

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 v0.6
Espressif Systems
Copyright © 2021

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_wroom-1u_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 μ 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:
 - 65 °C version: -40 ~ 65 °C
 - 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 are built around the ESP32-S3 series of SoCs. On top of a rich set of peripherals, the acceleration

for neural network computing and signal processing workloads provided by the SoC make the modules 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. Among the module variants, those embed ESP32-S3R8 operate at $-40 \sim 65$ °C ambient temperature, ESP32-S3-WROOM-1-H4 and ESP32-S3-WROOM-1U-H4 operate at $-40 \sim 105$ °C ambient temperature, and other module variants operate at $-40 \sim 85$ °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 (65 °C)	ESP32-S3R8	4	8 (Octal SPI)	
ESP32-S3-WROOM-1-N8R8 (65 °C)	ESP32-S3R8	8	8 (Octal SPI)	
ESP32-S3-WROOM-1-N16R8 (65 °C)	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 (65 °C)	ESP32-S3R8	4	8 (Octal SPI)	
ESP32-S3-WROOM-1U-N8R8 (65 °C)	ESP32-S3R8	8	8 (Octal SPI)	
ESP32-S3-WROOM-1U-N16R8 (65 °C)	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

Contents

1	Module Overview	2
1.1	Features	2
1.2	Description	2
1.3	Applications	4
2	Block Diagram	8
3	Pin Definitions	9
3.1	Pin Layout	9
3.2	Pin Description	10
3.3	Strapping Pins	11
4	Electrical Characteristics	14
4.1	Absolute Maximum Ratings	14
4.2	Recommended Operating Conditions	14
4.3	DC Characteristics (3.3 V, 25 °C)	14
4.4	Current Consumption Characteristics	15
4.5	Wi-Fi RF Characteristics	15
4.5.1	Wi-Fi RF Standards	15
4.5.2	Wi-Fi RF Transmitter (TX) Specifications	16
4.5.3	Wi-Fi RF Receiver (RX) Specifications	17
4.6	Bluetooth LE Radio	18
4.6.1	Bluetooth LE RF Transmitter (TX) Specifications	18
4.6.2	Bluetooth LE RF Receiver (RX) Specifications	20
5	Module Schematics	23
6	Peripheral Schematics	25
7	Physical Dimensions and PCB Land Pattern	26
7.1	Physical Dimensions	26
7.2	Recommended PCB Land Pattern	27
7.3	Dimensions of External Antenna Connector	29
8	Product Handling	30
8.1	Storage Conditions	30
8.2	Electrostatic Discharge (ESD)	30
8.3	Reflow Profile	30
9	Related Documentation and Resources	31
	Revision History	32

List of Tables

1	Ordering Information	3
2	Pin Definitions	10
3	JTAG Signal Source Selection	12
4	Strapping Pins	12
5	Parameter Descriptions of Setup and Hold Times for the Strapping Pin	13
6	Absolute Maximum Ratings	14
7	Recommended Operating Conditions	14
8	DC Characteristics (3.3 V, 25 °C)	14
9	Current Consumption Depending on RF Modes	15
10	Current Consumption Depending on Work Modes	15
11	Wi-Fi RF Standards	16
12	TX Power with Spectral Mask and EVM Meeting 802.11 Standards	16
13	TX EVM Test	16
14	RX Sensitivity	17
15	Maximum RX Level	17
16	RX Adjacent Channel Rejection	18
17	Bluetooth LE Frequency	18
18	Transmitter Characteristics - Bluetooth LE 1 Mbps	18
19	Transmitter Characteristics - Bluetooth LE 2 Mbps	19
20	Transmitter Characteristics - Bluetooth LE 125 Kbps	19
21	Transmitter Characteristics - Bluetooth LE 500 Kbps	19
22	Receiver Characteristics - Bluetooth LE 1 Mbps	20
23	Receiver Characteristics - Bluetooth LE 2 Mbps	20
24	Receiver Characteristics - Bluetooth LE 125 Kbps	21
25	Receiver Characteristics - Bluetooth LE 500 Kbps	21

List of Figures

1	ESP32-S3-WROOM-1 Block Diagram	8
2	ESP32-S3-WROOM-1U Block Diagram	8
3	Pin Layout (Top View)	9
4	Setup and Hold Times for the Strapping Pin	13
5	ESP32-S3-WROOM-1 Schematics	23
6	ESP32-S3-WROOM-1U Schematics	24
7	Peripheral Schematics	25
8	ESP32-S3-WROOM-1 Physical Dimensions	26
9	ESP32-S3-WROOM-1U Physical Dimensions	26
10	ESP32-S3-WROOM-1 Recommended PCB Land Pattern	27
11	ESP32-S3-WROOM-1U Recommended PCB Land Pattern	28
12	Dimensions of External Antenna Connector	29
13	Reflow Profile	30

2 Block Diagram

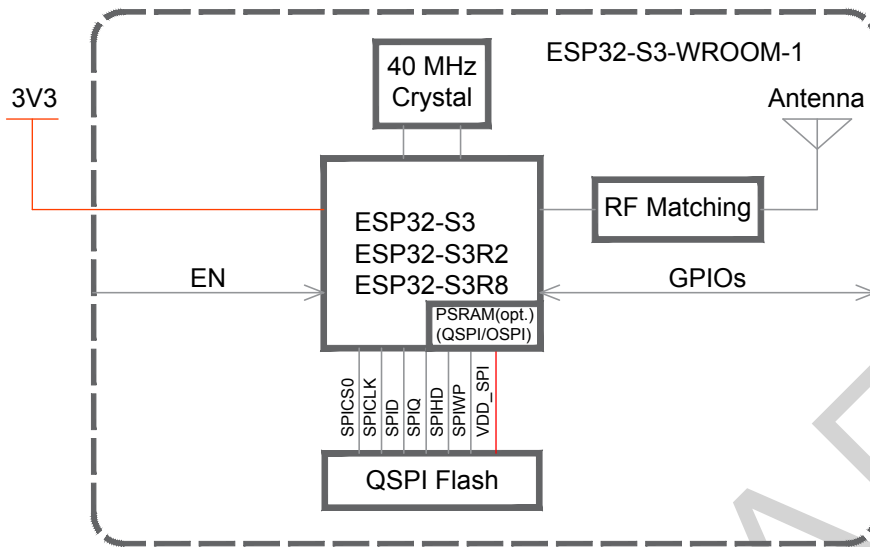


Figure 1: ESP32-S3-WROOM-1 Block Diagram

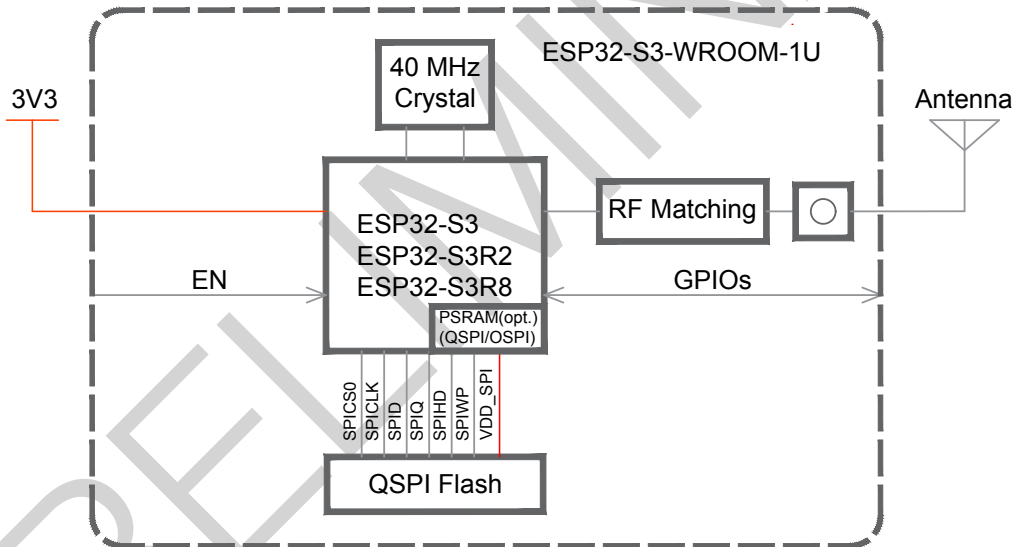


Figure 2: ESP32-S3-WROOM-1U Block Diagram

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.

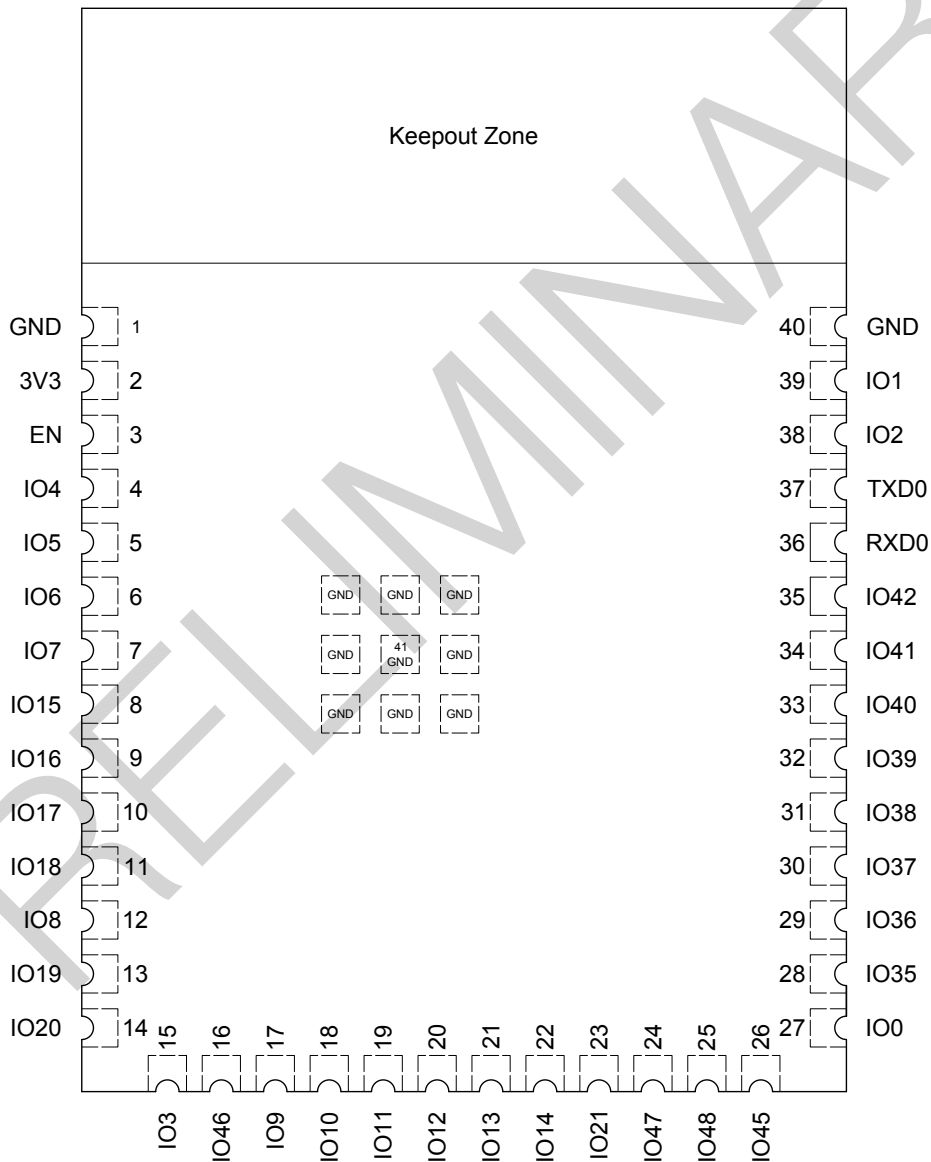


Figure 3: Pin Layout (Top View)

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 ^a	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, GPIO4 , TOUCH4, ADC1_CH3
IO5	5	I/O/T	RTC_GPIO5, GPIO5 , TOUCH5, ADC1_CH4
IO6	6	I/O/T	RTC_GPIO6, GPIO6 , TOUCH6, ADC1_CH5
IO7	7	I/O/T	RTC_GPIO7, GPIO7 , TOUCH7, ADC1_CH6
IO15	8	I/O/T	RTC_GPIO15, GPIO15 , U0RTS, ADC2_CH4, XTAL_32K_P
IO16	9	I/O/T	RTC_GPIO16, GPIO16 , U0CTS, ADC2_CH5, XTAL_32K_N
IO17	10	I/O/T	RTC_GPIO17, GPIO17 , U1TXD, ADC2_CH6
IO18	11	I/O/T	RTC_GPIO18, GPIO18 , U1RXD, ADC2_CH7, CLK_OUT3
IO8	12	I/O/T	RTC_GPIO8, GPIO8 , TOUCH8, ADC1_CH7, SUBSPICS1
IO19	13	I/O/T	RTC_GPIO19, GPIO19 , U1RTS, ADC2_CH8, CLK_OUT2, USB_D-
IO20	14	I/O/T	RTC_GPIO20, GPIO20 , U1CTS, ADC2_CH9, CLK_OUT1, USB_D+
IO3	15	I/O/T	RTC_GPIO3, GPIO3 , TOUCH3, ADC1_CH2
IO46	16	I/O/T	GPIO46
IO9	17	I/O/T	RTC_GPIO9, GPIO9 , TOUCH9, ADC1_CH8, FSPIHD, SUBSPIHD
IO10	18	I/O/T	RTC_GPIO10, GPIO10 , TOUCH10, ADC1_CH9, FSPICS0, FSPIIO4, SUBSPICS0
IO11	19	I/O/T	RTC_GPIO11, GPIO11 , TOUCH11, ADC2_CH0, FSPID, FSPIIO5, SUBSPID
IO12	20	I/O/T	RTC_GPIO12, GPIO12 , TOUCH12, ADC2_CH1, FSPICLK, FSPIIO6, SUBSPICLK
IO13	21	I/O/T	RTC_GPIO13, GPIO13 , TOUCH13, ADC2_CH2, FSPIQ, FSPIIO7, SUBSPIQ
IO14	22	I/O/T	RTC_GPIO14, GPIO14 , TOUCH14, ADC2_CH3, FSPIWP, FSPIDQS, SUBSPIWP
IO21	23	I/O/T	RTC_GPIO21, GPIO21
IO47	24	I/O/T	SPICLK_P_DIFF, GPIO47 , SUBSPICLK_P_DIFF
IO48	25	I/O/T	SPICLK_N_DIFF, GPIO48 , SUBSPICLK_N_DIFF
IO45	26	I/O/T	GPIO45
IO0	27	I/O/T	RTC_GPIO0, GPIO0
IO35 ^b	28	I/O/T	SPIIO6, GPIO35 , FSPID, SUBSPID
IO36 ^b	29	I/O/T	SPIIO7, GPIO36 , FSPICLK, SUBSPICLK

Cont'd on next page

Table 2 – cont'd from previous page

Name	No.	Type ^a	Function
IO37 ^b	30	I/O/T	SPIDQS, GPIO37 , FSPIQ, SUBSPIQ
IO38	31	I/O/T	GPIO38 , FSPIWP, SUBSPIWP
IO39	32	I/O/T	MTCK , GPIO39, CLK_OUT3, SUBSPICS1
IO40	33	I/O/T	MTDO , GPIO40, CLK_OUT2
IO41	34	I/O/T	MTDI , GPIO41, CLK_OUT1
IO42	35	I/O/T	MTMS , GPIO42
RXD0	36	I/O/T	U0RXD , GPIO44, CLK_OUT2
TXD0	37	I/O/T	U0TXD , GPIO43, CLK_OUT1
IO2	38	I/O/T	RTC_GPIO2, GPIO2 , TOUCH2, ADC1_CH1
IO1	39	I/O/T	RTC_GPIO1, GPIO1 , TOUCH1, ADC1_CH0
GND	40	P	GND
EPAD	41	P	GND

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

^b 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. Its strapping value can be configured to determine the source of the JTAG signal inside the CPU, as shown in Table 4. In this case, the strapping value is controlled by the external circuit that cannot be in a high impedance state. Table 3 shows more configuration combinations of EFUSE_DIS_USB_JTAG, EFUSE_DIS_PAD_JTAG, and EFUSE_STRAP_JTAG_SEL that determine the JTAG signal source.

Table 3: JTAG Signal Source Selection

EFUSE_STRAP_JTAG_SEL	EFUSE_DIS_USB_JTAG	EFUSE_DIS_PAD_JTAG	JTAG Signal Source
1	0	0	Refer to Table 4
0	0	0	USB Serial/JTAG controller
don't care	0	1	USB Serial/JTAG controller
don't care	1	0	On-chip JTAG pins
don't care	1	1	N/A

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 4 for a detailed configuration of the strapping pins.

Table 4: Strapping Pins

VDD_SPI Voltage ¹			
Pin	Default	3.3 V	1.8 V
GPIO45	Pull-down	0	1
Booting Mode ²			
Pin	Default	SPI Boot	Download Boot
GPIO0	Pull-up	1	0
GPIO46	Pull-down	Don't care	0
Enabling/Disabling ROM Messages Print During Booting ^{3 4}			
Pin	Default	Enabled	Disabled
GPIO46	Pull-down	See the fourth note	See the fourth note
JTAG Signal Selection			
Pin	Default	EFUSE_DIS_USB_JTAG = 0, EFUSE_DIS_PAD_JTAG = 0, EFUSE_STRAP_JTAG_SEL=1	
GPIO3	N/A	0: JTAG signal from on-chip JTAG pins 1: JTAG signal from USB Serial/JTAG controller	

Note:

- VDD_SPI voltage is determined either by the strapping value of GPIO45 or by VDD_SPI_TIEH. When EFUSE_VDD_SPI_FORCE is 0, VDD_SPI voltage is determined by the strapping value of GPIO45; when EFUSE_VDD_SPI_FORCE is 1, VDD_SPI voltage is determined by VDD_SPI_TIEH.
- The strapping combination of GPIO46 = 1 and GPIO0 = 0 is invalid and will trigger unexpected behavior.
- ROM boot messages can be printed over U0TXD (by default) or GPIO17 (U1TXD), depending on the eFuse bit EFUSE_UART_PRINT_CHANNEL.
- When both EFUSE_DIS_USB_SERIAL_JTAG and EFUSE_DIS_USB_OTG 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.

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 5.

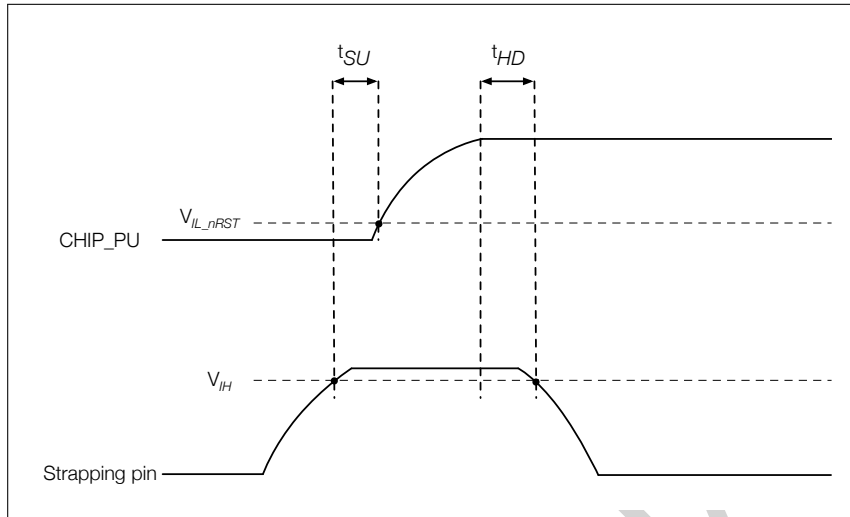


Figure 4: Setup and Hold Times for the Strapping Pin

Table 5: Parameter Descriptions of Setup and Hold Times for the Strapping Pin

Parameter	Description	Min (ms)
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 6: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
VDD33	Power supply voltage	-0.3	3.6	V
T _{STORE}	Storage temperature	-40	105	°C

4.2 Recommended Operating Conditions

Table 7: Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit	
VDD33	Power supply voltage	3.0	3.3	3.6	V	
I _{VDD}	Current delivered by external power supply	0.5	—	—	A	
T _A	Operating ambient temperature	65 °C version	-40	—	65	°C
		85 °C version			85	
		105 °C version			105	

4.3 DC Characteristics (3.3 V, 25 °C)

Table 8: DC Characteristics (3.3 V, 25 °C)

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

Cont'd on next page

Table 8 – cont'd from previous page

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

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

² V_{OH} and V_{OL} are measured using high-impedance load.

4.4 Current Consumption Characteristics

With 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 *Low Power Management* in [ESP32-S3 Series Datasheet](#).

Table 9: Current Consumption Depending on RF Modes

Work mode	Description	Peak (mA)	
Active (RF working)	TX	802.11b, 1 Mbps, @20.5 dBm	355
		802.11g, 54 Mbps, @18 dBm	297
		802.11n, HT20, MCS 7, @17.5 dBm	286
		802.11n, HT40, MCS 7, @17 dBm	285
	RX	802.11b/g/n, HT20	95
		802.11n, HT40	97

¹ 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.

² The current consumption figures for in RX mode are for cases when the peripherals are disabled and the CPU idle.

Note that the data in Table 10 only applies to the module variants that embed the chip variant ESP32-S3.

Table 10: Current Consumption Depending on Work Modes

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

4.5 Wi-Fi RF Characteristics

4.5.1 Wi-Fi RF Standards

Table 11: Wi-Fi RF Standards

Name		Description
Center frequency range of operating channel ¹		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

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

² 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 12.

Table 12: 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, MCS 0	—	19.0	—
802.11n, HT20, MCS 7	—	17.5	—
802.11n, HT40, MCS 0	—	18.5	—
802.11n, HT40, MCS 7	—	17.0	—

Table 13: TX EVM Test

Rate	Min (dB)	Typ (dB)	SL ¹ (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	—	-23.0	-5
802.11g, 54 Mbps, @18 dBm	—	-29.5	-25
802.11n, HT20, MCS 0, @19 dBm	—	-24.0	-5
802.11n, HT20, MCS 7, @17.5 dBm	—	-30.5	-27
802.11n, HT40, MCS 0, @18.5 dBm	—	-25.0	-5
802.11n, HT40, MCS 7, @17 dBm	—	-30.0	-27

¹ SL stands for standard limit value.

4.5.3 Wi-Fi RF Receiver (RX) Specifications

Table 14: RX Sensitivity

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	-98.2	—
802.11b, 2 Mbps	—	-95.6	—
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	—	-82.2	—
802.11g, 48 Mbps	—	-78.0	—
802.11g, 54 Mbps	—	-76.2	—
802.11n, HT20, MCS 0	—	-93.0	—
802.11n, HT20, MCS 1	—	-90.6	—
802.11n, HT20, MCS 2	—	-88.4	—
802.11n, HT20, MCS 3	—	-84.8	—
802.11n, HT20, MCS 4	—	-81.6	—
802.11n, HT20, MCS 5	—	-77.4	—
802.11n, HT20, MCS 6	—	-75.6	—
802.11n, HT20, MCS 7	—	-74.2	—
802.11n, HT40, MCS 0	—	-90.0	—
802.11n, HT40, MCS 1	—	-87.5	—
802.11n, HT40, MCS 2	—	-85.0	—
802.11n, HT40, MCS 3	—	-82.0	—
802.11n, HT40, MCS 4	—	-78.5	—
802.11n, HT40, MCS 5	—	-74.4	—
802.11n, HT40, MCS 6	—	-72.5	—
802.11n, HT40, MCS 7	—	-71.2	—

Table 15: 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, MCS 0	—	5	—
802.11n, HT20, MCS 7	—	0	—

Cont'd on next page

Table 15 – cont'd from previous page

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11n, HT40, MCS 0	—	5	—
802.11n, HT40, MCS 7	—	0	—

Table 16: 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, MCS 0	—	31	—
802.11n, HT20, MCS 7	—	13	—
802.11n, HT40, MCS 0	—	19	—
802.11n, HT40, MCS 7	—	8	—

4.6 Bluetooth LE Radio

Table 17: 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 18: 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}$	—	2.50	—	kHz
	Max $ f_0 - f_n $	—	2.00	—	kHz
	Max $ f_n - f_{n-5} $	—	1.40	—	kHz
	$ f_1 - f_0 $	—	1.00	—	kHz
Modulation characteristics	$\Delta f_{1\text{avg}}$	—	249.00	—	kHz
	Min $\Delta f_{2\text{max}}$ (for at least 99.9% of all $\Delta f_{2\text{max}}$)	—	198.00	—	kHz
	$\Delta f_{2\text{avg}}/\Delta f_{1\text{avg}}$	—	0.86	—	—
In-band spurious emissions	± 2 MHz offset	—	-37.00	—	dBm
	± 3 MHz offset	—	-42.00	—	dBm

Cont'd on next page

Table 18 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	>±3 MHz offset	—	-44.00	—	dBm

Table 19: 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}$	—	2.50	—	kHz
	Max $ f_0 - f_n $	—	2.00	—	kHz
	Max $ f_n - f_{n-5} $	—	1.40	—	kHz
	$ f_1 - f_0 $	—	1.00	—	kHz
Modulation characteristics	Δf_{1avg}	—	499.00	—	kHz
	Min Δf_{2max} (for at least 99.9% of all Δf_{2max})	—	416.00	—	kHz
	$\Delta f_{2avg}/\Delta f_{1avg}$	—	0.89	—	—
In-band spurious emissions	±4 MHz offset	—	-42.00	—	dBm
	±5 MHz offset	—	-44.00	—	dBm
	>±5 MHz offset	—	-47.00	—	dBm

Table 20: 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}$	—	0.80	—	kHz
	Max $ f_0 - f_n $	—	1.00	—	kHz
	$ f_n - f_{n-3} $	—	0.30	—	kHz
	$ f_0 - f_3 $	—	1.00	—	kHz
Modulation characteristics	Δf_{1avg}	—	248.00	—	kHz
	Min Δf_{1max} (for at least 99.9% of all Δf_{1max})	—	222.00	—	kHz
In-band spurious emissions	±2 MHz offset	—	-37.00	—	dBm
	±3 MHz offset	—	-42.00	—	dBm
	>±3 MHz offset	—	-44.00	—	dBm

Table 21: 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}$	—	0.80	—	kHz
	Max $ f_0 - f_n $	—	1.00	—	kHz

Cont'd on next page

Table 21 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	$ f_n - f_{n-3} $	—	0.85	—	kHz
	$ f_0 - f_3 $	—	0.34	—	kHz
Modulation characteristics	Δf_{2avg}	—	213.00	—	kHz
	Min Δf_{2max} (for at least 99.9% of all Δf_{2max})	—	196.00	—	kHz
In-band spurious emissions	± 2 MHz offset	—	-37.00	—	dBm
	± 3 MHz offset	—	-42.00	—	dBm
	$> \pm 3$ MHz offset	—	-44.00	—	dBm

4.6.2 Bluetooth LE RF Receiver (RX) Specifications

Table 22: Receiver Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-96.5	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	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	—	-30	—	dB
	F = F0 + 3 MHz	—	-31	—	dB
	F = F0 - 3 MHz	—	-33	—	dB
	F > F0 + 3 MHz	—	-32	—	dB
F > F0 - 3 MHz	—	-36	—	dB	
Image frequency	—	—	-32	—	dB
Adjacent channel to image frequency	F = F _{image} + 1 MHz	—	-39	—	dB
	F = F _{image} - 1 MHz	—	-31	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	-9	—	dBm
	2003 MHz ~ 2399 MHz	—	-18	—	dBm
	2484 MHz ~ 2997 MHz	—	-15	—	dBm
	3000 MHz ~ 12.75 GHz	—	-5	—	dBm
Intermodulation	—	—	-29	—	dBm

Table 23: Receiver Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-92.5	—	dBm
Maximum received signal @30.8% PER	—	—	3	—	dBm
Co-channel C/I	F = F0 MHz	—	10	—	dB
	F = F0 + 2 MHz	—	-8	—	dB
	F = F0 - 2 MHz	—	-5	—	dB

Cont'd on next page

Adjacent channel selectivity C/I

Table 23 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	$F = F_0 + 4 \text{ MHz}$	—	-31	—	dB
	$F = F_0 - 4 \text{ MHz}$	—	-33	—	dB
	$F = F_0 + 6 \text{ MHz}$	—	-37	—	dB
	$F = F_0 - 6 \text{ MHz}$	—	-37	—	dB
	$F > F_0 + 6 \text{ MHz}$	—	-40	—	dB
	$F > F_0 - 6 \text{ MHz}$	—	-40	—	dB
Image frequency	—	—	-31	—	dB
Adjacent channel to image frequency	$F = F_{image} + 2 \text{ MHz}$	—	-37	—	dB
	$F = F_{image} - 2 \text{ MHz}$	—	-8	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	-15	—	dBm
	2003 MHz ~ 2399 MHz	—	-19	—	dBm
	2484 MHz ~ 2997 MHz	—	-15	—	dBm
	3000 MHz ~ 12.75 GHz	—	-6	—	dBm
Intermodulation	—	—	-29	—	dBm

Table 24: Receiver Characteristics - Bluetooth LE 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-103.5	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	$F = F_0 \text{ MHz}$	—	6	—	dB
Adjacent channel selectivity C/I	$F = F_0 + 1 \text{ MHz}$	—	-6	—	dB
	$F = F_0 - 1 \text{ MHz}$	—	-5	—	dB
	$F = F_0 + 2 \text{ MHz}$	—	-32	—	dB
	$F = F_0 - 2 \text{ MHz}$	—	-39	—	dB
	$F = F_0 + 3 \text{ MHz}$	—	-35	—	dB
	$F = F_0 - 3 \text{ MHz}$	—	-45	—	dB
	$F > F_0 + 3 \text{ MHz}$	—	-35	—	dB
Image frequency	—	—	-35	—	dB
Adjacent channel to image frequency	$F = F_{image} + 1 \text{ MHz}$	—	-49	—	dB
	$F = F_{image} - 1 \text{ MHz}$	—	-32	—	dB

Table 25: Receiver Characteristics - Bluetooth LE 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-100	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	$F = F_0 \text{ MHz}$	—	4	—	dB
Adjacent channel selectivity C/I	$F = F_0 + 1 \text{ MHz}$	—	-5	—	dB
	$F = F_0 - 1 \text{ MHz}$	—	-5	—	dB
	$F = F_0 + 2 \text{ MHz}$	—	-28	—	dB

Adjacent channel selectivity C/I

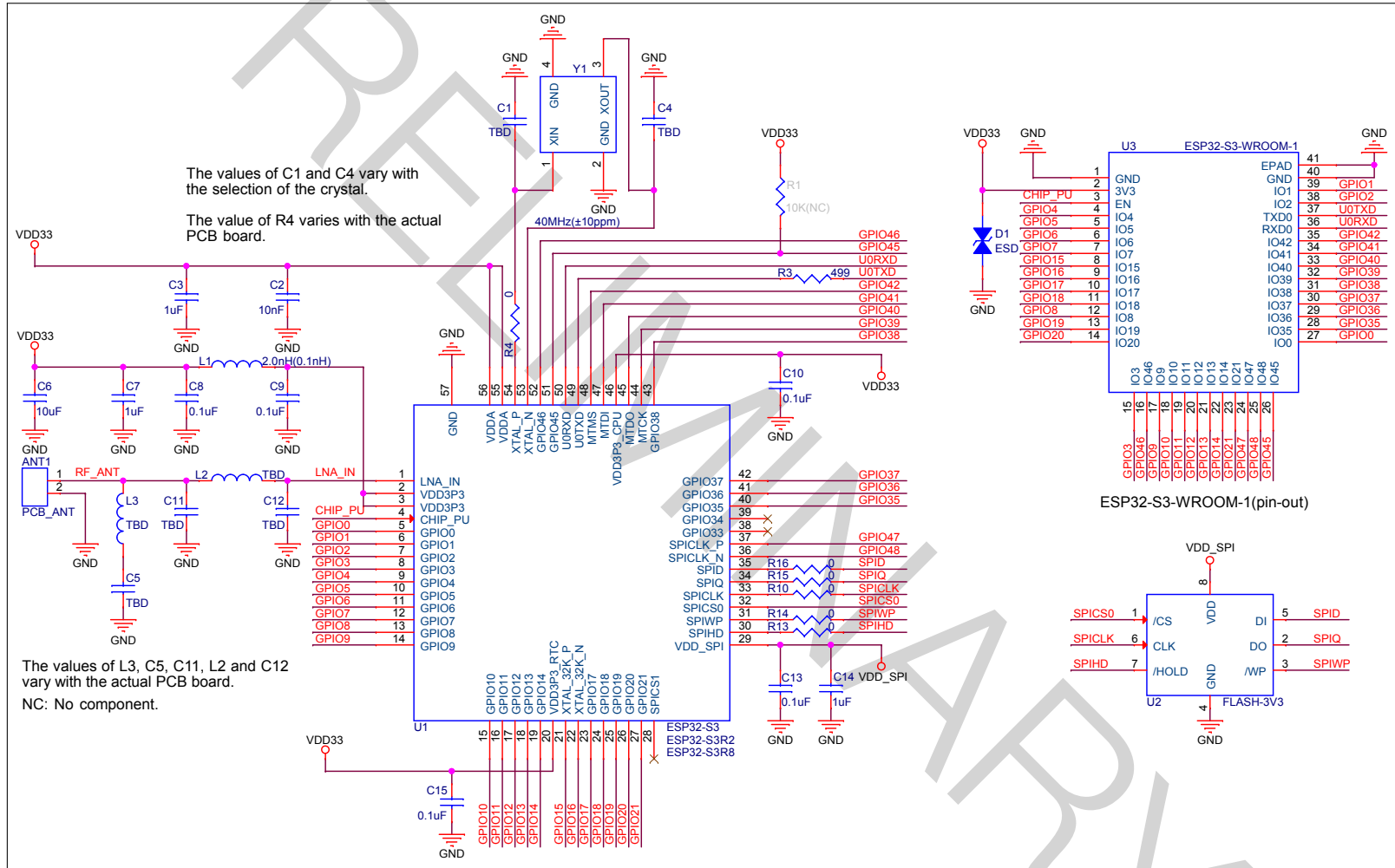
Cont'd on next page

Table 25 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	$F = F_0 - 2 \text{ MHz}$	—	-36	—	dB
	$F = F_0 + 3 \text{ MHz}$	—	-36	—	dB
	$F = F_0 - 3 \text{ MHz}$	—	-38	—	dB
	$F > F_0 + 3 \text{ MHz}$	—	-37	—	dB
	$F > F_0 - 3 \text{ MHz}$	—	-41	—	dB
Image frequency	—	—	-37	—	dB
Adjacent channel to image frequency	$F = F_{image} + 1 \text{ MHz}$	—	-44	—	dB
	$F = F_{image} - 1 \text{ MHz}$	—	-28	—	dB

5 Module Schematics

This is the reference design of the module.



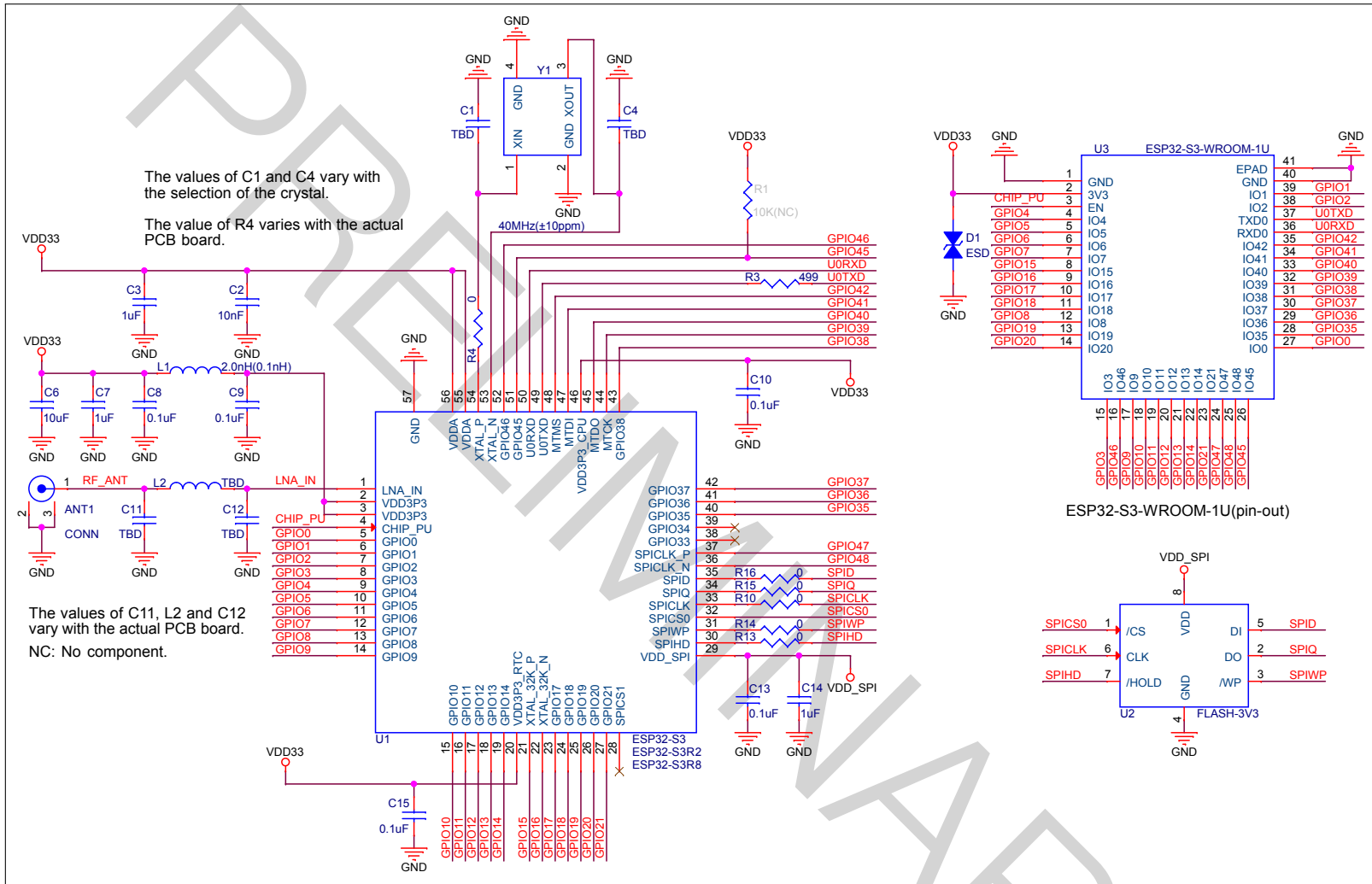


Figure 6: ESP32-S3-WROOM-1U Schematics

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 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).

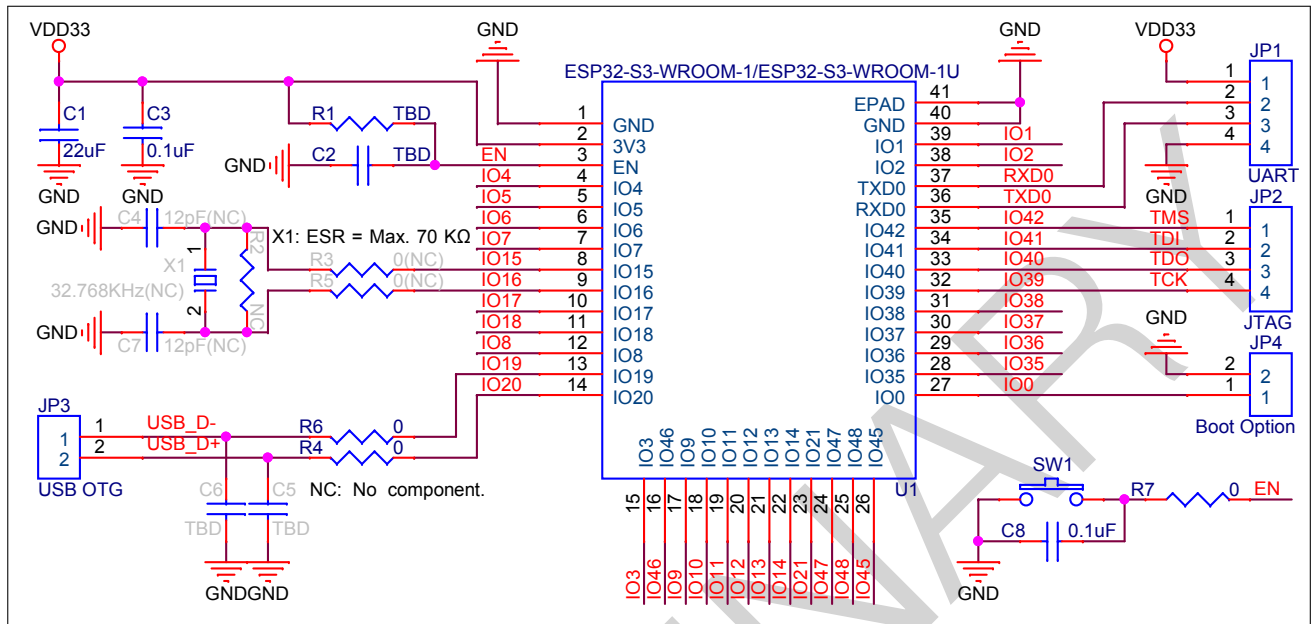


Figure 7: Peripheral Schematics

- 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 $C = 1\text{ }\mu\text{F}$. 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](#).

7.2 Recommended PCB Land Pattern

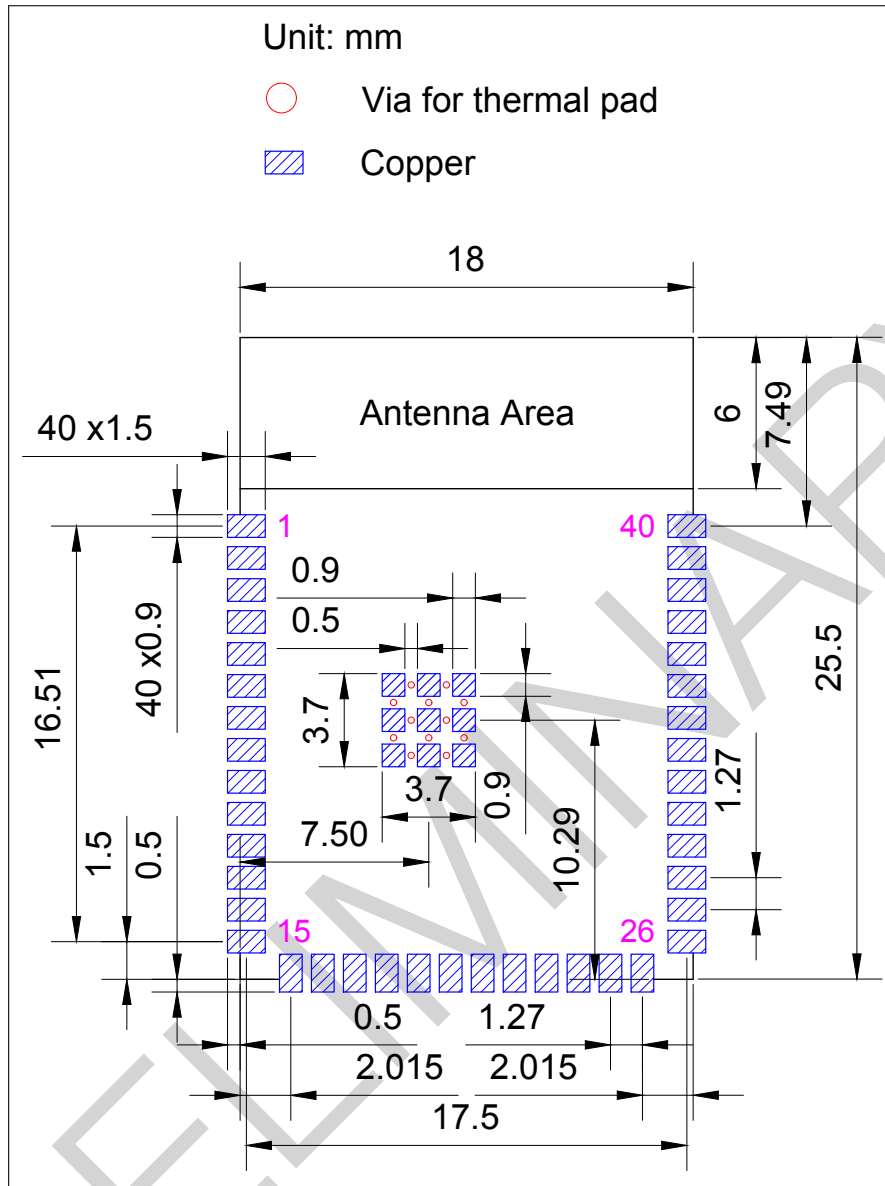


Figure 10: ESP32-S3-WROOM-1 Recommended PCB Land Pattern

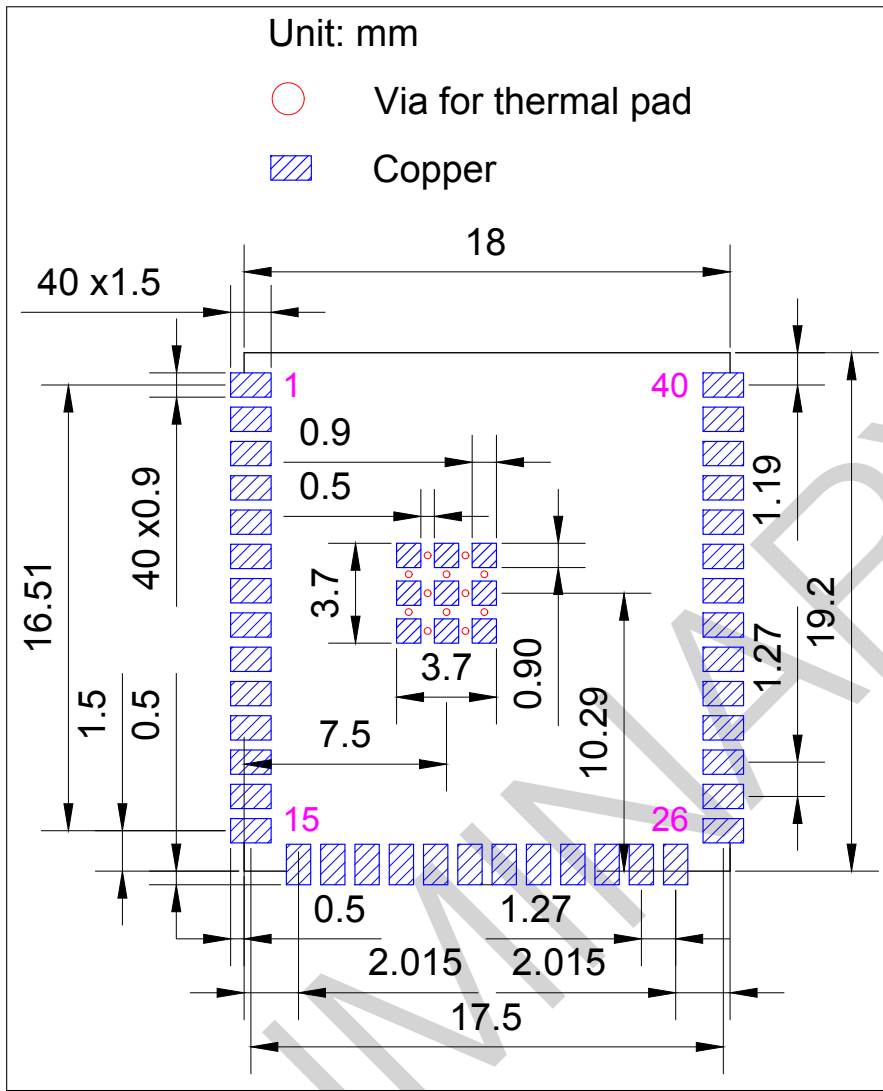


Figure 11: ESP32-S3-WROOM-1U Recommended PCB Land Pattern

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

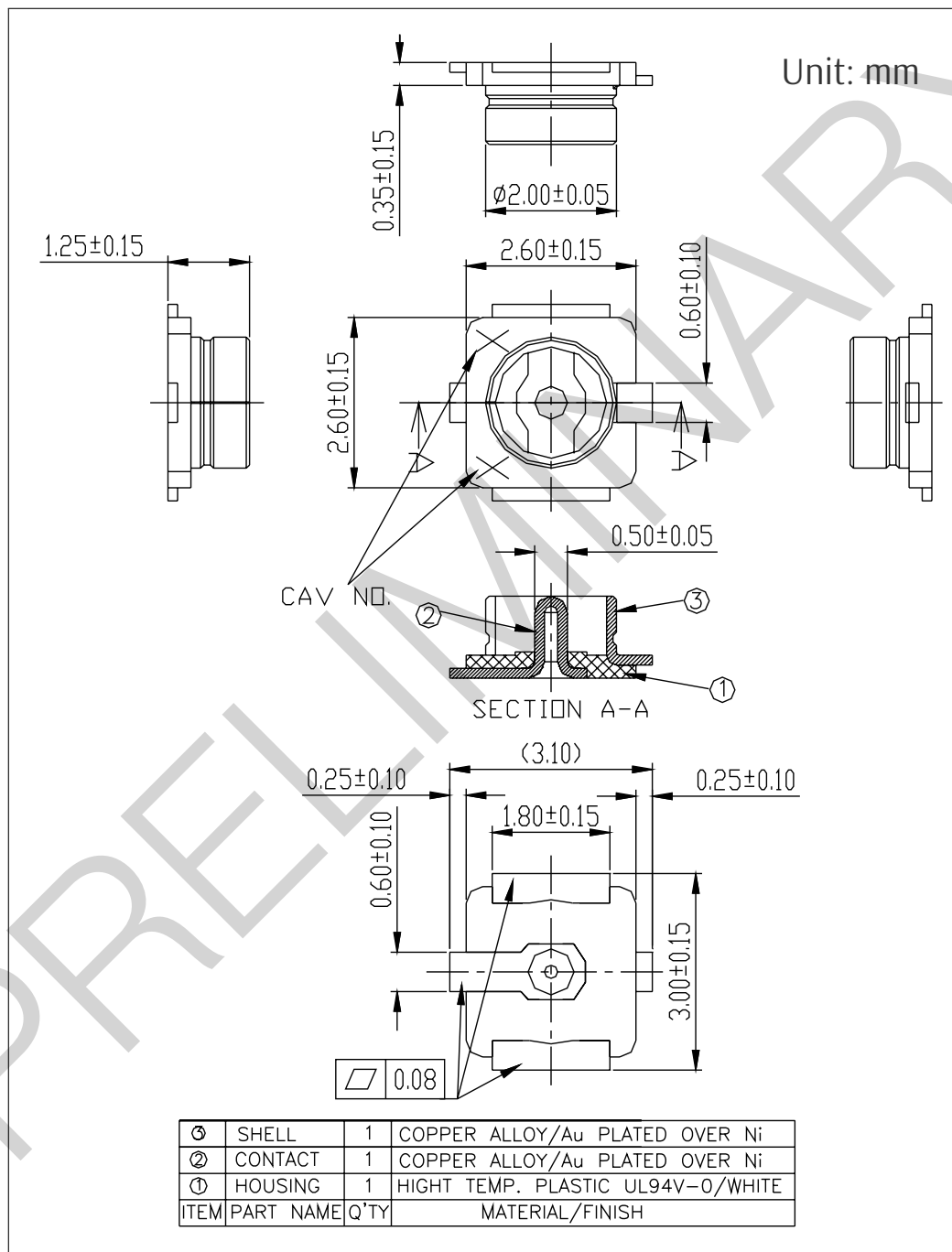


Figure 12: Dimensions of External Antenna Connector

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.

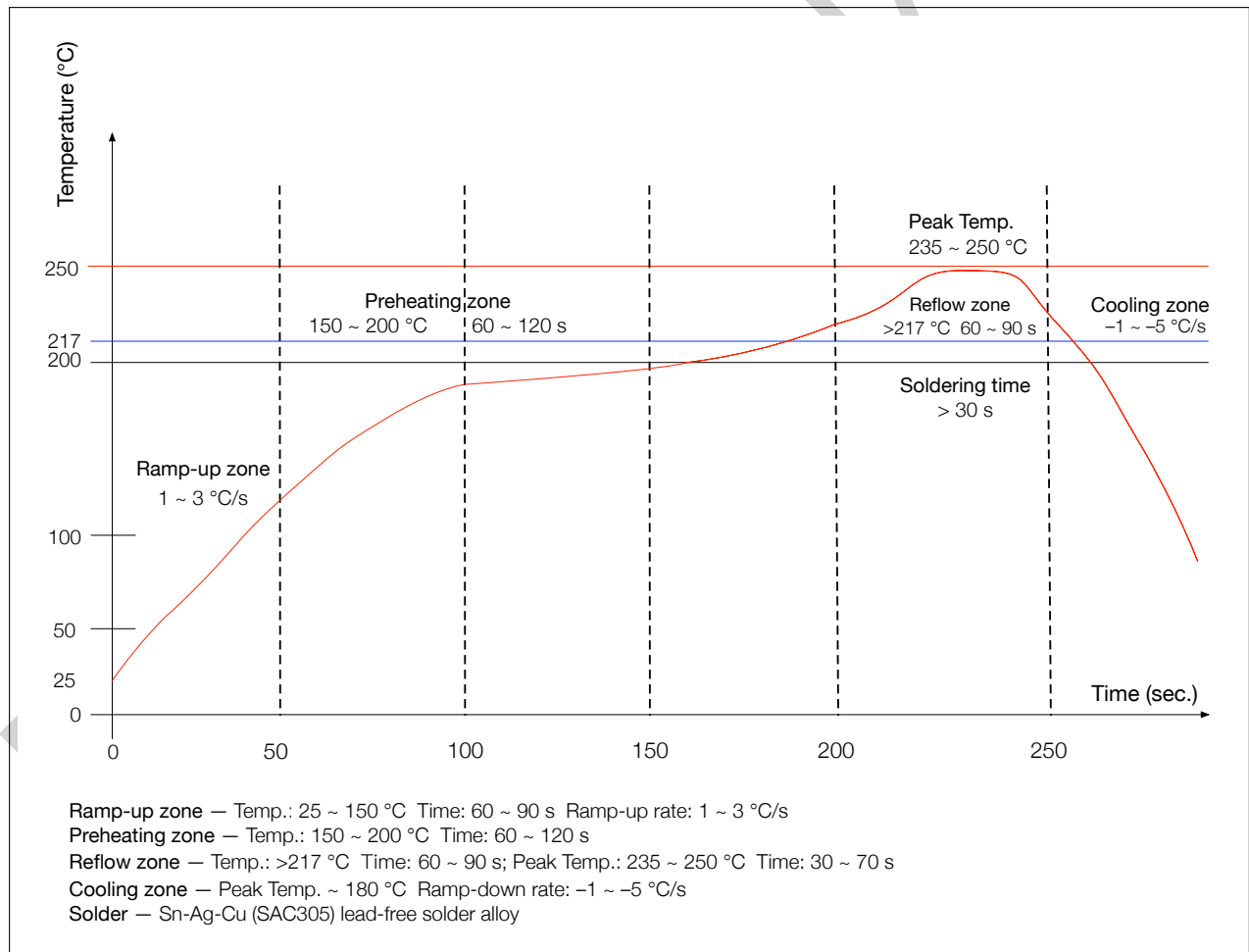


Figure 13: Reflow Profile

9 Related Documentation and Resources

Related Documentation

- [ESP32-S3 Series Datasheet](#) – Specifications of the ESP32-S3 hardware.
- [ESP32-S3 Technical Reference Manual](#) – Detailed information on how to use the ESP32-S3 memory and peripherals.
- [ESP32-S3 Hardware Design Guidelines](#) – Guidelines on how to integrate the ESP32-S3 into your hardware product.
- *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://blog.espressif.com/>
- 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>
- *ESP32-S3 Series DevKits* – Browse through all ESP32-S3-based devkits.
<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>

Contact Us

- See the tabs *Sales Questions, Technical Enquiries, Circuit Schematic & PCB Design Review, Get Samples (Online stores), Become Our Supplier, Comments & Suggestions*.
<http://espressif.com/en/contact-us/sales-questions>

Revision History

Date	Version	Release notes
2021-10-29	v0.6	Overall update for chip revision 1
2021-07-19	v0.5.1	Preliminary release, for chip revision 0

PRELIMINARY

PRELIMINARY



www.espressif.com

Disclaimer and Copyright Notice

Information in this document, including URL references, is subject to change without notice.

ALL THIRD PARTY'S INFORMATION IN THIS DOCUMENT IS PROVIDED AS IS WITH NO WARRANTIES TO ITS AUTHENTICITY AND ACCURACY.

NO WARRANTY IS PROVIDED TO THIS DOCUMENT FOR ITS MERCHANTABILITY, NON-INFRINGEMENT, FITNESS FOR ANY PARTICULAR PURPOSE, NOR DOES ANY WARRANTY OTHERWISE ARISING OUT OF ANY PROPOSAL, SPECIFICATION OR SAMPLE.

All liability, including liability for infringement of any proprietary rights, relating to use of information in this document is disclaimed. No licenses express or implied, by estoppel or otherwise, to any intellectual property rights are granted herein.

The Wi-Fi Alliance Member logo is a trademark of the Wi-Fi Alliance. The Bluetooth logo is a registered trademark of Bluetooth SIG.

All trade names, trademarks and registered trademarks mentioned in this document are property of their respective owners, and are hereby acknowledged.

Copyright © 2021 Espressif Systems (Shanghai) Co., Ltd. All rights reserved.