Raspberry Pi Radio Module 2

A wireless communication module for Raspberry Pi microcontrollers

Colophon

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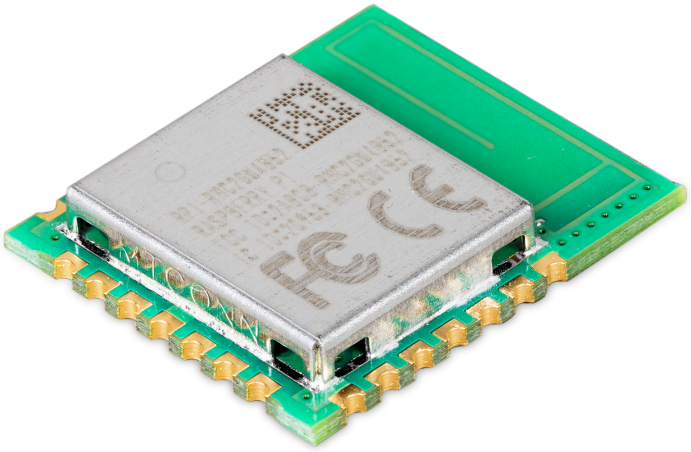
Table of Contents

Chapter 1. Introduction

Raspberry Pi Radio Module 2 (RM2) is a compact, self-contained Wi-Fi and Bluetooth® radio module designed to add wireless connectivity to Raspberry Pi's low-cost, high-performance microcontrollers. With minimal external components (requiring only SPI, power, and reset signals), RM2 is a cost-efficient solution for adding wireless connectivity in mass-produced devices. It also provides GPIO expansion options for added flexibility.

Figure 1.
Raspberry Pi Radio Module 2



1.1. Features

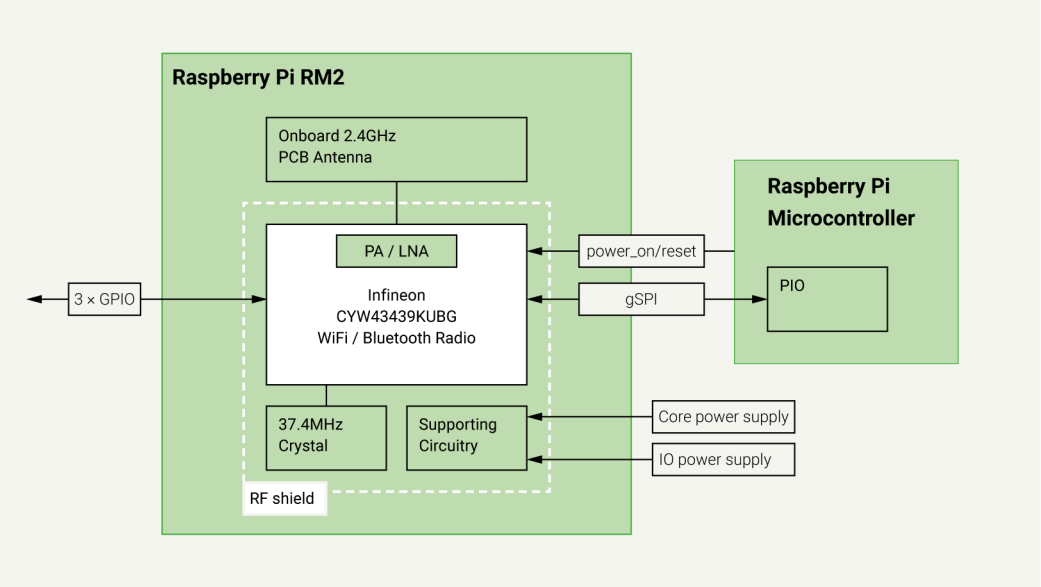
Using the **Infineon CYW43439** combo chip in a 1x1 single-band configuration, RM2 delivers reliable **2.4 GHz Wi-Fi 4 (802.11b/g/n)** and **Bluetooth® 5.2** connectivity. It features castellated edge pads (pins) for versatile mounting and integrates a shared 2.4 GHz antenna for both Wi-Fi and Bluetooth signals, simplifying hardware design. Specifically, RM2 offers the following features:

- **Wi-Fi Support.** Wi-Fi 4 (802.11b/g/n), single-band (2.4 GHz).
- **Bluetooth 5.2 support.** Bluetooth Classic and Bluetooth Low Energy (LE).
- **Compatibility.** Full software compatibility with Pico W and Pico 2 W SDK.
- **Simple GPIO expander.** Three host-controlled GPIOs for added I/O capabilities.
- **Modular wireless certification (region-specific).** Simplifies compliance with regulatory requirements.
- **Minimal I/O overhead.** Low-pin-count gSPI host interface allows for simplified integration with minimal I/O requirements.
- **Efficient single-antenna design:**
  - SISO (Single Input, Single Output) configuration supports efficient single-antenna wireless performance.
  - Shared antenna for Wi-Fi and Bluetooth.
- **Connectivity.** Integrated internal PA and LNA for signal range and reliability.
- **Speed.** Supports 20 MHz channels with data rates up to 96 Mbps (PHY rate).
- **Wide operating temperature range.** –30°C to +70°C.
- **Low power consumption:**
  - IEEE Power Save PM1 DTIM1 average rate 1: 1.19 mA
  - Receive active rate MCS7 (at –50 dBm): 43 mA
  - Transmit active rate MCS7 (at 16 dBm): 271 mA

1.2. Architecture

The following diagram shows the architecture of a Raspberry Pi RM2 (left) connected to a Raspberry Pi microcontroller (right) through a general-purpose SPI (gSPI) interface, reset signal, and power rail. The Infineon chip in the RM2 handles wireless communication signals, and the on board PCB antenna is shared for both Wi-Fi and Bluetooth radios.

Figure 2.
Block diagram of an RM2 connected to a Raspberry Pi microcontroller



- **Raspberry Pi RM2.** The communication module that enables wireless (Wi-Fi or Bluetooth) connectivity.
- **Raspberry Pi Microcontroller.** The host CPU that interfaces with an RM2. The host CPU can be any of Raspberry Pi's microcontrollers.
- **Onboard 2.4 GHz PCB Antenna.** The shared antenna used to transmit and receive wireless signals, both Wi-Fi and Bluetooth (BT/BLE).
- **Infineon CYW43439KUBG WiFi / Bluetooth Radio.** The core integrated circuit (IC) responsible for managing Wi-Fi and Bluetooth communication. This chip includes built-in **PA / LNA** (power and low-noise amplifiers) to enhance signal strength, range, and reliability.
- **37.4 MHz Crystal.** A dedicated crystal that provides a precise timing reference for RM2.
- **Supporting Circuitry.** Power supply that allows the RM2 to operate from a single external power rail (typically 3.3 V).
- **3 x GPIO.** Three General Purpose Input Output (GPIO) lines that connect from the microcontroller to the RM2 for additional control and signalling.
- **Power_on/reset.** The reset line, used to reset the RM2 from the microcontroller.
- **gSPI.** The general SPI (Serial Peripheral Interface) bus for communication between the microcontroller and the RM2. This is implemented in software through the **PIO** core in the Raspberry Pi microcontroller.
- **PIO.** Programmed Input / Output (PIO) hardware in the host CPU (microcontroller) that implements the **gSPI** communication between the RM2 and the host CPU.
- **Core power supply.** The power supply input that provides the main operating voltage for RM2.
- **IO power supply.** The power supply input that powers the I/O interfaces and allows voltage-level compatibility with the microcontroller.
- **RF shield.** A metallic shield that surrounds the radio components to reduce electromagnetic interference (EMI) and protect radio frequency (RF) integrity.

1.3. Main components

RM2 is a standalone wireless connectivity solution consisting of a fully supported software stack and hardware interfaces designed to pair with Raspberry Pi microcontrollers. This section describes the main components that allow RM2 to integrate Wi-

Fi and Bluetooth functionality with Raspberry Pi microcontrollers, including its radio hardware, supported CPUs, antenna design, and software stack.

1.3.1. Wireless radio (CYW43439)

At the core of RM2 is the **CYW43439 wireless radio** made by Infineon. This integrated circuit (IC) chip delivers a balance of radio frequency (RF) performance, integration, and power consumption. Raspberry Pi uses Infineon radios across multiple products, including Raspberry Pi Pico 2 W, and Raspberry Pi Compute Modules 4 and 5.

For more information about the CYW43439, see Infineon's documentation: https://www.infineon.com/cms/en/product/wireless-connectivity/airoc-wi-fi-plus-bluetooth-combos/wi-fi-4-802.11n/cyw43439/.

1.3.2. Host integration

RM2 is exclusively designed for **Raspberry Pi microcontrollers** and is not compatible with other platforms. The RM2 system and firmware (including the firmware running in the CYW43439) is bespoke, and tightly integrated with Raspberry Pi software and hardware.

RM2 is designed to be paired with host software and a gSPI interface enabled through the programmable PIO cores present in all of the Raspberry Pi microcontrollers. Use of RM2 with non-Raspberry Pi microcontrollers is unsupported. This means that attempts to integrate RM2 with other platforms will likely fail due to incompatible interfaces, firmware dependencies, and lack of required PIO-based gSPI support.

The following GPIO definitions indicate how a Raspberry Pi microcontroller connects to an RM2. Some signals are multiplexed or share GPIOs, and certain lines require external components such as series resistors.

Table 1.
GPIO connections needed to communicate with Raspberry Pi Radio Module 2

C code define	Purpose	Microcontroller default GPIO	Modules Pin
`CYW43_DEFAULT_PIN_W_REG_ON`	Regulator on to power up CYW43	23	6, 7
`CYW43_DEFAULT_PIN_WL_DATA_OUT`	SPI data out from CYW43	24; all three signals must share the same GPIO pin	5, 6 via a 470 Ω resistor
`CYW43_DEFAULT_PIN_WL_DATA_IN`	SPI data in to CYW43		
`CYW43_DEFAULT_PIN_WL_HOST_WAKE`	Interrupt from the CYW43 to indicate there's work for the host to do		
`CYW43_DEFAULT_PIN_WL_CLOCK`	SPI clock	29	3
`CYW43_DEFAULT_PIN_WL_CS`	SPI chip select	25	9

To enable communication between an RM2 module and Raspberry Pi microcontroller, RM2 relies on software provided by the **Raspberry Pi Pico SDK**. The Pico SDK handles communication with the onboard CYW43439 wireless radio, which requires the following configurations:

- **Firmware loading.** The Pico SDK supports the CYW43 only if `PICO_CYW43_SUPPORTED` is set to `true`.
- **SPI communication.** Communication between the host and RM2 is handled through the PIO-based gSPI interface.
- **Runtime control.** SPI clock defaults to approximately 31.25 MHz when the system clock is 125 MHz.

For more information about the Pico SDK software, see Section 1.3.3. Software.

NOTE

If the system clock frequency is changed, you might need to update the PIO clock divisor or modify the PIO program accordingly. For an example of how to change the clock divisor, see Pico W blink slow in the SDK on GiHub.

1.3.3. Software

RM2 uses existing software provided by the **Pico SDK**, which handles initialisation, communication, and runtime control of the **CYW43439** wireless radio. This is modelled on proven software architecture used in products like the **Pico W** and **Pico 2 W**, offering a familiar and reliable development experience.

Key aspects of the software integration include:

- The software for the CYW43439 is loaded at RM2 boot by the drivers in the Pico SDK.
- The software is precompiled and can't be modified.
- The software is transmitted over the gSPI bus.
- The Wi-Fi and Bluetooth stacks follow the same architecture as in Pico W and Pico 2 W.

Wi-Fi

Wi-Fi is handled by Raspberry Pi's proprietary firmware bundled in the Pico SDK. This firmware is precompiled and loaded to boot over the gSPI interface. It provides support for standard Wi-Fi networking features through the SDK's networking libraries.

Bluetooth

The Pico SDK uses the **BlueKitchen's BTstack** to provide Bluetooth functionality and is licensed for use with RM2. BlueKitchen's BTstack is an open-source Bluetooth stack that supports classic Bluetooth and Bluetooth Low Energy (BLE).

- For information about BlueKitchen's BTstack, view the README file on GitHub: https://github.com/bluekitchen/btstack?tab=readme-ov-file.
- To read the license for use with RM2, open it on GitHub: https://github.com/raspberrypi/pico-sdk/blob/master/src/rp2_common/pico_btstack/LICENSE.RP.

GPIO expansion

The CYW43439 exposes three GPIO pins over SPI, which can be read or controlled from the host, but only when the chip is powered and communication is active.

On Pico W and Pico 2 W, these GPIO pins are used for fixed functions: the onboard LED, SMPS power save, and VBUS sensing. On RM2, these GPIO pins are available for general-purpose use, offering more flexibility.

1.3.4. Antenna

RM2 features a custom, in-house antenna design developed by Raspberry Pi that ensures reliable wireless performance.

Unlike previous models, such as Pico 2 W, Zero 2 W, and so on, which use an antenna design licensed from Abracon, RM2 uses an inverted F-style antenna designed by Raspberry Pi. This design is tailored for integration with RM2's form factor and RF characteristics for optimal RF performance.

To ensure optimal performance in your hardware designs, we recommend that you follow the guidance outlined in Section 2.4. PCB footprint, which provides guidance for placement and clearance for effective antenna performance.

We also provide antenna pattern documentation to help you plan your module placement. You can access this documentation from: https://pip.raspberrypi.com/categories/602-antenna-patterns. You need a Raspberry Pi Product Information Portal (PIP) account to view this information.

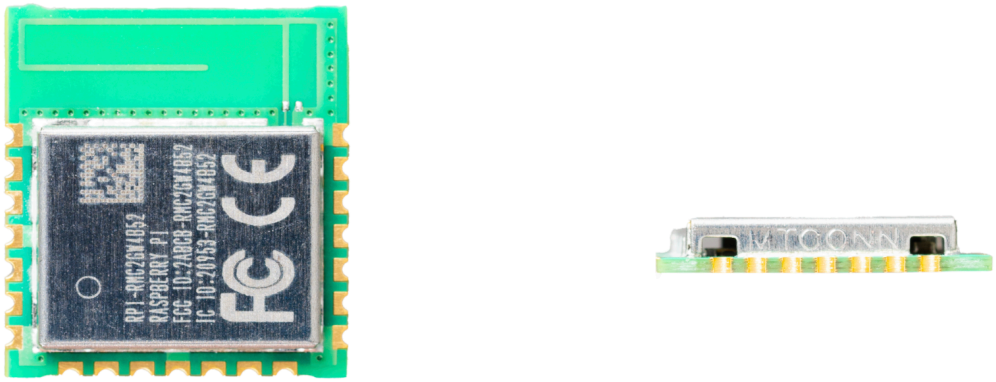
Chapter 2. Specifications

This section includes detailed technical descriptions of RM2's components and capabilities, including its dimensions, package markings, PCB footprint, pinout, electrical specifications, radio frequency specifications, storage and operating requirements, and solder profile.

2.1. Physical specifications

Figure 3 provides a visual reference of RM2 from the top and side. The image shows the external layout and physical connectors of RM2, including a 21-pin castellated package consisting of 1.5mm pitch gold contacts. These castellations are plated half-holes that allow for secure soldering onto another PCB, enabling an RM2 to be surface-mounted like a component. For more detail about the pins in RM2, see Section 2.5. Pinout.

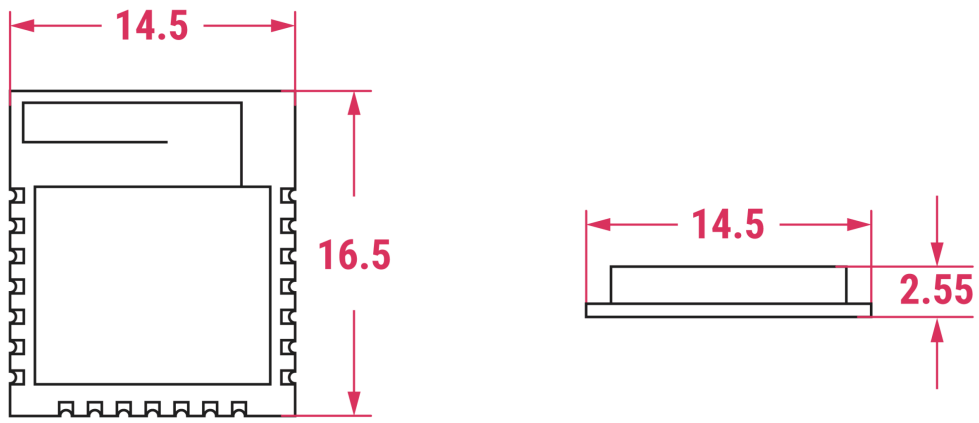
Figure 3.
Raspberry Pi Radio Module 2 from the top and the side



2.2. Mechanical specifications

The mechanical diagram in Figure 4 illustrates the approximate shape and dimensions of RM2, oriented to match the previous image (Figure 3). RM2's PCB is made from flame-retardant FR4 material and features 21 edge-plated castellated pins for mounting onto other boards, finished with a high-quality nickel/gold coating (ENIG) for reliable soldering. For more detail about the pins in the RM2, see Section 2.5. Pinout.

Figure 4.
Mechanical diagram of Raspberry Pi Radio Module 2 from the top and the side; dimensions are in millimetres (mm)



The approximate dimensions of RM2 depicted in Figure 4 are as follows:

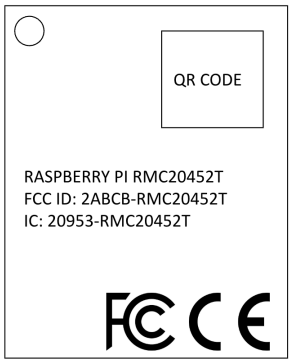
- Width: 14.5 mm
- Height: 16.5 mm
- Depth (thickness): 2.55 mm

2.3. Package markings

Figure 5 shows how the RM2 package is marked.

- The first line of text is the full product code, made up of **RASPBERRY PI** plus the RM2 part number: **RMC20452T**. For information about what **RMC20452T** means, see Section 4.2. Part number.
- The second line of text is the Federal Communications Commission identifier (**FCC ID**).
- The third line of text is the Industry Canada (**IC**) identifier.
- The logos at the bottom of the package indicate that RM2 meets regulatory standards in the USA (FCC compliance) and EU (Conformité Européenne compliance).

Figure 5.
Package marking format for Raspberry Pi Radio Module 2



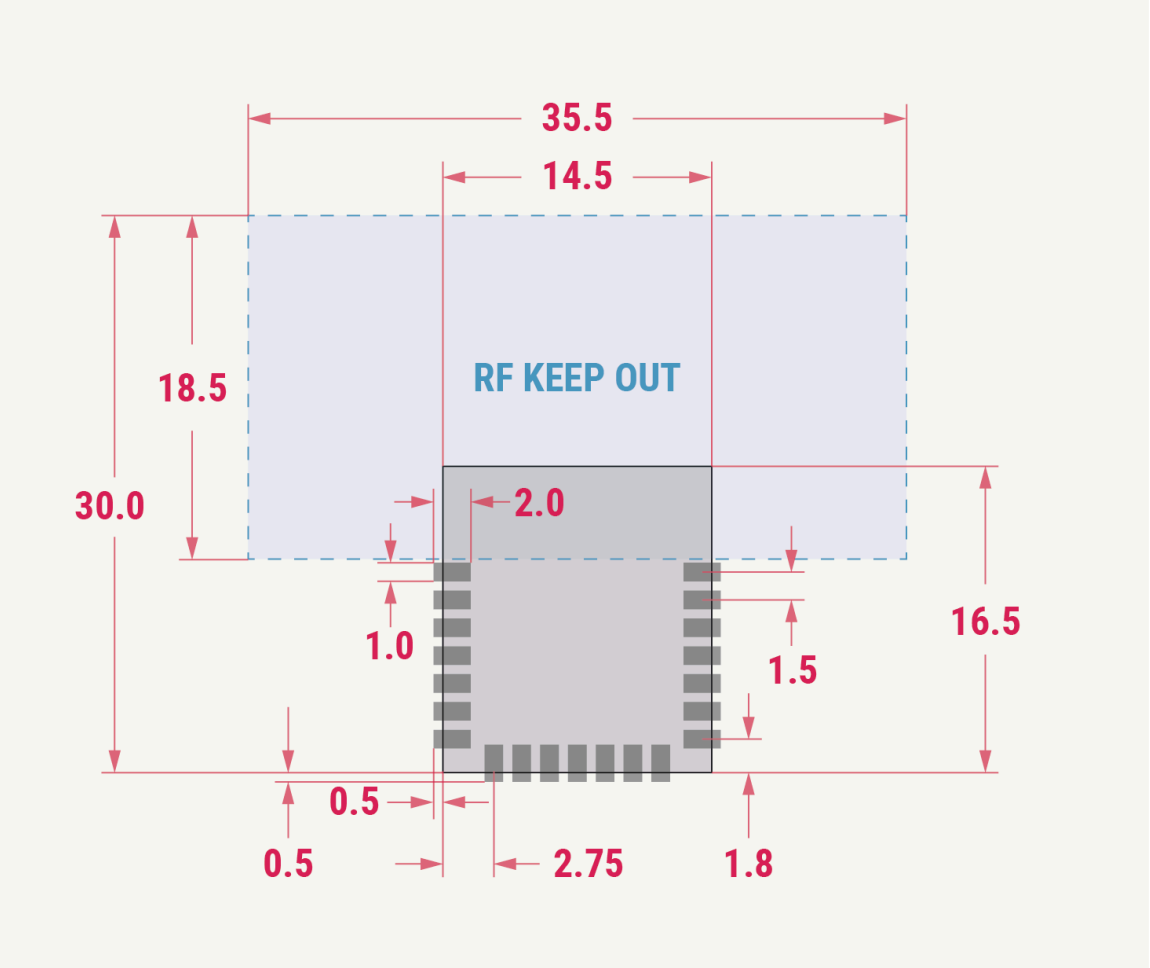
2.4. PCB footprint

The following diagram is a printed circuit board (PCB) footprint (Figure 6) of the RM2 module:

- The pink numbers, lines, and arrows represent mechanical measurements in millimetres (mm).

- The blue dashed box above pins 1 and 21 represents the “keep out area”, which is the minimum region around the pins that must remain free of any metal.
- The dark grey boxes represent the castellated edge pads (21 total), used to mount an RM2 to your PCB.
- The lighter grey box represents an RM2's physical boundary.

Figure 6.
PCB footprint diagram laying out the antenna placement and castellated edge pads for Raspberry Pi Radio Module 2



2.5. Pinout

RM2 includes 21 pins (pads). The following diagram (Figure 7) numbers the pins, starting with **Pin 1** in the top left, continuing counter-clockwise to **Pin 8** on the left side of the bottom row and **Pin 14** on the right side of the bottom row, and finishing with **Pin 21** in the top right.

Figure 7.
Mechanical diagram of Raspberry Pi Radio Module 2 with the pins numbered counter-clockwise, starting from the top left

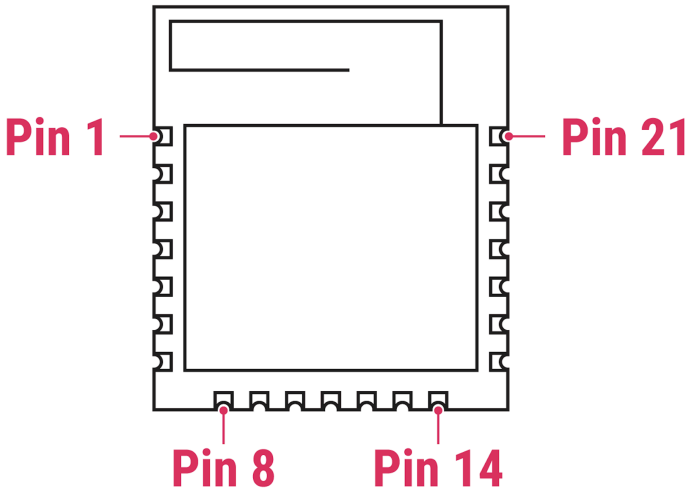


Table 2 lists the default software configuration for each pin in an RM2. It summarises how each pin in an RM2 is connected and what function it serves by default. These defaults match in **Pico W** configuration. You can change the default GPIO assignments at build time. For specific macro definitions, see Section 1.3.2. Host integration.

Table 2.
The function of each pin on a Raspberry Pi Radio Module 2

Pin	Description	Default connection
1	Ground	
2	No connect	
3	gSPI SCLK	GPIO29
4	Ground	
5	gSPI Data In	GPIO24
6	gSPI Data out	GPIO24 through a 470 Ω resistor
7	Ground	
8	GPIO0	
9	gSPI CS	GPIO25
10	nIRQ	GPIO24 through a 10 kΩ resistor
11	Ground	
12	Wi-Fi on	GPIO23
13	Bluetooth on	GPIO23
14	VDDIO (IO voltage either 3.3 V or 1.8 V)	3.3 V
15	Ground	
16	Vin (3.0 V to 4.8 V)	3.3 V
17	GPIO2	
18	GPIO1	
19	No connect	
20	No connect	
21	Ground	

2.6. Electrical specifications

RM2 requires a power supply between Vin 3.0 V to 4.8 V. A Vin of less than 3.2 V reduces RF performance. RM2 supports I/O voltages of either **1.8 V ±5%** or **3.3 V ±5%**. The following tables show the basic power consumption minimums and maximums for each I/O voltage.

Table 3 summarises the key voltage thresholds for RM2 when operating with an I/O voltage of 1.8 V ±5%.

Table 3.
Input and output voltage characteristics at 1.8 V ±5% I/O

VDDIO = 1.8 V	Symbol	Minimum	Typical	maximum
Input high voltage	VIH	0.65 × VDDIO	–	–
Input low voltage	VIL	–	–	0.35 × VDDIO
Output high voltage at 2 mA	VOH	VDDIO – 0.45 V	–	–
Output low voltage at 2 mA	VOL	–	–	0.45 V

Table 4 summarises the key voltage thresholds for RM2 when operating with an I/O voltage of 3.3 V ±5%.

Table 4.
Input and output voltage characteristics at 3.3 V ±5% I/O

VDDIO = 3.3 V	Symbol	Minimum	Typical	maximum
Input high voltage	VIH	2.0 V	–	–
Input low voltage	VIL	–	–	0.8 V
Output high voltage at 2 mA	VOH	VDDIO – 0.4 V	–	–
Output low voltage at 2 mA	VOL	–	–	0.4 V

Table 5 details the electrostatic discharge (ESD) specifications for RM2. The table summarises the maximum voltages that RM2 can safely withstand under various test conditions without sustaining damage.

Table 5.
Electrostatic discharge (ESD) specifications for Raspberry Pi Radio Module 2

Pin type	Symbol	Condition	ESD rating	Unit
ESD	ESD_HAND_HBM	Human body model contact discharge per JEDEC EID/ JESD22-A114	1000	V
Machine Model (MM)	ESD_HAND_HM	Machine model contact	30	V
CDM (MM)	ESD_HAND_CDM	Charged device model contact discharge per JEDC EIA/ JESD22-c101	300	V

For optimal RF performance, RM2 requires a good ground plane. Connect the ground of RM2 to the ground of the host system. The better the ground connections are, the lower inductance, and the better the RF performance. The area around the antenna must be clear of grounding to prevent shielding and de-tuning of the antenna.

2.7. Operating and storage conditions

To help to preserve shelf life and operating performance of the RM2, Table 6 lists recommended storage and operating conditions based on the environment (temperature and humidity).

Table 6.
Operating and storage conditions for the Raspberry Pi Radio Module 2

Environment	Value	Comments
Ambient operating temperature	−30°C to +70°C	Functionality is guaranteed, but specifications require de-rating at extreme temperatures.
Storage temperature	−40°C to +125°C	–
Relative operating humidity	Less than 85%	–
Relative storage humidity	Less than 60%	–

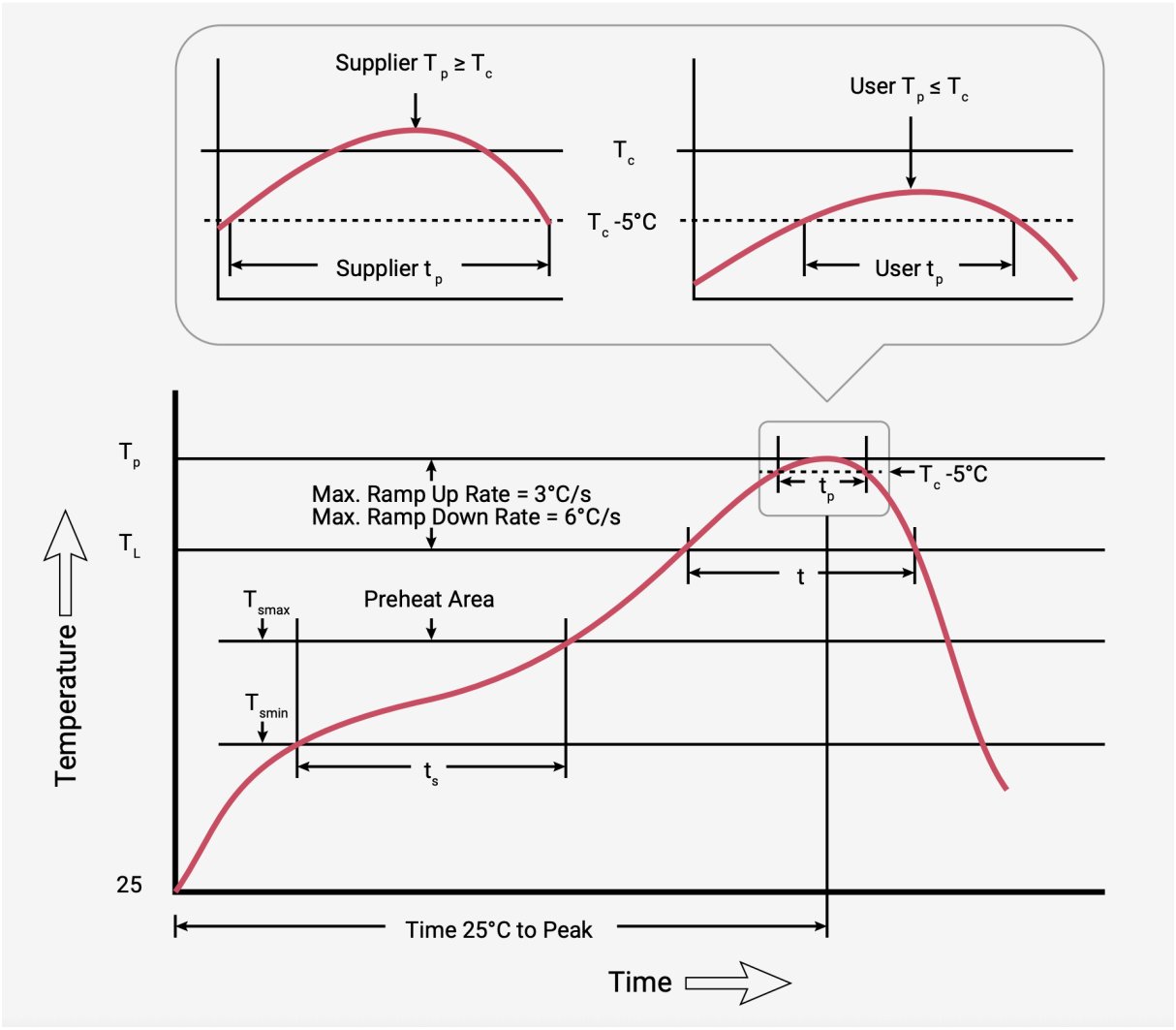
2.8. Solder profile

This section summarises the reflow soldering conditions during surface-mount assembly of RM2.

RM2 is a Pb-free component that must follow specific soldering profiles compliant with lead-free manufacturing regulations. RM2 has a peak temperature (T_p) of 260°C. This is the maximum temperature allowed at the centre of the module during reflow.

Temperature measurements should be taken at the top centre surface (live-bug orientation) of the RM2 body. If the module is reflowed upside down (dead-bug orientation), temperatures must be within ±2°C of the T_p (between 258°C and 262°C) and must still meet classification temperature T_c requirements during reflow. If you can't maintain the temperature within the required range in dead-bug orientation, you must adjust the reflow profile to meet the necessary thermal criteria.

Figure 8.
Classification reflow profile for Raspberry Pi Radio Module 2 (not to scale)



The classification profile depicted in Figure 8 shows the following:

- **Supplier condition (top left).** The module's ability to withstand a peak temperature (T_p) that's greater than or equal to the classification temperature (T_c) for a specified duration (T_p).
- **User (PCB assembler) condition (top right).** The actual reflow peak temperature (T_p) mustn't exceed the classification temperature (T_c) during production.
- **Complete reflow profile (bottom half).** The overall reflow curve from room temperature (~25°C) to peak temperature (T_p) and back down over time.

The classification reflow profile is for qualification and preconditioning purposes only; it isn't intended to specify a board assembly profile. Actual board assembly profiles must be developed based on specific process needs and board designs, and mustn't exceed the value outlined in Table 7, which lists the classification profile parameters.

Table 7.
Solder reflow profile values for Raspberry Pi Radio Module 2

Profile feature	Value
Temperature min (T_{smin})	150°C
Temperature max (T_{smax})	200°C
Time (T_s) from (T_{smin} to T_{smax})	60 to 120 seconds

Profile feature	Value
Ramp-up rate (T_L to T_p)	3°C/second max.
Liquidous temperature (T_L)	217°C
Time (t_L) maintained above T_L	60 to 150 seconds
Peak package body temperature (T_p)	260°C
Classification temperature (T_c)	260°C
Time (T_p) within 5°C of the specified classification temperature (T_c)	30 seconds
Ramp-down rate (T_p to T_L)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

Chapter 3. Compliance

RM2 is designed to comply with international radio regulations, offering pre-certified modular approval in key global markets. This section outlines RM2's certifications, and important safety and regulatory considerations for compliant use.

3.1. Certifications

RM2 is supplied fully tested and tuned by Raspberry Pi. This means that RM2's design doesn't require further RF tuning or module programming on your production line. You can access relevant product test reports, certifications, and integration test software through our **Product Information Portal (PIP)**: https://pip.raspberrypi.com.

RM2 comes with full modular approval in the following regions:

- European Union (EU)
- United Kingdom (UK)
- United States of America (USA)
- Canada

Modular approval means that you don't have to conduct full radio certification in these regions; you can integrate RM2 into your product with minimal additional testing.

If you need support with module integration or if you plan to use RM2 in regions beyond those listed above, contact the Global Market Access team at compliance@raspberrypi.com.

3.2. Warnings

To maintain regulatory compliance and ensure safe, reliable operation of RM2, follow the warnings in this section. These include requirements for power supplies and peripherals, as well as general handling guidelines to prevent damage or malfunction.

- **Device compatibility.** The connection of incompatible devices to the RM2 can compromise regulatory compliance, cause damage to the unit, and void the warranty.
- **Moisture.** Don't expose RM2 to water or moisture.
- **Heat.** Don't expose RM2 to heat; RM2 is designed for reliable operation at normal ambient temperatures. For information about temperatures for RM2, see Section 2.7. Operating and storage conditions.
- **Handling.** Handle with care to avoid mechanical and electrical damage to the printed circuit board and connectors.

Chapter 4. Purchasing information

Raspberry Pi RM2 is available to purchase from our worldwide network of approved resellers and distributors. To find approved resellers for RM2 in your region, visit https://www.raspberrypi.com/products/radio-module-2/?resellerType=industry.

4.1. Inventory management system information

Table 8 provides information for adding RM2 (indicated by part number **RMC20452T**) to your inventory management system, including packaging details (reel size), pricing (RRP), and regulatory identifiers.

Table 8.
Details needed to set RM2 up in your inventory management system

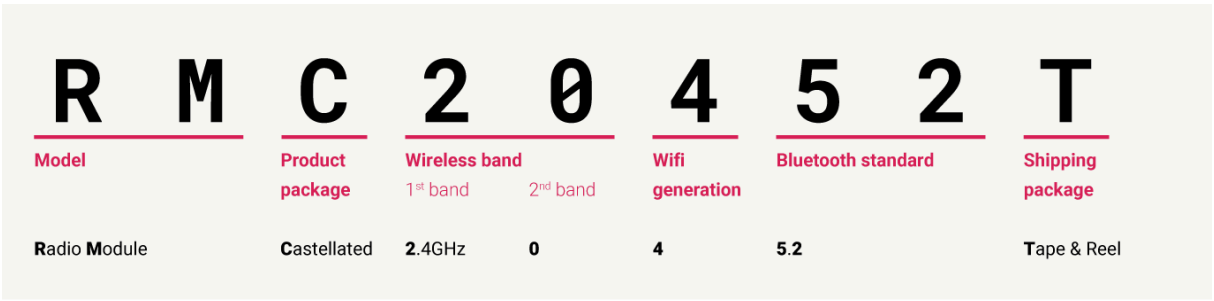
Part number	RMC20452T
Reel size	960
RRP	$4
Production lifetime	January 2036
HS code	8473302000

4.2. Part number

The part number, **RMC20452T**, corresponds to a specific configuration of RM2, and is derived as follows:

- **RM** refers to the model of the device and stands for **radio module**.
- **C** refers to the product package and indicates that the module is **castellated**. For more information about this feature, see Section 2.1. Physical specifications and Section 2.2. Mechanical specifications.
- **20** refers to supported radio frequency bands:
  - **2** indicates support for the **2.4 GHz** band.
  - **0** indicates that there is no second band.
- **4** refers to the Wi-Fi generation supported by the module: **Wi-Fi 4 (802.11b/g/n)**.
- **52** refers to the Bluetooth standard used by the module: **Bluetooth 5.2**.
- **T** refers to the package method: **Tape & Reel**, which is typical for surface-mount devices like RM2.

Figure 9.
Breakdown of the part number for Raspberry Pi Radio Module 2



Raspberry Pi