seconds, whenever the board is ARMED and the throttle is at idle (default < 10%).
- **Receiver type:** Sets whether the receiver is a standard multi-channel, CPPM or DSM2/DSMX satellite.
- **Rx Channel Map:** Activates the Rx Channel Map for standard receivers.
- **Lost Alarm:** Activates the buzzer if the board remains in SAFE mode for more than 30 minutes.
- **ESC Oneshot125:** Activates Oneshot125 for ESCs that support this mode. Servos remain unaffected.

Misc. Settings

- **Min Throttle:** Sets the idle threshold for the throttle in ARMED mode. Motors are deactivated below this point. Default (10%).

  WARNING: Setting the minimum throttle to 0% will cause the motors to become active when the board is ARMED.

  WARNING: Moving the throttle stick below the minimum throttle

threshold during flight, in any flight mode, will stop the motors resulting in a subsequent loss of control.

- **Alarm Volts:** Sets the battery voltage threshold below which the battery voltage low alarm is raised. The table gives an indication of the voltage setting for various LiPo batteries, these values are only a recommendation:

LiPo Cells	Alarm Volts
2S	6.8V – 7.2V
3S	10.5V – 10.8V
4S	14.0V – 14.4V

- **Batt V. Trim:** Allows the battery voltage threshold to be trimmed with an accuracy of ±0.1V. This is to account for manufacturing variations in the +3.3V regulated supply device.

- **Servo Center:** Selects whether the servos become active when the board is ARMED (ARM) or when power (PWR) is applied. ARM mode is a safety feature that prevents the servos from becoming immediately active when power is applied to the board.

- **Servo Filter:** Filters the servo outputs, including the 2-axis gimbal. Motors remain unaffected. The default is 70%.

Gyro Settings

- **Gyro DLP Filter:** Sets the frequency of the gyroscope's digital low pass filter. For optimum flight characteristics, this filter should be set to either 20Hz or 42Hz.

- **Gyro Range:** Sets the full scale range of the gyroscope. Options are ±250°/s, ±500°/s, ±1000°/s and ±2000°/s. A greater range is necessary for acrobatic flight (±1000°/s), but is at the expense of reduced sensitivity. The gyroscope should be recalibrated by unplugging either the battery or USB cable after changing its range.

Accel Settings

- **Accel DLP Filter:** Sets the frequency of the accelerometer's digital low pass filter. For optimum flight characteristics, this filter should be set to either 20Hz or 42Hz.

- **Acc. Range:** Accelerometer range sets the full scale range of the accelerometer measured in g-force (g). Options are ±2g, ±4g, ±8g and ±16g. A greater range is at the expense of reduced sensitivity. The accelerometer should be recalibrated after changing its range.

- **Comp. Filter:** Sets the contribution of the gyroscope input to the complementary filter. The filter combines both gyroscope and accelerometer,

to obtain a stable roll and pitch angle. The default 99.9%, (99.9% gyroscope, 0.01% accelerometer), is currently the optimum setting and should not be changed.

Compass Settings

- **Compass Type:** Sets whether to use the Falcon 2's internal (INT) compass, or an external (EXT) HMC5883L or HMC5983 magnetometer board / GPS connected to its external I2C port.

- **Declination:** Magnetic declination is the difference between magnetic north and true north in degrees with west being negative and east positive. Declination varies over time and depends on your geographical location. It is possible to find you local declination by using a website such as http://www.magnetic-declination.com/. This gives the declination in degrees and minutes. To convert the minutes to decimal degrees used by the Falcon 2, simply divide the minutes by 60. If declination in degrees is negative (west) subtract the minutes in terms of decimal degrees from it, if however it is positive (east) then add.

- **Comp. Filter:** Sets the contribution of the gyroscope input to the complementary filter. The filter combines both the gyroscope and the magnetometer (compass) to obtain a stable yaw angle. The default is 99.5%, (99.5% gyroscope, 0.5% magnetometer).

- **Ext Mount:** Selects the orientation of the external compass. The arrow "↑" indicates that the external compass is on the top side of the external board, while "↓" is on the bottom or back side. The 0, 90, 180 and 270 describes the orientation of the external magnetometer with reference to the direction of the Falcon 2 flight controller. 0 indicates that the magnetometer device is pointing forward, (its orientation dot on the top left).

Altitude Hold Settings

- **Mid Throttle:** Mid Throttle determines centre position of the throttle stick dead band during altitude hold. The dead band is ±10% of this mid point. With the throttle stick in the dead band the multi-rotor maintains its altitude. Above the dead band the multi-rotor ascends, below it descends. The default throttle mid point is 50%.

- **Comp. Filter:** Sets the contribution of the accelerometer input to the complementary filter. The filter combines both the accelerometer and barometer (that measures altitude), to obtain a stable altitude and rate of ascent/descent. The default is 99.7%, (99.7% accelerometer, 0.3% barometer).

- **Climb Rate:** The rate of ascent (in metres per second) when the throttle stick is above the mid point dead band.

- **Descent Rate:** The rate of descent (in metres per second) when the throttle stick is below the mid point dead band.

GPS Settings

- **GPS Power:** ON actives the attached GPS module. OFF places the GPS in standby, thus saving power. Loiter and RTL cannot be used with the GPS in standby mode.

- **Speed Filter:** Filters and smooths the GPS speed. The default is 50%.

RTL Settings

The RTL settings are divided into three pages:

RTL Settings 1

- **Altitude:** The altitude at which the aircraft returns to its launch site (in metres).

- **Climb Rate:** The rate of climb during the ascent to altitude (in metres per second).

- **Desc. Rate:** The rate of descent to specified altitude or land altitude (in metres per second).

- **Land Alt.:** The altitude at which the aircraft switches from its standard descent rate to this slower land rate in preparation for landing. The Falcon 2 will also generate a periodic warning tone on its buzzer as it continues to land.

RTL Settings 2

- **Land Rate:** The descent rate during the landing phase (in metres per second). This is usually slower than the standard descent rate.

- **Speed:** The return speed of the aircraft (in metres per second).

- **WP Dist.:** The Way Point Distance is the radius distance (in metres) from the launch point. Entering or passing this zone causes the aircraft to enter the landing phase.

- **Land:** Yes will cause the aircraft to enter the final flight phase and land. No will cause the aircraft to loiter at the land altitude, (see above). It is currently still necessary to deactivate the motors manually on landing, by cutting the throttle (moving the throttle stick to 0).

RTL Settings 3

- **Start Hold:** The time the aircraft loiters at its current altitude, before climbing or descending to its return altitude.

- **Alt. Hold:** The time the aircraft loiters at altitude, before rotating on to its return course.

- **Return Hold:** The time the aircraft loiters after entering way point distance zone, or passing the launch site.

- **Land Hold:** The time that the aircraft loiters at the land altitude before proceeding to land, (assuming that the “Land” settings has been set to YES).

Gimbal Settings

Settings for a 2-axis gimbal on motor outputs: M7 for roll and M8 for pitch.

- **Gimbal Ctrl:** Gimbal Control activates the 2-axis gimbal channels on M7 and M8, (not available on all motor layouts), otherwise M7 and M8 act as standard motor outputs.

- **SS Gimbal:** Select for super simple (SS) gimbal configuration. In the standard servo configuration the roll and pitch servos work independently. In SS configuration the two servos move in opposite directions for roll, but in unison for pitch.

- **Center Gimbal:** ARM activates the gimbal servos when the board is ARMED. PWR activates the gimbal servos when the board is powered.

Display Menu

Navigate: SAFE Mode – Main Menu – Display Menu

Display Raw Rx Data

Displays the receiver channels as raw data pulse widths in microseconds (µs).

Display Rx Data
Displays the receiver data. The throttle and the transmitter switches are displayed as a percentage (%). Roll and pitch are displayed degrees/s (°/s) in rate mode or degrees (°) in auto-level.

Display Gyro Data

Displays the 3-axis gyroscope data for roll, pitch and yaw in degrees/s. It also displays the Motion Processing Unit device's (MPU-9250) temperature.

Display Accel. Data

Displays the 3-axis accelerometer tilt angle for roll and pitch in degrees.

Display Filter Data

Displays the 3-axis complementary filter tilt angle for roll and pitch in degrees.

Display Compass Data

Displays the aircraft heading in degrees and a tilt compensated compass needle that points to magnetic north.

Display Barometer Data

Displays the air pressure (in millibar), device temperature, barometer altitude and filtered altitude (after fusion with the accelerometer). The altitude can be reset using the ZERO button.

Display GPS Data

Displays the GPS fix status, number of satellites, latitude, longitude and horizontal accuracy.

Display Loiter Data 1

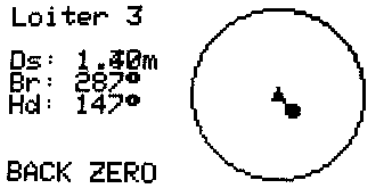
Displays the distance and bearing to its desired loiter GPS position. It also shows the aircraft's speed and heading, as well as the roll (R) and pitch (P) angles necessary to steer the multi-rotor back to the desired position. The loiter data can be reset (to the current aircraft GPS position) using the ZERO button.

Display Loiter Data 2

Displays the multi-rotor's distance and return bearing to its desired loiter GPS position, as well as the aircraft's heading. The course bearing and aircraft's heading are also displayed as two compass needles (solid: heading, wire: bearing). When the two needs match, the aircraft is pointing toward its desired position. The loiter data can be reset (to the current aircraft GPS position) using the ZERO button.

Display Loiter Data 3

Displays the same information as Display Loiter Data 2, but as an alternative graphical representation. It shows the aircraft as a central triangle surrounded by a 5m radius boundary circle. The small circle joined by a line to the triangle represents the desired loiter GPS position. The loiter data can be reset (to the current aircraft GPS position) using the ZERO button.



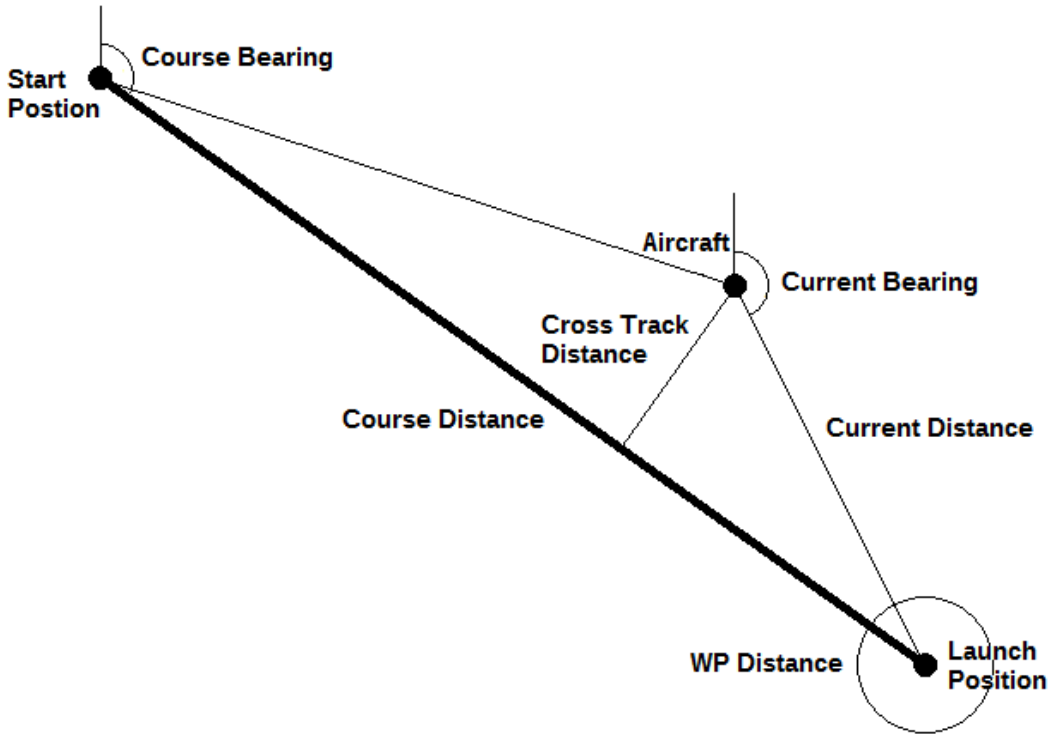
Display RTL Data 1

Displays the full RTL data:

- Course Distance: The distance from the RTL start position to the launch site.

- Course Bearing: The bearing (in degrees) from the RTL start position to the launch position.
- Current Distance: The distance from the aircraft's position to the launch site.
- Current Bearing: The bearing (in degrees) from the aircraft's position to the launch site.
- X Track (Cross Track Distance): This is the current distance of the aircraft perpendicular to (in other words at 90º to) its course. To put it simply it is a measure of how far the aircraft is off course.
- Heading: This is the aircraft's heading (in degrees).
- R: The roll angle required to maintain the aircraft's course (or 0 cross track error).
- P: The pitch angle required to maintain the aircraft's speed and position.

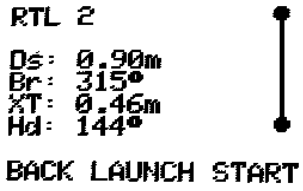
The LAUCH button sets the launch site, while the START button sets RTL start position.



Display RTL Data 2

Displays the RTL current distance and bearing, as well as the cross track distance (XT) and aircraft's heading.

The graphical representation shows the launch site (top) and start point (bottom) as small circles joined by a line. It shows the aircraft depicted as a small triangle as it moves between the launch and start points.



The LAUCH button sets the launch site, while the START button sets RTL start position.

Calibrate Menu

Important: Please ensure that the Falcon 2 is properly calibrated before attempting to get airborne.

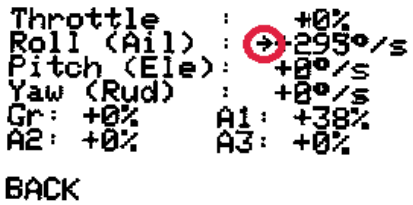
Calibrate Receiver

The receiver calibration procedure provides the Falcon 2 with the minimum and maximum stick and switch values. It also determines the stick centre positions:

1. Navigate: SAFE Mode – Main Menu – Calibration Menu – Receiver Calibration.
2. Select YES.
3. Move the transmitter sticks to their minimum and maximum positions.
4. Select CONTINUE when complete.
5. Do the same for the transmitter switches.
6. Select CONTINUE when complete.
7. Allow the transmitter sticks to centre (except throttle).
8. Select CONTINUE.
9. Calibration complete.

Now press the BACK button to return the main menu:

1. Navigate: Main Menu – Display Menu – Display Rx Data
2. **Important: Move the transmitter sticks to check that the arrows point in the correct direction, if the arrows point in the opposite direction, reverse that channel on your transmitter.**



3. If the sticks are not at 0°/s use the transmitter's sub-trim to centre the sticks.
4. Select the BACK button when complete.

If you are using a CPPM receiver and the channels are incorrectly mapped then:

1. Navigate: SAFE Mode – Main Menu – Radio Menu – Rx Channel Map.
2. On the Rx Channel Map page select the order of the incoming channel pulses.

3. Select the BACK button two times to return to the Main Menu.
4. Navigate: Main Menu – Display Menu – Display Rx Data.
5. Check the channels once more.

Calibrate Accelerometer

Accelerometer calibration determines the level position of the multi-rotor. Care must be taken to ensure that the multi-rotor is placed on level ground before calibration.

1. Navigate: SAFE Mode – Main Menu – Calibrate Menu – Calibrate Accel.
2. Place the multi-rotor on level ground and press YES to continue.
3. Wait for 1 second.
4. Calibration complete.

Calibrate Compass (Magnetometer)

The magnetometer calibration measures the Earth's magnetic field. Care must be taken to ensure that the multi-rotor is placed away from any sources of magnetism before calibration. Also, if you are using the internal magnetometer, do not mount the supplied buzzer close the to the flight controller board.

1. Navigate: SAFE Mode – Main Menu – Calibrate Menu – Calibrate Compass.
2. Rotate the aircraft until the buzzer stops clicking.
3. Press the CONTINE when done.
4. Calibration complete.

Separate calibration is required for both the internal and external compasses. Once have been calibrated it's possible to switch freely between them.

Gyroscope Calibration:

The gyroscope auto-calibrates 1 second after powering up the board. Your multi-rotor should not be moved during start-up, until the flight controller enters SAFE mode.

Calibrate ESCs

Displays instructions for ESC calibration. The ESC calibration procedure is as follows:

WARNING: ALWAYS REMOVE THE PROPELLERS DURING ESC CALIBRATION.

1. IMPORTANT: REMOVE THE PROPS
2. Switch on transmitter (and if necessary select the correct model)
3. Move the throttle to maximum
4. Plug in the battery while holding down the Falcon 2's two outer buttons
5. Listen for ESC beeps
6. Move the throttle to minimum
7. Listen for more ESC beeps
8. Release the buttons

9. Calibration complete

The Falcon 2 will now enter SAFE mode.

Motor Menu

Navigate: SAFE Mode – Main Menu – Motor Menu

Mixer Editor

The mixer editor determines the percentage (%) of the throttle, as well as the roll, pitch and yaw control loop outputs that are fed to each motor/servo channel. Positive values roll: to the right, pitch: up and yaw: counter clockwise.

- **Channel:** Steps through each motor/servo channel. Due to the microcontroller's internal architecture, the 8 motor channels outputs are grouped 1-4, 5-6 and 7-8. Changing the “Type” or “Rate” of the channel also alters the other channels in the group. For example, changing channel 2's “Rate” to 50Hz will also alter channels 1, 3 and 4.

- **Throttle:** The amount of throttle passed to the selected motor channel. Usually motors are set at 100%, servos 0%.

- **Airelon:** The amount of roll (+ right, - left) passed to the selected motor channel.

- **Elevator:** The amount of pitch (+ up, - down) passed to the selected motor channel.

- **Rudder:** The amount of yaw (+ counter clockwise, - clockwise) passed to the selected motor channel. If you are using a Tricopter configuration and the aircraft is yawing the wrong way, (despite the transmitter yaw channel being correct), reverse the Rudder setting on servo output channel M5 to -100%.

- **Offset:** The amount of offset applied to the servo channels only. Motors remain unaffected and are set at 0%. The default for servos is 50% (the centre point).

- **Type:** Determines whether the channel is an ESC (motor) or a servo.

- **Rate:** Determines the channel's output frequency. This can be 50Hz for analogue servos, 400Hz for ESCs and digital servos, and Os125 (Oneshot125) for ESCs only. Note that while it is possible to select 50Hz for ESCs, this should not be used for multi-rotor configurations.

Show Motor Layout

Displays the current motor layout configuration, for example Tricopter, Quadcopter X mode, etc... It also displays the direction of rotation of each motor and the type of propeller to be used, either clockwise or counter clockwise, however it does not determine the direction of rotation itself. If a given motor is spinning the wrong way,

turn the power off and reverse (any) two of the three motor wires.

Load Motor Layout

Load Motor Layout is a menu that allows you to select from a number of pre-set motor layout configurations. This changes the Mixer Editor settings for the selected configuration. The default configuration is Quadcopter X mode.

WARNING: Please ensure that the “Motor Layout” matches your airframe configuration, before attempting to ARM the board.

Factory Reset

Returns the Falcon 2 to its default factory settings. Requires the battery to be disconnected.

Version

Displays the current firmware version.

Appendix A

Falcon 2 Specification

Hardware:

Rev: 1.0
Board: FR4, double sided PCB, green solder mask, white silkscreen, gold finish
Board Dimensions: 50.5mm x 50.5mm x 1.6mm
Mounting Holes: diameter 3mm, 45mm spacing
Processor: RISC 32-bit, 48MHz, Atmel ARM Cortex M0+ SAMD21J18A, 64-pin TQFP package
Memory: 256k flash, 32k RAM, 32k on-board external EEPROM
Display: 1.3" monochrome OLED (super fast hardware SPI bus driven)
Gyro/Accel/Magnetometer: MPU9250
Barometer: MS5611 + cable tie and foam to protect it from wind and sunlight
Inputs: 8 receiver channels (T, A, E, R, G, 1, 2 & 3) + battery voltage monitor input
Outputs: 8, 11-bit resolution PWM channels at 400Hz (motors/digital servos) or 14-bit resolution at 50Hz (analogue servos) or OneShot125 (ESCs only) + buzzer output
Serial1: general purpose serial port
Serial2: general purpose serial port
Serial3: general purpose serial port (GPS)
Serial4: satellite receiver input (on the throttle input channel)
I2C: I2C expansion port
Firmware updates: via micro USB connector
Off-board GPS: uBlox, automatic configuration, supports UBX binary protocol, 10Hz at 9600bps, connects to general purpose serial port

Software:

Version: 1.0.0
Modes: Rate, Auto-Level, Heading Free, Altitude Hold, Loiter and Return To Launch
Receivers: Standard, CPPM, plus DSM2 and DSMX satellite receivers

Mixer modes: 12 channels with the following pre-set configurations - Tricopter, V-Tail, Quadcopter x, Quadcopter +, Hexacopter x, Hexacopter +, Octocopter x, Octocopter +, Singlecopter 1M4S, Singlecopter 2M2S, Dualcopter, Y4, Y6, X8 +, X8 x, H6, H8, V6 and V8
Sub Menus: Radio, PI Editor, Settings, Display, Calibrate, Motor Layout, Factory Reset, Version
Camera Gimbal: 2 axis gimbal option on outputs 7 and 8, standard and SS gimbals supported