ESP32-S2-MINI-1
ESP32-S2-MINI-1U

Datasheet

2.4 GHz Wi-Fi (802.11 b/g/n) module

Built around ESP32-S2 series of SoC (chip revision v0.0), Xtensa® single-core 32-bit LX7 microprocessor

4 MB flash and optional 2 MB PSRAM in chip package

37 GPIOs, rich set of peripherals

On-board PCB antenna or external antenna connector

ESP32-S2-MINI-1

ESP32-S2-MINI-1U

Version1.3

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-s2-mini-1_esp32-s2-mini-1u_datasheet_en.pdf

1.1 Features

CPU and On-Chip Memory

- ESP32-S2FH4 or ESP32-S2FN4R2 embedded, Xtensa® single-core 32-bit LX7 microprocessor, up to 240 MHz
- 128 KB ROM
- 320 KB SRAM
- 16 KB SRAM in RTC
- 4 MB embedded flash
- 2 MB embedded PSRAM (ESP32-S2FN4R2 only)

Wi-Fi

- 802.11 b/g/n
- Bit rate: 802.11n up to 150 Mbps
- A-MPDU and A-MSDU aggregation
- 0.4 μs guard interval support
- Operating frequency: 2412 ~ 2484 MHz

Peripherals

- GPIO, SPI, LCD, UART, I2C, I2S, Camera interface, IR, pulse counter, LED PWM, TWAI® (compatible with ISO 11898-1, i.e. CAN Specification 2.0), full-speed USB OTG, ADC, DAC, touch sensor, temperature sensor

Note:

* Please refer to *ESP32-S2 Series Datasheet* for detailed information about the module peripherals.

Integrated Components on Module

- 40 MHz crystal oscillator

Antenna Options

- On-board PCB antenna (ESP32-S2-MINI-1)
- External antenna via a connector (ESP32-S2-MINI-1U)

Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature:
  - 85 °C version: –40 ~ 85 °C
  - 105 °C version: –40 ~ 105 °C

Certification

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

Test

- HTOL/HTSL/uHAST/TCT/ESD

1.2 Description

ESP32-S2-MINI-1 and ESP32-S2-MINI-1U are two powerful, generic Wi-Fi MCU modules that have a rich set of peripherals. They are an ideal choice for a wide variety of application scenarios related to Internet of Things (IoT), such as wearable electronics and smart home.

ESP32-S2-MINI-1 comes with a PCB antenna (ANT). ESP32-S2-MINI-1U comes with an external antenna connector (CONN). A wide selection of module variants are available for customers as shown in Table 1 and Table 2.

Table 1: ESP32-S2-MINI-1 (ANT) Series Comparison[1]

Ordering Code	Flash	PSRAM	Ambient Temp.[2] (°C)	Size[3] (mm)
ESP32-S2-MINI-1-N4	4 MB (Quad SPI)[4]	—	–40 ~ 85	15.4 × 20.0 × 2.4
ESP32-S2-MINI-1-H4		—	–40 ~ 105	
ESP32-S2-MINI-1-N4R2		2 MB (Quad SPI)[5]	–40 ~ 85	

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

Table 2: ESP32-S2-MINI-1U (CONN) Series Comparison

Ordering Code	Flash	PSRAM	Ambient Temp.[2] (°C)	Size[3] (mm)
ESP32-S2-MINI-1U-N4	4 MB (Quad SPI)[4]	—	–40 ~ 85	15.4 × 15.4 × 2.4
ESP32-S2-MINI-1U-H4		—	–40 ~ 105	
ESP32-S2-MINI-1U-N4R2		2 MB (Quad SPI)[5]	–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*.

[4] The flash is integrated in the chip's package.

[5] The PSRAM is integrated in the chip's package.

In this datasheet unless otherwise stated, ESP32-S2-MINI-1 refers to ESP32-S2-MINI-1-N4, ESP32-S2-MINI-1-H4 and ESP32-S2-MINI-1-N4R2, whereas ESP32-S2-MINI-1U refers to ESP32-S2-MINI-1U-N4, ESP32-S2-MINI-1U-H4 and ESP32-S2-MINI-1U-N4R2.

The ESP32-S2FH4 chip and the ESP32-S2FN4R2 chip at the core of the two modules fall into the same category, namely ESP32-S2 chip series (chip revision v0.0). ESP32-S2 series of chips has an Xtensa® 32-bit LX7 CPU that operates at up to 240 MHz. It has a low-power co-processor that can be used instead of the CPU to save power while performing tasks that do not require much computing power, such as monitoring of peripherals.

ESP32-S2 series integrates a rich set of peripherals, ranging from SPI, I2S, UART, I2C, LED PWM, TWAI®, LCD, Camera interface, ADC, DAC, touch sensor, temperature sensor, as well as up to 43 GPIOs. It also includes a full-speed USB On-The-Go (OTG) interface to enable USB communication.

The ESP32-S2FH4 chip and the ESP32-S2FN4R2 chip vary in:

- temperature of embedded flash
- whether a PSRAM is embedded

For more information on ESP32-S2 series of SoCs, please refer to *ESP32-S2 Series Datasheet* and ESP32-S2 Series SoC Errata.

Information about ESP-IDF release that supports a specific chip revision is provided in ESP Product Selector.

1.3 Applications

- Generic Low-power IoT Sensor Hub
- Generic Low-power IoT Data Loggers
- Cameras for Video Streaming
- Over-the-top (OTT) Devices
- USB Devices
- Speech Recognition
- Image Recognition
- Mesh Network
- Home Automation
- Smart Home Control Panel
- Smart Building
- Industrial Automation
- Smart Agriculture
- Audio Applications
- Health Care Applications
- Wi-Fi-enabled Toys
- Wearable Electronics
- Retail & Catering Applications
- Smart POS Machines

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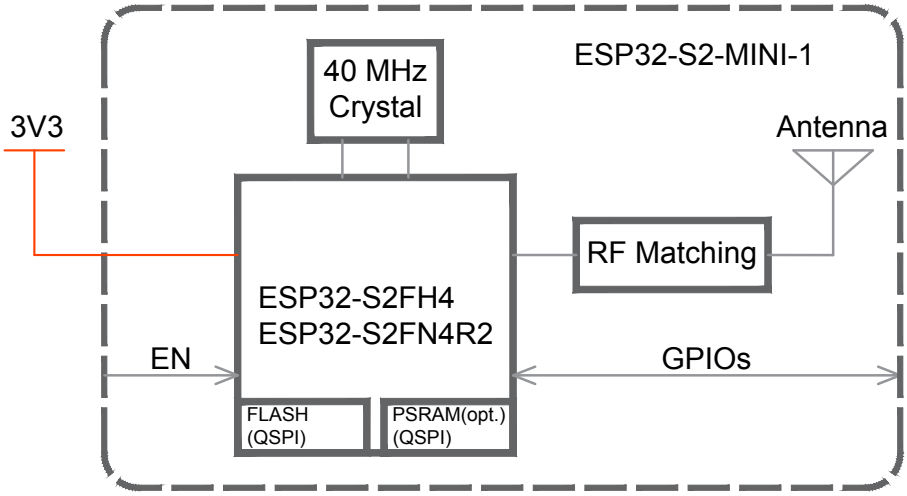

Figure 1: ESP32-S2-MINI-1 Block Diagram

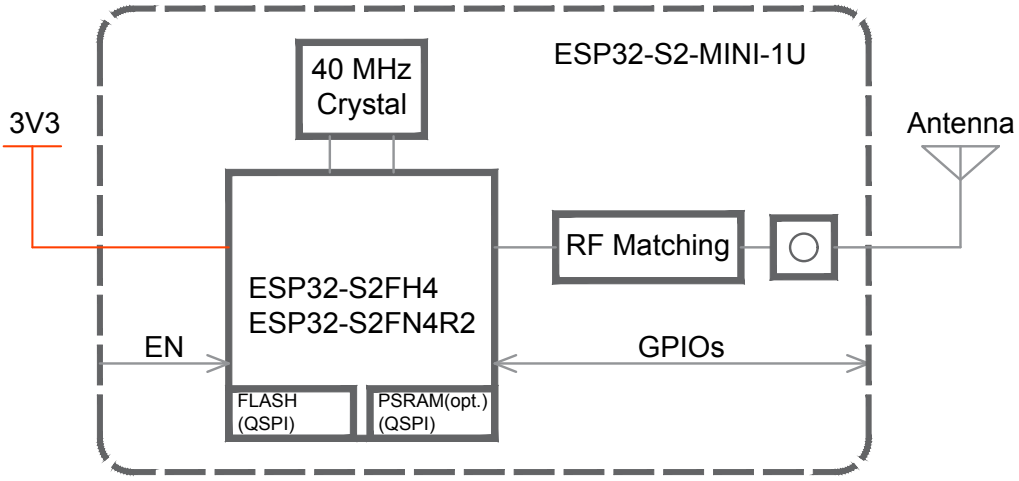

Figure 2: ESP32-S2-MINI-1U Block Diagram

3 Pin Definitions

3.1 Pin Layout

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

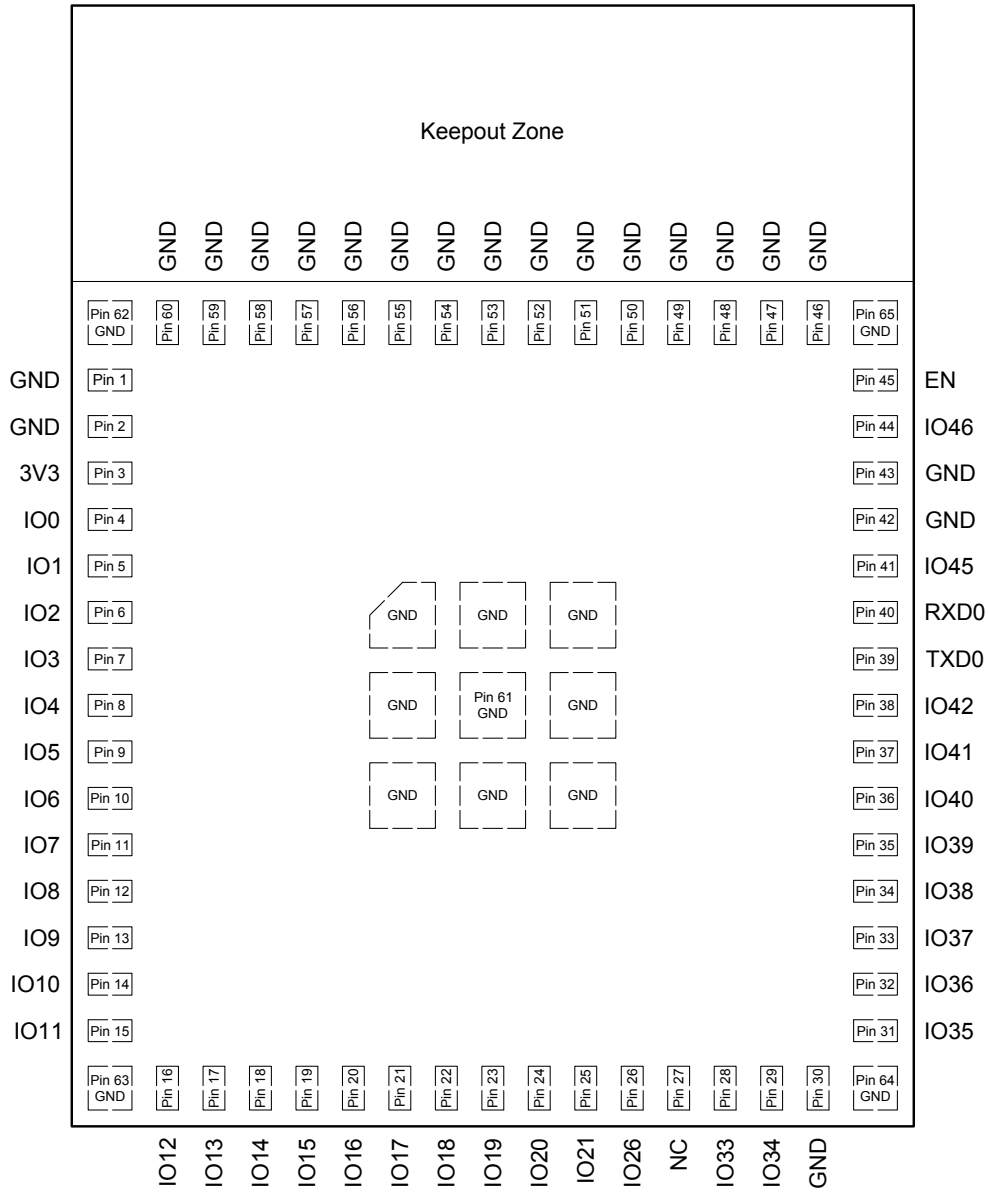

Figure 3: ESP32-S2-MINI-1 Pin Layout (Top View)

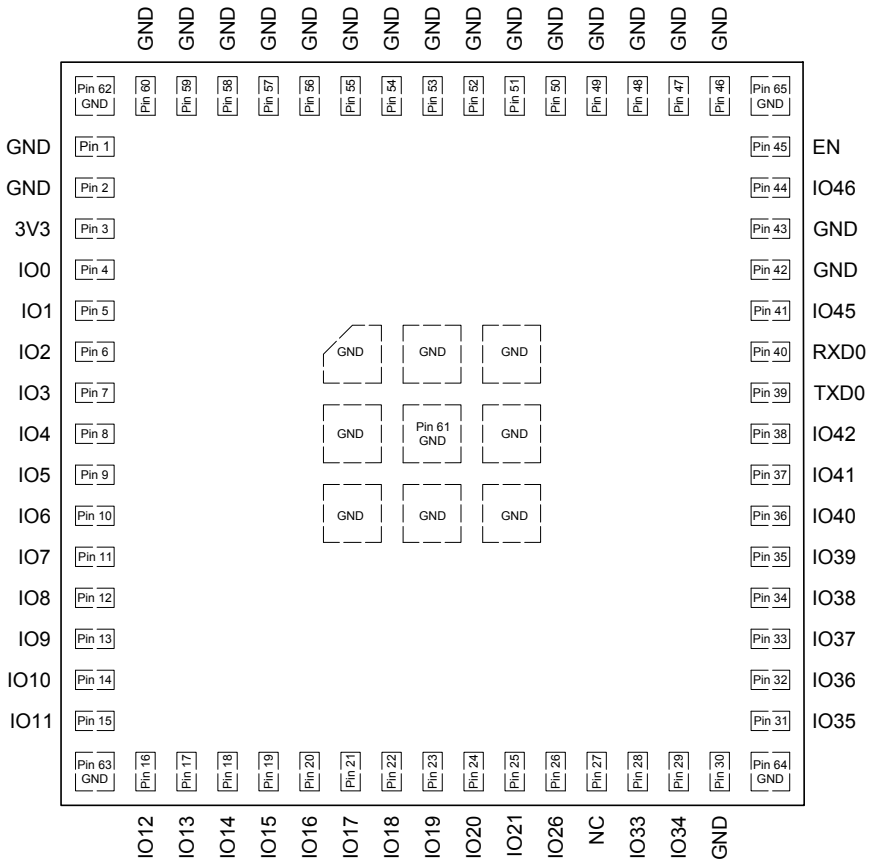

Figure 4: ESP32-S2-MINI-1U Pin Layout (Top View)

3.2 Pin Description

The module has 65 pins. See pin definitions in Table 3 *Pin Definitions*.

For peripheral pin configurations, please refer to *ESP32-S2 Series Datasheet* > Section *Peripheral Pin Configurations*.

Table 3: Pin Definitions

Name	No.	Type[1]	Function
GND	1, 2, 30, 42, 43, 46-65	P	Ground
3V3	3	P	Power supply
IO0	4	I/O/T	RTC_GPIO0, GPIO0
IO1	5	I/O/T	RTC_GPIO1, GPIO1, TOUCH1, ADC1_CH0
IO2	6	I/O/T	RTC_GPIO2, GPIO2, TOUCH2, ADC1_CH1
IO3	7	I/O/T	RTC_GPIO3, GPIO3, TOUCH3, ADC1_CH2
IO4	8	I/O/T	RTC_GPIO4, GPIO4, TOUCH4, ADC1_CH3
IO5	9	I/O/T	RTC_GPIO5, GPIO5, TOUCH5, ADC1_CH4
IO6	10	I/O/T	RTC_GPIO6, GPIO6, TOUCH6, ADC1_CH5

Cont'd on next page

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Name	No.	Type[1]	Function
IO7	11	I/O/T	RTC_GPIO7, GPIO7, TOUCH7, ADC1_CH6
IO8	12	I/O/T	RTC_GPIO8, GPIO8, TOUCH8, ADC1_CH7
IO9	13	I/O/T	RTC_GPIO9, GPIO9, TOUCH9, ADC1_CH8, FSPIHD
IO10	14	I/O/T	RTC_GPIO10, GPIO10, TOUCH10, ADC1_CH9, FSPICS0, FSPIIO4
IO11	15	I/O/T	RTC_GPIO11, GPIO11, TOUCH11, ADC2_CH0, FSPID, FSPIIO5
IO12	16	I/O/T	RTC_GPIO12, GPIO12, TOUCH12, ADC2_CH1, FSPICLK, FSPIIO6
IO13	17	I/O/T	RTC_GPIO13, GPIO13, TOUCH13, ADC2_CH2, FSPIQ, FSPIIO7
IO14	18	I/O/T	RTC_GPIO14, GPIO14, TOUCH14, ADC2_CH3, FSPIWP, FSPIDQS
IO15	19	I/O/T	RTC_GPIO15, GPIO15, U0RTS, ADC2_CH4, XTAL_32K_P
IO16	20	I/O/T	RTC_GPIO16, GPIO16, U0CTS, ADC2_CH5, XTAL_32K_N
IO17	21	I/O/T	RTC_GPIO17, GPIO17, U1TXD, ADC2_CH6, DAC_1
IO18 [2]	22	I/O/T	RTC_GPIO18, GPIO18, U1RXD, ADC2_CH7, DAC_2, CLK_OUT3
IO19	23	I/O/T	RTC_GPIO19, GPIO19, U1RTS, ADC2_CH8, CLK_OUT2, USB_D-
IO20	24	I/O/T	RTC_GPIO20, GPIO20, U1CTS, ADC2_CH9, CLK_OUT1, USB_D+
IO21	25	I/O/T	RTC_GPIO21, GPIO21
IO26 [3]	26	I/O/T	SPICS1, GPIO26
NC	27	—	NC
IO33	28	I/O/T	SPIIO4, GPIO33, FSPIHD
IO34	29	I/O/T	SPIIO5, GPIO34, FSPICS0
IO35	31	I/O/T	SPIIO6, GPIO35, FSPID
IO36	32	I/O/T	SPIIO7, GPIO36, FSPICLK
IO37	33	I/O/T	SPIDQS, GPIO37, FSPIQ
IO38	34	I/O/T	GPIO38, FSPIWP
IO39	35	I/O/T	MTCK, GPIO39, CLK_OUT3
IO40	36	I/O/T	MTDO, GPIO40, CLK_OUT2
IO41	37	I/O/T	MTDI, GPIO41, CLK_OUT1
IO42	38	I/O/T	MTMS, GPIO42
TXD0	39	I/O/T	U0TXD, GPIO43, CLK_OUT1
RXD0	40	I/O/T	U0RXD, GPIO44, CLK_OUT2
IO45	41	I/O/T	GPIO45
IO46	44	I	GPIO46
EN	45	I	High: on, enables the chip. Low: off, the chip powers off. Note: Do not leave the EN pin floating.

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

[2] IO18 on the module is pulled up to VDD33 through a 10 kΩ resistor. For details, please refer to Figure 5 and Figure 6.

[3] IO26 is used by the embedded PSRAM on the ESP32-S2-MINI-1-N4R2 and ESP32-S2-MINI-1U-N4R2 modules, and cannot be used for other purposes.

3.3 Strapping Pins

Note:
The content below is excerpted from Section *Strapping Pins* in *ESP32-S2 Series Datasheet*. For the strapping pin mapping between the chip and modules, please refer to Chapter 5 *Module Schematics*.

ESP32-S2 has three strapping pins:

- GPIO0
- GPIO45
- GPIO46

Software can read the values of corresponding bits from register "GPIO_STRAPPING".

During the chip's system reset (power-on-reset, RTC watchdog reset, brownout reset, analog super watchdog reset, and crystal clock glitch detection reset), the latches of the strapping pins sample the voltage level as strapping bits of "0" or "1", and hold these bits until the chip is powered down or shut down.

GPIO0, GPIO45 and GPIO46 are connected to the chip's internal weak pull-up/pull-down during the chip reset. Consequently, if they are unconnected or the connected external circuit is high-impedance, the internal weak pull-up/pull-down will determine the default input level of these strapping pins.

To change the strapping bit values, users can apply the external pull-down/pull-up resistances, or use the host MCU's GPIOs to control the voltage level of these pins when powering on ESP32-S2.

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

Refer to Table 4 for a detailed boot-mode configuration of the strapping pins.

Table 4: Strapping Pins

VDD_SPI Voltage [1] [2]			
Pin	Default	3.3 V	1.8 V
GPIO45	Pull-down	0	1
Booting Mode [3]			
Pin	Default	SPI Boot	Download Boot
GPIO0	Pull-up	1	0
GPIO46	Pull-down	Don't-care	0
Enabling/Disabling ROM Messages Print During Booting [4] [5]			
Pin	Default	Enabled	Disabled
GPIO46	Pull-down	See note 5	See note 5

Note:

1. The functionality of strapping pin GPIO45 to select VDD_SPI voltage may be disabled by setting VDD_SPI_FORCE eFuse to 1. In such a case the voltage is selected with eFuse bit VDD_SPI_TIEH.
2. Since ESP32-S2FH2, ESP32-S2FH4, ESP32-S2FN4R2, and ESP32-S2R2 come with both/either 3.3 V SPI flash and/or PSRAM, VDD_SPI must be configured to 3.3 V.
3. The strapping combination of GPIO46 = 1 and GPIO0 = 0 is invalid and will trigger unexpected behavior.

4. ROM code can be printed over U0TXD (by default) or DAC_1, depending on the eFuse bit.
5. When eFuse UART_PRINT_CONTROL value is:
   0, print is normal during boot and not controlled by GPIO46.
   1 and GPIO46 is 0, print is normal during boot; but if GPIO46 is 1, print is disabled.
   2 and GPIO46 is 0, print is disabled; but if GPIO46 is 1, print is normal.
   3, print is disabled and not controlled by GPIO46.

4 Electrical Characteristics

4.1 Absolute Maximum Ratings

Stresses above those listed in Table 5 *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 6 *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 5: 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 6: 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 7: 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 *RTC and Low-Power Management* in *ESP32-S2 Series Datasheet*.

4.4.1 Current Consumption in Active Mode

Table 8: Current Consumption Depending on RF Modes

Work mode	Description		Peak (mA)
Active (RF working)	TX	802.11b, 20 MHz, 1 Mbps, @19.5 dBm	310
		802.11g, 20 MHz, 54 Mbps, @15 dBm	220
		802.11n, 20 MHz, MCS7, @13.5 dBm	200
		802.11n, 40 MHz, MCS7, @13.5 dBm	160
	RX [2]	802.11b/g/n, 20 MHz	63
		802.11n, 40 MHz	68

[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 100% duty cycle.

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

Note:
The content below is excerpted from *Section Power Consumption in Other Modes* in *ESP32-S2 Series Datasheet*.

4.4.2 Current Consumption in Other Modes

The measurements below are applicable to ESP32-S2, ESP32-S2FH2, and ESP32-S2FH4. Since ESP32-S2FN4R2 and ESP32-S2R2 are embedded with PSRAM, their current consumption might be higher.

Table 9: 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]	240	CPU is idle	20.0	28.0
		CPU is running	23.0	32.0
	160	CPU is idle	14.0	21.0
		CPU is running	16.0	24.0
	80	CPU is idle	10.5	18.4
		CPU is running	12.0	20.0

[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 10: Current Consumption in Low-Power Modes

Mode	Description		Typ (μA)
Light-sleep[1]	VDD_SPI and Wi-Fi are powered down, and all GPIOs are high-impedance		750
Deep-sleep	The ULP co-processor is powered on[2]	ULP-FSM	170
		ULP-RISC-V	190
	ULP sensor-monitored pattern[3]		22
	RTC timer + RTC memory		25
	RTC timer only		20
Power off	CHIP_PU is set to low level, the chip is powered off		1

[1] In Light-sleep mode, with all related SPI pins pulled up, the current consumption of the embedded PSRAM is 140 μA. Chip variants with embedded PSRAM include ESP32-S2FN4R2 and ESP32-S2R2.

[2] During Deep-sleep, when the ULP co-processor is powered on, peripherals such as GPIO and I2C are able to operate.

[3] The "ULP sensor-monitored pattern" refers to the mode where the ULP coprocessor or the sensor works periodically. When touch sensors work with a duty cycle of 1%, the typical current consumption is 22 μA.

4.5 Wi-Fi RF Characteristics

4.5.1 Wi-Fi RF Standards

Table 11: Wi-Fi RF Standards

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

Target TX power is configurable based on device or certification requirements. The default characteristics are provided in Table 12.

Table 12: TX Power

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	19.5	—
802.11b, 11 Mbps	—	19.5	—
802.11g, 6 Mbps	—	18.0	—
802.11g, 54 Mbps	—	15.0	—
802.11n, HT20, MCS0	—	18.0	—
802.11n, HT20, MCS7	—	13.5	—
802.11n, HT40, MCS0	—	18.0	—
802.11n, HT40, MCS7	—	13.5	—

4.5.3 Receiver Characteristics

Table 13: RX Sensitivity

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	–97	—
802.11b, 2 Mbps	—	–95	—
802.11b, 5.5 Mbps	—	–93	—
802.11b, 11 Mbps	—	–88	—
802.11g, 6 Mbps	—	–92	—
802.11g, 9 Mbps	—	–91	—
802.11g, 12 Mbps	—	–89	—
802.11g, 18 Mbps	—	–86	—
802.11g, 24 Mbps	—	–83	—
802.11g, 36 Mbps	—	–80	—
802.11g, 48 Mbps	—	–76	—
802.11g, 54 Mbps	—	–74	—
802.11n, HT20, MCS0	—	–92	—
802.11n, HT20, MCS1	—	–88	—
802.11n, HT20, MCS2	—	–85	—
802.11n, HT20, MCS3	—	–82	—
802.11n, HT20, MCS4	—	–79	—
802.11n, HT20, MCS5	—	–75	—
802.11n, HT20, MCS6	—	–73	—
802.11n, HT20, MCS7	—	–72	—
802.11n, HT40, MCS0	—	–89	—
802.11n, HT40, MCS1	—	–85	—

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Table 13 – cont'd from previous page

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11n, HT40, MCS2	—	–83	—
802.11n, HT40, MCS3	—	–79	—
802.11n, HT40, MCS4	—	–76	—
802.11n, HT40, MCS5	—	–72	—
802.11n, HT40, MCS6	—	–70	—
802.11n, HT40, MCS7	—	–68	—

Table 14: 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 15: Adjacent Channel Rejection

Rate	Min (dB)	Typ (dB)	Max (dB)
802.11b, 11 Mbps	—	35	—
802.11g, 6 Mbps	—	31	—
802.11g, 54 Mbps	—	14	—
802.11n, HT20, MCS0	—	31	—
802.11n, HT20, MCS7	—	13	—
802.11n, HT40, MCS0	—	19	—
802.11n, HT40, MCS7	—	8	—

5 Module Schematics

This is the reference design of the module.

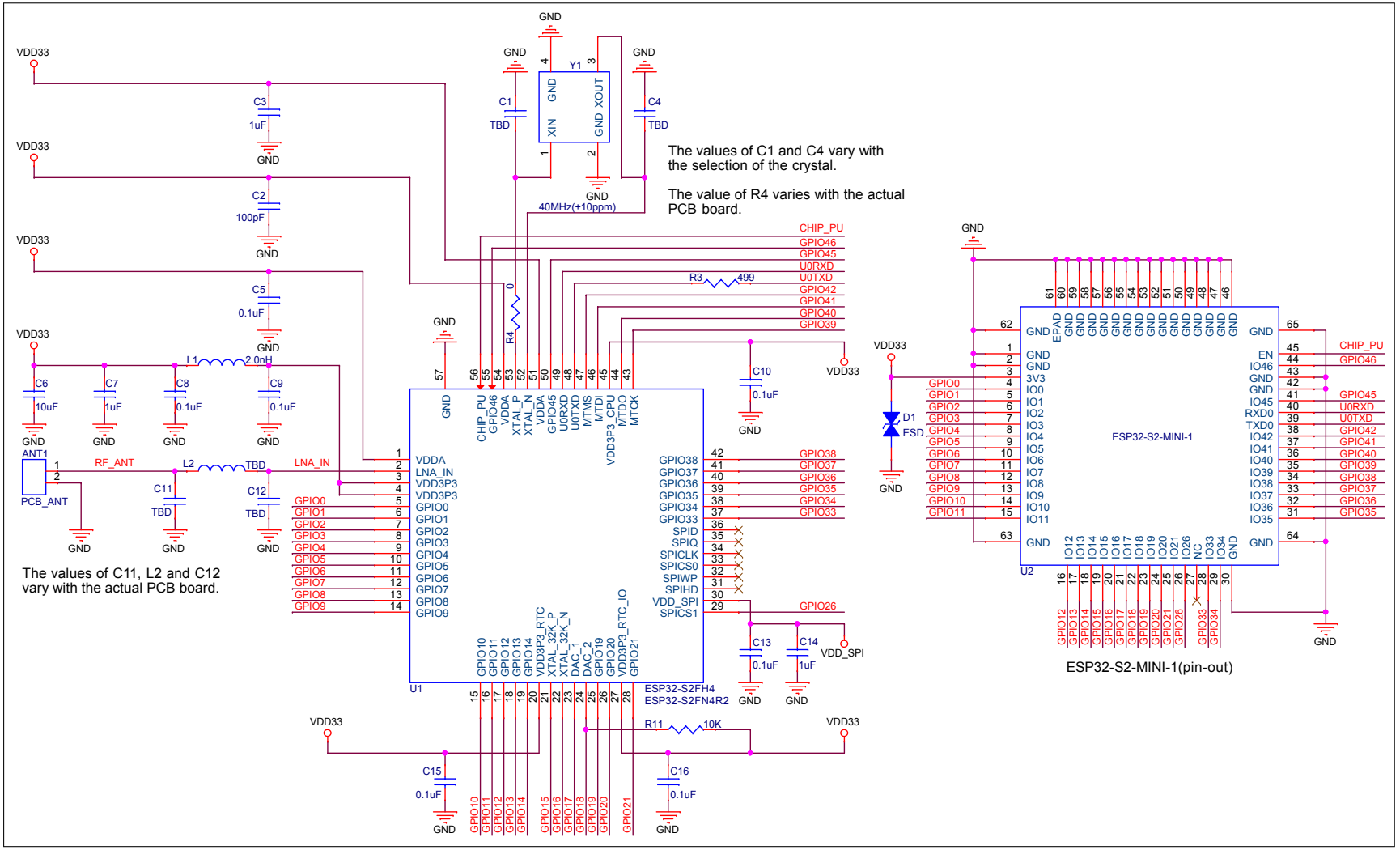


Figure 5: ESP32-S2-MINI-1 Schematics

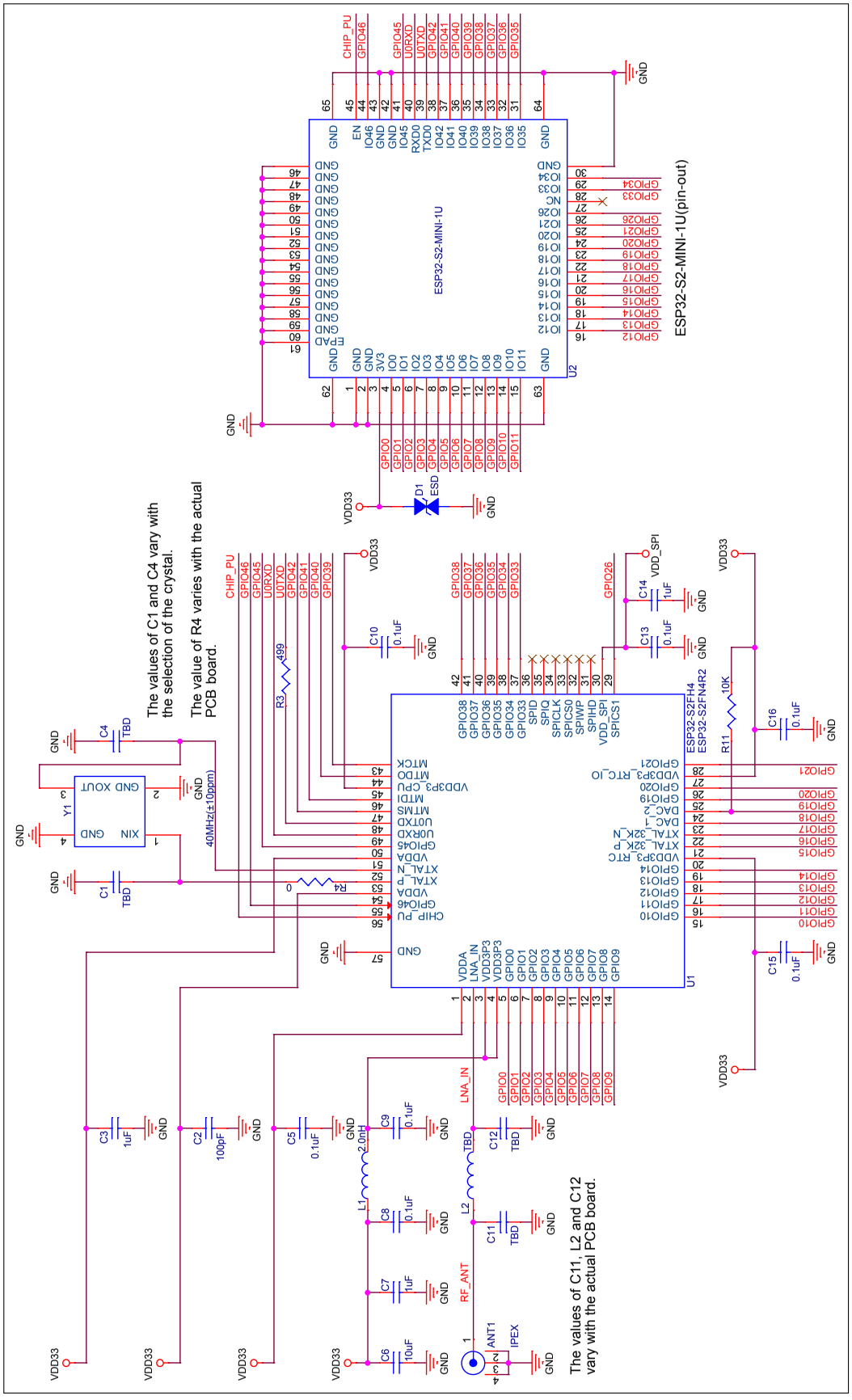


Figure 6: ESP32-S2-MINI-1U Schematics

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).

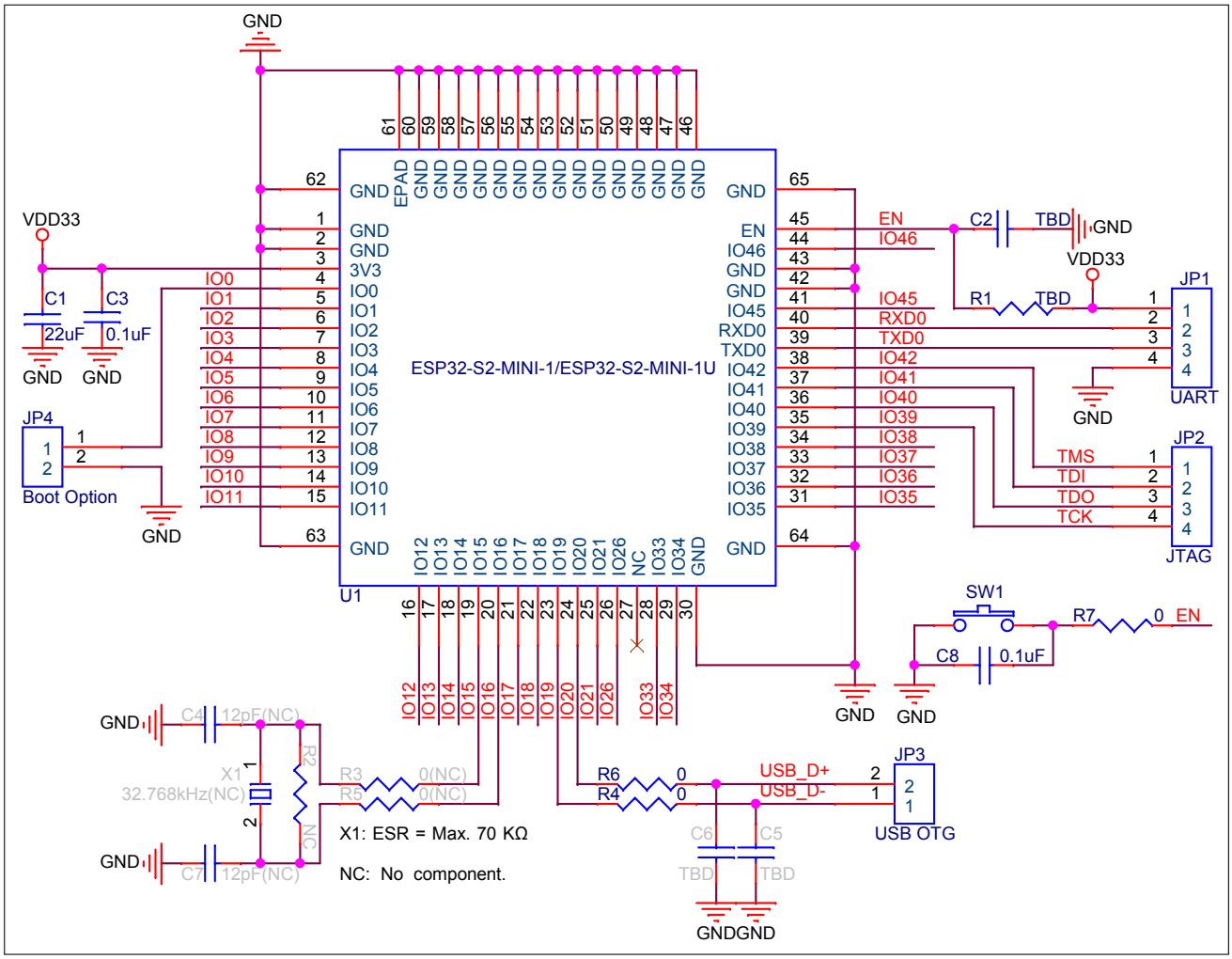


Figure 7: Peripheral Schematics

- 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. 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-S2 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-S2's power-up and reset sequence timing diagram, please refer to *ESP32-S2 Series Datasheet* > Section *Power Scheme*.

7 Physical Dimensions and PCB Land Pattern

7.1 Physical Dimensions

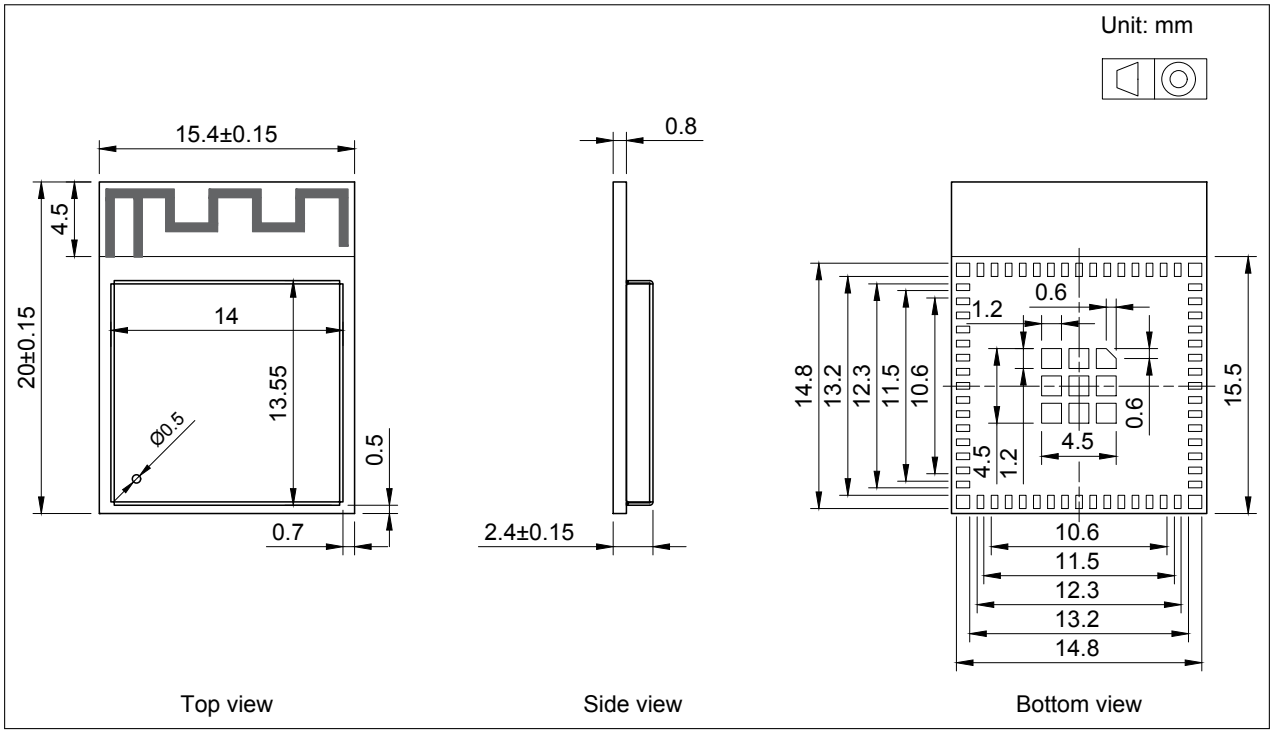


Figure 8: ESP32-S2-MINI-1 Physical Dimensions

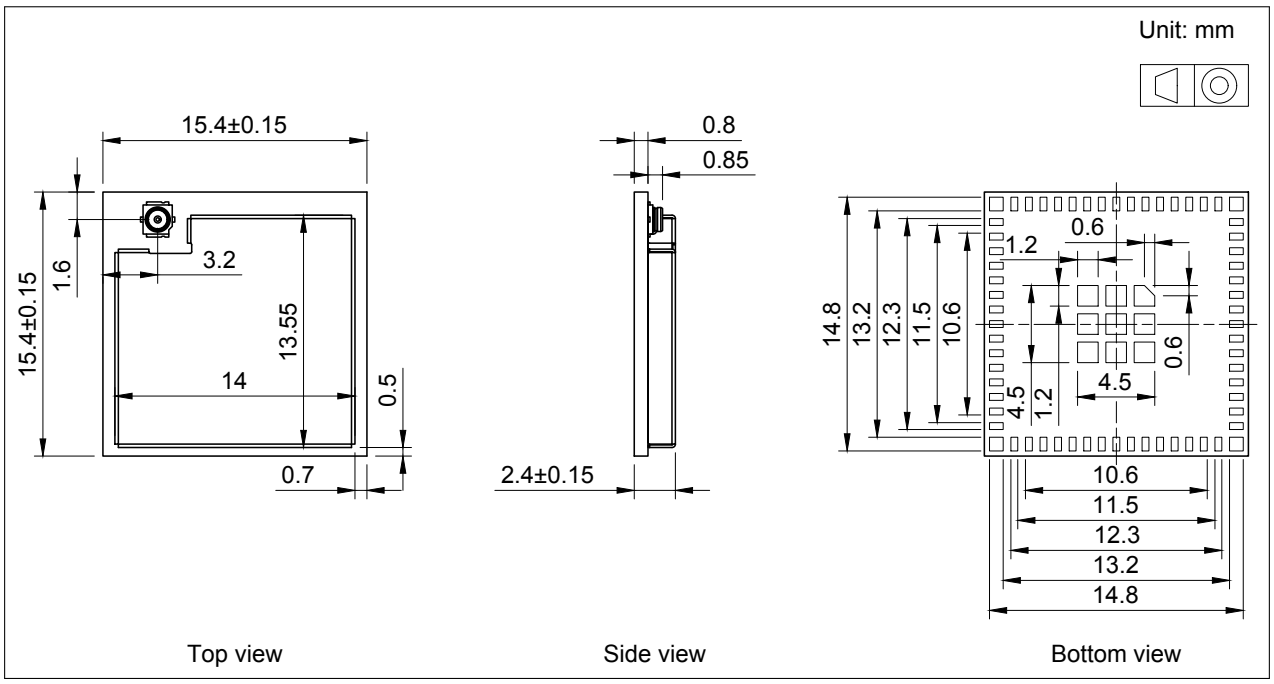


Figure 9: ESP32-S2-MINI-1U Physical Dimensions

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-S2-MINI-1 Recommended PCB Land Pattern* and Figure 11 *ESP32-S2-MINI-1U 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-S2-MINI-1 and ESP32-S2-MINI-1U with Autodesk Viewer.
- 3D models of ESP32-S2-MINI-1 and ESP32-S2-MINI-1U. Please make sure that you download the 3D model file in .STEP format (beware that some browsers might add .txt).

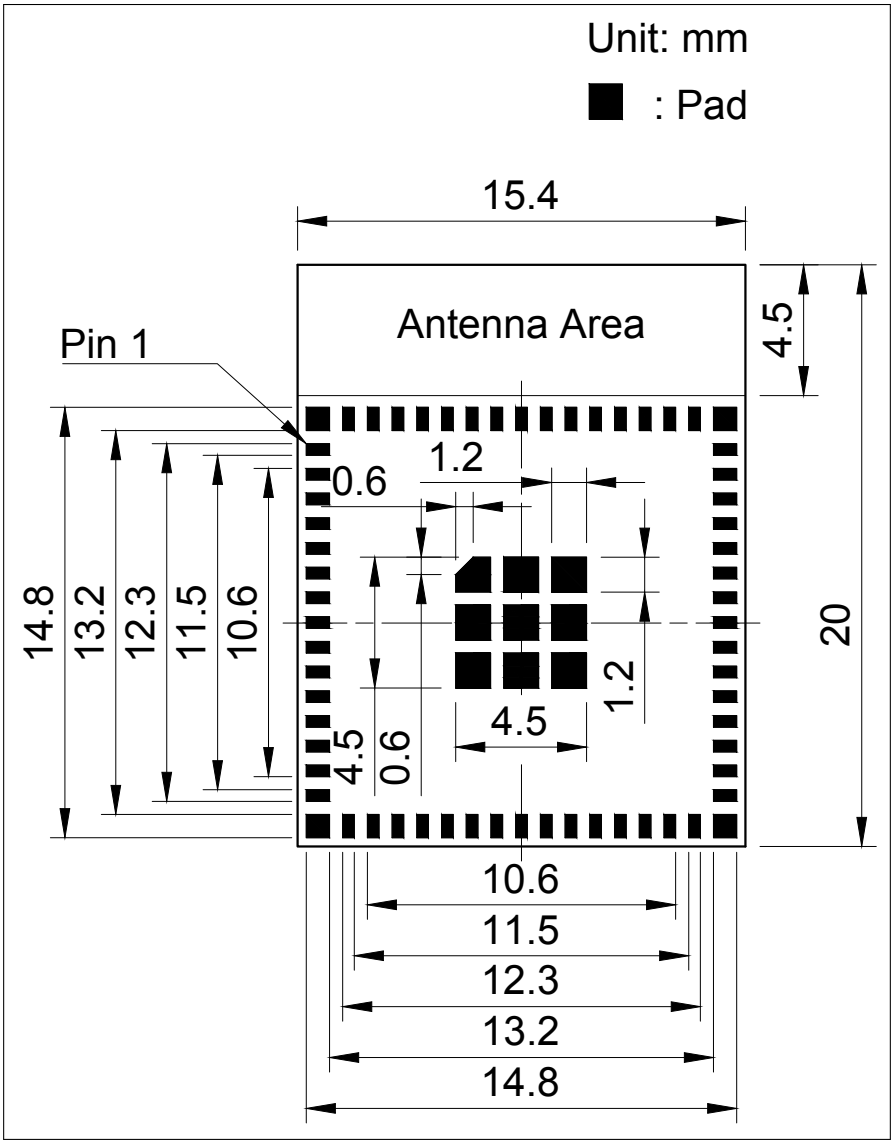


Figure 10: ESP32-S2-MINI-1 Recommended PCB Land Pattern

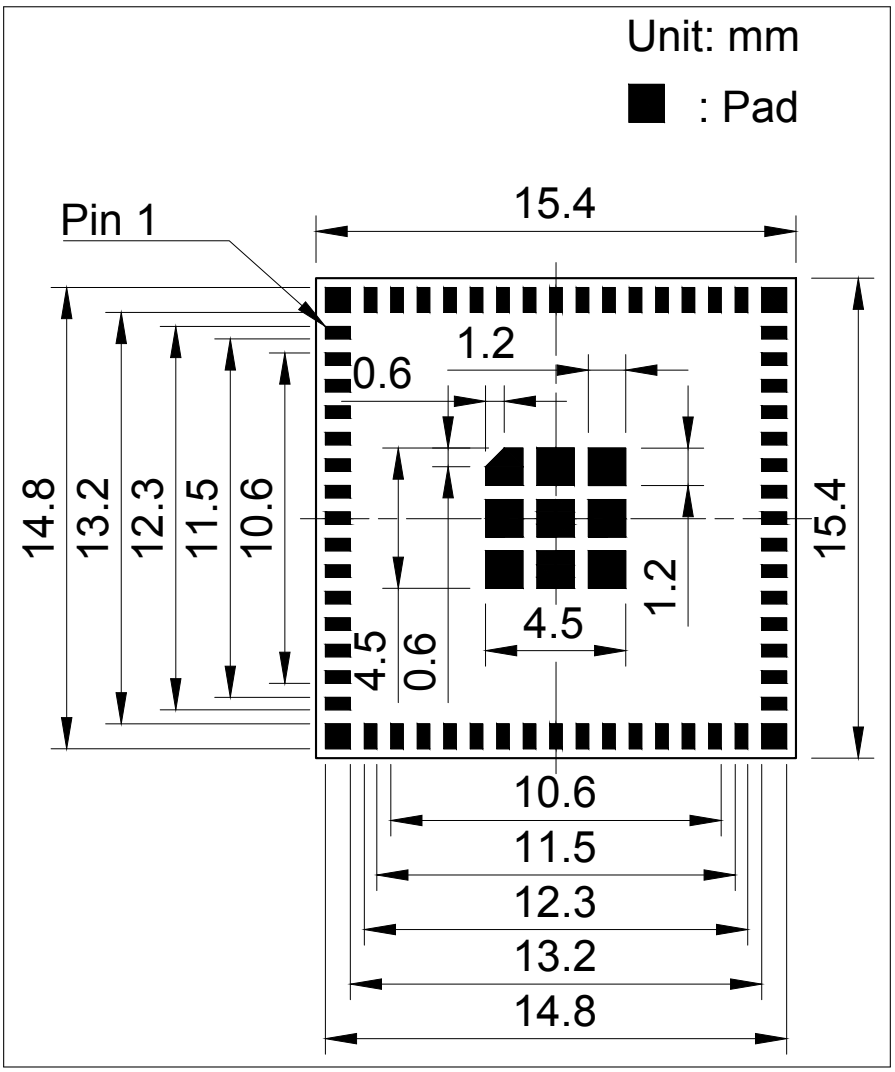


Figure 11: ESP32-S2-MINI-1U Recommended PCB Land Pattern

7.3 Dimensions of External Antenna Connector

ESP32-S2-MINI-1U uses the third generation external antenna connector as shown in Figure 12 *Dimensions of External Antenna Connector*. This connector is compatible with the following connectors:

- W.FL Series connector from Hirose
- MHF III connector from I-PEX
- AMMC connector from Amphenol

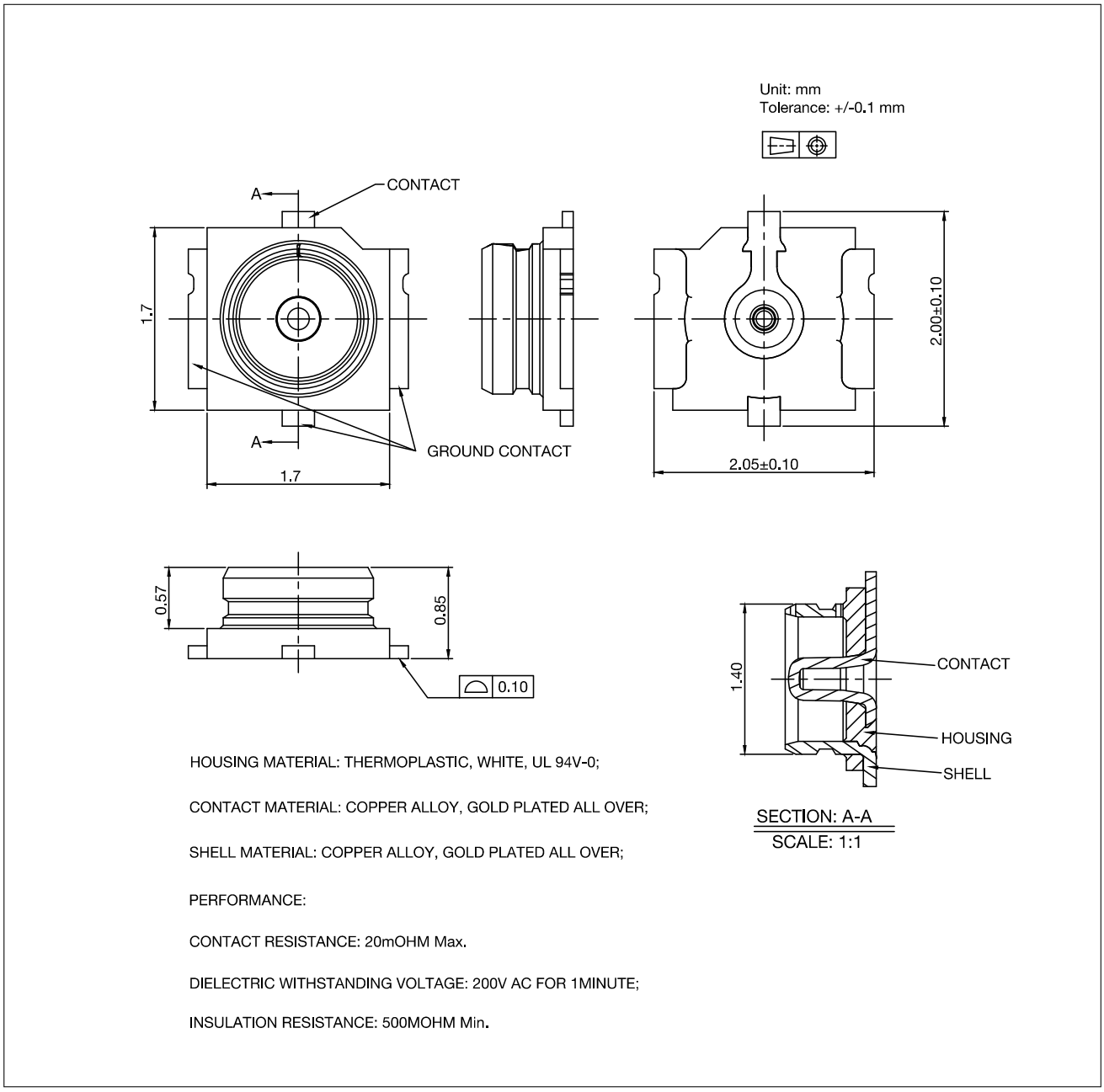


Figure 12: Dimensions of External Antenna Connector

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.

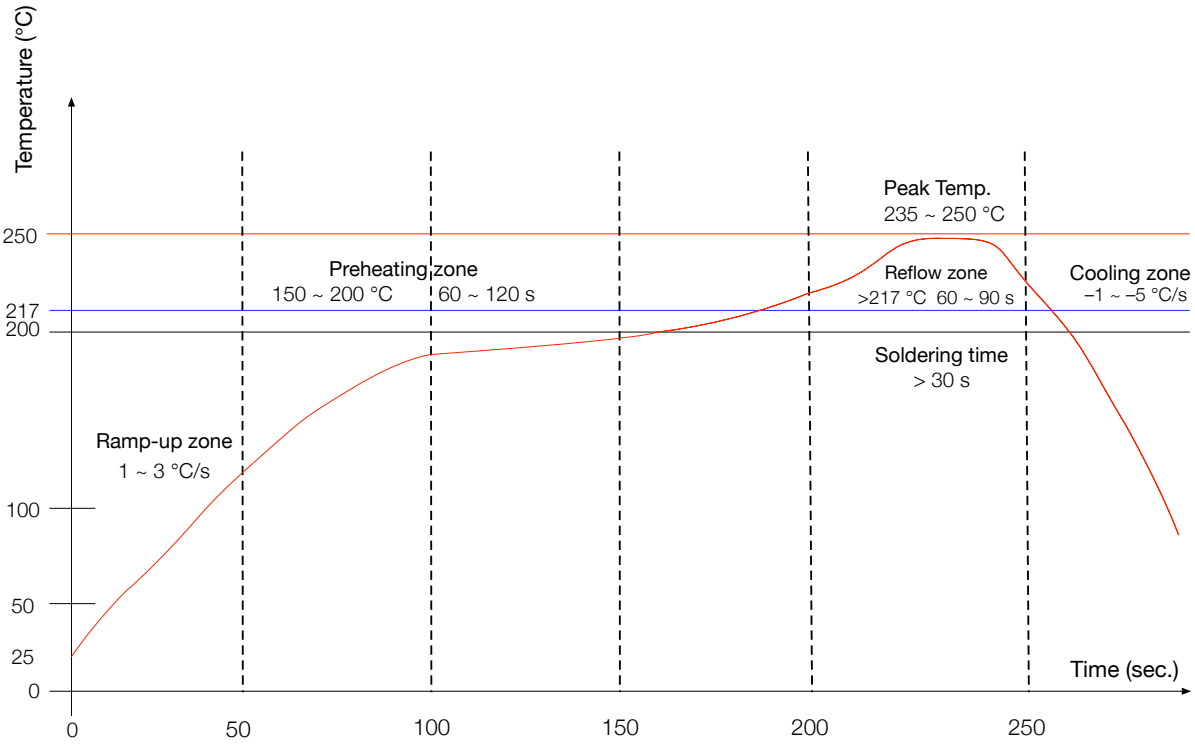
8.2 Electrostatic Discharge (ESD)

- 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 MAC Addresses and eFuse

The eFuse in ESP32-S2 family of chips has been burnt into 48-bit mac_address. The actual addresses the chip uses in station or AP modes correspond to mac_address in the following way:

- Station mode: mac_address
- AP mode: mac_address + 1

There are seven blocks in eFuse for users to use. Each block is 256 bits in size and has independent write/read disable controller. Six of them can be used to store encrypted key or user data, and the remaining one is only used to store user data.

10 Related Documentation and Resources

Related Documentation

- ESP32-S2 Series Datasheet – Specifications of the ESP32-S2 hardware.
- ESP32-S2 Technical Reference Manual – Detailed information on how to use the ESP32-S2 memory and peripherals.
- ESP32-S2 Hardware Design Guidelines – Guidelines on how to integrate the ESP32-S2 into your hardware product.
- ESP32-S2 Series SoC Errata – Descriptions of known errors in ESP32-S2 series of SoCs.
- *Certificates*
  https://espressif.com/en/support/documents/certificates
- *ESP32-S2 Product/Process Change Notifications (PCN)*
  https://espressif.com/en/support/documents/pcns?keys=ESP32-S2
- *ESP32-S2 Advisories* – Information on security, bugs, compatibility, component reliability.
  https://espressif.com/en/support/documents/advisories?keys=ESP32-S2
- *Documentation Updates and Update Notification Subscription*
  https://espressif.com/en/support/download/documents

Developer Zone

- ESP-IDF Programming Guide for ESP32-S2 – 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-S2 Series SoCs* – Browse through all ESP32-S2 SoCs.
  https://espressif.com/en/products/socs?id=ESP32-S2
- *ESP32-S2 Series Modules* – Browse through all ESP32-S2-based modules.
  https://espressif.com/en/products/modules?id=ESP32-S2
- *ESP32-S2 Series DevKits* – Browse through all ESP32-S2-based devkits.
  https://espressif.com/en/products/devkits?id=ESP32-S2
- *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
2023-05-25	v1.3	• Added NRND watermark • Changed Table *Ordering Information* to Table *ESP32-S2-MINI-1 (ANT) Series Comparison* and Table *ESP32-S2-MINI-1U (CONN) Series Comparison* • Added links to some reference documents in Section 1 *Module Overview* • Updated EPAD descriptions in Section 6 *Peripheral Schematics* • Added descriptions in Section 7.2 *Recommended PCB Land Pattern* • Other formatting updates
2022-09-23	v1.2	• Added Section 8.4 *Ultrasonic Vibration* • Removed NRND watermark
2022-03-01	v1.1	• Added information about ESP32-S2-MINI-1-H4 ESP32-S2-MINI-1U-H4 • Added module pictures on the title page • Added NRND watermark • Added a note with a link and QR code to the latest version of the document • Updated Section "Learning Resources" and renamed to "Related Documentation and Resources" • Updated the format for table notes • Updated Table 9 *Current Consumption in Modem-sleep Mode* and Table 10 *Current Consumption in Low-Power Modes*
2021-06-25	v1.0	• Added module variants embedded with the ESP32-S2FN4R2 chip • Added module description to the title page • Updated Chapter 1 *Module Overview* • Added description in Section 7.3 *Dimensions of External Antenna Connector* • Replaced "chip family" with "chip series" following Espressif's taxonomy
2020-12-17	v0.6	• Added TWAI to Chapter 1 *Module Overview* • Updated Table 8 *Current Consumption Depending on RF Modes* • Updated the capacitance value of RC delay circuit to 1 μF in Chapter 6 *Peripheral Schematics* • Updated note in Section 8.3.1 *Reflow Profile*
2020-09-23	v0.5	Preliminary release.

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Not Recommended For New Designs (NRND)