Seriously Pro

SP Racing H7RF Flight Controller

Seriously Pro Racing H7RF Flight Controller Manual (Draft)

About

The Seriously Pro Racing H7RF Flight Controller (SPRacingH7RF) was designed for the lowest possible stick-to-motors latency that is possible, in addition to having the fastest CPU and latest low-noise and high presicion sensors for a flight experience like no other.

As always, SPRacing is the first with new technology like the amazingly capable H730 CPU and ICM42688P sensors.

Not only that, but the flight controller (FC) also features our very own full-graphic pixel-based OSD system (SPRacingPixelOSD) which gives you ultra-smooth 60FPS heads-up-display. Other flight controllers using character based OSD systems or pixel OSDs connected via serial cannot match the fully integrated OSD system that only the SPRacingPixelOSD system delivers.

As the H7RF has an integrated RC receiver there's no need to puchase an additional receiver, this gives the following benefits:

- Lowest latency possible - external RX's have their own CPU which adds latency.
- Smaller overall size - no need to find somewhere to mount an external RX.
- Lower weight
- Fewer wires to connect or maintain
- Simpler hardware and software setup.
- Higher durability - less to go wrong

The SPRacingH7RF gives you all the features you need for the heart of your aircraft, whether you're into FPV racing, freestyle acrobatic flying or stable and smooth aerial photography it's perfect!

Software

The SPRacingH7RF runs the open-source Betaflight flight control (FC) software which is based on Cleanflight. It has an ever-growing community of friendly developers and users. Being open-source means that you too can contribute to the system.

The SPRacingH7RF uses a port of the open-source ExpressLRS integrated into Betaflight for the RC link. Also technically, the system is capable of running 3rd party or closed-source RX systems using encrypted firmware on the external flash such as Ghost, Spectrum or Tracer if manufactuers wish. RC manufactuers should contact us for details.

The ExpressLRS radio RC link software has been proven to give the best range and lowest latency and best of all it's open-source so you can contribute or modify it to suit your needs!

As software is under constant development, especially Betaflight and ExpressLRS, this manual mostly covers hardware.

For latest and detailed software setup refer to the Betaflight documentation and wiki, see the Getting Started section of the manual.

History

The hardware was designed by the lead developer of Cleanflight to be the first STM32H730 board on the market that features RF and PixelOSD systems and to set the benchmark for a premium STM32H730 RF based board.

The SPRacingH7RF is the first H730-based flight controller that runs Betaflight. The Betaflight STM32H730 support and the SPRacingPixelOSD systems were designed and implemented by Dominic Clifton.

Features

- Next-generation STM32 H7 processor with hardware floating point unit for efficient flight calculations and faster ARM-Cortex M7 core running at 520Mhz.
- 2MB External Flash for firmware.
- RX receiver built in, using an SX1280 2.4Ghz RF IC connected via SPI with hardware interupts on dedicated timer channels. No need to purchase an additional receiver which keeps your over-all cost down.
- Latest 32khz capable Accelerometer, Gyro sensor devices connected via the fast SPI bus, hardware interrupts also on dedicated timer channels.

- New high-accuracy Baro/Altitude sensor with less drift than previous sensors.
- Full-graphic pixel-based On Screen Display (OSD) system gives you all the information you need when flying and a menu system to allow you to configure the FC.
- MicroSD-Card socket for black box flight log recorder - optimize your tuning and see the results of your setup without guesswork.
- 8 Motor outputs. DSHOT/OneShot/PWM for ESCs and Servos.
- Also supports direct connection external of SBus, SumH, SumD, Spektrum1024/2048, CRSF, FPort, SRXL/XBus receivers. No external inverters required (built-in). Legacy PPM and PWM 1 wire per channel receivers are not supported.
- 5 Serial Ports - NOT shared with the USB socket.
- Micro USB socket.
- Dedicated output for programmable LEDs - great for orientation, racing and night flying.
- Dedicated I2C port for connection of OLED display or MAG. Configurable without needing flight battery.
- Battery monitoring for voltage and current. Note BF currently only supports one current meter, though the hardware supports connecting two, one from each 4in1ESC.
- Buzzer port for audible warnings and notifications.
- Developer friendly debugging port (SWD) and boot mode selection, unbrickable bootloader.
- Side-press settings/bind button for easy receiver binding, VTX control and SPRacing bootloader control.
- Symmetrical design for a super tidy wiring.
- JST-SH sockets and through hole header-pin pads for IO.
- Firmware upgradable via USB.
- Stackable design - optional VTX board available.
- Standard 30.5mm AND 20mm mounting hole patterns with 4mm holes and grommets for 3mm screws.
- Break-off PCB sections to change the PCB size from 37x37mm to 27x27mm
- LEDs for 3v, 5v and Status for easy diagnostics.
- SP Racing logos.

ANTENNA WARNINGS

Failure to adhere to these warnings will void your warranty and destroy your flight controller.

- ALWAYS have an antenna connected to the flight controller or you will DESTROY it.
- Check antenna condition after each use.
- Do not use damaged antennas.
- Replace damaged antennas immediately.

WARNINGS

Failure to adhere to these warnings will void your warranty and destroy your flight controller.

- Do NOT rely on cable color-coding due to manufacturer variations.
- Observe polarity at ALL TIMES. Check and DOUBLE CHECK before applying power.
- POWER OFF before unplugging, plugging in or making any connections.
- Do not connect SOURCES of power to the pins marked with 5v. They are OUTPUTS for supplying power to other devices.
- Do not connect GND, 5v, VBAT or 3.3v to each other (short circuit).
- Do not connect GND, 5v, VBAT or 3.3v to any inputs or outputs unless specifically stated.
- Do not connect any input or output to any other input or output unless specifically stated.
- Do not connect all three pads of the 3 pin solder bridges, connect the center pad to one other pad ONLY.
- Do not allow dirt/dust/glue/liquid/etc into the pressure sensor (barometer).
- Keep magnets away from the flight controller.
- Keep all conductive liquids away from the flight controller.
- Do not attempt to clean using an ultra-sonic cleaner - all the sensors will be damaged.
- Do not use excessive force when inserting or removing MicroSD cards.
- Always align USB plug and socket when inserting/removing USB cables to prevent damage to the USB socket.
- Never power up any VTX without an antenna connected otherwise you will DESTROY the VTX.

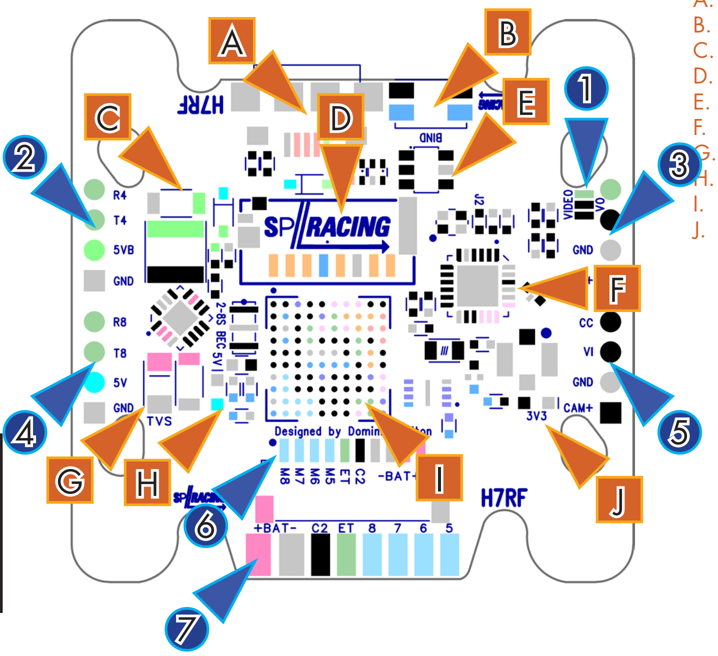
GENERAL ADVICE

Follow the advice below for best performance and long-life of your flight controller:

- Apply resin/glue to reinforce JST-SH connectors - helps if you crash your aircraft.
- To further protect the board from crashes you can add a some additional solder to the edges of the JST-SH and USB sockets to reinforce them.
- Support connector sockets when inserting cables.
- Install open-cell foam over the pressure sensor for more accurate readings.
- If the noise from motors is too loud you can also install open-cell foam over the microphone.
- Do not cover the hole in baro and microphone sensors (e.g. with glue, resin, etc) or allow foreign object to enter it.
- Using color-coded wires and connectors is recommended, especially for BATTERY connections.
- For optimum performance do everything you can to prevent vibrations reaching the accelerometer/gyro sensor. e.g. balance motors, props use rubber isolation grommets and secure everything. Do not allow any wires to vibrate against the FC.
- If any incorrect flight behaviour is observed check props, motor bearings and other sources of vibrations BEFORE adjusting any software filters or other settings.

TOP

1. Video Out pin-select jumper.
2. UART4 pads.
3. VTX pads.
4. UART8 pads.
5. Camera pads.
6. ESC2 JST-SH 10 pin connector.
7. ESC2 snap-off pads.



A. MicroUSB socket.
B. Bind button.
C. 2-8S BEC.
D. MicroSD card socket.
E. VTX pit switch.
F. RF tranceiver.
G. TVS diode.
H. 5V OK LED.
I. STM32H730 BGA CPU.
J. 3V OK LED.

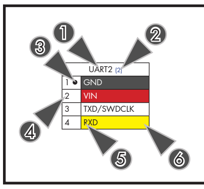


Table Legend

1. Port name
2. Port number
3. PCB marker / Pad shape
4. Pin number
5. Signal Name
6. Signal/Wire Color

Video Out pin-select (1)	
1◀	Pin 4 (closest to USB socket)
2 ■	Video Out
3▶	Pin 3 (closest to antenna socket)

Video Out pin-select jumper.

This jumper allows pin 3 and 4 of the VTX pads to be configured. Has no effect on VTX socket on the bottom of the board. See also the VTX control/telemetry pin select jumper on the bottom and set the jumper to the OPPOSITE of this jumper.
Do NOT configure the same pin for both Video Out and VTX Control/Telemetry.
The purpose of this is to allow stacking of VTXs with different pinouts directely to the FC since there is no standard for signal order of VTX systems.
Note: ideally all manufactuers should use the POWER/GND/VIDEO/TLM order for best signal integrity.

Create a solder bridge between TWO PADS ONLY to select Video Out pin.
a) bridge ◀ and ■ to set the Pin 4 to Video Out.
b) bridge ■ and ▶ to set the Pin 3 to Video Out.

UART4 (2)	
1 ■	GND
2 ●	5V BEC
3 ●	TXD (T4)
4 ●	RXD (R4)

UART4

Primarily used external OSD system (e.g. DJI/SharkByte) that are only powered when a battery is connected.

UART8 (4)	
1 ■	GND
2 ●	5V
3 ●	TXD (T8)
4 ●	RXD (R8)

UART8

Primarily used for external RC receiver systems or always-on external logging devices.

VTX pads (3)	
1 ■	VTX Power (+)
2 ●	GND (-)
3 ●	Configured by Video Out pin select
4 ●	Configured by Video Out pin select

VTX

Connect an NTSC or PAL Video transmitter camera. Ensure your Camera, VTX and Video Receiver and Display can use the same video format as the camera. i.e. All NTSC or all PAL devices.
VTX voltage is configured by the VTX bridge on the bottom of the board. Set the voltage to either BATTERY or 5V.
NOTE: The VTX pit switch is OFF by default when the FC powers on so there will be no power to the VTX until the FC turns the VTX on.
Use the Video Out pin select jumper and VTX Control/Telemetry select jumper on the bottom of the board to configure Pin 3 and Pin 4.

Camera (5)	
1 ■	CAM Power (+)
2 ●	GND (-)
3 ●	Video In (Camera Video Out)
4 ●	Camera Control

Camera

Connect an NTSC or PAL FPV camera. Ensure your Camera, VTX and Video Receiver and Display can use the same video format as the camera. i.e. All NTSC or all PAL devices.

Camera voltage is configured by the CAM bridge on the bottom of the board. Set the voltage to either BATTERY or 5V.

Use the Camera Control and GND connections to control your camera's OSD with the transmitter sticks.
See Betaflight wiki for details of connections and supported cameras. The FC uses a 1uF capacitor to ground and 470ohm resistor in series with the data signal on PD7/D07.

Recommend using cameras that have positive-only video signals (0V sync) and have video voltages that do not drift with temperature otherwise in-flight display resyncs may occur.

ESC2 connector (6)	
1 ●	Motor Signal 8
2	Motor Signal 7
3	Motor Signal 6
4	Motor Signal 5
5	ESC TLM (R5)
6	Current Sensor Input 2.
7	GND (-)
8	GND (-)
9	Battery (+)
10	Battery (+)

ESC2 - Motor 5-8

Connect to a 4in1 ESC or connect GND and one motor signal to each ESC.

The FC is powered using any of the Battery (+) and adjacent GND pins/pads.

Note: Each JST-SH connection and wire is only rated to 1Amp.

A 10pin socket is used to allow the ESC to deliver more current. Use both Battery (+) and GND pins/pads to provide the FC with enough current to power itself and the VTX, Camera, LED strip, etc. Especially when using many LEDs and/or a high-wattage VTX.

If your 4in1 ESC supports ESC telemetry then use the ESC TLM input (UART5 RX).
If your 4in1 ESC has an analog current sensor output then connect it to the Current Sensor Input.

ESC2 snap-off pads (7)	
M8	Motor Signal 8
M7	Motor Signal 7
M6	Motor Signal 6
M5	Motor Signal 5
ET	ESC TLM (R5)
C2	Current Sensor Input 2.
-	GND (-)
+	Battery (+)

ESC2 - Motor 5-8

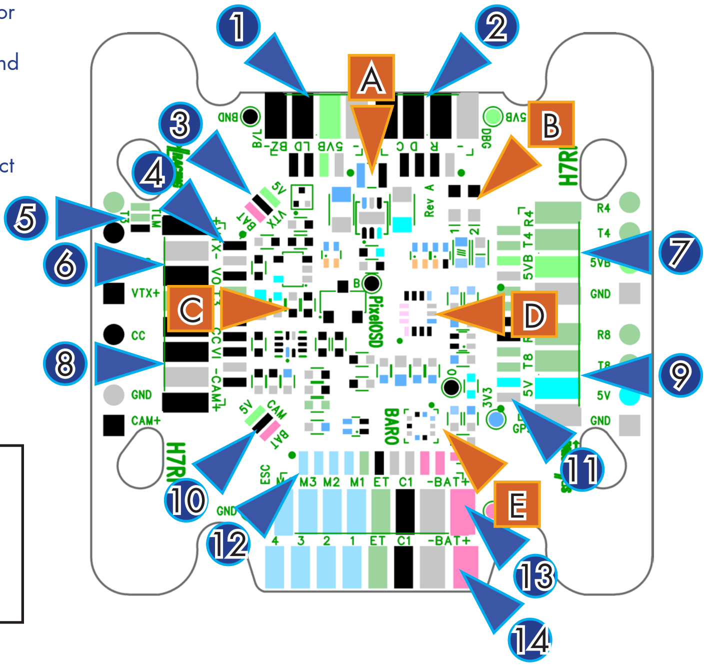
Connect to a 4in1 ESC or connect GND and one motor signal to each ESC.

The FC is powered using any of the Battery (+) and adjacent GND pins/pads.

If your 4in1 ESC supports ESC telemetry then use the ESC TLM input (UART5 RX).
If your 4in1 ESC has an analog current sensor output then connect it to the Current Sensor Input.

BOTTOM

1. LED Strip and Buzzer connector and hidden pads.
2. SWD debugging connector and hidden pads.
3. VTX voltage-select pads.
4. VTX/Camera connector.
5. VTX control/telemetry pin-select jumper.
6. VTX hidden pads.
7. UART4 hidden pads.
8. Camera hidden pads.
9. UART8 hidden pads.
10. CAMERA voltage-select pads.
11. GPS/IO connector.
12. ESC1 connector.
13. ESC1 hidden pads.
14. ESC1 snap-off pads.



A. 3.3V Switching Regulator.
B. Status 1/2 LEDs.
C. Full-graphic pixel OSD.
D. ICM42688P Gyro and Accelerometer.
E. BMP388 barometer.

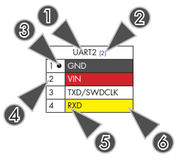


Table Legend

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3. PCB marker / Pad shape
4. Pin number
5. Signal Name
6. Signal/Wire Color

LED Strip and Buzzer (1)		
1●	-	GND
2	5VB	BUZZER+ (B+) / 5v
3	LD	LED Strip Data Out (DO)
4	BZ	BUZZER- (B-)

LED Strip and Buzzer connector and hidden pads

Use 5V and BUZZER- to connect to an external buzzer.
5.0v is also supplied when powering via USB.

Use GND, 5VB and LD for connecting an LED strip. Note that some LED strips require a MAXIMUM voltage LESS than 5V. In this case connect a DIODE between the LED strip + and the 5V BEC pad to drop the voltage. This works because diodes generally have a forward voltage drop of 0.7V. Reducing the voltage will reduce the LED brightness. Use a diode that can handle the power required for all your LEDs to be on and WHITE. On an RGB LED strip white requires 3 LEDs and uses the most power.

The hidden pads under the connector have the same signals as the pins on the connector.

SWD/DEBUG socket (2)		
1●	-	GND
2	R	NRST
3	D	SWDIO
4	C	SWDCLK

SWD/DEBUG connector - Used for software development

Use a compatible SWD debugger. Black Magic Probe, ST-Link, OpenOCD, Segger J-Link, etc.

IMPORTANT: Do not attempt to reflash the firmware on the H7 CPU via SWD. Firmware is stored on external flash.

VTX voltage-select pads (3)		
1◀	BAT	Battery + (Near VTX pads)
2■	VTX	VTX Voltage
3▶	5V	5V BEC (Near LED/Buzzer pads)

VTX Voltage select bridge pads

Create a solder bridge between TWO PADS ONLY to select VTX voltage.
a) bridge ◀ and ■ to set the VTX voltage to BATTERY voltage.
b) bridge ■ and ▶ to set the VTX voltage to 5V.

Camera voltage-select pads (10)		
1◀	BAT	Battery + (Near ESC1 pads)
2■	CAM	Camera Voltage
3▶	5V	5V BEC (Near CAM pads)

Camera Voltage select bridge pads

Create a solder bridge between TWO PADS ONLY to select the Camera voltage.
a) bridge ◀ and ■ to set the camera voltage to BATTERY voltage.
b) bridge ■ and ▶ to set the camera voltage to 5V.

NOTE:

Use solder with flux and/or non-corrosive no-clean flux when bridging voltage-select pads. Check for shorts/continuity between BAT and 5V after soldering. i.e. set Camera voltage, check for shorts, set VTX voltage, check for shorts. If short detected remove excess solder until short is removed. See soldering tips section in this manual!

VERY IMPORTANT: DO NOT CONNECT ALL THREE PADS TOGETHER.

VTX/Camera connector (4)		
1●	+	VTX Voltage
2	-	GND
3	VO	Video Out (VTX Video In)
4	T3	TXD (T3) VTX Control/Telemetry
5	R3	RXD (R3)
6	G1	Reserved (DO NOT CONNECT)
7	CC	Camera Control
8	VI	Video In (Camera Video Out)
9	-	GND
10	+	Camera Voltage

VTX and Camera connector

Connect a PAL or NTSC Camera and VTX. Ensure your Camera, VTX and Video Receiver and Display can use the same video format as the camera. i.e. All NTSC or all PAL devices.

If your VTX has control/telemetry input then use the T3 pin. e.g. for Tramp/SmartAudio.

NOTE: The VTX pit switch is OFF by default when the FC powers on so there will be no power to the VTX until the FC turns the VTX on.

Use the Camera Control and GND connections to control your camera's OSD with the transmitter sticks.
See Betaflight wiki for details of connections and supported cameras. The FC uses a 1uF capacitor to ground and 470ohm resistor in series with the data signal on PD7/D07.

VTX voltage is configured by the VTX bridge on the bottom of the board. Set the voltage to either BATTERY or 5V.
Camera voltage is configured by the CAM bridge on the bottom of the board. Set the voltage to either BATTERY or 5V.

If your VTX has a 2-wire serial port, then connect both T3 and R3 (UART3).

G1 is a reserved GPIO pin DO NOT CONNECT. It is connected to the NRESET pin of the SX1280. A 0 ohm resistor can be removed from the board to use that pin for a different function. Removal of the 0 ohm resistor is NOT covered under warranty as it requires specialist equipment and is only detailed here for completeness.

UART4 hidden pads (7)		
1●	-	GND
2	5VB	5V BEC
3	T4	TXD (T4)
4	R4	RXD (R4)

UART4 hidden pads

Primarily used external OSD system (e.g. DJI/SharkByte) that are only powered when a battery is connected.

UART8 hidden pads (9)		
1●	-	GND
2	5VB	5V
3	T8	TXD (T8)
4	R8	RXD (R8)

UART8 hidden pads

Primarily used for external RC receiver systems or always-on external logging devices.

GPS/IO connector (11)		
1●	-	GND
2	5V	5V
3	T8	TXD (T8)
4	R8	RXD (R8)
5	R2	RXD (R2)
6	T2	TXD (T2)
7	SDA	I2C1 SDA
8	SCL	I2C1 SCL
9	-	GND
10	5VB	5V BEC
11	T4	TXD (T4)
12	R4	RXD (R4)

GPS/IO connector

Use this socket to connect a GPS receiver with I2C MAG sensors to use GPS features.

IMPORTANT: The SCL and SDA are 3.3v signals.

5.0v is also supplied when powering via USB.

IMPORTANT: 5.0v to 3.3v logic level converters are REQUIRED for SCL/SDA if your sensors use 5.0v signals.

VTX control/telemetry pin-select (5)	
1◀	Pin 4 (closest to USB socket)
2■	VTX Control/Telemetry (T3)
3▶	Pin 3 (closest to antenna socket)

VTX control/telemetry pin-select.

This jumper allows pin 3 and 4 of the VTX pads to be configured. Has no effect on VTX socket on the bottom of the board. See also the Video Out pin-select jumper on the top and set the jumper to the OPPOSITE of this jumper.
Do NOT configure the same pin for both Video Out and VTX Control/Telemetry.
The purpose of this is to allow stacking of VTXs with different pinouts directely to the FC since there is no standard for signal order of VTX systems.
Note: ideally all manufactuers should use the POWER/GND/VIDEO/TLM order for best signal integrity.

Create a solder bridge between TWO PADS ONLY to select VTX Control/Telemetry pin.
a) bridge ◀ and ■ to set the Pin 4 to VTX Control/Telemetry.
b) bridge ■ and ▶ to set the Pin 3 to VTX Control/Telemetry.

VTX hidden pads (6)		
1	+	VTX Voltage
2	-	GND
3	VO	Video Out (VTX Video In)
4	T3	TXD (T3) VTX Control/Telemetry

VTX hidden pads

Connect an NTSC or PAL Video transmitter camera. Ensure your Camera, VTX and Video Receiver and Display can use the same video format as the camera. i.e. All NTSC or all PAL devices.

If your VTX has control/telemetry input then use the T3 pin. e.g. for Tramp/SmartAudio.

NOTE: The VTX pit switch is OFF by default when the FC powers on so there will be no power to the VTX until the FC turns the VTX on.

VTX voltage is configured by the VTX bridge on the bottom of the board. Set the voltage to either BATTERY or 5V.

Camera hidden pads (8)		
1	CC	Camera Control
2	VI	Video In (Camera Video Out)
3	-	GND
4	+	Camera Voltage

Camera hidden pads

Connect an NTSC or PAL FPV camera. Ensure your Camera, VTX and Video Receiver and Display can use the same video format as the camera. i.e. All NTSC or all PAL devices.

Camera voltage is configured by the CAM bridge on the bottom of the board. Set the voltage to either BATTERY or 5V.

Use the Camera Control and GND connections to control your camera's OSD with the transmitter sticks.
See Betaflight wiki for details of connections and supported cameras. The FC uses a 1uF capacitor to ground and 470ohm resistor in series with the data signal on PD7/D07.

Recommend using cameras that have positive-only video signals (0V sync) and have video voltages that do not drift with temperature otherwise in-flight display resyncs may occur.

ESC1 connector (12)	
1 ●	Motor Signal 4
2	Motor Signal 3
3	Motor Signal 2
4	Motor Signal 1
5	ESC TLM (R5)
6	Current Sensor Input 1
7	GND (-)
8	GND (-)
9	Battery (+)
10	Battery (+)

ESC1 - Motor 1-4

Connect to a 4in1 ESC or connect GND and one motor signal to each ESC.

The FC is powered using any of the Battery (+) and adjacent GND pins/pads.

Note: Each JST-SH connection and wire is only rated to 1Amp.

A 10pin socket is used to allow the ESC to deliver more current. Use both Battery (+) and GND pins/pads to provide the FC with enough current to power itself and the VTX, Camera, LED strip, etc. Especially when using many LEDs and/or a high-wattage VTX.

If your 4in1 ESC supports ESC telemetry then use the ESC TLM input (UART5 RX).
If your 4in1 ESC has an analog current sensor output then connect it to the Current Sensor Input.

ESC1 hidden and snap-off pads (13,14)	
M4	Motor Signal 4
M3	Motor Signal 3
M2	Motor Signal 2
M1	Motor Signal 1
ET	ESC TLM (R5)
C1	Current Sensor Input 1
-	GND (-)
+	Battery (+)

ESC2 - Motor 5-8

Connect to a 4in1 ESC or connect GND and one motor signal to each ESC.

The FC is powered using any of the Battery (+) and adjacent GND pins/pads.

If your 4in1 ESC supports ESC telemetry then use the ESC TLM input (UART5 RX).
If your 4in1 ESC has an analog current sensor output then connect it to the Current Sensor Input.

Receiver Connections

The H7RF has a built-in RC receiver so connection to an external receiver is not necessary. However, you can connect one and switch between the built-in receiver and an external receiver if required.

When using an external receiver use UART8.

It is possible to stack an external receiver to the FC using the 2mm pitch holes and 2mm pitch pin headers. Check receiver signals match the FC's signal before soldering! It may be possible to either turn the receiver upside down or solder the pin headers to the opposite side of the FC to acheive the desired fitting an pin-order.

Camera/VTX/LED-Strip BEC Connections.

The H7RF supports 5V or BATTERY voltage Cameras and VTXs, the on-board 5V regulator components are rated for 2Amps, but other devices, such as the FC itself and any receivers or LED strip connected to it will use the regulator. To be on the safe side do not use more than 1.5A at 5V. Suggest measuring the current usage of each connected device, one at a time prior to using them all at the same time. If you run more than a few LED-STRIP LEDs it is better to have a seperate BEC for the LEDs to ensure that LED operation doesn't interfere with flight behavior. When checking current draw of LEDs set them to WHITE as this will use the most current.

Cameras and VTXs that support LiPo battery voltages are recommended, more flexible and can be connected to either 5V or BATTERY and thus allow you to spread the load. Cameras and VTXs that support BATTERY input often also have additional signal filtering for a clearer picture.

Camera Connection.

Set the CAM voltage-select bridge to either 5V or BATTERY voltages, refer to your Camera manual for support voltage range.

Connect the Camera Control signal if your camera supports it.

VTX Connection

Set the VTX voltage-select bridge to either 5V or BATTERY voltages, refer to your VTX manual.

Connect VTX control/telemetry if your VTX supports it.

ESC Connections.

The H7RF supports connection of 8 ESCs, either using 2 4in1 ESCs or up-to 8 separate ESCs.

4in1 ESC Connection.

If you are using 4in1 ESCs, using one 4in1 ESC for up to 4 motors, then simply connect the 4in1 pads or use the 4in1 ESC connectors for each 4in1 ESC, referring to ESC and FC pinouts and adjust cables as necessary.

Separate ESC Connections.

If you are using separate ESCs, one ESC per motor, proceed as follows.

1. Connect FC battery wire to a PDB's Battery +/- pads.
2. Connect each ESC's +/- pads to a PDB's Battery +/- pads.
3. Connect the Battery +/- pads from the PDB to the FC's Battery +/- pads.
4. Connect a GND and a Motor signal wire from the FC to each ESC.

Soldering

VERY IMPORTANT! - Do NOT solder your flight controller until you have plugged in a USB cable and checked that the GREEN, BLUE and RED lights operate! GREEN and BLUE must be ALWAYS ON Red and Orange are controlled by software. Once you have checked the FC is OK then unplug it and solder your wires.

IMPORTANT:

- Use a high quality soldering iron and good solder.
- Tin/Lead solder is MUCH easier to use than other Lead-free solder.
- Use solder with flux and remove any flux residue after soldering. AVOID CORROSIVE FLUX!
- Check for and remove solder balls you may have created after soldering - use a magnifying glass.
- Ensure you have sufficient fume extraction when soldering.
- Pin headers that connect to the GND signal and large battery/esc pads will be more difficult to solder because the PCB will sink the heat from your soldering iron. Solder the signal pins, then the VIN pins, then the GND pin or large pads - by the time you get to the GND pins or large pads you will have heated the board and it will be easier to solder them.
- If you have never soldered before then DO NOT attempt to solder the flight controller, practice on something else first.
- Position your soldering iron tip so that you do not accidentally de-solder other components on the board.
- Always start soldering with a little bit of solder on the tip to aid in thermal transfer between the tip and the cable/pin/pad.

The flight controller may be supplied with some pin-headers and connectors. Choose very carefully which ones you want to use. You can solder headers to top or the bottom of the board.

Once you have soldered pin headers or connectors in place DO NOT attempt to remove them unless you are highly skilled in de-soldering and have the correct tools. Overheating the board or components will destroy it.

Cables

The flight controller comes without cables, a cable pack and spares are available.

Do NOT rely on cable color-coding due to manufacturer variations. Always check before applying power.

IMPORTANT: Ensure that you leave some slack in your cable routing as this will help if you crash your aircraft.

Spare or replacement cables are available from your retailer.

JST-SH connectors have a pitch of 1mm, the FC has male sockets. (Sockets with pins). Cables use female plugs.

Mounting

The SPRacing H7 RF is supplied with grommets. Install the grommets in each corner of each board. Then use appropriate spacers between your frame and the FC.

The SP Racing H7 RF does not have directional arrow on it indicating the front of the board. Usually, the USB socket should be on the RIGHT when the quad is facing FORWARDS. However, most flight control software allows the board to be mounted in any orientation, including upside-down (flipped).

Ensure that all wires soldered to the FC do NOT touch any other boards above and below it.

MicroSD Card

The MicroSD socket allows MicroSD/SDHC/SDXC to be inserted.

HOWEVER, Currently only MicroSD and MicroSDHC are supported. MicroSDXC is NOT currently supported by Betaflight.

For full details on how to enable logging, SD card speed requirements and how to view logs please see the Betaflight software manual.

The H7RF FC's are QA'd using Kingston Canvas Select Plus 32GB SDHC cards.

Your aircraft will fly better if you analyze your logs and tune accordingly.

Getting started

Verify flight controller operation via the configuration software.

- Disconnect the flight controller from your computer.
- Disconnect ALL connectors and headers from the flight controller.
- Install latest STM32 Virtual COM Port Driver
  http://www.st.com/web/en/catalog/tools/PF257938
- Install and launch the Betaflight Configurator tool
  https://github.com/betaflight/betaflight-configurator
- Connect flight controller to computer via USB cable.
- Select the correct COM port if it is not automatically detected.
- Verify all sensors on your board are giving correct readings.
- Disconnect and upgrade the firmware if new firmware is available.

For further software configuration see the getting started guide in the Betaflight wiki or manual.

The basic steps, after firmware upgrade, are as follows.

- Choose board alignment - you can mount it in any orientation.
- Calibrate sensors.
- Configure serial ports.
- Choose model/mixer (default is Quad X)
- Enable features.
- Configure receiver, set channel mapping.
- Bind receiver to TX.
- Configure channel mid and endpoints (1000-2000) and trim channels on transmitter.
- Configure voltage/current monitoring.
- Configure outputs (servos/ESCs)
- Ensure ESC calibration matches ESC configuration, recalibrate ESCs if needed.
- Learn about flight modes and configure channels/switches to activate them as required.
- Learn how to arm/disarm.
- Bench-test failsafe without props attached.
- Read safety notes.
- Learn how to download and view your flight logs to help tune your aircraft.
- Enable blackbox logging before your first flight (so you have a log).
- Learn how to recognise un-tuned flight characteristics and the effects of a PID controller. (Watch some videos).
- First flight should be in Acro/Rate mode (the default mode when no other modes are active).
- Tune PIDs.
- Backup settings.
- Contribute to the Betaflight project with feedback, suggestions, code, etc.

ExpressLRS Receiver configuration and Binding

The ExpressLRS receiver configuration is specific to each flight controller firmware.

For Betaflight, the instructions are here while the code is waiting to be merged into Betaflight. When the code is merged it is hoped the documentation will be in a better location.

https://github.com/betaflight/betaflight/pull/10788

Firmware Upgrade

VERY IMPORTANT:

It is REQUIRED that you immediately upgrade the firmware of the flight controller to the latest stable version so that you have the latest features and bug fixes. DO NOT ATTEMPT TO FLY until you have installed the latest stable firmware. Due to the fast-paced development cycle of Betaflight and manufacturing lead-times the firmware installed in the factory may not have all features enabled and issues may have been fixed.

On Windows USB DFU drivers must be installed.

1. Click the Firmware Flasher tab.
2. Select the correct COM port and speed, use the default speed unless you have changed it on the FC.
3. Select the latest "SPRacingH7RF" stable release. (Do not use other targets). If no firmware is currently available or the target is not listed do NOT attempt to flash and refer to the betaflight wiki/issue tracker for firmware availability. NOTE: Flashing the wrong firmware can cause the FC to be permanently damaged.
4. Click 'Load firmware [Online]' and wait for firmware to download and read release notes before flashing.
5. Click 'Flash Firmware'. At this point the FC should reboot into DFU mode. DFU will appear in the list of ports and flashing via DFU will proceed. After flashing the virtual COM port will re-appear.

IMPORTANT: Verify operation using latest official firmware before attempting to use alternative firmware. Not all features may be supported by alternative firmware.

NOTE: Do not use the configurator to versions that do not have support H730 EXST flashing. Configurators released after BF4.3 should have this, until then refer to the links below for flashing via dfu-util.Attempts to flash using the incorrect configurator version will not succeed.

Official firmware and source:

https://github.com/spracing/betaflight/releases

Bootloader

The SP Racing H7 RF does not store the Betaflight/Cleanflight software on the CPU itself, instead the software is stored and run from the external flash chip.

The SP Racing H7 RF has a small program, called the SPRacing Bootloader, which handles this task.

The bootloader will start as soon as the CPU powers on, and it will look for firmware and attempt to load it immediately, without requiring user interaction. If the bootloader does not find suitable firmware, it will blink error codes and then enter SPRacing DFU mode so that it can be updated.

If you need to enter the SPRacing Bootloader you can do it from the configurator tool or by keeping the bind button pressedwhen powering on the FC. When the bind button is pressed on boot the status led will blink very fast until the bind button is released. When the button is released the bootloader software will flash the status led slowly and the FC will be in Bootloader DFU mode.

When the bind button is held during SP Racing bootloader mode the LED will flash once every 2 seconds, each LED flash indicates a different function. keep the bind button pressed until the LED has flashed the amount of times that correspond to the function number below, then release the bind button to start the function.

Bootloader functions:

1 Load and launch system software and firmware from external flash.
2 Launch loaded system software and firmware in RAM (for developers).
3 Clear firmware in RAM.
4 Enter CPU ROM DFU bootloader (for developers).
5 Reboot.
6 Erase config on external flash.
7 Erase firmware on external flash.

Special bootloader functions:

8 Erase entire external flash including system software, firmware and config. (Do NOT do this unless instructed by Seriously Pro / SP Racing).
15 Erase CPU bootloader (DO NOT DO THIS - You will have to return the FC to the factory for reprogramming).
16 Erase external flash reserved area. (Do NOT do this unless instructed by Seriously Pro / SP Racing)
17 Erase system software on external flash. (Do NOT do this unless instructed by Seriously Pro / SP Racing)

IMPORTANT: The bootloader is non-user-upgradable. If you erase it you will not be able to use the FC until a bootloader is restored to it by the factory, at your cost! If you are a developer you can erase it and write your own if you like; the bootloader has a function (15) which allows you to erase it for this purpose only.

Failure patterns:

When the bootloader can't do something, it will give a failure pattern. The patterns starts with a few quick flashes, then some slow flashes. Count the slow flashes and use the table below.

2 = Firmware verification failed. Corruption, hash mismatch.
3 = Firmware load failed. No valid firmware found.
4 = Firmware write failed (e.g. when flashing).
5 = External flash write failed.
6 = External flash read failed.
7 = SD write failed.
8 = SD read failed.

There are other codes, if you experience them contact SP Racing support with your symptoms.

Note: The betaflight failure patterns start with fewer and slower 'fast' flashes than the bootloader failure patterns which begin with much faster 'fast' flashes.

Firmware flashing for developers

Manual flashing can be performed when the SP Racing bootloader is in DFU mode. The SP Racing bootloader allows full access to the external flash.

Firmware Partition Program

```
dfu-util -D obj/betaflight_4.3.0_SPRacingH7RF.bin -s 0x90100000:leave
```

Firmware Partition Erase

```
dd if=/dev/zero ibs=1k count=1024 of=ZERO_1024K.bin
dfu-util -D ZERO_1024K.bin -s 0x90100000:0x100000
```

Firmware Partition Read

```
dfu-util -U fw_1024K.bin -s 0x90100000:0x100000
```

Config Partition Erase

```
dd if=/dev/zero ibs=1k count=8 of=ZERO_8K.bin
dfu-util -D ZERO_8K.bin -s 0x900FE000:0x2000
```

Config Partition Read

```
dfu-util -U config_8K.bin -s 0x900FE000:0x2000
```

System Partition Program

```
dfu-util -D SPRacingH7RF.bin -s 0x900DE000:leave
```

The SP Racing bootloader firmware supports SWD debugging of the flight controller code (betaflight, etc), just set breakpoints in the code as you would normally. Refer to the flight controller source for Bootloader address space usage.

Troubleshooting

Q: Unable to flash firmware via DFU.
A: Likely the correct DFU drivers are not installed. Put the FC in SP Racing BOOTLOADER mode by holding BIND and connecting the USB cable. Release BIND when the status LED flashes fast repeatedly. Then update DFU drivers. See USB Flashing section of Betaflight manual for details.

Q: When flashing firmware using configurator I receive message about 8K image size.
A: Use a version of the configurator that supports the H7RF.

Q: The COM port does not show up.
A: Ensure latest USB STM VCP (Virtual Com Port) drivers are installed.

Q: DFU does not appear in the port list when flashing.
A: Try disconnecting the FC. Hold BIND button to enter the SP Racing bootloader. Connect the USB cable. Release BIND, retry flashing.

Q: I have no LEDs on at all.
A: Check 5v supply. (Battery Charged?, USB cable damaged?)

Q: The status LED never lights or is always on.
A: Follow recovery procedure in the configurator. Likely caused by flashing wrong firmware. Could also be caused by stuck-down BOOT switch - check button for dirt, etc. You can also use the SP Racing Bootloader to erase/reset the FC configuration to defaults which may also help. Early versions of the H7RF firmware REQUIRE an SD Card for config storage. If the SD card is not formatted or supported the Status LED will be RED.

Q: Unable to connect and a repeating light sequence occurs on the activity LED.
A: Check the Betaflight manual for how to interpret the error code (count the long flashes).

Q: Unable to connect to the board (and status LED shows non-repeating pattern at boot-up).
A: Close all Chrome browsers and Chome apps, retry. COM Port drivers not installed? Try connecting via different UART OR Reset the board to defaults using buttons OR erase the config partition on the external flash or config file on the SD card. (Likely caused by mis-configuration of ports or other resource).

Q: The COM port does not show up after flashing firmware.
A: Wrong firmware was flashed; Use SP Racing bootloader to erase the firmware and config, reflash correct firmware.

Q: The receiver tab does not show any activity.
A: Check configuration tab - receiver mode. Center sticks, configure endpoints and trim on transmitter. Check ports tab if using Serial RX. Check wiring. Ensure TX and RX/FC are bound.

Q: You have a problem not listed here.
A: Reset and/or upgrade the firmware, try again, report issues via the forums - links are in the configurator on the 'Documentation & Support' tab. Before contacting your retailer reflash with latest Betaflight, reset FC to default setting and double check your issue - perhaps the firmware you are using is old or incorrect?

Q: Only 5V LED lights up, No BLUE 3V LED or RED STATUS LED.
A: Most common cause is misconnection or short of power/battery wires - FC will probably be destroyed! Check for short in Spektrum Satellite cable if using Spektrum Satellite RX. Normally only caused by destroyed CPU or overloaded/shorted voltage regulator.

Hardware Specifications

- STM32H730 CPU, 520MHz inc FPU with ECC
- 2.4Ghz RF receiver IC directly connected to the CPU via SPI for lowest stick-to-motors latency possible. Designed for ExpressLRS RC system
- SPRacing Pixel OSD with customisable layout, profiles and configuration menu system. Double buffered and capable of 60FPS (NTSC) or 50FPS (PAL)
- Very low-noise ICM42688P accelerometer/gyro (connected via SPI)
- BMP388 High-precision Barometer - bottom mounted for wind isolation (I2C + interrupt)
- 2MByte 16MBit NOR flash via OctoSPI
- MicroSD card slot (SD/SDHC, upto 32GB) connected via 4-Bit SDIO
- High quality 1.4mm thick 6-layer copper gold-plated PCB with snap-off sections
- 2-8S BEC 5V 2A Switching regulator.
- TVS protection diode.
- High-current 3V switching regulator with extra filter capacitors for sensors
- Buzzer circuitry
- RSSI Analog and PWM circuit
- 8 motor outputs with 2 4in1ESC connectors (JST-SH 10pin)
- 4 sets of 2mm pitch break-out through holes for stacking VTXs or other peripherials
- 1x SPI breakout onto stacking connector
- 5 Serial Ports (4x TX+RX + 1x TX only bi-directional for ESC Telemetry)
- 4 LEDs for 5V, 3V and STATUS A/B (Green, Blue, Red, Orange)
- 37x37mm PCB with 30.5mm and 20mm mounting hole patterns
- 27x27mm PCB after break-off PCB sections (left/right/bottom) are removed
- 4mm mounting holes for soft-mount grommets and M3 bolts
- MicroUSB socket for configuration and ESC programming
- Supplied with 4x soft-mount grommets
- Optionally supplied with 2x Audio/Video JST-SH cables. (Camera Input, VTX Output)
- Optionally supplied with IO cables. (for GPS, etc)
- Optional receiver cables for FrSky XSR receivers and 3-pin style receivers available
- 2x sets of 4 solder pads for ESC connections (Bi-Directional DSHOT compatible, 8 motors + 2x TLM + 2x Current)
- 2x sets of 4 solder pads for ESC connections under the connectors! (Same signals as connectors and other pads)
- 4x special solder pads with through-holes for Camera In + Camera OSD
- 4x special solder pads with through-holes for Audio+Video Out (VTX)
- 1x 4 pin JST-SH connector for LED Strip and BUZZER.
- 1x 4 pin JST-SH connector for SWD debugging.
- 1x 12 pin JST-SH connector for 3 UARTS + I2C + 5VBEC + 5V for IO connections.
- 1x 10 pin JST-SH connector for Camera/VTX/UART3/GPIO/Camera Control connections.
- 1x 4pin though-holes for pin headers for UART4 RX/TX
- 1x 8pin though-holes for pin headers for UART8 RX/TX
- 1x 4pin though-holes for pin headers for Camera (GND/Power/Video IN/Camera Control).
- 1x 4pin though-holes for pin headers for VTX (GND/Power/Video OUT/VTX Control (TLM) via UART3).
- 1x Side-press BIND button (top mounted).
- 2x 5V/BATTERY voltage selectors for Camera and VTX outputs
- SP Racing logo
- 1x Additional easter eggs!

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Hardware design and manufacturing by Dominic Clifton.
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Software support and contributions from many, many authors. For a complete list see github contributors.
https://github.com/cleanflight/cleanflight/graphs/contributors
https://github.com/betaflight/betaflight/graphs/contributors

Community

Thanks to everyone from the AWESOME Cleanflight/Betaflight/iNAV/PX4/Ardupilot communities for code, artwork, support, ideas, feedback, and everything else. Without you all this product would not exist.