ESP32-C3-WROOM-02
ESP32-C3-WROOM-02U

Datasheet

2.4 GHz Wi-Fi (802.11 b/g/n) and Bluetooth® 5 module
Built around ESP32-C3 series of SoCs, RISC-V single-core microprocessor
Flash up to 8 MB
15 GPIOs
On-board PCB antenna or external antenna connector

ESP32-C3-WROOM-02

ESP32-C3-WROOM-02U

Version 1.3
Espressif Systems

1 Module Overview

Note:

Check the link or the QR code to make sure that you use the latest version of this document:
https://www.espressif.com/documentation/esp32-c3-wroom-02_datasheet_en.pdf

1.1 Features

CPU and On-Chip Memory

- ESP32-C3 embedded, 32-bit RISC-V single-core processor, up to 160 MHz
- 384 KB ROM
- 400 KB SRAM (16 KB for cache)
- 8 KB SRAM in RTC

Wi-Fi

- IEEE 802.11 b/g/n-compliant
- Center frequency range of operating channel: 2412 ~ 2484 MHz
- Supports 20 MHz, 40 MHz bandwidth in 2.4 GHz band
- 1T1R mode with 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-C3 series scans in Station mode, the SoftAP channel will change along with the Station channel
- 802.11mc FTM

Bluetooth®

- Bluetooth LE: Bluetooth 5, Bluetooth mesh
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
- Advertising extensions
- Multiple advertisement sets
- Channel selection algorithm #2
- Internal co-existence mechanism between Wi-Fi and Bluetooth to share the same antenna

Peripherals

- GPIO, SPI, UART, I2C, I2S, remote control peripheral, LED PWM controller, general DMA controller, TWAI® controller (compatible with ISO 11898-1, i.e. CAN Specification 2.0), USB Serial/JTAG controller, temperature sensor, SAR ADC, general-purpose timers, watchdog timers

Integrated Components on Module

- 40 MHz crystal oscillator
- SPI flash

Antenna Options

- On-board PCB antenna (ESP32-C3-WROOM-02)
- External antenna via a connector (ESP32-C3-WROOM-02U)

Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V

- Operating ambient temperature:
  - 85 °C version module: –40 ~ 85 °C
  - 105 °C version module: –40 ~ 105 °C

Certification

- RF certification: See certificates
- Green certification: RoHS/REACH

Test

- HTOL/HTSL/uHAST/TCT/ESD/Latch-up

1.2 Description

ESP32-C3-WROOM-02 and ESP32-C3-WROOM-02U are two general-purpose Wi-Fi and Bluetooth LE modules. The rich set of peripherals and high performance make the two modules an ideal choice for smart homes, industrial automation, health care, consumer electronics, etc.

ESP32-C3-WROOM-02 and ESP32-C3-WROOM-02U both feature an external SPI flash. ESP32-C3-WROOM-02 comes with a on-board PCB antenna. ESP32-C3-WROOM-02U comes with a connector for an external antenna.

A wide selection of module variants are available as shown in Table 1 and 2.

Table 1: ESP32-C3-WROOM-02 (ANT) Series Comparison[1]

Ordering Code	Flash	Ambient Temp.[2] (°C)	Size[3] (mm)
ESP32-C3-WROOM-02-N4	4 MB (Quad SPI)	–40 ~ 85	18.0 × 20.0 × 3.2
ESP32-C3-WROOM-02-H4		–40 ~ 105	
ESP32-C3-WROOM-02-N8	8 MB (Quad SPI)	–40 ~ 85	

[1] This table shares the same notes presented in Table 2 below.

Table 2: ESP32-C3-WROOM-02U (CONN) Series Comparison

Ordering Code	Flash	Ambient Temp.[2] (°C)	Size[3] (mm)
ESP32-C3-WROOM-02U-N4	4 MB (Quad SPI)	–40 ~ 85	18.0 × 14.3 × 3.2
ESP32-C3-WROOM-02U-H4		–40 ~ 105	
ESP32-C3-WROOM-02U-N8	8 MB (Quad SPI)	–40 ~ 85	

[2] Ambient temperature specifies the recommended temperature range of the environment immediately outside the Espressif module.

[3] For details, refer to Section 7.1 *Physical Dimensions*.

Both ESP32-C3-WROOM-02 and ESP32-C3-WROOM-02U has two operating ambient temperature options: –40 ~ 85 °C variants and –40 ~ 105 °C variants, all embedded with the ESP32-C3 chip.

ESP32-C3 has a 32-bit RISC-V single-core processor. It integrates a rich set of peripherals, ranging from UART, I2C, I2S, remote control peripheral, LED PWM controller, general DMA controller, TWAI® controller, USB Serial/JTAG controller, temperature sensor, ADC, etc. It also includes SPI, Dual SPI and Quad SPI interfaces.

Note:
For more information on ESP32-C3, please refer to *ESP32-C3 Series Datasheet*.

1.3 Applications

- Smart Home
  - Light control
  - Smart button
  - Smart plug
  - Indoor positioning
- Industrial Automation
  - Industrial robot
  - Mesh network
  - Human machine interface (HMI)
  - Industrial field bus
- Health Care
  - Health monitor
  - Baby monitor
- Consumer Electronics
  - Smart watch and bracelet
  - Over-the-top (OTT) devices
  - Wi-Fi speaker
  - Logger toys and proximity sensing toys
- Smart Agriculture
  - Smart greenhouse
  - Smart irrigation
  - Agriculture robot
- Retail and Catering
  - POS machines
  - Service robot
- Audio Device
  - Internet music players
  - Live streaming devices
  - Internet radio players
- Generic Low-power IoT Sensor Hubs
- Generic Low-power IoT Data Loggers

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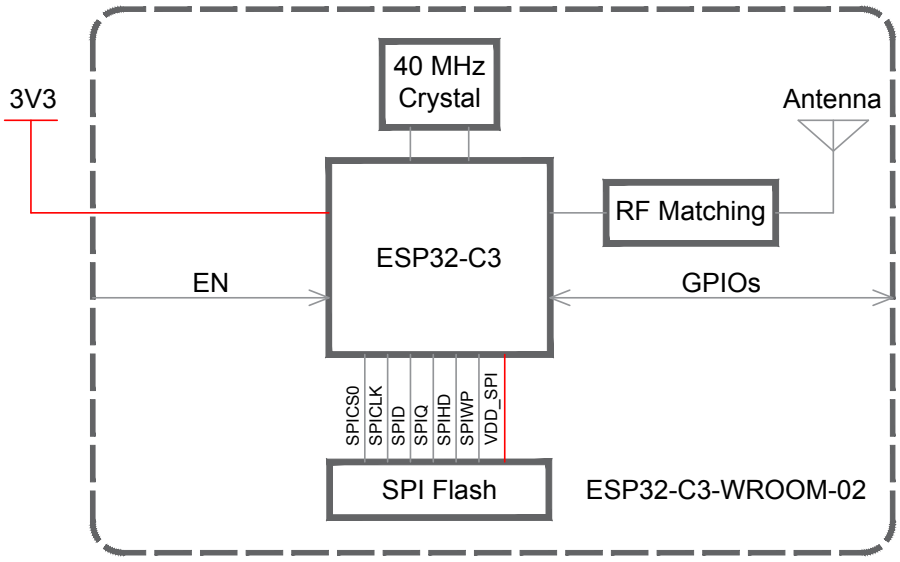

Figure 1: ESP32-C3-WROOM-02 Block Diagram

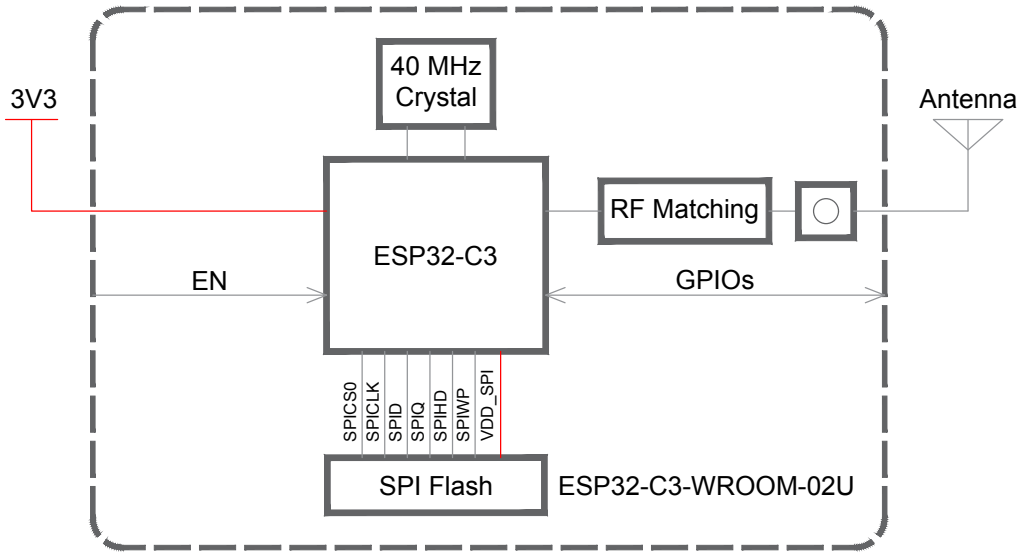

Figure 2: ESP32-C3-WROOM-02U Block Diagram

3 Pin Definitions

3.1 Pin Layout

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

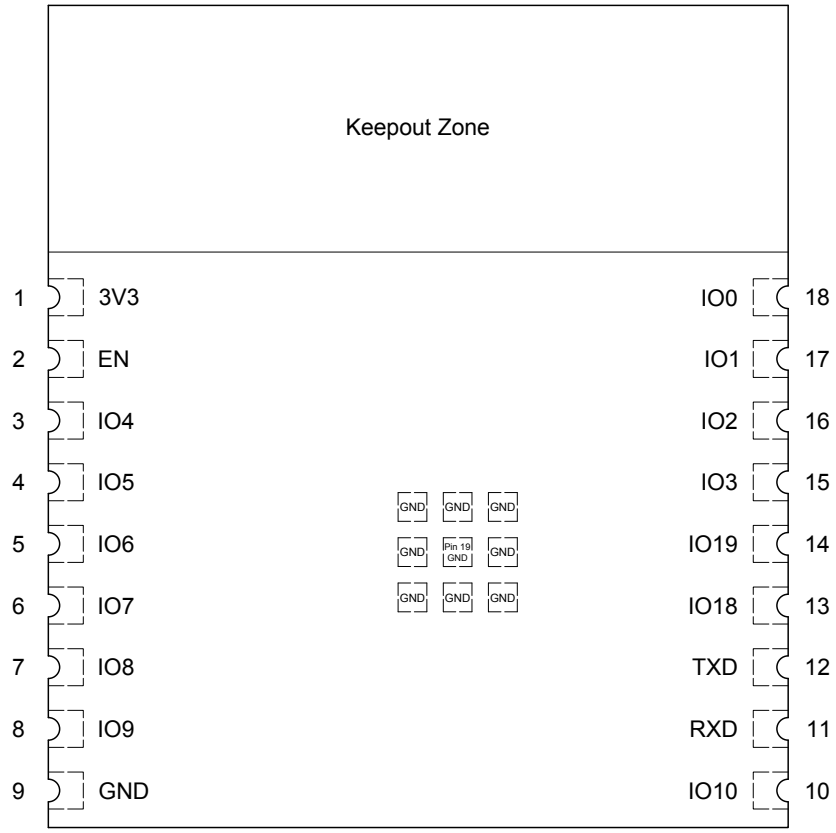

Figure 3: Pin Layout (Top View)

3.2 Pin Description

The module has 19 pins. See pin definitions in Table 3 *Pin Definitions*.

For peripheral pin configurations, please refer to *ESP32-C3 Series Datasheet*.

Table 3: Pin Definitions

Name	No.	Type[1]	Function
3V3	1	P	Power supply
EN	2	I	High: on, enables the chip. Low: off, the chip powers off. Note: Do not leave the EN pin floating.
IO4	3	I/O/T	GPIO4, ADC1_CH4, FSPIHD, MTMS
IO5	4	I/O/T	GPIO5, ADC2_CH0, FSPIWP, MTDI
IO6	5	I/O/T	GPIO6, FSPICLK, MTCK

Cont'd on next page

Table 3 – cont'd from previous page

Name	No.	Type[1]	Function
IO7	6	I/O/T	GPIO7, FSPID, MTDO
IO8	7	I/O/T	GPIO8
IO9	8	I/O/T	GPIO9
GND	9,19	P	Ground
IO10	10	I/O/T	GPIO10, FSPICS0
RXD	11	I/O/T	GPIO20, U0RXD
TXD	12	I/O/T	GPIO21, U0TXD
IO18	13	I/O/T	GPIO18, USB_D-
IO19	14	I/O/T	GPIO19, USB_D+
IO3	15	I/O/T	GPIO3, ADC1_CH3
IO2	16	I/O/T	GPIO2, ADC1_CH2, FSPIQ
IO1	17	I/O/T	GPIO1, ADC1_CH1, XTAL_32K_N
IO0	18	I/O/T	GPIO0, ADC1_CH0, XTAL_32K_P

[1] P: power supply; I: input; O: output; T: high impedance.

3.3 Strapping Pins

Note:
The content below is excerpted from Section *Strapping Pins* in *ESP32-C3 Series Datasheet*. For the strapping pin mapping between the chip and modules, please refer to Chapter 5 *Module Schematics*.

ESP32-C3 has three strapping pins:

- GPIO2
- GPIO8
- GPIO9

Software can read the values of GPIO2, GPIO8 and GPIO9 from GPIO_STRAPPING field in GPIO_STRAP_REG register. For register description, please refer to Section GPIO Matrix Register Summary in *ESP32-C3 Technical Reference Manual*.

During the chip's system 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.

Types of system reset include:

- power-on reset
- RTC watchdog reset
- brownout reset
- analog super watchdog reset
- crystal clock glitch detection reset

By default, GPIO9 is connected to the internal weak pull-up resistor. If GPIO9 is not connected or connected to an external high-impedance circuit, the latched bit value will be "1"

To change the strapping bit values, you 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-C3.

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

Table 4 lists detailed booting configurations of the strapping pins.

Table 4: Strapping Pins

Booting Mode [1]			
Pin	Default	SPI Boot	Download Boot
GPIO2	N/A	1	1
GPIO8	N/A	Don't care	1
GPIO9	Internal weak pull-up	1	0
Enabling/Disabling ROM Messages Print in SPI Boot Mode			
Pin	Default	Functionality	
GPIO8	N/A	When the value of eFuse field EFUSE_UART_PRINT_CONTROL is 0 (default), print is enabled and not controlled by GPIO8. 1, if GPIO8 is 0, print is enabled; if GPIO8 is 1, it is disabled. 2, if GPIO8 is 0, print is disabled; if GPIO8 is 1, it is enabled. 3, print is disabled and not controlled by GPIO8.	

[1] The strapping combination of GPIO8 = 0 and GPIO9 = 0 is invalid and will trigger unexpected behavior.

Figure 4 shows the setup and hold times for the strapping pins before and after the CHIP_EN signal goes high. Details about the parameters are listed in Table 5.

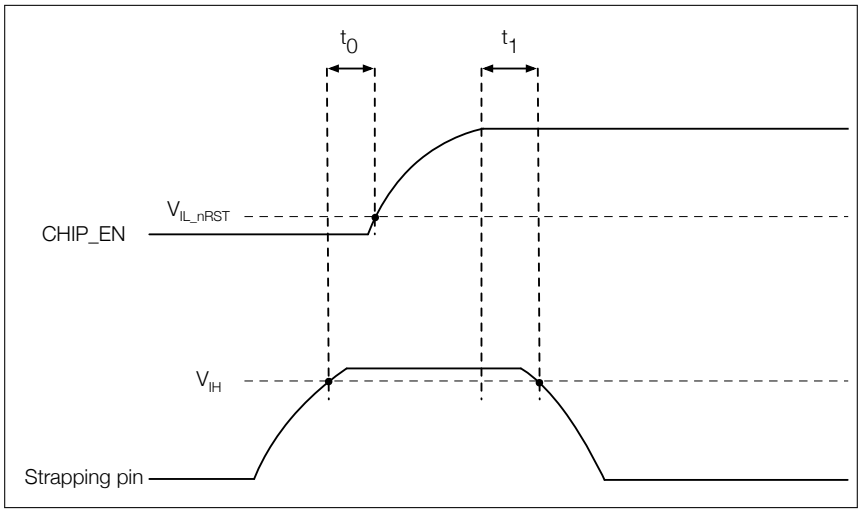

Figure 4: Setup and Hold Times for the Strapping Pins

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

Parameter	Description	Min (ms)
t_0	Setup time before CHIP_EN goes from low to high	0
t_1	Hold time after CHIP_EN goes high	3

4 Electrical Characteristics

4.1 Absolute Maximum Ratings

Stresses above those listed in Table 6 *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 6: Absolute Maximum Ratings

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

4.2 Recommended Operating Conditions

Table 7: Recommended Operating Conditions

Symbol	Parameter		Min	Typ	Max	Unit
VDD33	Power supply voltage		3.0	3.3	3.6	V
I_{VDD}	Current delivered by external power supply		0.5	—	—	A
T_A	Operating ambient temperature	85 °C version	–40	—	85	°C
		105 °C version			105	

4.3 DC Characteristics (3.3 V, 25 °C)

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

Symbol	Parameter	Min	Typ	Max	Unit
C_{IN}	Pin capacitance	—	2	—	pF
V_{IH}	High-level input voltage	0.75 × VDD[1]	—	VDD[1]+ 0.3	V
V_{IL}	Low-level input voltage	–0.3	—	0.25 × VDD[1]	V
I_{IH}	High-level input current	—	—	50	nA
I_{IL}	Low-level input current	—	—	50	nA
V_{OH}[2]	High-level output voltage	0.8 × VDD[1]	—	—	V
V_{OL}[2]	Low-level output voltage	—	—	0.1 × VDD[1]	V
I_{OH}	High-level source current (VDD[1]= 3.3 V, V_{OH} >= 2.64 V, PAD_DRIVER = 3)	—	40	—	mA
I_{OL}	Low-level sink current (VDD[1]= 3.3 V, V_{OL} = 0.495 V, PAD_DRIVER = 3)	—	28	—	mA
R_{PU}	Pull-up resistor	—	45	—	kΩ
R_{PD}	Pull-down resistor	—	45	—	kΩ
V_{IH_nRST}	Chip reset release voltage	0.75 × VDD[1]	—	VDD[1]+ 0.3	V
V_{IL_nRST}	Chip reset voltage	–0.3	—	0.25 × VDD[1]	V

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

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

4.4 Current Consumption Characteristics

Owing to the use of advanced power-management technologies, the module can switch between different power modes. For details on different power modes, please refer to Section *Low Power Management* in *ESP32-C3 Series Datasheet*.

Table 9: Current Consumption Depending on RF Modes

Work mode	Description		Peak (mA)
Active (RF working)	TX	802.11b, 1 Mbps, @20.5 dBm	345
		802.11g, 54 Mbps, @18 dBm	285
		802.11n, HT20, MCS7, @17.5 dBm	280
		802.11n, HT40, MCS7, @17 dBm	280
	RX	802.11b/g/n, HT20	82
		802.11n, HT40	84

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

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

Note:
The content below is excerpted from *Section Power Consumption in Other Modes* in *ESP32-C3 Series Datasheet*.

4.4.1 Current Consumption in Other Modes

Table 10: Current Consumption in Modem-sleep Mode

Mode	CPU Frequency (MHz)	Description	Typ	
			All Peripherals Clocks Disabled (mA)	All Peripherals Clocks Enabled (mA)[1]
Modem-sleep[2,3]	160	CPU is idle	16	21
		CPU is running	23	28
	80	CPU is idle	13	18
		CPU is running	17	22

[1] In practice, the current consumption might be different depending on which peripherals are enabled.

[2] In Modem-sleep mode, Wi-Fi is clock gated.

[3] In Modem-sleep mode, the consumption might be higher when accessing flash. For a flash rated at 80 Mbit/s, in SPI 2-line mode the consumption is 10 mA.

Table 11: Current Consumption in Low-Power Modes

Mode	Description	Typ (μA)
Light-sleep	VDD_SPI and Wi-Fi are powered down, and all GPIOs are high-impedance	130
Deep-sleep	RTC timer + RTC memory	5
Power off	CHIP_EN is set to low level, the chip is powered off	1

4.5 Wi-Fi Radio

4.5.1 Wi-Fi RF Standards

Table 12: Wi-Fi RF Standards

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

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

[2] For the modules that use external antenna connectors, the output impedance is 50 Ω. For other modules without external antenna connectors, the output impedance is irrelevant.

4.5.2 Wi-Fi RF Transmitter (TX) Specifications

Target TX power is configurable based on device or certification requirements. The default characteristics are provided in Table 13.

Table 13: TX Power with Spectral Mask and EVM Meeting 802.11 Standards

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

Table 14: TX EVM Test

Rate	Min (dB)	Typ (dB)	SL[1] (dB)
802.11b, 1 Mbps, @20.5 dBm	—	–24.5	–10
802.11b, 11 Mbps, @20.5 dBm	—	–25.0	–10
802.11g, 6 Mbps, @20 dBm	—	–23.0	–5
802.11g, 54 Mbps, @18 dBm	—	–28.0	–25
802.11n, HT20, MCS0, @19 dBm	—	–23.5	–5
802.11n, HT20, MCS7, @17.5 dBm	—	–29.5	–27
802.11n, HT40, MCS0, @18.5 dBm	—	–26.5	–5
802.11n, HT40, MCS7, @17 dBm	—	–29.5	–27

[1] SL stands for standard limit value.

4.5.3 Wi-Fi RF Receiver (RX) Specifications

Table 15: RX Sensitivity

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	–98.0	—
802.11b, 2 Mbps	—	–96.0	—
802.11b, 5.5 Mbps	—	–93.0	—
802.11b, 11 Mbps	—	–88.6	—
802.11g, 6 Mbps	—	–93.0	—
802.11g, 9 Mbps	—	–92.0	—
802.11g, 12 Mbps	—	–90.8	—
802.11g, 18 Mbps	—	–88.4	—
802.11g, 24 Mbps	—	–85.4	—
802.11g, 36 Mbps	—	–82.0	—
802.11g, 48 Mbps	—	–78.0	—
802.11g, 54 Mbps	—	–76.4	—
802.11n, HT20, MCS0	—	–93.0	—
802.11n, HT20, MCS1	—	–90.8	—
802.11n, HT20, MCS2	—	–88.2	—
802.11n, HT20, MCS3	—	–84.6	—
802.11n, HT20, MCS4	—	–81.4	—
802.11n, HT20, MCS5	—	–77.4	—
802.11n, HT20, MCS6	—	–75.4	—
802.11n, HT20, MCS7	—	–74.4	—
802.11n, HT40, MCS0	—	–90.0	—
802.11n, HT40, MCS1	—	–87.6	—
802.11n, HT40, MCS2	—	–84.8	—
802.11n, HT40, MCS3	—	–81.8	—
802.11n, HT40, MCS4	—	–78.4	—

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Table 15 – cont'd from previous page

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11n, HT40, MCS5	—	–74.4	—
802.11n, HT40, MCS6	—	–72.6	—
802.11n, HT40, MCS7	—	–71.2	—

Table 16: Maximum RX Level

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	5	—
802.11b, 11 Mbps	—	5	—
802.11g, 6 Mbps	—	5	—
802.11g, 54 Mbps	—	0	—
802.11n, HT20, MCS0	—	5	—
802.11n, HT20, MCS7	—	0	—
802.11n, HT40, MCS0	—	5	—
802.11n, HT40, MCS7	—	0	—

Table 17: RX Adjacent Channel Rejection

Rate	Min (dB)	Typ (dB)	Max (dB)
802.11b, 1 Mbps	—	35	—
802.11b, 11 Mbps	—	35	—
802.11g, 6 Mbps	—	31	—
802.11g, 54 Mbps	—	20	—
802.11n, HT20, MCS0	—	31	—
802.11n, HT20, MCS7	—	16	—
802.11n, HT40, MCS0	—	25	—
802.11n, HT40, MCS7	—	11	—

4.6 Bluetooth LE Radio

4.6.1 Bluetooth LE RF Transmitter (TX) Specifications

Table 18: Transmitter General Characteristics

Parameter	Min	Typ	Max	Unit
RF transmit power	—	0	—	dBm
Gain control step	—	3	—	dB
RF power control range	–24	—	20	dBm

Table 19: Transmitter Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	–37.62	—	dBm
	F = F0 ± 3 MHz	—	–41.95	—	dBm
	F = F0 ± > 3 MHz	—	–44.48	—	dBm
Modulation characteristics	$\Delta\ f1_{avg}$	—	245.00	—	kHz
	$\Delta\ f2_{max}$	—	208.00	—	kHz
	$\Delta\ f2_{avg}/\Delta\ f1_{avg}$	—	0.93	—	—
Carrier frequency offset	—	—	–9.00	—	kHz
Carrier frequency drift	$\lvert f_0 - f_n \rvert_{n=2,\ 3,\ 4,\ ..k}$	—	1.17	—	kHz
	$\lvert f_1 - f_0 \rvert$	—	0.30	—	kHz
	$\lvert f_n - f_{n-5} \rvert_{n=6,\ 7,\ 8,\ ..k}$	—	4.90	—	kHz

Table 20: Transmitter Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 4 MHz	—	–43.55	—	dBm
	F = F0 ± 5 MHz	—	–45.26	—	dBm
	F = F0 ± > 5 MHz	—	–47.00	—	dBm
Modulation characteristics	$\Delta\ f1_{avg}$	—	497.00	—	kHz
	$\Delta\ f2_{max}$	—	398.00	—	kHz
	$\Delta\ f2_{avg}/\Delta\ f1_{avg}$	—	0.95	—	—
Carrier frequency offset	—	—	–9.00	—	kHz
Carrier frequency drift	$\lvert f_0 - f_n \rvert_{n=2,\ 3,\ 4,\ ..k}$	—	0.46	—	kHz
	$\lvert f_1 - f_0 \rvert$	—	0.70	—	kHz
	$\lvert f_n - f_{n-5} \rvert_{n=6,\ 7,\ 8,\ ..k}$	—	6.80	—	kHz

Table 21: Transmitter Characteristics - Bluetooth LE 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	–37.90	—	dBm
	F = F0 ± 3 MHz	—	–41.00	—	dBm
	F = F0 ± > 3 MHz	—	–42.50	—	dBm
Modulation characteristics	$\Delta\ f1_{avg}$	—	252.00	—	kHz
	$\Delta\ f1_{max}$	—	200.00	—	kHz
Carrier frequency offset	—	—	–13.70	—	kHz
Carrier frequency drift	$\lvert f_0 - f_n \rvert_{n=1,\ 2,\ 3,\ ..k}$	—	1.52	—	kHz
	$\lvert f_0 - f_3 \rvert$	—	0.65	—	kHz
	$\lvert f_n - f_{n-3} \rvert_{n=7,\ 8,\ 9,\ ..k}$	—	0.70	—	kHz

Table 22: Transmitter Characteristics - Bluetooth LE 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	–37.90	—	dBm
	F = F0 ± 3 MHz	—	–41.30	—	dBm
	F = F0 ± > 3 MHz	—	–42.80	—	dBm
Modulation characteristics	$\Delta\ f2_{avg}$	—	220.00	—	kHz
	$\Delta\ f2_{max}$	—	205.00	—	kHz
Carrier frequency offset	—	—	–11.90	—	kHz
Carrier frequency drift	$\lvert f_0 - f_n \rvert_{n=1,\ 2,\ 3,\ ..k}$	—	1.37	—	kHz
	$\lvert f_0 - f_3 \rvert$	—	1.09	—	kHz
	$\lvert f_n - f_{n-3} \rvert_{n=7,\ 8,\ 9,\ ..k}$	—	0.51	—	kHz

4.6.2 Bluetooth LE RF Receiver (RX) Specifications

Table 23: Receiver Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–97	—	dBm
Maximum received signal @30.8% PER	—	—	10	—	dBm
Co-channel C/I	—	—	7	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–4	—	dB
	F = F0 – 1 MHz	—	–4	—	dB
	F = F0 + 2 MHz	—	–29	—	dB
	F = F0 – 2 MHz	—	–31	—	dB
	F ≥ F0 + 3 MHz	—	–33	—	dB
	F ≤ F0 – 3 MHz	—	–35	—	dB
	F ≥ F0 + 4 MHz	—	–35	—	dB
	F ≤ F0 – 4 MHz	—	–37	—	dB
Image frequency	—	—	–35	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–40	—	dB
	F = F_{image} – 1 MHz	—	–33	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	–6	—	dBm
	2003 MHz ~ 2399 MHz	—	–26	—	dBm
	2484 MHz ~ 2997 MHz	—	–25	—	dBm
	3000 MHz ~ 12.75 GHz	—	–5	—	dBm
Intermodulation	—	—	–30	—	dBm

Table 24: Receiver Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–93	—	dBm
Maximum received signal @30.8% PER	—	—	5	—	dBm
Co-channel C/I	—	—	10	—	dB
Adjacent channel selectivity C/I	F = F0 + 2 MHz	—	–8	—	dB
	F = F0 – 2 MHz	—	–7	—	dB
	F = F0 + 4 MHz	—	–32	—	dB
	F = F0 – 4 MHz	—	–34	—	dB
	F ≥ F0 + 6 MHz	—	–39	—	dB
	F ≤ F0 – 6 MHz	—	–39	—	dB
Image frequency	—	—	–32	—	dB
Adjacent channel to image frequency	F = F_{image} + 2 MHz	—	–39	—	dB
	F = F_{image} – 2 MHz(2)	—	–8	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	–12	—	dBm
	2003 MHz ~ 2399 MHz	—	–30	—	dBm
	2484 MHz ~ 2997 MHz	—	–28	—	dBm
	3000 MHz ~ 12.75 GHz	—	–6	—	dBm
Intermodulation	—	—	–29	—	dBm

Table 25: Receiver Characteristics - Bluetooth LE 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–105	—	dBm
Maximum received signal @30.8% PER	—	—	10	—	dBm
Co-channel C/I	—	—	2	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–6	—	dB
	F = F0 – 1 MHz	—	–4	—	dB
	F = F0 + 2 MHz	—	–33	—	dB
	F = F0 – 2 MHz	—	–41	—	dB
	F ≥ F0 + 3 MHz	—	–37	—	dB
	F ≤ F0 – 3 MHz	—	–46	—	dB
	F ≥ F0 + 4 MHz	—	–40	—	dB
	F ≤ F0 – 4 MHz	—	–49	—	dB
Image frequency	—	—	–40	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–46	—	dB
	F = F_{image} – 1 MHz	—	–37	—	dB

Table 26: Receiver Characteristics - Bluetooth LE 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–101	—	dBm
Maximum received signal @30.8% PER	—	—	10	—	dBm
Co-channel C/I	—	—	3	—	dB

Cont'd on next page

Table 26 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–6	—	dB
	F = F0 – 1 MHz	—	–7	—	dB
	F = F0 + 2 MHz	—	–34	—	dB
	F = F0 – 2 MHz	—	–37	—	dB
	F $\geq$ F0 + 3 MHz	—	–38	—	dB
	F $\leq$ F0 – 3 MHz	—	–40	—	dB
	F $\geq$ F0 + 4 MHz	—	–40	—	dB
	F $\leq$ F0 – 4 MHz	—	–42	—	dB
Image frequency	—	—	–40	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–45	—	dB
	F = F_{image} – 1 MHz	—	–38	—	dB

5 Module Schematics

This is the reference design of the module.

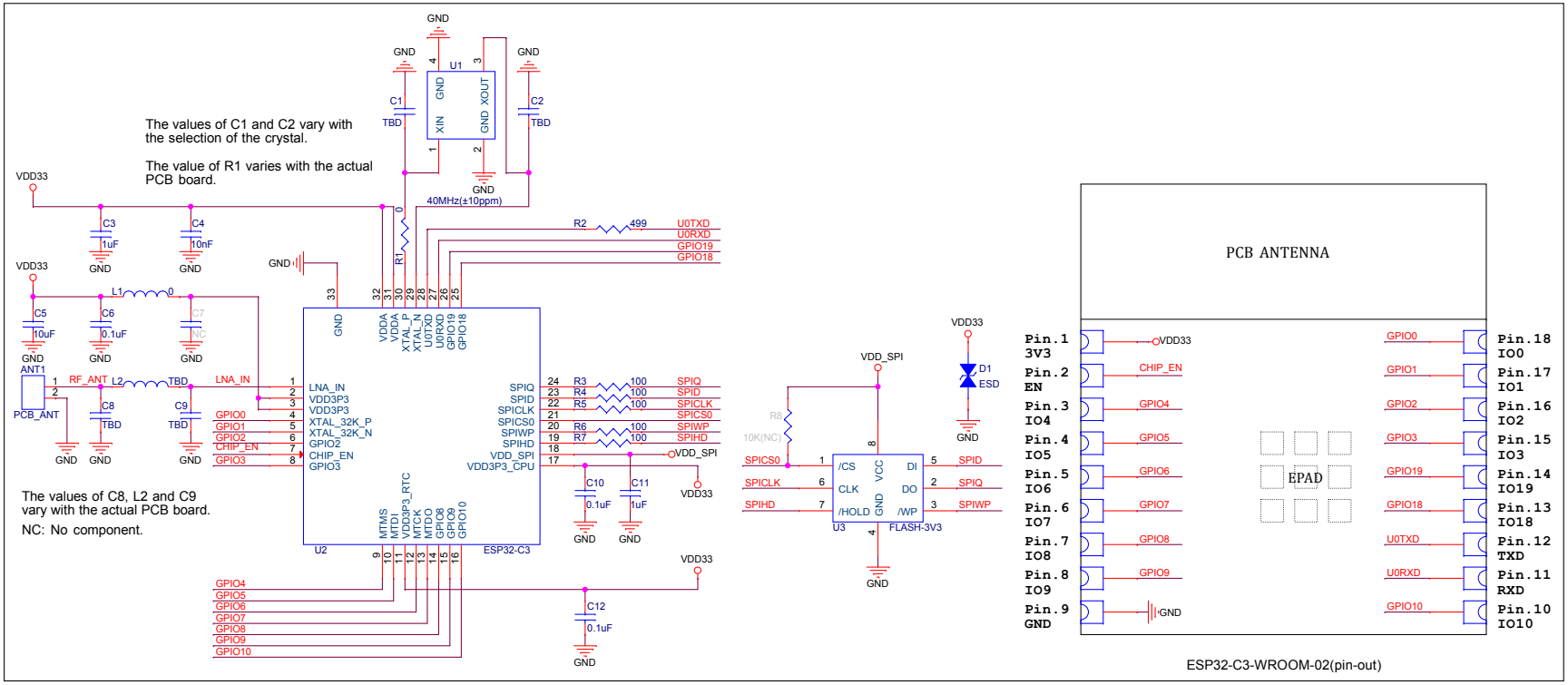


Figure 5: ESP32-C3-WROOM-02 Schematics

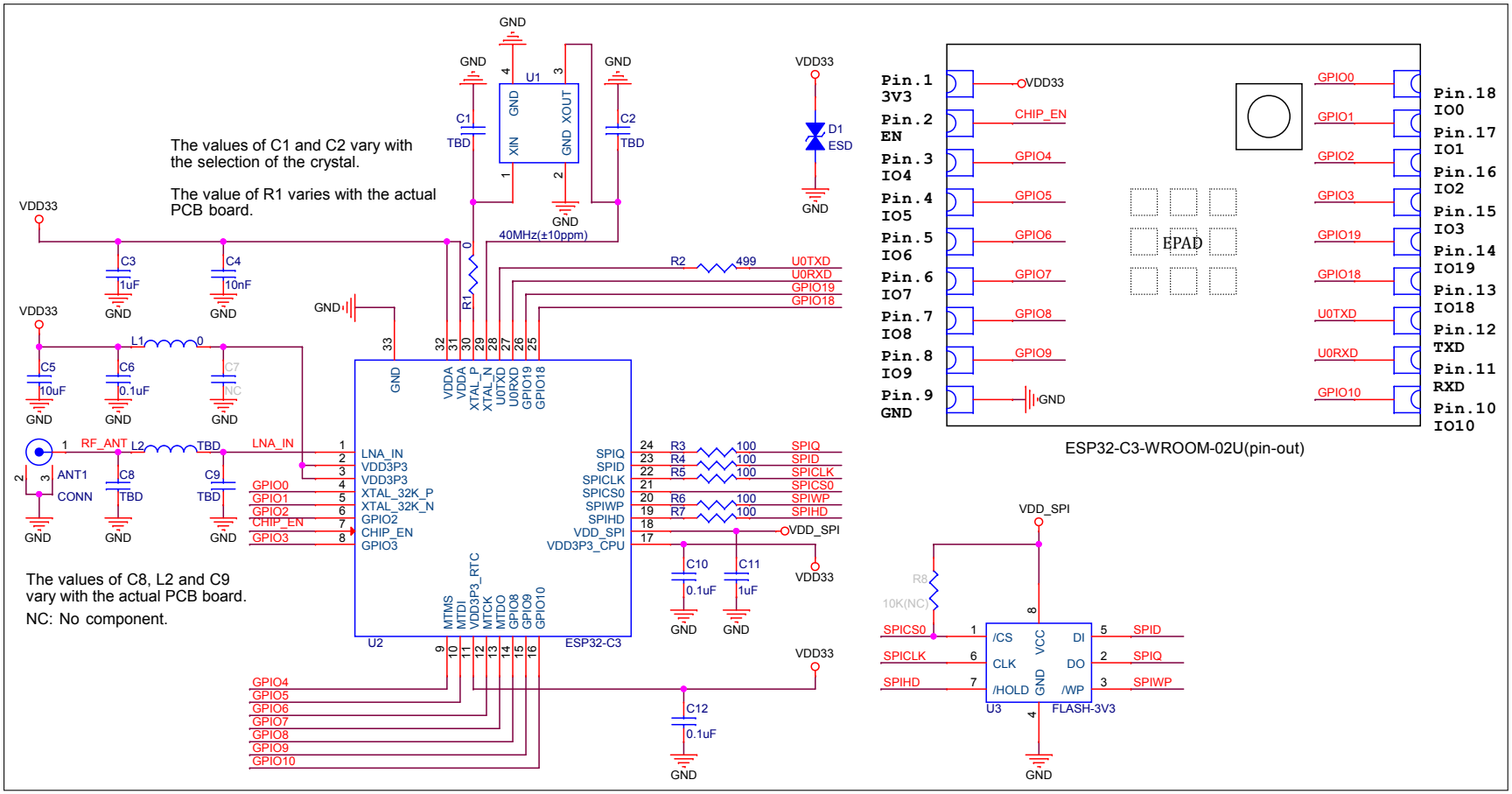


Figure 6: ESP32-C3-WROOM-02U Schematics

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).

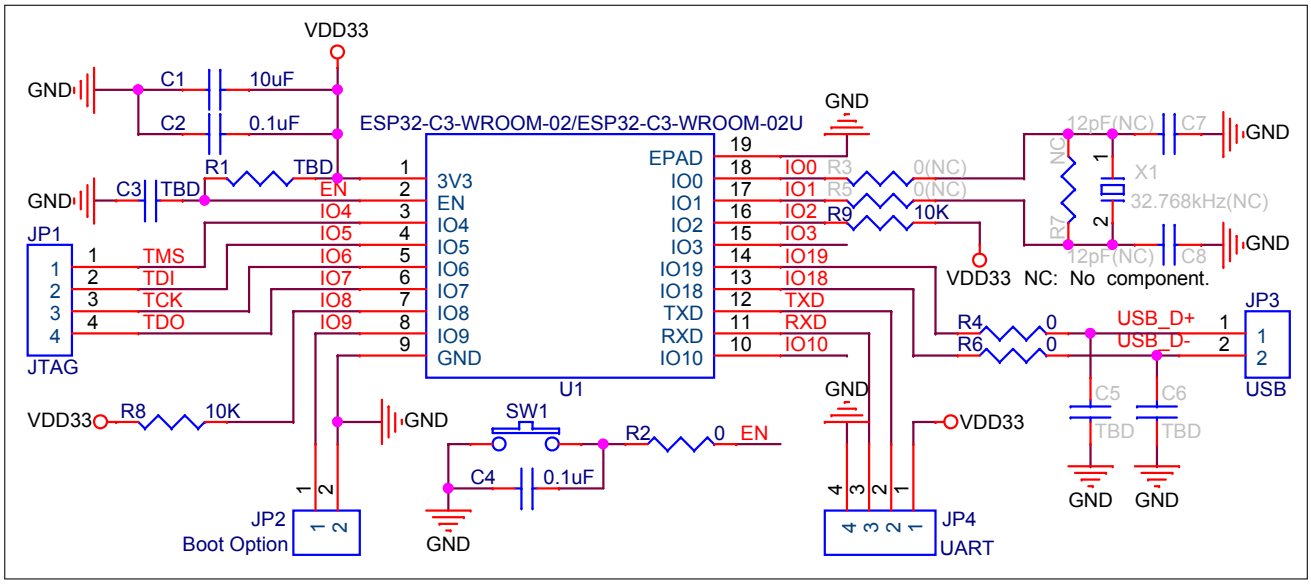


Figure 7: Peripheral Schematics

- Soldering the EPAD to the ground of the base board is not a must, however, it can optimize thermal performance. If you choose to solder it, please apply the correct amount of soldering paste.
- To ensure that the power supply to the ESP32-C3 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 kΩ and C = 1 μF. 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-C3's power-up and reset sequence timing diagram, please refer to *ESP32-C3 Series Datasheet* > Section *Power Scheme*.

7 Physical Dimensions and PCB Land Pattern

7.1 Physical Dimensions

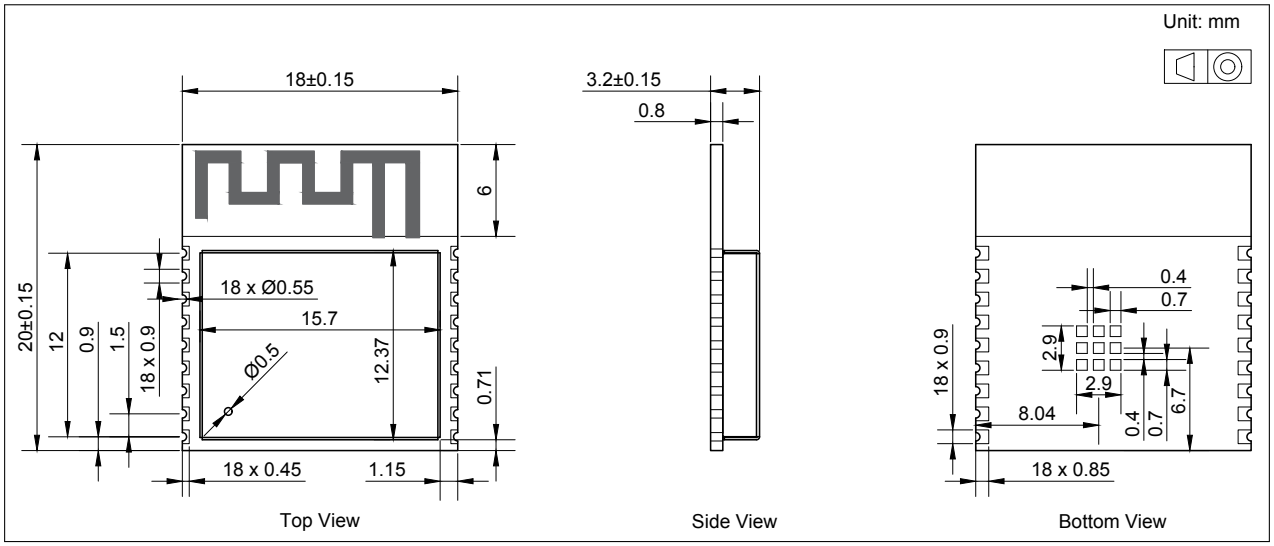


Figure 8: ESP32-C3-WROOM-02 Physical Dimensions

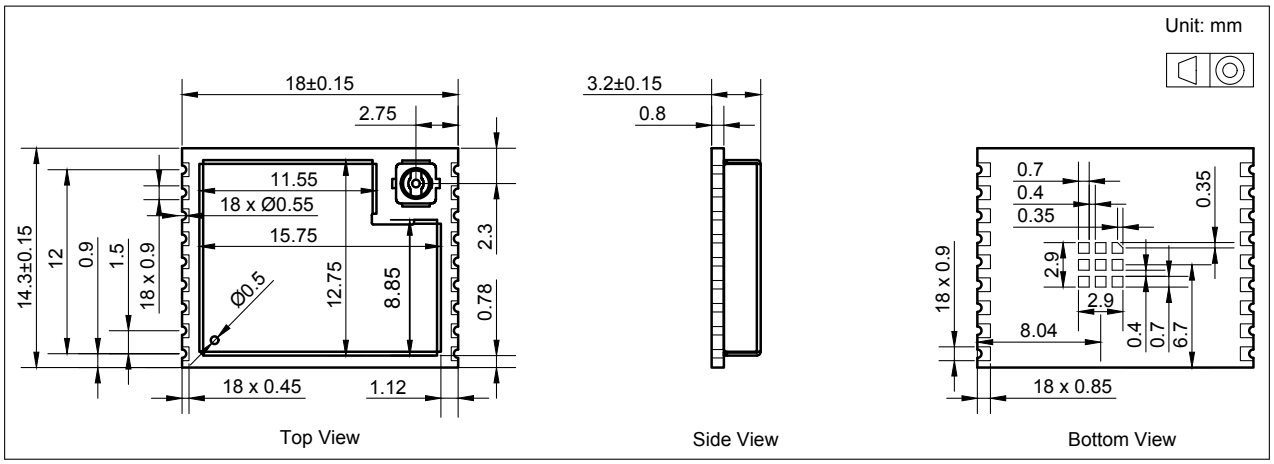


Figure 9: ESP32-C3-WROOM-02U Physical Dimensions

Note:

For information about tape, reel, and product marking, please refer to *Espressif Module Packaging Information*.

7.2 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-C3-WROOM-02 Recommended PCB Land Pattern* and Figure 11 *ESP32-C3-WROOM-02U Recommended PCB Land Pattern*.
- Source files of recommended PCB land patterns to measure dimensions not covered in Figure 10 and Figure 11. You can view the source files for ESP32-C3-WROOM-02 and ESP32-C3-WROOM-02U with Autodesk Viewer.
- 3D models of ESP32-C3-WROOM-02 and ESP32-C3-WROOM-02U. Please make sure that you download the 3D model file in .STEP format (beware that some browsers might add .txt).

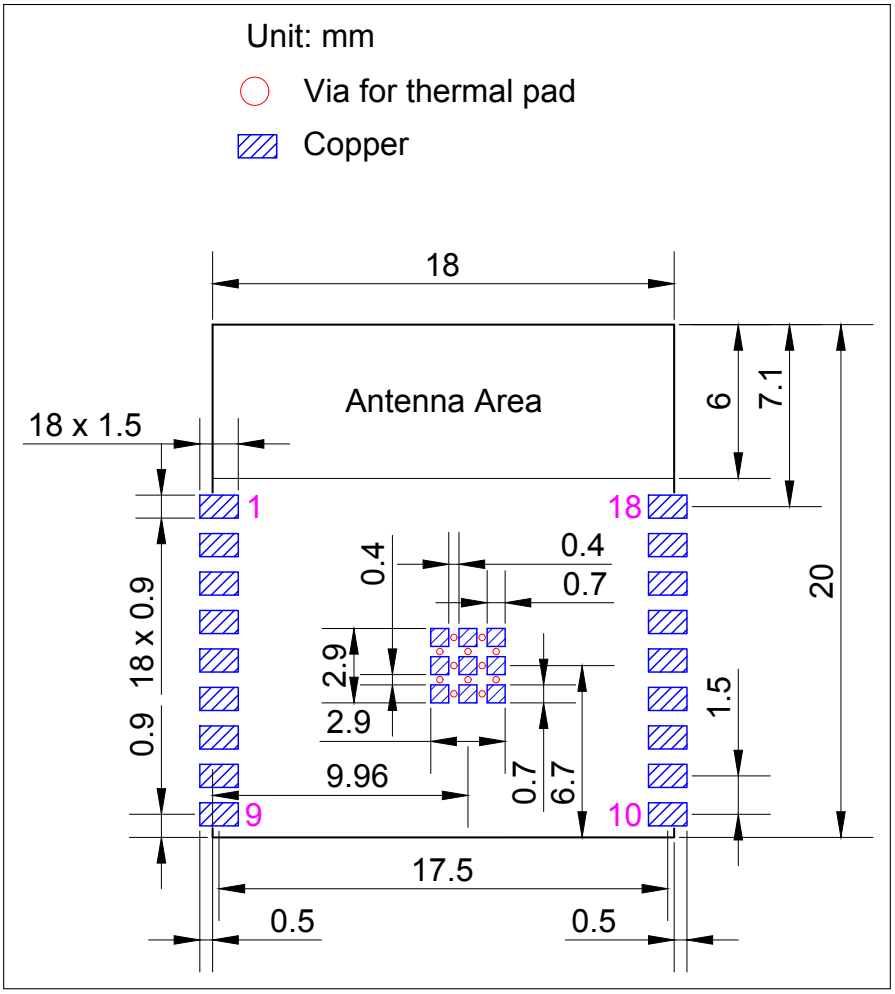


Figure 10: ESP32-C3-WROOM-02 Recommended PCB Land Pattern

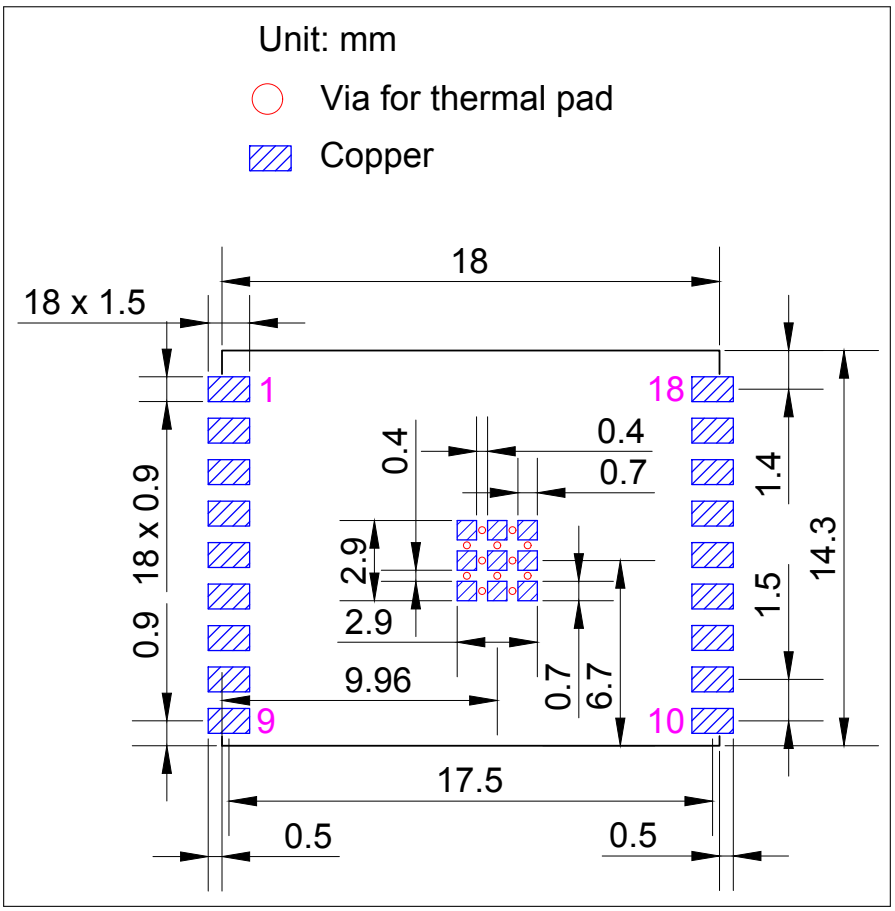


Figure 11: ESP32-C3-WROOM-02U Recommended PCB Land Pattern

7.3 Dimensions of External Antenna Connector

ESP32-C3-WROOM-02U 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

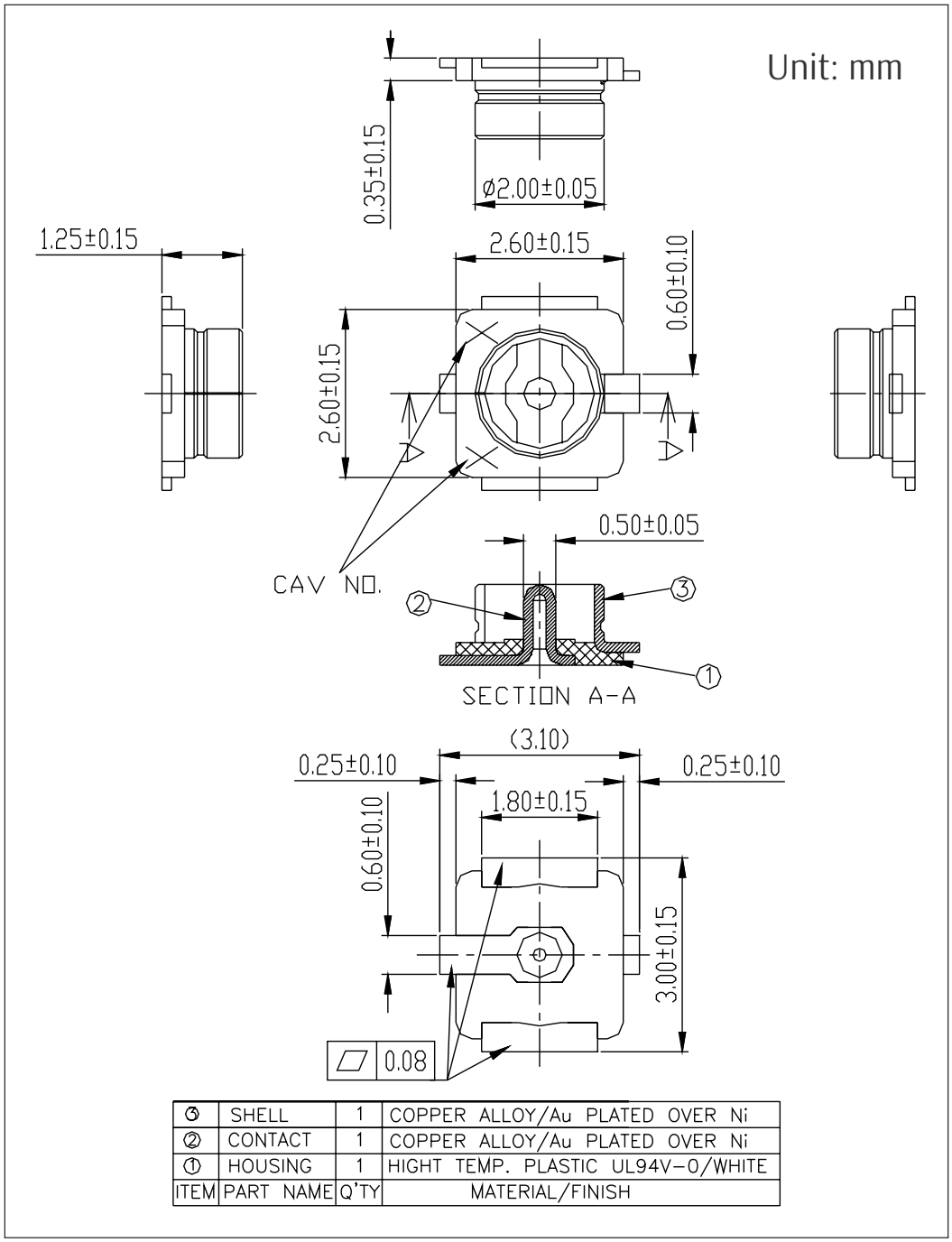


Figure 12: Dimensions of External Antenna Connector

8 Product Handling

8.1 Storage Conditions

The products sealed in moisture barrier bags (MBB) should be stored in a non-condensing atmospheric environment of < 40 °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±5 °C and 60%RH. If the above conditions are not met, the module needs to be baked.

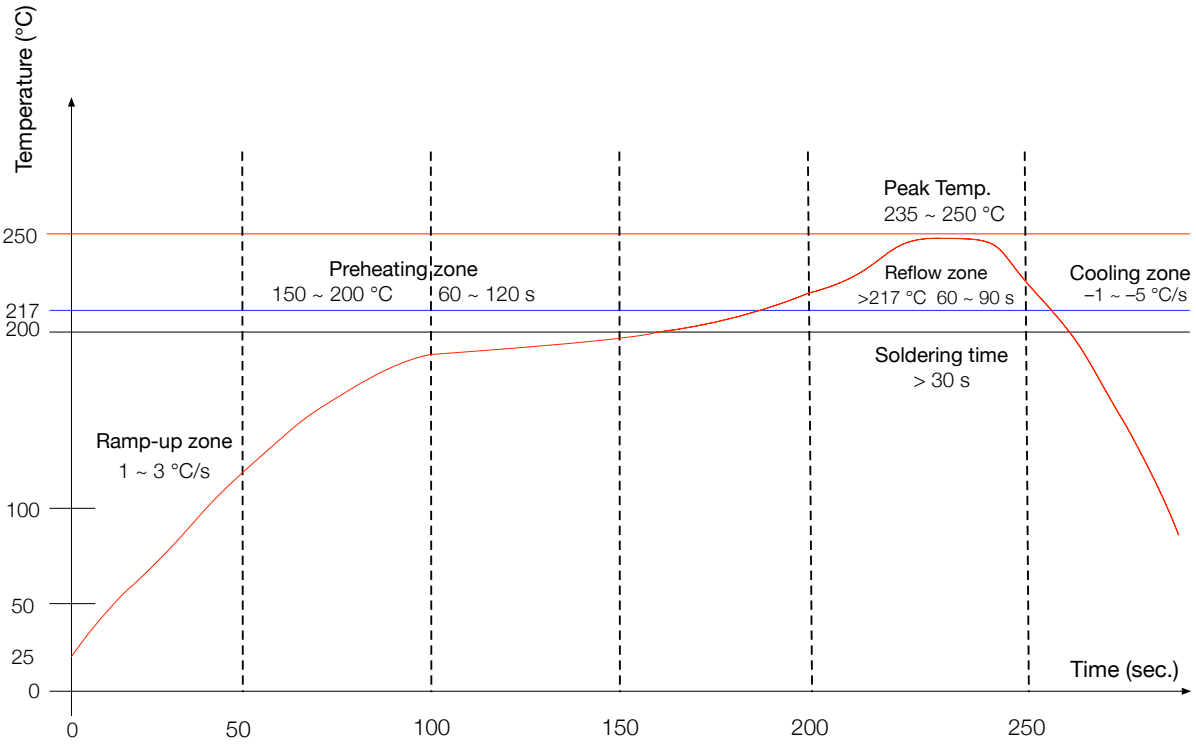
8.2 Electrostatic Discharge (ESD)

- Human body model (HBM): ±2000 V
- Charged-device model (CDM): ±500 V

8.3 Soldering Profile

8.3.1 Reflow Profile

Solder the module in a single reflow.



Ramp-up zone — Temp.: 25 ~ 150 °C Time: 60 ~ 90 s Ramp-up rate: 1 ~ 3 °C/s
Preheating zone — Temp.: 150 ~ 200 °C Time: 60 ~ 120 s
Reflow zone — Temp.: >217 °C Time: 60 ~ 90 s; Peak Temp.: 235 ~ 250 °C Time: 30 ~ 70 s
Cooling zone — Peak Temp. ~ 180 °C Ramp-down rate: –1 ~ –5 °C/s
Solder — Sn-Ag-Cu (SAC305) lead-free solder alloy

Figure 13: Reflow Profile

8.4 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**.

9 Related Documentation and Resources

Related Documentation

- ESP32-C3 Series Datasheet – Specifications of the ESP32-C3 hardware.
- ESP32-C3 Technical Reference Manual – Detailed information on how to use the ESP32-C3 memory and peripherals.
- ESP32-C3 Hardware Design Guidelines – Guidelines on how to integrate the ESP32-C3 into your hardware product.
- ESP32-C3 Series SoC Errata – Descriptions of known errors in ESP32-C3 series of SoCs.
- *Certificates*
  https://espressif.com/en/support/documents/certificates
- *ESP32-C3 Product/Process Change Notifications (PCN)*
  https://espressif.com/en/support/documents/pcns?keys=ESP32-C3
- *ESP32-C3 Advisories* – Information on security, bugs, compatibility, component reliability.
  https://espressif.com/en/support/documents/advisories?keys=ESP32-C3
- *Documentation Updates and Update Notification Subscription*
  https://espressif.com/en/support/download/documents

Developer Zone

- ESP-IDF Programming Guide for ESP32-C3 – 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-C3 Series SoCs* – Browse through all ESP32-C3 SoCs.
  https://espressif.com/en/products/socs?id=ESP32-C3
- *ESP32-C3 Series Modules* – Browse through all ESP32-C3-based modules.
  https://espressif.com/en/products/modules?id=ESP32-C3
- *ESP32-C3 Series DevKits* – Browse through all ESP32-C3-based devkits.
  https://espressif.com/en/products/devkits?id=ESP32-C3
- *ESP Product Selector* – Find an Espressif hardware product suitable for your needs by comparing or applying filters.
  https://products.espressif.com/#/product-selector?language=en

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  https://espressif.com/en/contact-us/sales-questions

Revision History

Date	Version	Release notes
2023-02-01	v1.3	• Added module variants ESP32-C3-WROOM-02-N8 and ESP32-C3-WROOM-02U-N8 • Updated the maximum value of "RF power control range" to 20 dBm in Table *Transmitter General Characteristics*
2022-11-08	v1.2	• Changed Table *Ordering Information* to Table *ESP32-C3-WROOM-02 (ANT) Series Comparison* and Table *ESP32-C3-WROOM-02U (CONN) Series Comparison* • Updated test condition descriptions and data in Section 4.4 *Current Consumption Characteristics* • Updated "RF power control range" in Table *Transmitter General Characteristics* • Added descriptions in Section 7.2 *Recommended PCB Land Pattern*
2022-06-13	v1.1	Updated Table *Ordering Information*
2021-08-20	v1.0	• Updated module description on the title page • Deleted Section "About This Document" • Restructured Section 1.1 *Features* • Updated Table 14 *TX EVM Test* • Updated Table 17 *RX Adjacent Channel Rejection* • Updated Chapter 5 *Module Schematics* • Updated ESP32-C3-WROOM-02U *Physical Dimensions* • Added descriptions in Section 7.3 *Dimensions of External Antenna Connector* • Updated Section "Learning Resources" and renamed to "Related Documentation and Resources" • Replaced "chip family" with "chip series" following Espressif's taxonomy
2021-05-17	v0.7	• Updated Section 3.3 *Strapping Pins* • Updated ESP32-C3-WROOM-02U *Physical Dimensions*
2021-04-16	v0.6	Added information about ESP32-C3-WROOM-02U module
2021-03-05	v0.5	Preliminary release

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