

# ESP32-WROOM-32E & ESP32-WROOM-32UE

## Datasheet



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Espressif Systems  
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This document provides the specifications for the ESP32-WROOM-32E and ESP32-WROOM-32UE modules.

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# 1. Module Overview

## 1.1 Features

### MCU

- ESP32-D0WD-V3 embedded, Xtensa® dual-core 32-bit LX6 microprocessor, up to 240 MHz
- 448 KB ROM for booting and core functions
- 520 KB SRAM for data and instructions
- 16 KB SRAM in RTC

### Wi-Fi

- 802.11b/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 V4.2 BR/EDR and Bluetooth LE specification

- Class-1, class-2 and class-3 transmitter
- AFH
- CVSD and SBC

### Hardware

- Interfaces: SD card, UART, SPI, SDIO, I<sup>2</sup>C, LED PWM, Motor PWM, I<sup>2</sup>S, IR, pulse counter, GPIO, capacitive touch sensor, ADC, DAC
- 40 MHz crystal oscillator
- 4 MB SPI flash
- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating temperature range: -40 ~ 85 °C
- Dimensions: See Table 1

### Certification

- Bluetooth certification: BQB
- RF certification: FCC/CE-RED/SRRC
- Green certification: REACH/RoHS

## 1.2 Description

ESP32-WROOM-32E and ESP32-WROOM-32UE are two powerful, generic Wi-Fi+BT+BLE MCU modules that target a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming and MP3 decoding.

ESP32-WROOM-32E comes with a PCB antenna, and ESP32-WROOM-32UE with an IPEX antenna. They both feature a 4 MB external SPI flash. **The information in this datasheet is applicable to both modules.**

The ordering information of the two modules is listed as follows:

**Table 1: Ordering Information**

| Module                                                                                                                                                                                                                                                                        | Chip embedded | Flash             | Module dimensions (mm)                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------|---------------------------------------|
| ESP32-WROOM-32E (PCB)                                                                                                                                                                                                                                                         | ESP32-D0WD-V3 | 4 MB <sup>1</sup> | (18.00±0.15)×(25.50±0.15)×(3.10±0.15) |
| ESP32-WROOM-32UE (IPEX)                                                                                                                                                                                                                                                       |               |                   | (18.00±0.15)×(19.20±0.15)×(3.20±0.15) |
| <b>Notes:</b><br>1. The module with 8 MB flash or 16 MB flash is available for custom order.<br>2. For detailed ordering information, please see <a href="#">Espressif Product Ordering Information</a> .<br>3. For dimensions of the IPEX connector, please see Chapter 7.3. |               |                   |                                       |

At the core of the module is the ESP32-D0WD-V3 chip\*. The chip embedded is designed to be scalable and adaptive. There are two CPU cores that can be individually controlled, and the CPU clock frequency is adjustable from 80 MHz to 240 MHz. The chip also has a low-power co-processor that can be used instead of the CPU to save power while performing tasks that do not require much computing power, such as monitoring of peripherals. ESP32 integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, SD card interface, Ethernet, high-speed SPI, UART, I<sup>2</sup>S and I<sup>2</sup>C.

**Note:**

\* For details on the part numbers of the ESP32 family of chips, please refer to the document [ESP32 Datasheet](#).

The integration of Bluetooth®, Bluetooth LE and Wi-Fi ensures that a wide range of applications can be targeted, and that the module is all-around: using Wi-Fi allows a large physical range and direct connection to the Internet through a Wi-Fi router, while using Bluetooth allows the user to conveniently connect to the phone or broadcast low energy beacons for its detection. The sleep current of the ESP32 chip is less than 5  $\mu$ A, making it suitable for battery powered and wearable electronics applications. The module supports a data rate of up to 150 Mbps, and 20 dBm output power at the antenna to ensure the widest physical range. As such the module does offer industry-leading specifications and the best performance for electronic integration, range, power consumption, and connectivity.

The operating system chosen for ESP32 is freeRTOS with LwIP; TLS 1.2 with hardware acceleration is built in as well. Secure (encrypted) over the air (OTA) upgrade is also supported, so that users can upgrade their products even after their release, at minimum cost and effort.

## 1.3 Applications

- Generic Low-power IoT Sensor Hub
- Generic Low-power IoT Data Loggers
- Cameras for Video Streaming
- Over-the-top (OTT) 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

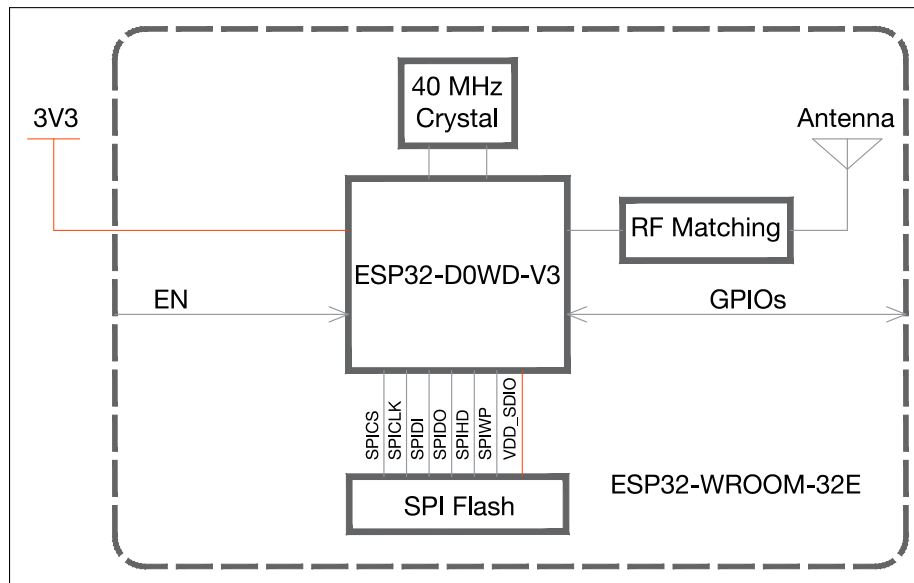


Figure 1: ESP32-WROOM-32E Block Diagram

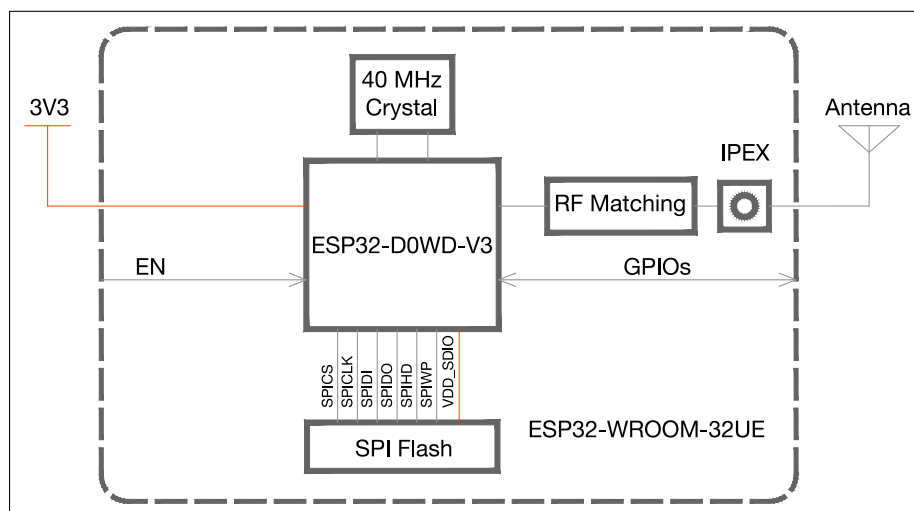


Figure 2: ESP32-WROOM-32UE Block Diagram

## 3. Pin Definitions

### 3.1 Pin Layout

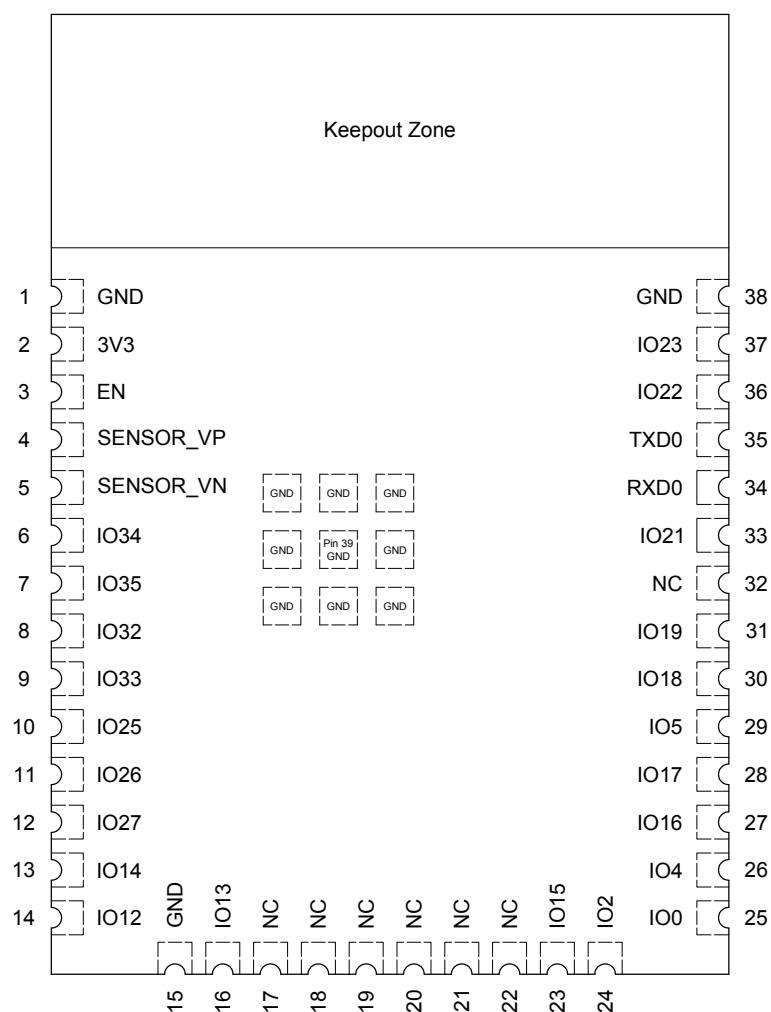


Figure 3: Pin Layout of ESP32-WROOM-32E (Top View)

**Note:**

- The pin layout of ESP32-WROOM-32UE is the same as that of ESP32-WROOM-32E, except that ESP32-WROOM-32UE has no keepout zone.
- The pin diagram shows the approximate location of pins on the module. For the actual mechanical diagram, please refer to Section 7.1 *Physical Dimensions*.

### 3.2 Pin Description

The module has 38 pins. See pin definitions in Table 2.

Table 2: Pin Definitions

| Name      | No. | Type | Function                                                                                            |
|-----------|-----|------|-----------------------------------------------------------------------------------------------------|
| GND       | 1   | P    | Ground                                                                                              |
| 3V3       | 2   | P    | Power supply                                                                                        |
| EN        | 3   | I    | High: On; enables the chip<br>Low: Off; the chip powers off<br>Note: Do not leave the pin floating. |
| SENSOR_VP | 4   | I    | GPIO36, ADC1_CH0, RTC_GPIO0                                                                         |
| SENSOR_VN | 5   | I    | GPIO39, ADC1_CH3, RTC_GPIO3                                                                         |
| IO34      | 6   | I    | GPIO34, ADC1_CH6, RTC_GPIO4                                                                         |
| IO35      | 7   | I    | GPIO35, ADC1_CH7, RTC_GPIO5                                                                         |
| IO32      | 8   | I/O  | GPIO32, XTAL_32K_P (32.768 kHz crystal oscillator input), ADC1_CH4, TOUCH9, RTC_GPIO9               |
| IO33      | 9   | I/O  | GPIO33, XTAL_32K_N (32.768 kHz crystal oscillator output), ADC1_CH5, TOUCH8, RTC_GPIO8              |
| IO25      | 10  | I/O  | GPIO25, DAC_1, ADC2_CH8, RTC_GPIO6, EMAC_RXD0                                                       |
| IO26      | 11  | I/O  | GPIO26, DAC_2, ADC2_CH9, RTC_GPIO7, EMAC_RXD1                                                       |
| IO27      | 12  | I/O  | GPIO27, ADC2_CH7, TOUCH7, RTC_GPIO17, EMAC_RX_DV                                                    |
| IO14      | 13  | I/O  | GPIO14, ADC2_CH6, TOUCH6, RTC_GPIO16, MTMS, HSPICLK, HS2_CLK, SD_CLK, EMAC_TXD2                     |
| IO12      | 14  | I/O  | GPIO12, ADC2_CH5, TOUCH5, RTC_GPIO15, MTDI, HSPIQ, HS2_DATA2, SD_DATA2, EMAC_TXD3                   |
| GND       | 15  | P    | Ground                                                                                              |
| IO13      | 16  | I/O  | GPIO13, ADC2_CH4, TOUCH4, RTC_GPIO14, MTCK, HSPID, HS2_DATA3, SD_DATA3, EMAC_RX_ER                  |
| NC        | 17  | -    | See <a href="#">note 1</a> under the table.                                                         |
| NC        | 18  | -    | See <a href="#">note 1</a> under the table.                                                         |
| NC        | 19  | -    | See <a href="#">note 1</a> under the table.                                                         |
| NC        | 20  | -    | See <a href="#">note 1</a> under the table.                                                         |
| NC        | 21  | -    | See <a href="#">note 1</a> under the table.                                                         |
| NC        | 22  | -    | See <a href="#">note 1</a> under the table.                                                         |
| IO15      | 23  | I/O  | GPIO15, ADC2_CH3, TOUCH3, MTDO, HSPICS0, RTC_GPIO13, HS2_CMD, SD_CMD, EMAC_RXD3                     |
| IO2       | 24  | I/O  | GPIO2, ADC2_CH2, TOUCH2, RTC_GPIO12, HSPIWP, HS2_DATA0, SD_DATA0                                    |
| IO0       | 25  | I/O  | GPIO0, ADC2_CH1, TOUCH1, RTC_GPIO11, CLK_OUT1, EMAC_TX_CLK                                          |
| IO4       | 26  | I/O  | GPIO4, ADC2_CH0, TOUCH0, RTC_GPIO10, HSPIHD, HS2_DATA1, SD_DATA1, EMAC_TX_ER                        |
| IO16      | 27  | I/O  | GPIO16, HS1_DATA4, U2RXD, EMAC_CLK_OUT                                                              |
| IO17      | 28  | I/O  | GPIO17, HS1_DATA5, U2TXD, EMAC_CLK_OUT_180                                                          |
| IO5       | 29  | I/O  | GPIO5, VSPICS0, HS1_DATA6, EMAC_RX_CLK                                                              |
| IO18      | 30  | I/O  | GPIO18, VSPICLK, HS1_DATA7                                                                          |

| Name | No. | Type | Function                          |
|------|-----|------|-----------------------------------|
| IO19 | 31  | I/O  | GPIO19, VSPIQ, U0CTS, EMAC_TXD0   |
| NC   | 32  | -    | -                                 |
| IO21 | 33  | I/O  | GPIO21, VSPIHD, EMAC_TX_EN        |
| RXD0 | 34  | I/O  | GPIO3, U0RXD, CLK_OUT2            |
| TXD0 | 35  | I/O  | GPIO1, U0TXD, CLK_OUT3, EMAC_RXD2 |
| IO22 | 36  | I/O  | GPIO22, VSPIWP, U0RTS, EMAC_TXD1  |
| IO23 | 37  | I/O  | GPIO23, VSPID, HS1_STROBE         |
| GND  | 38  | P    | Ground                            |

**Note:**

1. Pins GPIO6 to GPIO11 on the ESP32-D0WD-V3 chip are connected to the SPI flash integrated on the module and are not led out.
2. For peripheral pin configurations, please refer to [ESP32 Datasheet](#).

### 3.3 Strapping Pins

ESP32 has five strapping pins: MTDI, GPIO0, GPIO2, MTDO, GPIO5. The pin-pin mapping between ESP32 and the module is as follows, which can be seen in Chapter 5 *Schematics*:

- MTDI = IO12
- GPIO0 = BOOT/IO0
- GPIO2 = IO2
- MTDO = IO15
- GPIO5 = IO5

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

During the chip's system reset release (power-on-reset, RTC watchdog reset and brownout 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. The strapping bits configure the device's boot mode, the operating voltage of VDD\_SDIO and other initial system settings.

Each strapping pin is connected to its internal pull-up/pull-down during the chip reset. Consequently, if a strapping pin is unconnected or the connected external circuit is high-impedance, the internal weak pull-up/pull-down will determine the default input level of the strapping pins.

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.

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

Refer to Table 3 for a detailed boot-mode configuration by strapping pins.

**Table 3: Strapping Pins**

Voltage of Internal LDO (VDD\_SDIO)

|                                                                   |           |                          |                          |                          |                          |
|-------------------------------------------------------------------|-----------|--------------------------|--------------------------|--------------------------|--------------------------|
| Pin                                                               | Default   | 3.3 V                    |                          | 1.8 V                    |                          |
| MTDI                                                              | Pull-down | 0                        |                          | 1                        |                          |
| Bootling Mode                                                     |           |                          |                          |                          |                          |
| Pin                                                               | Default   | SPI Boot                 |                          | Download Boot            |                          |
| GPIO0                                                             | Pull-up   | 1                        |                          | 0                        |                          |
| GPIO2                                                             | Pull-down | Don't-care               |                          | 0                        |                          |
| Enabling/Disabling Debugging Log Print over U0TXD During Bootling |           |                          |                          |                          |                          |
| Pin                                                               | Default   | U0TXD Active             |                          | U0TXD Silent             |                          |
| MTDO                                                              | Pull-up   | 1                        |                          | 0                        |                          |
| Timing of SDIO Slave                                              |           |                          |                          |                          |                          |
| Pin                                                               | Default   | FE Sampling<br>FE Output | FE Sampling<br>RE Output | RE Sampling<br>FE Output | RE Sampling<br>RE Output |
| MTDO                                                              | Pull-up   | 0                        | 0                        | 1                        | 1                        |
| GPIO5                                                             | Pull-up   | 0                        | 1                        | 0                        | 1                        |

**Note:**

- FE: falling-edge, RE: rising-edge.
- Firmware can configure register bits to change the settings of "Voltage of Internal LDO (VDD\_SDIO)" and "Timing of SDIO Slave", after bootling.
- The module integrates a 3.3 V SPI flash, so the pin MTDI cannot be set to 1 when the module is powered up.

## 4. Electrical Characteristics

### 4.1 Absolute Maximum Ratings

Stresses beyond the absolute maximum ratings listed in the table below may cause permanent damage to the device. These are stress ratings only, and do not refer to the functional operation of the device that should follow the [recommended operating conditions](#).

**Table 4: Absolute Maximum Ratings**

| Symbol             | Parameter            | Min  | Max | Unit |
|--------------------|----------------------|------|-----|------|
| VDD33              | Power supply voltage | −0.3 | 3.6 | V    |
| T <sub>STORE</sub> | Storage temperature  | −40  | 85  | °C   |

**Note:**

Please see Appendix IO\_MUX of [ESP32 Datasheet](#) for IO's power domain.

### 4.2 Recommended Operating Conditions

**Table 5: 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                | Operating temperature                      | −40 | —   | 85  | °C   |
| Humidity         | Humidity condition                         | —   | 85  | —   | %RH  |

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

**Table 6: 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> | High-level output voltage | 0.8×VDD <sup>1</sup>  | -   | -                     | V    |
| V <sub>OL</sub> | Low-level output voltage  | -                     | -   | 0.1×VDD <sup>1</sup>  | V    |

| Symbol         | Parameter                                                                                                                             |                                            | Min | Typ | Max | Unit |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|-----|-----|-----|------|
| $I_{OH}$       | High-level source current<br>(VDD <sup>1</sup> = 3.3 V,<br>V <sub>OH</sub> >= 2.64 V,<br>output drive strength set<br>to the maximum) | VDD3P3_CPU<br>power domain <sup>1, 2</sup> | -   | 40  | -   | mA   |
|                |                                                                                                                                       | VDD3P3_RTC<br>power domain <sup>1, 2</sup> | -   | 40  | -   | mA   |
|                |                                                                                                                                       | VDD_SDIO power<br>domain <sup>1, 3</sup>   | -   | 20  | -   | mA   |
| $I_{OL}$       | Low-level sink current<br>(VDD <sup>1</sup> = 3.3 V, V <sub>OL</sub> = 0.495 V,<br>output drive strength set to the maximum)          |                                            | -   | 28  | -   | mA   |
| $R_{PU}$       | Resistance of internal pull-up resistor                                                                                               |                                            | -   | 45  | -   | kΩ   |
| $R_{PD}$       | Resistance of internal pull-down resistor                                                                                             |                                            | -   | 45  | -   | kΩ   |
| $V_{IL\_nRST}$ | Low-level input voltage of CHIP_PU<br>to power off the chip                                                                           |                                            | -   | -   | 0.6 | V    |

**Note:**

1. Please see Appendix IO\_MUX of [ESP32 Datasheet](#) for IO's power domain. VDD is the I/O voltage for a particular power domain of pins.
2. For VDD3P3\_CPU and VDD3P3\_RTC power domain, per-pin current sourced in the same domain is gradually reduced from around 40 mA to around 29 mA,  $V_{OH} \geq 2.64\text{ V}$ , as the number of current-source pins increases.
3. Pins occupied by flash and/or PSRAM in the VDD\_SDIO power domain were excluded from the test.

## 4.4 Current Consumption Characteristics

With the use of advanced power-management technologies, ESP32 can switch between different power modes.

For details on ESP32's power consumption in different power modes, please refer to section "RTC and Low-Power Management" in [ESP32 Datasheet](#).

### 4.4.1 Current Consumption Depending on RF Modes

**Table 7: Current Consumption Depending on RF Modes**

| Work mode           | Description |                                    | Average (mA) | Peak (mA) |
|---------------------|-------------|------------------------------------|--------------|-----------|
| Active (RF working) | TX          | 802.11b, 20 MHz, 1 Mbps, @19.5 dBm | 239          | 379       |
|                     |             | 802.11g, 20 MHz, 54 Mbps, @15 dBm  | 190          | 276       |
|                     |             | 802.11b, 20 MHz, MCS7, @13 dBm     | 183          | 258       |
|                     |             | 802.11n, 40 MHz, MCS7, @13 dBm     | 165          | 211       |
|                     | RX          | 802.11b/g/n                        | 112          | 112       |
|                     |             | 802.11n, 40 MHz                    | 118          | 118       |

**Note:**

- 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 50% duty cycle.
- The current consumption figures for in RX mode are for cases when the peripherals are disabled and the CPU idle.

## 4.5 Wi-Fi RF Characteristics

### 4.5.1 Wi-Fi RF Standards

**Table 8: Wi-Fi RF Standards**

| Name                                                     |        | Description                                                                                          |
|----------------------------------------------------------|--------|------------------------------------------------------------------------------------------------------|
| Center frequency range of operating channel <i>note1</i> |        | 2412 ~ 2484 MHz                                                                                      |
| Wi-Fi wireless standard                                  |        | IEEE 802.11b/g/n                                                                                     |
| Data rate                                                | 20 MHz | 11b: 1, 2, 5.5 and 11 Mbps<br>11g: 6, 9, 12, 18, 24, 36, 48, 54 Mbps<br>11n: MCS0-7, 72.2 Mbps (Max) |
|                                                          | 40 MHz | 11n: MCS0-7, 150 Mbps (Max)                                                                          |
| Antenna type                                             |        | PCB antenna, IPEX antenna                                                                            |

**Note:**

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 IPEX antennas, the output impedance is 50 Ω. For other modules without IPEX antennas, users do not need to concern about the output impedance.

### 4.5.2 Transmitter Characteristics

**Table 9: Transmitter Characteristics**

| Parameter            | Rate            | Typ  | Unit |
|----------------------|-----------------|------|------|
| TX Power <i>note</i> | 11b, 1 Mbps     | 19.5 | dBm  |
|                      | 11b, 11 Mbps    | 19.5 |      |
|                      | 11g, 6 Mbps     | 18   |      |
|                      | 11g, 54 Mbps    | 14   |      |
|                      | 11n, HT20, MCS0 | 18   |      |
|                      | 11n, HT20, MCS7 | 13   |      |
|                      | 11n, HT40, MCS0 | 18   |      |
|                      | 11n, HT40, MCS7 | 13   |      |

**Note:**

Target TX power is configurable based on device or certification requirements.



### 4.5.3 Receiver Characteristics

**Table 10: Receiver Characteristics**

| Parameter                  | Rate            | Typ | Unit |
|----------------------------|-----------------|-----|------|
| RX Sensitivity             | 1 Mbps          | −97 | dBm  |
|                            | 2 Mbps          | −94 |      |
|                            | 5.5 Mbps        | −92 |      |
|                            | 11 Mbps         | −88 |      |
|                            | 6 Mbps          | −93 |      |
|                            | 9 Mbps          | −91 |      |
|                            | 12 Mbps         | −89 |      |
|                            | 18 Mbps         | −87 |      |
|                            | 24 Mbps         | −84 |      |
|                            | 36 Mbps         | −80 |      |
|                            | 48 Mbps         | −77 |      |
|                            | 54 Mbps         | −75 |      |
|                            | 11n, HT20, MCS0 | −92 |      |
|                            | 11n, HT20, MCS1 | −88 |      |
|                            | 11n, HT20, MCS2 | −86 |      |
|                            | 11n, HT20, MCS3 | −83 |      |
|                            | 11n, HT20, MCS4 | −80 |      |
|                            | 11n, HT20, MCS5 | −76 |      |
|                            | 11n, HT20, MCS6 | −74 |      |
|                            | 11n, HT20, MCS7 | −72 |      |
|                            | 11n, HT40, MCS0 | −89 |      |
|                            | 11n, HT40, MCS1 | −85 |      |
|                            | 11n, HT40, MCS2 | −83 |      |
|                            | 11n, HT40, MCS3 | −80 |      |
|                            | 11n, HT40, MCS4 | −76 |      |
|                            | 11n, HT40, MCS5 | −72 |      |
|                            | 11n, HT40, MCS6 | −71 |      |
|                            | 11n, HT40, MCS7 | −69 |      |
| RX Maximum Input Level     | 11b, 1 Mbps     | 5   | dBm  |
|                            | 11b, 11 Mbps    | 5   |      |
|                            | 11g, 6 Mbps     | 0   |      |
|                            | 11g, 54 Mbps    | −8  |      |
|                            | 11n, HT20, MCS0 | 0   |      |
|                            | 11n, HT20, MCS7 | −8  |      |
|                            | 11n, HT40, MCS0 | 0   |      |
|                            | 11n, HT40, MCS7 | −8  |      |
| Adjacent Channel Rejection | 11b, 11 Mbps    | 35  | dB   |
|                            | 11g, 6 Mbps     | 27  |      |
|                            | 11g, 54 Mbps    | 13  |      |
|                            | 11n, HT20, MCS0 | 27  |      |

| Parameter | Rate            | Typ | Unit |
|-----------|-----------------|-----|------|
|           | 11n, HT20, MCS7 | 12  |      |
|           | 11n, HT40, MCS0 | 16  |      |
|           | 11n, HT40, MCS7 | 7   |      |

## 4.6 Bluetooth Radio

### 4.6.1 Receiver – Basic Data Rate

**Table 11: Receiver Characteristics – Basic Data Rate**

| Parameter                         | Conditions          | Min | Typ | Max | Unit |
|-----------------------------------|---------------------|-----|-----|-----|------|
| Sensitivity @0.1% BER             | -                   | -90 | -89 | -88 | dBm  |
| Maximum received signal @0.1% BER | -                   | 0   | -   | -   | dBm  |
| Co-channel C/I                    | -                   | -   | +7  | -   | dB   |
| Adjacent channel selectivity C/I  | F = F0 + 1 MHz      | -   | -   | -6  | dB   |
|                                   | F = F0 - 1 MHz      | -   | -   | -6  | dB   |
|                                   | F = F0 + 2 MHz      | -   | -   | -25 | dB   |
|                                   | F = F0 - 2 MHz      | -   | -   | -33 | dB   |
|                                   | F = F0 + 3 MHz      | -   | -   | -25 | dB   |
|                                   | F = F0 - 3 MHz      | -   | -   | -45 | dB   |
| Out-of-band blocking performance  | 30 MHz ~ 2000 MHz   | -10 | -   | -   | dBm  |
|                                   | 2000 MHz ~ 2400 MHz | -27 | -   | -   | dBm  |
|                                   | 2500 MHz ~ 3000 MHz | -27 | -   | -   | dBm  |
|                                   | 3000 MHz ~ 12.5 GHz | -10 | -   | -   | dBm  |
| Intermodulation                   | -                   | -36 | -   | -   | dBm  |

### 4.6.2 Transmitter – Basic Data Rate

**Table 12: Transmitter Characteristics – Basic Data Rate**

| Parameter                                                   | Conditions       | Min | Typ  | Max | Unit           |
|-------------------------------------------------------------|------------------|-----|------|-----|----------------|
| RF transmit power (see <a href="#">note</a> under Table 12) | -                | -   | 0    | -   | dBm            |
| Gain control step                                           | -                | -   | 3    | -   | dB             |
| RF power control range                                      | -                | -12 | -    | +9  | dBm            |
| +20 dB bandwidth                                            | -                | -   | 0.9  | -   | MHz            |
| Adjacent channel transmit power                             | F = F0 ± 2 MHz   | -   | -55  | -   | dBm            |
|                                                             | F = F0 ± 3 MHz   | -   | -55  | -   | dBm            |
|                                                             | F = F0 ± > 3 MHz | -   | -59  | -   | dBm            |
| $\Delta f_{1avg}$                                           | -                | -   | -    | 155 | kHz            |
| $\Delta f_{2max}$                                           | -                | 127 | -    | -   | kHz            |
| $\Delta f_{2avg}/\Delta f_{1avg}$                           | -                | -   | 0.92 | -   | -              |
| ICFT                                                        | -                | -   | -7   | -   | kHz            |
| Drift rate                                                  | -                | -   | 0.7  | -   | kHz/50 $\mu$ s |
| Drift (DH1)                                                 | -                | -   | 6    | -   | kHz            |

| Parameter   | Conditions | Min | Typ | Max | Unit |
|-------------|------------|-----|-----|-----|------|
| Drift (DH5) | -          | -   | 6   | -   | kHz  |

**Note:**

There are a total of eight power levels from 0 to 7, and the transmit power ranges from -12 dBm to 9 dBm. When the power level rises by 1, the transmit power increases by 3 dB. Power level 4 is used by default and the corresponding transmit power is 0 dBm.

### 4.6.3 Receiver – Enhanced Data Rate

**Table 13: Receiver Characteristics – Enhanced Data Rate**

| Parameter                          | Conditions     | Min | Typ | Max | Unit |
|------------------------------------|----------------|-----|-----|-----|------|
| $\pi/4$ DQPSK                      |                |     |     |     |      |
| Sensitivity @0.01% BER             | -              | -90 | -89 | -88 | dBm  |
| Maximum received signal @0.01% BER | -              | -   | 0   | -   | dBm  |
| Co-channel C/I                     | -              | -   | 11  | -   | dB   |
| Adjacent channel selectivity C/I   | F = F0 + 1 MHz | -   | -7  | -   | dB   |
|                                    | F = F0 - 1 MHz | -   | -7  | -   | dB   |
|                                    | F = F0 + 2 MHz | -   | -25 | -   | dB   |
|                                    | F = F0 - 2 MHz | -   | -35 | -   | dB   |
|                                    | F = F0 + 3 MHz | -   | -25 | -   | dB   |
|                                    | F = F0 - 3 MHz | -   | -45 | -   | dB   |
| 8DPSK                              |                |     |     |     |      |
| Sensitivity @0.01% BER             | -              | -84 | -83 | -82 | dBm  |
| Maximum received signal @0.01% BER | -              | -   | -5  | -   | dBm  |
| C/I c-channel                      | -              | -   | 18  | -   | dB   |
| Adjacent channel selectivity C/I   | F = F0 + 1 MHz | -   | 2   | -   | dB   |
|                                    | F = F0 - 1 MHz | -   | 2   | -   | dB   |
|                                    | F = F0 + 2 MHz | -   | -25 | -   | dB   |
|                                    | F = F0 - 2 MHz | -   | -25 | -   | dB   |
|                                    | F = F0 + 3 MHz | -   | -25 | -   | dB   |
|                                    | F = F0 - 3 MHz | -   | -38 | -   | dB   |

### 4.6.4 Transmitter – Enhanced Data Rate

**Table 14: Transmitter Characteristics – Enhanced Data Rate**

| Parameter                                                   | Conditions | Min | Typ   | Max | Unit |
|-------------------------------------------------------------|------------|-----|-------|-----|------|
| RF transmit power (see <a href="#">note</a> under Table 12) | -          | -   | 0     | -   | dBm  |
| Gain control step                                           | -          | -   | 3     | -   | dB   |
| RF power control range                                      | -          | -12 | -     | +9  | dBm  |
| $\pi/4$ DQPSK max w0                                        | -          | -   | -0.72 | -   | kHz  |
| $\pi/4$ DQPSK max wi                                        | -          | -   | -6    | -   | kHz  |
| $\pi/4$ DQPSK max  wi + w0                                  | -          | -   | -7.42 | -   | kHz  |

| Parameter                         | Conditions                     | Min | Typ  | Max | Unit |
|-----------------------------------|--------------------------------|-----|------|-----|------|
| 8DPSK max w0                      | -                              | -   | 0.7  | -   | kHz  |
| 8DPSK max wi                      | -                              | -   | -9.6 | -   | kHz  |
| 8DPSK max  wi + w0                | -                              | -   | -10  | -   | kHz  |
| $\pi/4$ DQPSK modulation accuracy | RMS DEVM                       | -   | 4.28 | -   | %    |
|                                   | 99% DEVM                       | -   | 100  | -   | %    |
|                                   | Peak DEVM                      | -   | 13.3 | -   | %    |
| 8 DPSK modulation accuracy        | RMS DEVM                       | -   | 5.8  | -   | %    |
|                                   | 99% DEVM                       | -   | 100  | -   | %    |
|                                   | Peak DEVM                      | -   | 14   | -   | %    |
| In-band spurious emissions        | $F = F_0 \pm 1 \text{ MHz}$    | -   | -46  | -   | dBm  |
|                                   | $F = F_0 \pm 2 \text{ MHz}$    | -   | -44  | -   | dBm  |
|                                   | $F = F_0 \pm 3 \text{ MHz}$    | -   | -49  | -   | dBm  |
|                                   | $F = F_0 +/ - > 3 \text{ MHz}$ | -   | -    | -53 | dBm  |
| EDR differential phase coding     | -                              | -   | 100  | -   | %    |

## 4.7 Bluetooth LE Radio

### 4.7.1 Receiver

Table 15: Receiver Characteristics – BLE

| Parameter                          | Conditions                | Min | Typ | Max | Unit |
|------------------------------------|---------------------------|-----|-----|-----|------|
| Sensitivity @30.8% PER             | -                         | -94 | -93 | -92 | dBm  |
| Maximum received signal @30.8% PER | -                         | 0   | -   | -   | dBm  |
| Co-channel C/I                     | -                         | -   | +10 | -   | dB   |
| Adjacent channel selectivity C/I   | $F = F_0 + 1 \text{ MHz}$ | -   | -5  | -   | dB   |
|                                    | $F = F_0 - 1 \text{ MHz}$ | -   | -5  | -   | dB   |
|                                    | $F = F_0 + 2 \text{ MHz}$ | -   | -25 | -   | dB   |
|                                    | $F = F_0 - 2 \text{ MHz}$ | -   | -35 | -   | dB   |
|                                    | $F = F_0 + 3 \text{ MHz}$ | -   | -25 | -   | dB   |
|                                    | $F = F_0 - 3 \text{ MHz}$ | -   | -45 | -   | dB   |
| Out-of-band blocking performance   | 30 MHz ~ 2000 MHz         | -10 | -   | -   | dBm  |
|                                    | 2000 MHz ~ 2400 MHz       | -27 | -   | -   | dBm  |
|                                    | 2500 MHz ~ 3000 MHz       | -27 | -   | -   | dBm  |
|                                    | 3000 MHz ~ 12.5 GHz       | -10 | -   | -   | dBm  |
| Intermodulation                    | -                         | -36 | -   | -   | dBm  |

### 4.7.2 Transmitter

Table 16: Transmitter Characteristics – BLE

| Parameter                                                   | Conditions | Min | Typ | Max | Unit |
|-------------------------------------------------------------|------------|-----|-----|-----|------|
| RF transmit power (see <a href="#">note</a> under Table 12) | -          | -   | 0   | -   | dBm  |
| Gain control step                                           | -          | -   | 3   | -   | dB   |

| Parameter                                             | Conditions                    | Min | Typ   | Max | Unit                 |
|-------------------------------------------------------|-------------------------------|-----|-------|-----|----------------------|
| RF power control range                                | -                             | -12 | -     | +9  | dBm                  |
| Adjacent channel transmit power                       | $F = F_0 \pm 2 \text{ MHz}$   | -   | -55   | -   | dBm                  |
|                                                       | $F = F_0 \pm 3 \text{ MHz}$   | -   | -57   | -   | dBm                  |
|                                                       | $F = F_0 \pm > 3 \text{ MHz}$ | -   | -59   | -   | dBm                  |
| $\Delta f_{1_{\text{avg}}}$                           | -                             | -   | -     | 265 | kHz                  |
| $\Delta f_{2_{\text{max}}}$                           | -                             | 210 | -     | -   | kHz                  |
| $\Delta f_{2_{\text{avg}}}/\Delta f_{1_{\text{avg}}}$ | -                             | -   | +0.92 | -   | -                    |
| ICFT                                                  | -                             | -   | -10   | -   | kHz                  |
| Drift rate                                            | -                             | -   | 0.7   | -   | kHz/50 $\mu\text{s}$ |
| Drift                                                 | -                             | -   | 2     | -   | kHz                  |

## 5. Schematics

This is the reference design of the module.

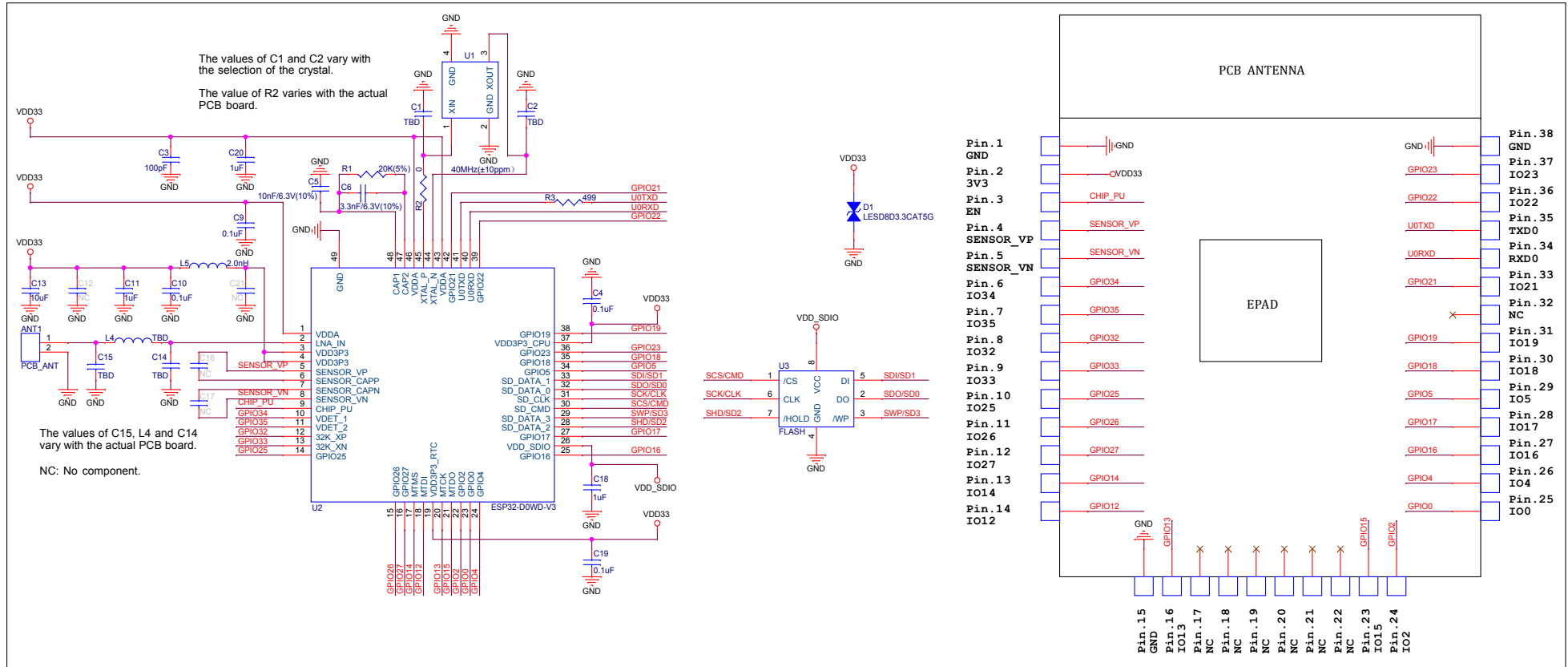


Figure 4: ESP32-WROOM-32E Schematics

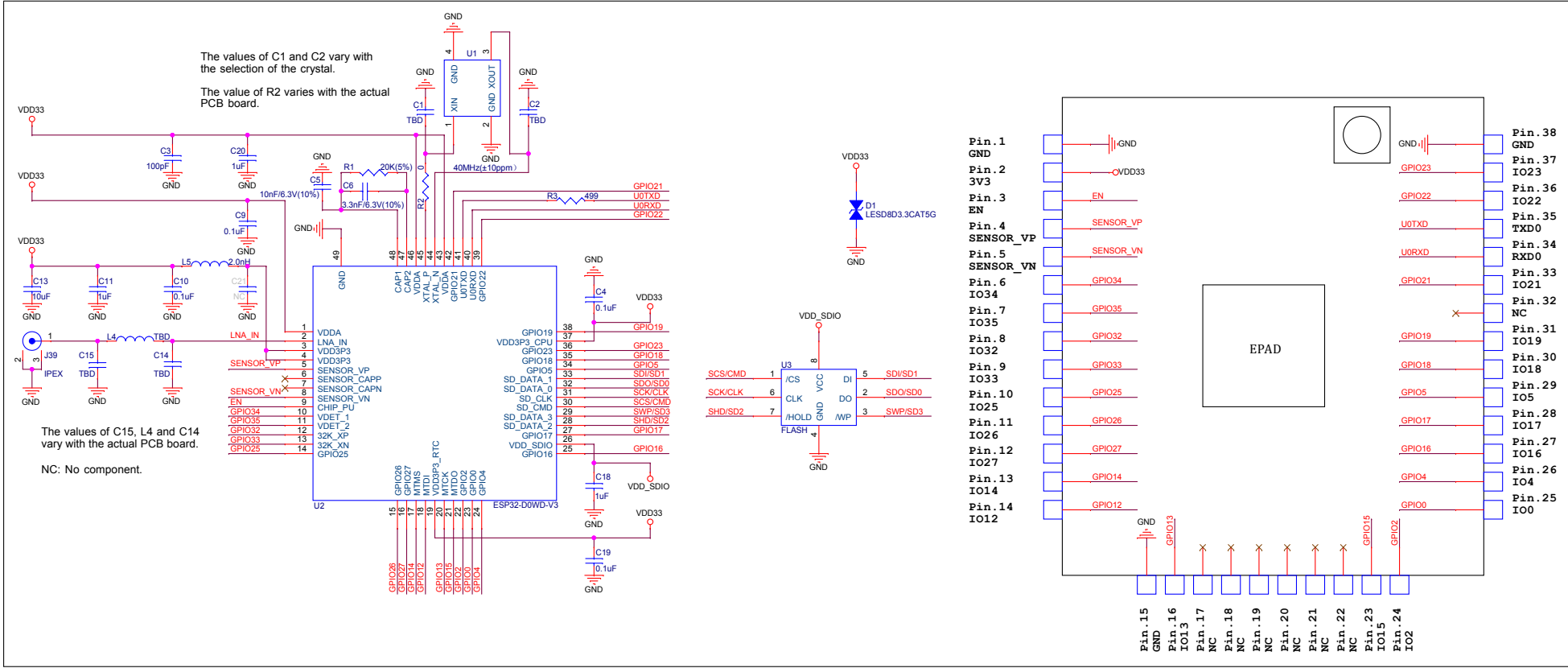


Figure 5: ESP32-WROOM-32UE Schematics

## 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).

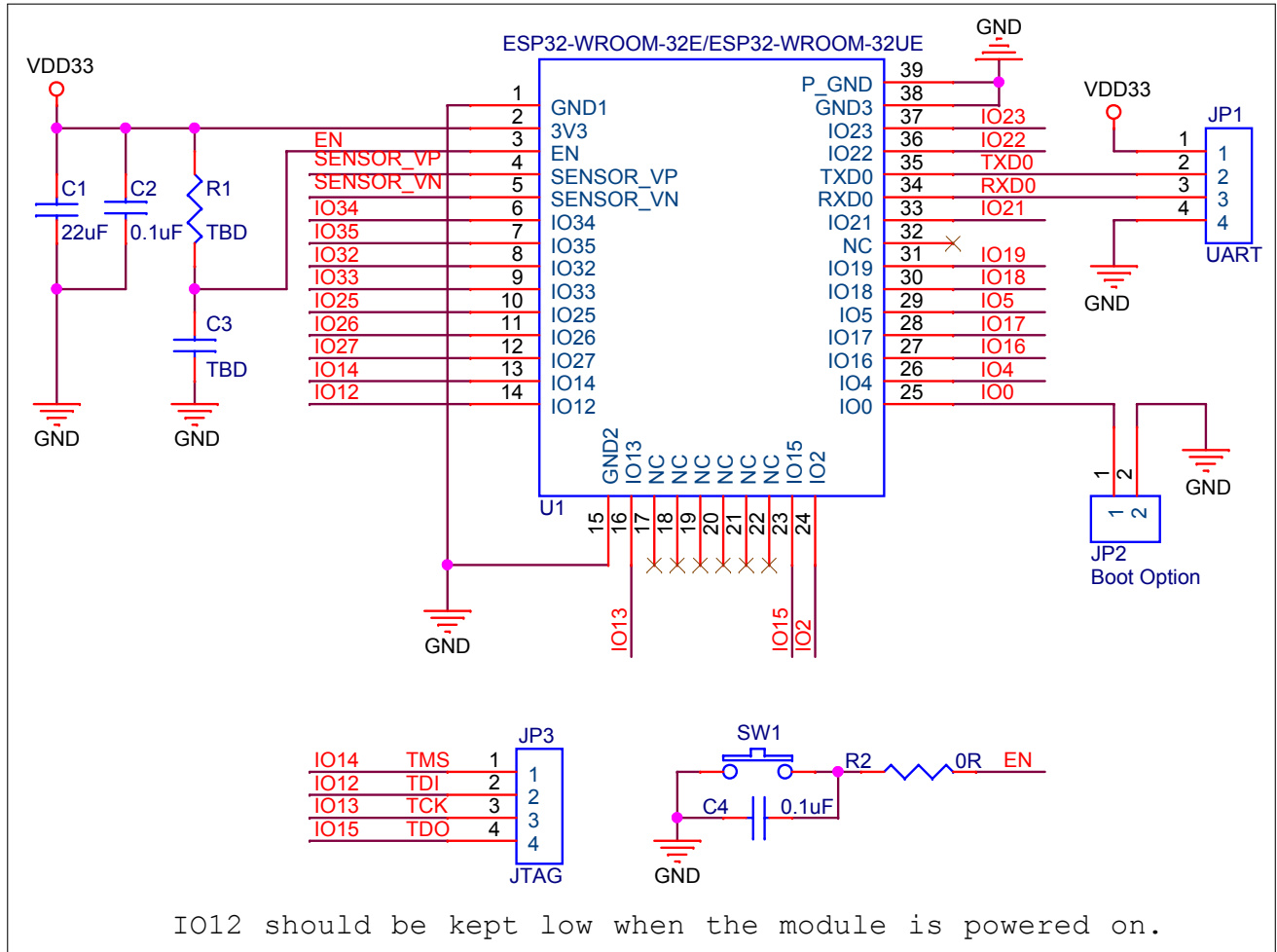


Figure 6: ESP32-WROOM-32E & ESP32-WROOM-32UE Peripheral Schematics

### Note:

- Soldering Pad 39 to the Ground of the base board is not necessary for a satisfactory thermal performance. If users do want to solder it, they need to ensure that the correct quantity of soldering paste is applied.
- To ensure the power supply to the ESP32 chip 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  $C = 0.1\text{ }\mu\text{F}$ . 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's power-up and reset sequence timing diagram, please refer to Section *Power Scheme* in [ESP32 Datasheet](#).



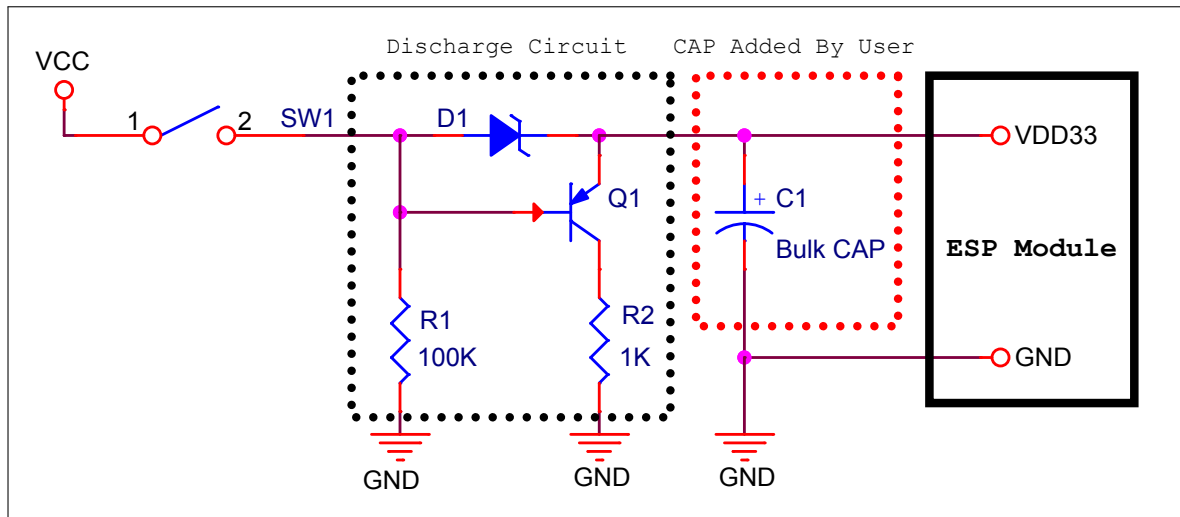


Figure 7: Discharge Circuit for VDD33 Rail

**Note:**

The discharge circuit can be applied in scenarios where ESP32 is powered on and off repeatedly by switching the power rails, and there is a large capacitor on the VDD33 rail. For details, please refer to Section *Power Scheme* in [ESP32 Datasheet](#).

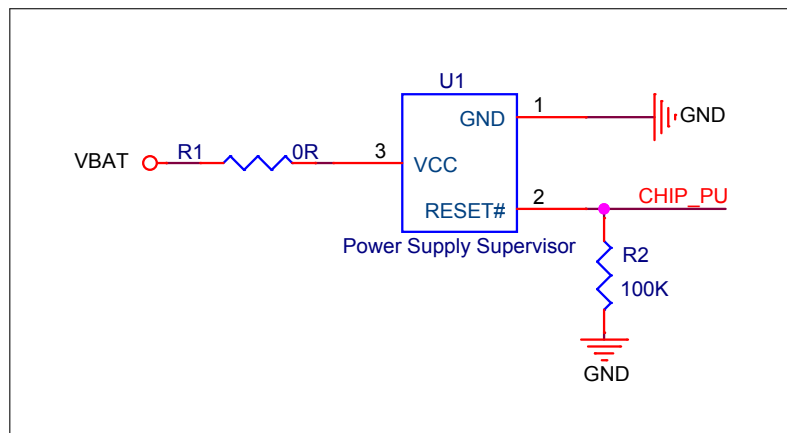


Figure 8: Reset Circuit

**Note:**

When battery is used as the power supply for ESP32 series of chips and modules, a supply voltage supervisor is recommended to avoid boot failure due to low voltage. Users are recommended to pull CHIP\_PU low if the power supply for ESP32 is below 2.3 V.

## 7. Physical Dimensions and PCB Layout

### 7.1 Physical Dimensions

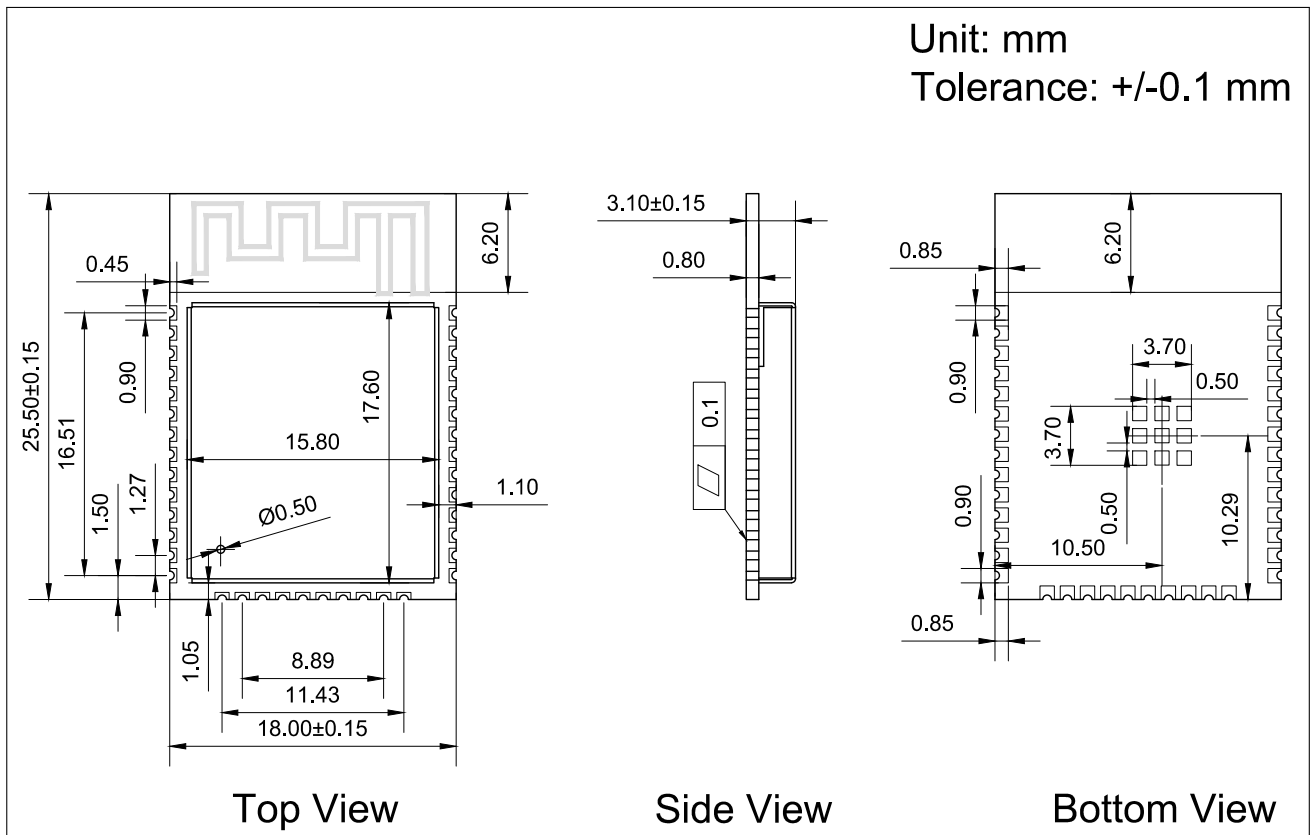


Figure 9: ESP32-WROOM-32E Physical Dimensions

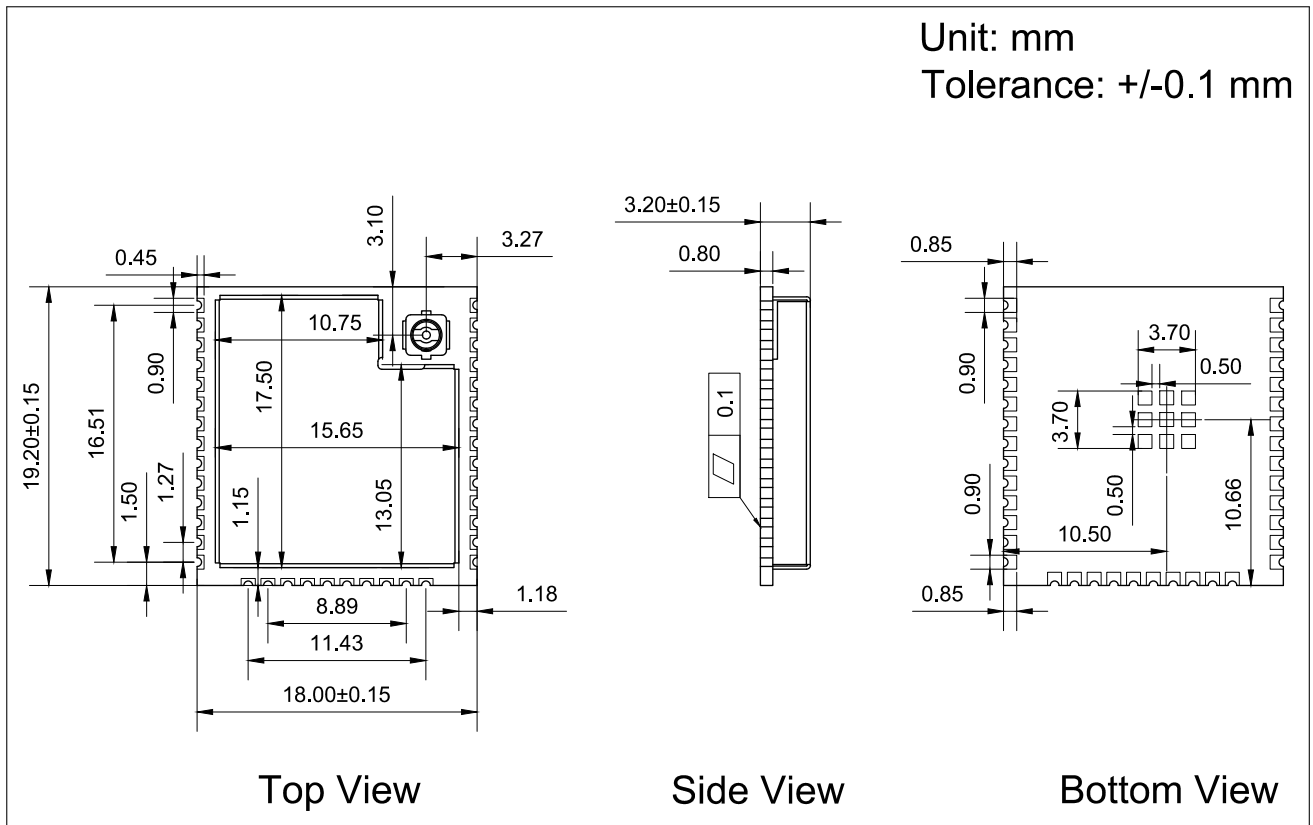


Figure 10: ESP32-WROOM-32UE Physical Dimensions



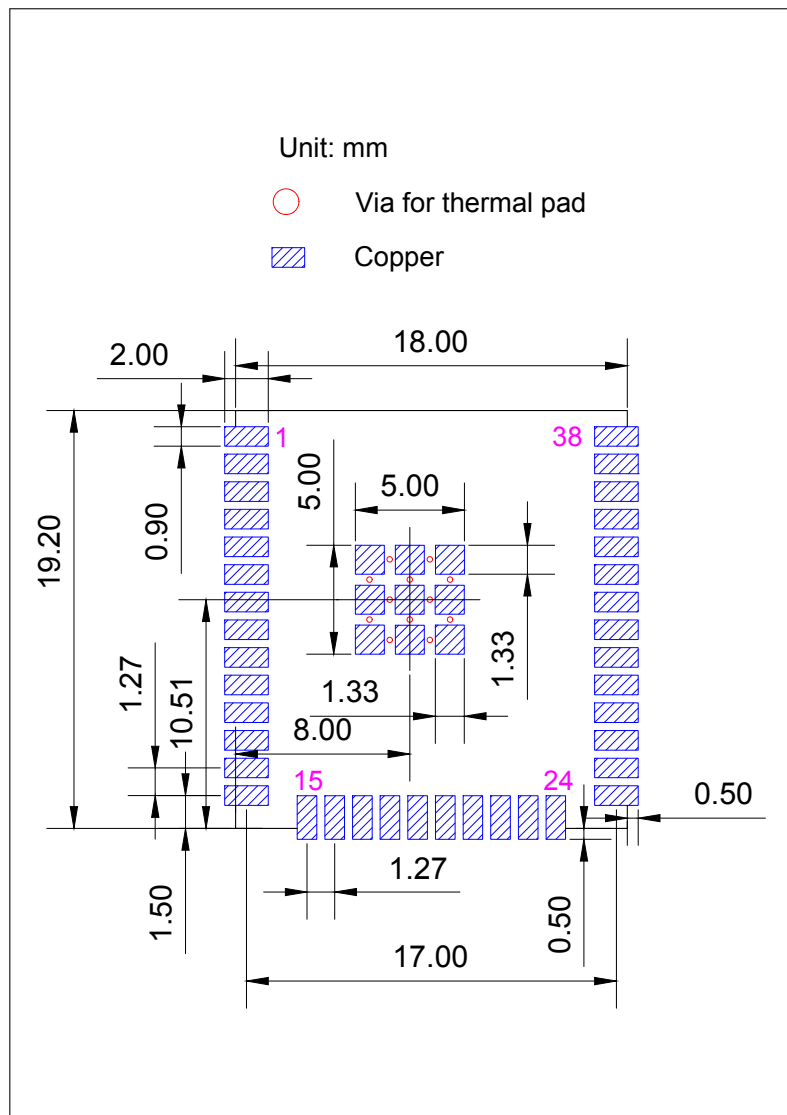


Figure 12: ESP32-WROOM-32UE Recommended PCB Land Pattern

## 7.3 U.FL Connector Dimensions

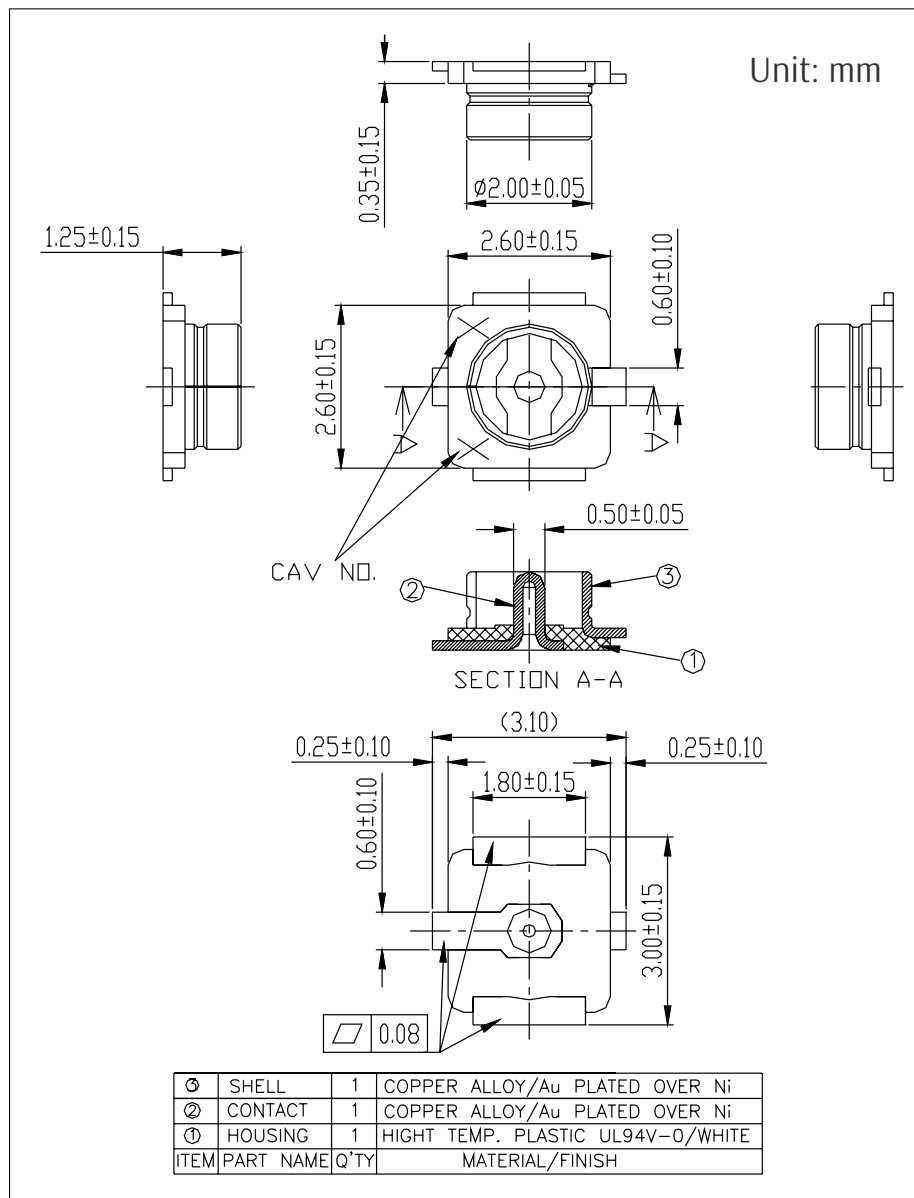


Figure 13: U.FL Connector Dimensions

## 8. Product Handling

### 8.1 Storage Condition

The products sealed in Moisture Barrier Bag (MBB) should be stored in a noncondensing atmospheric environment of  $< 40\text{ }^{\circ}\text{C}/90\%\text{ RH}$ .

The module is rated at moisture sensitivity level (MSL) 3.

After unpacking, the module must be soldered within 168 hours with factory conditions  $25\pm5\text{ }^{\circ}\text{C}$  and 60% RH. The module needs to be baked if the above conditions are not met.

### 8.2 ESD

- Human body model (HBM): 2000 V
- Charged-device model (CDM): 500 V
- Air discharge: 6000 V
- Contact discharge: 4000 V

### 8.3 Reflow Profile

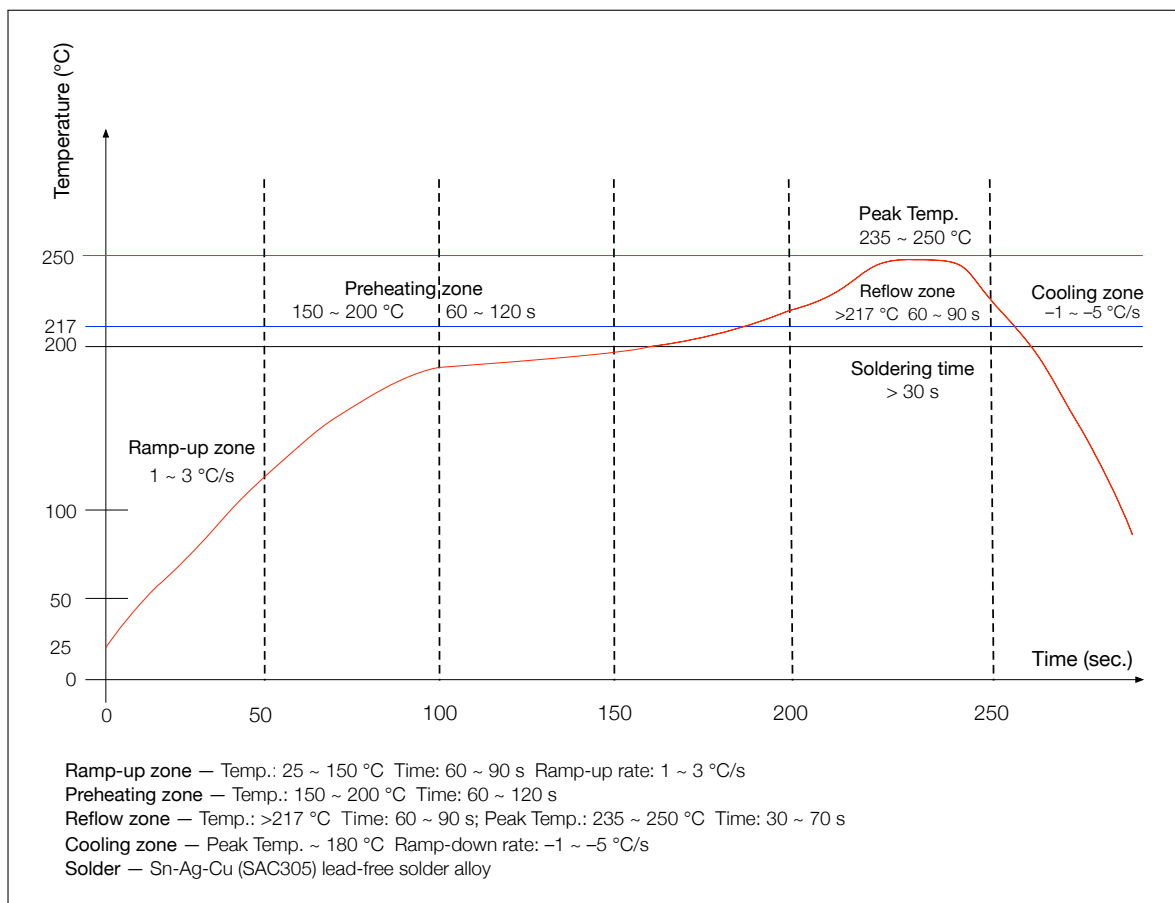


Figure 14: Reflow Profile

**Note:**

Solder the module in a single reflow. If the PCBA requires multiple reflows, place the module on the PCB during the final reflow.

## 9. MAC Addresses and eFuse

The eFuse in ESP32 has been burnt into 48-bit `mac_address`. The actual addresses the chip uses in station, AP, BLE, and Ethernet modes correspond to `mac_address` in the following way:

- Station mode: `mac_address`
- AP mode: `mac_address + 1`
- BLE mode: `mac_address + 2`
- Ethernet mode: `mac_address + 3`

In the 1 Kbit eFuse, 256 bits are used for the system (MAC address and chip configuration) and the remaining 768 bits are reserved for customer applications, including flash-encryption and chip-ID.



## 10. Learning Resources

### 10.1 Must-Read Documents

The following link provides documents related to ESP32.

- [ESP32 Datasheet](#)  
This document provides an introduction to the specifications of the ESP32 hardware, including overview, pin definitions, functional description, peripheral interface, electrical characteristics, etc.
- [ESP32 ECO V3 User Guide](#)  
This document describes differences between V3 and previous ESP32 silicon wafer revisions.
- [ECO and Workarounds for Bugs in ESP32](#)  
This document details hardware errata and workarounds in the ESP32.
- [ESP-IDF Programming Guide](#)  
It hosts extensive documentation for ESP-IDF ranging from hardware guides to API reference.
- [ESP32 Technical Reference Manual](#)  
The manual provides detailed information on how to use the ESP32 memory and peripherals.
- [ESP32 Hardware Resources](#)  
The zip files include the schematics, PCB layout, Gerber and BOM list of ESP32 modules and development boards.
- [ESP32 Hardware Design Guidelines](#)  
The guidelines outline recommended design practices when developing standalone or add-on systems based on the ESP32 series of products, including the ESP32 chip, the ESP32 modules and development boards.
- [ESP32 AT Instruction Set and Examples](#)  
This document introduces the ESP32 AT commands, explains how to use them, and provides examples of several common AT commands.
- [Espressif Products Ordering Information](#)

### 10.2 Must-Have Resources

Here are the ESP32-related must-have resources.

- [ESP32 BBS](#)  
This is an Engineer-to-Engineer (E2E) Community for ESP32 where you can post questions, share knowledge, explore ideas, and help solve problems with fellow engineers.
- [ESP32 GitHub](#)  
ESP32 development projects are freely distributed under Espressif's MIT license on GitHub. It is established to help developers get started with ESP32 and foster innovation and the growth of general knowledge about the hardware and software surrounding ESP32 devices.

- [ESP32 Tools](#)

This is a webpage where users can download ESP32 Flash Download Tools and the zip file "ESP32 Certification and Test".

- [ESP-IDF](#)

This webpage links users to the official IoT development framework for ESP32.

- [ESP32 Resources](#)

This webpage provides the links to all available ESP32 documents, SDK and tools.

## Revision History

| Date       | Version | Release notes        |
|------------|---------|----------------------|
| 2020-05-18 | V0.5    | Preliminary release. |
| 2020-05-29 | V1.0    | Official release.    |

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