FETTEC SFOC 50A 4in1 ESC preliminary manual

Introduction

FETtec SFOC (Simplified Field Oriented Control) is a new method for controlling brushless three-phase motors, designed to make them more efficient and responsive. By using this approach, motors can run up to 13% more efficiently and accelerate up to 30% faster. Additionally, it offers other benefits like better motor startup without sensors, less noise, and smoother overall performance.

1. FETTEC SFOC 50A 4in1 ESC

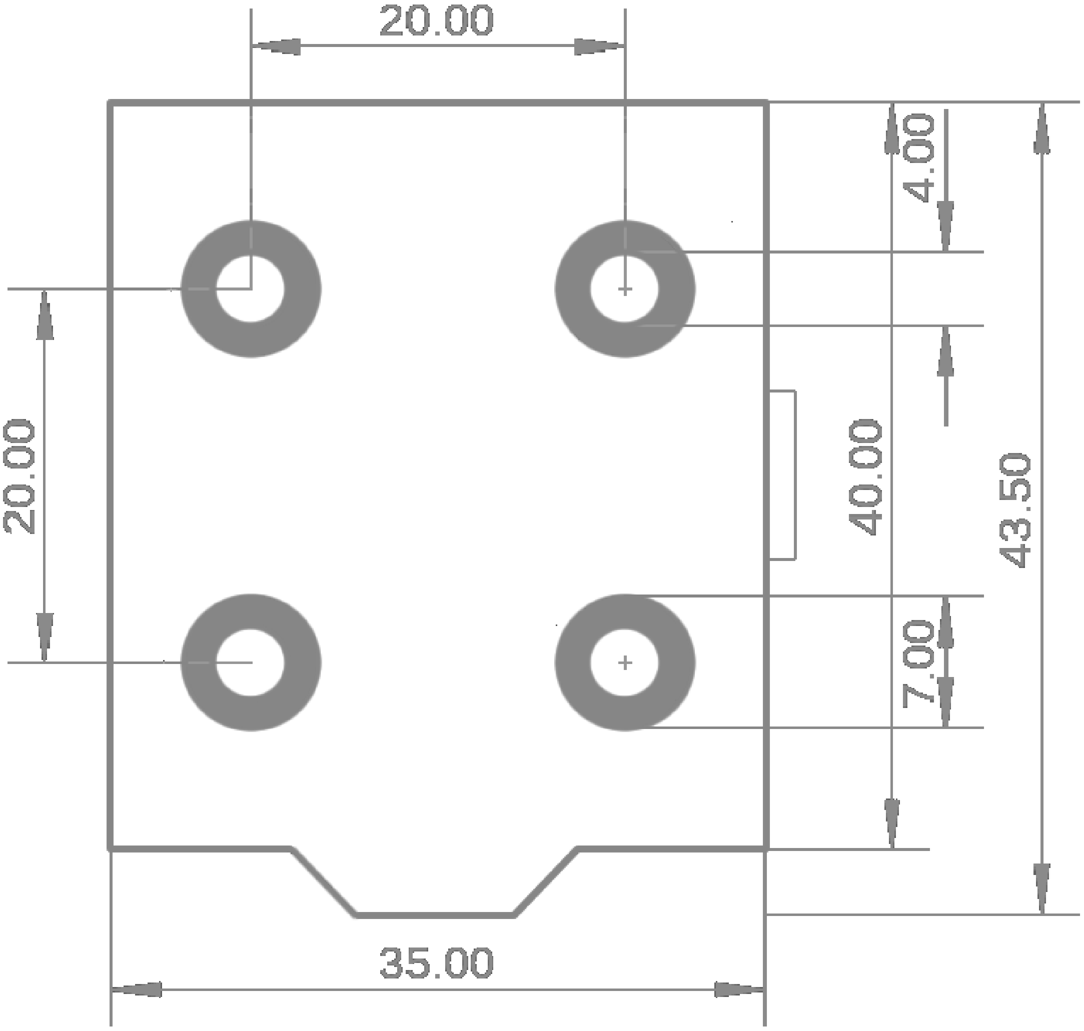
Technical Data:

- Controls 4 BLDC/PMSM motors using a single microcontroller
- STM32H56 ARM Cortex M33 @ 250 MHz
- 2-8S (6-34V) 40V MOSFETs
- Up to 50A per channel with good airflow (e.g., mounted in an open drone frame)
- USB-C
- 20x20 mounting
- Weight: 10g (board only)
- Dimensions: 35x43.5 mm
- FETtec SFOC motor control method
- Dshot 300-2400, OneWire, S2M
- Bidirectional Dshot with extended Dshot telemetry
- 64kHz and 128kHz motor PWM
- Up to 450k e-rpm per channel

FETTEC SFOC (Simplified Field-Oriented Control) is a new sensorless motor control method invented by FETTEC.

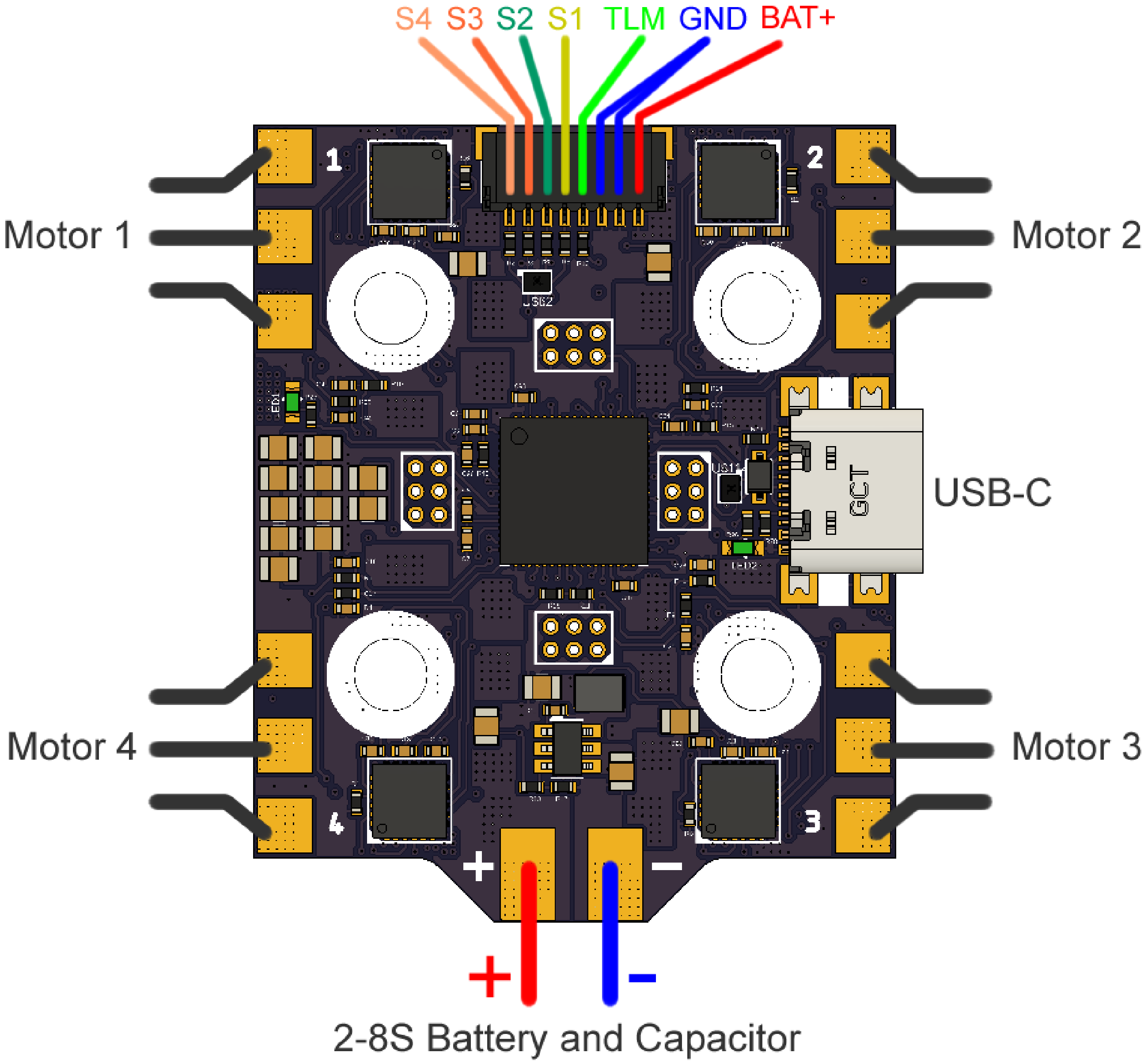
SFOC aims to combine the simplicity of block commutation ESCs with the advantages of FOC (Field-Oriented Control).
This is achieved through new hardware and software that require no complex motor data, yet provide full sinusoidal motor current output, high efficiency, and smooth torque even at very high RPM. This method does not require significant computational power, allowing multiple motors to be driven by a single MCU while still leaving enough capacity for additional tasks.

2. Board size and mounting



The board's mounting pattern is 20x20mm with 4mm drill holes. There are white-marked rings around each mounting hole indicating the maximum screw or nut size (7mm). Underneath these white-marked rings are conductive copper traces that must not be scratched. Please use plastic washers, plastic screws, plastic nuts, or rubber bumpers for mounting.

3. Board connection



- (+) / BAT+: Positive supply +6 - +34V (board will get damaged on +40V or more)
- (-) / GND: Negative supply (0V)
- TLM: FETTEC Onewire or D-shot serial Telemetry signal
- S1, S2, S3, S4: ESC Signal input (PWM, Dshot, BiDir Dshot, S2M)
- Motor (1-4): Motor-Phase Solder connection
- USB-C: USB connection for settings and firmware updates

4. Supported ESC protocols

The listed ESC motor control signals will be auto-detected:

1. PWM Signal: 1000-2000µs with 40-490Hz
2. Dshot: Dshot150, Dshot300, Dshot600, Dshot1200, and Dshot2400
3. Bidirectional Dshot600: RPM, temperature, voltage, and current feedback
4. FETTEC S2M: Serial protocol
5. FETTEC OneWire

5. Getting started

Installation and Setup Instructions

1. Install the ESC
- Refer to Section 2: Board Size and Mounting and Section 3: Board Connection.
- Ensure a capacitor (minimum 35V, preferably 50V, at least 220µF) is soldered close to the ESC's battery pads.

2. First Power-Up
- During the initial start, the ESC may perform its sensor calibration. To facilitate this, ensure the power supply or battery provides at least 10V and 10A.
- On each power-up, the ESC will measure some motor values, causing a slight squeaking noise from each motor.

Note: When using a smoke stopper, the voltage should be 4-5V to prevent the ESC from starting its calibration process. If there is no short circuit, remove the smoke stopper and proceed.

- For more details on sensor calibration, see Section 7: **ESC Sensor Calibration**.

3. Connect to the ESC Configurator
- Refer to Section 6: **ESC Settings and Firmware Update**.
- Ensure the ESC is updated to the latest firmware version.
- If you are using a Betaflight flight controller, see Section 10: **Betaflight Pass-Through**.

4. Adjust ESC Settings for Larger Motors
- If using motors with a stator size larger than (21-23mm) x (4-7mm), adjust the ESC settings accordingly for stator size and length.

5. Verify Propeller Rotation Directions
- Check the rotation directions of the propellers. These can be adjusted in the ESC configurator or the flight controller settings.

6. Ready for Flight
- You are now ready to go. Please exercise caution during the first flight.

6. ESC settings and Firmware update

The preliminary ESC configurator can be found at https://gui.fettec.net/ESC.

The recommended web browser is Google Chrome.

Establishing a Connection to the ESC

There are two ways to connect to the ESC:

1. **Using the ESC's Own USB-C Port**
   - Ensure no flight controller (FC) is connected.
   - Select “USB” as the connection type.

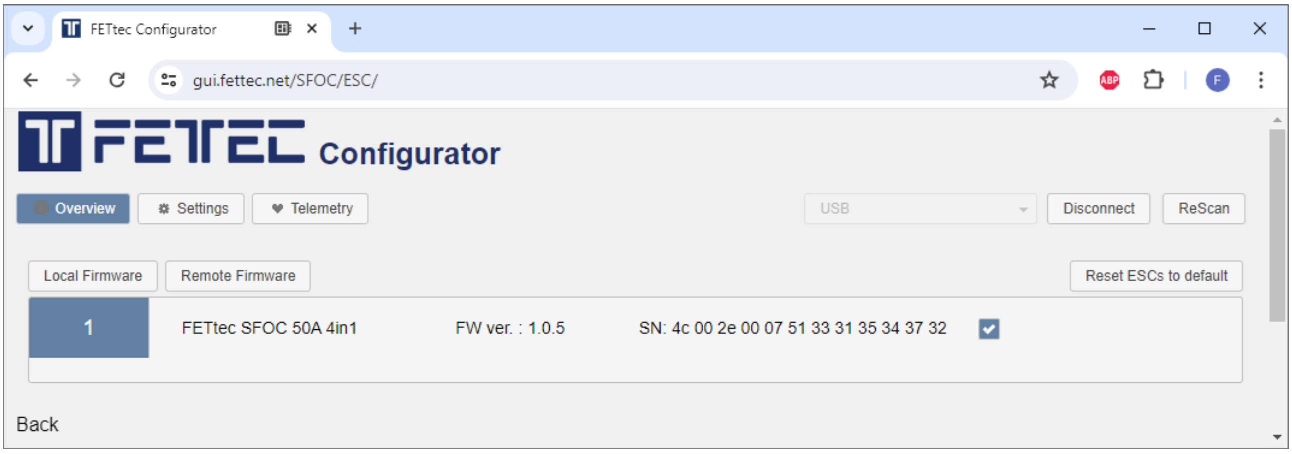
2. **Using Passthrough via a Flight Controller**

   - **For FETTEC ALPHA Firmware:**
     - Ensure the TLM signal is connected.
     - Select “USB”.

   - **For KISS FC Firmware:**
     - Ensure the TLM signal is connected.
     - Select “KISS FC Passthrough”.

   - **For Betaflight Firmware:**
     - Ensure the TLM signal is connected to a half-duplex UART pin on the FC.
     - Reconfigure the ESC telemetry correctly in the Betaflight GUI.
     - Select “Betaflight Passthrough”.

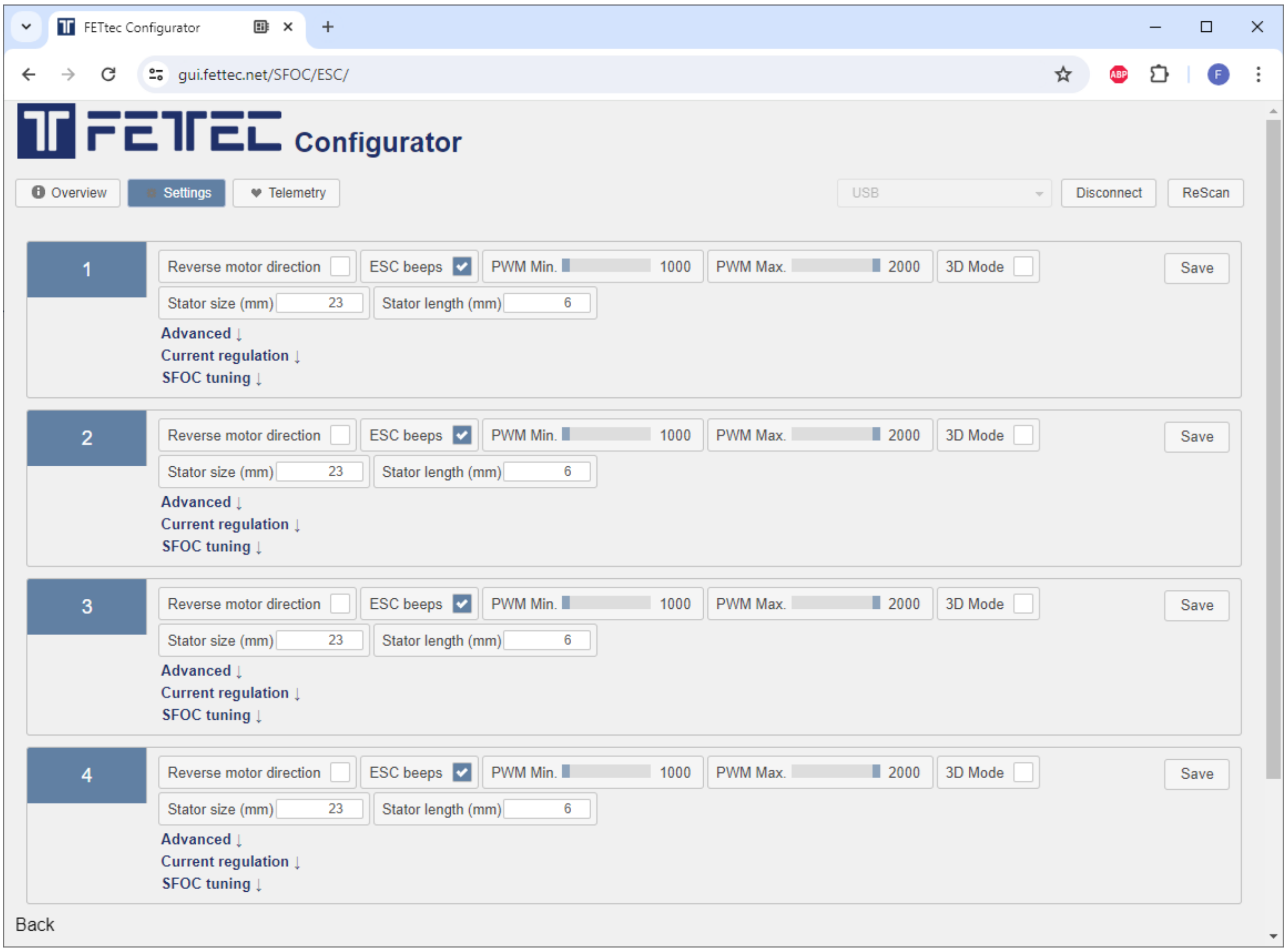
After the connection is established, the ESC should display its name and firmware version.



1 FETtec SFOC 50A 4in1 FW ver. : 1.0.5 SN: 4c 00 2e 00 07 51 33 31 35 34 37 32 ☑

The Overview tab is used for firmware updates.

In the Settings tab, the ESC's configuration can be changed for each motor.



1

Reverse motor direction □ ESC beeps ☑ PWM Min. 1000 PWM Max. 2000 3D Mode □ Save

Stator size (mm) 23 Stator length (mm) 6

Advanced ↓

Current regulation ↓

SFOC tuning ↓

2

Reverse motor direction □ ESC beeps ☑ PWM Min. 1000 PWM Max. 2000 3D Mode □ Save

Stator size (mm) 23 Stator length (mm) 6

Advanced ↓

Current regulation ↓

SFOC tuning ↓

3

Reverse motor direction □ ESC beeps ☑ PWM Min. 1000 PWM Max. 2000 3D Mode □ Save

Stator size (mm) 23 Stator length (mm) 6

Advanced ↓

Current regulation ↓

SFOC tuning ↓

4

Reverse motor direction □ ESC beeps ☑ PWM Min. 1000 PWM Max. 2000 3D Mode □ Save

Stator size (mm) 23 Stator length (mm) 6

Advanced ↓

Current regulation ↓

SFOC tuning ↓

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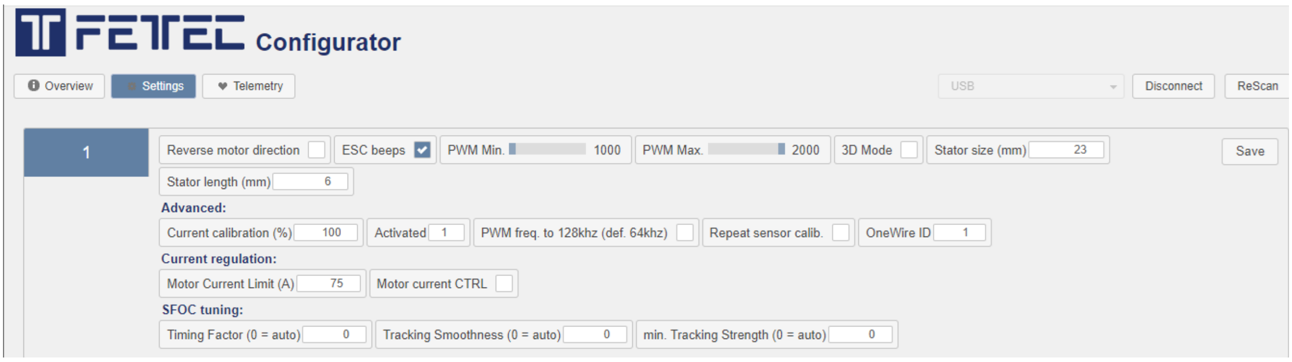
Detailed SFOC ESC Settings



Reverse motor direction □ ESC beeps ☑ PWM Min. 1000 PWM Max. 2000 3D Mode □ Stator size (mm) 23

Stator length (mm) 6

Advanced:

Current calibration (%) 100 Activated 1 PWM freq. to 128khz (def. 64khz) □ Repeat sensor calib. □ OneWire ID 1

Current regulation:

Motor Current Limit (A) 75 Motor current CTRL □

SFOC tuning:

Timing Factor (0 = auto) 0 Tracking Smoothness (0 = auto) 0 min. Tracking Strength (0 = auto) 0

- **Reverse Motor Direction:** Reverses the motor rotation direction (default: off).

- **ESC Beeps:** Enables or disables the ESC's status beep tones (default: on).

- **PWM Min.:** Minimum PWM input signal width in µs (default: 1000).

- **PWM Max.:** Maximum PWM input signal width in µs (default: 2000).

- **3D Mode:** Enables "3D mode". The ESC initializes at half throttle. Moving the throttle from middle to minimum command makes it spin in reverse (lower throttle, faster reverse), and from middle to maximum command makes it spin normally. This mode does not affect S2M and OneWire signals, which always control both directions. Dshot inputs have special handling in 3D mode (default: off).

- **Stator Size:** Diameter of the connected motor's stator in mm (default: 23).

- **Stator Length:** Length of the connected motor's stator in mm (default: 6).

- **Current Calibration (%):** Adjusts telemetry-reported current to match actual current. For example, set to 110% if reported current is 10% lower than actual (default: 100).

- **Activated:** Indicates if the ESC's serial number is activated by our license server.

- **PWM Frequency to 128kHz:** Changes motor PWM frequency to 128kHz, recommended for small motors (180x-210x) with high RPM (e.g., 3000KV on 6S whoops) (default: off, 64kHz).

- **Repeat Sensor Calibration:** Allows repeated calibration of current sensors on next power-up if initial calibration was unsuccessful. Deactivates automatically after calibration (see "Sensor calibration" for details).

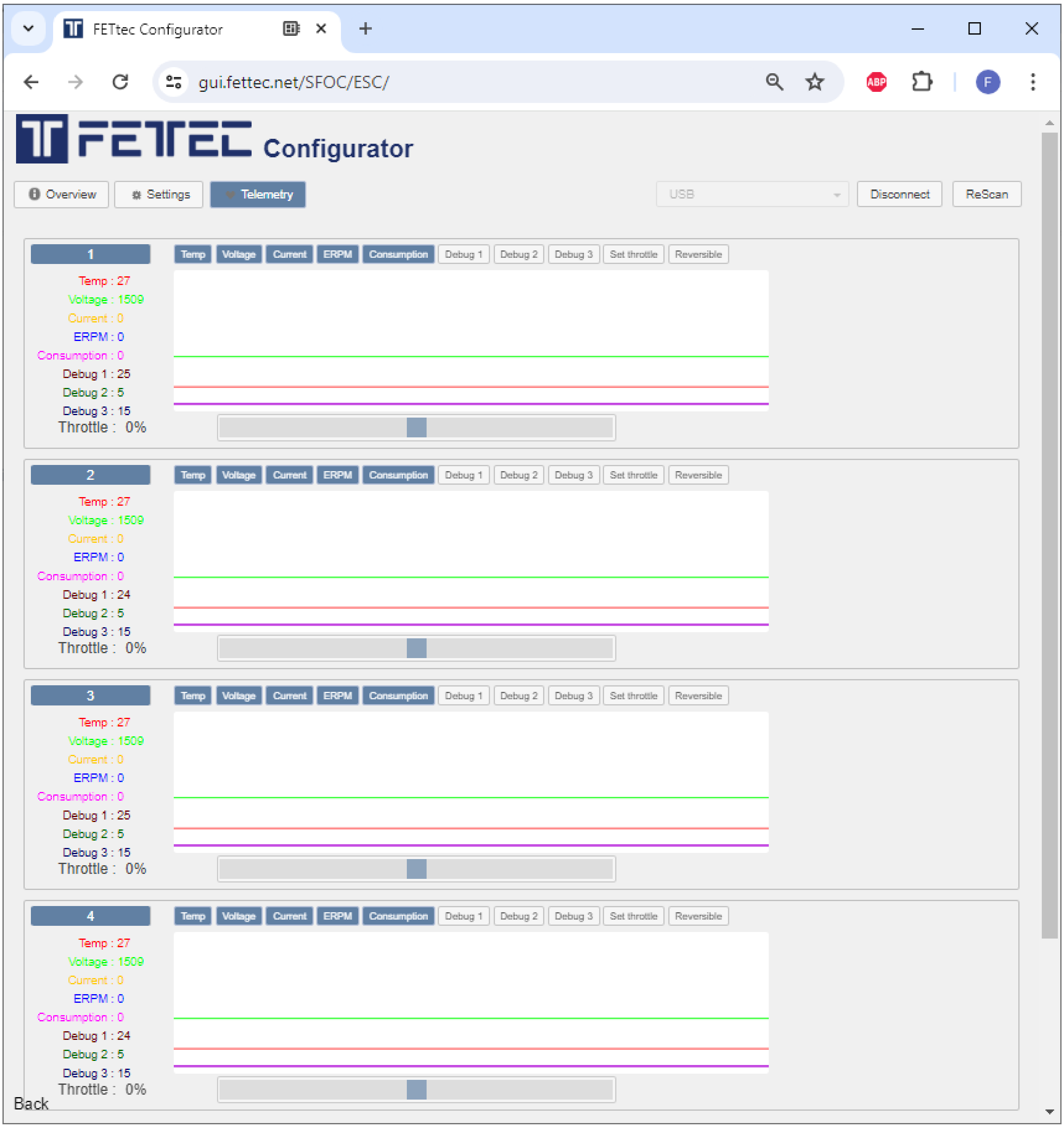
- **OneWire ID:** Represents the ESC unit's FETtec OneWire ID (range: 1 – 20). Care must be taken to avoid conflicts if multiple ESCs share the same ID on the OneWire bus (default: auto-managed by configurator).

- **Motor Current Limit (A):** Limits maximum motor current (default: 75A).

- **Motor Current CTRL**: Enables motor current control, scaling to throttle input with a maximum set by Motor Current Limit. Not recommended for agile multirotor drones as it does not actively brake propellers on throttle reduction (default: off).

- **SFOC Tuning:** Recommended to leave values at zero for auto-detect. Can be tuned if setup issues occur (see Section 8: SFOC Tuning for details) (default: all values 0, auto-detect).

In the Telemetry tab, connected motors can be tested, and telemetry can be viewed.



1

Temp : 27
Voltage : 1509
Current : 0
ERPM : 0
Consumption : 0
Debug 1 : 25
Debug 2 : 5
Debug 3 : 15
Throttle : 0%

2

Temp : 27
Voltage : 1509
Current : 0
ERPM : 0
Consumption : 0
Debug 1 : 24
Debug 2 : 5
Debug 3 : 15
Throttle : 0%

3

Temp : 27
Voltage : 1509
Current : 0
ERPM : 0
Consumption : 0
Debug 1 : 25
Debug 2 : 5
Debug 3 : 15
Throttle : 0%

4

Temp : 27
Voltage : 1509
Current : 0
ERPM : 0
Consumption : 0
Debug 1 : 24
Debug 2 : 5
Debug 3 : 15
Throttle : 0%

To enable the throttle bar, select **"Set Throttle."**

To allow negative throttle settings, select **"Reversible."**

Telemetry values are displayed in a fixed-point format. For example, a voltage of 1500 represents 15V, and a current of 1200 represents 12A. Consumption is measured in mAh.

7. ESC sensor calibration

The ESC's current sensor calibration is performed once after production. If a new firmware update requires recalibration, the ESC configurator will notify you.

Note: Sensor calibration is independent of the motor and uses the motor only to calibrate its onboard current sensors. Motor values necessary for calibration are measured on every power-up.

The calibration process can be initiated by activating the "Repeat sensor calibration" setting. If this setting is activated and the configuration is saved in the ESC configurator, the ESC will perform calibration after the next power cycle.

The process proceeds as follows:

1. **Requirements to Start Calibration:**
- Minimum 10V and 10A power supply
- A motor must be connected

2. The ESC will send specific current signals to each motor, which may cause slight movement but will not spin them. This may produce a strange or squeaky sound, which is normal.

3. After all ESC units complete calibration (no further movements or sounds for about 20 seconds), the ESC should be power cycled again.

4. Calibration is complete, and the ESC is ready for use.

8. SFOC tuning

For most setups, this tuning should not be necessary. However, if you experience issues with motor performance, you can make improvements here.

Warning: Incorrect values in the SFOC tuning settings can cause sync losses and motor overheating. In the worst-case scenario, it can burn your motor.

Please follow this guide carefully to avoid damage to the ESC or your motor. There are three values that can be adjusted:

1. Timing Factor
- The timing factor is the most important setting. It represents the motor's individual timing base value.
- If it is too high, the motor cannot increase its RPM quickly enough during throttle punches and will overheat.
- If it is too low, the ESC can lose tracking of the motor rotor during throttle punches, causing desynchronization.

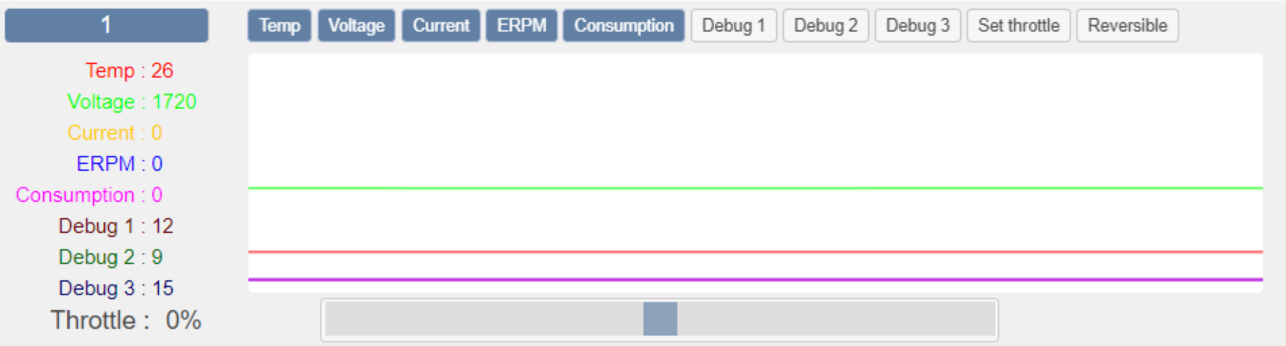
2. Tracking Smoothness
- Tracking smoothness prevents rough motor operation under load.
- If it is too high, the RPM can start to oscillate, potentially causing desynchronization.
- If it is too low, the motor will run rough and inefficient under load.

3. Minimum Tracking Strength

- This setting limits the minimum tracking strength for operation with no or very light load.
- If it is too high, the motor will run rough with no load or very light load.
- If it is too low, the motor might not increase its RPM during throttle changes with no or very light load.

These values are automatically detected at each ESC startup. Each motor type requires different values, so it is important to start with the auto-detected values to understand the motor's requirements.

The auto-detected values can be seen in the telemetry tab, but only after startup and before a motor has run. This is visible only if the SFOC tuning setting value is 0. If any other value is saved, the manually set values will be displayed.



Temp : 26
Voltage : 1720
Current : 0
ERPM : 0
Consumption : 0
Debug 1 : 12
Debug 2 : 9
Debug 3 : 15
Throttle : 0%

In the telemetry tab, you can see Debug 1-3:

- **Debug 1**: Shows the Timing Factor (e.g., 12 in this case)

- **Debug 2**: Shows the Tracking Smoothness (e.g., 9 in this case)

- **Debug 3**: Shows the Minimum Tracking Strength (e.g., 15 in this case)

The auto-detected values can vary slightly even if the same motors are connected to multiple ESCs. This variation is mostly due to factory drifts in the ESC components and the motors.

If you want to tune these settings, please follow these steps:

1. Ensure all SFOC tuning values in the ESC settings are zero and the motor has not run since power-up.
2. Go to the telemetry tab and copy the values shown in Debug 1-3.
3. Change the values as needed. It is recommended to change them in small steps (±1 or ±2) to avoid problems or damage.
4. Enter your new values in the SFOC tuning settings, save, and restart.
5. Test your new tuning, and if needed, repeat the process.

9. Beep codes

If the "ESC Beeps" setting is active, the ESC will beep to indicate its status.

- On start-up, it will beep two short tones: "low-high" → indicating it has started.
- When it receives a valid input signal, it will make one longer beep. The frequency of this beep will increase with its OneWire ID (e.g., ID 1 is lower than ID 2, and so on). There is also a delay that increases with the ID to prevent them from beeping simultaneously.

Error Beep Codes

In case of an error, the ESC will repeat the error beep codes every 2 seconds as long as the motor is not running.

- **1 Beep**: ESC signal fail-safe. The input signal was lost while the motor was running, causing the motor to stop and the ESC to disarm.

- **2 Beeps:** Motor tracking fail-safe. The ESC could not start the motor or the motor was blocked while running, causing the ESC to disarm.

- **3 Beeps:** The ESC temperature exceeded 100°C, reducing the maximum output power to prevent damage.

- **5 Beeps:** The ESC was running with FETtec OneWire and S2M in parallel, and one of these signals experienced a fail-safe.

10. Beta flight pass through

The FETTEC ESCs use a half-duplex serial connection at 2000,000 baud on the "TLM" pin to connect to the ESC configurator.

Most Betaflight flight controllers (FCs) have a "Dshot TLM" pin in the ESC connector, which is typically connected to the RX pin of one of the FC's UARTs.

To use the pass-through, a TX pin of a hardware UART must be connected to the ESC's "TLM" pin and configured to work in half-duplex mode.

Note: On FCs using STM32F4 microcontrollers, the pass-through might not work as they don't offer half-duplex functionality by hardware.

Note 2: [To be removed on release] The SFOC ESC samples/prototypes will need a 1K pull-up resistor on the TLM line to 3.3V or a 2.2K resistor to 5V to work properly. The series ESCs will have this resistor onboard.

To achieve this connection, you can use a separate TX pin of any hardware UART on the FC or use the ESC TLM RX pin in the ESC connector (if the FC is not using an STM32F4).

Steps to Set Up the Connection

1. Find the Used UART in the Manual:
- Locate the UART used for ESC TLM in your Betaflight FC manual.

2. Remap the RX Pin to be a TX Pin:
- Open the Betaflight CLI.
- Enter `dump` to view the full configuration of your FC. At the top, find the UART RX and TX pin mapping.
- Find the UART pin used as the RX pin in the ESC connector and the TX pin of the same UART.
- Enter `resource SERIAL_RX <UART number> NONE`.
- Enter `resource SERIAL_TX <UART number> <RX pin number>`.

3. Enable Half-Duplex Mode:
- Enter `set esc_sensor_halfduplex = ON`.
- Enter `save`.

4. Reconfigure the UART and Enable ESC Telemetry:
- In Betaflight, go to the "Ports" menu and reconfigure the UART as ESC sensor.
- In the "Motors" menu, ensure the ESC telemetry pin is enabled.

Connecting to the ESC Configurator

After setting up the connection:

1. Open the FETTEC ESC configurator.

2. Select "Betaflight Passthrough" to connect to the ESCs.