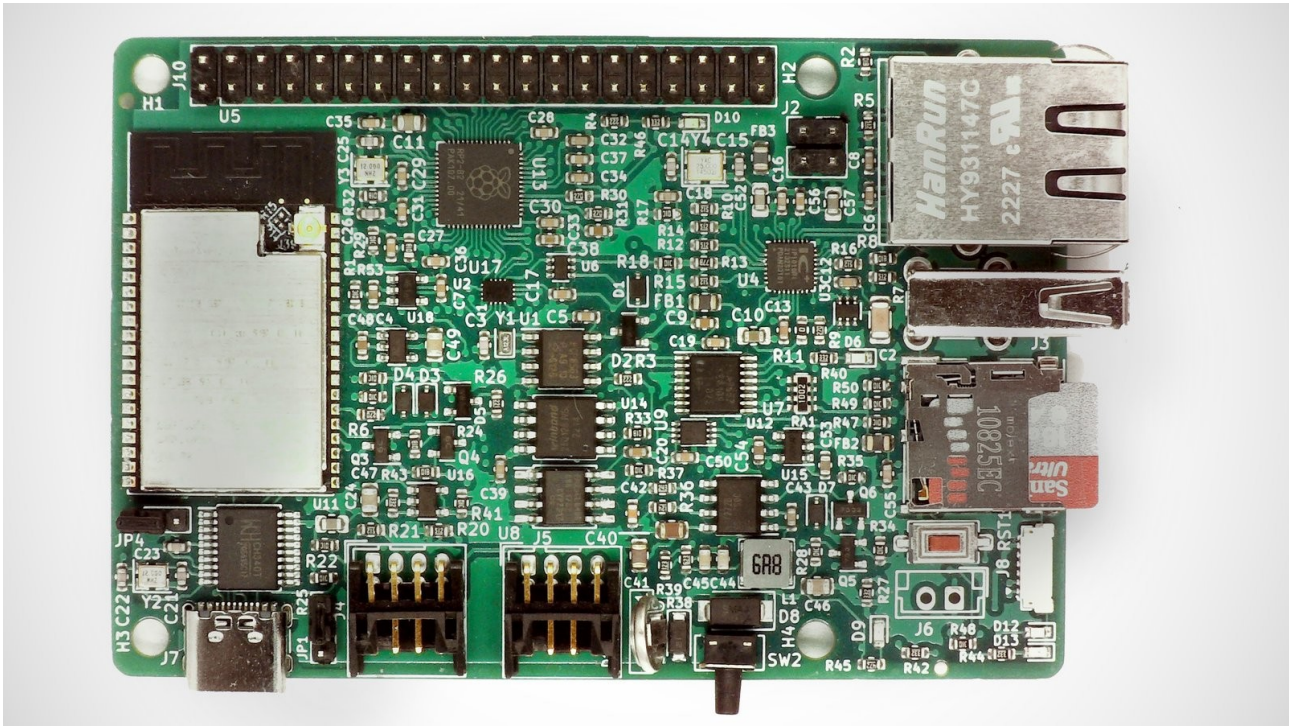
Preliminary



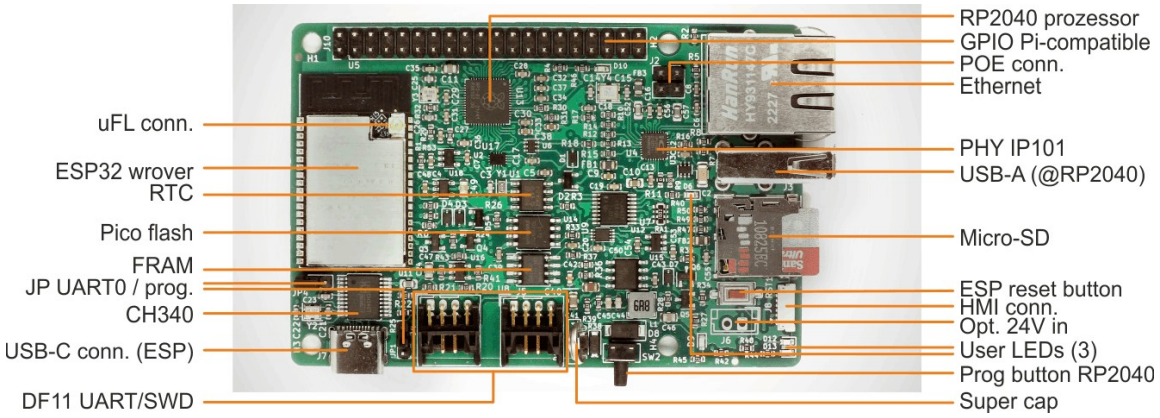
EsPiFF is an ESP32 in a Raspberry Pi 4 form factor, capable of utilizing nearly every Pi 4 enclosure and HAT. EsPiFF packs an additional punch with wired and wireless Ethernet, an SD card socket, and a RP2040 co-processor.

EsPiff is particularly well suited to measurement, control, and automation projects where the current consumption and heat generation of a Pi—or the potential instability of its SD card—could be problematic.

Features & Specifications

- ESP32-WROVER with 8 MB PSRAM and 16 MB Flash in a Raspberry Pi 4 form factor
- Wi-Fi connectivity (requires an external U.FL antenna)
- 10/100 wired Ethernet via IP101 PHY
- PoE header, to use Raspberry Pi PoE HATs. EsPiFF can be powered from a HAT or can power the HAT
- Micro SD card socket for storage
- Up to 3 UARTs
- USB Type-C connector on CH340 USB-UART for programming as well as power draw up to 5 V / 3 A for power-hungry HATs

- 40-pin Rasperry Pi header, compatible with all Raspberry Pi HATs
- RP2040 co-processor to emulate the Pi on the 40 pin connector, with 8 MB Flash
- External realtime clock, watchdog, and supervisor for high-availability, 24/7 applications
- On-board supercap to keep the realtime clock running for days, even without power. The supercap has, in contrast to a battery, a practically infinite lifetime
- USB-Host on the USB Type-A connector
- BOOT button for the RP2040, to switch between USB-Programming and USB-Host/Device
- ESP32 reset button and three user LEDs



Specifications	**Value**	**Remarks**
Dimensions	86 * 56mm	RasPi 4 compatible
Power supply	5V, up to 3A via USB 3 connector Optional 24V input via Pin Header	
Connectivity		
Ethernet	RJ45	
Wifi	External uFL antenna connector	PCB antenna not usable
Serial	2 DF11 connector with a total of 3 UART (TTL 3.3V)	Cable assemblies available (Mouser etc.)
Programming ESP32	USB-C (CH340 USB to UART)	
Programming RP2040	USB-A	
USB-Host/device	USB-A	
Raspberry Pi HAT	40 pol pin header	
UART TFT display (HMI)	6 pol JST	
ESP32-WROVER specs		
Dual core LX6 MCU	240 MHz	
Flash	16 MByte (W25Q128JVSIQ)	
PSRAM	8 MByte	

Pi Pico RP2040 specs		
Dual core M0+ MCU	133 MHz	
Flash	16 MByte	
ESP32 – RP2040 connectivity	SPI or UART	
Current consumption		
Wi-Fi Tx packet 13dBm~21dBm	170 to 295 mA	TBD
Wi-Fi/BT Tx packet 0dBm	140 mA	TBD
Wi-Fi/BT Rx and listening	85 to 115 mA	TBD
ESP32 modem sleep mode	3 to 28 mA	TBD
No load current standard mode	70 mA	
Nuttx 11.0, no app	115 mA	
Sdcard	SPI mode	
FRAM	FM25CL64B – 1 MByte	
Supervisor	APX823	
Real time clock	PCF8563T	
Ethernet PHY	IP101	
PoE header	4 pol header	Identical to Pi 4
Supercap for real time clock	220mF	
Buttons		
PROG button for RP2040	On the position of the Pi audio connector	Can be operated when inside a Pi 4 enclosure
Reset button for the ESP32	On the position of the Pi USB	
Operating temperature	-20 to +70 degree Celsius	
Storage temperature	-40 to +85 degree Celsius	
Weight	37g	
CE	Compliant	
RoHS (2011/65/EU)	Compliant	
EMC (2014/30/EU)	Compliant	
Low Voltage Directive (2014/35/EU)	Compliant	
FCC	pending	

Product contains Transmitter Module FCC ID: 2AC7Z-ESP32WROVERE.

Pin outs

J4 – DF11

Pin number	Function	Remark
1	+5V	Max. 2.7 A, when USB powered
2	+5V	Max. 1.5A, when 24V powered
3	GND	
4	GND	
5	UART0 RXD	Labled HF_MISO in schematic
6	UART1 RXD	Labled TFT_MISO in schematic
7	UART0 TXD	Labled HF_MOSI in schematic
8	UART1 TXD	Labled TFT_MOSI in schematic

J5 – DF11

Pin number	Function	Remark
1	+5V	Max. 2.7 A, when USB powered
2	+5V	Max. 1.5A, when 24V powered
3	GND	
4	GND	
5	UART2 RXD	Labled UHF_MISO in schematic
6	Pico SWCLK	Debug clock pin for PicoProbe
7	UART2 TXD	Labled UHF_MOSI in schematic
8	Pico SWDIO	Debug data pin for PicoProbe

Cable assemblies for J4, J5: Hirose DF11-8DS-2C(17), Mouser No 798-DF11-8DS-2C17

J8 – SM06B-SURS-TF(LF)(SN)

Pin number	Function	Remark
1	UART1 TXD	Labled TFT_MOSI in schematic
2	UART1 RXD	Labled TFT_MISO in schematic
3	GND	
4, 5	nc	Not connected
6	+5V	

Cable assemblies for J8: A06SUR06SUR32Wxxx (replace xxx with the cable length in mm). For example, A06SUR06SUR32W305B, Digikey part number 455-2995-ND.

Jumper JP1 - U0TXD

1-2	CH340 to ESP32	position to program
2-3	DF11 connector to ESP	To access the 3th UART

Jumper JP4 - U0RXD

1-2	CH340 to ESP32	position to program
2-3	DF11 connector to ESP	To access the 3th UART

Pin mapping 40 pol Raspberry Pi HAT to RP2040 pins

HAT pin on 40 pol header	Pi HAT function	RP2040	Remarks
1	3.3V (from EsPiFF to HAT)	-	HAT can take up to 150 mA
2	5V (both directions possible)	-	HAT can take up to 2.7 A
3	Pi_GPIO2_SDA	IO10	
4	5V (both directions possible)	-	
5	Pi_GPIO3_SCL	IO11	
6	GND	-	
7	Pi_GPIO4_CLK0	IO23	
8	Pi_GPIO14_TXD	IO8	
9	GND	-	
10	Pi_GPIO15_RXD	IO9	
11	Pi_GPIO17	IO6	
12	Pi_GPIO18_PWM0	IO0	
13	Pi_GPIO27	IO22	
14	GND	-	
15	Pi_GPIO22	IO5	
16	Pi_GPIO23	IO7	
17	3.3V (from EsPiFF to HAT)	-	
18	Pi_GPIO24	IO20	
19	Pi_GPIO10_MOSI0	IO16	
20	GND	-	

21	Pi_GPIO9_MISO0	IO19
22	Pi_GPIO25	IO3
23	Pi_GPIO11_SCK0	IO18
24	Pi_GPIO8_nCS0	IO17
25	GND	-
26	Pi_GPIO7_nCS1	IO13
27	Pi_GPIO0_ID_SD	Not connected to Connect to ESP32-I2C0 RP2040
28	Pi_GPIO1_ID_SC	Not connected to Connect to ESP32-I2C0 RP2040
29	Pi_GPIO5_CLK1	IO24
30	GND	-
31	Pi_GPIO6_CLK2	IO25
32	Pi_GPIO12_PWM0	IO1
33	Pi_GPIO13_PWM1	IO2
34	GND	-
35	Pi_GPIO19_MISO1	IO15
36	Pi_GPIO16	IO4
37	Pi_GPIO26	IO21
38	Pi_GPIO20_MOSI1	IO12
39	GND	-
40	Pi_GPIO21_SCK1	IO14

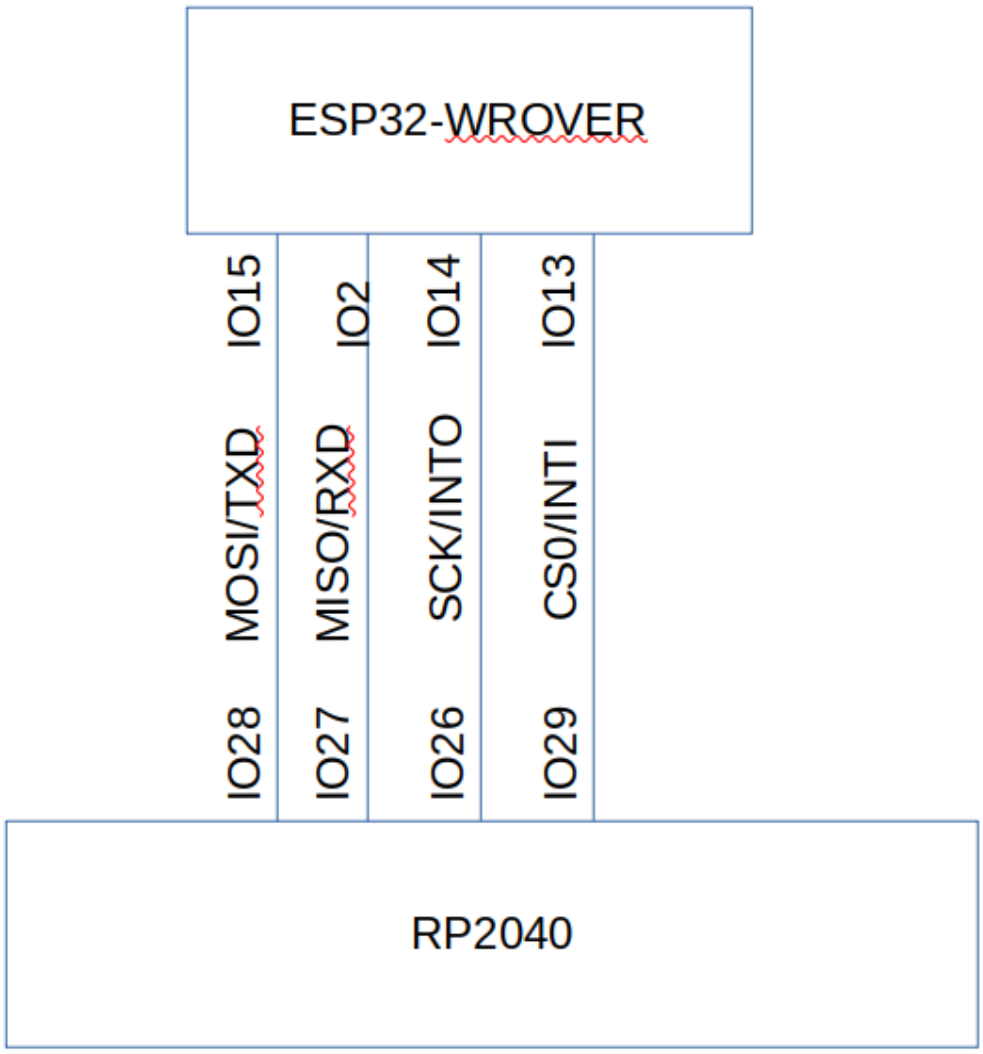
The I2C lines to read out the HAT EEPROM is not connected to the RP2040, but instead to the ESP32-WROVER.
To expose the HAT to the ESP, a open source project called Configurable Firmata (https://github.com/firmata/ConfigurableFirmata) can be used. At the time of writing, Configurable Firmata just support UART as transport between the EsPiFF and the RP2040. In a future version, SPI will be supported as transport, additional to UART.

ESP32 – RP2040 interconnection

Communication between the ESP32 and the RP2040

Option 1: SPI. 4 pins are used for MOSI, MISO, SCK and CS0. Keep in mind, that CS0 is shared for communication with the RP2040 and the SD card. The IO expander need to be programmed for communication with the RP2040
Option 2: UART. Up to 5 Mbit are supported and 2 interrupt lines help to synchronize the UART transfers. With UART transfer, SCK/INT0 is set by the ESP32 and the ESP32 is listen on CS0/INTI on an interrupt from RP2040.

For now, interrupt driven UART communication is preferred, until SPI transport is implemented into Firmata.



To establish a SPI connection between the ESP32 and the RP2040, the IO expander PCA9557 need to set the line nSPI_PICO to low, additional to the SPI_nCS0 lines. While reading/writing to the RP2040, the ESP32 can not use the SDcard.

ESP32-WROVER		RP2040	Remarks
GPIO14	SPI_SCK	IO26	
GPIO13	SPI_nCS0	IO29	
GPIO15	SPI_MOSI	IO28	
GPIO2	SPI_MISO	IO27	

Please keep in mind, that the speed of the SPI communication, when based on the Espressif IDF, depend on the block size, as explained
https://docs.espressif.com/projects/esp-idf/en/latest/esp32/api-reference/peripherals/spi_master.html

Frequency (MHz)	Transaction Interval (us)	Transaction Length (bytes)	Total Time (us)	Total Speed (KBpS)	Speed at 64MHz
8	25	1	26	38.5	308
8	25	8	33	242	1936
8	25	16	41	490	3920
8	25	64	89	719	5752
8	25	128	153	836	6688

As on the above table can be seen, the over all transfer speed on SPI is not far from 5 Mbit UART. The UART interface is supported by Firmata and our suggestion is, to use the interrupt supported UART communication. The ESP32 would allows to place any UART signal to any pin, where as the RP2040 need to use the predefined pins IO27 + IO28, what then also dictate the corresponding pins on the ESP32.

Using UART as communication line between ESP32 and RP2040, makes CS0 free for exclusive usage for the SD card. On the other hand, 1 of the 3 available hardware UARTs inside the ESP32 will then be occupied, and is no longer available on the connectors. UART 1 or UART 2 should be used for the communication to the RP2040, and UART 0 should be kept to enable debug messages via the USB-C connector.

ESP32 – FRAM

To establish a SPI connection between the ESP32 and the FRAM, the nSPI_CS1 line (ESP32-GPIO12) is to use. The nSPI_CS1 chip select line is exclusive for the FRAM.

ESP32 – SDcard

To establish a SPI connection between the ESP32 and the RP2040, the IO expander PCA9557 need to set the line mSPI_SDcard to low, additional to the SPI_nCS0 lines. While reading/writing to the Sdcard, the ESP32 can not communicate with the RP2040.

Wifi antenna

The EsPiFF is delivered with an external antenna. To use Wifi, connect the uFL connector of the antenna to the ESP32-WROVER and place the antenna to a suitable position for best signal strength.

Optional cable settings

An optional cable set for the EsPiFF is available. It consists of

- 2 Hirose DF11 female to DF11 female connectors with 30 cm color coded cable,
- 2 Hirose DF11 female to 8 individual Dupont headers with 30 cm color coded cable,
- 1 JST 06SUR female to 06SUR female connectors with 30 cm color coded cable,
- 1 JST 06SUR female to 6 individual Dupont headers with 30 cm color coded cable,

Attention: The color code will change in the next version 3.2: red will be +5V, black will be GND on all cables. The pinout will stay the same.

Pinout and color code DF11 to DF11 cable

pin	Wire color	Signal
1	brown	+5V
2	grey	+5V
3	white	GND
4	blue	GND
5	red	UHF_MISO (U0RXD)
6	yellow	TFT_MISO (U1RXD)
7	black	UHF_MOSI (U0TXD)
8	green	TFT_MOSI (U1TXD)

Pinout and color code DF11 to Dupont cable

pin	Wire color	Signal
1	brown	+5V
2	grey	+5V
3	white	GND
4	blue	GND
5	red	UHF_MISO (U0RXD)
6	yellow	TFT_MISO (U1RXD)
7	black	UHF_MOSI (U0TXD)
8	green	TFT_MOSI (U1TXD)

Pinout and color code 06SUR to 06SUR

pin	Wire color	Signal
1	blue	TFT_MOSI (U1TXD)
2	green	TFT_MISO (U1RXD)
3	yellow	GND
4	white	SCL
5	red	SDA
6	black	+5V

Software development

ESP32-WROVER

Important notice for Ubuntu/Linux users:

Ubuntu identify the CH340 USB to UART chip as braille device. To make the EsPiFF be recognized by Ubuntu need to disable the braille support.

systemctl stop brltty-udev.service
sudo systemctl mask brltty-udev.service
systemctl stop brltty.service
systemctl disable brltty.service

Espressif IDF

Please follow the instructions on https://docs.espressif.com/projects/esp-idf/en/latest/esp32/get-started/index.html

Arduino

Please follow the instructions on https://espressif-docs.readthedocs-hosted.com/projects/arduino-esp32/en/latest/getting_started.html

uPython

Please follow the instructions on https://docs.micropython.org/en/latest/esp32/tutorial/intro.html

Javascript

For Espruino, please follow the instructions on https://www.espruino.com/ESP32. There are other Javascript interpreters for ESP32, you might check out:
- https://github.com/marcelkottmann/esp32-javascript
- https://github.com/Moddable-OpenSource/moddable
- https://www.neonious-iot.com/lowjs/
to name a few.

Rust

Please follow the instructions on https://github.com/espressif/rust-esp32-example

RP2040

Raspberry Pi Pico SDK

Please follow the instructions on https://github.com/raspberrypi/pico-sdk

Arduino – Pico

If you have the Arduino IDE installed, add the board support package for the Raspberry Pi Pico RP2040. At the time of writing, you have to add under settings, additional board URL,

https://github.com/earlephilhower/arduino-pico/releases/download/global/package_rp2040_index.json

Then in boards, boards manager, select “Raspberry Pi Pico”. From here on, you can follow all tutorials from the Raspberry Pi Foundation for the Pi Pico and/or Arduino-Pico tutorials.

EsPiFF REGULATORY COMPLIANCE AND SAFETY INFORMATION

Product name: EsPiFF V3.2

IMPORTANT: PLEASE RETAIN THIS INFORMATION FOR FUTURE REFERENCE

Getting Started
For full set up and installation instructions please visit
https://github.com/MDCservice/EsPiFF/tree/main/examples

Warnings

- This product shall only be connected to an external power supply ether rated at 5V dc, and a minimum current of 300-1800mA, if power is supplied by USB-C. If powered by the 24V pin header, an external power supply rated from 9V to 32V and minimum current of 200mA must be used. Any external power supply used with the EsPiFF shall comply with relevant regulations and standards applicable in the country of intended use.
- This product should be placed on a stable, flat, non-conductive surface in use and should not be contacted by conductive items.
- The connection of unapproved devices to the GPIO connector may affect compliance or result in damage to the unit and invalidate the warranty.
- All peripherals used with the EsPiFF should comply with relevant standards for the country of use and be marked accordingly to ensure that safety and performance requirements are met. These articles include but are not limited to keyboards, monitors, and mice used in conjunction with the EsPiFF.
- Where peripherals are connected that do not include the cable or connector, the cable or connector used must offer adequate insulation and operation in order that the requirements of the relevant performance and safety requirements are met.

Instructions for safe use

To avoid malfunction or damage to your EsPiFF please observe the following:

- Do **not** expose it to water, moisture or place on a conductive surface whilst in operation.

- Do not expose it to heat from any source; the EsPiFF is designed for reliable operation at normal ambient room temperatures.
- Take care whilst handling to avoid mechanical or electrical damage to the printed circuit board and connectors.
- Avoid handling the printed circuit board while it is powered. Only handle by the edges to minimize the risk of electrostatic discharge damage.
- The EsPiFF is designed to be powered from a USB port, from a PoE HAT or the 24V pin header. Do not power the EsPiFF by other means.

Compliance information

The EsPiFF complies with the relevant provisions of the RoHS Directive for the European Union. In common with all Electrical and Electronic Equipment (EEE) the EspiFF should not be disposed of as household waste. Alternative arrangements may apply in other jurisdictions.

Electromagnetic compatibility and operation

- This product is in conformity with the protection requirements of EU Council Directive 2004/108/EC on the approximation of the laws of the Member States relating to electromagnetic compatibility.
- This product has been tested and found to comply with the limits for Class B Information Technology Equipment according to the European Standard.
  NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
  - Reorient or relocate the receiving antenna
  - Increase the separation between the equipment and receiver
  - Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
  - Consult the dealer or an experienced radio/TV technician for help

WARNING: Please do not alter or modify the design of this product, doing so may void your ability to use the product freely, this includes altering the frequency at which the product operates.

Version history

Document version	Author	changes	Date
0.1	Michael Schmid	Initial version	01.11.2022
0.2	Michael Schmid	Added external antenna info	03.11.2022
0.3	Michael Schmid	Added color codes in cables	09.11.2022
0.4	Michael Schmid	Added CE and safety info	10.11.2022
0.5	Michael Schmid	Added ESP32 <> RP2040 interconnect info	23.11.2022

Simplified Declaration of Conformity (RED)

DE - Hiermit erklärt die MDC-Service Wittenburg GmbH, dass der Funkanlagentyp, der in diesem Dokument definiert ist, der Richtlinie 2014/53/EU entspricht. Der vollständige Text der EU-Konformitätserklärung ist unter der folgenden Internetadresse verfügbar: https://github.com/MDCservice/EsPiFF/tree/main/certificates

EN - Hereby, MDC-Service Wittenburg GmbH declares that the radio equipment type defined within this document is in compliance with Directive 2014/53/EU. The full text of the EU declaration of conformity is available at the following internet address: https://github.com/MDCservice/EsPiFF/tree/main/certificates

Hereby, MDC-Service Wittenburg GmbH declares that the radio equipment type defined within this document is in compliance with the Radio Equipment Regulations 2017, Statutory Instrument 2017/1206. The full text of the UK declaration of conformity is available at https://github.com/MDCservice/EsPiFF/tree/main/certificates.

MDC-Service Wittenburg GmbH Recycling Notice
Meets the following EC Directives:
DO NOT
Discard with normal waste, please recycle.
ROHS Directive 2011/65/EU as amendment by 2015/863/EU
Specifies certain limits for hazardous substances.
WEEE Directive 2012/19/EU
Waste electrical & electronic equipment. This product must be disposed of through a licensed WEEE collection point.
MDC-Service Wittenburg GmbH, fulfills its WEEE obligations by membership of an approved compliance scheme.

Hereby, MDC-Service Wittenburg GmbH declares that the radio equipment type defined within this document is in compliance with the Radio Equipment Regulations 2017, Statutory Instrument 2017/1206. The full text of the UK declaration of conformity is available at https://github.com/MDCservice/EsPiFF/tree/main/certificates