ESP32-S3-MINI-1
ESP32-S3-MINI-1U

Datasheet

Small-sized module supporting 2.4 GHz Wi-Fi (802.11 b/g/n) and Bluetooth® 5 (LE)
Built around ESP32-S3 series of SoCs, Xtensa® dual-core 32-bit LX7 microprocessor
8 MB flash
39 GPIOs, rich set of peripherals
On-board PCB antenna or external antenna connector

ESP32-S3-MINI-1

ESP32-S3-MINI-1U

Pre-release v0.6
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/sites/default/files/documentation/esp32-s3-mini-1_mini-1u_datasheet_en.pdf

1.1 Features

CPU and On-Chip Memory

- ESP32-S3FN8 embedded, Xtensa® dual-core 32-bit LX7 microprocessor, up to 240 MHz
- 384 KB ROM
- 512 KB SRAM
- 16 KB SRAM in RTC
- 8 MB SPI flash

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
- Center frequency range of operating channel: 2412 ~ 2484 MHz

Bluetooth

- Bluetooth LE: Bluetooth 5, Bluetooth mesh
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
- Advertising extensions
- Multiple advertisement sets
- Channel selection algorithm #2

Peripherals

- GPIO, SPI, LCD interface, Camera interface, UART, I2C, I2S, remote control, pulse counter, LED PWM, USB 1.1 OTG, USB Serial/JTAG controller, MCPWM, SDIO host, GDMA, TWAI® controller (compatible with ISO 11898-1, i.e. CAN Specification 2.0), ADC, touch sensor, temperature sensor, timers and watchdogs

Integrated Components on Module

- 40 MHz crystal oscillator

Antenna Options

- On-board PCB antenna (ESP32-S3-MINI-1)
- External antenna via a connector (ESP32-S3-MINI-1U)

Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature: –40 ~ 85 °C
- Dimensions: See Table 1

1.2 Description

ESP32-S3-MINI-1 and ESP32-S3-MINI-1U are two powerful, generic Wi-Fi + Bluetooth LE MCU modules that feature a rich set of peripherals, yet an optimized size. They are an ideal choice for a wide variety of application scenarios related to Internet of Things (IoT), such as embedded systems, smart home, wearable electronics, etc.

ESP32-S3-MINI-1 comes with a PCB antenna. ESP32-S3-MINI-1U comes with an external antenna connector.

The ordering information of the module is shown in Table 1.

The information in this datasheet is applicable to both modules.

Table 1: Ordering Information

Module	ESP32-S3-MINI-1	ESP32-S3-MINI-1U
Variants	ESP32-S3-MINI-1-N8	ESP32-S3-MINI-1U-N8
Chip Embedded	ESP32-S3FN8	
Flash	8 MB (Quad SPI)	
PSRAM	0	
Dimensions	15.4 × 20.5 × 2.4	15.4 × 15.4 × 2.4

At the core of the modules is an ESP32-S3FN8, an Xtensa® 32-bit LX7 CPU that operates at up to 240 MHz. You can power off the CPU and make use of the low-power co-processor to constantly monitor the peripherals for changes or crossing of thresholds.

ESP32-S3FN8 integrates a rich set of peripherals including SPI, LCD, Camera interface, UART, I2C, I2S, remote control, pulse counter, LED PWM, USB Serial/Jtag, MCPWM, SDIO host, GDMA, TWAI® controller (compatible with ISO 11898-1, i.e. CAN Specification 2.0), ADC, touch sensor, temperature sensor, timers and watchdogs, as well as up to 45 GPIOs. It also includes a full-speed USB 1.1 On-The-Go (OTG) interface to enable USB communication.

Note:
* For more information on ESP32-S3FN8, please refer to *ESP32-S3 Series Datasheet*.

1.3 Applications

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

Contents

List of Tables

List of Figures

2 Block Diagram

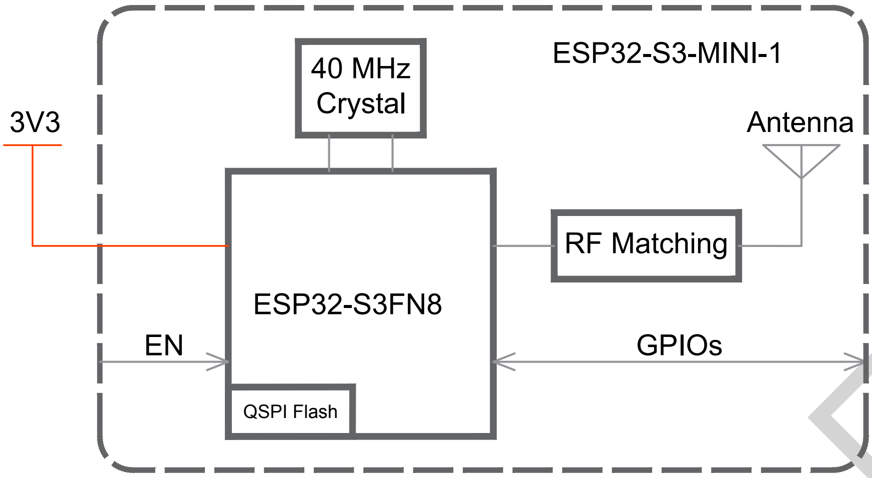

Figure 1: ESP32-S3-MINI-1 Block Diagram

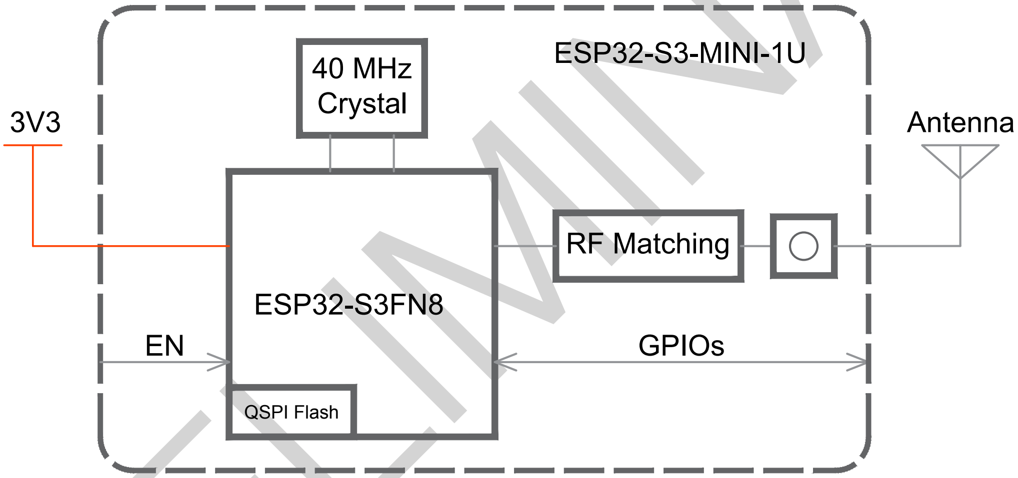

Figure 2: ESP32-S3-MINI-1U Block Diagram

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*.

The pin diagram is applicable for ESP32-S3-MINI-1 and ESP32-S3-MINI-1U, but the latter has no keepout zone.

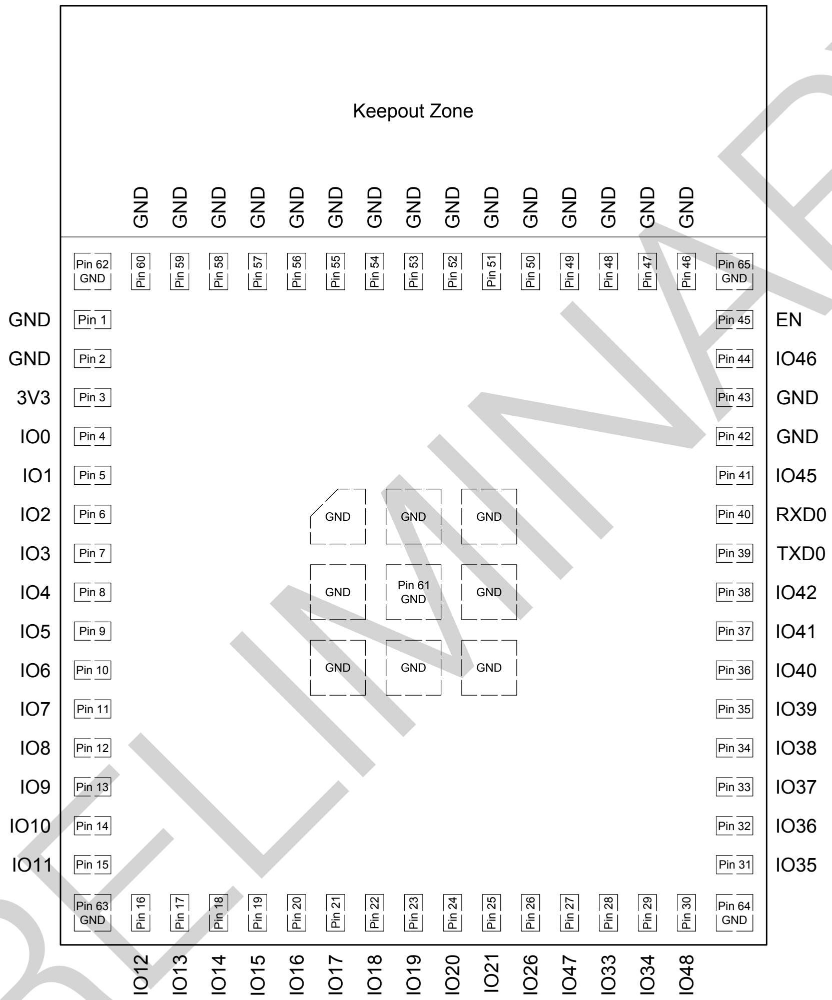

Figure 3: Pin Layout (Top View)

3.2 Pin Description

The module has 65 pins. See pin definitions in Table 2.

For explanations of pin names and function names, as well as configurations of peripheral pins, please refer to *ESP32-S3 Series Datasheet*.

Table 2: Pin Definitions

Name	No.	Type [a]	Function
GND	1, 2, 42, 43, 46-65	P	GND
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
IO7	11	I/O/T	RTC_GPIO7, **GPIO7**, TOUCH7, ADC1_CH6
IO8	12	I/O/T	RTC_GPIO8, **GPIO8**, TOUCH8, ADC1_CH7, SUBSPICS1
IO9	13	I/O/T	RTC_GPIO9, **GPIO9**, TOUCH9, ADC1_CH8, FSPIHD, SUBSPIHD
IO10	14	I/O/T	RTC_GPIO10, **GPIO10**, TOUCH10, ADC1_CH9, FSPICS0, FSPIIO4, SUBSPICS0
IO11	15	I/O/T	RTC_GPIO11, **GPIO11**, TOUCH11, ADC2_CH0, FSPID, FSPIIO5, SUBSPID
IO12	16	I/O/T	RTC_GPIO12, **GPIO12**, TOUCH12, ADC2_CH1, FSPICLK, FSPIIO6, SUBSPICLK
IO13	17	I/O/T	RTC_GPIO13, **GPIO13**, TOUCH13, ADC2_CH2, FSPIQ, FSPIIO7, SUBSPIQ
IO14	18	I/O/T	RTC_GPIO14, **GPIO14**, TOUCH14, ADC2_CH3, FSPIWP, FSPIDQS, SUBSPIWP
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
IO18	22	I/O/T	RTC_GPIO18, **GPIO18**, U1RXD, ADC2_CH7, 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	26	I/O/T	SPICS1, **GPIO26**
IO47	27	I/O/T	SPICLK_P_DIFF, **GPIO47**, SUBSPICLK_P_DIFF
IO33	28	I/O/T	SPIIO4, **GPIO33**, FSPIHD, SUBSPIHD
IO34	29	I/O/T	SPIIO5, **GPIO34**, FSPICS0, SUBSPICS0
IO48	30	I/O/T	SPICLK_N_DIFF, **GPIO48**, SUBSPICLK_N_DIFF
IO35	31	I/O/T	SPIIO6, **GPIO35**, FSPID, SUBSPID
IO36	32	I/O/T	SPIIO7, **GPIO36**, FSPICLK, SUBSPICLK
IO37	33	I/O/T	SPIDQS, **GPIO37**, FSPIQ, SUBSPIQ
IO38	34	I/O/T	**GPIO38**, FSPIWP, SUBSPIWP
IO39	35	I/O/T	**MTCK**, GPIO39, CLK_OUT3, SUBSPICS1
IO40	36	I/O/T	**MTDO**, GPIO40, CLK_OUT2
IO41	37	I/O/T	**MTDI**, GPIO41, CLK_OUT1

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Table 2 – cont’d from previous page

Name	No.	Type [a]	Function
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/O/T	**GPIO46**
EN	45	I	High: on, enables the chip. Low: off, the chip powers off. Note: Do not leave the EN pin floating.

[a] P: power supply; I: input; O: output; T: high impedance. Pin functions in bold font are the default pin functions.

3.3 Strapping Pins

Note:

The content below is excerpted from Section Strapping Pins in *ESP32-S3 Series Datasheet*. For the strapping pin mapping between the chip and modules, please refer to Chapter 5 *Module Schematics*.

ESP32-S3 has four strapping pins:

- GPIO0
- GPIO45
- GPIO46
- GPIO3

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

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

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

GPIO3 is floating by default. Its strapping value can be configured to determine the source of the JTAG signal inside the CPU, as shown in Table 4. In this case, the strapping value is controlled by the external circuit that cannot be in a high impedance state. Table 3 shows more configuration combinations of EFUSE_DIS_USB_JTAG, EFUSE_DIS_PAD_JTAG, and EFUSE_STRAP_JTAG_SEL that determine the JTAG signal source.

Table 3: JTAG Signal Source Selection

EFUSE_STRAP_JTAG_SEL	EFUSE_DIS_USB_JTAG	EFUSE_DIS_PAD_JTAG	JTAG Signal Source
1	0	0	Refer to Table 4
0	0	0	USB Serial/JTAG controller
don’t care	0	1	USB Serial/JTAG controller

don't care	1	0	On-chip JTAG pins
don't care	1	1	N/A

To change the strapping bit values, users can apply the external pull-down/pull-up resistances, or use the host MCU's GPIOs to control the voltage level of these pins when powering on ESP32-S3.

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

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

Table 4: Strapping Pins

VDD_SPI Voltage [1]			
Pin	Default	3.3 V	1.8 V
GPIO45	Pull-down	0	1
Booting Mode [2]			
Pin	Default	SPI Boot	Download Boot
GPIO0	Pull-up	1	0
GPIO46	Pull-down	Don't care	0
Enabling/Disabling ROM Messages Print During Booting [3] [4]			
Pin	Default	Enabled	Disabled
GPIO46	Pull-down	See the fourth note	See the fourth note
JTAG Signal Selection			
Pin	Default	EFUSE_DIS_USB_JTAG = 0, EFUSE_DIS_PAD_JTAG = 0, EFUSE_STRAP_JTAG_SEL=1	
GPIO3	N/A	0: JTAG signal from on-chip JTAG pins 1: JTAG signal from USB Serial/JTAG controller	

Note:

1. VDD_SPI voltage is determined either by the strapping value of GPIO45 or by VDD_SPI_TIEH. When EFUSE_VDD_SPI_FORCE is 0, VDD_SPI voltage is determined by the strapping value of GPIO45; when EFUSE_VDD_SPI_FORCE is 1, VDD_SPI voltage is determined by VDD_SPI_TIEH.
2. The strapping combination of GPIO46 = 1 and GPIO0 = 0 is invalid and will trigger unexpected behavior.
3. ROM boot messages can be printed over U0TXD (by default) or GPIO17 (U1TXD), depending on the eFuse bit EFUSE_UART_PRINT_CHANNEL.
4. When both EFUSE_DIS_USB_SERIAL_JTAG and EFUSE_DIS_USB_OTG are 0, ROM boot messages will be printed to the USB Serial/JTAG controller. Otherwise, the messages will be printed to UART, controlled by GPIO46 and EFUSE_UART_PRINT_CONTROL. Specifically, when EFUSE_UART_PRINT_CONTROL value is:
   0, print is normal during boot and not controlled by GPIO46.
   1 and GPIO46 is 0, print is normal during boot; but if GPIO46 is 1, print is disabled.
   2 and GPIO46 is 0, print is disabled; but if GPIO46 is 1, print is normal.
   3, print is disabled and not controlled by GPIO46.

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

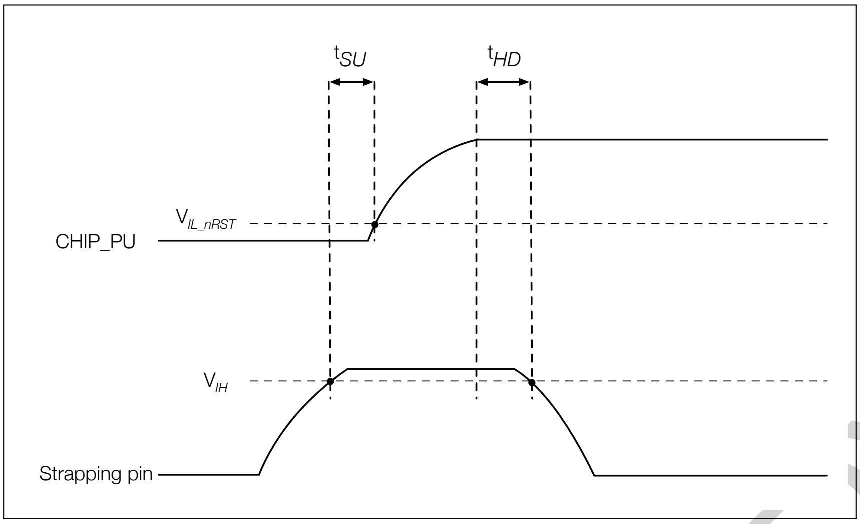

Figure 4: Setup and Hold Times for the Strapping Pin

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

Parameter	Description	Min (ms)
t_{SU}	Setup time before CHIP_PU goes from low to high	0
t_{HD}	Hold time after CHIP_PU goes high	3

4 Electrical Characteristics

The values presented in this section are preliminary and may change with the final release of this datasheet.

4.1 Absolute Maximum Ratings

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

Table 6: Absolute Maximum Ratings

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

4.2 Recommended Operating Conditions

Table 7: Recommended Operating Conditions

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

4.3 DC Characteristics (3.3 V, 25 °C)

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

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

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Table 8 – cont'd from previous page

Symbol	Parameter	Min	Typ	Max	Unit
V_{IH_nRST}	Chip reset release voltage (EN voltage is within the specified range)	0.75 × VDD[1]	—	VDD[1]+ 0.3	V
V_{IL_nRST}	Chip reset voltage (EN voltage is within the specified range)	–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

With the use of advanced power-management technologies, the module can switch between different power modes. For details on different power modes, please refer to Section *Low Power Management* in *ESP32-S3 Series Datasheet* .

Table 9: Current Consumption Depending on RF Modes

Work mode	Description		Peak (mA)
Active (RF working)	TX	802.11b, 1 Mbps, @20.5 dBm	355
		802.11g, 54 Mbps, @18 dBm	297
		802.11n, HT20, MCS 7, @17.5 dBm	286
		802.11n, HT40, MCS 7, @17 dBm	285
	RX	802.11b/g/n, HT20	95
		802.11n, HT40	97

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

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

Table 10: Current Consumption Depending on Work Modes

Work mode	Description	Typ	Unit
Light-sleep	—	240	μA
Deep-sleep	RTC memory and RTC peripherals are powered on.	8	μA
Hibernation	RTC memory is powered on. RTC peripherals are powered off.	7	μA
Power off	CHIP_PU is set to low level. The chip is powered off.	1	μA

4.5 Wi-Fi RF Characteristics

4.5.1 Wi-Fi RF Standards

Table 11: Wi-Fi RF Standards

Name	Description
Center frequency range of operating channel [1]	2412 ~ 2484 MHz

Table 11: Wi-Fi RF Standards

Name		Description
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 via the 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 antennas, the output impedance is 50 Ω. For other modules without external antennas, 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 12.

Table 12: TX Power with Spectral Mask and EVM Meeting 802.11 Standards

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	20.5	—
802.11b, 11 Mbps	—	20.5	—
802.11g, 6 Mbps	—	20.0	—
802.11g, 54 Mbps	—	18.0	—
802.11n, HT20, MCS 0	—	19.0	—
802.11n, HT20, MCS 7	—	17.5	—
802.11n, HT40, MCS 0	—	18.5	—
802.11n, HT40, MCS 7	—	17.0	—

Table 13: TX EVM Test

Rate	Min (dB)	Typ (dB)	SL[1] (dB)
802.11b, 1 Mbps, @20.5 dBm	—	–24.5	–10
802.11b, 11 Mbps, @20.5 dBm	—	–24.5	–10
802.11g, 6 Mbps, @20 dBm	—	–23.0	–5
802.11g, 54 Mbps, @18 dBm	—	–29.5	–25
802.11n, HT20, MCS 0, @19 dBm	—	–24.0	–5
802.11n, HT20, MCS 7, @17.5 dBm	—	–30.5	–27
802.11n, HT40, MCS 0, @18.5 dBm	—	–25.0	–5
802.11n, HT40, MCS 7, @17 dBm	—	–30.0	–27

[1] SL stands for standard limit value.

4.5.3 Wi-Fi RF Receiver (RX) Specifications

Table 14: RX Sensitivity

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	–98.2	—
802.11b, 2 Mbps	—	–95.6	—
802.11b, 5.5 Mbps	—	–92.8	—
802.11b, 11 Mbps	—	–88.5	—
802.11g, 6 Mbps	—	–93.0	—
802.11g, 9 Mbps	—	–92.0	—
802.11g, 12 Mbps	—	–90.8	—
802.11g, 18 Mbps	—	–88.5	—
802.11g, 24 Mbps	—	–85.5	—
802.11g, 36 Mbps	—	–82.2	—
802.11g, 48 Mbps	—	–78.0	—
802.11g, 54 Mbps	—	–76.2	—
802.11n, HT20, MCS 0	—	–93.0	—
802.11n, HT20, MCS 1	—	–90.6	—
802.11n, HT20, MCS 2	—	–88.4	—
802.11n, HT20, MCS 3	—	–84.8	—
802.11n, HT20, MCS 4	—	–81.6	—
802.11n, HT20, MCS 5	—	–77.4	—
802.11n, HT20, MCS 6	—	–75.6	—
802.11n, HT20, MCS 7	—	–74.2	—
802.11n, HT40, MCS 0	—	–90.0	—
802.11n, HT40, MCS 1	—	–87.5	—
802.11n, HT40, MCS 2	—	–85.0	—
802.11n, HT40, MCS 3	—	–82.0	—
802.11n, HT40, MCS 4	—	–78.5	—
802.11n, HT40, MCS 5	—	–74.4	—
802.11n, HT40, MCS 6	—	–72.5	—
802.11n, HT40, MCS 7	—	–71.2	—

Table 15: Maximum RX Level

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	5	—
802.11b, 11 Mbps	—	5	—
802.11g, 6 Mbps	—	5	—
802.11g, 54 Mbps	—	0	—
802.11n, HT20, MCS 0	—	5	—
802.11n, HT20, MCS 7	—	0	—

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Table 15 – cont'd from previous page

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11n, HT40, MCS 0	—	5	—
802.11n, HT40, MCS 7	—	0	—

Table 16: RX Adjacent Channel Rejection

Rate	Min (dB)	Typ (dB)	Max (dB)
802.11b, 1 Mbps	—	35	—
802.11b, 11 Mbps	—	35	—
802.11g, 6 Mbps	—	31	—
802.11g, 54 Mbps	—	14	—
802.11n, HT20, MCS 0	—	31	—
802.11n, HT20, MCS 7	—	13	—
802.11n, HT40, MCS 0	—	19	—
802.11n, HT40, MCS 7	—	8	—

4.6 Bluetooth LE Radio

Table 17: Bluetooth LE Frequency

Parameter	Min (MHz)	Typ (MHz)	Max (MHz)
Center frequency of operating channel	2402	—	2480

4.6.1 Bluetooth LE RF Transmitter (TX) Specifications

Table 18: Transmitter Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	–25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $\|f_n\|_{n=0,\,1,\,2,\,..k}$	—	2.50	—	kHz
	Max $\|f_0 - f_n\|$	—	2.00	—	kHz
	Max $\|f_n - f_{n-5}\|$	—	1.40	—	kHz
	$\|f_1 - f_0\|$	—	1.00	—	kHz
Modulation characteristics	$\Delta\ f1_{\text{avg}}$	—	249.00	—	kHz
	Min $\Delta\ f2_{\text{max}}$ (for at least 99.9% of all $\Delta\ f2_{\text{max}}$)	—	198.00	—	kHz
	$\Delta\ f2_{\text{avg}}/\Delta\ f1_{\text{avg}}$	—	0.86	—	—
In-band spurious emissions	±2 MHz offset	—	–37.00	—	dBm
	±3 MHz offset	—	–42.00	—	dBm

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Table 18 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	>±3 MHz offset	—	–44.00	—	dBm

Table 19: Transmitter Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	–25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $\|f_n\|_{n=0,\ 1,\ 2,\ ..k}$	—	2.50	—	kHz
	Max $\|f_0 - f_n\|$	—	2.00	—	kHz
	Max $\|f_n - f_{n-5}\|$	—	1.40	—	kHz
	$\|f_1 - f_0\|$	—	1.00	—	kHz
Modulation characteristics	$\Delta\ f1_{\text{avg}}$	—	499.00	—	kHz
	Min $\Delta\ f2_{\text{max}}$ (for at least 99.9% of all $\Delta\ f2_{\text{max}}$)	—	416.00	—	kHz
	$\Delta\ f2_{\text{avg}}/\Delta\ f1_{\text{avg}}$	—	0.89	—	—
In-band spurious emissions	±4 MHz offset	—	–42.00	—	dBm
	±5 MHz offset	—	–44.00	—	dBm
	>±5 MHz offset	—	–47.00	—	dBm

Table 20: Transmitter Characteristics - Bluetooth LE 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	–25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $\|f_n\|_{n=0,\ 1,\ 2,\ ..k}$	—	0.80	—	kHz
	Max $\|f_0 - f_n\|$	—	1.00	—	kHz
	$\|f_n - f_{n-3}\|$	—	0.30	—	kHz
	$\|f_0 - f_3\|$	—	1.00	—	kHz
Modulation characteristics	$\Delta\ f1_{\text{avg}}$	—	248.00	—	kHz
	Min $\Delta\ f1_{\text{max}}$ (for at least 99.9% of all$\Delta\ f1_{\text{max}}$)	—	222.00	—	kHz
In-band spurious emissions	±2 MHz offset	—	–37.00	—	dBm
	±3 MHz offset	—	–42.00	—	dBm
	>±3 MHz offset	—	–44.00	—	dBm

Table 21: Transmitter Characteristics - Bluetooth LE 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
RF transmit power	RF power control range	–25.00	0	20.00	dBm
	Gain control step	—	3.00	—	dB
Carrier frequency offset and drift	Max $\|f_n\|_{n=0,\ 1,\ 2,\ ..k}$	—	0.80	—	kHz
	Max $\|f_0 - f_n\|$	—	1.00	—	kHz

Cont'd on next page

Table 21 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	$\|f_n - f_{n-3}\|$	—	0.85	—	kHz
	$\|f_0 - f_3\|$	—	0.34	—	kHz
Modulation characteristics	$\Delta\ f2_{\text{avg}}$	—	213.00	—	kHz
	Min $\Delta\ f2_{\text{max}}$ (for at least 99.9% of all $\Delta\ f2_{\text{max}}$)	—	196.00	—	kHz
In-band spurious emissions	±2 MHz offset	—	–37.00	—	dBm
	±3 MHz offset	—	–42.00	—	dBm
	>±3 MHz offset	—	–44.00	—	dBm

4.6.2 Bluetooth LE RF Receiver (RX) Specifications

Table 22: Receiver Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–96.5	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	F = F0 MHz	—	9	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–3	—	dB
	F = F0 – 1 MHz	—	–3	—	dB
	F = F0 + 2 MHz	—	–28	—	dB
	F = F0 – 2 MHz	—	–30	—	dB
	F = F0 + 3 MHz	—	–31	—	dB
	F = F0 – 3 MHz	—	–33	—	dB
	F > F0 + 3 MHz	—	–32	—	dB
	F > F0 – 3 MHz	—	–36	—	dB
Image frequency	—	—	–32	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–39	—	dB
	F = F_{image} – 1 MHz	—	–31	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	–9	—	dBm
	2003 MHz ~ 2399 MHz	—	–18	—	dBm
	2484 MHz ~ 2997 MHz	—	–15	—	dBm
	3000 MHz ~ 12.75 GHz	—	–5	—	dBm
Intermodulation	—	—	–29	—	dBm

Table 23: Receiver Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–92.5	—	dBm
Maximum received signal @30.8% PER	—	—	3	—	dBm
Co-channel C/I	F = F0 MHz	—	10	—	dB

Cont'd on next page

Table 23 – cont’d from previous page

Parameter	Description	Min	Typ	Max	Unit
Adjacent channel selectivity C/I	F = F0 + 2 MHz	—	–8	—	dB
	F = F0 – 2 MHz	—	–5	—	dB
	F = F0 + 4 MHz	—	–31	—	dB
	F = F0 – 4 MHz	—	–33	—	dB
	F = F0 + 6 MHz	—	–37	—	dB
	F = F0 – 6 MHz	—	–37	—	dB
	F > F0 + 6 MHz	—	–40	—	dB
	F > F0 – 6 MHz	—	–40	—	dB
Image frequency	—	—	–31	—	dB
Adjacent channel to image frequency	F = F_{image} + 2 MHz	—	–37	—	dB
	F = F_{image} – 2 MHz	—	–8	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	–15	—	dBm
	2003 MHz ~ 2399 MHz	—	–19	—	dBm
	2484 MHz ~ 2997 MHz	—	–15	—	dBm
	3000 MHz ~ 12.75 GHz	—	–6	—	dBm
Intermodulation	—	—	–29	—	dBm

Table 24: Receiver Characteristics - Bluetooth LE 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–103.5	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	F = F0 MHz	—	6	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–6	—	dB
	F = F0 – 1 MHz	—	–5	—	dB
	F = F0 + 2 MHz	—	–32	—	dB
	F = F0 – 2 MHz	—	–39	—	dB
	F = F0 + 3 MHz	—	–35	—	dB
	F = F0 – 3 MHz	—	–45	—	dB
	F > F0 + 3 MHz	—	–35	—	dB
	F > F0 – 3 MHz	—	–48	—	dB
Image frequency	—	—	–35	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–49	—	dB
	F = F_{image} – 1 MHz	—	–32	—	dB

Table 25: Receiver Characteristics - Bluetooth LE 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–100	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	F = F0 MHz	—	4	—	dB

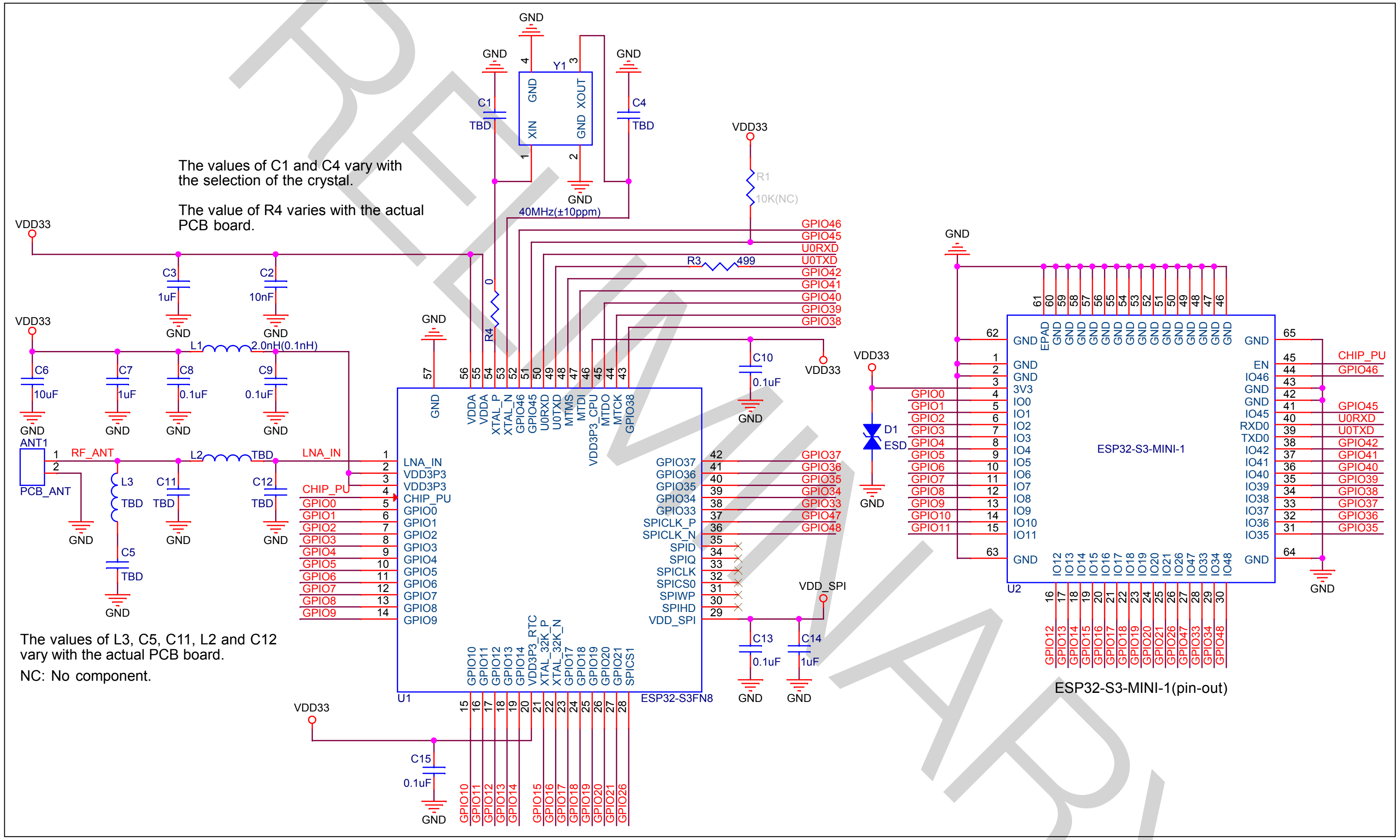
Cont’d on next page

Table 25 – cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–5	—	dB
	F = F0 – 1 MHz	—	–5	—	dB
	F = F0 + 2 MHz	—	–28	—	dB
	F = F0 – 2 MHz	—	–36	—	dB
	F = F0 + 3 MHz	—	–36	—	dB
	F = F0 – 3 MHz	—	–38	—	dB
	F $>$ F0 + 3 MHz	—	–37	—	dB
	F $>$ F0 – 3 MHz	—	–41	—	dB
Image frequency	—	—	–37	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–44	—	dB
	F = F_{image} – 1 MHz	—	–28	—	dB

5 Module Schematics

This is the reference design of the module.



The values of C1 and C4 vary with the selection of the crystal.

The value of R4 varies with the actual PCB board.

The values of L3, C5, C11, L2 and C12 vary with the actual PCB board.

NC: No component.

Figure 5: ESP32-S3-MINI-1 Schematics

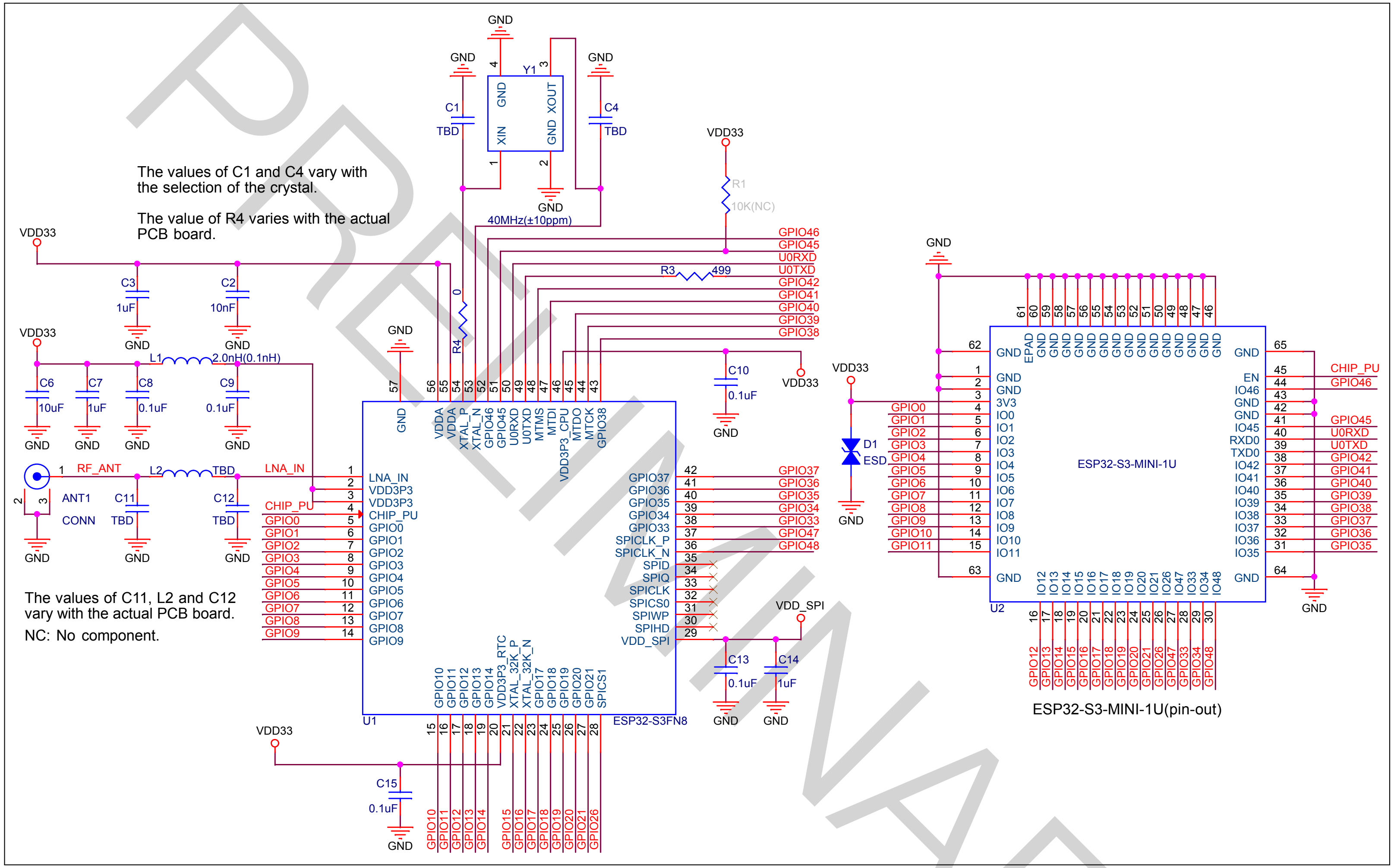


Figure 6: ESP32-S3-MINI-1U Schematics

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).

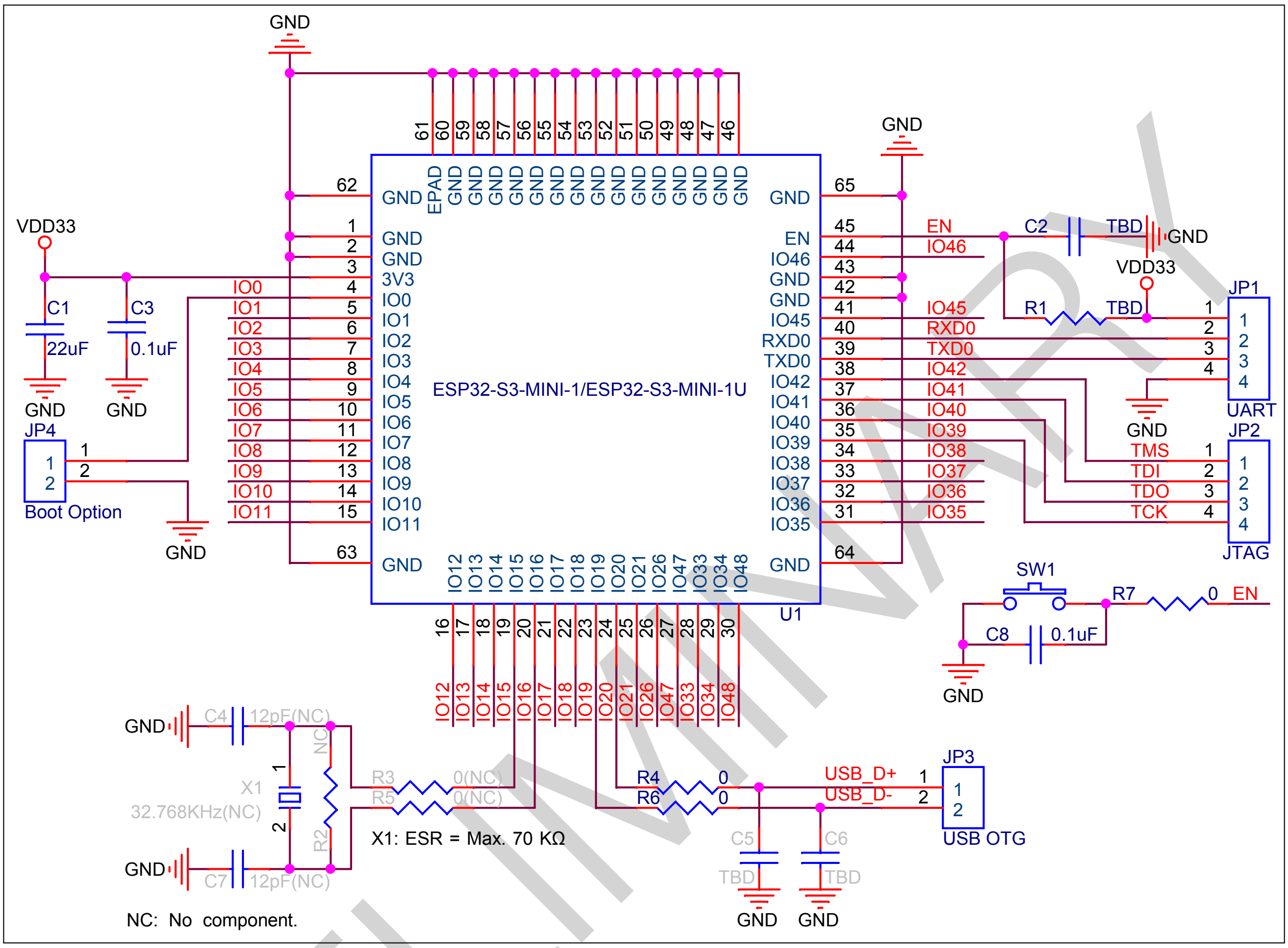


Figure 7: Peripheral Schematics

- 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.
- To ensure that the power supply to the ESP32-S3 chip is stable during power-up, it is advised to add an RC delay circuit at the EN pin. The recommended setting for the RC delay circuit is usually R = 10 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-S3's power-up and reset sequence timing diagram, please refer to Section *Power Scheme* in ESP32-S3 Series Datasheet.

7 Physical Dimensions and PCB Land Pattern

7.1 Physical Dimensions

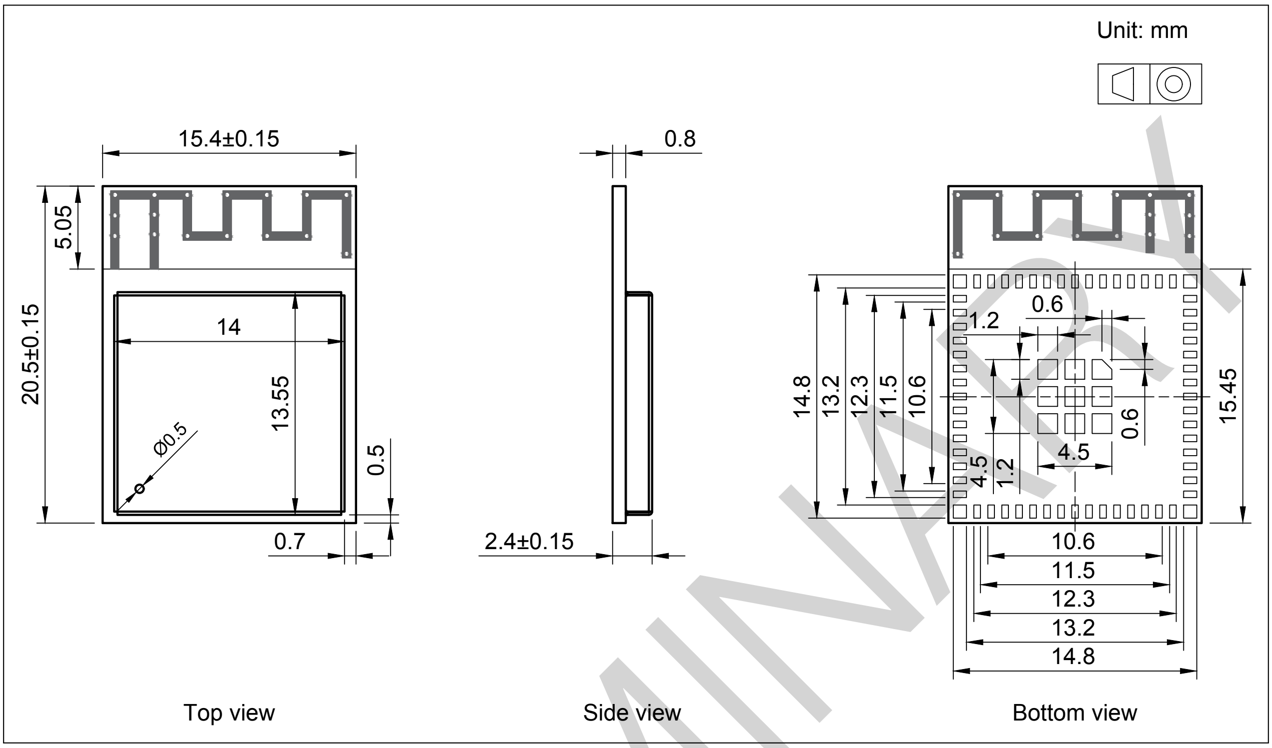


Figure 8: ESP32-S3-MINI-1 Physical Dimensions

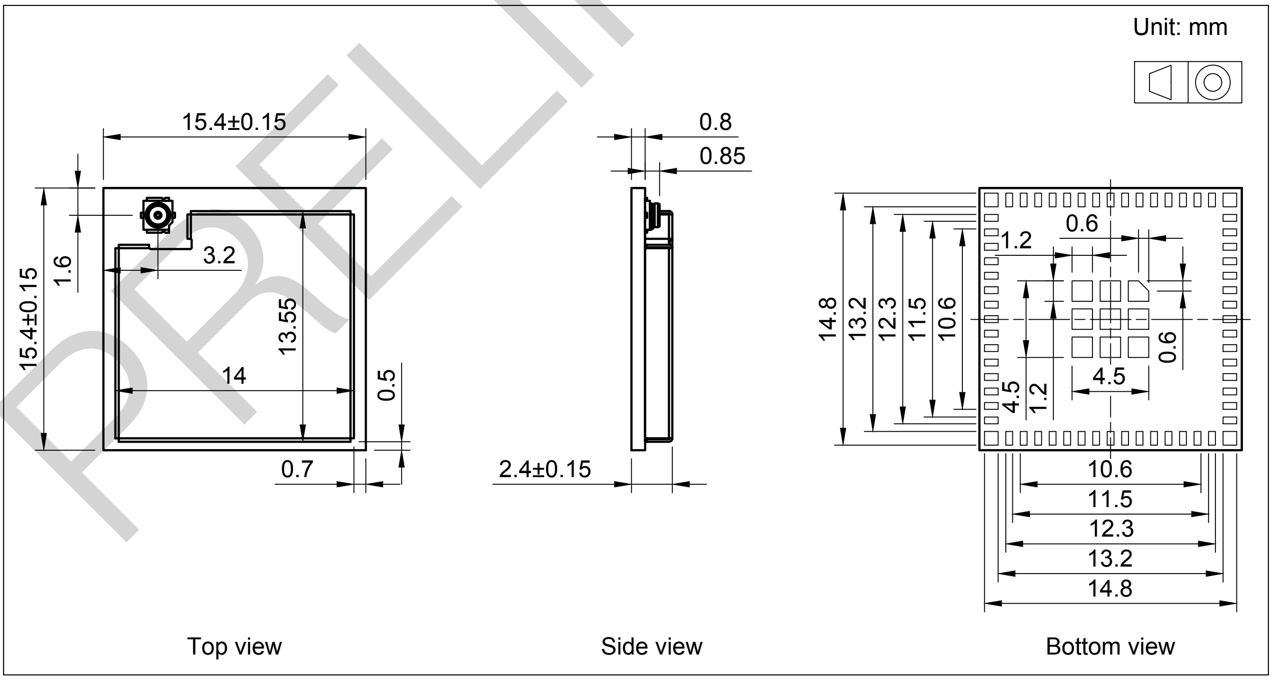


Figure 9: ESP32-S3-MINI-1U Physical Dimensions

Note:

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

7.2 Recommended PCB Land Pattern

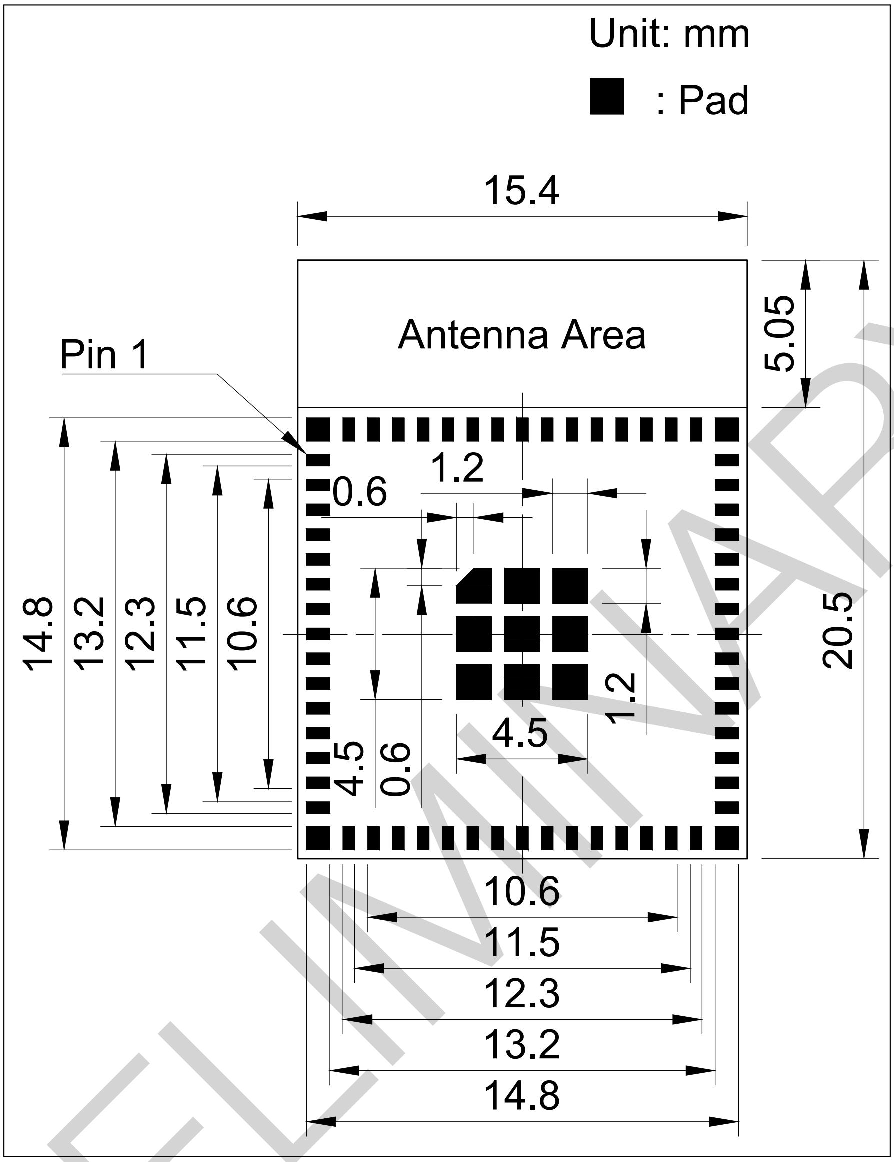


Figure 10: ESP32-S3-MINI-1 Recommended PCB Land Pattern

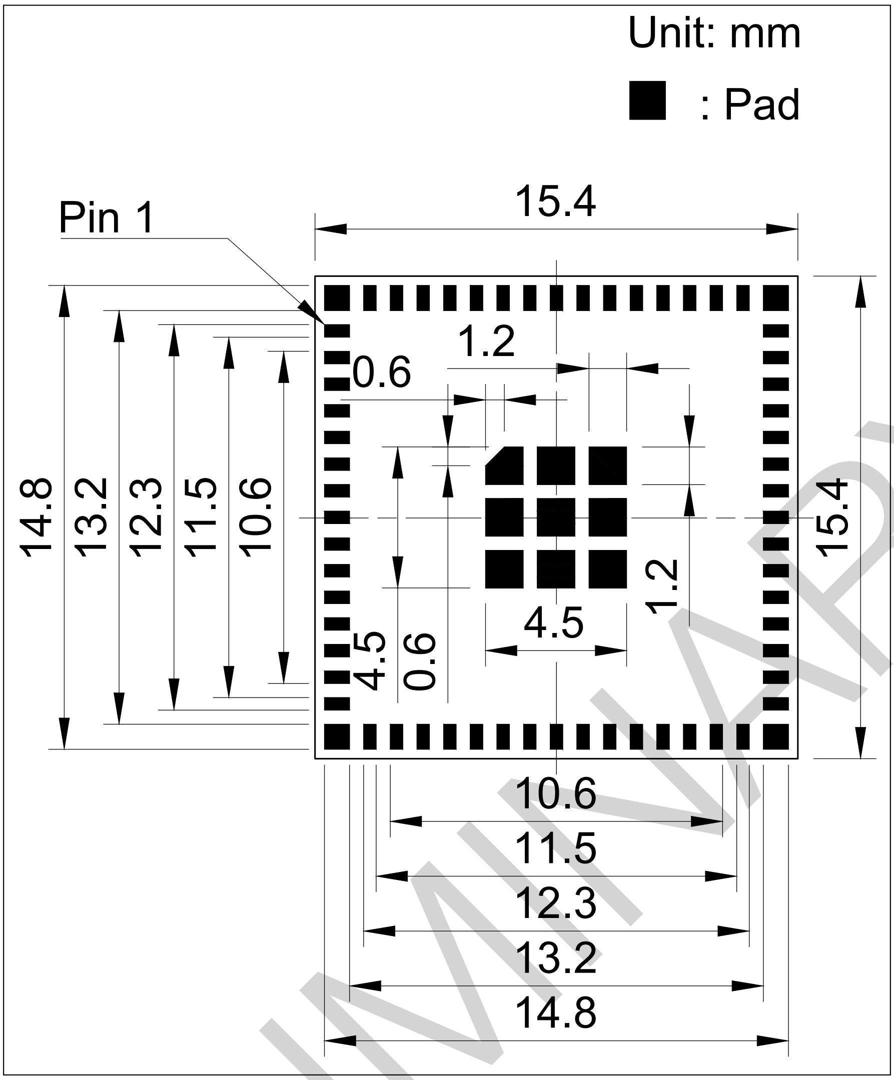
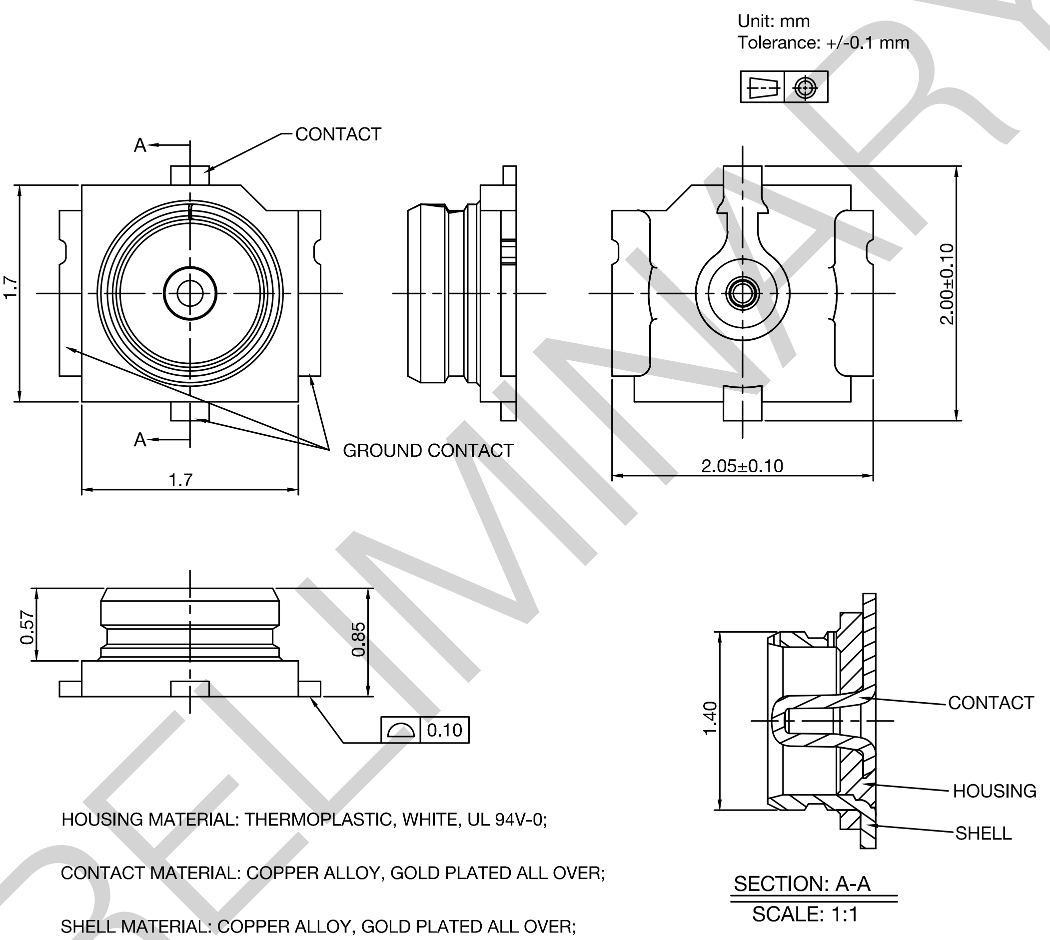


Figure 11: ESP32-S3-MINI-1U Recommended PCB Land Pattern

7.3 Dimensions of External Antenna Connector

ESP32-S3-MINI-1U uses the third generation external antenna connector as shown in Figure 12. This connector is compatible with the following connectors:

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



HOUSING MATERIAL: THERMOPLASTIC, WHITE, UL 94V-0;

CONTACT MATERIAL: COPPER ALLOY, GOLD PLATED ALL OVER;

SHELL MATERIAL: COPPER ALLOY, GOLD PLATED ALL OVER;

PERFORMANCE:

CONTACT RESISTANCE: 20mOHM Max.

DIELECTRIC WITHSTANDING VOLTAGE: 200V AC FOR 1MINUTE;

INSULATION RESISTANCE: 500MOHM Min.

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.

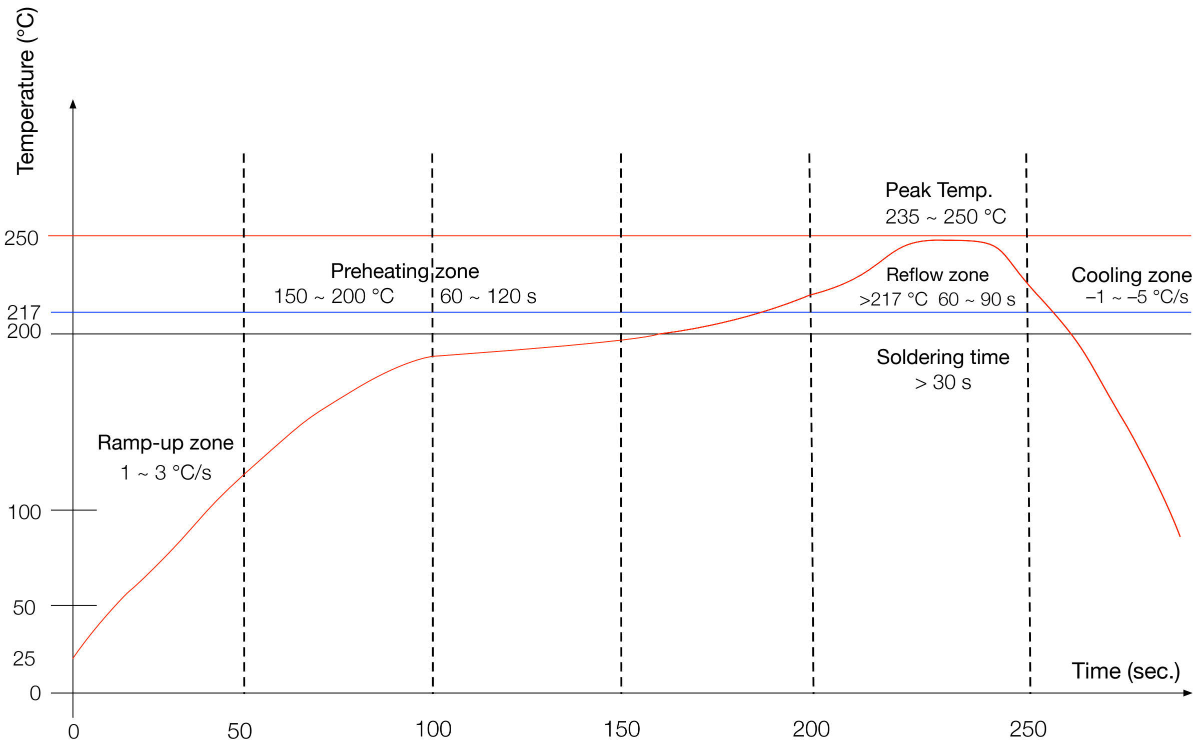
After unpacking, the module must be soldered within 168 hours with the factory conditions 25±5 °C and /60%RH. If the above conditions are not met, the module needs to be baked.

8.2 Electrostatic Discharge (ESD)

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

8.3 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

9 Related Documentation and Resources

Related Documentation

- ESP32-S3 Series Datasheet – Specifications of the ESP32-S3 hardware.
- ESP32-S3 Technical Reference Manual – Detailed information on how to use the ESP32-S3 memory and peripherals.
- ESP32-S3 Hardware Design Guidelines – Guidelines on how to integrate the ESP32-S3 into your hardware product.
- *Certificates*
  http://espressif.com/en/support/documents/certificates
- *Documentation Updates and Update Notification Subscription*
  http://espressif.com/en/support/download/documents

Developer Zone

- *ESP-IDF* and other development frameworks on GitHub.
  http://github.com/espressif
- *ESP32 BBS Forum* – Engineer-to-Engineer (E2E) Community for Espressif products where you can post questions, share knowledge, explore ideas, and help solve problems with fellow engineers.
  http://esp32.com/
- *The ESP Journal* – Best Practices, Articles, and Notes from Espressif folks.
  http://blog.espressif.com/
- See the tabs *SDKs and Demos*, *Apps*, *Tools*, *AT Firmware*.
  http://espressif.com/en/support/download/sdks-demos

Products

- *ESP32-S3 Series SoCs* – Browse through all ESP32-S3 SoCs.
  http://espressif.com/en/products/socs?id=ESP32-S3
- *ESP32-S3 Series Modules* – Browse through all ESP32-S3-based modules.
  http://espressif.com/en/products/modules?id=ESP32-S3
- *ESP32-S3 Series DevKits* – Browse through all ESP32-S3-based devkits.
  http://espressif.com/en/products/devkits?id=ESP32-S3
- *ESP Product Selector* – Find an Espressif hardware product suitable for your needs by comparing or applying filters.
  http://products.espressif.com/#/product-selector?language=en

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Revision History

Date	Version	Release notes
2021-11-16	v0.6	Overall update for chip revision 1
2021-03-30	v0.1	Preliminary release, for chip revision 0

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