ESP32-PICO-MINI-02

Datasheet

Stand-Alone Module with Antenna

Containing Ultra-Low-Power SoC with dual-core CPU

Supporting 2.4 GHz Wi-Fi, Bluetooth®, and Bluetooth® LE

Version 0.5
Espressif Systems

About This Document

This document provides an introduction to the specifications of the ESP32-PICO-MINI-02 module.

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1 Module Overview

1.1 Features

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

Wi-Fi
- 802.11b/g/n
- Bit rate: 802.11n up to 150 Mbps
- A-MPDU and A-MSDU aggregation
- 0.4 μs guard interval support
- Center frequency range of operating channel: 2412 ~ 2484 MHz

Bluetooth®
- Bluetooth V4.2 BR/EDR and Bluetooth LE specification
- Class-1, class-2 and class-3 transmitter
- AFH
- CVSD and SBC

Hardware
- Module interfaces: SD card, UART, SPI, SDIO, I^2C, LED PWM, Motor PWM, I^2S, IR, pulse counter, GPIO, capacitive touch sensor, ADC, DAC, Two-Wire Automotive Interface (TWAI®, compatible with ISO11898-1), Ethernet MAC
- 40 MHz crystal oscillator
- 8 MB SPI flash
- 2 MB PSRAM
- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating temperature range: –40 ~ 85 °C
- Dimensions: Table 1

Certification
- RF certification: SRRC

Test
- Reliablity: HTOL/HTSL/uHAST/TCT/ESD

1.2 Description

ESP32-PICO-MINI-02 is a small-sized powerful Wi-Fi+Bluetooth®+Bluetooth® LE MCU module. It is based on ESP32-PICO-V3-02, a System-in-Package (SiP) device, which itegrates an 8 MB SPI flash, 2 MB SPI Pseudo static RAM (PSRAM) and 40 MHz crystal oscillator. This module targets a wide variety of IoT applications, ranging from home automation, smart building, consumer electronics to industrial control, and it is suitable for intelligent speakers, speech recognition toys, intelligent gateway and Ethernet, etc.

The ordering information of the module is listed as follows:

Table 1: Ordering Information

Module	Chip embedded	Flash	PSRAM	Module dimensions (mm)
ESP32-PICO-MINI-02 (PCB)	ESP32-PICO-V3-02	8 MB	2 MB	13.2 × 16.6 × 2.4
Note: For detailed ordering information, please see *Espressif Product Ordering Information*.				

At the core of the module is the ESP32-PICO-V3-02 sip*. The chip embedded is designed to be scalable and adaptive. There are two CPU cores that can be individually controlled, and the CPU clock frequency is adjustable from 80 MHz to 240 MHz. The chip also has a low-power co-processor that can be used instead of the CPU to save power while performing tasks that do not require much computing power, such as monitoring of peripherals. ESP32 integrates a rich set of peripherals, ranging from SD card interface, capacitive touch sensors, ADC, DAC, Two-Wire Automotive Interface, to Ethernet, high-speed SPI, UART, I^2S, I^2C, etc.

Note:
* For details on the part numbers of the ESP32 family of chips, please refer to the document *ESP32 Datasheet*.

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

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

1.3 Applications

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

Contents

List of Tables

List of Figures

2 Block Diagram

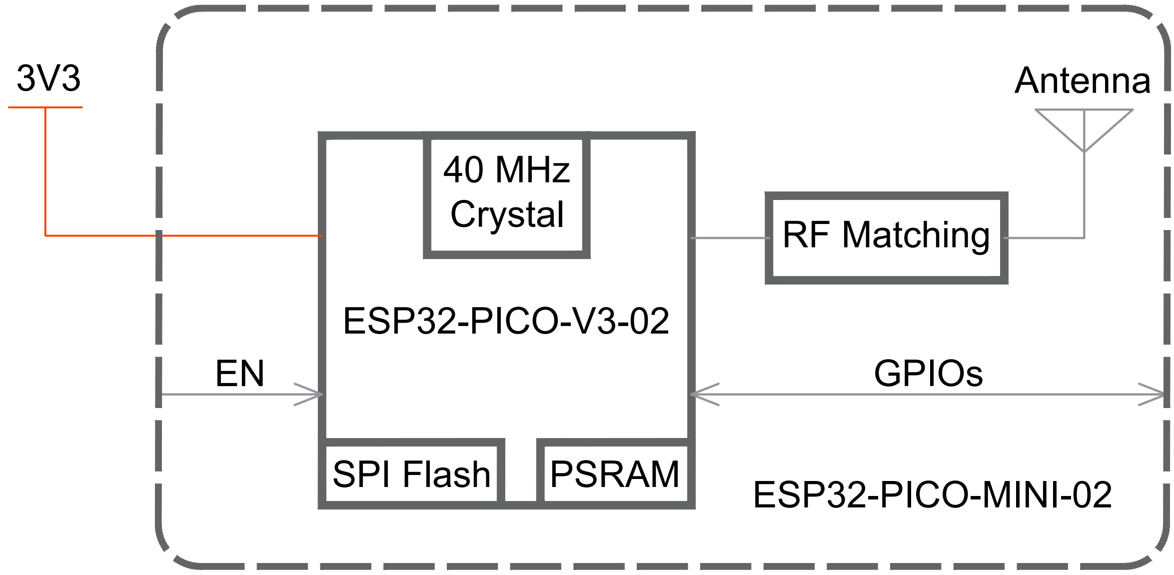


Figure 1: ESP32-PICO-MINI-02 Block Diagram

3 Pin Definitions

3.1 Pin Layout

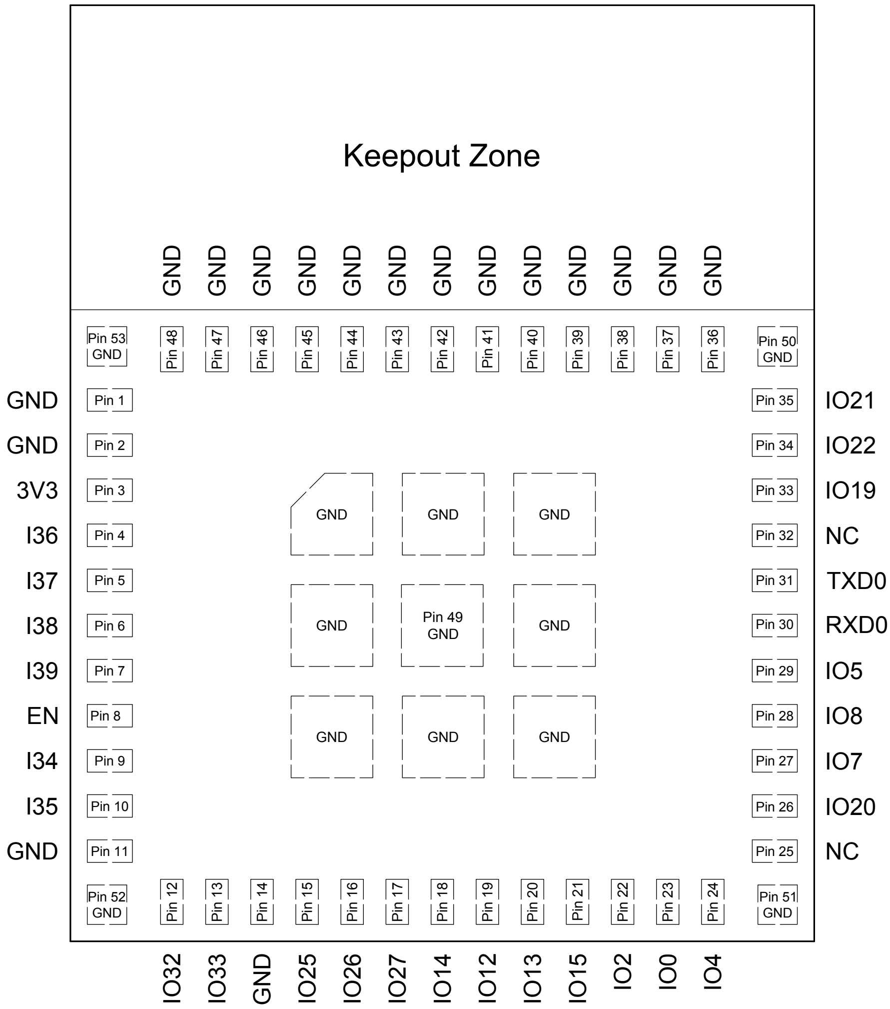


Figure 2: Pin Layout (Top View)

3.2 Pin Description

The module has 53 pins. See pin definitions in Table 2.

Table 2: Pin Definitions

Name	Pin Number	Type	Function
GND	1, 2, 11, 14, 36-53	P	Ground
3V3	3	P	Power supply
I36	4	I	GPIO36, ADC1_CH0, RTC_GPIO0
I37	5	I	GPIO37, ADC1_CH1, RTC_GPIO1
I38	6	I	GPIO38, ADC1_CH2, RTC_GPIO2
I39	7	I	GPIO39, ADC1_CH3, RTC_GPIO3

Name	Pin Number	Type	Function
EN	8	I	High: On; enables the chip Low: Off; the chip powers off Note: Do not leave EN pin floating.
I34	9	I	GPIO34, ADC1_CH6, RTC_GPIO4
I35	10	I	GPIO35, ADC1_CH7, RTC_GPIO5
IO32	12	I/O	GPIO32, XTAL_32K_P (32.768 kHz crystal oscillator input), ADC1_CH4, TOUCH9, RTC_GPIO9
IO33	13	I/O	GPIO33, XTAL_32K_N (32.768 kHz crystal oscillator output), ADC1_CH5, TOUCH8, RTC_GPIO8
IO25	15	I/O	GPIO25, DAC_1, ADC2_CH8, RTC_GPIO6, EMAC_RXD0
IO26	16	I/O	GPIO26, DAC_2, ADC2_CH9, RTC_GPIO7, EMAC_RXD1
IO27	17	I/O	GPIO27, ADC2_CH7, TOUCH7, RTC_GPIO17, EMAC_RX_DV
IO14	18	I/O	GPIO14, ADC2_CH6, TOUCH6, RTC_GPIO16, MTMS, HSPICLK, HS2_CLK, SD_CLK, EMAC_TXD2
IO12	19	I/O	GPIO12, ADC2_CH5, TOUCH5, RTC_GPIO15, MTDI, HSPIQ, HS2_DATA2, SD_DATA2, EMAC_TXD3
IO13	20	I/O	GPIO13, ADC2_CH4, TOUCH4, RTC_GPIO14, MTCK, HSPID, HS2_DATA3, SD_DATA3, EMAC_RX_ER
IO15	21	I/O	GPIO15, ADC2_CH3, TOUCH3, RTC_GPIO13, MTDO, HSPICS0, HS2_CMD, SD_CMD, EMAC_RXD3
IO2	22	I/O	GPIO2, ADC2_CH2, TOUCH2, RTC_GPIO12, HSPIWP, HS2_DATA0, SD_DATA0
IO0	23	I/O	GPIO0, ADC2_CH1, TOUCH1, RTC_GPIO11, CLK_OUT1, EMAC_TX_CLK
IO4	24	I/O	GPIO4, ADC2_CH0, TOUCH0, RTC_GPIO10, HSPIHD, HS2_DATA1, SD_DATA1, EMAC_TX_ER
NC	25	-	-
IO20	26	I/O	GPIO20
IO7	27	I/O	GPIO7, HS1_DATA0, U2RTS, SD_DATA0
IO8	28	I/O	GPIO8, HS1_DATA1, U2CTS, SD_DATA1
IO5	29	I/O	GPIO5, VSPICS0, HS1_DATA6, EMAC_RX_CLK
RXD0	30	I/O	GPIO3, U0RXD, CLK_OUT2
TXD0	31	I/O	GPIO1, U0TXD, CLK_OUT3, EMAC_RXD2
NC	32	-	-
IO19	33	I/O	GPIO19, VSPIQ, U0CTS, EMAC_TXD0
IO22	34	I/O	GPIO22, VSPIWP, U0RTS, EMAC_TXD1
IO21	35	I/O	GPIO21, VSPIHD, EMAC_TX_EN

Notice: * Pins CMD/IO11 and CLK/IO6 are used for connecting the embedded flash, and pins SD2/IO9 and SD3/IO10 are used for connecting embeded PSRAM. These pins are not led out.

3.3 Strapping Pins

ESP32 has five strapping pins, which can be seen in Chapter 5 Schematics:

- MTDI
- GPIO0
- GPIO2
- MTDO
- GPIO5

Software can read the values of these five bits from register ”GPIO_STRAPPING”.

During the chip’s system reset release (power-on-reset, RTC watchdog reset and brownout reset), the latches of the strapping pins sample the voltage level as strapping bits of ”0” or ”1”, and hold these bits until the chip is powered down or shut down. The strapping bits configure the device’s boot mode, the operating voltage of VDD_SDIO and other initial system settings.

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

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

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

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

Table 3: Strapping Pins

Voltage of Internal LDO (VDD_SDIO)					
Pin	Default	3.3 V		1.8 V	
MTDI	Pull-down	0		1	
Booting Mode					
Pin	Default	SPI Boot		Download Boot	
GPIO0	Pull-up	1		0	
GPIO2	Pull-down	Don’t-care		0	
Enabling/Disabling Debugging Log Print over U0TXD During Booting					
Pin	Default	U0TXD Active		U0TXD Silent	
MTDO	Pull-up	1		0	
Timing of SDIO Slave					
Pin	Default	FE Sampling FE Output	FE Sampling RE Output	RE Sampling FE Output	RE Sampling RE Output
MTDO	Pull-up	0	0	1	1
GPIO5	Pull-up	0	1	0	1

Note:

- FE: falling-edge, RE: rising-edge.
- Firmware can configure register bits to change the settings of ”Voltage of Internal LDO (VDD_SDIO)” and ”Timing of SDIO Slave” after booting.
- The built-in flash and PSRAM can only support a power voltage of 3.3 V (output by VDD_SDIO). MTDI should be kept low when the module is powered on.

4 Electrical Characteristics

4.1 Absolute Maximum Ratings

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

Table 4: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
VDD33	Power supply voltage	–0.3	3.6	V
T_{store}	Storage temperature	–40	85	°C

Note:

- Please see Appendix *IO_MUX* in *ESP32 Datasheet* for IO's power domain.

4.2 Recommended Operating Conditions

Table 5: Recommended Operating Conditions

Symbol	Parameter	Min	Typical	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	Operating temperature	–40	-	85	°C
Humidity	Humidity condition	-	-	85	%RH

4.3 DC Characteristics (3.3 V, 25 °C)

Table 6: DC Characteristics (3.3 V, 25 °C)

Symbol	Parameter	Min	Typ	Max	Unit
C_{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}	High-level output voltage	0.8×VDD[1]	-	-	V
V_{OL}	Low-level output voltage	-	-	0.1×VDD[1]	V

<table>
<tr><th>Symbol</th><th colspan="2">Parameter</th><th>Min</th><th>Typ</th><th>Max</th><th>Unit</th></tr>
<tr><td rowspan="3">I_{OH}</td><td rowspan="3">High-level source current (VDD[1] = 3.3 V, V_{OH} >= 2.64 V, output drive strength set to the maximum)</td><td>VDD3P3_CPU power domain [1, 2]</td><td>-</td><td>40</td><td>-</td><td>mA</td></tr>
<tr><td>VDD3P3_RTC power domain [1, 2]</td><td>-</td><td>40</td><td>-</td><td>mA</td></tr>
<tr><td>VDD_SDIO power domain [1, 3]</td><td>-</td><td>20</td><td>-</td><td>mA</td></tr>
<tr><td>I_{OL}</td><td colspan="2">Low-level sink current (VDD[1] = 3.3 V, V_{OL} = 0.495 V, output drive strength set to the maximum)</td><td>-</td><td>28</td><td>-</td><td>mA</td></tr>
<tr><td>R_{PU}</td><td colspan="2">Resistance of internal pull-up resistor</td><td>-</td><td>45</td><td>-</td><td>kΩ</td></tr>
<tr><td>R_{PD}</td><td colspan="2">Resistance of internal pull-down resistor</td><td>-</td><td>45</td><td>-</td><td>kΩ</td></tr>
<tr><td>V_{IL_nRST}</td><td colspan="2">Low-level input voltage of CHIP_PU to power off the chip</td><td>-</td><td>-</td><td>0.6</td><td>V</td></tr>
</table>

Note:

1. Please see Appendix *IO_MUX* in *ESP32 Datasheet* for IO's power domain. VDD is the I/O voltage for a particular power domain of pins.
2. For VDD3P3_CPU and VDD3P3_RTC power domain, per-pin current sourced in the same domain is gradually reduced from around 40 mA to around 29 mA, V_{OH}>=2.64 V, as the number of current-source pins increases.
3. Pins occupied by flash and/or PSRAM in the VDD_SDIO power domain were excluded from the test.

4.4 Current Consumption Characteristics

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

For details on different power modes, please refer to Section *RTC and Low-Power Management* in *ESP32 Datasheet*.

4.4.1 Current Consumption Depending on RF Modes

Table 7: Current Consumption Depending on RF Modes

<table>
<tr><th>Work mode</th><th colspan="2">Description</th><th>Peak (mA)</th></tr>
<tr><td rowspan="6">Active (RF working)</td><td rowspan="4">TX</td><td>802.11b, 20 MHz, 1 Mbps, @19.5 dBm</td><td>368</td></tr>
<tr><td>802.11g, 20 MHz, 54 Mbps, @14 dBm</td><td>258</td></tr>
<tr><td>802.11n, 20 MHz, MCS7, @13 dBm</td><td>248</td></tr>
<tr><td>802.11n, 40 MHz, MCS7, @13 dBm</td><td>250</td></tr>
<tr><td rowspan="2">RX</td><td>802.11b/g/n, 20 MHz</td><td>111</td></tr>
<tr><td>802.11n, 40 MHz</td><td>117</td></tr>
</table>

Note:

- The current consumption measurements are taken with a 3.3 V supply at 25 °C of ambient temperature at the RF port. All transmitter measurements are based on a 100% duty cycle.
- The current consumption figures for in RX mode are for cases when the peripherals are disabled and the CPU idle.

4.5 Wi-Fi RF Characteristics

4.5.1 Wi-Fi RF Standards

Table 8: Wi-Fi RF Standards

Name		Description
Center frequency range of operating channel *note1*		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

Note:

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

4.5.2 Transmitter Characteristics

Table 9: Transmitter Characteristics

Parameter	Rate	Typ	Unit
TX Power *note*	11b, 1 Mbps	19.5	dBm
	11b, 11 Mbps	19.5	
	11g, 6 Mbps	18	
	11g, 54 Mbps	14	
	11n, HT20, MCS0	18	
	11n, HT20, MCS7	13	
	11n, HT40, MCS0	18	
	11n, HT40, MCS7	13	

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

4.5.3 Receiver Characteristics

Table 10: Receiver Characteristics

Parameter	Rate	Typ	Unit
RX Sensitivity	1 Mbps	–97	dBm
	2 Mbps	–94	
	5.5 Mbps	–92	
	11 Mbps	–88	
	6 Mbps	–93	
	9 Mbps	–91	
	12 Mbps	–89	
	18 Mbps	–87	
	24 Mbps	–84	
	36 Mbps	–80	
	48 Mbps	–77	
	54 Mbps	–75	
	11n, HT20, MCS0	–92	
	11n, HT20, MCS1	–88	
	11n, HT20, MCS2	–86	
	11n, HT20, MCS3	–83	
	11n, HT20, MCS4	–80	
	11n, HT20, MCS5	–76	
	11n, HT20, MCS6	–74	
	11n, HT20, MCS7	–72	
	11n, HT40, MCS0	–89	
	11n, HT40, MCS1	–85	
	11n, HT40, MCS2	–83	
	11n, HT40, MCS3	–80	
	11n, HT40, MCS4	–76	
	11n, HT40, MCS5	–72	
	11n, HT40, MCS6	–71	
	11n, HT40, MCS7	–69	
RX Maximum Input Level	11b, 1 Mbps	5	dBm
	11b, 11 Mbps	5	
	11g, 6 Mbps	0	
	11g, 54 Mbps	–8	
	11n, HT20, MCS0	0	
	11n, HT20, MCS7	–8	
	11n, HT40, MCS0	0	
	11n, HT40, MCS7	–8	
Adjacent Channel Rejection	11b, 11 Mbps	35	dB
	11g, 6 Mbps	27	
	11g, 54 Mbps	13	
	11n, HT20, MCS0	27	
	11n, HT20, MCS7	12	
	11n, HT40, MCS0	16	
	11n, HT40, MCS7	7	

4.6 Bluetooth Radio

4.6.1 Receiver – Basic Data Rate

Table 11: Receiver Characteristics – Basic Data Rate

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

4.6.2 Transmitter – Basic Data Rate

Table 12: Transmitter Characteristics – Basic Data Rate

Parameter	Conditions	Min	Typ	Max	Unit
RF transmit power (see note under Table 12)	-	-	0	-	dBm
Gain control step	-	-	3	-	dB
RF power control range	-	–12	-	+9	dBm
+20 dB bandwidth	-	-	0.9	-	MHz
Adjacent channel transmit power	F = F0 ± 2 MHz	-	–55	-	dBm
	F = F0 ± 3 MHz	-	–55	-	dBm
	F = F0 ± > 3 MHz	-	–59	-	dBm
$\Delta f1_{\text{avg}}$	-	-	-	155	kHz
$\Delta f2_{\text{max}}$	-	127	-	-	kHz
$\Delta f2_{\text{avg}}/\Delta f1_{\text{avg}}$	-	-	0.92	-	-
ICFT	-	-	–7	-	kHz
Drift rate	-	-	0.7	-	kHz/50 μs
Drift (DH1)	-	-	6	-	kHz
Drift (DH5)	-	-	6	-	kHz

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

4.6.3 Receiver – Enhanced Data Rate

Table 13: Receiver Characteristics – Enhanced Data Rate

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

4.6.4 Transmitter – Enhanced Data Rate

Table 14: Transmitter Characteristics – Enhanced Data Rate

Parameter	Conditions	Min	Typ	Max	Unit
RF transmit power (see note under Table 12)	-	-	0	-	dBm
Gain control step	-	-	3	-	dB
RF power control range	-	–12	-	+9	dBm
π/4 DQPSK max w0	-	-	–0.72	-	kHz
π/4 DQPSK max wi	-	-	–6	-	kHz
π/4 DQPSK max |wi + w0|	-	-	–7.42	-	kHz
8DPSK max w0	-	-	0.7	-	kHz
8DPSK max wi	-	-	–9.6	-	kHz
8DPSK max |wi + w0|	-	-	–10	-	kHz
π/4 DQPSK modulation accuracy	RMS DEVM	-	4.28	-	%
	99% DEVM	-	100	-	%
	Peak DEVM	-	13.3	-	%
8 DPSK modulation accuracy	RMS DEVM	-	5.8	-	%
	99% DEVM	-	100	-	%
	Peak DEVM	-	14	-	%

Parameter	Conditions	Min	Typ	Max	Unit
In-band spurious emissions	F = F0 ± 1 MHz	-	–46	-	dBm
	F = F0 ± 2 MHz	-	–44	-	dBm
	F = F0 ± 3 MHz	-	–49	-	dBm
	F = F0 +/– > 3 MHz	-	-	–53	dBm
EDR differential phase coding	-	-	100	-	%

4.7 Bluetooth LE Radio

4.7.1 Receiver

Table 15: Receiver Characteristics – BLE

Parameter	Conditions	Min	Typ	Max	Unit
Sensitivity @30.8% PER	-	–94	–93	–92	dBm
Maximum received signal @30.8% PER	-	0	-	-	dBm
Co-channel C/I	-	-	+10	-	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	-	–5	-	dB
	F = F0 – 1 MHz	-	–5	-	dB
	F = F0 + 2 MHz	-	–25	-	dB
	F = F0 – 2 MHz	-	–35	-	dB
	F = F0 + 3 MHz	-	–25	-	dB
	F = F0 – 3 MHz	-	–45	-	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	–10	-	-	dBm
	2000 MHz ~ 2400 MHz	–27	-	-	dBm
	2500 MHz ~ 3000 MHz	–27	-	-	dBm
	3000 MHz ~ 12.5 GHz	–10	-	-	dBm
Intermodulation	-	–36	-	-	dBm

4.7.2 Transmitter

Table 16: Transmitter Characteristics – BLE

Parameter	Conditions	Min	Typ	Max	Unit
RF transmit power	-	-	0	-	dBm
Gain control step	-	-	3	-	dBm
RF power control range	-	–12	-	+9	dBm
Adjacent channel transmit power	F = F0 ± 2 MHz	-	–52	-	dBm
	F = F0 ± 3 MHz	-	–58	-	dBm
	F = F0 ± > 3 MHz	-	–60	-	dBm
$\Delta f1_{\text{avg}}$	-	-	-	265	kHz
$\Delta f2_{\text{max}}$	-	247	-	-	kHz
$\Delta f2_{\text{avg}}/\Delta f1_{\text{avg}}$	-	-	+0.92	-	-
ICFT	-	-	–10	-	kHz
Drift rate	-	-	0.7	-	kHz/50 μs
Drift	-	-	2	-	kHz

5 Schematics

This is the schematics of the module.

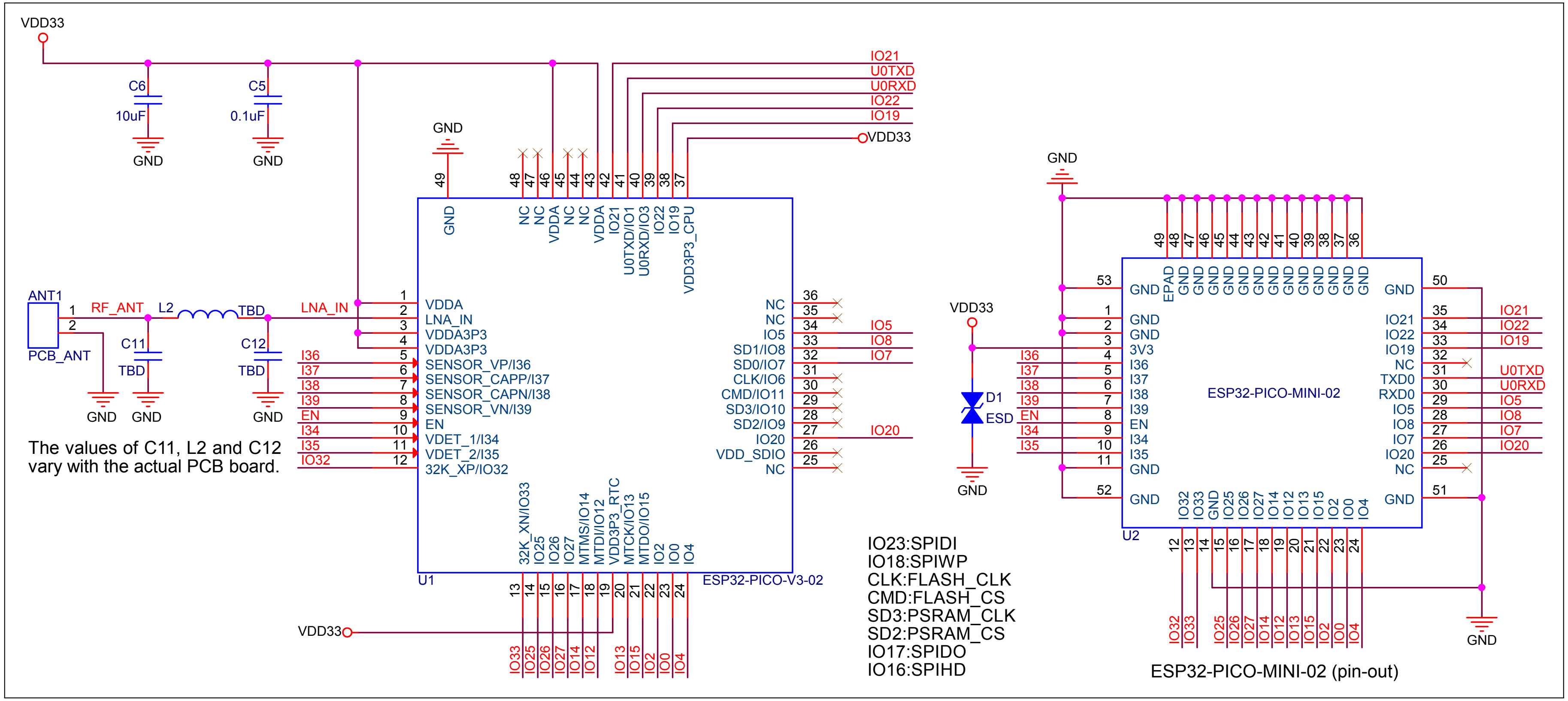


Figure 3: Schematics of ESP32-PICO-MINI-02

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).

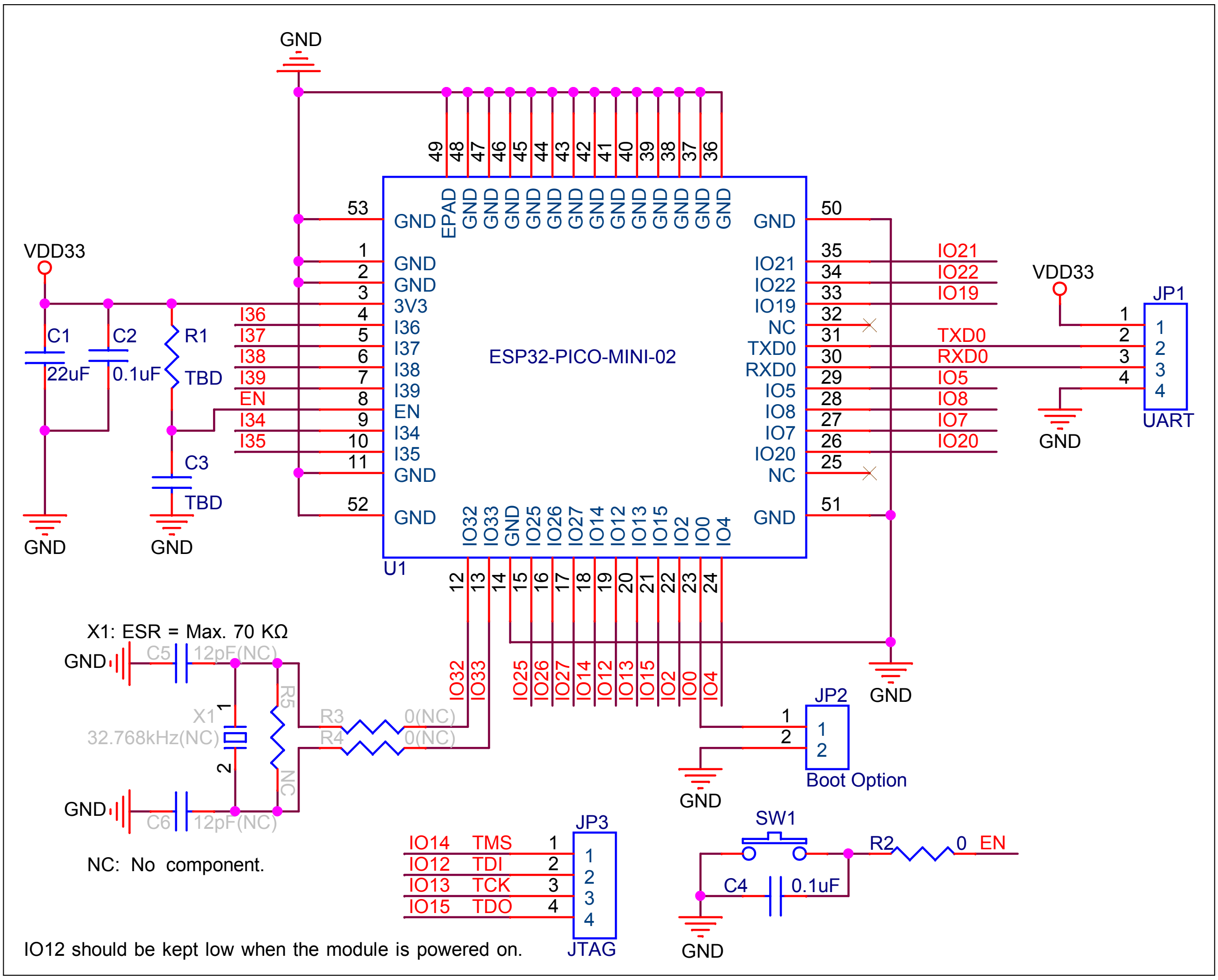


Figure 4: Peripheral Schematics

Note:

- Soldering EPAD to the Ground of the base board is not necessary for a satisfactory thermal performance. If users do want to solder it, they need to ensure that the correct quantity of soldering paste is applied.
- To ensure the power supply to the ESP32 chip during power-up, it is advised to add an RC delay circuit at the EN pin. The recommended setting for the RC delay circuit is usually R = 10 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's power-up and reset sequence timing diagram, please refer to Section *Power Scheme* in *ESP32 Datasheet*.

7 Physical Dimensions and PCB Layout

7.1 Physical Dimensions

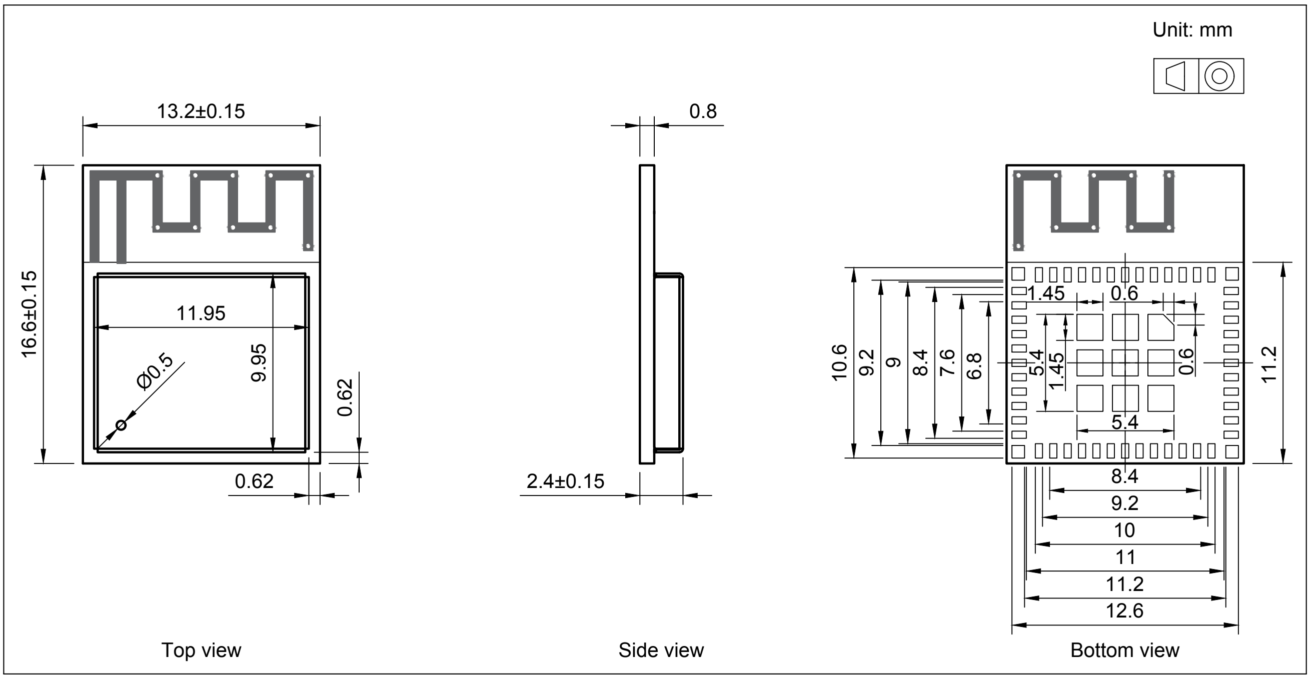


Figure 5: Physical Dimensions

7.2 PCB Layout

7.2.1 Recommended PCB Land Pattern

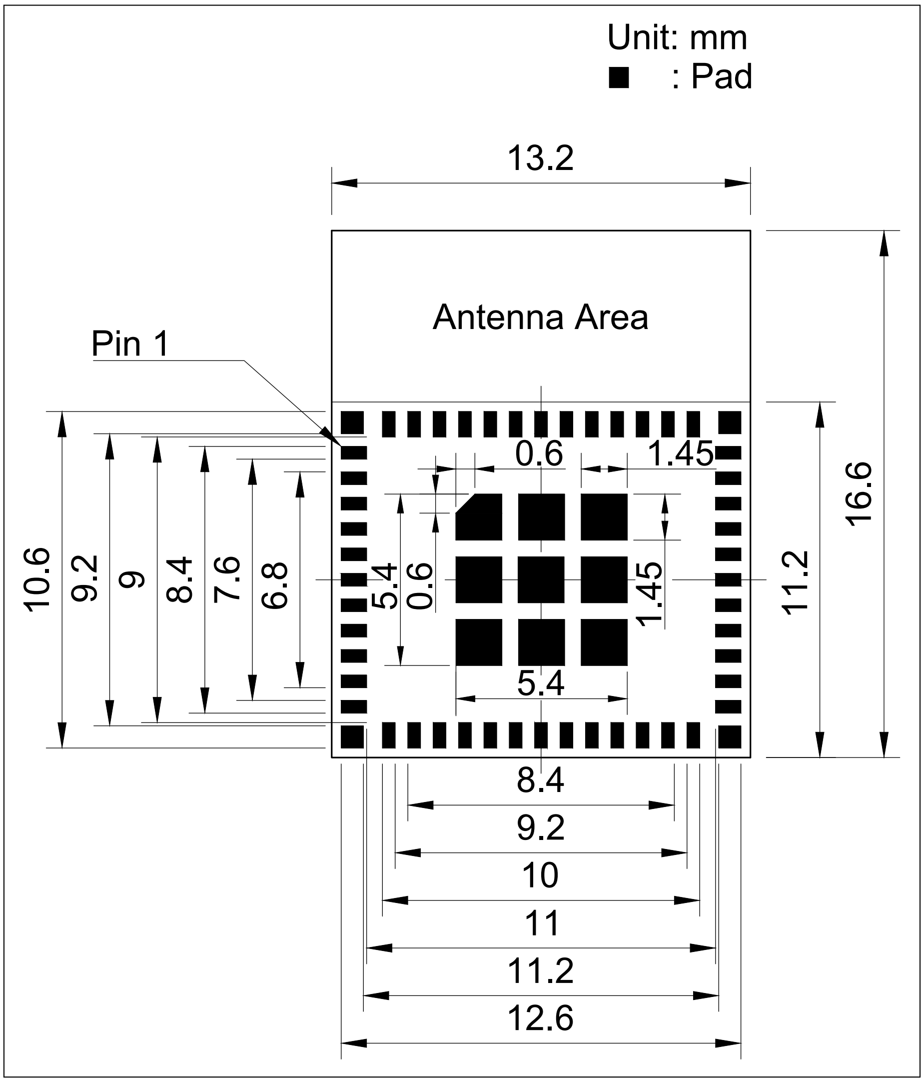


Figure 6: Recommended PCB Land Pattern

7.2.2 PCB Layout Guide

To achieve the optimum RF performance on a device with on-board antenna, please follow the guidelines below.

The module uses an inverted-F antenna design, and the antenna area of the module should have specific placement against the base board. The feed point of the antenna should be as close to the board edge as possible. The PCB antenna area should be placed outside the base board whenever possible while the module be put as close as possible to the edge of the base board.

As is shown in Figure 7, examples 1 and 5 of the module position on the base board are highly recommended, while examples 2, 3, and 4 are not recommended.

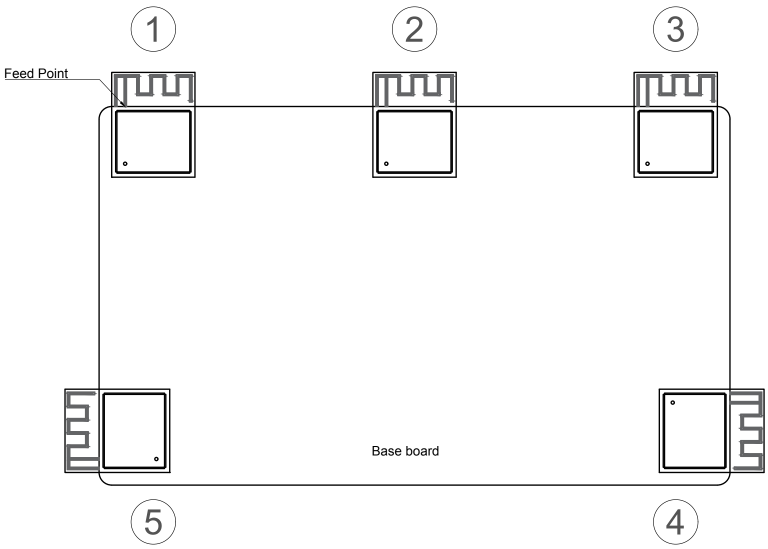


Figure 7: Module Placement on a Base Board

If the positions recommended above are not possible, then please make sure that the module is not covered by any metal shell and that a clearance area (without copper, routing, or components) outside the antenna is large enough, as shown in Figure 8. In addition, if there is base board under the antenna area, it is recommended to cut it off to minimize its impact on the antenna.

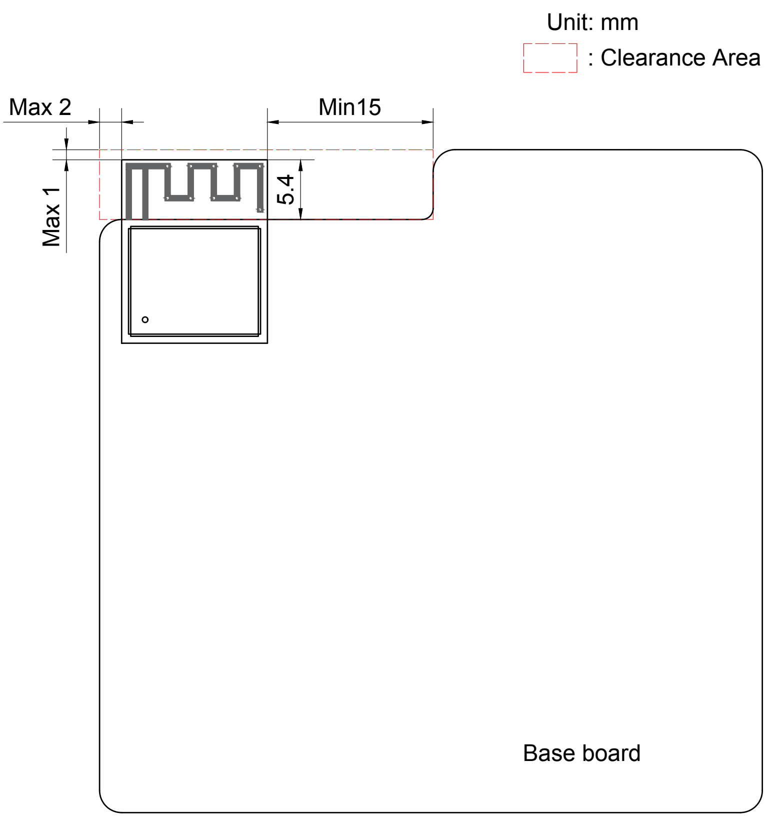


Figure 8: Keepout Zone for Module's Antenna on the Base Board

If the PCB layout does not follow the above rules, then RF throughput and RF range testing should be performed to ensure that the end product performance is satisfactory. When designing an end product, pay attention to the impact of enclosure on the antenna and verify the device performance by making RF verification.

8 Product Handling

8.1 Storage Condition

The products sealed in Moisture Barrier Bag (MBB) should be stored in a noncondensing atmospheric environment of < 40 °C/90% RH.

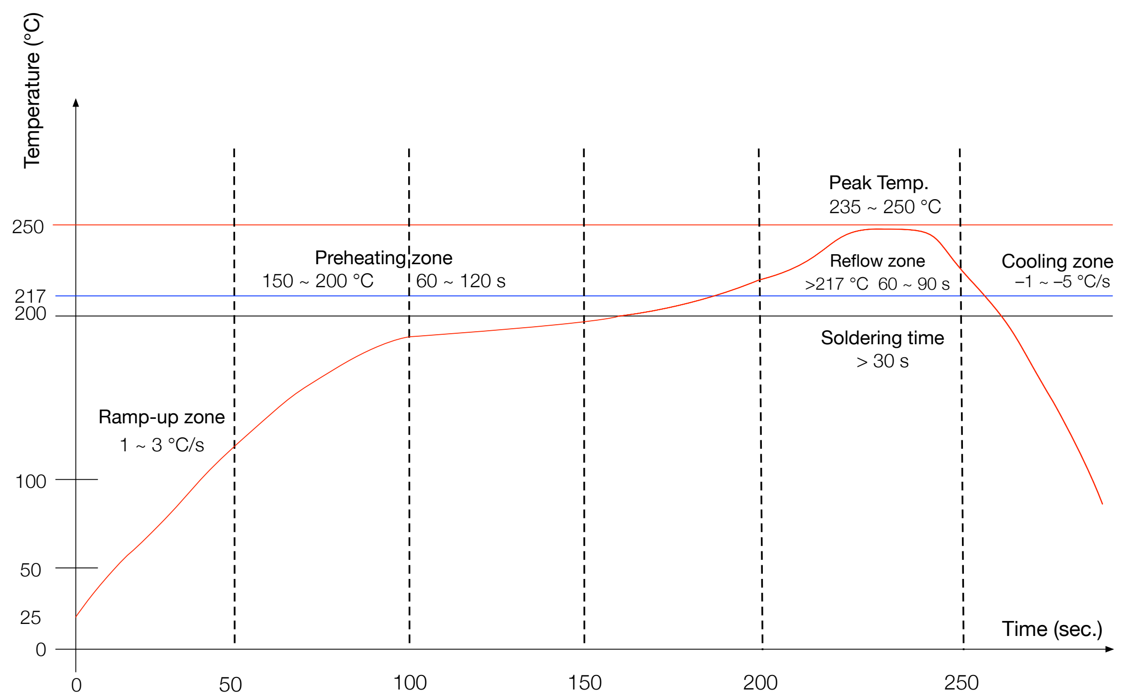
The module is rated at moisture sensitivity level (MSL) 3.

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

8.2 ESD

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

8.3 Reflow Profile



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 9: Reflow Profile

> **Note:**
> Solder the module in a single reflow.

9 MAC Addresses and eFuse

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

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

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

10 Learning Resources

10.1 Must-Read Documents

The following link provides documents related to ESP32.

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

10.2 Must-Have Resources

Here are the ESP32-related must-have resources.

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

- ESP-IDF
  This webpage links users to the official IoT development framework for ESP32.
- ESP32 Resources
  This webpage provides the links to all available ESP32 documents, SDK and tools.

Revision History

Date	Version	Release notes
2021-01-12	V0.5	Updated 4.4 to "All transmitter measurements are based on 100% duty cycle"; Added "Two-Wire Automotive Interface" to hardware in 1.1;
2020-11-18	V0.4	updated C from 0.1 μF to C = 1 μF in the section 4
2020-11-12	V0.3	Updated the module description in section 1.2
2020-09-27	V0.2	Updated the Pin Layout in section 2 Updated Physical Dimensions in section 5 Updated the Recommended PCB Land Pattern in section 7.2.1
2020-08-20	V0.1	Preliminary release