

# ESP32-S3-WROOM-1

# ESP32-S3-WROOM-1U

## Datasheet

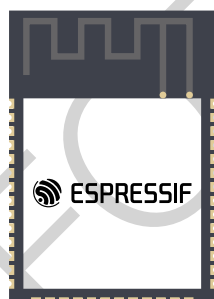
2.4 GHz Wi-Fi (802.11 b/g/n) and Bluetooth® 5 (LE) module

Built around ESP32-S3 series of SoCs, Xtensa® dual-core 32-bit LX7 microprocessor

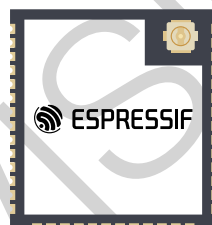
Flash up to 16 MB, PSRAM up to 8 MB

36 GPIOs, rich set of peripherals

On-board PCB antenna or external antenna connector



ESP32-S3-WROOM-1



ESP32-S3-WROOM-1U



Pre-release v0.5.1  
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# 1 Module Overview

**Note:**

Check the link or the QR code to make sure that you use the latest version of this document:

[https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1\\_datasheet\\_en.pdf](https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_datasheet_en.pdf)



## 1.1 Features

### CPU and On-Chip Memory

- ESP32-S3 series of SoCs embedded, Xtensa® dual-core 32-bit LX7 microprocessor, up to 240 MHz
- 384 KB ROM
- 512 KB SRAM
- 16 KB SRAM in RTC
- Up to 8 MB PSRAM

### Wi-Fi

- 802.11 b/g/n
- Bit rate: 802.11n up to 150 Mbps
- A-MPDU and A-MSDU aggregation
- 0.4  $\mu$ s guard interval support
- Center frequency range of operating channel: 2412 ~ 2484 MHz

### Bluetooth

- Bluetooth LE: Bluetooth 5, Bluetooth mesh
- 2 Mbps PHY
- Long range mode
- Advertising extensions
- Multiple advertisement sets

- Channel selection algorithm #2

### Peripherals

- GPIO, SPI, LCD interface, Camera interface, UART, I2C, I2S, remote control, pulse counter, LED PWM, USB 1.1 OTG, USB Serial/JTAG controller, MCPWM, SDIO host, GDMA, TWAI® controller (compatible with ISO 11898-1), ADC, touch sensor, temperature sensor, timers and watchdogs

### Integrated Components on Module

- 40 MHz crystal oscillator
- Up to 16 MB SPI flash

### Antenna Options

- On-board PCB antenna (ESP32-S3-WROOM-1)
- External antenna via a connector (ESP32-S3-WROOM-1U)

### Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature:
  - 85 °C version: -40 ~ 85 °C
  - 105 °C version: -40 ~ 105 °C
- Dimensions: See Table 1

## 1.2 Description

ESP32-S3-WROOM-1 and ESP32-S3-WROOM-1U are two powerful, generic Wi-Fi + Bluetooth LE MCU modules that have a rich set of peripherals. They provide acceleration for neural network computing and signal processing workloads. They are an ideal choice for a wide variety of application scenarios related to AI and

Artificial Intelligence of Things (AIoT), such as wake word detection, speech commands recognition, face detection and recognition, smart home, smart appliances, smart control panel, smart speaker, etc.

ESP32-S3-WROOM-1 comes with a PCB antenna. ESP32-S3-WROOM-1U comes with an external antenna connector. A wide selection of module variants are available for customers as shown in Table 1. All the module variants operate at  $-40 \sim 85 \text{ }^{\circ}\text{C}$  ambient temperature, except for ESP32-S3-WROOM-1-H4 and ESP32-S3-WROOM-1U-H4 that operate at  $-40 \sim 105 \text{ }^{\circ}\text{C}$  ambient temperature.

**Table 1: Ordering Information**

Ordering Code	Chip Embedded	Flash (MB)	PSRAM (MB)	Dimensions (mm)
ESP32-S3-WROOM-1-N4	ESP32-S3	4	0	18 × 25.5 × 3.1
ESP32-S3-WROOM-1-N8	ESP32-S3	8	0	
ESP32-S3-WROOM-1-N16	ESP32-S3	16	0	
ESP32-S3-WROOM-1-H4 (105 °C)	ESP32-S3	4	0	
ESP32-S3-WROOM-1-N4R2	ESP32-S3R2	4	2 (Quad SPI)	
ESP32-S3-WROOM-1-N8R2	ESP32-S3R2	8	2 (Quad SPI)	
ESP32-S3-WROOM-1-N16R2	ESP32-S3R2	16	2 (Quad SPI)	
ESP32-S3-WROOM-1-N4R8	ESP32-S3R8	4	8 (Octal SPI)	
ESP32-S3-WROOM-1-N8R8	ESP32-S3R8	8	8 (Octal SPI)	
ESP32-S3-WROOM-1-N16R8	ESP32-S3R8	16	8 (Octal SPI)	
ESP32-S3-WROOM-1U-N4	ESP32-S3	4	0	18 × 19.2 × 3.2
ESP32-S3-WROOM-1U-N8	ESP32-S3	8	0	
ESP32-S3-WROOM-1U-N16	ESP32-S3	16	0	
ESP32-S3-WROOM-1U-H4 (105 °C)	ESP32-S3	4	0	
ESP32-S3-WROOM-1U-N4R2	ESP32-S3R2	4	2 (Quad SPI)	
ESP32-S3-WROOM-1U-N8R2	ESP32-S3R2	8	2 (Quad SPI)	
ESP32-S3-WROOM-1U-N16R2	ESP32-S3R2	16	2 (Quad SPI)	
ESP32-S3-WROOM-1U-N4R8	ESP32-S3R8	4	8 (Octal SPI)	
ESP32-S3-WROOM-1U-N8R8	ESP32-S3R8	8	8 (Octal SPI)	
ESP32-S3-WROOM-1U-N16R8	ESP32-S3R8	16	8 (Octal SPI)	

At the core of the modules is an ESP32-S3 series of SoC \*, an Xtensa® 32-bit LX7 CPU that operates at up to 240 MHz. You can power off the CPU and make use of the low-power co-processor to constantly monitor the peripherals for changes or crossing of thresholds.

ESP32-S3 integrates a rich set of peripherals including SPI, LCD, Camera interface, UART, I2C, I2S, remote control, pulse counter, LED PWM, USB Serial/JTAG controller, MCPWM, SDIO host, GDMA, TWAI® controller (compatible with ISO 11898-1), ADC, touch sensor, temperature sensor, timers and watchdogs, as well as up to 45 GPIOs. It also includes a full-speed USB 1.1 On-The-Go (OTG) interface to enable USB communication.

**Note:**

\* For more information on ESP32-S3 series of SoCs, please refer to [ESP32-S3 Series Datasheet](#).

## 1.3 Applications

- Generic Low-power IoT Sensor Hub
- Generic Low-power IoT Data Loggers
- Cameras for Video Streaming
- Over-the-top (OTT) Devices
- USB Devices
- Speech Recognition
- Image Recognition
- Mesh Network
- Home Automation
- Smart Building
- Industrial Automation
- Smart Agriculture
- Audio Applications
- Health Care Applications
- Wi-Fi-enabled Toys
- Wearable Electronics
- Retail & Catering Applications

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## 2 Block Diagram

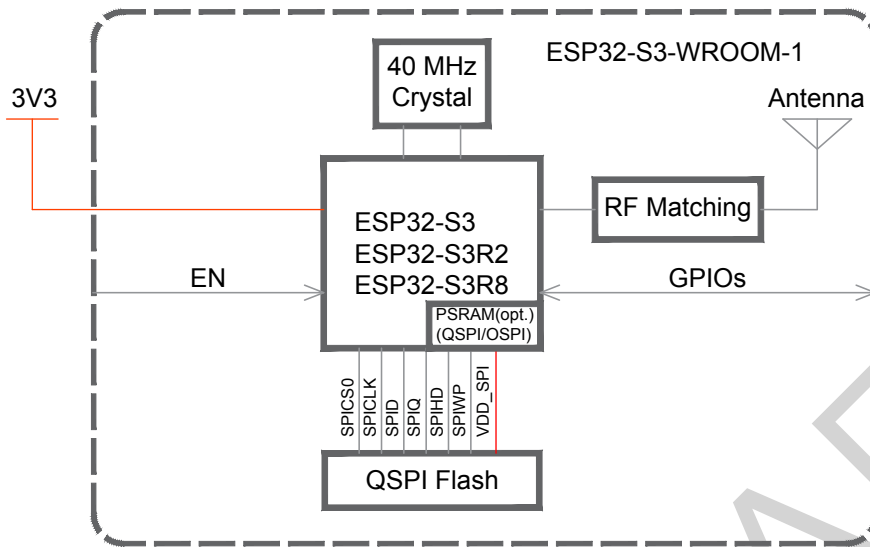


Figure 1: ESP32-S3-WROOM-1 Block Diagram

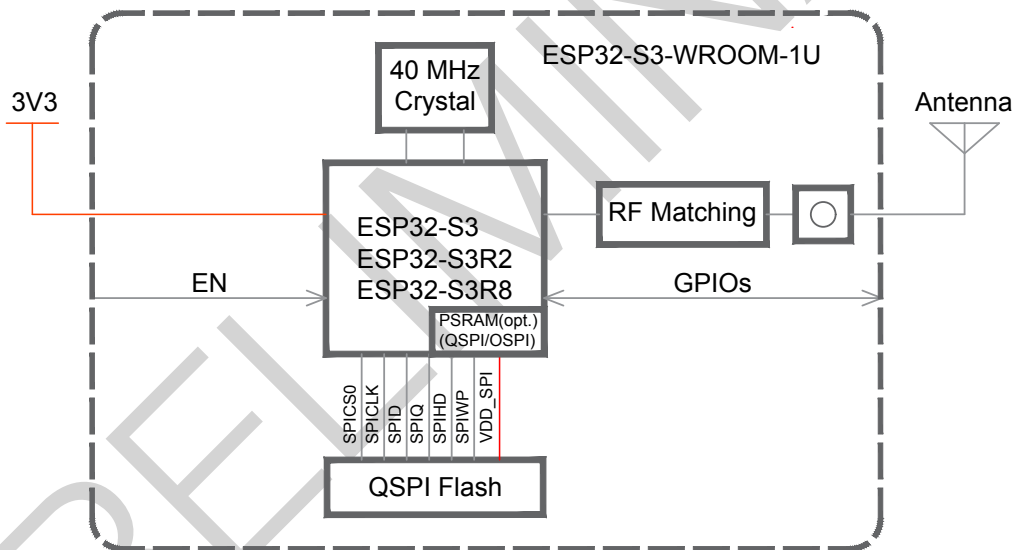


Figure 2: ESP32-S3-WROOM-1U Block Diagram



## 3 Pin Definitions

### 3.1 Pin Layout

The pin diagram below shows the approximate location of pins on the module. For the actual diagram drawn to scale, please refer to Figure 7.1 *Physical Dimensions*.

The pin diagram is applicable for ESP32-S3-WROOM-1 and ESP32-S3-WROOM-1U, but the latter has no keepout zone.

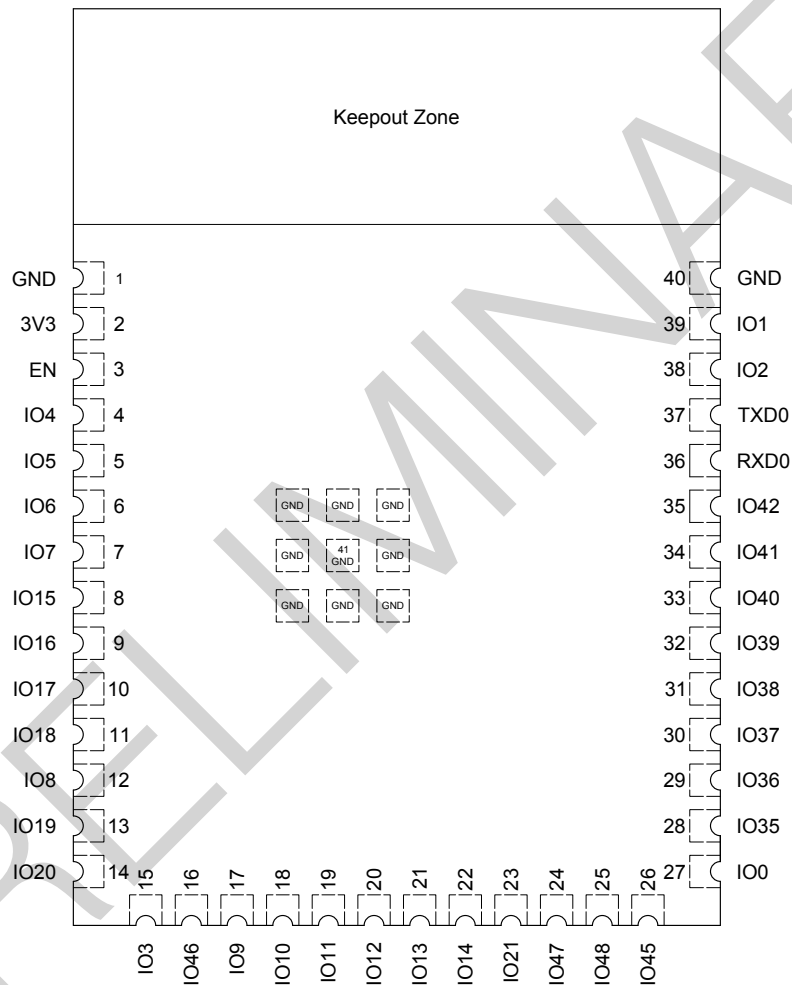


Figure 3: Pin Layout (Top View)

### 3.2 Pin Description

The module has 41 pins. See pin definitions in Table 2.

For explanations of pin names and function names, as well as configurations of peripheral pins, please refer to [ESP32-S3 Series Datasheet](#).

Table 2: Pin Definitions

Name	No.	Type <sup>a</sup>	Function
GND	1	P	GND
3V3	2	P	Power supply
EN	3	I	High: on, enables the chip. Low: off, the chip powers off. Note: Do not leave the EN pin floating.
IO4	4	I/O/T	RTC_GPIO4, <b>GPIO4</b> , TOUCH4, ADC1_CH3
IO5	5	I/O/T	RTC_GPIO5, <b>GPIO5</b> , TOUCH5, ADC1_CH4
IO6	6	I/O/T	RTC_GPIO6, <b>GPIO6</b> , TOUCH6, ADC1_CH5
IO7	7	I/O/T	RTC_GPIO7, <b>GPIO7</b> , TOUCH7, ADC1_CH6
IO15	8	I/O/T	RTC_GPIO15, <b>GPIO15</b> , U0RTS, ADC2_CH4, XTAL_32K_P
IO16	9	I/O/T	RTC_GPIO16, <b>GPIO16</b> , U0CTS, ADC2_CH5, XTAL_32K_N
IO17	10	I/O/T	RTC_GPIO17, <b>GPIO17</b> , U1TXD, ADC2_CH6
IO18	11	I/O/T	RTC_GPIO18, <b>GPIO18</b> , U1RXD, ADC2_CH7, CLK_OUT3
IO8	12	I/O/T	RTC_GPIO8, <b>GPIO8</b> , TOUCH8, ADC1_CH7, SUBSPICS1
IO19	13	I/O/T	RTC_GPIO19, <b>GPIO19</b> , U1RTS, ADC2_CH8, CLK_OUT2, USB_D-
IO20	14	I/O/T	RTC_GPIO20, <b>GPIO20</b> , U1CTS, ADC2_CH9, CLK_OUT1, USB_D+
IO3	15	I/O/T	RTC_GPIO3, <b>GPIO3</b> , TOUCH3, ADC1_CH2
IO46	16	I/O/T	<b>GPIO46</b>
IO9	17	I/O/T	RTC_GPIO9, <b>GPIO9</b> , TOUCH9, ADC1_CH8, FSPiHD, SUBSPiHD
IO10	18	I/O/T	RTC_GPIO10, <b>GPIO10</b> , TOUCH10, ADC1_CH9, FSPiCS0, FSPiIO4, SUBSPiCS0
IO11	19	I/O/T	RTC_GPIO11, <b>GPIO11</b> , TOUCH11, ADC2_CH0, FSPiD, FSPiIO5, SUBSPiD
IO12	20	I/O/T	RTC_GPIO12, <b>GPIO12</b> , TOUCH12, ADC2_CH1, FSPiCLK, FSPiIO6, SUBSPiCLK
IO13	21	I/O/T	RTC_GPIO13, <b>GPIO13</b> , TOUCH13, ADC2_CH2, FSPiQ, FSPiIO7, SUBSPiQ
IO14	22	I/O/T	RTC_GPIO14, <b>GPIO14</b> , TOUCH14, ADC2_CH3, FSPiWP, FSPiDQS, SUBSPiWP
IO21	23	I/O/T	RTC_GPIO21, <b>GPIO21</b>
IO47	24	I/O/T	SPiCLK_P_DIFF, <b>GPIO47</b> , SUBSPiCLK_P_DIFF
IO48	25	I/O/T	SPiCLK_N_DIFF, <b>GPIO48</b> , SUBSPiCLK_N_DIFF
IO45	26	I/O/T	<b>GPIO45</b>
IO0	27	I/O/T	RTC_GPIO0, <b>GPIO0</b>
IO35 <sup>b</sup>	28	I/O/T	SPIIO6, <b>GPIO35</b> , FSPiD, SUBSPiD
IO36 <sup>b</sup>	29	I/O/T	SPIIO7, <b>GPIO36</b> , FSPiCLK, SUBSPiCLK
IO37 <sup>b</sup>	30	I/O/T	SPiDQS, <b>GPIO37</b> , FSPiQ, SUBSPiQ
IO38	31	I/O/T	<b>GPIO38</b> , FSPiWP, SUBSPiWP
IO39	32	I/O/T	<b>MTCK</b> , GPIO39, CLK_OUT3, SUBSPiCS1
IO40	33	I/O/T	<b>MTDO</b> , GPIO40, CLK_OUT2
IO41	34	I/O/T	<b>MTDI</b> , GPIO41, CLK_OUT1

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Table 2 – cont'd from previous page

Name	No.	Type <sup>a</sup>	Function
IO42	35	I/O/T	<b>MTMS</b> , GPIO42
RXD0	36	I/O/T	<b>U0RXD</b> , GPIO44, CLK_OUT2
TXD0	37	I/O/T	<b>U0TXD</b> , GPIO43, CLK_OUT1
IO2	38	I/O/T	RTC_GPIO2, <b>GPIO2</b> , TOUCH2, ADC1_CH1
IO1	39	I/O/T	RTC_GPIO1, <b>GPIO1</b> , TOUCH1, ADC1_CH0
GND	40	P	GND
EPAD	41	P	GND

<sup>a</sup> P: power supply; I: input; O: output; T: high impedance. Pin functions in bold font are the default pin functions.

<sup>b</sup> In module variants that have embedded OSPI PSRAM, i.e., that embed ESP32-S3R8, pins IO35, IO36, and IO37 connect to the OSPI PSRAM and are not available for other uses.

### 3.3 Strapping Pins

**Note:**

The content below is excerpted from Section Strapping Pins in [ESP32-S3 Series Datasheet](#). For the strapping pin mapping between the chip and modules, please refer to Chapter [5 Module Schematics](#).

ESP32-S3 has four strapping pins:

- GPIO0
- GPIO45
- GPIO46
- GPIO3

Software can read the values of corresponding bits from register "GPIO\_STRAPPING".

During the chip's system reset (power-on-reset, RTC watchdog reset, brownout reset, analog super watchdog reset, and crystal clock glitch detection reset), the latches of the strapping pins sample the voltage level as strapping bits of "0" or "1", and hold these bits until the chip is powered down or shut down.

GPIO0, GPIO45 and GPIO46 are connected to the chip's internal weak pull-up/pull-down during the chip reset. Consequently, if they are unconnected or the connected external circuit is high-impedance, the internal weak pull-up/pull-down will determine the default input level of these strapping pins.

GPIO3 is floating by default. When EFUSE\_STRAP\_JTAG\_SEL is set, the strapping value of GPIO3 determines the source of the JTAG signal inside the CPU. In this case, the strapping value is controlled by the external circuit that cannot be in a high impedance state.

- When GPIO3 strapping value is 0, the JTAG signal comes from the on-chip JTAG pin.
- When GPIO3 strapping value is 1, the JTAG signal comes from the USB Serial/JTAG controller.

When EFUSE\_STRAP\_JTAG\_SEL is 0, the JTAG signal comes from the USB Serial/JTAG controller.

To change the strapping bit values, users can apply the external pull-down/pull-up resistances, or use the host MCU's GPIOs to control the voltage level of these pins when powering on ESP32-S3.

After reset, the strapping pins work as normal-function pins.

Refer to Table 3 for a detailed configuration of the strapping pins.

**Table 3: Strapping Pins**

VDD_SPI Voltage <sup>1</sup>			
Pin	Default	3.3 V	1.8 V
GPIO45	Pull-down	0	1
Bootling Mode <sup>2</sup>			
Pin	Default	SPI Boot	Download Boot
GPIO0	Pull-up	1	0
GPIO46	Pull-down	Don't care	0
Enabling/Disabling ROM Messages Print During Bootling <sup>3 4</sup>			
Pin	Default	Enabled	Disabled
GPIO46	Pull-down	See the fourth note	See the fourth note
JTAG Signal Selection			
Pin	Default	EFUSE_STRAP_JTAG_SEL=0	EFUSE_STRAP_JTAG_SEL=1
GPIO3	N/A	USB Serial/JTAG	Strapping value: 0: PAD JTAG <sup>5</sup> 1: USB Serial/JTAG <sup>5</sup>

**Note:**

1. The functionality of strapping pin GPIO45 to select VDD\_SPI voltage may be disabled by setting VDD\_SPI\_FORCE eFuse to 1. In such a case the voltage is selected with eFuse bit VDD\_SPI\_TIEH.
2. The strapping combination of GPIO46 = 1 and GPIO0 = 0 is invalid and will trigger unexpected behavior.
3. ROM boot messages can be printed over U0TXD (by default) or GPIO17, depending on the eFuse bit.
4. When both EFUSE\_DIS\_USB\_DEVICE and USB\_DIS\_USB are 0, ROM boot messages will be printed to the USB Serial/JTAG controller. Otherwise, the messages will be printed to UART, controlled by GPIO46 and eFuse UART\_PRINT\_CONTROL. Specifically, when eFuse UART\_PRINT\_CONTROL value is:
  - 0, print is normal during boot and not controlled by GPIO46.
  - 1 and GPIO46 is 0, print is normal during boot; but if GPIO46 is 1, print is disabled.
  - 2 and GPIO46 is 0, print is disabled; but if GPIO46 is 1, print is normal.
  - 3, print is disabled and not controlled by GPIO46.
5. PAD JTAG: JTAG signal comes from the on-chip JTAG pin;  
USB Serial/JTAG: JTAG signal comes from the USB Serial/JTAG controller.

Figure 4 shows the setup and hold times for the strapping pin before and after the CHIP\_PU signal goes high. Details about the parameters are listed in Table 4.

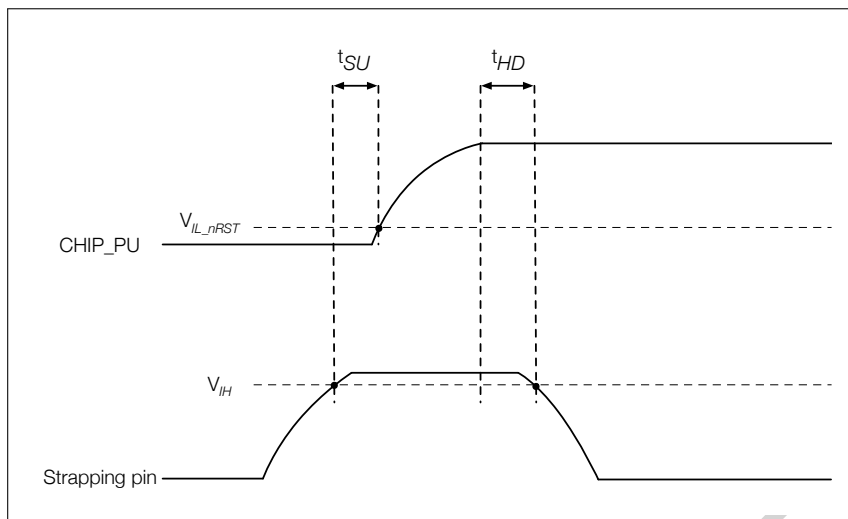


Figure 4: Setup and Hold Times for the Strapping Pin

Table 4: Parameter Descriptions of Setup and Hold Times for the Strapping Pin

Parameter	Description	Min ( $\mu\text{s}$ )
$t_{SU}$	Setup time before CHIP_PU goes from low to high	0
$t_{HD}$	Hold time after CHIP_PU goes high	3

## 4 Electrical Characteristics

The values presented in this section are preliminary and may change with the final release of this datasheet.

### 4.1 Absolute Maximum Ratings

Stresses above those listed in *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 5: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
VDD33	Power supply voltage	-0.3	3.6	V
T <sub>STORE</sub>	Storage temperature	-40	105	°C

### 4.2 Recommended Operating Conditions

Table 6: Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit	
VDD33	Power supply voltage	3.0	3.3	3.6	V	
I <sub>VDD</sub>	Current delivered by external power supply	0.5	—	—	A	
T <sub>A</sub>	Operating ambient temperature	85 °C version	-40	—	85	°C
		105 °C version			105	
Humidity	Humidity condition	—	—	85	%RH	

### 4.3 DC Characteristics (3.3 V, 25 °C)

Table 7: DC Characteristics (3.3 V, 25 °C)

Symbol	Parameter	Min	Typ	Max	Unit
C <sub>IN</sub>	Pin capacitance	—	2	—	pF
V <sub>IH</sub>	High-level input voltage	0.75 × VDD <sup>1</sup>	—	VDD <sup>1</sup> + 0.3	V
V <sub>IL</sub>	Low-level input voltage	-0.3	—	0.25 × VDD <sup>1</sup>	V
I <sub>IH</sub>	High-level input current	—	—	50	nA
I <sub>IL</sub>	Low-level input current	—	—	50	nA
V <sub>OH</sub> <sup>2</sup>	High-level output voltage	0.8 × VDD <sup>1</sup>	—	—	V
V <sub>OL</sub> <sup>2</sup>	Low-level output voltage	—	—	0.1 × VDD <sup>1</sup>	V
I <sub>OH</sub>	High-level source current (VDD <sup>1</sup> = 3.3 V, V <sub>OH</sub> ≥ 2.64 V, PAD_DRIVER = 3)	—	40	—	mA
I <sub>OL</sub>	Low-level sink current (VDD <sup>1</sup> = 3.3 V, V <sub>OL</sub> = 0.495 V, PAD_DRIVER = 3)	—	28	—	mA

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Symbol	Parameter	Min	Typ	Max	Unit
$R_{PU}$	Internal weak pull-up resistor	—	45	—	$k\Omega$
$R_{PD}$	Internal weak pull-down resistor	—	45	—	$k\Omega$
$V_{IH\_nRST}$	Chip reset release voltage (EN voltage is within the specified range)	$0.75 \times VDD^1$	—	$VDD^1 + 0.3$	V
$V_{IL\_nRST}$	Chip reset voltage (EN voltage is within the specified range)	-0.3	—	$0.25 \times VDD^1$	V

<sup>1</sup> VDD is the I/O voltage for pins of a particular power domain.

<sup>2</sup>  $V_{OH}$  and  $V_{OL}$  are measured using high-impedance load.

## 4.4 Current Consumption Characteristics

Owing to the use of advanced power-management technologies, the module can switch between different power modes. For details on different power modes, please refer to Section *RTC and Low-Power Management* in [ESP32-S3 Series Datasheet](#).

Table 8: Current Consumption Depending on RF Modes

Work mode	Description		Peak (mA)
Active (RF working)	TX	802.11b, 1 Mbps, @20.5 dBm	330
		802.11g, 54 Mbps, @18 dBm	280
		802.11n, HT20, MCS7, @17.5 dBm	273
		802.11n, HT40, MCS7, @17 dBm	278
	RX	802.11b/g/n, HT20	97
		802.11n, HT40	100

<sup>1</sup> The current consumption measurements are taken with a 3.3 V supply at 25 °C of ambient temperature at the RF port. All transmitters' measurements are based on a 100% duty cycle.

<sup>2</sup> The current consumption figures in RX mode are for cases where the peripherals are disabled and the CPU idle.

Note that the data in Table 9 only applies to the module variants that embed ESP32-S3.

Table 9: Current Consumption Depending on Work Modes

Work mode	Description	Typ	Unit
Light-sleep	—	240	$\mu A$
Deep-sleep	RTC memory and RTC peripherals are powered on.	8	$\mu A$
Hibernation	RTC memory is powered on. RTC peripherals are powered off.	7	$\mu A$
Power off	CHIP_PU is set to low level. The chip is powered off.	1	$\mu A$

## 4.5 Wi-Fi RF Characteristics

### 4.5.1 Wi-Fi RF Standards

Table 10: Wi-Fi RF Standards

Name		Description
Center frequency range of operating channel <sup>1</sup>		2412 ~ 2484 MHz
Wi-Fi wireless standard		IEEE 802.11b/g/n
Data rate	20 MHz	11b: 1, 2, 5.5 and 11 Mbps 11g: 6, 9, 12, 18, 24, 36, 48, 54 Mbps 11n: MCS0-7, 72.2 Mbps (Max)
	40 MHz	11n: MCS0-7, 150 Mbps (Max)
Antenna type		PCB antenna, external antenna via the connector

<sup>1</sup> Device should operate in the center frequency range allocated by regional regulatory authorities. Target center frequency range is configurable by software.

<sup>2</sup> For the modules that use external antennas, the output impedance is 50 Ω. For other modules without external antennas, the output impedance is irrelevant.

#### 4.5.2 Wi-Fi RF Transmitter (TX) Specifications

Target TX power is configurable based on device or certification requirements. The default characteristics are provided in Table 11.

Table 11: TX Power with Spectral Mask and EVM Meeting 802.11 Standards

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	20.5	—
802.11b, 11 Mbps	—	20.5	—
802.11g, 6 Mbps	—	20.0	—
802.11g, 54 Mbps	—	18.0	—
802.11n, HT20, MCS0	—	19.0	—
802.11n, HT20, MCS7	—	17.5	—
802.11n, HT40, MCS0	—	18.5	—
802.11n, HT40, MCS7	—	17.0	—

Table 12: TX EVM Test

Rate	Min (dB)	Typ (dB)	SL <sup>1</sup> (dB)
802.11b, 1 Mbps, @20.5 dBm	—	-24.5	-10
802.11b, 11 Mbps, @20.5 dBm	—	-24.5	-10
802.11g, 6 Mbps, @20 dBm	—	-21.5	-5
802.11g, 54 Mbps, @18 dBm	—	-27.5	-25
802.11n, HT20, MCS0, @19 dBm	—	-22.0	-5
802.11n, HT20, MCS7, @17.5 dBm	—	-29.2	-27
802.11n, HT40, MCS0, @18.5 dBm	—	-22.0	-5
802.11n, HT40, MCS7, @17 dBm	—	-28.0	-27

<sup>1</sup> SL stands for standard limit value.



### 4.5.3 Wi-Fi RF Receiver (RX) Specifications

Table 13: RX Sensitivity

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	-98.4	—
802.11b, 2 Mbps	—	-95.3	—
802.11b, 5.5 Mbps	—	-92.8	—
802.11b, 11 Mbps	—	-88.5	—
802.11g, 6 Mbps	—	-93.0	—
802.11g, 9 Mbps	—	-92.0	—
802.11g, 12 Mbps	—	-90.8	—
802.11g, 18 Mbps	—	-88.5	—
802.11g, 24 Mbps	—	-85.5	—
802.11g, 36 Mbps	—	-82.0	—
802.11g, 48 Mbps	—	-78.0	—
802.11g, 54 Mbps	—	-76.2	—
802.11n, HT20, MCS0	—	-92.6	—
802.11n, HT20, MCS1	—	-90.6	—
802.11n, HT20, MCS2	—	-88.0	—
802.11n, HT20, MCS3	—	-84.8	—
802.11n, HT20, MCS4	—	-81.6	—
802.11n, HT20, MCS5	—	-77.4	—
802.11n, HT20, MCS6	—	-75.2	—
802.11n, HT20, MCS7	—	-74.0	—
802.11n, HT40, MCS0	—	-90.0	—
802.11n, HT40, MCS1	—	-87.6	—
802.11n, HT40, MCS2	—	-84.8	—
802.11n, HT40, MCS3	—	-81.8	—
802.11n, HT40, MCS4	—	-78.4	—
802.11n, HT40, MCS5	—	-74.2	—
802.11n, HT40, MCS6	—	-72.2	—
802.11n, HT40, MCS7	—	-71.0	—

Table 14: Maximum RX Level

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	5	—
802.11b, 11 Mbps	—	5	—
802.11g, 6 Mbps	—	5	—
802.11g, 54 Mbps	—	0	—
802.11n, HT20, MCS0	—	5	—
802.11n, HT20, MCS7	—	0	—

Cont'd on next page

Table 14 – cont'd from previous page

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11n, HT40, MCS0	—	5	—
802.11n, HT40, MCS7	—	0	—

Table 15: RX Adjacent Channel Rejection

Rate	Min (dB)	Typ (dB)	Max (dB)
802.11b, 1 Mbps	—	35	—
802.11b, 11 Mbps	—	35	—
802.11g, 6 Mbps	—	31	—
802.11g, 54 Mbps	—	14	—
802.11n, HT20, MCS0	—	31	—
802.11n, HT20, MCS7	—	13	—
802.11n, HT40, MCS0	—	19	—
802.11n, HT40, MCS7	—	8	—

## 4.6 Bluetooth LE Radio

Table 16: Bluetooth LE Frequency

Parameter	Min (MHz)	Typ (MHz)	Max (MHz)
Center frequency of operating channel	2402	—	2480

### 4.6.1 Bluetooth LE RF Transmitter (TX) Specifications

Table 17: Transmitter Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	-25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $ f_n _{n=0, 1, 2, \dots, k}$	—	15.00	—	kHz
	Max $ f_0 - f_n $	—	3.00	—	kHz
	Max $ f_n - f_{n-5} $	—	1.80	—	kHz
	$ f_1 - f_0 $	—	1.00	—	kHz
Modulation characteristics	$\Delta f_{1avg}$	—	250.00	—	kHz
	Min $\Delta f_{2max}$ (for at least 99.9% of all $\Delta f_{2max}$ )	—	190.00	—	kHz
	$\Delta f_{2avg}/\Delta f_{1avg}$	—	0.86	—	—
In-band spurious emissions	$\pm 2$ MHz offset	—	-36.20	—	dBm
	$\pm 3$ MHz offset	—	-41.20	—	dBm

Cont'd on next page

Table 17 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	>±3 MHz offset	—	-44.60	—	dBm

Table 18: Transmitter Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	-25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $ f_n _{n=0, 1, 2, \dots, k}$	—	15.00	—	kHz
	Max $ f_0 - f_n $	—	2.50	—	kHz
	Max $ f_n - f_{n-5} $	—	1.80	—	kHz
	$ f_1 - f_0 $	—	1.00	—	kHz
Modulation characteristics	$\Delta f_{1\text{avg}}$	—	498.00	—	kHz
	Min $\Delta f_{2\text{max}}$ (for at least 99.9% of all $\Delta f_{2\text{max}}$ )	—	420.00	—	kHz
	$\Delta f_{2\text{avg}}/\Delta f_{1\text{avg}}$	—	0.93	—	—
In-band spurious emissions	±2 MHz offset	—	-43.70	—	dBm
	±3 MHz offset	—	-45.80	—	dBm
	>±3 MHz offset	—	-47.00	—	dBm

Table 19: Transmitter Characteristics - Bluetooth LE 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	-25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $ f_n _{n=0, 1, 2, \dots, k}$	—	15.00	—	kHz
	Max $ f_0 - f_n $	—	0.90	—	kHz
	$ f_n - f_{n-3} $	—	0.40	—	kHz
	$ f_0 - f_3 $	—	0.65	—	kHz
Modulation characteristics	$\Delta f_{1\text{avg}}$	—	250.00	—	kHz
	Min $\Delta f_{1\text{max}}$ (for at least 99.9% of all $\Delta f_{2\text{max}}$ )	—	210.00	—	kHz
In-band spurious emissions	±2 MHz offset	—	-36.20	—	dBm
	±3 MHz offset	—	-41.20	—	dBm
	>±3 MHz offset	—	-44.60	—	dBm

Table 20: Transmitter Characteristics - Bluetooth LE 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	-25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $ f_n _{n=0, 1, 2, \dots, k}$	—	15.00	—	kHz
	Max $ f_0 - f_n $	—	0.90	—	kHz

Cont'd on next page

Table 20 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	$ f_n - f_{n-3} $	—	0.46	—	kHz
	$ f_0 - f_3 $	—	0.80	—	kHz
Modulation characteristics	$\Delta f_{2avg}$	—	210.00	—	kHz
	Min $\Delta f_{2max}$ (for at least 99.9% of all $\Delta f_{2max}$ )	—	174.00	—	kHz
In-band spurious emissions	$\pm 2$ MHz offset	—	-36.20	—	dBm
	$\pm 3$ MHz offset	—	-41.20	—	dBm
	$> \pm 3$ MHz offset	—	-44.60	—	dBm

#### 4.6.2 Bluetooth LE RF Receiver (RX) Specifications

Table 21: Receiver Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-97	—	dBm
Maximum received signal @30.8% PER	—	—	5	—	dBm
Co-channel C/I	F = F0 MHz	—	9	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	-3	—	dB
	F = F0 - 1 MHz	—	-3	—	dB
	F = F0 + 2 MHz	—	-28	—	dB
	F = F0 - 2 MHz	—	-36	—	dB
	F = F0 + 3 MHz	—	-33	—	dB
	F = F0 - 3 MHz	—	-35	—	dB
	F > F0 + 3 MHz	—	-31	—	dB
F > F0 - 3 MHz	—	-38	—	dB	
Image frequency	—	—	-31	—	dB
Adjacent channel to image frequency	F = F <sub>image</sub> + 1 MHz	—	-39	—	dB
	F = F <sub>image</sub> - 1 MHz	—	-33	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	-5	—	dBm
	2003 MHz ~ 2399 MHz	—	-19	—	dBm
	2484 MHz ~ 2997 MHz	—	-17	—	dBm
	3000 MHz ~ 12.75 GHz	—	-5	—	dBm
Intermodulation	—	—	-26	—	dBm

Table 22: Receiver Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-93	—	dBm
Maximum received signal @30.8% PER	—	—	3	—	dBm
Co-channel C/I	F = F0 MHz	—	11	—	dB
	F = F0 + 2 MHz	—	-7	—	dB
	F = F0 - 2 MHz	—	-6	—	dB

Cont'd on next page

Adjacent channel selectivity C/I

Table 22 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	$F = F_0 + 4 \text{ MHz}$	—	-29	—	dB
	$F = F_0 - 4 \text{ MHz}$	—	-35	—	dB
	$F = F_0 + 6 \text{ MHz}$	—	-39	—	dB
	$F = F_0 - 6 \text{ MHz}$	—	-39	—	dB
	$F > F_0 + 6 \text{ MHz}$	—	-42	—	dB
	$F > F_0 - 6 \text{ MHz}$	—	-42	—	dB
Image frequency	—	—	-29	—	dB
Adjacent channel to image frequency	$F = F_{image} + 2 \text{ MHz}$	—	-39	—	dB
	$F = F_{image} - 2 \text{ MHz}$	—	-7	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	-5	—	dBm
	2003 MHz ~ 2399 MHz	—	-29	—	dBm
	2484 MHz ~ 2997 MHz	—	-26	—	dBm
	3000 MHz ~ 12.75 GHz	—	-5	—	dBm
Intermodulation	—	—	-29	—	dBm

Table 23: Receiver Characteristics - Bluetooth LE 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-104.5	—	dBm
Maximum received signal @30.8% PER	—	—	5	—	dBm
Co-channel C/I	$F = F_0 \text{ MHz}$	—	7	—	dB
Adjacent channel selectivity C/I	$F = F_0 + 1 \text{ MHz}$	—	-5	—	dB
	$F = F_0 - 1 \text{ MHz}$	—	-6	—	dB
	$F = F_0 + 2 \text{ MHz}$	—	-32	—	dB
	$F = F_0 - 2 \text{ MHz}$	—	-40	—	dB
	$F = F_0 + 3 \text{ MHz}$	—	-44	—	dB
	$F = F_0 - 3 \text{ MHz}$	—	-47	—	dB
	$F > F_0 + 3 \text{ MHz}$	—	-33	—	dB
$F > F_0 - 3 \text{ MHz}$	—	-50	—	dB	
Image frequency	—	—	-33	—	dB
Adjacent channel to image frequency	$F = F_{image} + 1 \text{ MHz}$	—	-46	—	dB
	$F = F_{image} - 1 \text{ MHz}$	—	-44	—	dB

Table 24: Receiver Characteristics - Bluetooth LE 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-100.5	—	dBm
Maximum received signal @30.8% PER	—	—	5	—	dBm
Co-channel C/I	$F = F_0 \text{ MHz}$	—	4	—	dB
Adjacent channel selectivity C/I	$F = F_0 + 1 \text{ MHz}$	—	-4	—	dB
	$F = F_0 - 1 \text{ MHz}$	—	-6	—	dB
	$F = F_0 + 2 \text{ MHz}$	—	-32	—	dB

Adjacent channel selectivity C/I

Cont'd on next page

Table 24 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	$F = F_0 - 2 \text{ MHz}$	—	-36	—	dB
	$F = F_0 + 3 \text{ MHz}$	—	-37	—	dB
	$F = F_0 - 3 \text{ MHz}$	—	-40	—	dB
	$F > F_0 + 3 \text{ MHz}$	—	-35	—	dB
	$F > F_0 - 3 \text{ MHz}$	—	-43	—	dB
Image frequency	—	—	-35	—	dB
Adjacent channel to image frequency	$F = F_{image} + 1 \text{ MHz}$	—	-43	—	dB
	$F = F_{image} - 1 \text{ MHz}$	—	-37	—	dB

# 5 Module Schematics

This is the reference design of the module.

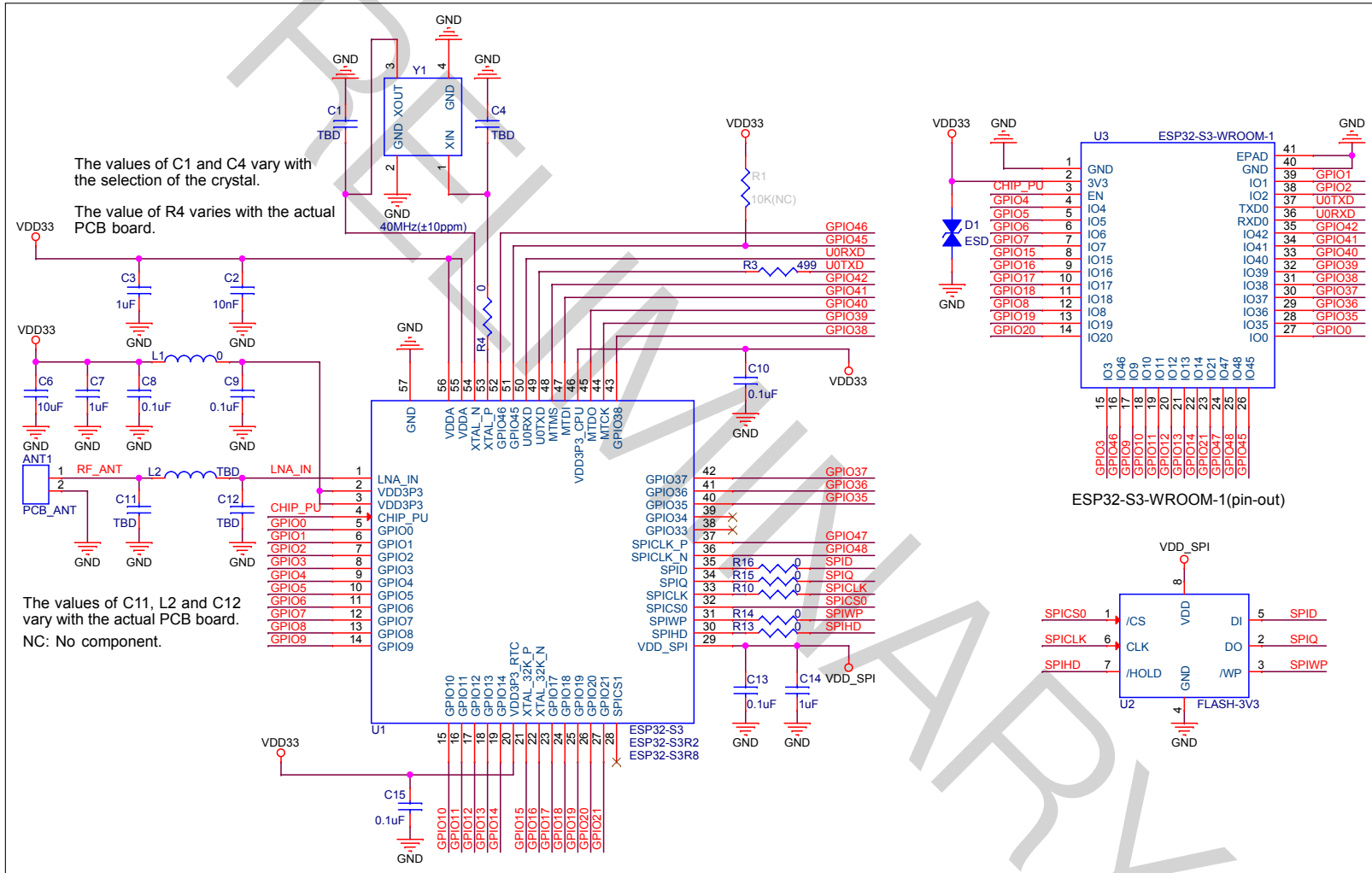


Figure 5: ESP32-S3-WROOM-1 Schematics

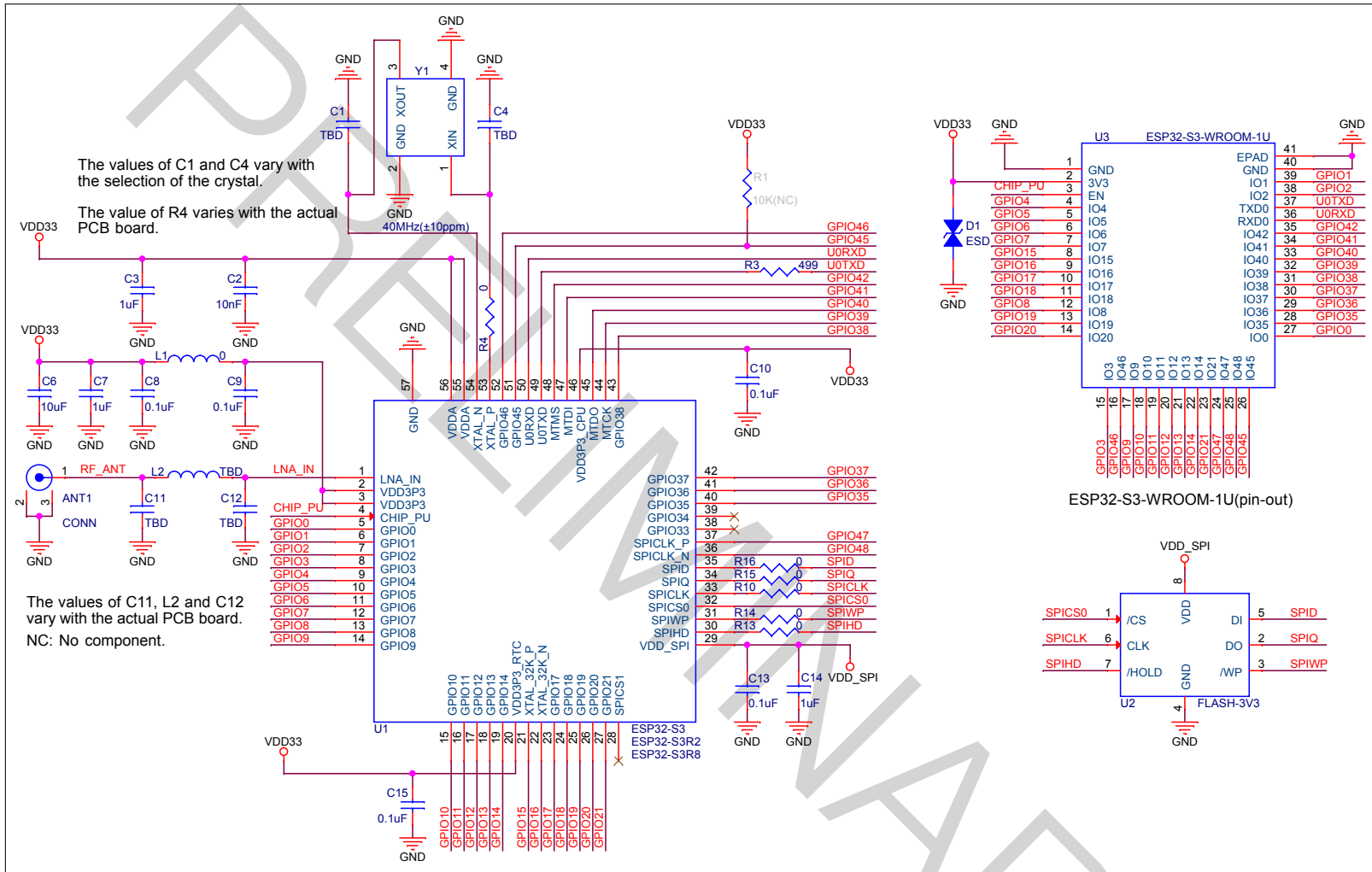


Figure 6: ESP32-S3-WROOM-1U Schematics

Internal pull-up resistor (R1) for IO45 is not populated in the module, as the flash in the module works at 3.3 V by default (output by VDD\_SPI). Please make sure IO45 is not pulled high when the module, L2 is powered up by external circuit.



## 6 Peripheral Schematics

This is the typical application circuit of the module connected with peripheral components (for example, power supply, antenna, reset button, JTAG interface, and UART interface).

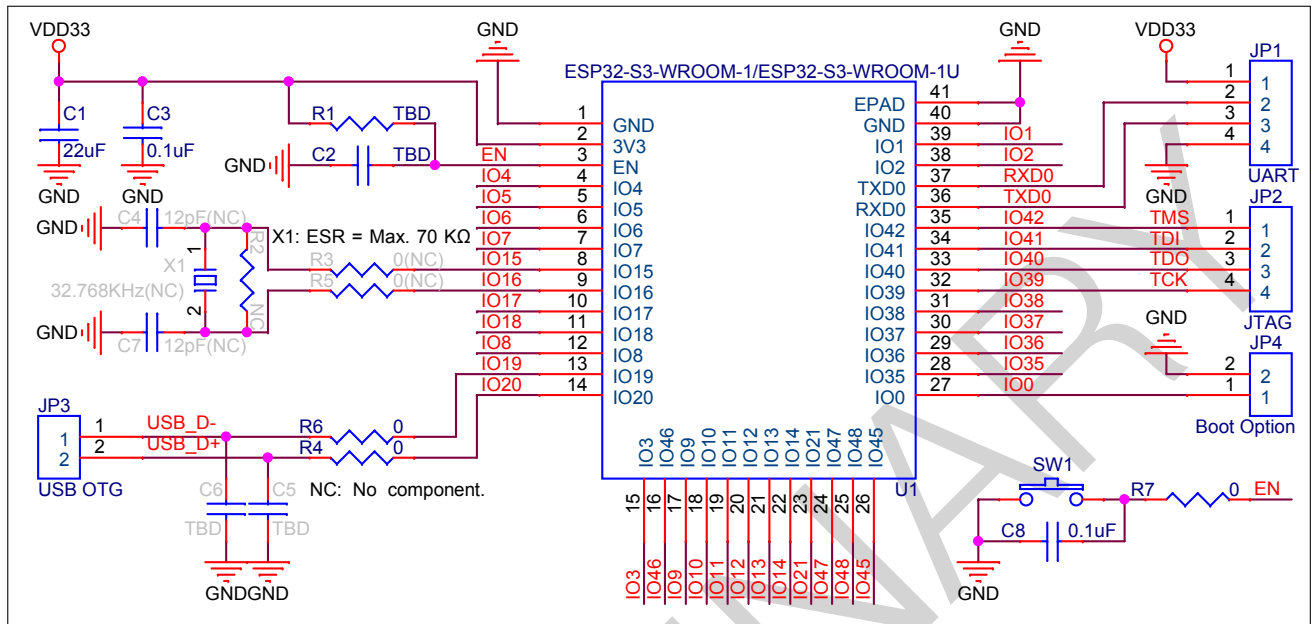


Figure 7: Peripheral Schematics

- Soldering the EPAD to the ground of the base board is not a must, however, it can optimize thermal performance. If you choose to solder it, please apply the correct amount of soldering paste.
- To ensure that the power supply to the ESP32-S3 chip is stable during power-up, it is advised to add an RC delay circuit at the EN pin. The recommended setting for the RC delay circuit is usually  $R = 10\text{ k}\Omega$  and  $C = 1\ \mu\text{F}$ . However, specific parameters should be adjusted based on the power-up timing of the module and the power-up and reset sequence timing of the chip. For ESP32-S3's power-up and reset sequence timing diagram, please refer to Section *Power Scheme* in [ESP32-S3 Series Datasheet](#).

## 7 Physical Dimensions and PCB Land Pattern

### 7.1 Physical Dimensions

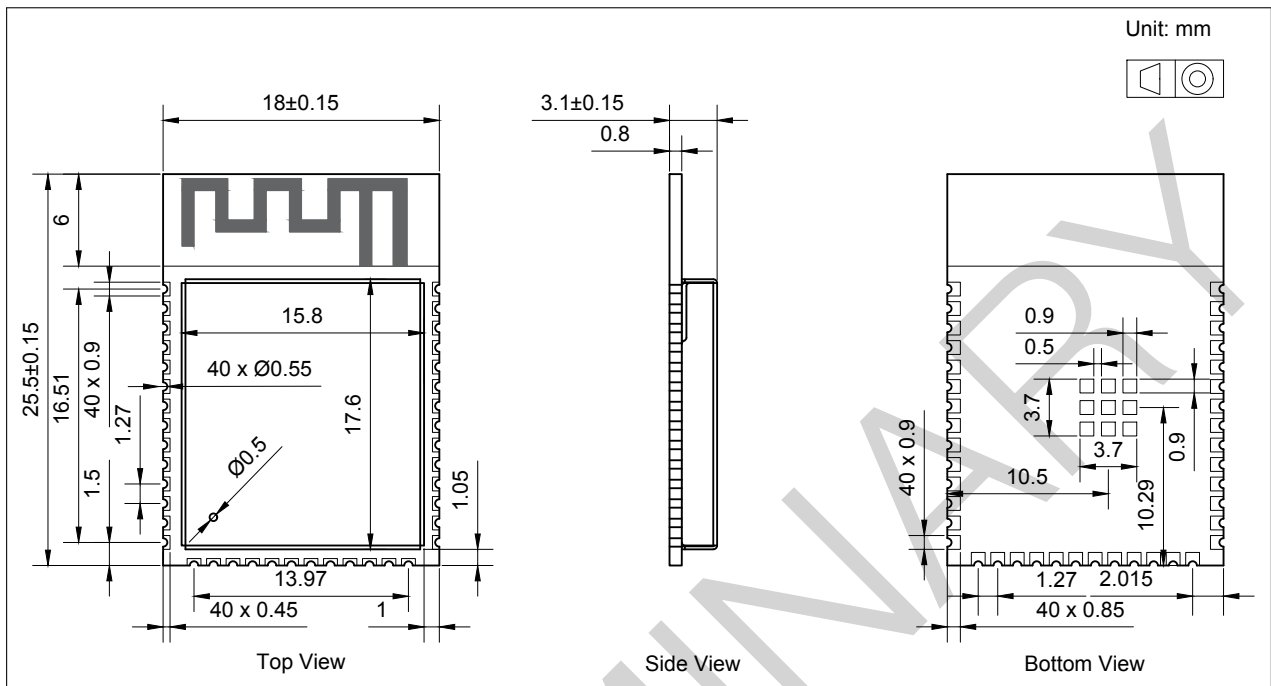


Figure 8: ESP32-S3-WROOM-1 Physical Dimensions

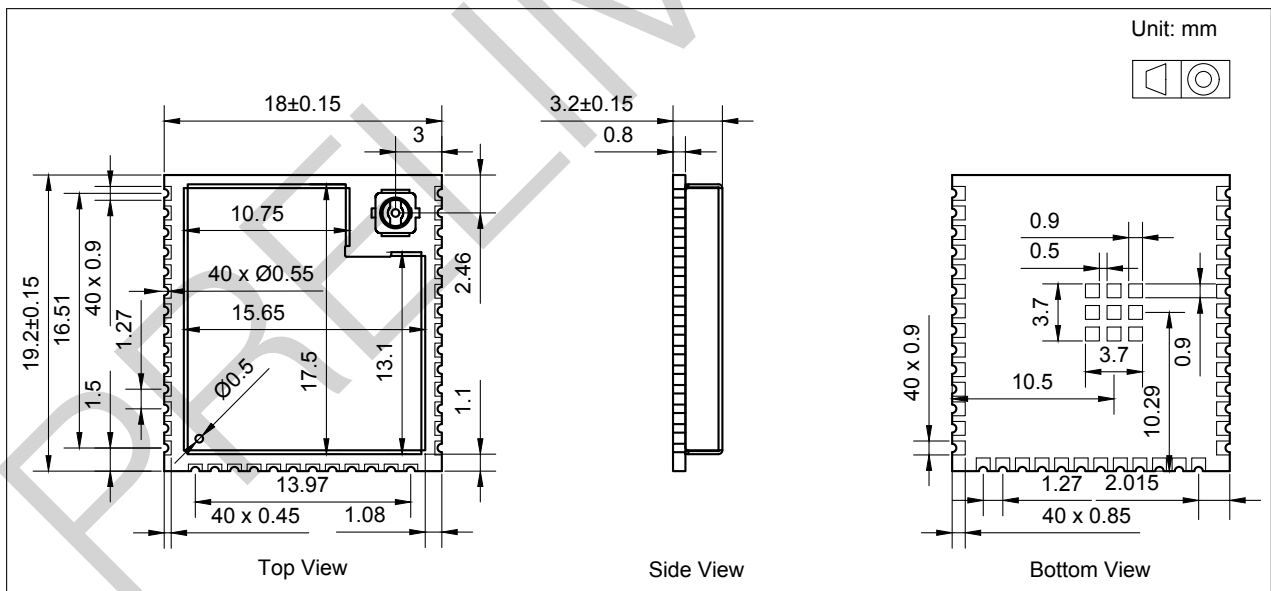


Figure 9: ESP32-S3-WROOM-1U Physical Dimensions

**Note:**

For information about tape, reel, and product marking, please refer to [Espressif Module Package Information](#).

## 7.2 Recommended PCB Land Pattern

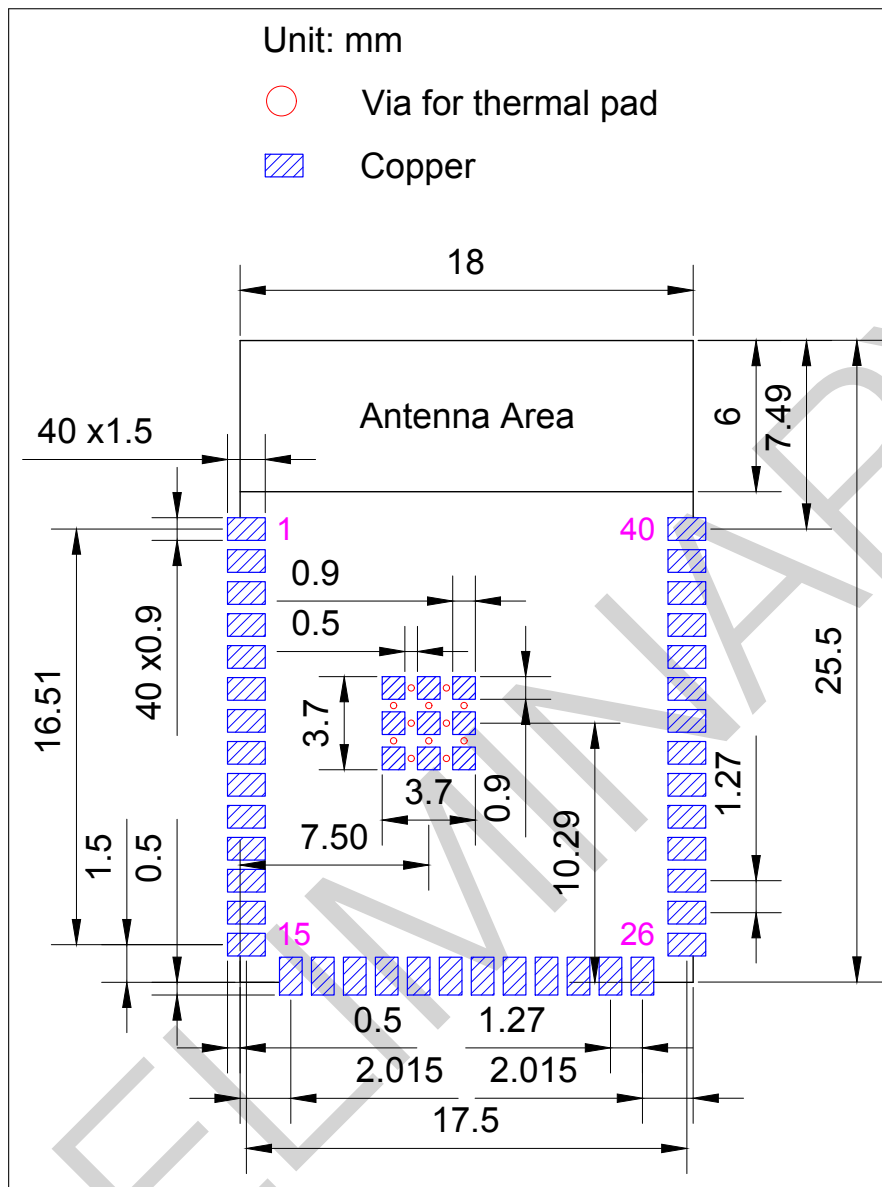


Figure 10: ESP32-S3-WROOM-1 Recommended PCB Land Pattern

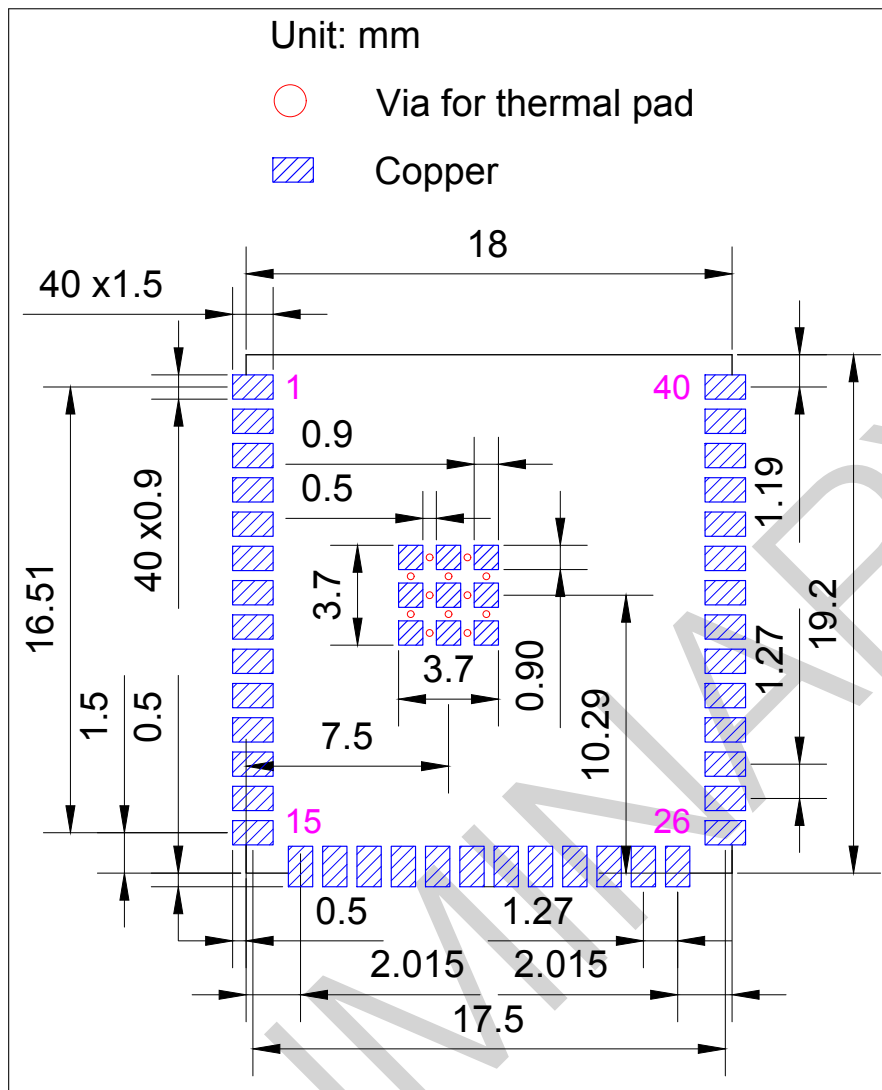


Figure 11: ESP32-S3-WROOM-1U Recommended PCB Land Pattern

### 7.3 Dimensions of External Antenna Connector

ESP32-S3-WROOM-1U uses the first generation external antenna connector as shown in Figure 12. This connector is compatible with the following connectors:

- U.FL Series connector from Hirose
- MHF I connector from I-PEX
- AMC connector from Amphenol

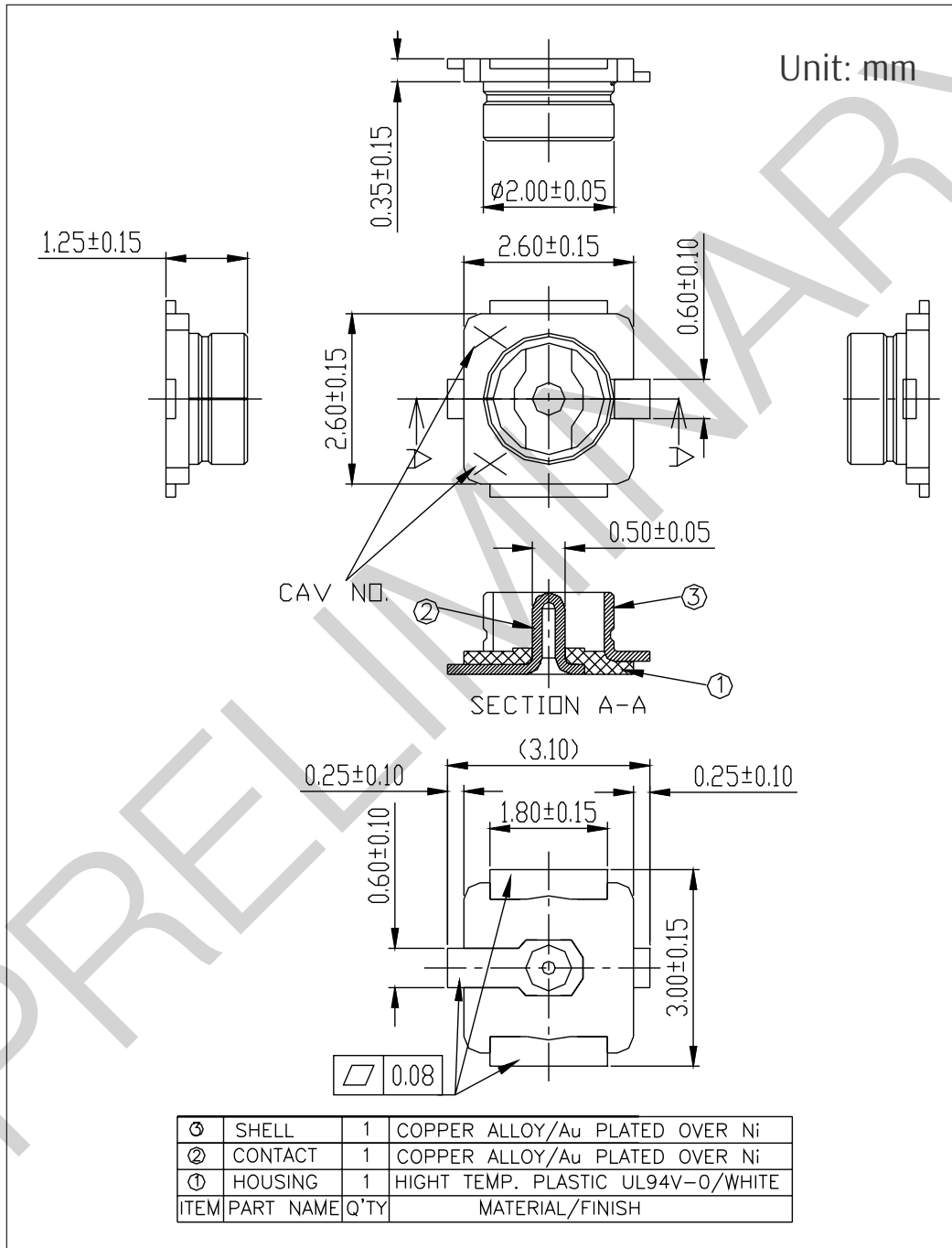


Figure 12: Dimensions of External Antenna Connector

## 8 Product Handling

### 8.1 Storage Conditions

The products sealed in moisture barrier bags (MBB) should be stored in a non-condensing atmospheric environment of  $< 40\text{ }^{\circ}\text{C}$  and  $/90\%\text{RH}$ . The module is rated at the moisture sensitivity level (MSL) of 3.

After unpacking, the module must be soldered within 168 hours with the factory conditions  $25\pm 5\text{ }^{\circ}\text{C}$  and  $/60\%\text{RH}$ . If the above conditions are not met, the module needs to be baked.

### 8.2 Electrostatic Discharge (ESD)

- Human body model (HBM):  $\pm 2000\text{ V}$
- Charged-device model (CDM):  $\pm 500\text{ V}$

### 8.3 Reflow Profile

Solder the module in a single reflow.

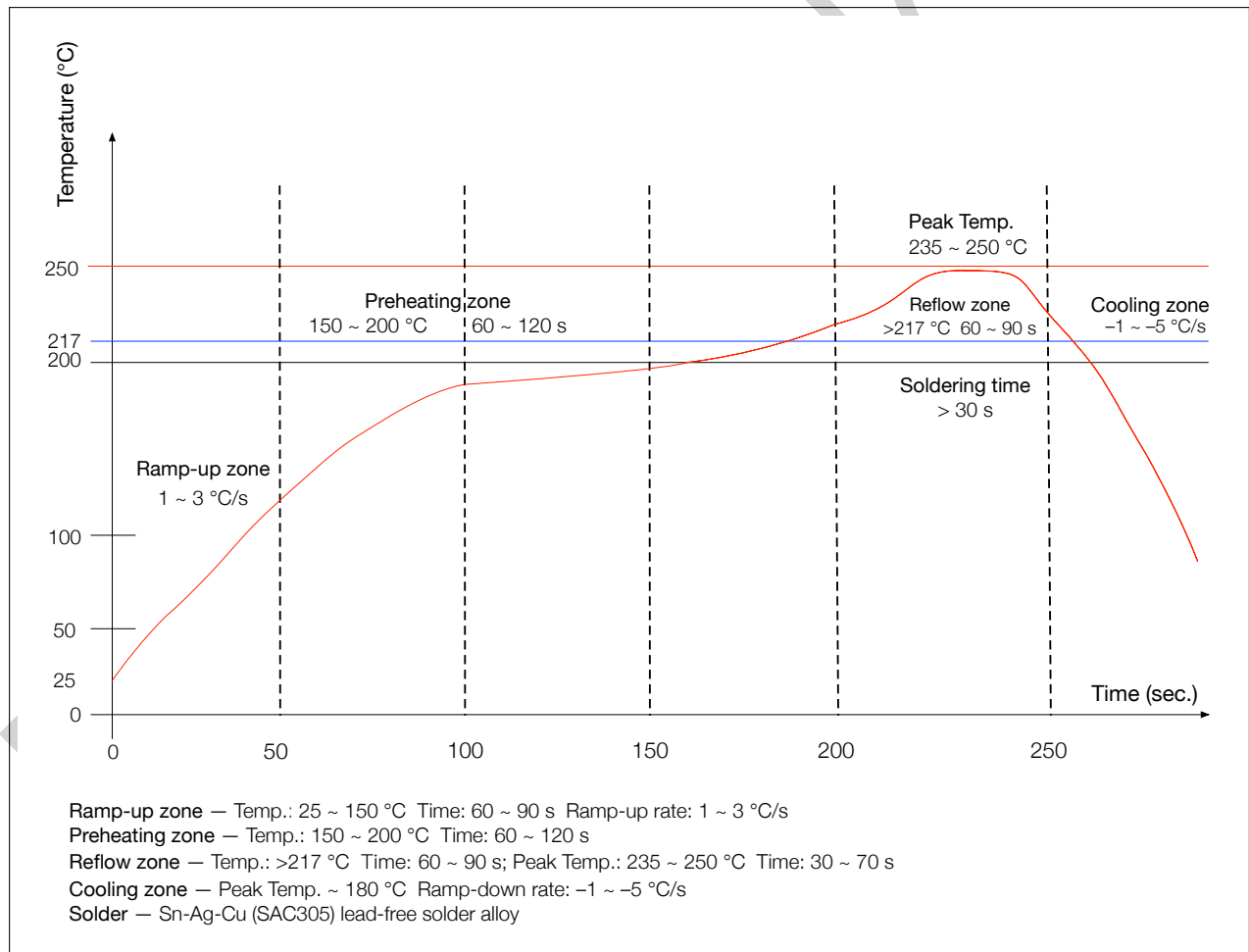


Figure 13: Reflow Profile

## 9 Related Documentation and Resources

### Related Documentation

- [ESP32-S3 Technical Reference Manual](#) – Detailed information on how to use the ESP32-S3 memory and peripherals.
- [ESP32-S3 Series Datasheet](#) – Specifications of the ESP32-S3 hardware.
- *Certificates*  
<http://espressif.com/en/support/documents/certificates>
- *Documentation Updates and Update Notification Subscription*  
<http://espressif.com/en/support/download/documents>

### Developer Zone

- *ESP-IDF* and other development frameworks on GitHub.  
<http://github.com/espressif>
- *ESP32 BBS Forum* – Engineer-to-Engineer (E2E) Community for Espressif products where you can post questions, share knowledge, explore ideas, and help solve problems with fellow engineers.  
<http://esp32.com/>
- *The ESP Journal* – Best Practices, Articles, and Notes from Espressif folks.  
<http://medium.com/the-esp-journal>
- See the tabs *SDKs and Demos, Apps, Tools, AT Firmware*.  
<http://espressif.com/en/support/download/sdks-demos>

### Products

- *ESP32-S3 Series SoCs* – Browse through all ESP32-S3 SoCs.  
<http://espressif.com/en/products/socs?id=ESP32-S3>
- *ESP32-S3 Series Modules* – Browse through all ESP32-S3-based modules.  
<http://espressif.com/en/products/modules?id=ESP32-S3>
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<http://espressif.com/en/products/devkits?id=ESP32-S3>
- *ESP Product Selector* – Find an Espressif hardware product suitable for your needs by comparing or applying filters.  
<http://products.espressif.com/#/product-selector?language=en>

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## Revision History

Date	Version	Release notes
2021-07-19	v0.5.1	Preliminary release, for chip revision 0

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