

# ESP32-C6-WROOM-1

# ESP32-C6-WROOM-1U

## Datasheet

Module that supports 2.4 GHz Wi-Fi 6 (802.11ax), Bluetooth® 5 (LE), Zigbee and Thread (802.15.4)

Built around ESP32-C6 series of SoCs, 32-bit RISC-V single-core microprocessor

Flash up to 8 MB

23 GPIOs, rich set of peripherals

On-board PCB antenna or external antenna connector



ESP32-C6-WROOM-1



ESP32-C6-WROOM-1U



Version 1.0  
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://espressif.com/documentation/esp32-c6-wroom-1\\_wroom-1u\\_datasheet\\_en.pdf](https://espressif.com/documentation/esp32-c6-wroom-1_wroom-1u_datasheet_en.pdf)



## 1.1 Features

### CPU and On-Chip Memory

- ESP32-C6 embedded, 32-bit RISC-V single-core microprocessor, up to 160 MHz
- ROM: 320 KB
- HP SRAM: 512 KB
- LP SRAM: 16 KB

### Wi-Fi

- 1T1R in 2.4 GHz band
- Operating frequency: 2412 ~ 2484 MHz
- IEEE 802.11ax-compliant
  - 20 MHz-only non-AP mode
  - MCS0 ~MCS9
  - Uplink and downlink OFDMA, especially suitable for simultaneous connections in high-density environments
  - Downlink MU-MIMO (multi-user, multiple input, multiple output) to increase network capacity
  - Beamformee that improves signal quality
  - Channel quality indication (CQI)
  - DCM (dual carrier modulation) to improve link robustness
  - Spatial reuse to maximize parallel transmissions
  - Target wake time (TWT) that optimizes power saving mechanisms
- Fully compatible with IEEE 802.11b/g/n protocol

- 20 MHz and 40 MHz bandwidth
- Data rate up to 150 Mbps
- Wi-Fi Multimedia (WMM)
- TX/RX A-MPDU, TX/RX A-MSDU
- Immediate Block ACK
- Fragmentation and defragmentation
- Transmit opportunity (TXOP)
- Automatic Beacon monitoring (hardware TSF)
- 4 × virtual Wi-Fi interfaces
- Simultaneous support for Infrastructure BSS in Station mode, SoftAP mode, Station + SoftAP mode, and promiscuous mode  
*Note that when ESP32-C6 scans in Station mode, the SoftAP channel will change along with the Station channel*
- 802.11mc FTM

### Bluetooth®

- Bluetooth LE: Bluetooth 5.3 certified
- Bluetooth mesh
- High power mode (20 dBm)
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
- Advertising extensions
- Multiple advertisement sets
- Channel selection algorithm #2
- LE power control

- Internal co-existence mechanism between Wi-Fi and Bluetooth to share the same antenna

ADC, temperature sensor, system timer, general-purpose timers, and watchdog timers

### IEEE 802.15.4

- Compliant with IEEE 802.15.4-2015 protocol
- OQPSK PHY in 2.4 GHz band
- Data rate: 250 Kbps
- Thread 1.3
- Zigbee 3.0

### Peripherals

- GPIO, SPI, parallel IO interface, UART, I2C, I2S, RMT (TX/RX), pulse counter, LED PWM, USB Serial/JTAG controller, MCPWM, SDIO2.0 slave controller, GDMA, TWAI® controller, on-chip debug functionality via JTAG, event task matrix,

### Integrated Components on Module

- 40 MHz crystal oscillator
- SPI flash

### Antenna Options

- On-board PCB antenna (ESP32-C6-WROOM-1)
- External antenna via a connector (ESP32-C6-WROOM-1U)

### Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature: -40 ~ 85 °C

## 1.2 Description

ESP32-C6-WROOM-1 and ESP32-C6-WROOM-1U are two powerful, general-purpose Wi-Fi, IEEE 802.15.4, and Bluetooth LE modules. The rich set of peripherals and high performance make the module an ideal choice for smart homes, industrial automation, health care, consumer electronics, etc.

ESP32-C6-WROOM-1 comes with a PCB antenna. ESP32-C6-WROOM-1U comes with a connector for an external antenna. They both feature an external SPI flash up to 8 MB.

Both ESP32-C6-WROOM-1 and ESP32-C6-WROOM-1U come in two versions:

- 4 MB flash version
- 8 MB flash version

The two versions only vary in flash part number. In this datasheet unless otherwise stated, ESP32-C6-WROOM-1 and ESP32-C6-WROOM-1U refer to the variants in 4 MB and 8 MB flash versions.

The series comparison for the two modules is as follows:

**Table 1: ESP32-C6-WROOM-1 (ANT) Series Comparison<sup>1</sup>**

| Ordering Code       | Flash           | Ambient Temp. <sup>1</sup><br>(°C) | Size <sup>2</sup><br>(mm) |
|---------------------|-----------------|------------------------------------|---------------------------|
| ESP32-C6-WROOM-1-N4 | 4 MB (Quad SPI) | -40 ~ 85                           | 18.0 × 25.5 × 3.2         |
| ESP32-C6-WROOM-1-N8 | 8 MB (Quad SPI) |                                    |                           |

<sup>1</sup> This table shares the same notes presented in Table 2 below.

Table 2: ESP32-C6-WROOM-1U (CONN) Series Comparison

| Ordering Code        | Flash           | Ambient Temp. <sup>1</sup><br>(°C) | Size <sup>2</sup><br>(mm) |
|----------------------|-----------------|------------------------------------|---------------------------|
| ESP32-C6-WROOM-1U-N4 | 4 MB (Quad SPI) | -40 ~ 85                           | 18.0 × 19.2 × 3.2         |
| ESP32-C6-WROOM-1U-N8 | 8 MB (Quad SPI) |                                    |                           |

<sup>1</sup> Ambient temperature specifies the recommended temperature range of the environment immediately outside the Espressif module.

<sup>2</sup> For details, refer to Section [9.1 Physical Dimensions](#).

At the core of the modules is ESP32-C6, a 32-bit RISC-V single-core processor. For more information on ESP32-C6, please refer to [ESP32-C6 Series Datasheet](#).

Please [contact our sales team](#) if you require modules with 16 MB flash and maximum ambient temperature of 85 °C, or modules with 4 MB flash and maximum ambient temperature of 105 °C.

## 1.3 Applications

- Smart Home
- Industrial Automation
- Health Care
- Consumer Electronics
- Smart Agriculture
- POS machines
- Service robot
- Audio Devices
- Generic Low-power IoT Sensor Hubs
- Generic Low-power IoT Data Loggers

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## 2 Block Diagram

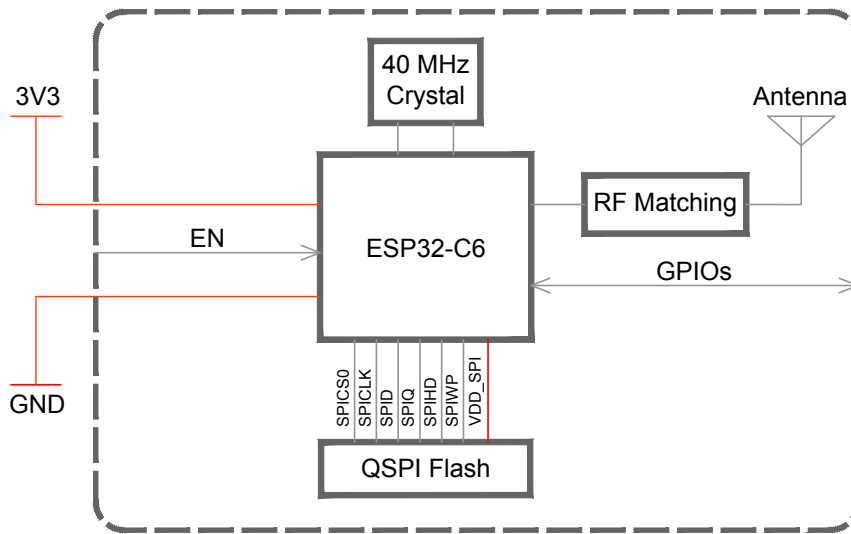


Figure 1: ESP32-C6-WROOM-1 Block Diagram

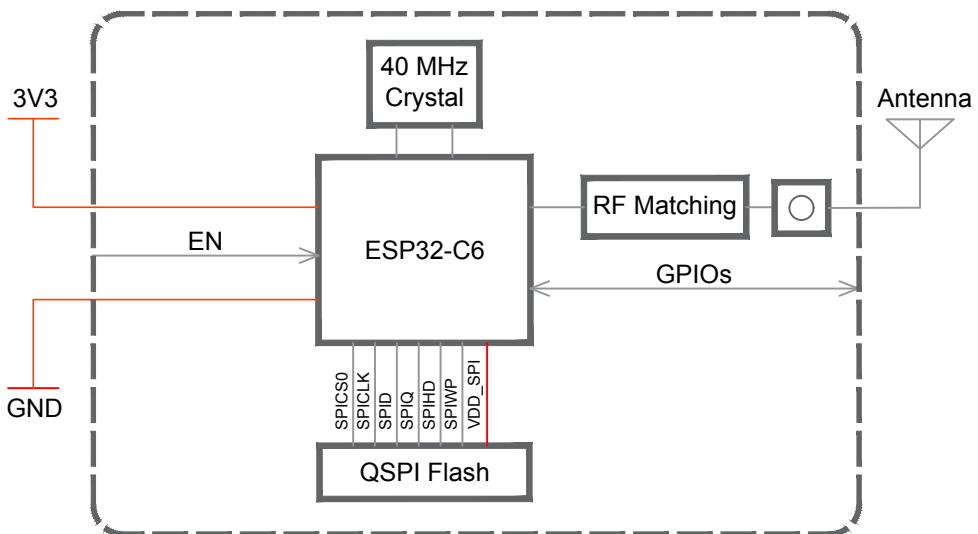


Figure 2: ESP32-C6-WROOM-1U Block Diagram

## 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 9.1 *Physical Dimensions*.

The pin diagram is applicable for ESP32-C6-WROOM-1 and ESP32-C6-WROOM-1U, but the latter has no keepout zone.

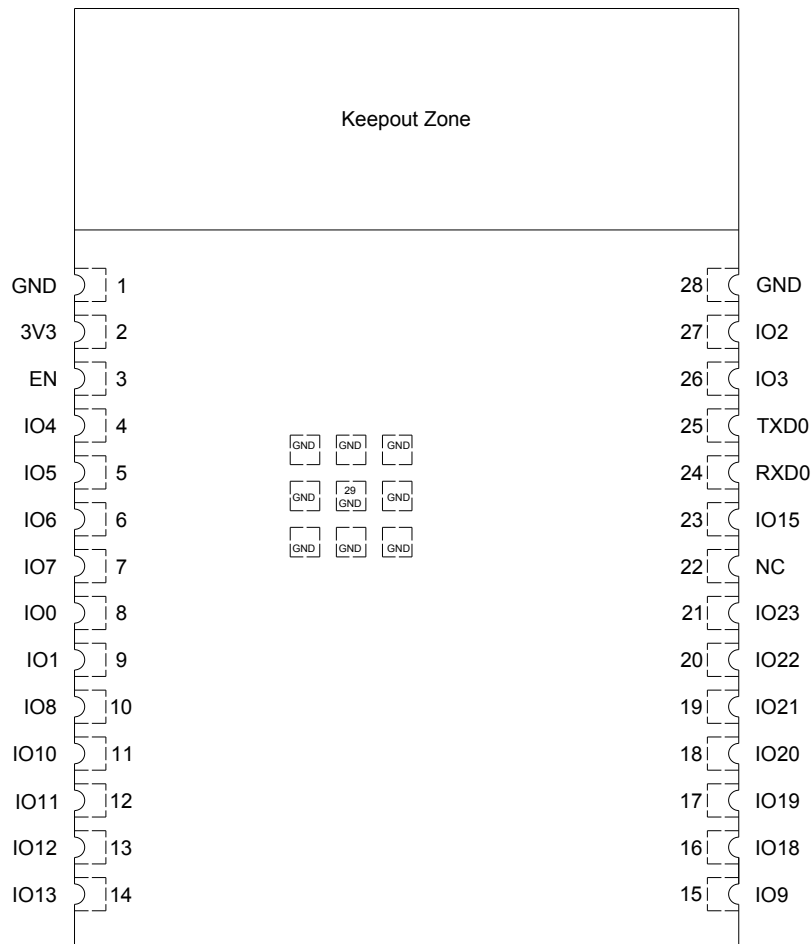


Figure 3: Pin Layout (Top View)

### 3.2 Pin Description

The module has 29 pins. See pin definitions in Table 3 *Pin Description*.

For peripheral pin configurations, please refer to [ESP32-C6 Series Datasheet](#).

Table 3: Pin Definitions

| Name | No. | Type <sup>1</sup> | Function |
|------|-----|-------------------|----------|
| GND  | 1   | P                 | Ground   |

Cont'd on next page

Table 3 – cont'd from previous page

| Name | No. | Type <sup>1</sup> | Function   |
|------|-----|-------------------|--|
| 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 EN pin floating. |
| IO4  | 4   | I/O/T             | MTMS, GPIO4, LP_GPIO4, LP_UART_RXD, ADC1_CH4, FSPiHD   |
| IO5  | 5   | I/O/T             | MTDI, GPIO5, LP_GPIO5, LP_UART_TXD, ADC1_CH5, FSPiWP   |
| IO6  | 6   | I/O/T             | MTCK, GPIO6, LP_GPIO6, LP_I2C_SDA, ADC1_CH6, FSPiCLK   |
| IO7  | 7   | I/O/T             | MTDO, GPIO7, LP_GPIO7, LP_I2C_SCL, FSPiD   |
| IO0  | 8   | I/O/T             | GPIO0, XTAL_32K_P, LP_GPIO0, LP_UART_DTRN, ADC1_CH0  |
| IO1  | 9   | I/O/T             | GPIO1, XTAL_32K_N, LP_GPIO1, LP_UART_DSRN, ADC1_CH1  |
| IO8  | 10  | I/O/T             | GPIO8  |
| IO10 | 11  | I/O/T             | GPIO10   |
| IO11 | 12  | I/O/T             | GPIO11   |
| IO12 | 13  | I/O/T             | GPIO12, USB_D-   |
| IO13 | 14  | I/O/T             | GPIO13, USB_D+   |
| IO9  | 15  | I/O/T             | GPIO9  |
| IO18 | 16  | I/O/T             | GPIO18, SDIO_CMD, FSPiCS2  |
| IO19 | 17  | I/O/T             | GPIO19, SDIO_CLK, FSPiCS3  |
| IO20 | 18  | I/O/T             | GPIO20, SDIO_DATA0, FSPiCS4  |
| IO21 | 19  | I/O/T             | GPIO21, SDIO_DATA1, FSPiCS5  |
| IO22 | 20  | I/O/T             | GPIO22, SDIO_DATA2   |
| IO23 | 21  | I/O/T             | GPIO23, SDIO_DATA3   |
| NC   | 22  | —                 | NC   |
| IO15 | 23  | I/O/T             | GPIO15   |
| RXD0 | 24  | I/O/T             | U0RXD, GPIO17, FSPiCS1   |
| TXD0 | 25  | I/O/T             | U0TXD, GPIO16, FSPiCS0   |
| IO3  | 26  | I/O/T             | GPIO3, LP_GPIO3, LP_UART_CTSN, ADC1_CH3  |
| IO2  | 27  | I/O/T             | GPIO2, LP_GPIO2, LP_UART_RTSN, ADC1_CH2, FSPiQ   |
| GND  | 28  | P                 | Ground   |
| EPAD | 29  | P                 | Ground   |

<sup>1</sup> P: power supply; I: input; O: output; T: high impedance.

### 3.3 Strapping Pins

**Note:**

The content below is excerpted from [ESP32-C6 Series Datasheet](#) > Section *Strapping Pins*. For the strapping pin mapping between the chip and modules, please refer to Chapter *7 Module Schematics*.

At each startup or reset, a chip requires some initial configuration parameters, such as in which boot mode to load the chip, etc. These parameters are passed over via the strapping pins. After reset, the strapping pins operate as regular IO pins.

The parameters controlled by the given strapping pins at chip reset are as follows:

- **SDIO sampling and driving clock edge** – MTMS and MTDI
- **Chip boot mode** – GPIO8 and GPIO9
- **ROM code printing to UART** – GPIO8
- **JTAG signal source** – GPIO15

GPIO9 is connected to the chip's internal weak pull-up resistor at chip reset. This resistor determines the default bit value of GPIO9. Also, the resistor determines the bit value if GPIO9 is connected to an external high-impedance circuit.

**Table 4: Default Configuration of Strapping Pins**

| Strapping Pin | Default Configuration | Bit Value |
|---------------|-----------------------|-----------|
| <b>MTMS</b>   | Floating              | –         |
| <b>MTDI</b>   | Floating              | –         |
| <b>GPIO8</b>  | Floating              | –         |
| <b>GPIO9</b>  | Pull-up               | 1         |
| <b>GPIO15</b> | Floating              | –         |

To change the bit values, the strapping pins should be connected to external pull-down/pull-up resistances. If the ESP32-C6 is used as a device by a host MCU, the strapping pin voltage levels can also be controlled by the host MCU.

All strapping pins have latches. At system reset, the latches sample the bit values of their respective strapping pins and store them until the chip is powered down or shut down. The states of latches cannot be changed in any other way. It makes the strapping pin values available during the entire chip operation, and the pins are freed up to be used as regular IO pins after reset.

Regarding the timing requirements for the strapping pins, there are such parameters as *setup time* and *hold time*. For more information, see Table 5 and Figure 4.

**Table 5: Description of Timing Parameters for the Strapping Pins**

| Parameter | Description   | Min (ms) |
|-----------|---|----------|
| $t_{SU}$  | <i>Setup time</i> is the time reserved for the power rails to stabilize before the CHIP_PU pin is pulled high to activate the chip.   | 0        |
| $t_H$     | <i>Hold time</i> is the time reserved for the chip to read the strapping pin values after CHIP_PU is already high and before these pins start operating as regular IO pins. | 3        |

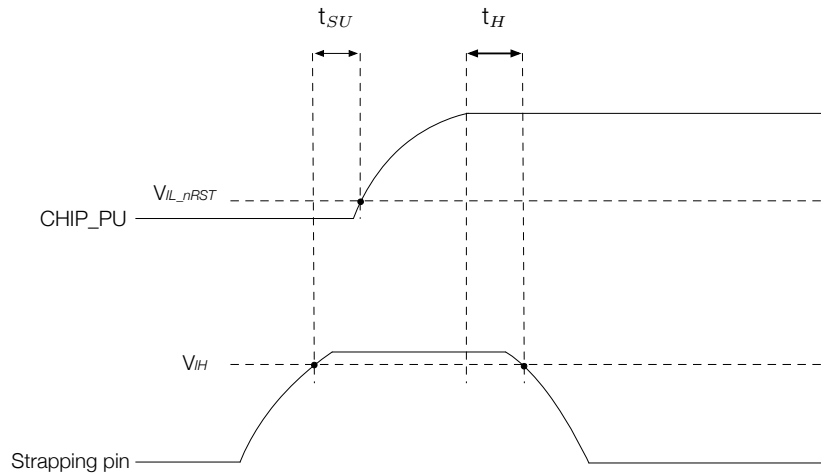


Figure 4: Visualization of Timing Parameters for the Strapping Pins

### 3.3.1 SDIO Sampling and Driving Clock Edge Control

The strapping pin MTMS and MTDI can be used to decide on which clock edge to sample signals and drive output lines. See Table 6 [SDIO Input Sampling Edge/Output Driving Edge Control](#).

Table 6: SDIO Input Sampling Edge/Output Driving Edge Control

| MTMS         | MTDI         | Edge behavior                              |
|--------------|--------------|--|
| – (Floating) | – (Floating) | Default Configuration                      |
| 0            | 0            | Falling edge sampling, falling edge output |
| 0            | 1            | Falling edge sampling, rising edge output  |
| 1            | 0            | Rising edge sampling, falling edge output  |
| 1            | 1            | Rising edge sampling, rising edge output   |

### 3.3.2 Chip Boot Mode Control

GPIO8 and GPIO9 control the boot mode after the reset is released. See Table 7 [Boot Mode Control Boot Mode Control](#).

Table 7: Boot Mode Control

| Boot Mode                        | GPIO8        | GPIO9       |
|----------------------------------|--------------|-------------|
| Default Configuration            | – (Floating) | 1 (Pull-up) |
| <b>SPI Boot</b> (default)        | Any value    | 1           |
| <b>Download Boot</b>             | 1            | 0           |
| Invalid combination <sup>1</sup> | 0            | 0           |

<sup>1</sup> This combination triggers unexpected behavior and should be avoided.

### 3.3.3 ROM Messages Printing Control

During the boot process, the messages by the ROM code can be printed to:

- **(Default) UART0 and USB Serial/JTAG controller**
- **USB Serial/JTAG controller**
- **UART0**

EFUSE\_UART\_PRINT\_CONTROL and GPIO8 control ROM messages printing to **UART0** as shown in Table 8 [ROM Messages Printing Control](#).

**Table 8: ROM Messages Printing Control**

| eFuse <sup>1</sup> | GPIO8   | ROM Code Printing |
|--------------------|---------|-------------------|
| 0                  | Ignored | Always enabled    |
| 1                  | 0       | Enabled           |
|                    | 1       | Disabled          |
| 2                  | 0       | Disabled          |
|                    | 1       | Enabled           |
| 3                  | Ignored | Always disabled   |

<sup>1</sup> eFuse: EFUSE\_UART\_PRINT\_CONTROL

EFUSE\_DIS\_USB\_SERIAL\_JTAG\_ROM\_PRINT controls the printing to **USB Serial/JTAG controller**. When this bit is 1, printing to USB Serial/JTAG controller is disabled. When this bit is 0, and USB Serial/JTAG controller is enabled via EFUSE\_DIS\_USB\_SERIAL\_JTAG, ROM messages can be printed to USB Serial/JTAG controller.

### 3.3.4 JTAG Signal Source Control

The strapping pin GPIO15 can be used to control the source of JTAG signals during the early boot process. This pin does not have any internal pull resistors and the strapping value must be controlled by the external circuit that cannot be in a high impedance state.

As Table 9 shows, GPIO15 is used in combination with EFUSE\_DIS\_PAD\_JTAG, EFUSE\_DIS\_USB\_JTAG, and EFUSE\_JTAG\_SEL\_ENABLE.

**Table 9: JTAG Signal Source Control**

| eFuse 1 <sup>a</sup> | eFuse 2 <sup>b</sup> | eFuse 3 <sup>c</sup> | GPIO15  | JTAG Signal Source                   |
|----------------------|----------------------|----------------------|---------|--------------------------------------|
| 0                    | 0                    | 0                    | Ignored | USB Serial/JTAG Controller           |
|                      |                      | 1                    | 0       | JTAG pins MTDI, MTCK, MTMS, and MTDO |
|                      |                      |                      | 1       | USB Serial/JTAG Controller           |
| 0                    | 1                    | Ignored              | Ignored | JTAG pins MTDI, MTCK, MTMS, and MTDO |
| 1                    | 0                    | Ignored              | Ignored | USB Serial/JTAG Controller           |
| 1                    | 1                    | Ignored              | Ignored | JTAG is disabled                     |

<sup>a</sup> eFuse 1: EFUSE\_DIS\_PAD\_JTAG

<sup>b</sup> eFuse 2: EFUSE\_DIS\_USB\_JTAG

<sup>c</sup> eFuse 3: EFUSE\_JTAG\_SEL\_ENABLE

## 4 Peripherals

### 4.1 Functional Overview

ESP32-C6 integrates a rich set of peripherals including SPI, parallel IO interface, UART, I2C, I2S, RMT (TX/RX), LED PWM, USB Serial/JTAG controller, MCPWM, SDIO2.0 slave controller, GDMA, TWAI<sup>®</sup> controller, on-chip debug functionality via JTAG, event task matrix, ADC, as well as up to 23 GPIOs, etc.

For detailed information about module peripherals, please refer to [ESP32-C6 Series Datasheet](#) > Section *Functional Description*. Note that the ADC measurement range and accuracy in the [ESP32-C6 Series Datasheet](#) are applicable to modules manufactured on and after the PW Number **PW-2023-07-XXX** on packaging labels. For modules manufactured earlier than these PW numbers, please [ask our sales team](#) to provide the actual range and accuracy according to batches.

**Note:**

The content below is excerpted from [ESP32-C6 Series Datasheet](#) > Section *Peripheral Pin Configurations*, so not all the information is applicable to ESP32-C6-WROOM-1 and ESP32-C6-WROOM-1U. To learn more details about peripherals signals, please refer to [ESP32-C6 Technical Reference Manual](#) > Section *Peripheral Signal List*.

### 4.2 Peripheral Pin Configurations

Table 10: Peripheral Pin Configurations

| Interface | Signal    | Pin           | Function  |
|-----------|-----------|---------------|---|
| ADC       | ADC1_CH0  | XTAL_32K_P    | 12-bit SAR ADC  |
|           | ADC1_CH1  | XTAL_32K_N    |   |
|           | ADC1_CH2  | GPIO2         |   |
|           | ADC1_CH3  | GPIO3         |   |
|           | ADC1_CH4  | MTMS          |   |
|           | ADC1_CH5  | MTDI          |   |
|           | ADC1_CH6  | MTCK          |   |
| JTAG      | MTDI      | MTDI          | JTAG for software debugging                           |
|           | MTCK      | MTCK          |   |
|           | MTMS      | MTMS          |   |
|           | MTDO      | MTDO          |   |
| UART      | U0RXD_in  | Any GPIO pins | Two UART channels with hardware flow control and GDMA |
|           | U0CTS_in  |               |   |
|           | U0DSR_in  |               |   |
|           | U0TXD_out |               |   |
|           | U0RTS_out |               |   |
|           | U0DTR_out |               |   |
|           | U1RXD_in  |               |   |
|           | U1CTS_in  |               |   |
|           | U1DSR_in  |               |   |
|           | U1TXD_out |               |   |
|           | U1RTS_out |               |   |
|           | U1DTR_out |               |   |

| Interface                 | Signal              | Pin           | Function   |
|---------------------------|---------------------|---------------|--|
| LP UART                   | LP_UART_DTRN        | XTAL_32K_P    | One LP UART channel with hardware flow control and GDMA  |
|                           | LP_UART_DSRN        | XTAL_32K_N    |  |
|                           | LP_UART_RTSN        | GPIO2         |  |
|                           | LP_UART_CTSN        | GPIO3         |  |
|                           | LP_UART_RXD         | MTMS          |  |
|                           | LP_UART_TXD         | MTDI          |  |
| I2C                       | I2CEXT0_SCL_in      | Any GPIO pins | One I2C channel in slave or master mode  |
|                           | I2CEXT0_SDA_in      |               |  |
|                           | I2CEXT0_SCL_out     |               |  |
|                           | I2CEXT0_SDA_out     |               |  |
| LP I2C                    | LP_I2C_SDA          | MTCK          | One LP I2C channel in slave or master mode   |
|                           | LP_I2C_SCL          | MTDO          |  |
| LED PWM                   | ledc_ls_sig_out0~5  | Any GPIO pins | Six independent PWM channels   |
| I2S                       | I2SOO_BCK_in        | Any GPIO pins | Stereo input and output from/to the audiocodec   |
|                           | I2S_MCLK_in         |               |  |
|                           | I2SO_WS_in          |               |  |
|                           | I2SI_SD_in          |               |  |
|                           | I2SI_BCK_in         |               |  |
|                           | I2SI_WS_in          |               |  |
|                           | I2SO_BCK_out        |               |  |
|                           | I2S_MCLK_out        |               |  |
|                           | I2SO_WS_out         |               |  |
|                           | I2SO_SD_out         |               |  |
|                           | I2SI_BCK_out        |               |  |
|                           | I2SI_WS_out         |               |  |
|                           | I2SO_SD1_out        |               |  |
| Remote Control Peripheral | RMT_SIG_IN0~1       | Any GPIO pins | Two channels for an IR transceiver of various waveforms  |
|                           | RMT_SIG_OUT0~1      |               |  |
| SPI0/1                    | SPICLK_out_mux      | SPICLK        | Support Standard SPI, Dual SPI, Quad SPI, and QPI that allow connection to off-package flash   |
|                           | SPICS0_out          | SPICS0        |  |
|                           | SPICS1_out          | Any GPIO pins |  |
|                           | SPID_in/_out        | SPID          |  |
|                           | SPIQ_in/_out        | SPIQ          |  |
|                           | SPIWP_in/_out       | SPIWP         |  |
|                           | SPIHD_in/_out       | SPIHD         |  |
| SPI2                      | FSPICLK_in/_out_mux | Any GPIO pins | The following functionality is supported: <ul style="list-style-type: none"> <li>• Master mode and slave mode of SPI, Dual SPI, Quad SPI, and QPI</li> <li>• Connection to off-package flash, RAM and other SPI devices</li> <li>• Four modes of SPI transfer format</li> <li>• Configurable SPI frequency</li> <li>• 64-byte FIFO or GDMA buffer</li> </ul> |
|                           | FSPICS0_in/_out     |               |  |
|                           | FSPICS1~5_out       |               |  |
|                           | FSPID_in/_out       |               |  |
|                           |                     |               |  |



| Interface              | Signal              | Pin           | Function   |
|------------------------|---------------------|---------------|--|
|                        | FSPIQ_in/_out       |               |  |
|                        | FSPIWP_in/_out      |               |  |
|                        | FSPIHD_in/_out      |               |  |
| USB Serial/JTAG        | USB_D+              | GPIO13        | USB-to-serial converter, and USB-to-JTAG converter   |
|                        | USB_D-              | GPIO12        |  |
| TWAI®                  | TWAI0_RX            | Any GPIO pins | Compatible with ISO 11898-1 protocol   |
|                        | TWAI0_TX            |               |  |
|                        | TWAI0_BUS_OFF_ON    |               |  |
|                        | TWAI0_CLKOUT        |               |  |
|                        | TWAI0_STANDBY       |               |  |
|                        | TWAI1_RX            |               |  |
|                        | TWAI1_TX            |               |  |
|                        | TWAI1_BUS_OFF_ON    |               |  |
|                        | TWAI1_CLKOUT        |               |  |
|                        | TWAI1_STANDBY       |               |  |
| Pulse Count Controller | PCNT_SIG_CH0_in0~3  | Any GPIO pins | Captures pulses and counts pulse edges in seven modes  |
|                        | PCNT_SIG_CH1_in0~3  |               |  |
|                        | PCNT_CTRL_CH0_in0~3 |               |  |
|                        | PCNT_CTRL_CH1_in0~3 |               |  |
| MCPWM                  | PWM0_SYNC0~2_in     | Any GPIO pins | One MCPWM to generate: <ul style="list-style-type: none"> <li>• differential PWM output signals</li> <li>• fault input signals to be detected</li> <li>• input signals to be captured</li> <li>• external synchronization signals for PWM timers</li> </ul>                            |
|                        | PWM0_out0a          |               |  |
|                        | PWM0_out0b          |               |  |
|                        | PWM0_out1a          |               |  |
|                        | PWM0_F0~2_in        |               |  |
|                        | PWM0_out1b          |               |  |
|                        | PWM0_out2a          |               |  |
|                        | PWM0_out2b          |               |  |
|                        | PWM0_CAP0~2_in      |               |  |
| PARLIO                 | PARL_RX_DATA0~15    | Any GPIO pins | A module for parallel data transfer, with <ul style="list-style-type: none"> <li>• 16 pins to receive parallel data</li> <li>• 16 pins to transmit parallel data</li> <li>• 1 receiver clock pin (clock input)</li> <li>• 2 transmitter clock pins (clock input and output)</li> </ul> |
|                        | PARL_TX_DATA0~15    |               |  |
|                        | PARL_RX_CLK_in      |               |  |
|                        | PARL_TX_CLK_in/_out |               |  |
| SDIO                   | SDIO_CMD            | SDIO_CMD      | SDIO interface, conforming to the industry standard SDIO Specification Version 2.0   |
|                        | SDIO_CLK            | SDIO_CLK      |  |
|                        | SDIO_DATA0          | SDIO_DATA0    |  |
|                        | SDIO_DATA1          | SDIO_DATA1    |  |
|                        | SDIO_DATA2          | SDIO_DATA2    |  |

| Interface | Signal     | Pin        | Function |
|-----------|------------|------------|----------|
|           | SDIO_DATA3 | SDIO_DATA3 |          |

## 5 Electrical Characteristics

### 5.1 Absolute Maximum Ratings

Stresses above those listed in Table 11 *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 Table 12 *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 11: 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   |

### 5.2 Recommended Operating Conditions

Table 12: Recommended Operating Conditions

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

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

Table 13: DC Characteristics (3.3 V, 25 °C)

| Symbol                       | Parameter  | Min                     | Typ | Max                     | Unit |
|------------------------------|--|-------------------------|-----|-------------------------|------|
| C <sub>IN</sub>              | Pin capacitance  | —                       | 2   | —                       | pF   |
| V <sub>IH</sub>              | High-level input voltage   | 0.75 × VDD <sup>1</sup> | —   | VDD <sup>1</sup> + 0.3  | V    |
| V <sub>IL</sub>              | Low-level input voltage  | -0.3                    | —   | 0.25 × VDD <sup>1</sup> | V    |
| I <sub>IH</sub>              | High-level input current   | —                       | —   | 50                      | nA   |
| I <sub>IL</sub>              | Low-level input current  | —                       | —   | 50                      | nA   |
| V <sub>OH</sub> <sup>2</sup> | High-level output voltage  | 0.8 × VDD <sup>1</sup>  | —   | —                       | V    |
| V <sub>OL</sub> <sup>2</sup> | Low-level output voltage   | —                       | —   | 0.1 × VDD <sup>1</sup>  | V    |
| I <sub>OH</sub>              | High-level source current (VDD <sup>1</sup> = 3.3 V, V <sub>OH</sub> ≥ 2.64 V, PAD_DRIVER = 3) | —                       | 40  | —                       | mA   |
| I <sub>OL</sub>              | Low-level sink current (VDD <sup>1</sup> = 3.3 V, V <sub>OL</sub> = 0.495 V, PAD_DRIVER = 3)   | —                       | 28  | —                       | mA   |
| R <sub>PU</sub>              | Pull-up resistor   | —                       | 45  | —                       | kΩ   |
| R <sub>PD</sub>              | Pull-down resistor   | —                       | 45  | —                       | kΩ   |
| V <sub>IH_nRST</sub>         | Chip reset release voltage   | 0.75 × VDD <sup>1</sup> | —   | VDD <sup>1</sup> + 0.3  | V    |
| V <sub>IL_nRST</sub>         | Chip reset voltage   | -0.3                    | —   | 0.25 × VDD <sup>1</sup> | V    |

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

<sup>2</sup> V<sub>OH</sub> and V<sub>OL</sub> are measured using high-impedance load.

## 5.4 Current Consumption Characteristics

### 5.4.1 Current Consumption in Active Mode

The current consumption measurements are taken with a 3.3 V supply at 25 °C ambient temperature.

TX current consumption is rated at a 100% duty cycle.

RX current consumption is rated when the peripherals are disabled and the CPU idle.

**Table 14: Current Consumption for Wi-Fi (2.4 GHz) in Active Mode**

| Work Mode           | RF Condition | Description                       | Peak (mA) |
|---------------------|--------------|-----------------------------------|-----------|
| Active (RF working) | TX           | 802.11b, 1 Mbps, DSSS @ 20.5 dBm  | 382       |
|                     |              | 802.11g, 54 Mbps, OFDM @ 19.0 dBm | 316       |
|                     |              | 802.11n, HT20, MCS7 @ 18.0 dBm    | 295       |
|                     |              | 802.11n, HT40, MCS7 @ 17.5 dBm    | 280       |
|                     |              | 802.11ax, MCS9 @ 15.5 dBm         | 251       |
|                     | RX           | 802.11b/g/n, HT20                 | 78        |
|                     |              | 802.11n, HT40                     | 82        |
|                     |              | 802.11ax, HE20                    | 78        |

**Table 15: Current Consumption for Bluetooth LE in Active Mode**

| Work Mode           | RF Condition | Description              | Peak (mA) |
|---------------------|--------------|--------------------------|-----------|
| Active (RF working) | TX           | Bluetooth LE @ 20.0 dBm  | 322       |
|                     |              | Bluetooth LE @ 9.0 dBm   | 190       |
|                     |              | Bluetooth LE @ 0 dBm     | 130       |
|                     |              | Bluetooth LE @ -24.0 dBm | 90        |
|                     | RX           | Bluetooth LE             | 73        |

**Table 16: Current Consumption for 802.15.4 in Active Mode**

| Work Mode           | RF Condition | Description          | Peak (mA) |
|---------------------|--------------|----------------------|-----------|
| Active (RF working) | TX           | 802.15.4 @ 20.0 dBm  | 316       |
|                     |              | 802.15.4 @ 12.0 dBm  | 190       |
|                     |              | 802.15.4 @ 0 dBm     | 120       |
|                     |              | 802.15.4 @ -24.0 dBm | 84        |
|                     | RX           | 802.15.4             | 73        |

**Note:**

The content below is excerpted from *Section Current Consumption in Other Modes* in [ESP32-C6 Series Datasheet](#).

## 5.4.2 Current Consumption in Other Modes

**Table 17: Current Consumption in Modem-sleep Mode**

| Mode                       | CPU Frequency (MHz) | Description    | Typ (mA)                        |   |
|----------------------------|---------------------|----------------|---------------------------------|---|
|                            |                     |                | All Peripherals Clocks Disabled | All Peripherals Clocks Enabled <sup>1</sup> |
| Modem-sleep <sup>2,3</sup> | 160                 | CPU is running | 27                              | 38  |
|                            |                     | CPU is idle    | 17                              | 28  |
|                            | 80                  | CPU is running | 19                              | 30  |
|                            |                     | CPU is idle    | 14                              | 25  |

<sup>1</sup> In practice, the current consumption might be different depending on which peripherals are enabled.

<sup>2</sup> In Modem-sleep mode, Wi-Fi is clock gated.

<sup>3</sup> In Modem-sleep mode, the consumption might be higher when accessing flash.

**Table 18: Current Consumption in Low-Power Modes**

| Mode        | Description   | Typ ( $\mu$ A) |
|-------------|---|----------------|
| Light-sleep | CPU and wireless communication modules are powered down, peripheral clocks are disabled, and all GPIOs are high-impedance | 180            |
|             | CPU, wireless communication modules and peripherals are powered down, and all GPIOs are high-impedance                    | 35             |
| Deep-sleep  | RTC timer and LP memory are powered on  | 7              |
| Power off   | CHIP_PU is set to low level, the chip is powered off  | 1              |

## 6 RF Characteristics

This section contains tables with RF characteristics of the Espressif product.

The RF data is measured at the antenna port, where RF cable is connected, including the front-end loss. The external antennas used for the tests on the modules with external antenna connectors have an impedance of 50  $\Omega$ .

Devices should operate in the center frequency range allocated by regional regulatory authorities. The target center frequency range and the target transmit power are configurable by software. See [ESP RF Test Tool and Test Guide](#) for instructions.

Unless otherwise stated, the RF tests are conducted with a 3.3 V ( $\pm 5\%$ ) supply at 25 °C ambient temperature.

### 6.1 Wi-Fi Radio

**Table 19: Wi-Fi RF Characteristics**

| Name  | Description         |
|---|---------------------|
| Center frequency range of operating channel | 2412 ~ 2484 MHz     |
| Wi-Fi wireless standard                     | IEEE 802.11b/g/n/ax |

#### 6.1.1 Wi-Fi RF Transmitter (TX) Characteristics

**Table 20: TX Power with Spectral Mask and EVM Meeting 802.11 Standards**

| Rate                   | Min (dBm) | Typ (dBm) | Max (dBm) |
|------------------------|-----------|-----------|-----------|
| 802.11b, 1 Mbps, DSSS  | —         | 20.5      | —         |
| 802.11b, 11 Mbps, CCK  | —         | 20.5      | —         |
| 802.11g, 6 Mbps, OFDM  | —         | 20.0      | —         |
| 802.11g, 54 Mbps, OFDM | —         | 19.0      | —         |
| 802.11n, HT20, MCS0    | —         | 19.0      | —         |
| 802.11n, HT20, MCS7    | —         | 18.0      | —         |
| 802.11n, HT40, MCS0    | —         | 18.5      | —         |
| 802.11n, HT40, MCS7    | —         | 17.5      | —         |
| 802.11ax, HE20, MCS0   | —         | 19.0      | —         |
| 802.11ax, HE20, MCS9   | —         | 15.5      | —         |

**Table 21: TX EVM Test<sup>1</sup>**

| Rate                  | Min (dB) | Typ (dB) | Limit (dB) |
|-----------------------|----------|----------|------------|
| 802.11b, 1 Mbps, DSSS | —        | -25.0    | -10.0      |
| 802.11b, 11 Mbps, CCK | —        | -25.0    | -10.0      |

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Table 21 – cont'd from previous page

| Rate                   | Min (dB) | Typ (dB) | Limit (dB) |
|------------------------|----------|----------|------------|
| 802.11g, 6 Mbps, OFDM  | —        | -24.0    | -5.0       |
| 802.11g, 54 Mbps, OFDM | —        | -28.0    | -25.0      |
| 802.11n, HT20, MCS0    | —        | -27.5    | -5.0       |
| 802.11n, HT20, MCS7    | —        | -30.0    | -27.0      |
| 802.11n, HT40, MCS0    | —        | -27.0    | -5.0       |
| 802.11n, HT40, MCS7    | —        | -29.5    | -27.0      |
| 802.11ax, HE20, MCS0   | —        | -27.0    | -5.0       |
| 802.11ax, HE20, MCS9   | —        | -34.0    | -32.0      |

<sup>1</sup> EVM is measured at the corresponding typical TX power provided in Table 20 *Wi-Fi RF Transmitter (TX) Characteristics* above.

## 6.1.2 Wi-Fi RF Receiver (RX) Characteristics

For RX tests, the PER (packet error rate) limit is 8% for 802.11b, and 10% for 802.11g/n/ax.

Table 22: RX Sensitivity

| Rate                   | Min (dBm) | Typ (dBm) | Max (dBm) |
|------------------------|-----------|-----------|-----------|
| 802.11b, 1 Mbps, DSSS  | —         | -99.2     | —         |
| 802.11b, 2 Mbps, DSSS  | —         | -96.8     | —         |
| 802.11b, 5.5 Mbps, CCK | —         | -93.6     | —         |
| 802.11b, 11 Mbps, CCK  | —         | -90.0     | —         |
| 802.11g, 6 Mbps, OFDM  | —         | -94.0     | —         |
| 802.11g, 9 Mbps, OFDM  | —         | -93.0     | —         |
| 802.11g, 12 Mbps, OFDM | —         | -92.4     | —         |
| 802.11g, 18 Mbps, OFDM | —         | -90.0     | —         |
| 802.11g, 24 Mbps, OFDM | —         | -86.8     | —         |
| 802.11g, 36 Mbps, OFDM | —         | -83.0     | —         |
| 802.11g, 48 Mbps, OFDM | —         | -78.8     | —         |
| 802.11g, 54 Mbps, OFDM | —         | -77.6     | —         |
| 802.11n, HT20, MCS0    | —         | -93.6     | —         |
| 802.11n, HT20, MCS1    | —         | -92.0     | —         |
| 802.11n, HT20, MCS2    | —         | -89.4     | —         |
| 802.11n, HT20, MCS3    | —         | -86.0     | —         |
| 802.11n, HT20, MCS4    | —         | -82.8     | —         |
| 802.11n, HT20, MCS5    | —         | -78.6     | —         |
| 802.11n, HT20, MCS6    | —         | -77.0     | —         |
| 802.11n, HT20, MCS7    | —         | -75.4     | —         |
| 802.11n, HT40, MCS0    | —         | -91.0     | —         |
| 802.11n, HT40, MCS1    | —         | -89.6     | —         |

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Table 22 – cont'd from previous page

| Rate                 | Min (dBm) | Typ (dBm) | Max (dBm) |
|----------------------|-----------|-----------|-----------|
| 802.11n, HT40, MCS2  | —         | -87.0     | —         |
| 802.11n, HT40, MCS3  | —         | -83.4     | —         |
| 802.11n, HT40, MCS4  | —         | -80.4     | —         |
| 802.11n, HT40, MCS5  | —         | -76.2     | —         |
| 802.11n, HT40, MCS6  | —         | -74.6     | —         |
| 802.11n, HT40, MCS7  | —         | -73.2     | —         |
| 802.11ax, HE20, MCS0 | —         | -93.8     | —         |
| 802.11ax, HE20, MCS1 | —         | -91.0     | —         |
| 802.11ax, HE20, MCS2 | —         | -88.0     | —         |
| 802.11ax, HE20, MCS3 | —         | -85.6     | —         |
| 802.11ax, HE20, MCS4 | —         | -82.0     | —         |
| 802.11ax, HE20, MCS5 | —         | -78.0     | —         |
| 802.11ax, HE20, MCS6 | —         | -76.6     | —         |
| 802.11ax, HE20, MCS7 | —         | -74.4     | —         |
| 802.11ax, HE20, MCS8 | —         | -70.8     | —         |
| 802.11ax, HE20, MCS9 | —         | -68.6     | —         |

Table 23: Maximum RX Level

| Rate                   | Min (dBm) | Typ (dBm) | Max (dBm) |
|------------------------|-----------|-----------|-----------|
| 802.11b, 1 Mbps, DSSS  | —         | 5         | —         |
| 802.11b, 11 Mbps, CCK  | —         | 5         | —         |
| 802.11g, 6 Mbps, OFDM  | —         | 5         | —         |
| 802.11g, 54 Mbps, OFDM | —         | 0         | —         |
| 802.11n, HT20, MCS0    | —         | 5         | —         |
| 802.11n, HT20, MCS7    | —         | 0         | —         |
| 802.11n, HT40, MCS0    | —         | 5         | —         |
| 802.11n, HT40, MCS7    | —         | 0         | —         |
| 802.11ax, HE20, MCS0   | —         | 5         | —         |
| 802.11ax, HE20, MCS9   | —         | 0         | —         |

Table 24: RX Adjacent Channel Rejection

| Rate                   | Min (dB) | Typ (dB) | Max (dB) |
|------------------------|----------|----------|----------|
| 802.11b, 1 Mbps, DSSS  | —        | 38       | —        |
| 802.11b, 11 Mbps, CCK  | —        | 38       | —        |
| 802.11g, 6 Mbps, OFDM  | —        | 31       | —        |
| 802.11g, 54 Mbps, OFDM | —        | 20       | —        |

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Table 24 – cont'd from previous page

| Rate                 | Min (dB) | Typ (dB) | Max (dB) |
|----------------------|----------|----------|----------|
| 802.11n, HT20, MCS0  | —        | 31       | —        |
| 802.11n, HT20, MCS7  | —        | 16       | —        |
| 802.11n, HT40, MCS0  | —        | 28       | —        |
| 802.11n, HT40, MCS7  | —        | 10       | —        |
| 802.11ax, HE20, MCS0 | —        | 25       | —        |
| 802.11ax, HE20, MCS9 | —        | 2        | —        |

## 6.2 Bluetooth 5 (LE) Radio

Table 25: Bluetooth LE RF Characteristics

| Name  | Description      |
|---|------------------|
| Center frequency range of operating channel | 2402 ~ 2480 MHz  |
| RF transmit power range                     | -24.0 ~ 20.0 dBm |

### 6.2.1 Bluetooth LE RF Transmitter (TX) Characteristics

Table 26: Bluetooth LE - Transmitter Characteristics - 1 Mbps

| Parameter                          | Description   | Min | Typ   | Max | Unit |
|------------------------------------|---|-----|-------|-----|------|
| Carrier frequency offset and drift | Max. $ f_n _{n=0, 1, 2, 3, \dots k}$                                  | —   | 1.3   | —   | kHz  |
|                                    | Max. $ f_0 - f_n _{n=2, 3, 4, \dots k}$                               | —   | 1.5   | —   | kHz  |
|                                    | Max. $ f_n - f_{n-5} _{n=6, 7, 8, \dots k}$                           | —   | 0.9   | —   | kHz  |
|                                    | $ f_1 - f_0 $   | —   | 0.6   | —   | kHz  |
| Modulation characteristics         | $\Delta F1_{avg}$   | —   | 249.9 | —   | kHz  |
|                                    | Min. $\Delta F2_{max}$ (for at least 99.9% of all $\Delta F2_{max}$ ) | —   | 212.1 | —   | kHz  |
|                                    | $\Delta F2_{avg}/\Delta F1_{avg}$                                     | —   | 0.88  | —   | —    |
| In-band emissions                  | $\pm 2$ MHz offset  | —   | -29   | —   | dBm  |
|                                    | $\pm 3$ MHz offset  | —   | -36   | —   | dBm  |
|                                    | $> \pm 3$ MHz offset  | —   | -39   | —   | dBm  |

Table 27: Bluetooth LE - Transmitter Characteristics - 2 Mbps

| Parameter                          | Description                                 | Min | Typ   | Max | Unit |
|------------------------------------|---|-----|-------|-----|------|
| Carrier frequency offset and drift | Max. $ f_n _{n=0, 1, 2, 3, \dots k}$        | —   | 2.2   | —   | kHz  |
|                                    | Max. $ f_0 - f_n _{n=2, 3, 4, \dots k}$     | —   | 1.1   | —   | kHz  |
|                                    | Max. $ f_n - f_{n-5} _{n=6, 7, 8, \dots k}$ | —   | 1.1   | —   | kHz  |
|                                    | $ f_1 - f_0 $                               | —   | 0.5   | —   | kHz  |
| Modulation characteristics         | $\Delta F1_{avg}$                           | —   | 499.4 | —   | kHz  |

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Table 27 – cont'd from previous page

| Parameter         | Description   | Min | Typ   | Max | Unit |
|-------------------|---|-----|-------|-----|------|
|                   | Min. $\Delta F2_{\max}$ (for at least 99.9% of all $\Delta F2_{\max}$ ) | —   | 443.5 | —   | kHz  |
|                   | $\Delta F2_{\text{avg}}/\Delta F1_{\text{avg}}$                         | —   | 0.95  | —   | —    |
| In-band emissions | $\pm 4$ MHz offset  | —   | -40   | —   | dBm  |
|                   | $\pm 5$ MHz offset  | —   | -41   | —   | dBm  |
|                   | $> \pm 5$ MHz offset  | —   | -42   | —   | dBm  |

Table 28: Bluetooth LE - Transmitter Characteristics - 125 Kbps

| Parameter                          | Description   | Min | Typ   | Max | Unit |
|------------------------------------|---|-----|-------|-----|------|
| Carrier frequency offset and drift | Max. $ f_n _{n=0, 1, 2, 3, \dots, k}$                                   | —   | 0.7   | —   | kHz  |
|                                    | Max. $ f_0 - f_n _{n=1, 2, 3, \dots, k}$                                | —   | 0.3   | —   | kHz  |
|                                    | $ f_0 - f_3 $   | —   | 0.1   | —   | kHz  |
|                                    | Max. $ f_n - f_{n-3} _{n=7, 8, 9, \dots, k}$                            | —   | 0.4   | —   | kHz  |
| Modulation characteristics         | $\Delta F1_{\text{avg}}$  | —   | 250.0 | —   | kHz  |
|                                    | Min. $\Delta F1_{\max}$ (for at least 99.9% of all $\Delta F1_{\max}$ ) | —   | 238.0 | —   | kHz  |
| In-band emissions                  | $\pm 2$ MHz offset  | —   | -29   | —   | dBm  |
|                                    | $\pm 3$ MHz offset  | —   | -36   | —   | dBm  |
|                                    | $> \pm 3$ MHz offset  | —   | -39   | —   | dBm  |

Table 29: Bluetooth LE - Transmitter Characteristics - 500 Kbps

| Parameter                          | Description   | Min | Typ   | Max | Unit |
|------------------------------------|---|-----|-------|-----|------|
| Carrier frequency offset and drift | Max. $ f_n _{n=0, 1, 2, 3, \dots, k}$                                   | —   | 0.5   | —   | kHz  |
|                                    | Max. $ f_0 - f_n _{n=1, 2, 3, \dots, k}$                                | —   | 0.3   | —   | kHz  |
|                                    | $ f_0 - f_3 $   | —   | 0.1   | —   | kHz  |
|                                    | Max. $ f_n - f_{n-3} _{n=7, 8, 9, \dots, k}$                            | —   | 0.4   | —   | kHz  |
| Modulation characteristics         | $\Delta F2_{\text{avg}}$  | —   | 230.7 | —   | kHz  |
|                                    | Min. $\Delta F2_{\max}$ (for at least 99.9% of all $\Delta F2_{\max}$ ) | —   | 217.6 | —   | kHz  |
| In-band emissions                  | $\pm 2$ MHz offset  | —   | -28   | —   | dBm  |
|                                    | $\pm 3$ MHz offset  | —   | -36   | —   | dBm  |
|                                    | $> \pm 3$ MHz offset  | —   | -39   | —   | dBm  |

## 6.2.2 Bluetooth LE RF Receiver (RX) Characteristics

Table 30: Bluetooth LE - Receiver Characteristics - 1 Mbps

| Parameter                          | Description | Min | Typ   | Max | Unit |
|------------------------------------|-------------|-----|-------|-----|------|
| Sensitivity @30.8% PER             | —           | —   | -98.0 | —   | dBm  |
| Maximum received signal @30.8% PER | —           | —   | 8     | —   | dBm  |

Cont'd on next page

Table 30 – cont'd from previous page

| Parameter                                |                         | Description          | Min | Typ | Max | Unit |
|--|-------------------------|----------------------|-----|-----|-----|------|
| C/I and receiver selectivity performance | Co-channel              | $F = F_0$ MHz        | —   | 7   | —   | dB   |
|  | Adjacent channel        | $F = F_0 + 1$ MHz    | —   | 4   | —   | dB   |
|  |                         | $F = F_0 - 1$ MHz    | —   | 3   | —   | dB   |
|  |                         | $F = F_0 + 2$ MHz    | —   | -21 | —   | dB   |
|  |                         | $F = F_0 - 2$ MHz    | —   | -22 | —   | dB   |
|  |                         | $F = F_0 + 3$ MHz    | —   | -28 | —   | dB   |
|  |                         | $F = F_0 - 3$ MHz    | —   | -36 | —   | dB   |
|  |                         | $F \geq F_0 + 4$ MHz | —   | -27 | —   | dB   |
|  |                         | $F \leq F_0 - 4$ MHz | —   | -36 | —   | dB   |
|  | Image frequency         | —                    | —   | -26 | —   | dB   |
| Adjacent channel to image frequency      | $F = F_{image} + 1$ MHz | —                    | -29 | —   | dB  |      |
|  | $F = F_{image} - 1$ MHz | —                    | -28 | —   | dB  |      |
| Out-of-band blocking performance         |                         | 30 MHz ~ 2000 MHz    | —   | -16 | —   | dBm  |
|  |                         | 2003 MHz ~ 2399 MHz  | —   | -24 | —   | dBm  |
|  |                         | 2484 MHz ~ 2997 MHz  | —   | -16 | —   | dBm  |
|  |                         | 3000 MHz ~ 12.75 GHz | —   | -1  | —   | dBm  |
| Intermodulation                          |                         | —                    | —   | -27 | —   | dBm  |

Table 31: Bluetooth LE - Receiver Characteristics - 2 Mbps

| Parameter                                |                         | Description          | Min | Typ   | Max | Unit |
|--|-------------------------|----------------------|-----|-------|-----|------|
| Sensitivity @30.8% PER                   |                         | —                    | —   | -95.0 | —   | dBm  |
| Maximum received signal @30.8% PER       |                         | —                    | —   | 8     | —   | dBm  |
| C/I and receiver selectivity performance | Co-channel              | $F = F_0$ MHz        | —   | 8     | —   | dB   |
|  | Adjacent channel        | $F = F_0 + 2$ MHz    | —   | 3     | —   | dB   |
|  |                         | $F = F_0 - 2$ MHz    | —   | 2     | —   | dB   |
|  |                         | $F = F_0 + 4$ MHz    | —   | -23   | —   | dB   |
|  |                         | $F = F_0 - 4$ MHz    | —   | -25   | —   | dB   |
|  |                         | $F = F_0 + 6$ MHz    | —   | -31   | —   | dB   |
|  |                         | $F = F_0 - 6$ MHz    | —   | -35   | —   | dB   |
|  |                         | $F \geq F_0 + 8$ MHz | —   | -36   | —   | dB   |
|  |                         | $F \leq F_0 - 8$ MHz | —   | -36   | —   | dB   |
|  | Image frequency         | —                    | —   | -23   | —   | dB   |
| Adjacent channel to image frequency      | $F = F_{image} + 2$ MHz | —                    | -30 | —     | dB  |      |
|  | $F = F_{image} - 2$ MHz | —                    | 3   | —     | dB  |      |
| Out-of-band blocking performance         |                         | 30 MHz ~ 2000 MHz    | —   | -18   | —   | dBm  |
|  |                         | 2003 MHz ~ 2399 MHz  | —   | -28   | —   | dBm  |
|  |                         | 2484 MHz ~ 2997 MHz  | —   | -16   | —   | dBm  |
|  |                         | 3000 MHz ~ 12.75 GHz | —   | -1    | —   | dBm  |
| Intermodulation                          |                         | —                    | —   | -29   | —   | dBm  |

Table 32: Bluetooth LE - Receiver Characteristics - 125 Kbps

| Parameter                                | Description             | Min                  | Typ    | Max | Unit |    |
|--|-------------------------|----------------------|--------|-----|------|----|
| Sensitivity @30.8% PER                   | —                       | —                    | -105.5 | —   | dBm  |    |
| Maximum received signal @30.8% PER       | —                       | —                    | 8      | —   | dBm  |    |
| C/I and receiver selectivity performance | Co-channel              | $F = F_0$ MHz        | —      | 2   | —    | dB |
|  | Adjacent channel        | $F = F_0 + 1$ MHz    | —      | -1  | —    | dB |
|  |                         | $F = F_0 - 1$ MHz    | —      | -3  | —    | dB |
|  |                         | $F = F_0 + 2$ MHz    | —      | -31 | —    | dB |
|  |                         | $F = F_0 - 2$ MHz    | —      | -27 | —    | dB |
|  |                         | $F = F_0 + 3$ MHz    | —      | -33 | —    | dB |
|  |                         | $F = F_0 - 3$ MHz    | —      | -42 | —    | dB |
|  |                         | $F \geq F_0 + 4$ MHz | —      | -31 | —    | dB |
|  |                         | $F \leq F_0 - 4$ MHz | —      | -48 | —    | dB |
|  | Image frequency         | —                    | —      | -31 | —    | dB |
| Adjacent channel to image frequency      | $F = F_{image} + 1$ MHz | —                    | -36    | —   | dB   |    |
|  | $F = F_{image} - 1$ MHz | —                    | -33    | —   | dB   |    |

Table 33: Bluetooth LE - Receiver Characteristics - 500 Kbps

| Parameter                                | Description             | Min                  | Typ    | Max | Unit |    |
|--|-------------------------|----------------------|--------|-----|------|----|
| Sensitivity @30.8% PER                   | —                       | —                    | -101.5 | —   | dBm  |    |
| Maximum received signal @30.8% PER       | —                       | —                    | 8      | —   | dBm  |    |
| C/I and receiver selectivity performance | Co-channel              | $F = F_0$ MHz        | —      | 4   | —    | dB |
|  | Adjacent channel        | $F = F_0 + 1$ MHz    | —      | 1   | —    | dB |
|  |                         | $F = F_0 - 1$ MHz    | —      | -1  | —    | dB |
|  |                         | $F = F_0 + 2$ MHz    | —      | -23 | —    | dB |
|  |                         | $F = F_0 - 2$ MHz    | —      | -24 | —    | dB |
|  |                         | $F = F_0 + 3$ MHz    | —      | -33 | —    | dB |
|  |                         | $F = F_0 - 3$ MHz    | —      | -41 | —    | dB |
|  |                         | $F \geq F_0 + 4$ MHz | —      | -31 | —    | dB |
|  |                         | $F \leq F_0 - 4$ MHz | —      | -41 | —    | dB |
|  | Image frequency         | —                    | —      | -30 | —    | dB |
| Adjacent channel to image frequency      | $F = F_{image} + 1$ MHz | —                    | -35    | —   | dB   |    |
|  | $F = F_{image} - 1$ MHz | —                    | -27    | —   | dB   |    |

## 6.3 802.15.4 Radio

Table 34: 802.15.4 RF Characteristics

| Name  | Description     |
|---|-----------------|
| Center frequency range of operating channel | 2405 ~ 2480 MHz |

<sup>1</sup> Zigbee in the 2.4 GHz range supports 16 channels at 5 MHz spacing from channel 11 to channel 26.

### 6.3.1 802.15.4 RF Transmitter (TX) Characteristics

Table 35: 802.15.4 Transmitter Characteristics - 250 Kbps

| Parameter               | Min   | Typ   | Max  | Unit |
|-------------------------|-------|-------|------|------|
| RF transmit power range | -24.0 | —     | 20.0 | dBm  |
| EVM                     | —     | 13.0% | —    | —    |

### 6.3.2 802.15.4 RF Receiver (RX) Characteristics

Table 36: 802.15.4 Receiver Characteristics - 250 Kbps

| Parameter                       | Description       | Min                        | Typ    | Max | Unit |    |
|---------------------------------|-------------------|----------------------------|--------|-----|------|----|
| Sensitivity @1% PER             | —                 | —                          | -104.0 | —   | dBm  |    |
| Maximum received signal @1% PER | —                 | —                          | 8      | —   | dBm  |    |
| Relative jamming level          | Adjacent channel  | $F = F_0 + 5 \text{ MHz}$  | —      | 27  | —    | dB |
|                                 |                   | $F = F_0 - 5 \text{ MHz}$  | —      | 32  | —    | dB |
|                                 | Alternate channel | $F = F_0 + 10 \text{ MHz}$ | —      | 47  | —    | dB |
|                                 |                   | $F = F_0 - 10 \text{ MHz}$ | —      | 50  | —    | dB |

# 7 Module Schematics

This is the reference design of the module.

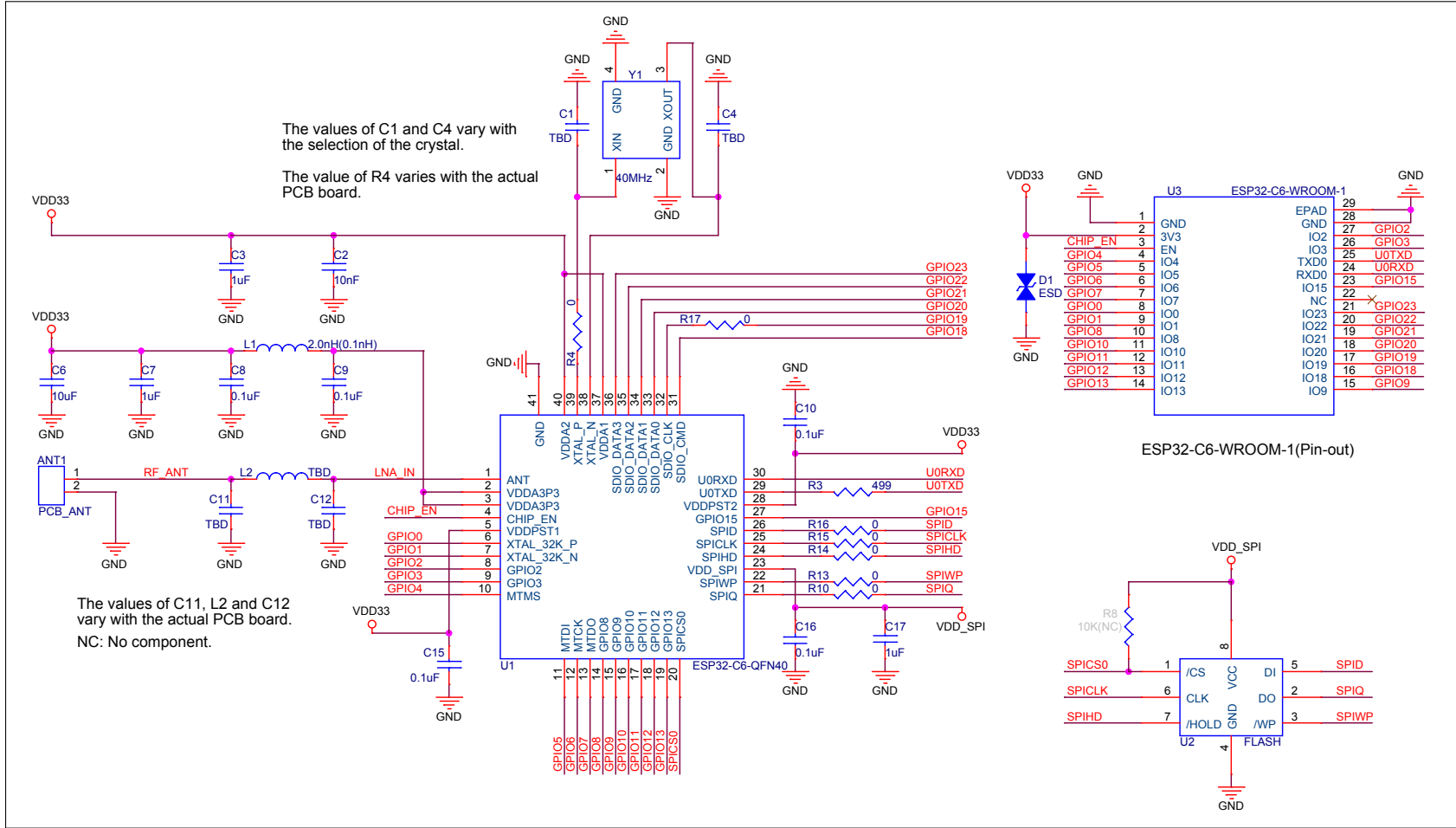


Figure 5: ESP32-C6-WROOM-1 Schematics

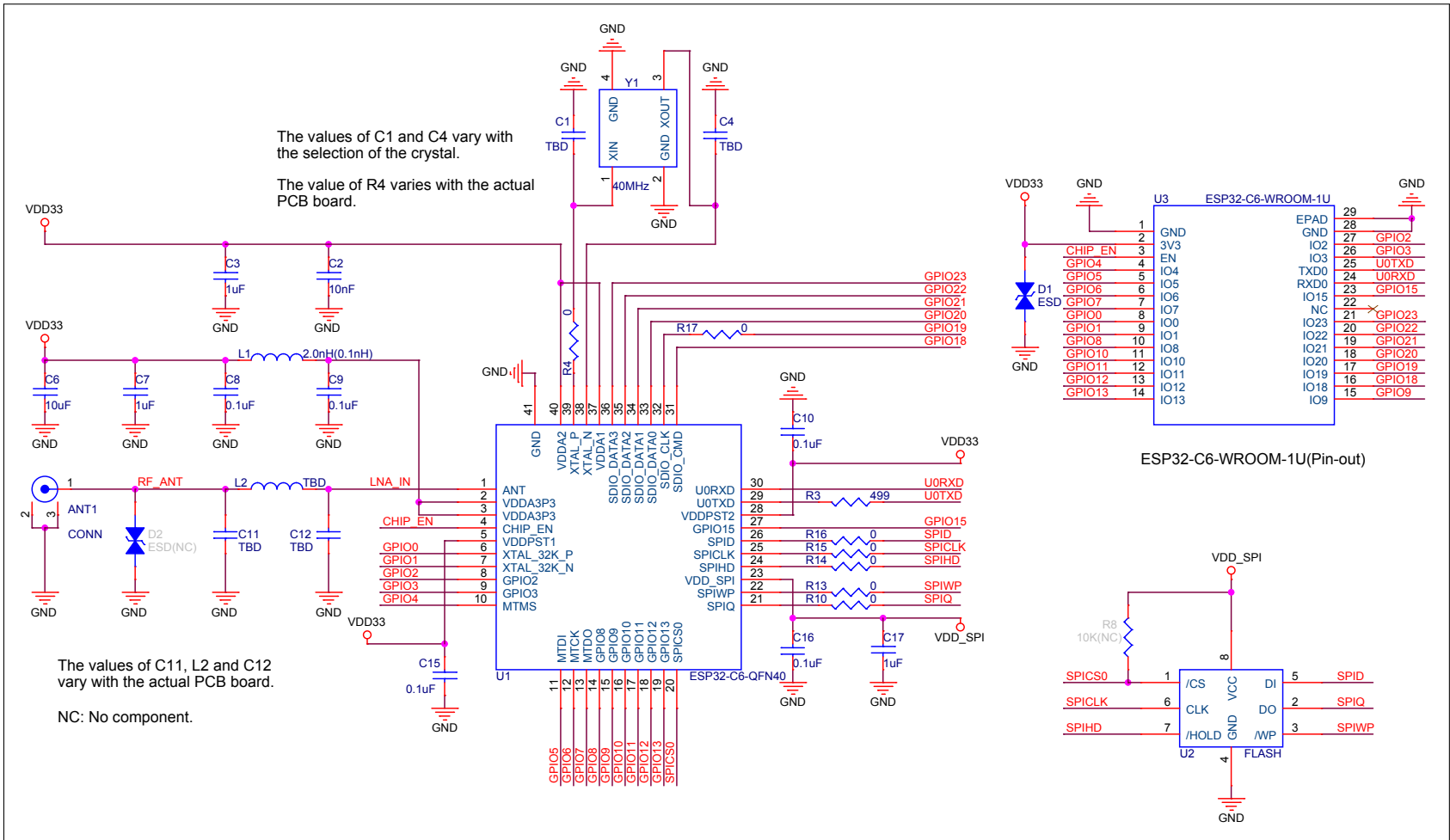


Figure 6: ESP32-C6-WROOM-1U Schematics

## 8 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).

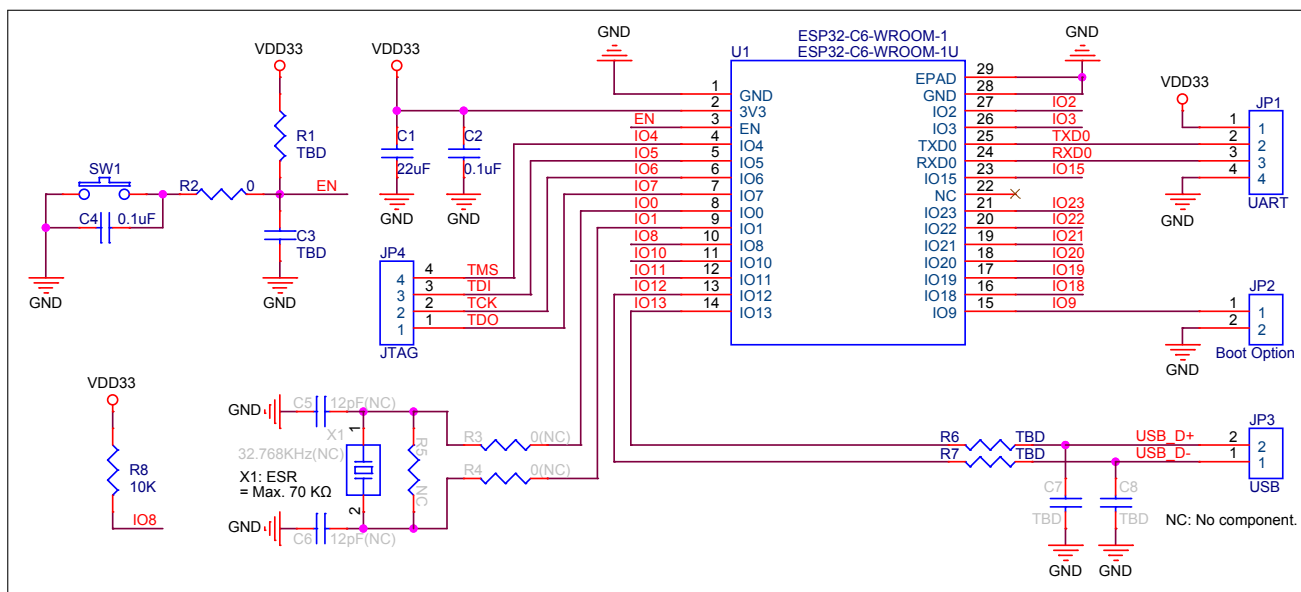


Figure 7: Peripheral Schematics

- 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. Too much soldering paste may increase the gap between the module and the baseboard. As a result, the adhesion between other pins and the baseboard may be poor.
- To ensure that the power supply to the ESP32-C6 chip is stable during power-up, it is advised to add an RC delay circuit at the EN pin. The recommended setting for the RC delay circuit is usually  $R = 10\text{ k}\Omega$  and  $C = 1\ \mu\text{F}$ . However, specific parameters should be adjusted based on the power-up timing of the module and the power-up and reset sequence timing of the chip. For ESP32-C6's power-up and reset sequence timing diagram, please refer to [ESP32-C6 Series Datasheet](#) > Section *Power Supply*.



## 9 Physical Dimensions and PCB Land Pattern

### 9.1 Physical Dimensions

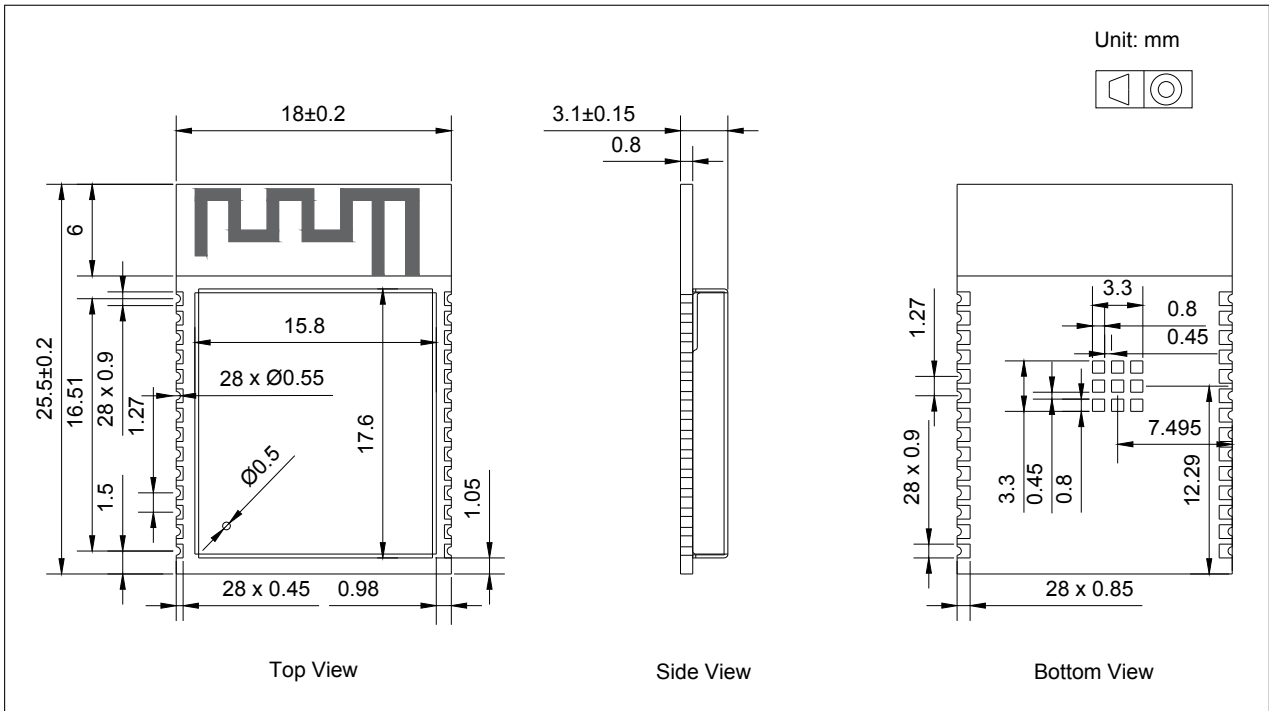


Figure 8: ESP32-C6-WROOM-1 Physical Dimensions

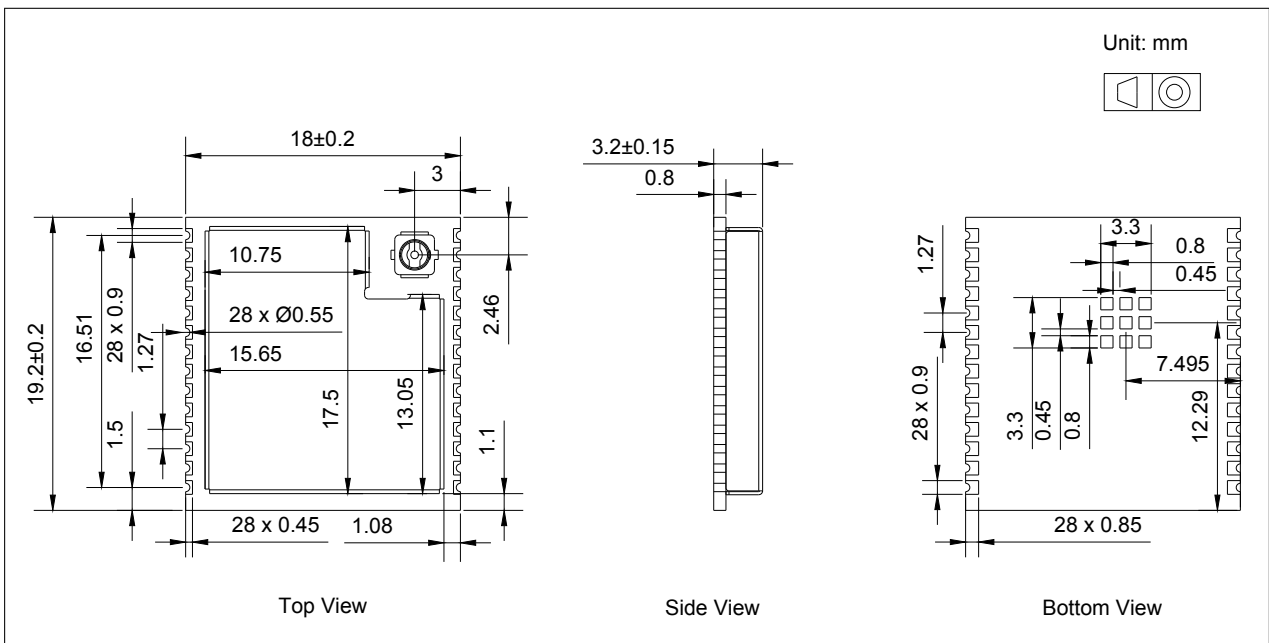


Figure 9: ESP32-C6-WROOM-1U Physical Dimensions

**Note:**

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

## 9.2 Recommended PCB Land Pattern

This section provides the following resources for your reference:

- Figures for recommended PCB land patterns with all the dimensions needed for PCB design. See Figure 10 *ESP32-C6-WROOM-1 Recommended PCB Land Pattern* and Figure 11 *ESP32-C6-WROOM-1U Recommended PCB Land Pattern*.
- Source files of recommended PCB land patterns to measure dimensions not covered in Figure 10. You can view the source files for [ESP32-C6-WROOM-1](#) with [Autodesk Viewer](#).

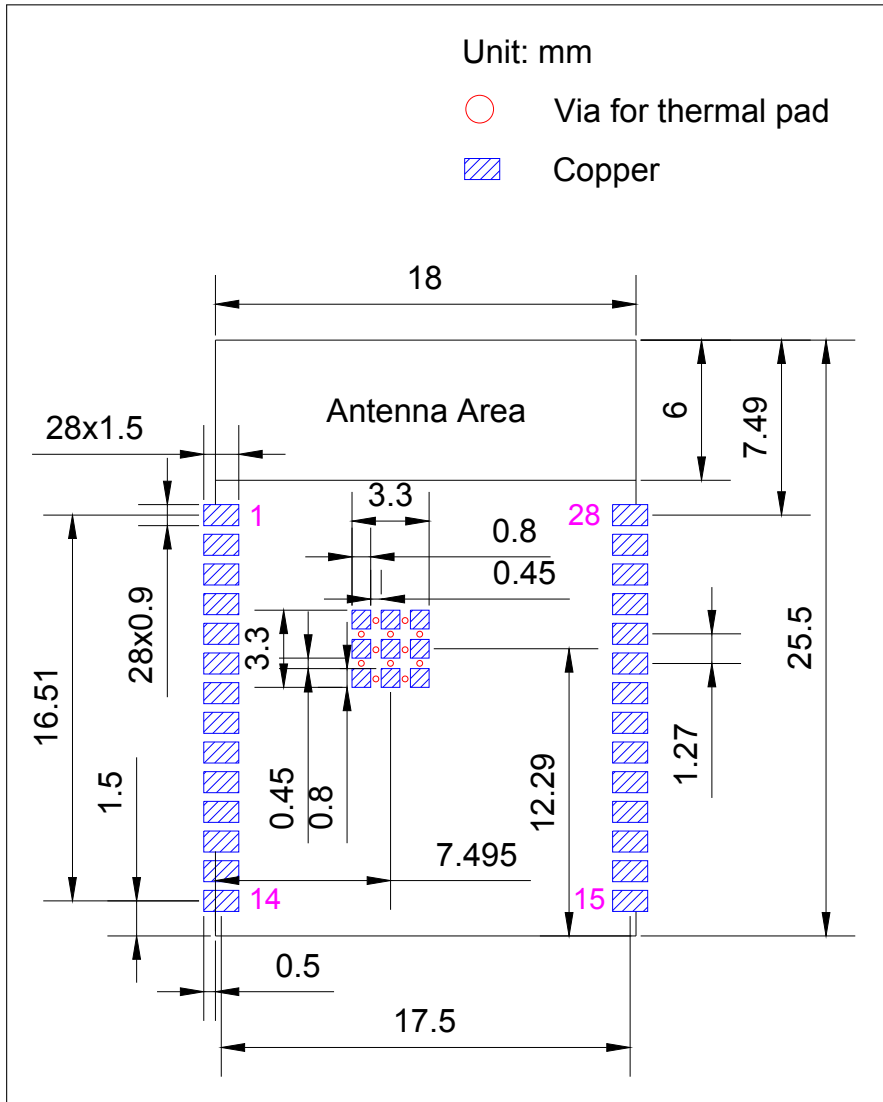


Figure 10: ESP32-C6-WROOM-1 Recommended PCB Land Pattern

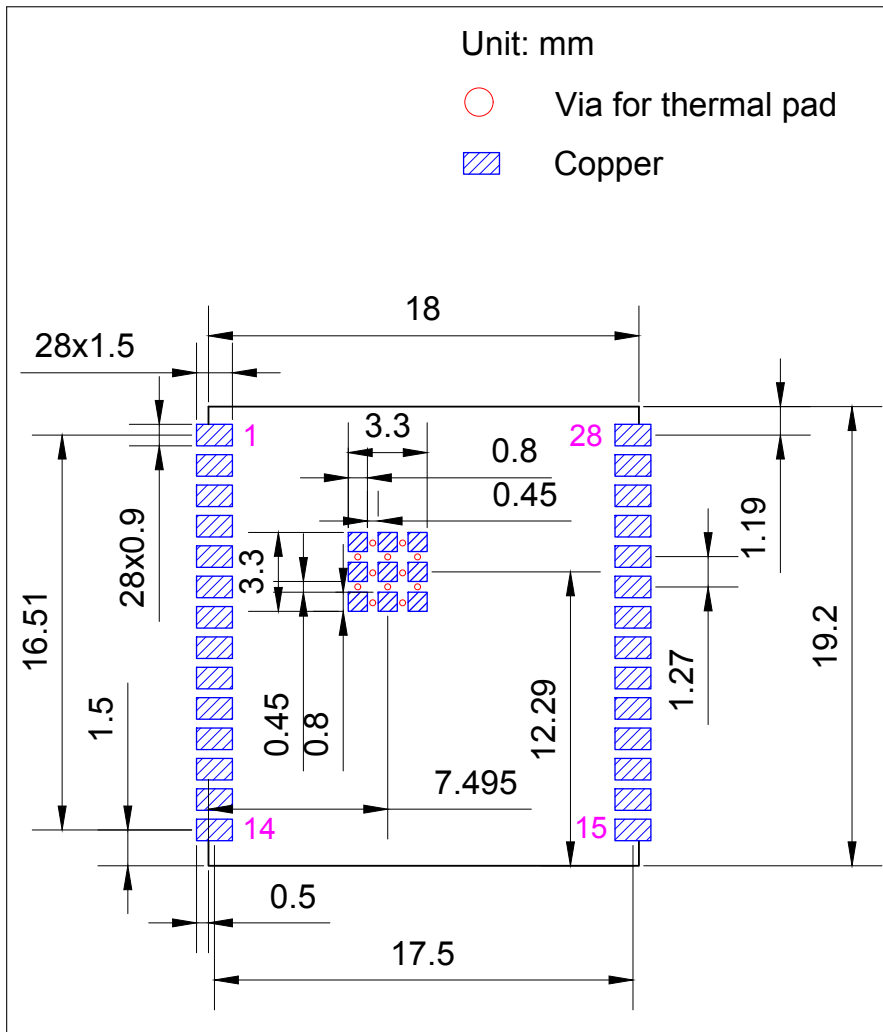


Figure 11: ESP32-C6-WROOM-1U Recommended PCB Land Pattern

### 9.3 Dimensions of External Antenna Connector

ESP32-C6-WROOM-1U uses the first generation external antenna connector as shown in Figure 12 *Dimensions of External Antenna Connector*. This connector is compatible with the following connectors:

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

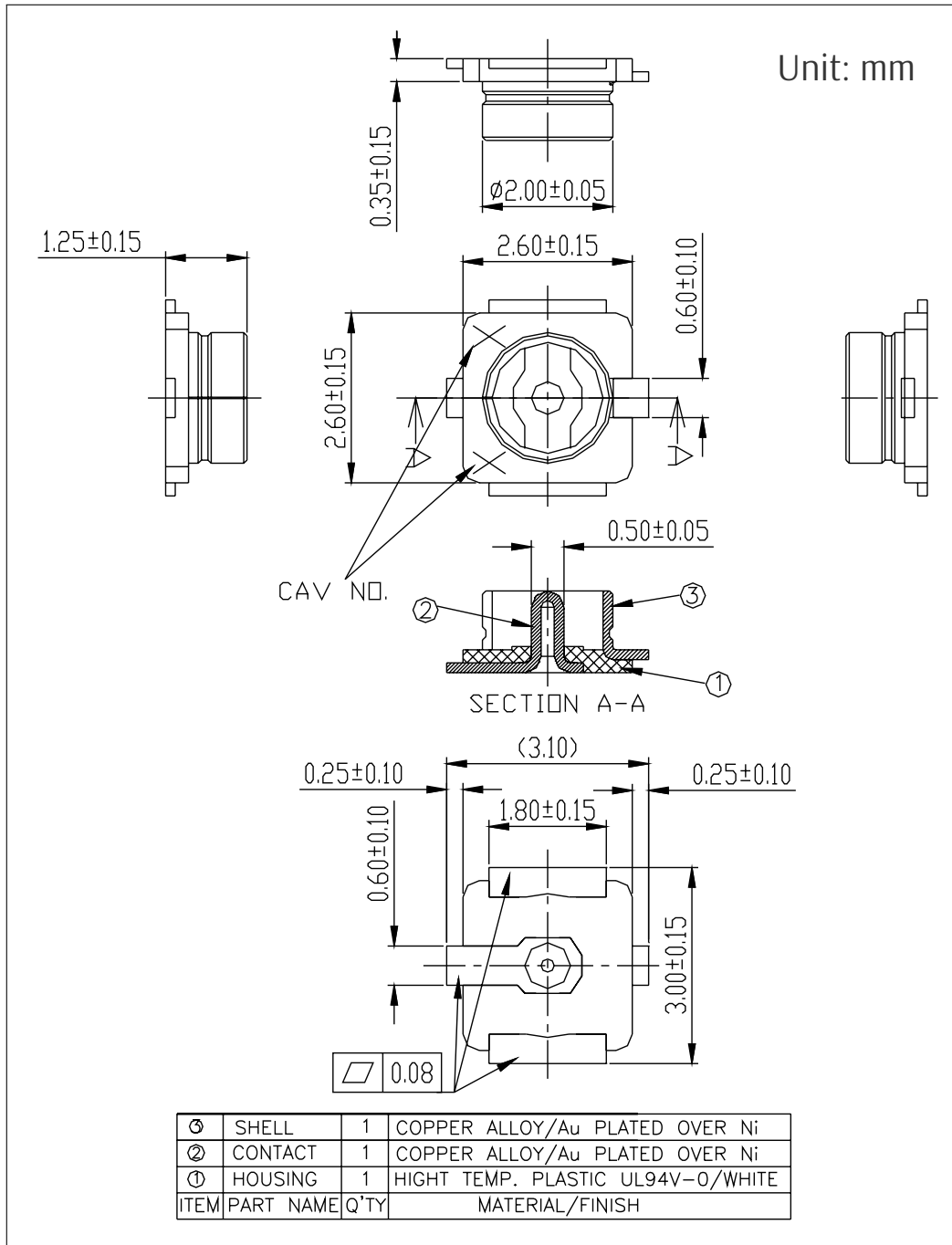


Figure 12: Dimensions of External Antenna Connector

## 10 Product Handling

### 10.1 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%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%RH. If the above conditions are not met, the module needs to be baked.

### 10.2 Electrostatic Discharge (ESD)

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

### 10.3 Soldering Profile

#### 10.3.1 Reflow Profile

Solder the module in a single reflow.

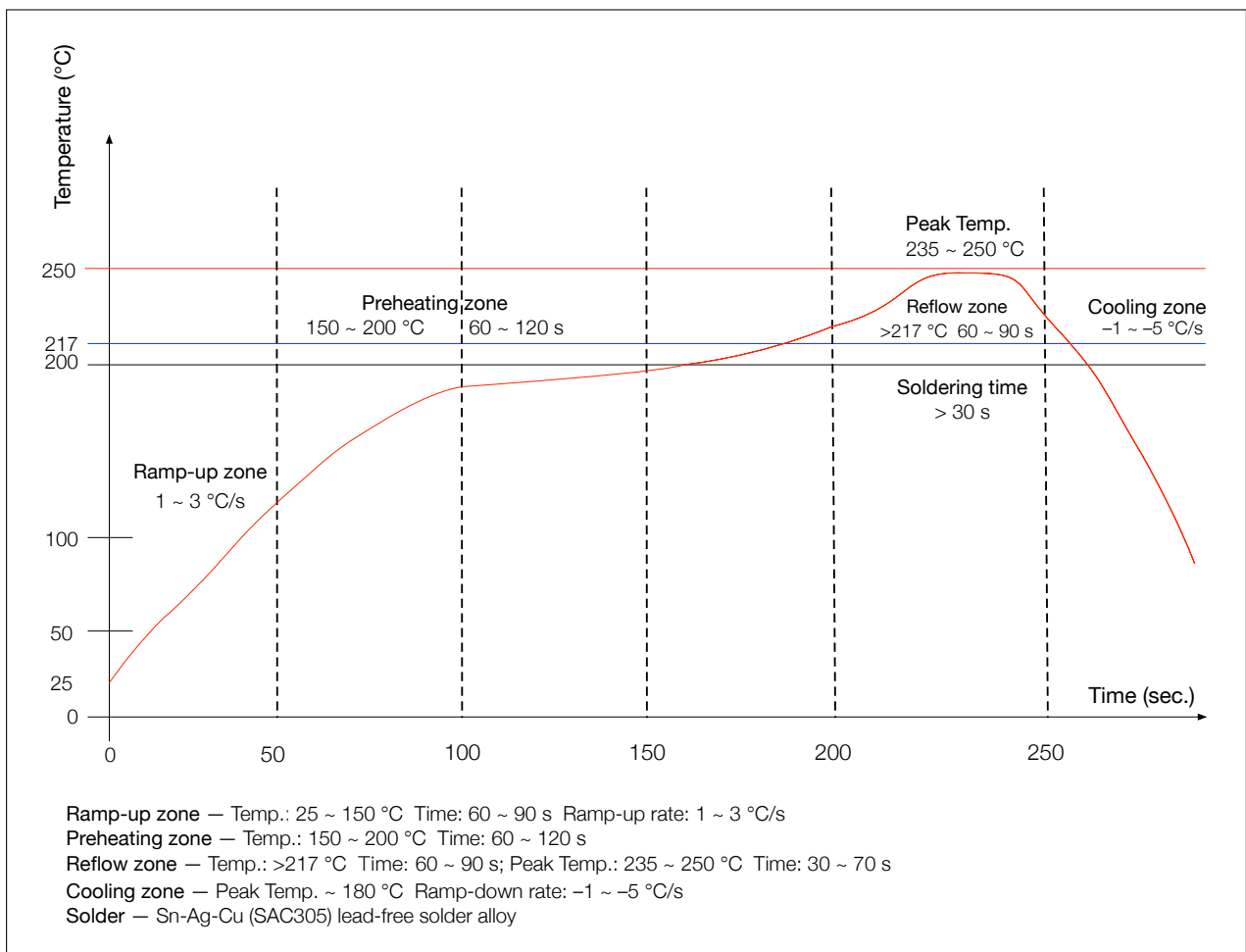


Figure 13: Reflow Profile

## 10.4 Ultrasonic Vibration

Avoid exposing Espressif modules to vibration from ultrasonic equipment, such as ultrasonic welders or ultrasonic cleaners. This vibration may induce resonance in the in-module crystal and lead to its malfunction or even failure. As a consequence, **the module may stop working or its performance may deteriorate.**

# 11 Related Documentation and Resources

## Related Documentation

- [ESP32-C6 Series Datasheet](#) – Specifications of the ESP32-C6 hardware.
- [ESP32-C6 Technical Reference Manual](#) – Detailed information on how to use the ESP32-C6 memory and peripherals.
- [ESP32-C6 Hardware Design Guidelines](#) – Guidelines on how to integrate the ESP32-C6 into your hardware product.
- *Certificates*  
<https://espressif.com/en/support/documents/certificates>
- *ESP32-C6 Product/Process Change Notifications (PCN)*  
<https://espressif.com/en/support/documents/pcns?keys=ESP32-C6>
- *Documentation Updates and Update Notification Subscription*  
<https://espressif.com/en/support/download/documents>

## Developer Zone

- [ESP-IDF Programming Guide for ESP32-C6](#) – Extensive documentation for the ESP-IDF development framework.
- *ESP-IDF* and other development frameworks on GitHub.  
<https://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.  
<https://esp32.com/>
- *The ESP Journal* – Best Practices, Articles, and Notes from Espressif folks.  
<https://blog.espressif.com/>
- See the tabs *SDKs and Demos*, *Apps*, *Tools*, *AT Firmware*.  
<https://espressif.com/en/support/download/sdks-demos>

## Products

- *ESP32-C6 Series SoCs* – Browse through all ESP32-C6 SoCs.  
<https://espressif.com/en/products/socs?id=ESP32-C6>
- *ESP32-C6 Series Modules* – Browse through all ESP32-C6-based modules.  
<https://espressif.com/en/products/modules?id=ESP32-C6>
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## Revision History

| Date       | Version | Release notes   |
|------------|---------|---|
| 2023-07-04 | v1.0    | <ul style="list-style-type: none"><li>• Updated the vector picture of ESP32-C6-WROOM-1U on the titlepage to remove the castellated pins at the bottom</li><li>• In Section <a href="#">1.2 Description</a>, removed peripheral-related information and information on ESP32-C6-WROOM-1-H4, ESP32-C6-WROOM-1-N16, ESP32-C6-WROOM-1U-H4, and ESP32-C6-WROOM-1U-N16, and added a note about module customization</li><li>• Added Chapter <a href="#">4 Peripherals</a></li><li>• Updated Table <a href="#">8 ESP32-C6-WROOM-1 Physical Dimensions</a> and Table <a href="#">9 ESP32-C6-WROOM-1U Physical Dimensions</a> to change the tolerance in the top view from 0.25 to 0.2</li></ul> |
| 2023-04-17 | v0.6    | Added information about ESP32-C6-WROOM-1U module  |
| 2023-02-16 | v0.5    | Preliminary release   |





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