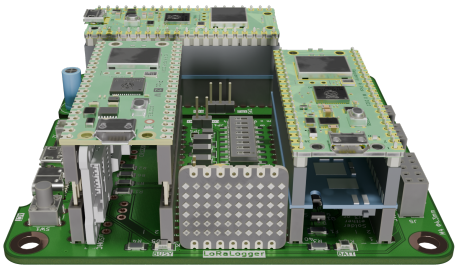
LoRaLogger

User Manual



Device Under Test Hardware Not For Distribution

Colophon

Not CE Marked
Not UKCA Marked
Not FCC Marked
Not for distribution

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3 4 5 6 7 8 9 10 29 28 27 26

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An IMPORTANT NOTICE at the end of this manual addresses warranty, changes, use in safety-critical applications, and other important disclaimer.

Hardware Revision: 2612A
PCB Manufacturer: JLCPCB
PCB Manufacturer Reference: 6l7md
Firmware Version: e45e1223
Manual Version: June 22, 2026

Warnings

Danger Do not short-circuit, crush or incinerate Lithium Polymer (LiPo) batteries (if present).

Warning This device may emit radio frequency (RF) energy. Do not use in or near hospitals, aircraft, or other areas where RF transmissions are restricted.

Warning This device must be operated only in frequency bands permitted by the local government or regulatory body, such as the Industrial, Scientific and Medical (ISM) bands.

Caution Handle this product only in an ESD-protected environment.

Caution RF components may become hot during operation.

Contents

1 Quick Start Guide **5**

2 Overview **7**

3 Radio I/O Configuration **7**

4 Logger I/O Configuration **8**

5 Logger File System **10**

6 Logger Display and Error Messages **11**

7 Power **15**

8 Electrical Characteristics **17**

9 Example Housing **18**

10 Schematic **19**

11 Bill of Materials **23**

12 Environment **24**

1 Quick Start Guide

Prerequisites

Before powering the device, ensure the following:

- A micro SD card is formatted as FAT32 and with the required files (see *Section 5: Logger File System* on page 10).
- Compatible antennas for the radio modules are installed to the radio modules.
- At least one power source: USB-C, Micro USB, LiPo battery, or customized power source (max. 5 V) (see *Section 7: Power* on page 15).

Hardware Setup

Warning Do not power on the instrument without antennas connected to the radio modules. Due to a chip malfunction, antenna mismatch protection for the RF amplifier against over-voltage has been removed from the firmware for certain radios. Therefore, doing so may permanently damage the RF front-end.

1. Insert the micro SD card into the slot on the Adalogger FeatherWing.
2. Attach the antennas to the u.FL connectors on the Waveshare Pico-LoRa-SX1262 modules.
3. If using the LiPo battery from the Waveshare Pico-LoRa-SX1262 modules, attach the battery to Radio0.
4. Attach the Raspberry Pi Picos to the Waveshare Pico-LoRa-SX1262 modules.
5. Connect external UART to header J4. Ensure Tx connects to Rx.

Operation

1. Apply power. If using multiple power sources, refer to *Section 7: Power* on page 15.

2. If the display shows a Node ID (e.g. N0), the device is ready. If the display shows “RTC” and/or “Ti?”, the real-time clock has lost the time. Refer to *Section 4.2: Logger USB Console* on page 10.
3. The SD Busy LED will blink when data is being written.
4. The Matrix Display will visualize packet activity and node status.
5. Operate the radios by sending commands via the UART connections on J4.

Manual and information available online
https://go.soton.ac.uk/hvm

2 Overview

2.1 Description

The LoRaLogger is a dual-channel telemetry and debugging instrument designed for field-deployed LoRa networks. It captures serial debug streams from up to two radio modules simultaneously, timestamps them using an onboard Real-Time Clock (RTC), and logs the data to a micro SD card. A 10x6 WS2812B RGB LED matrix provides immediate visual feedback on packet traffic, node status, and system errors without requiring a connected computer.

2.2 Applications

- LoRa Network Debugging & Optimization
- Field Range Testing
- Long-term Environmental Telemetry Logging
- Protocol Development & Firmware Validation

2.3 System Architecture

The device utilizes a distributed processing architecture comprising three independent microcontrollers to ensure real-time logging does not interfere with radio timing.

The logger Raspberry Pi Pico aggregates UART streams from the radios, manages the FAT file system, drives the LED matrix, and synchronizes time via I^2C with the RTC. Two Raspberry Pi Picos for the radios pass traffic information to the logger via UART1 while handling user traffic via UART0 on the external headers (J4). An integrated OR-ing circuit prioritizes power sources and protects against back-powering.

3 Radio I/O Configuration

Each radio Raspberry Pi Pico has two UART interfaces and two GPIO pins. UART0 is connected to J4 (and to both J4 and J6 for radio1) for sending and receiving end-user data, such as transmitted or received packets and user commands.

UART1 is connected to the logger for logging data and command transmission. GPIO6 and GPIO7 are exposed via SW1 for debugging or configuration. The internal pull-up resistors should be enabled.

The pin configuration for Radio0 is listed below.

Pin	Function	Description
1	UART0	Tx (output data to end-user)
2	UART0	Rx (receive data from end-user)
6	UART1	Tx (output logs to logger)
7	UART1	Rx (receive commands from logger)
9	GPIO6	User-defined Switch 5 (pull-up)
10	GPIO7	User-defined Switch 6 (pull-up)

The pin configuration for Radio1 is listed below.

Pin	Function	Description
1	UART0	Tx (output data to end-user)
2	UART0	Rx (receive data from end-user)
6	UART1	Tx (output logs to logger)
7	UART1	Rx (receive commands from logger)
9	GPIO6	User-defined Switch 7 (pull-up)
10	GPIO7	User-defined Switch 8 (pull-up)

4 Logger I/O Configuration

4.1 Logger I/O Overview

The logging Raspberry Pi Pico has three UART interfaces (UART0, UART1 and a PIO UART), two I^2C interfaces for the RTC and optionally the compass, one SPI interface for the SD card, one PIO pin for WS2812B, and five exposed GPIO pins. UART0 and UART1 are connected to the radios; optionally, the PIO UART is for GNSS (e.g., GPS). GPIO2, GPIO3,

GPIO6 and GPIO7 are exposed via SW1 for debugging or configuration. GPIO22 is exposed via SW1 as a push button. The internal pull-up resistors should be enabled. The logger also exposes a serial terminal via micro USB for configuration and logging.

Pin	Function	Description
1	UART0	Tx (radio0)
2	UART0	Rx (radio0)
4	GPIO2	User-defined Switch 1 (pull-up)
5	GPIO3	User-defined Switch 2 (pull-up)
6	I2C0	SDA (RTC)
7	I2C0	SCL (RTC)
9	GPIO6	User-defined Switch 3 (pull-up)
10	GPIO7	User-defined Switch 4 (pull-up)
11	UART1	Tx (radio1)
12	UART1	Rx (radio1)
16	GPIO12	PIO (UART Tx) (GNSS)
17	GPIO13	PIO (UART Rx) (GNSS)
19	I2C1	SDA (Compass)
20	I2C1	SCL (Compass)
21	SPI0	MISO (SD)
22	SPI0	/CS (SD)
24	SPI0	SCK (SD)
25	SPI0	MOSI (SD)
26	GPIO20	SD Busy LED
27	GPIO21	Battery LED
29	GPIO22	ACT (button)
34	GPIO28	PIO (WS2812B)

4.2 Logger USB Console

The logger starts a 115200 baud serial terminal during boot. A logger programmed using Raspberry Pi Pico SDK has USB Vendor ID 0x2E8A, Product ID 0x0009 or 0x000A. On GNU/Linux, it would appear as a communications device class abstract control model device, usually `/dev/ttyACM*`. On macOS, it might appear as a call-out device, usually `/dev/cu.*`.

If the RTC time is lost or bogus, the logger asks for input from this console. There are several commands available: `y` (year, last 2 digits), `m` (month), `d` (day), `u` (day of week), `H` (hour), `M` (minute), `S` (second), `p` (print current time), `^X` (write the time to RTC), `^G` (quit). For commands starting with `^`, press Control and type the followed letter.

For example, to set time to 2026-02-28 12:34:56, save, then quit, the commands are:

```
y26m02d28H12M34S56^X^G
```

Alternatively, the `settime.sh` script in the repository may also be used on a GNU/Linux or a UNIX machine.

5 Logger File System

The file system on the SD card needs to be FAT, which has a DOS partition table, one primary partition numbered 1 with type 0b (W95 FAT32). The `mklogfs.sh` script in the repository may be used on a GNU/Linux or UNIX machine to make the file system for the logger.

After making the file system, the following files should be manually created:

- "`NODENAME.TXT`": the node names, one per line.
- "`MYNAME.TXT`": this node's name.

The following files are optional for the logger to automatically trigger transmission on both radios periodically:

- "`AUTOTX.INT`": a single line containing an automatic transmission interval, in milliseconds.

- "AUTOTX.STR": automatic transmission packet string, which accepts the following format specifier:
  - "%n": the node's name, read from "MYNAME.TXT".
  - "%t": the time at transmission, read from the RTC.

The following files will be generated by the logger:

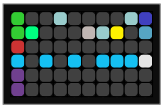
- "META.LOG": meta logs.
- "$mmddHHMM$.TXT": logs first generated on mm month dd day at HH:MM.

There is an LED indicating whether the SD card is busy. Do not eject the SD card when the LED is on.

6 Logger Display and Error Messages

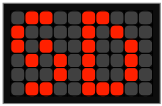
6.1 Logger Display

The logger displays the nodes and the received packets on the matrix display using different colors and brightness. The nodes are displayed in the leftmost row, in the order defined in "NODENAME.TXT". The online nodes (received at least one message) are displayed in green (see rows 1 and 2); the offline nodes (no received messages) are displayed in red (see row 3); the sender node defined in "MYNAME.TXT" is displayed in cyan (see row 4); the unused columns are displayed in dark purple (see rows 5 and 6). When a message is received, it is displayed in high brightness on the row corresponding to the sender, in column 2. It then changes to normal brightness and shifts right until it reaches the last column. The color is a combination of the message's RSSI (blue) and SNR (green). The last column indicates the number of received messages; its color transitions from blue to cyan and then white, while its brightness increases to reflect the rising message count.

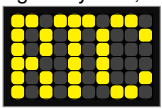


6.2 Logger Error Messages

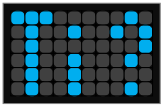
The logger outputs the detailed error messages to the micro USB console. As it is not always possible to connect the logger to a computer, the logger also displays some of the error messages to the matrix display. Below is a list of possible error displays and their meanings.



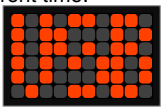
(SD) There is an error related to the SD card or its file system, such as the SD card not being detected, wrong file system, or a file not found.



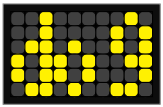
(RTC) There is a communication error with the RTC, or the RTC returned a bogus date/time.

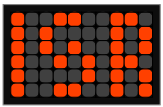


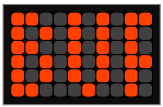
(Ti?) The logger cannot determine the current time.

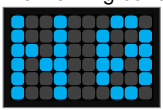


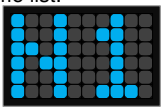
(USB) An action is required to be done via the USB serial console.

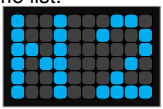

(dog) Watchdog triggered a reboot.

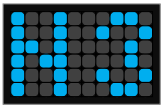

(ISR) There is an error during an Interrupt Service Routine that cannot be safely handled.

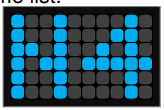

(BUF) There is an unavoidable buffer overflow or ring buffer overflow.

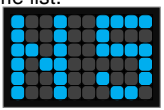

(N0) This is the 0th node in the node name list.

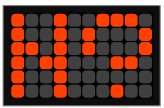

(N1) This is the 1st node in the node name list.

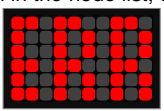

(N2) This is the 2nd node in the node name list.

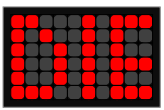

(N3) This is the 3rd node in the node name list.


(N4) This is the 4th node in the node name list.


(N5) This is the 5th node in the node list.


(N?) Cannot determine this node’s position in the node list, or the position is greater than 5.


(ERR) There is an error.


(DIE) There is an error and the logger decides to wait to be killed by the watchdog.

7 Power

7.1 ORing

There are multiple voltage input options to power the instrument. The built-in diode in Raspberry Pi Pico, the MAX40200 ideal diode (U3, U4), the DMG2305UX P-channel MOSFET (Q1), and the Schottky diodes (D2, D3) can be used to OR the circuitry and prevent back-powering the voltage sources. The power source with the highest voltage should be used.

There are 8 possible power inputs: Logger USB (L), Radio0 USB (R0U), Radio0 LiPo battery (R0B) (fused), Radio1 USB (R1U), Radio1 LiPo battery (R1B), USB-C (J1), JST/screw terminal (J2), and micro USB-B (J3).

Due to a design defect, some of the power inputs are not properly protected. Please refer to the table below for possible configurations.

Protected Inputs Combination	Condition
L, R0B, J1, J2, J3	
L, R0U, R0B, J1, J2, J3	JP1 open
L, R0U, R0B, J1, J2, J3	SW3 No effect
L, R1U, R1B, J1, J2, J3	JP2 open
L, R1U, R1B, J1, J2, J3	SW2 shorts Pwr
L, R0U, R0B, R1U, R1B, J1, J2, J3	JP1, JP2 open
L, R0U, R0B, R1U, R1B, J1, J2, J3	SW3 No effect, SW2 shorts Pwr

7.2 Absolute Maximum Ratings

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum ratings for extended periods may affect device functionality. The ratings for LiPo batteries are not considered in the Absolute Maximum Ratings. The ratings are at ambient temperature $T_A = +25\,^{\circ}\mathrm{C}$ unless otherwise noted.

Parameter	Symbol	Value	Unit
Max Operating Temp	T_{max}	70	°C
Min Operating Temp	T_{min}	−20	°C
Max Voltage on J1	$V_{\text{J1,max}}$	5.5	V
Min Voltage on J1	$V_{\text{J1,min}}$	2.15	V
Max Voltage on J2	$V_{\text{J2,max}}$	5.5	V
Min Voltage on J2	$V_{\text{J2,min}}$	2.15	V
Max Voltage on J3	$V_{\text{J3,max}}$	5.5	V
Min Voltage on J3	$V_{\text{J3,min}}$	2.15	V
Max Voltage on Radio0 LiPo	$V_{\text{BATT,max}}$	5.5	V
Min Voltage on Radio0 LiPo	$V_{\text{BATT,min}}$	2.15	V
Max Voltage on Radio USB	$V_{\text{Radio,max}}$	5.5	V
Min Voltage on Radio USB	$V_{\text{Radio,min}}$	4.5	V

7.3 Battery Voltage Detection

Pin 31 of the logger Raspberry Pi Pico is configured as ADC0. A voltage divider with two 680 kΩ resistors (R5 and R6) is built to halve V_{BATT}. The BATT LED blinks in a pattern to indicate a battery voltage range.

Voltage Range/V	Blink Pattern (every 10 s)
≤ 0.16	● ● ● ●
(0.16, 2.9]	• • • • • • • • • •
(2.9, 3.3]	• • • • • •
(3.3, 4.5)	•
≥ 4.5	● ●

8 Electrical Characteristics

Parameter	Symbol	MIN	TYP	MAX	Unit	Condition
J5 3V3 Pin Voltage	V_{3V3}		3.3		V	LoRaLogger properly powered
J5 3V3 Pin Current	I_{3V3}			500	mA	
J5 LED Pin Voltage	$V_{s,\mathrm{LED}}$		3.3		V	LoRaLogger properly powered
J5 LED Pin Current	I_{LED}		24	59	mA	R3 = R4 = 56 Ω, $V_{f,\mathrm{LED}} = 1.95$ V
J5 LED Forward Voltage	$V_{f,\mathrm{LED}}$		1.95		V	R3 = R4 = 56 Ω
J6 V Pin Voltage Input	$V_{\mathrm{I,radio1}}$	1.8	5.0	5.5	V	Radio1 isolated from main board
UART Tx Voltage High	$V_{\mathrm{OH,UART}}$	1.24	3.3	3.63	V	
UART Tx Voltage Low	$V_{\mathrm{OL,UART}}$	0	0	0.5	V	
UART Rx Voltage High	$V_{\mathrm{IH,UART}}$	2	3.3	3.93	V	
UART Rx Voltage Low	$V_{\mathrm{IL,UART}}$	−0.3	0	0.63	V	
Logger Current+	I_{logger}	0.30[a]	0.36	1.58[b*]	A	$V_{\mathrm{logger}} = 5$ V
Single Radio Current	I_{radio}	0.30[c]	0.38[d]	1.08[e*]	A	$V_{\mathrm{radio}} = 5$ V

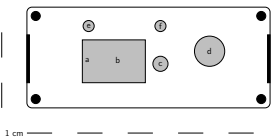
(+) Including the Adalogger and the matrix display.
(a) The display is switched off.
(b) The display shows the start-up splash screen.
(c) The radio is in Rx mode (idle).
(d) Mean current when the radio transmits a packet every 20 s.
(e) The radio is transmitting.
(*) Excluding the spikes for charging the capacitors. The spike current for each module can be up to 1 A.

9 Example Housing

The LoRaLogger can be installed into a 90 mm × 90 mm × 40 mm housing. Extra space is suggested if the antennas are installed on the front or rear opening.

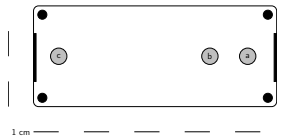
Below is an example of the front and rear panels for a 90 mm × 90 mm × 40 mm housing (scale 1:3).

LoRaLogger Housing, Front Panel, Outside View



(a) µSD; (b) Disp; (c) Pwr Sw, Ø 6; (d) Act, Ø 12; (e–f) LED, Ø 4.4 mm

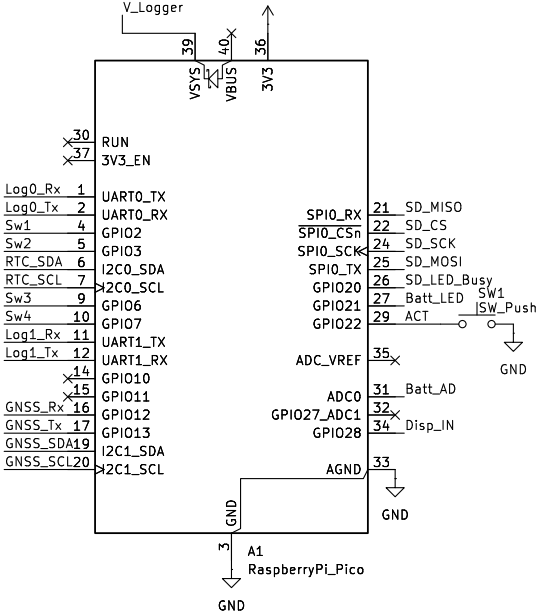
LoRaLogger Housing, Rear Panel, Inside View



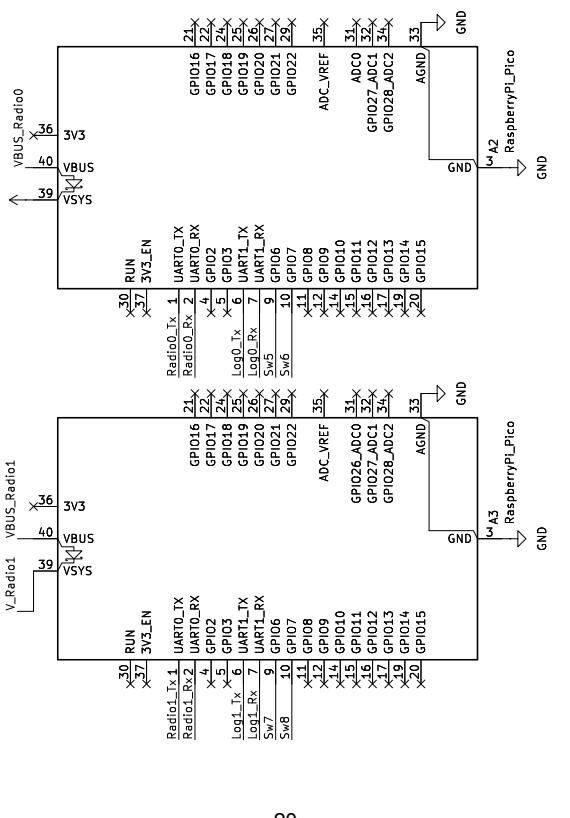
(a) SMA, Ø6.5 mm; (b) GNSS; (c) SMA, Ø 6.5mm

10 Schematic

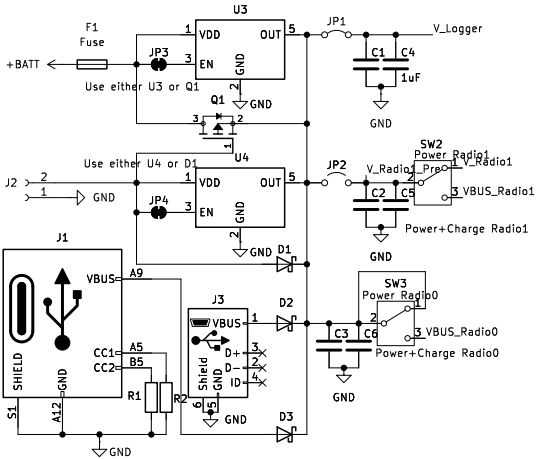
10.1 Logger



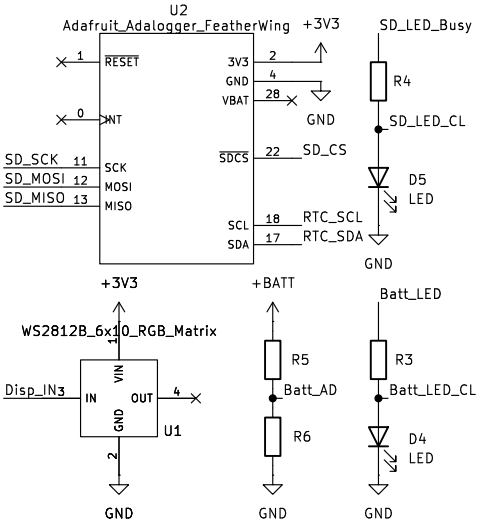
10.2 Radios


VBUS_Radio0
3V3
VBUS
VSYS
RUN
3V3_EN
UART0_TX
UART0_RX
GPIO2
GPIO3
UART1_TX
UART1_RX
GPIO6
GPIO7
GPIO8
GPIO9
GPIO10
GPIO11
GPIO12
GPIO13
GPIO14
GPIO15
GPIO16
GPIO17
GPIO18
GPIO19
GPIO20
GPIO21
GPIO22
ADC_VREF
ADC0
GPIO27_ADC1
GPIO28_ADC2
AGND
GND
Radio0_Tx
Radio0_Rx
Log0_Tx
Log0_Rx
Sw5
Sw6
A2
RaspberryPI_Pico
V_Radio1
VBUS_Radio1
Radio1_Tx
Radio1_Rx
Log1_Tx
Log1_Rx
Sw7
Sw8
A3
RaspberryPI_Pico

10.3 Power


U3
F1
Fuse
+BATT
JP3
VDD
OUT
EN
GND
JP1
V_Logger
C1
C4
1uF
GND
Use either U3 or Q1
Q1
GND
U4
Use either U4 or D1
J2
GND
JP4
JP2
SW2
Power Radio1
V_Radio1
Pre
VBUS_Radio1
C2
C5
Power+Charge Radio1
J1
VBUS
A9
D1
SW3
Power Radio0
J3
D2
SHIELD
CC1
CC2
A5
B5
D+
D-
ID
C3
C6
VBUS_Radio0
Power+Charge Radio0
R1
R2
S1
A12
D3

10.4 RTC, Matrix, Voltage Divider, LED



These schematics are provided as a reference and may be different from the actual instrument.

11 Bill of Materials

Reference	Value	Manufacturer Part Number	Qty
R1, R2	5K1	RMCF1206JT5K10	2
R3, R4	56R	RC1206JR-0756RL	2
R5, R6	680K	RC1206FR-10680KL	2
C1–C3	10uF	ESH106M035AC3AA	3
C4–C6	1uF	CL31B105KAHNNNE	3
D1–D3	SS22	SS22AF	3
D4	LED-Yellow	APTR3216SYCK	1
D5	LED-Red	APT3216SURCK	1
F1	1A	SF-1206FP100-2	1
J3	USB-B-Micro	1050170002	1
J1	USB-C	USB4125-GF-A-0190	1
J2	JST-PH-B2B-K	B2B-PH-K-S(LF)(SN)	1
J4, J6	02x03	RS2-06-G	2
J5	02x05	RS2-10-G	1
JP1, JP2	01x02	67997-400HLF	2
SW2, SW3	01x03	PR20203VBNN	2
SW4	DIP-x08	DS01C-254-S-08BE	1
SW1	Push	TS02-66-60-BK-160-LCR-D	1
Q1	DMG2305UX-7	DMG2305UX-13	1
U3, U4	MAX40200AUK	MAX40200AUK+T	2

Raspberry Pi Picos and their header sockets, radios, jumpers, matrix displays and additional header pins are excluded from the BOM.

The footprints for R1–R6, C4–C6, D4, D5, and F1 are 1206 (metric: 3216). The footprints for D1–D3 are SMAF.

12 Environment



This instrument falls under the Waste Electrical and Electronic Equipment (WEEE) Directive. At the end of its life, it should be taken to an appropriate collection point for recycling and recovery of electronic equipment.

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