

ESP32-S3-WROOM-2

Datasheet

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

Built around ESP32-S3R8V SoC, Xtensa® dual-core 32-bit LX7 microprocessor

Flash up to 32 MB, 8 MB PSRAM

33 GPIOs, rich set of peripherals

On-board PCB antenna



ESP32-S3-WROOM-2



Pre-release v0.6
Espressif Systems
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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/documentation/esp32-s3-wroom-2_datasheet_en.pdf



1.1 Features

CPU and On-Chip Memory

- ESP32-S3R8V SoC embedded, Xtensa® dual-core 32-bit LX7 microprocessor (with single precision FPU), up to 240 MHz
- 384 KB ROM
- 512 KB SRAM
- 16 KB SRAM in RTC
- 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
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps

- 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 32 MB octal SPI flash

Antenna Options

- On-board PCB antenna

Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature: -40 ~ 65 °C

1.2 Description

ESP32-S3-WROOM-2 is a powerful, generic Wi-Fi + Bluetooth LE MCU module that has a rich set of peripherals. It provides acceleration for neural network computing and signal processing workloads. It is an ideal choice for a wide variety of application scenarios related to AI and Artificial Intelligence of Things (AIoT), such as wake word detection and speech commands recognition, face detection and recognition, smart home, smart appliances, smart control panel, smart speaker, etc.

ESP32-S3-WROOM-2 comes with a PCB antenna. It has ESP32-S3R8V SoC embedded. A selection of module variants are available for customers with flash memory of 16/32 MB and PSRAM memory of 8 MB.

The ordering information for the module is as follows:

Table 1: Ordering Information

| Ordering Code | Chip Embedded | Flash (MB) | PSRAM (MB) | Dimensions (mm) |
|-------------------------|---------------|------------|---------------|-----------------|
| ESP32-S3-WROOM-2-N16R8V | ESP32-S3R8V | 16 | 8 (Octal SPI) | 18 × 25.5 × 3.1 |
| ESP32-S3-WROOM-2-N32R8V | ESP32-S3R8V | 32 | 8 (Octal SPI) | |

At the core of the modules is an ESP32-S3R8V, 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-S3R8V integrates a rich set of peripherals including SPI, LCD interface, 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, 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

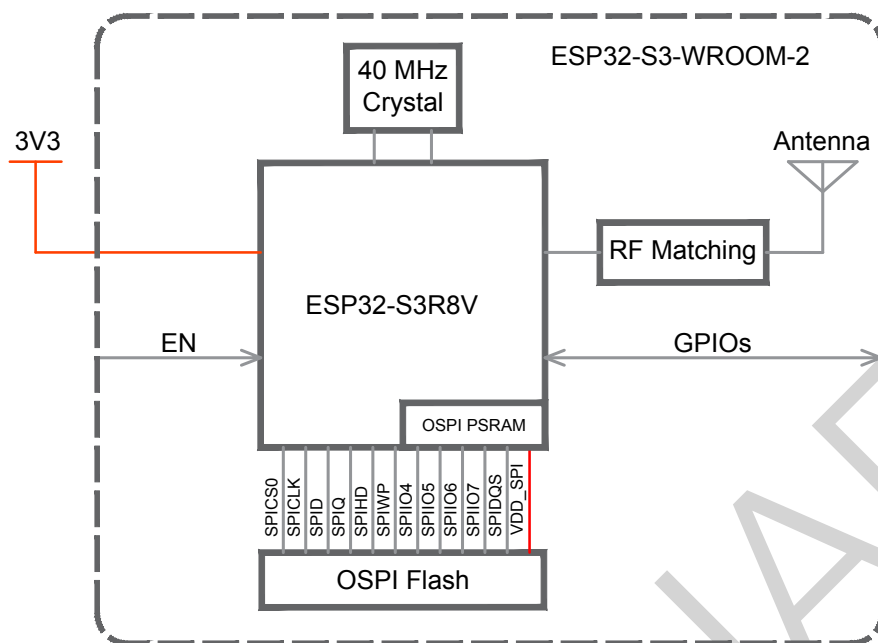


Figure 1: ESP32-S3-WROOM-2 Block Diagram

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*.

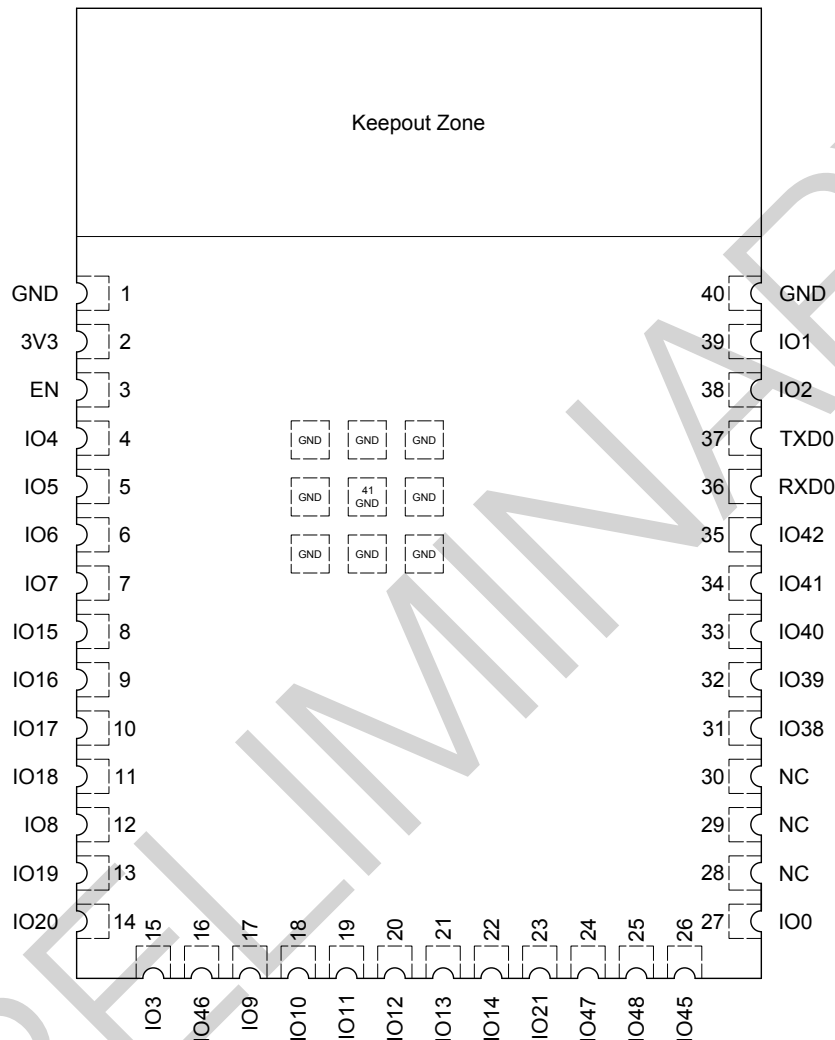


Figure 2: Pin Layout (Top View)

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 ¹ | Function |
|------|-----|-------------------|----------|
| GND | 1 | P | GND |

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Table 2 – cont'd from previous page

| Name | No. | Type ¹ | Function |
|------|-----|-------------------|--|
| 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 |
| NC | 28 | - | NC |
| NC | 29 | - | NC |
| NC | 30 | - | NC |
| 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 |

Cont'd on next page

Table 2 – cont'd from previous page

| Name | No. | Type ¹ | Function |
|------------|-----|-------------------|--|
| 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 |

¹ P: power supply; I: input; O: output; T: high impedance. Bold font is the default function of the pin.

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 |
| Bootling 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 Bootling ^{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:

1. The VDD_SPI voltage of the ESP32-S3R8V chip has been set to 1.8 V by eFuse VDD_SPI_TIEH and VDD_SPI_FORCE, and is no longer controlled by GPIO45.
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 (U1TXD), depending on the eFuse bit EFUSE_UART_PRINT_CHANNEL.
4. 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 3 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.

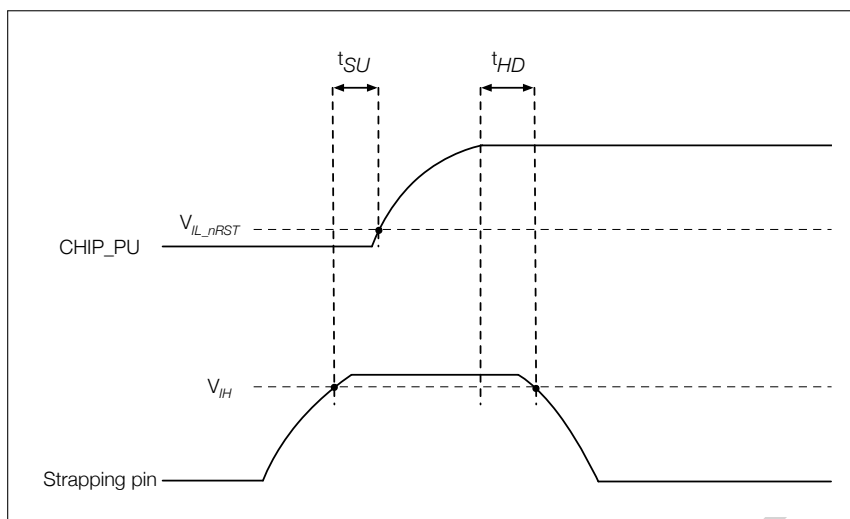


Figure 3: Setup and Hold Times for the Strapping Pin

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 | -40 | — | 65 | °C |

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 |
| R _{PU} | Internal weak pull-up resistor | — | 45 | — | kΩ |
| R _{PD} | Internal weak pull-down resistor | — | 45 | — | kΩ |

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Table 8 – cont'd from previous page

| Symbol | Parameter | Min | Typ | Max | Unit |
|----------------|---|---------------------|-----|---------------------|------|
| 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.

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 |
| 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 |

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

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 |

Cont'd on next page

Table 13 – cont'd from previous page

| Rate | Min (dB) | Typ (dB) | SL ¹ (dB) |
|---------------------------------|----------|----------|----------------------|
| 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 | — |
| 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 |

Cont'd on next page

Table 18 – cont'd from previous page

| Parameter | Description | Min | Typ | Max | Unit |
|----------------------------|--|-----|--------|-----|------|
| | $ 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 |
| | $>\pm 3$ 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 | $\Delta f_{1\text{avg}}$ | — | 499.00 | — | kHz |
| | Min $\Delta f_{2\text{max}}$ (for at least 99.9% of all $\Delta f_{2\text{max}}$) | — | 416.00 | — | kHz |
| | $\Delta f_{2\text{avg}}/\Delta f_{1\text{avg}}$ | — | 0.89 | — | — |
| In-band spurious emissions | ± 4 MHz offset | — | -42.00 | — | dBm |
| | ± 5 MHz offset | — | -44.00 | — | dBm |
| | $>\pm 5$ 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 | $\Delta f_{1\text{avg}}$ | — | 248.00 | — | kHz |
| | Min $\Delta f_{1\text{max}}$ (for at least 99.9% of all $\Delta f_{1\text{max}}$) | — | 222.00 | — | kHz |
| In-band spurious emissions | ± 2 MHz offset | — | -37.00 | — | dBm |
| | ± 3 MHz offset | — | -42.00 | — | dBm |
| | $>\pm 3$ MHz offset | — | -44.00 | — | dBm |

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 | $\text{Max } f_n _{n=0, 1, 2, \dots, k}$ | — | 0.80 | — | kHz |
| | $\text{Max } f_0 - f_n $ | — | 1.00 | — | kHz |
| | $ f_n - f_{n-3} $ | — | 0.85 | — | kHz |
| | $ f_0 - f_3 $ | — | 0.34 | — | kHz |
| Modulation characteristics | $\Delta f_{2\text{avg}}$ | — | 213.00 | — | kHz |
| | Min $\Delta f_{2\text{max}}$ (for at least 99.9% of all $\Delta f_{2\text{max}}$) | — | 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 | $F = F_0$ MHz | — | 9 | — | dB |
| Adjacent channel selectivity C/I | $F = F_0 + 1$ MHz | — | -3 | — | dB |
| | $F = F_0 - 1$ MHz | — | -3 | — | dB |
| | $F = F_0 + 2$ MHz | — | -28 | — | dB |
| | $F = F_0 - 2$ MHz | — | -30 | — | dB |
| | $F = F_0 + 3$ MHz | — | -31 | — | dB |
| | $F = F_0 - 3$ MHz | — | -33 | — | dB |
| | $F > F_0 + 3$ MHz | — | -32 | — | dB |
| | $F > F_0 - 3$ MHz | — | -36 | — | dB |
| Image frequency | — | — | -32 | — | dB |
| Adjacent channel to image frequency | $F = F_{\text{image}} + 1$ MHz | — | -39 | — | dB |
| | $F = F_{\text{image}} - 1$ 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 | $F = F_0$ MHz | — | 10 | — | dB |
| Adjacent channel selectivity C/I | $F = F_0 + 2$ MHz | — | -8 | — | dB |
| | $F = F_0 - 2$ MHz | — | -5 | — | dB |
| | $F = F_0 + 4$ MHz | — | -31 | — | dB |
| | $F = F_0 - 4$ MHz | — | -33 | — | dB |
| | $F = F_0 + 6$ MHz | — | -37 | — | dB |
| | $F = F_0 - 6$ MHz | — | -37 | — | dB |
| | $F > F_0 + 6$ MHz | — | -40 | — | dB |
| | $F > F_0 - 6$ MHz | — | -40 | — | dB |
| Image frequency | — | — | -31 | — | dB |
| Adjacent channel to image frequency | $F = F_{image} + 2$ MHz | — | -37 | — | dB |
| | $F = F_{image} - 2$ 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 | $F = F_0$ MHz | — | 6 | — | dB |
| Adjacent channel selectivity C/I | $F = F_0 + 1$ MHz | — | -6 | — | dB |
| | $F = F_0 - 1$ MHz | — | -5 | — | dB |
| | $F = F_0 + 2$ MHz | — | -32 | — | dB |
| | $F = F_0 - 2$ MHz | — | -39 | — | dB |
| | $F = F_0 + 3$ MHz | — | -35 | — | dB |
| | $F = F_0 - 3$ MHz | — | -45 | — | dB |
| | $F > F_0 + 3$ MHz | — | -35 | — | dB |
| | $F > F_0 - 3$ MHz | — | -48 | — | dB |
| Image frequency | — | — | -35 | — | dB |
| Adjacent channel to image frequency | $F = F_{image} + 1$ MHz | — | -49 | — | dB |
| | $F = F_{image} - 1$ 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 |
| | $F = F_0 - 2 \text{ MHz}$ | — | -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 |

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ESP32-S3-WROOM-2 Datasheet v0.6



Note that for ESP32_S3R8V, VDD_SPI has been set to 1.8 V by eFuse VDD_SPI_TIEH and VDD_SPI_FORCE.

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).

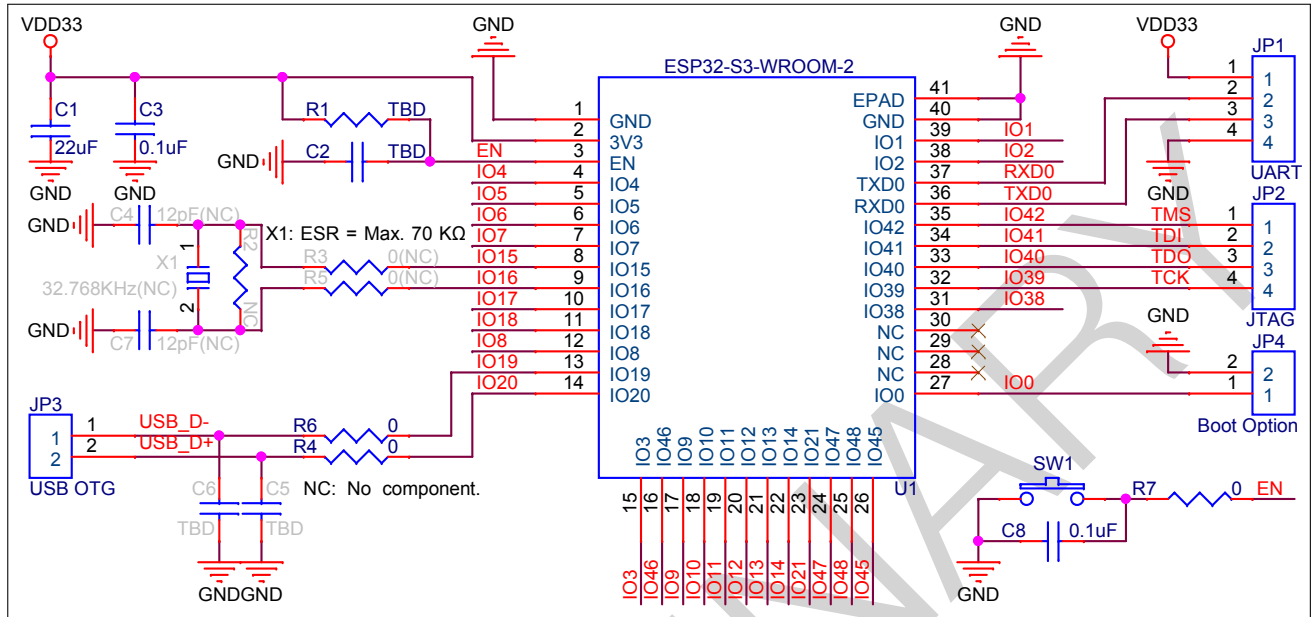


Figure 5: Peripheral Schematics

- 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 Physical Dimensions and PCB Land Pattern

7.1 Physical Dimensions

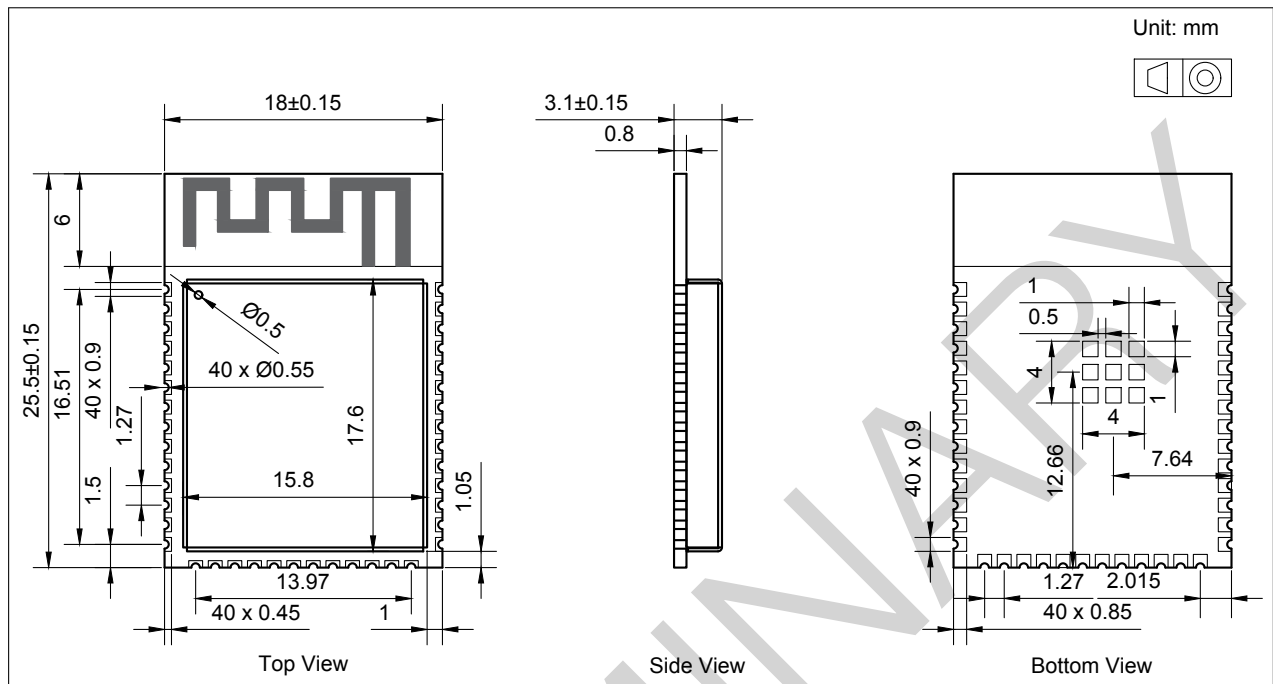


Figure 6: ESP32-S3-WROOM-2 Physical Dimensions

Note:

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

7.2 Recommended PCB Land Pattern

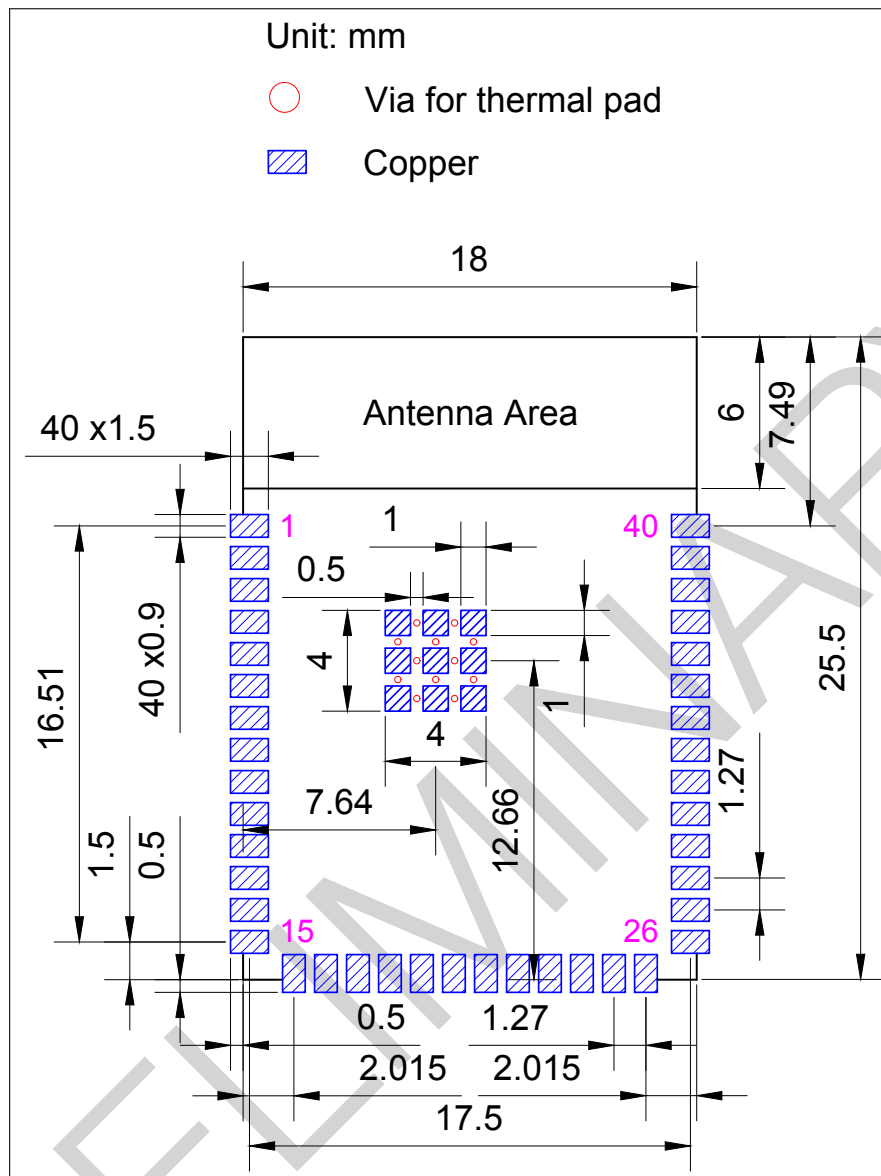


Figure 7: ESP32-S3-WROOM-2 Recommended PCB Land Pattern

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 $< 40^{\circ}\text{C}$ 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 $25\pm 5^{\circ}\text{C}$ 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.

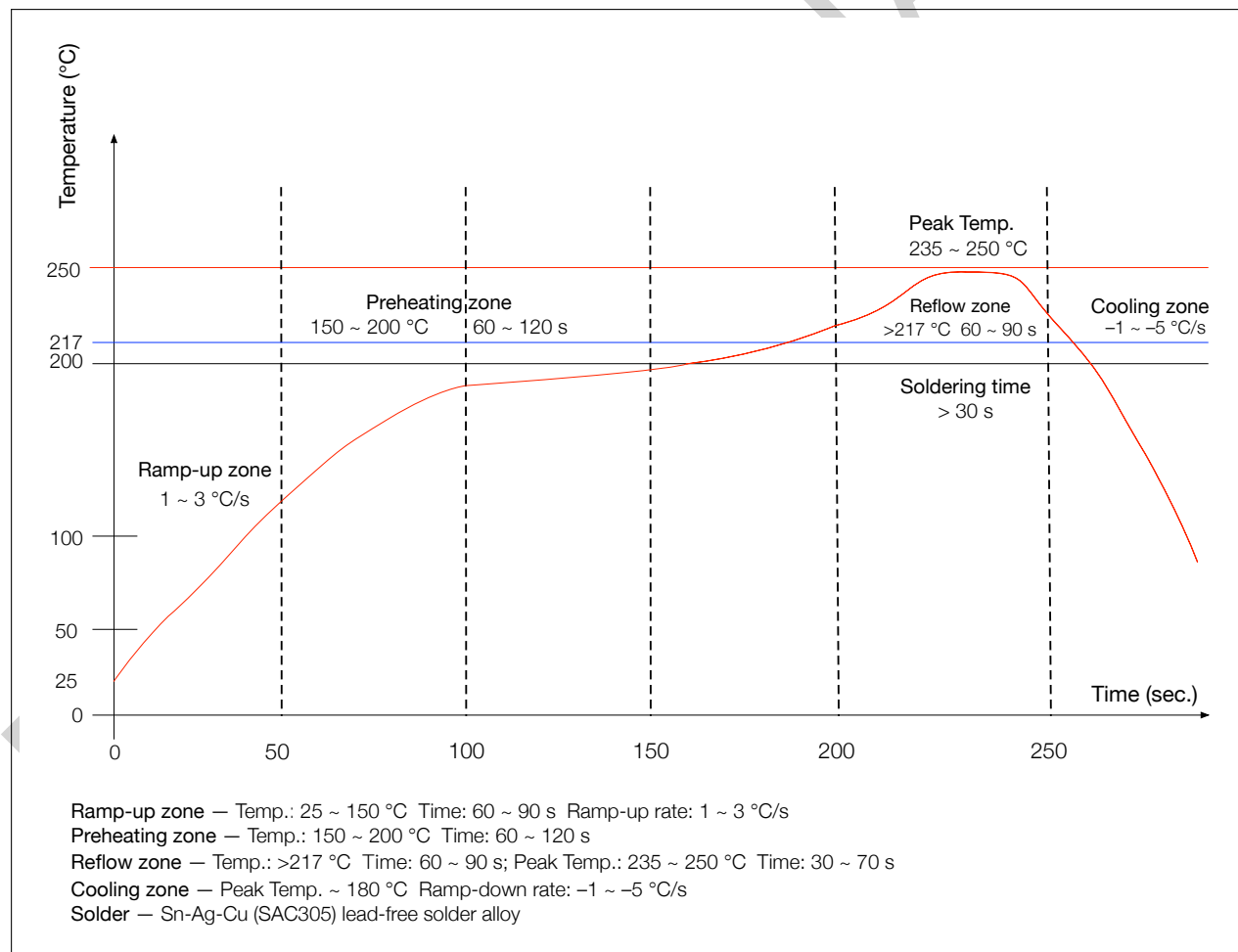


Figure 8: Reflow Profile

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>

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Revision History

| Date | Version | Release notes |
|------------|---------|--|
| 2021-12-31 | v0.6 | Overall update for chip revision 1 |
| 2021-07-13 | v0.1 | Preliminary release, for chip revision 0 |

PRELIMINARY



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