ESP8684-WROOM-03

Datasheet Version 1.1

2.4 GHz Wi-Fi (802.11 b/g/n) and Bluetooth® 5 module
Built around ESP8684 series of SoC, RISC-V single-core microprocessor
2 MB/4 MB flash in chip package
8 GPIOs, rich set of peripherals
On-board PCB antenna

ESP8684-WROOM-03

ESPRESSIF

1 Module Overview

Note:

Check the link or the QR code to make sure that you use the latest version of this document:
https://espressif.com/documentation/esp8684-wroom-03_datasheet_en.pdf

1.1 Features

CPU and On-Chip Memory

- ESP8684H2X or ESP8684H4X embedded, 32-bit RISC-V single-core processor, up to 120 MHz
- 576 KB ROM
- 272 KB SRAM (16 KB for cache)
- In-Package flash (see details in Table 1 *Series Comparison*)
- Access to flash accelerated by cache
- Supports flash in-Circuit Programming (ICP)

Wi-Fi

- IEEE 802.11 b/g/n-compliant
- Center frequency range of operating channel: 2412 ~ 2484 MHz
- Supports 20 MHz bandwidth in 2.4 GHz band
- 1T1R mode with data rate up to 72.2 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)
- 3 × virtual Wi-Fi interfaces
- Simultaneous support for Infrastructure BSS in Station mode, SoftAP mode, Station + SoftAP mode, and promiscuous mode

  Note that when ESP8684 series scans in Station mode, the SoftAP channel will change along with the Station channel

Bluetooth®

- Bluetooth LE: Bluetooth 5.3 certified
- High power mode (20 dBm)
- 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

- Up to 8 GPIOs
- GPIO, SPI, UART, I2C, LED PWM controller, general DMA controller, SAR ADC, temperature sensor, general-purpose timers, system timers, and watchdog timers

Note:
* Please refer to *ESP8684 Series Datasheet* for detailed information about the module peripherals.

Integrated Components on Module

- 26 MHz crystal oscillator

Antenna Options

- On-board PCB antenna

Operating Conditions

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

1.2 Series Comparison

ESP8684-WROOM-03 is a general-purpose Wi-Fi and Bluetooth LE module. The rich set of peripherals and high performance make this module an ideal choice for smart homes, industrial automation, health care, consumer electronics, etc.

ESP8684-WROOM-03 can be vertically soldered to a PCB board via wave soldering. The module has 8 available GPIOs.

ESP8684-WROOM-03 comes with a PCB antenna.

The series comparison for ESP8684-WROOM-03 is as follows:

Table 1: ESP8684-WROOM-03 Series Comparison

Ordering Code	In-Package Flash [1,2]	Chip Revision[3]	Ambient Temp.[4] (°C)	Size[5] (mm)
ESP8684-WROOM-03-H2X	2 MB	v2.0	−40 ~105	15.0 × 17.3 × 2.8
ESP8684-WROOM-03-H4X	4 MB			

[1] The in-package flash supports:
- More than 100,000 program/erase cycles
- More than 20 years data retention time

[2] By default, the SPI flash on the module operates at a maximum clock frequency of 60 MHz and does not support the auto suspend feature. If you need the flash auto suspend feature, please contact us.

[3] Compared to previous chip versions, chip version v2.0 provides an additional 20 KB of SRAM and approximately 100 KB of flash memory (subject to actual application).

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

[5] For details, refer to Section 10 *Module Dimensions*.

The ESP8684H2X chip and the ESP8684H4X chip fall into the same category, namely ESP8684 chip series. ESP8684 integrates a rich set of peripherals including GPIO, SPI, UART, I2C, LED PWM controller, general DMA controller, SAR ADC, temperature sensor, general-purpose timers, system timers, and watchdog timers.

Note:
For more information on ESP8684 chip, please refer to *ESP8684 Series Datasheet*.

1.3 Applications

- Smart Home
- Industrial Automation
- Health Care
- Consumer Electronics
- Smart Agriculture
- POS Machines
- Service Robot
- Generic Low-power IoT Sensor Hubs
- Generic Low-power IoT Data Loggers

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2 Block Diagram

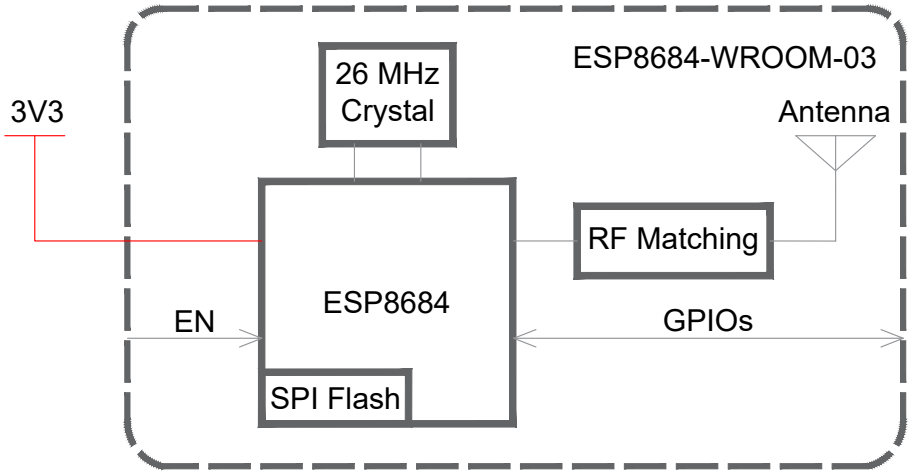

Figure 1: ESP8684-WROOM-03 Block Diagram

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 10 *Module Dimensions*.

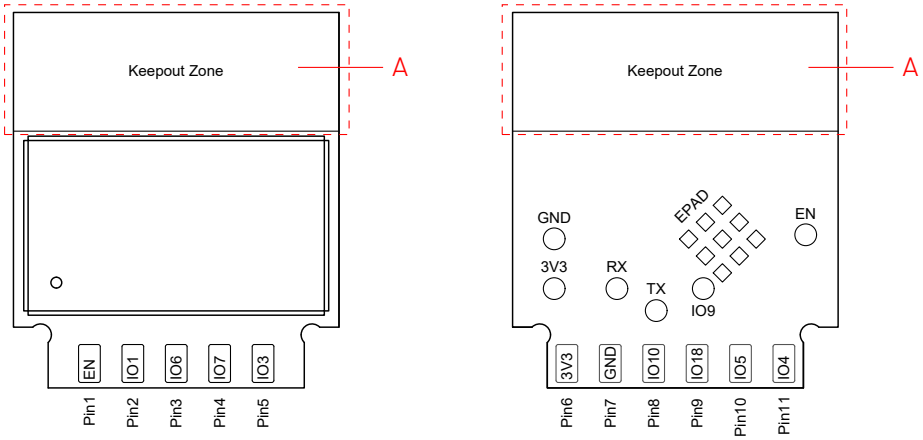

Figure 2: Pin Layout (Top View and Bottom View)

Note A:
The zone marked with dotted lines is the antenna keepout zone. To learn more about the keepout zone for module's antenna on the base board, please refer to *ESP8684 Hardware Design Guidelines* > Section *Positioning a Module on a Base Board*.

3.2 Pin Description

The module has 11 pins. See pin definitions in Table 2 *Pin Description*.

For peripheral pin configurations, please refer to *ESP8684 Series Datasheet*.

Table 2: Pin Definitions

Name	No.	Type[1]	Function
EN	1	I	High: on, enables the chip. Low: off, the chip powers off. Default: internally pulled-up.
IO1	2	I/O/T	GPIO1, ADC1_CH1
IO6	3	I/O/T	GPIO6, FSPICLK, MTCK, LED PWM
IO7	4	I/O/T	GPIO7, FSPID, MTDO, LED PWM
IO3	5	I/O/T	GPIO3, ADC1_CH3, LED PWM
3V3	6	P	Power supply
GND	7	P	Ground
IO10	8	I/O/T	GPIO10, FSPICS0, UART1_RXD

Cont'd on next page

Table 2 – cont'd from previous page

Name	No.	Type[1]	Function
IO18	9	I/O/T	GPIO18, UART1_TXD
IO5	10	I/O/T	GPIO5, FSPIWP, MTDI, LED PWM
IO4	11	I/O/T	GPIO4, ADC1_CH4, FSPIHD, MTMS, LED PWM

Table 3: Test Point Definitions

Name	Type[1]	Function
EN	I	High: on, enables the chip. Low: off, the chip powers off. Default: internally pulled-up
TX	I/O/T	GPIO20, U0TXD
RX	I/O/T	GPIO19 U0RXD
GND	P	Ground
3V3	P	Power supply
IO9	I/O/T	GPIO9

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

Note:
IO0, IO1, IO3, IO5/MTDI pins have low-level glitches during chip power up. See details in section General Purpose Input / Output Interface (GPIO) of ESP8684 Series Datasheet.

4 Boot Configurations

Note:
The content below is excerpted from *ESP8684 Series Datasheet* > Section *Boot Configurations*. For the strapping pin mapping between the chip and modules, please refer to Chapter 8 *Module Schematics*.

The module allows for configuring the following boot parameters through strapping pins and eFuse parameters at power-up or a hardware reset, without microcontroller interaction.

- **Chip boot mode**
  - Strapping pin: GPIO8 and GPIO9
- **ROM message printing**
  - Strapping pin: GPIO8
  - eFuse parameter: EFUSE_UART_PRINT_CONTROL

The default values of all the above eFuse parameters are 0, which means that they are not burnt. Given that eFuse is one-time programmable, once programmed to 1, it can never be reverted to 0. For how to program eFuse parameters, please refer to *ESP8684 Technical Reference Manual* > Chapter *eFuse Controller*.

The default values of the strapping pins, namely the logic levels, are determined by pins' internal weak pull-up/pull-down resistors at reset if the pins are not connected to any circuit, or connected to an external high-impedance circuit.

Table 4: Default Configuration of Strapping Pins

Strapping Pin	Default Configuration	Bit Value
GPIO8	N/A	-
GPIO9	Internal weak pull-up	1

To change the bit values, the strapping pins should be connected to external pull-down/pull-up resistances. If the ESP8684 is used as a device by a host MCU, the strapping pin voltage levels can also be controlled by the host MCU.

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

The timing of signals connected to the strapping pins should adhere to the *setup time* and *hold time* specifications in Table 5 and Figure 3.

Table 5: Description of Timing Parameters 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

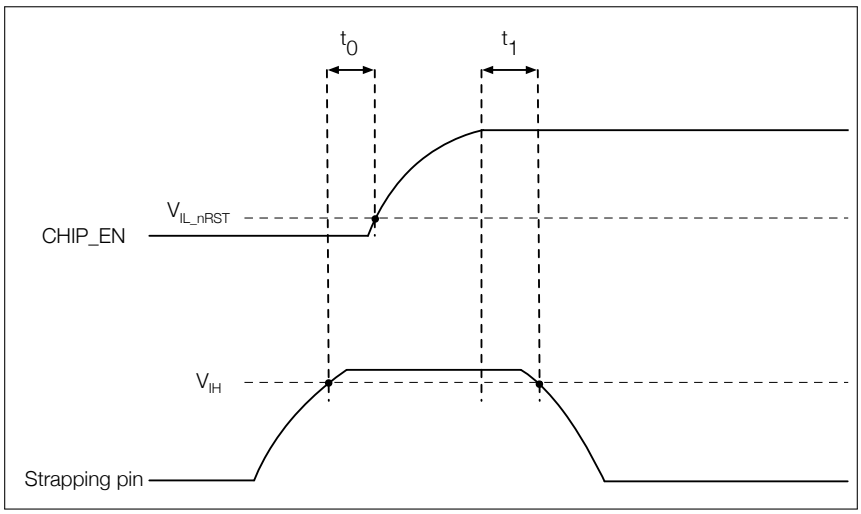

Figure 3: Visualization of Timing Parameters for the Strapping Pins

4.1 Chip Boot Mode Control

GPIO8 and GPIO9 control the boot mode after the reset is released. See Table 6 *Chip Boot Mode Control*.

Table 6: Chip Boot Mode Control

Boot Mode	GPIO9	GPIO8
SPI boot mode	**1**	x[2]
Joint download boot mode[3]	0	1

[1] **Bold** marks the default value and configuration.

[2] Values that have no effect on the result and can therefore be ignored.

[3] Joint Download Boot mode supports UART Download Boot. In addition to SPI Boot and Joint Download Boot modes, ESP8684 also supports SPI Download Boot mode. For details, please see *ESP8684 Technical Reference Manual* > Chapter *Chip Boot Control*.

4.2 ROM Messages Printing Control

EFUSE_UART_PRINT_CONTROL and GPIO8 control ROM messages printing to **UART0** as shown in Table 7 *UART0 ROM Message Printing Control*.

Table 7: UART0 ROM Message Printing Control

UART0 ROM Code Printing	eFuse[1]	GPIO8
Enabled	**0**	Ignored
	1	0
	2	1
Disabled	1	1
	2	0
	3	Ignored

[1] EFUSE_UART_PRINT_CONTROL

5 Peripherals

5.1 Peripheral Overview

ESP8684 integrates a rich set of peripherals including GPIO, SPI, UART, I2C, LED PWM controller, general DMA controller, SAR ADC, temperature sensor, general-purpose timers, system timers, and watchdog timers.

To learn more about on-chip components, please refer to *ESP8684 Series Datasheet* > Section *Functional Description*.

Note:
The content below is sourced from *ESP8684 Series Datasheet* > Section *Peripherals*. Some information may not be applicable to ESP8684-WROOM-03 as not all the IO signals are exposed on the module.
To learn more about peripheral signals, please refer to *ESP8684 Technical Reference Manual* > Section *Peripheral Signal List*.

5.2 Peripheral Description

This section describes the chip's peripheral capabilities, covering connectivity interfaces and on-chip sensors that extend its functionality.

5.2.1 Connectivity Interface

This subsection describes the connectivity interfaces on the chip that enable communication and interaction with external devices and networks.

5.2.1.1 UART Controller

The UART Controller in the ESP8684 chip facilitates the transmission and reception of asynchronous serial data between the chip and external UART devices. It supports two UART interfaces.

Feature List

- Full-duplex asynchronous communication
- Configurable baud rate, up to 2.5 Mbaud
- Automatic baud rate detection of input signals
- Data frame format:
  - a START bit
  - data bits, ranging from 5 ~ 8
  - a parity bit
  - stop bits, whose length can be 1, 1.5, or 2 bits
- Special character AT_CMD detection
- Supported protocols: RS485, IrDA

- UART as wake-up source
- Software and hardware flow control
- Three clock sources that can be divided:
  - 40 MHz PLL_F40M_CLK
  - internal fast RC oscillator RC_FAST_CLK
  - external crystal clock XTAL_CLK
- 512 x 8-bit RAM shared by TX FIFOs and RX FIFOs of the two UART controllers

Pin Assignment

For UART, the pins used can be chosen from any GPIOs via the GPIO Matrix.

For more information about the pin assignment, see *ESP8684 Series Datasheet* > Section *IO Pins* and *ESP8684 Technical Reference Manual* > Chapter *IO MUX and GPIO Matrix*.

5.2.1.2 SPI Controller

ESP8684 series features three SPI interfaces (SPI0, SPI1, and SPI2). SPI0 and SPI1 can be configured to operate in SPI memory mode and SPI2 can be configured to operate in general-purpose SPI mode.

SPI0 and SPI1 are reserved for system use, and only SPI2 is available for users.

Features of SPI0 and SPI1

- Data is transferred in bytes
- Up to four-line STR reads and writes are supported
- The clock frequency is configurable to a maximum of 60 MHz in STR mode

Features of SPI2 General-purpose SPI (GP-SPI)

- It can operate in master and slave modes
- It supports two-line full-duplex communication and single-/two-/four-line half-duplex communication in both master and slave modes
- The host's clock frequency of SPI2 is configurable. The clock frequency is 40 MHz at most
- Data is transferred in bytes
- The clock polarity (CPOL) and phase (CPHA) are also configurable
- The SPI2 interface can connect to GDMA

Pin Assignment

For SPI2, the pins used can be chosen from any GPIOs via the GPIO Matrix.

For more information about the pin assignment, see *ESP8684 Series Datasheet* > Section *IO Pins* and *ESP8684 Technical Reference Manual* > Chapter *IO MUX and GPIO Matrix*.

5.2.1.3 I2C Controller

The I2C Controller supports communication between the master and slave devices using the I2C bus.

Feature List

- one I2C controller operating in master mode
- Standard mode (100 Kbit/s) and fast mode (400 Kbit/s)
- Up to 800 Kbit/s (constrained by SCL and SDA pull-up strength)
- Support for 7-bit and 10-bit addressing, as well as dual address mode
- 7-bit broadcast address

Pin Assignment

For I2C, the pins used can be chosen from any GPIOs via the GPIO Matrix.

For more information about the pin assignment, see *ESP8684 Series Datasheet* > Section *IO Pins* and *ESP8684 Technical Reference Manual* > Chapter *IO MUX and GPIO Matrix*.

5.2.1.4 LED PWM Controller

The LED PWM Controller (LEDC) is designed to generate PWM signals for LED control.

Feature List

- Six independent PWM generators
- Maximum PWM duty cycle resolution of 14 bits
- Four independent timers with 14-bit counters, configurable fractional clock dividers and counter overflow values
- Adjustable phase of PWM signal output
- PWM duty cycle dithering
- Automatic duty cycle fading
- PWM signal output in low-power mode (Light-sleep mode)

Pin Assignment

The pins for the LED PWM Controller can be chosen from any GPIOs via the GPIO Matrix.

For more information about the pin assignment, see *ESP8684 Series Datasheet* > Section *IO Pins* and *ESP8684 Technical Reference Manual* > Chapter *IO MUX and GPIO Matrix*.

5.2.2 Analog Signal Processing

This subsection describes components on the chip that sense and process real-world data.

5.2.2.1 SAR ADC

ESP8684 integrates a Successive Approximation Analog-to-Digital Converter (SAR ADC) to convert analog signals into digital representations.

Feature List

- 12-bit sampling resolution
- Analog voltage sampling from up to five pins
- One DIG ADC controller
  - Provides separate control modules for one-time sampling and multi-channel scanning
  - Supports one-time sampling and multi-channel scanning working simultaneously
  - User-defined scanning sequence in multi-channel scanning mode
  - Provides two filters with configurable filter coefficient
  - Supports threshold monitoring

Pin Assignment

The pins for the SAR ADC are multiplexed with GPIO0 ~ GPIO4, JTAG.

For more information about the pin assignment, see *ESP8684 Series Datasheet* > Section *IO Pins* and *ESP8684 Technical Reference Manual* > Chapter *IO MUX and GPIO Matrix*.

5.2.2.2 Temperature Sensor

The Temperature Sensor in the ESP8684 chip allows for real-time monitoring of temperature changes inside the chip.

Feature List

- Measurement range: −40 °C ~ 125 °C
- Software triggering, wherein the data can be read continuously once triggered
- Configurable temperature offset based on the environment to improve the accuracy
- Adjustable measurement range

6 Electrical Characteristics

6.1 Absolute Maximum Ratings

Stresses above those listed in Table 8 *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 9 *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 8: Absolute Maximum Ratings

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

6.2 Recommended Operating Conditions

Table 9: 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	—	105	°C

6.3 DC Characteristics (3.3 V, 25 °C)

Table 10: 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 a particular power domain of pins.

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

6.4 Current Consumption Characteristics

6.4.1 Current Consumption in Active Mode

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

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

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

Table 11: Current Consumption Depending on RF Modes

Work mode	Description		Peak (mA)
Active (RF working)	TX	802.11b, 1 Mbps, @21 dBm	330
		802.11g, 54 Mbps, @19 dBm	280
		802.11n, HT20, MCS 7, @18 dBm	260
	RX	802.11b/g/n, HT20	65

Note:
The content below is excerpted from *Section Power Consumption in Other Modes* in *ESP8684 Series Datasheet*.

6.4.2 Current Consumption in Other Modes

Table 12: Current Consumption in Low-Power Modes

Work mode	Description	Typ
Light-sleep	—	140
Deep-sleep	Only RTC timer is powered on	5
Power off	CHIP_EN is set to low level, and the chip is powered off	1

Table 13: 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]	80	WFI (Wait-for-Interrupt)	9.4	10.3
		CPU run at full speed	12.1	13.0
	120	WFI (Wait-for-Interrupt)	10.7	11.5
		CPU run at full speed	14.7	15.6

[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.

7 RF Characteristics

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

The RF data is measured at the antenna port, where RF cable is connected, including the front-end loss.

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

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

7.1 Wi-Fi Radio

Table 14: Wi-Fi RF Standards

Name	Description
Center frequency range of operating channel	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: MCS 0-7, 72.2 Mbps (Max)
Antenna type	PCB antenna

7.1.1 Wi-Fi RF Transmitter (TX) Specifications

Target TX power is configurable based on device or certification requirements. The default characteristics are provided in Table 15.

Table 15: TX Power with Spectral Mask and EVM Meeting 802.11 Standards

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	21	—
802.11b, 11 Mbps	—	21	—
802.11g, 6 Mbps	—	21	—
802.11g, 54 Mbps	—	19	—
802.11n, HT20, MCS 0	—	19	—
802.11n, HT20, MCS 7	—	18	—

Table 16: TX EVM Test

Rate	Min (dB)	Typ (dB)	SL[1] (dB)
802.11b, 1 Mbps, @21 dBm	—	–24	–10

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Table 16 – cont'd from previous page

Rate	Min (dB)	Typ (dB)	SL[1] (dB)
802.11b, 11 Mbps, @21 dBm	—	–24	–10
802.11g, 6 Mbps, @21 dBm	—	–23	–5
802.11g, 54 Mbps, @19 dBm	—	–30	–25
802.11n, HT20, MCS 0, @20 dBm	—	–27	–5
802.11n, HT20, MCS 7, @18 dBm	—	–31	–27

[1] SL stands for standard limit value.

7.1.2 Wi-Fi RF Receiver (RX) Specifications

Table 17: RX Sensitivity

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	–98.0	—
802.11b, 2 Mbps	—	–96.5	—
802.11b, 5.5 Mbps	—	–94.0	—
802.11b, 11 Mbps	—	–90.0	—
802.11g, 6 Mbps	—	–94.0	—
802.11g, 9 Mbps	—	–92.0	—
802.11g, 12 Mbps	—	–91.0	—
802.11g, 18 Mbps	—	–89.0	—
802.11g, 24 Mbps	—	–86.0	—
802.11g, 36 Mbps	—	–83.0	—
802.11g, 48 Mbps	—	–78.5	—
802.11g, 54 Mbps	—	–77.0	—
802.11n, HT20, MCS 0	—	–93.0	—
802.11n, HT20, MCS 1	—	–91.0	—
802.11n, HT20, MCS 2	—	–88.0	—
802.11n, HT20, MCS 3	—	–85.0	—
802.11n, HT20, MCS 4	—	–82.0	—
802.11n, HT20, MCS 5	—	–75.0	—
802.11n, HT20, MCS 6	—	–76.0	—
802.11n, HT20, MCS 7	—	–74.0	—

Table 18: 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	—

Cont'd on next page

Table 18 – cont'd from previous page

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

Table 19: 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, MCS 0	—	16	—
802.11n, HT20, MCS 7	—	25	—

7.2 Bluetooth LE Radio

7.2.1 Bluetooth LE RF Transmitter (TX) Specifications

Table 20: Transmitter General Characteristics

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

Table 21: Transmitter Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	-32.0	—	dBm
	F = F0 ± 3 MHz	—	-38.0	—	dBm
	F = F0 ± > 3 MHz	—	-41.0	—	dBm
Modulation characteristics	$\Delta f1_{avg}$	—	249.0	—	kHz
	$\Delta f2_{max}$	—	246.0	—	kHz
	$\Delta f2_{avg}/\Delta f1_{avg}$	—	1.1	—	—
Carrier frequency offset	Max $\lvert f_n \rvert_{n=0,\,1,\,2,\,..k}$	—	2.0	—	kHz
Carrier frequency drift	Max $\lvert f_0 - f_n \rvert_{n=2,\,3,\,4,\,..k}$	—	1.0	—	kHz
	Max $\lvert f_0 - f_1 \rvert$	—	0.5	—	kHz
	Max $\lvert f_n - f_{n-5} \rvert_{n=6,\,7,\,8,\,..k}$	—	1.0	—	kHz

Table 22: Transmitter Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 4 MHz	—	–40.0	—	dBm
	F = F0 ± 5 MHz	—	–43.0	—	dBm
	F = F0 ± > 5 MHz	—	–44.0	—	dBm
Modulation characteristics	$\Delta\ f1_{avg}$	—	498.0	—	kHz
	$\Delta\ f2_{max}$	—	589.0	—	kHz
	$\Delta\ f2_{avg}/\Delta\ f1_{avg}$	—	1.2	—	—
Carrier frequency offset	Max $\lvert f_n \rvert_{n=0,\ 1,\ 2,\ ..k}$	—	1.0	—	kHz
Carrier frequency drift	Max $\lvert f_0 - f_n \rvert_{n=2,\ 3,\ 4,\ ..k}$	—	3.0	—	kHz
	Max $\lvert f_0 - f_1 \rvert$	—	2.4	—	kHz
	Max $\lvert f_n - f_{n-5} \rvert_{n=6,\ 7,\ 8,\ ..k}$	—	1.2	—	kHz

Table 23: Transmitter Characteristics - Bluetooth LE 125 kbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	–32.0	—	dBm
	F = F0 ± 3 MHz	—	–38.0	—	dBm
	F = F0 ± > 3 MHz	—	–41.0	—	dBm
Modulation characteristics	$\Delta\ f1_{avg}$	—	248.0	—	kHz
	$\Delta\ f1_{max}$	—	224.0	—	kHz
Carrier frequency offset	Max $\lvert f_n \rvert_{n=0,\ 1,\ 2,\ ..k}$	—	0.5	—	kHz
Carrier frequency drift	Max $\lvert f_0 - f_n \rvert_{n=1,\ 2,\ 3,\ ..k}$	—	0.7	—	kHz
	Max $\lvert f_0 - f_3 \rvert$	—	0.2	—	kHz
	Max $\lvert f_n - f_{n-3} \rvert_{n=7,\ 8,\ 9,\ ..k}$	—	0.7	—	kHz

Table 24: Transmitter Characteristics - Bluetooth LE 500 kbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	–32.0	—	dBm
	F = F0 ± 3 MHz	—	–38.0	—	dBm
	F = F0 ± > 3 MHz	—	–41.0	—	dBm
Modulation characteristics	$\Delta\ f2_{avg}$	—	273.0	—	kHz
	$\Delta\ f2_{max}$	—	243.0	—	kHz
Carrier frequency offset	Max $\lvert f_n \rvert_{n=0,\ 1,\ 2,\ ..k}$	—	0.5	—	kHz
Carrier frequency drift	Max $\lvert f_0 - f_n \rvert_{n=1,\ 2,\ 3,\ ..k}$	—	0.7	—	kHz
	Max $\lvert f_0 - f_3 \rvert$	—	0.7	—	kHz
	Max $\lvert f_n - f_{n-3} \rvert_{n=7,\ 8,\ 9,\ ..k}$	—	0.2	—	kHz

7.2.2 Bluetooth LE RF Receiver (RX) Specifications

Table 25: Receiver Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–98	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	F = F0 MHz	—	8	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–1	—	dB
	F = F0 – 1 MHz	—	–3	—	dB
	F = F0 + 2 MHz	—	–26	—	dB
	F = F0 – 2 MHz	—	–28	—	dB
	F ≥ F0 + 3 MHz[1]	—	—	—	dB
	F ≤ F0 – 3 MHz	—	–31	—	dB
Image frequency	—	—	–33	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–32	—	dB
	F = F_{image} – 1 MHz	—	–34	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	–23	—	dBm
	2003 MHz ~ 2399 MHz	—	–30	—	dBm
	2484 MHz ~ 2997 MHz	—	–10	—	dBm
	3000 MHz ~ 12.75 GHz	—	–17	—	dBm
Intermodulation	—	—	–31	—	dBm

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz.

Table 26: Receiver Characteristics - Bluetooth LE 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–95	—	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 + 2 MHz	—	–11	—	dB
	F = F0 – 2 MHz	—	–7	—	dB
	F = F0 + 4 MHz[1]	—	—	—	dB
	F = F0 – 4 MHz	—	–30	—	dB
	F ≥ F0 + 6 MHz	—	–35	—	dB
	F ≤ F0 – 6 MHz	—	–29	—	dB
Image frequency	—	—	–35	—	dB
Adjacent channel to image frequency	F = F_{image} + 2 MHz	—	–35	—	dB
	F = F_{image} – 2 MHz[2]	—	—	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	–30	—	dBm
	2003 MHz ~ 2399 MHz	—	–34	—	dBm
	2484 MHz ~ 2997 MHz	—	–19	—	dBm
	3000 MHz ~ 12.75 GHz	—	–28	—	dBm
Intermodulation	—	—	–33	—	dBm

[1] Refer to the value of Image frequency.

[2] Refer to the value of Adjacent channel selectivity C/I when F = F0 + 2 MHz.

Table 27: Receiver Characteristics - Bluetooth LE 125 kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–106	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	F = F0 MHz	—	3	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–7	—	dB
	F = F0 – 1 MHz	—	–5	—	dB
	F = F0 + 2 MHz	—	–35	—	dB
	F = F0 – 2 MHz	—	–34	—	dB
	F ≥ F0 + 3 MHz[1]	—	—	—	dB
	F ≤ F0 – 3 MHz	—	–37	—	dB
Image frequency	—	—	–41	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–43	—	dB
	F = F_{image} – 1 MHz	—	–38	—	dB

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz.

Table 28: Receiver Characteristics - Bluetooth LE 500 kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–102	—	dBm
Maximum received signal @30.8% PER	—	—	8	—	dBm
Co-channel C/I	F = F0 MHz	—	4	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–6	—	dB
	F = F0 – 1 MHz	—	–5	—	dB
	F = F0 + 2 MHz	—	–29	—	dB
	F = F0 – 2 MHz	—	–32	—	dB
	F ≥ F0 + 3 MHz[1]	—	—	—	dB
	F ≤ F0 – 3 MHz	—	–36	—	dB
Image frequency	—	—	–34	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–37	—	dB
	F = F_{image} – 1 MHz	—	–31	—	dB

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz.

8 Module Schematics

This is the reference design of the module.

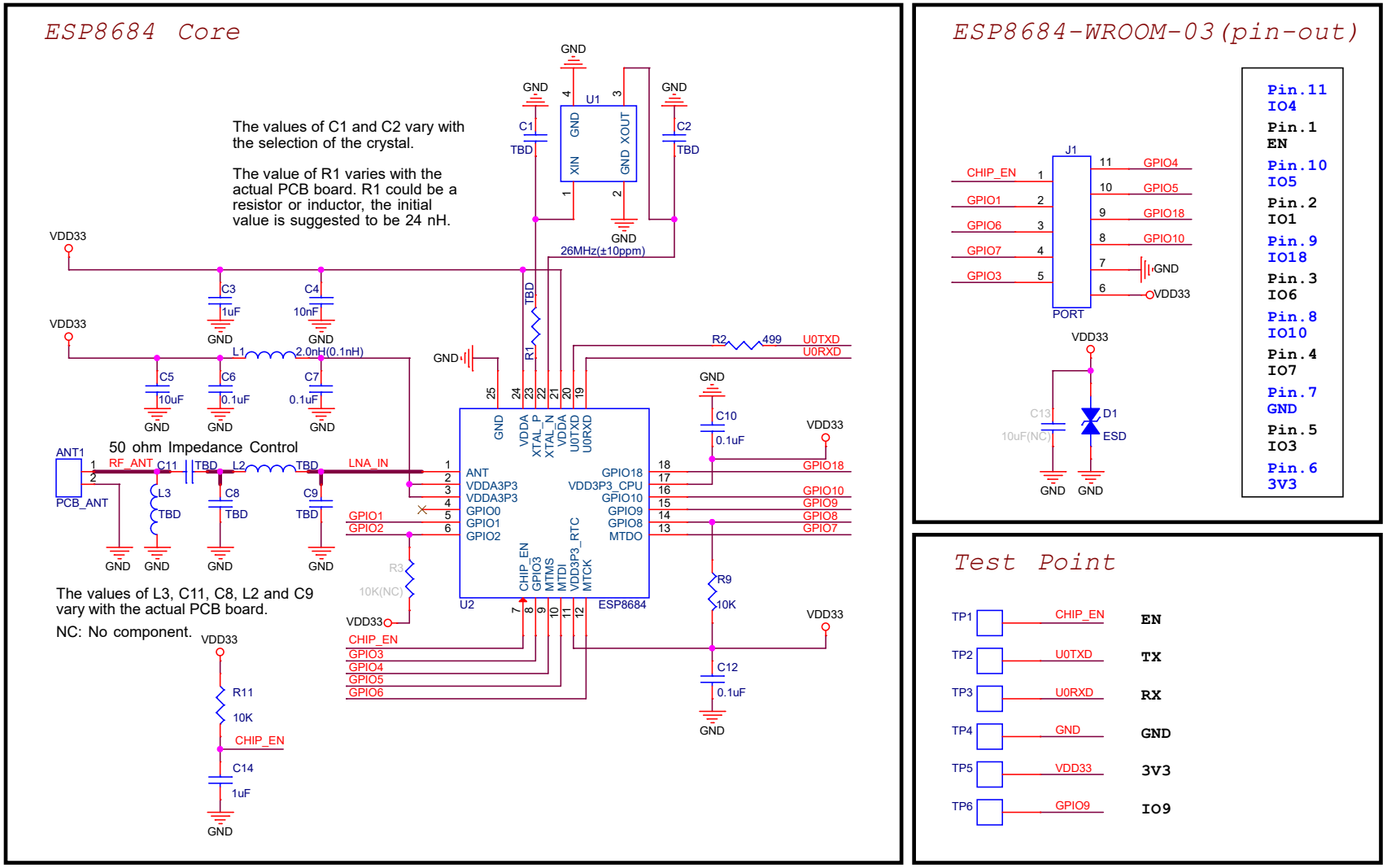

Figure 4: ESP8684-WROOM-03 Schematics

9 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).

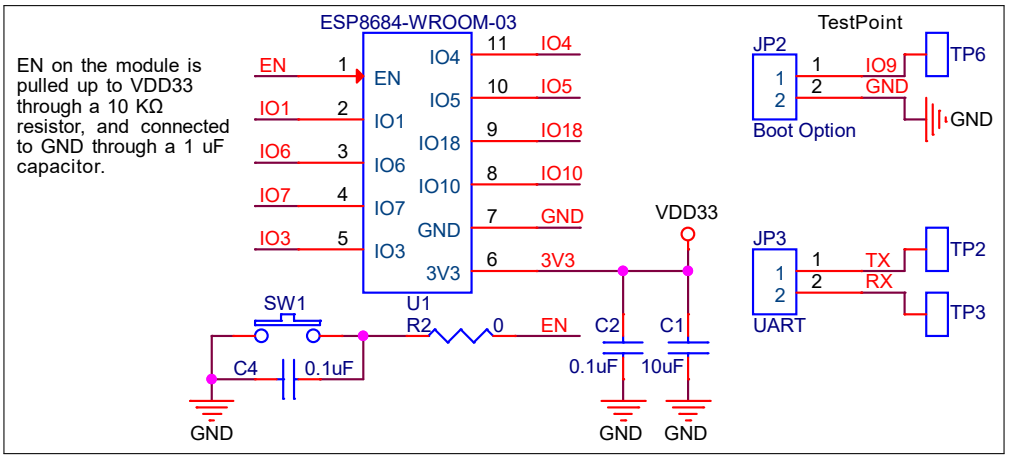

Figure 5: Peripheral Schematics

- To ensure that the power supply to the ESP8684 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 (such RC delay circuit has already been built into the module). 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 ESP8684's power-up and reset sequence timing diagram, please refer to Section *Power Scheme* in *ESP8684 Series Datasheet*.

10 Module Dimensions

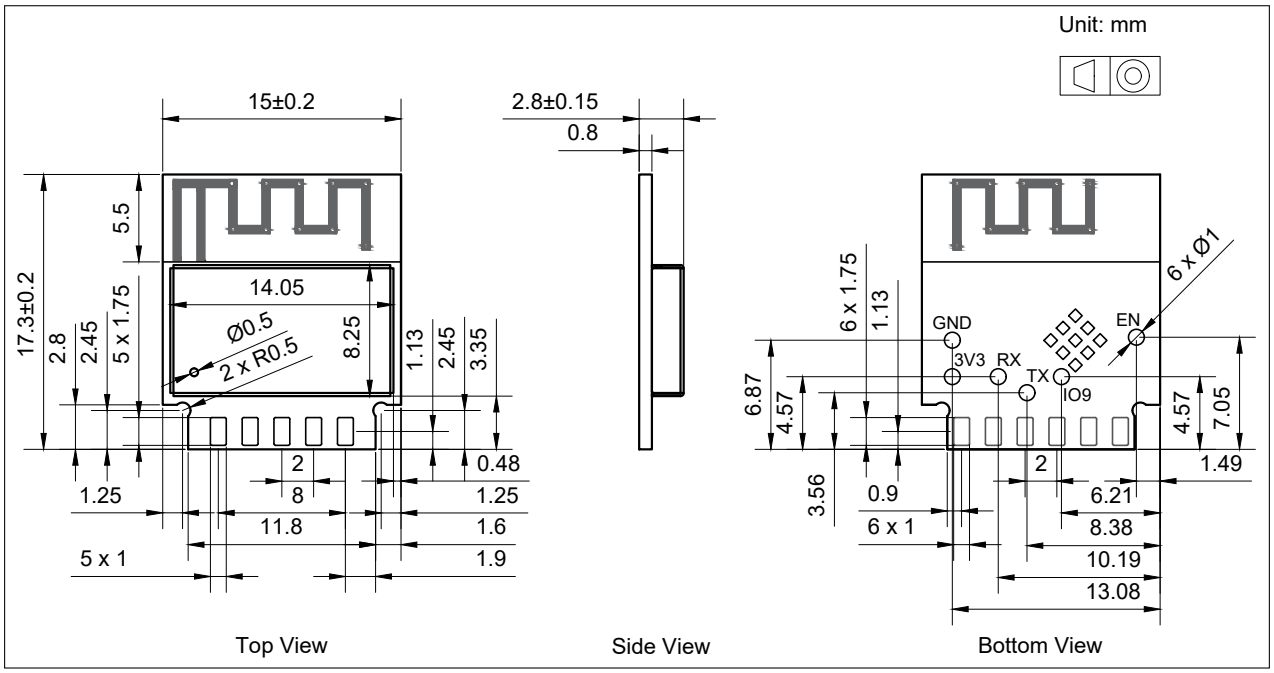

Figure 6: Physical Dimensions

Note:

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

11 PCB Layout Recommendations

11.1 PCB Land Pattern

This section provides the following resources for your reference:

- Figure for the recommended PCB land pattern with all the dimensions needed for PCB design. See Figure 7 *Recommended PCB Land Pattern*.
- Source file of the recommended PCB land pattern to measure dimensions not covered in Figure 7. You can view the source files for ESP8684-WROOM-03 with Autodesk Viewer.

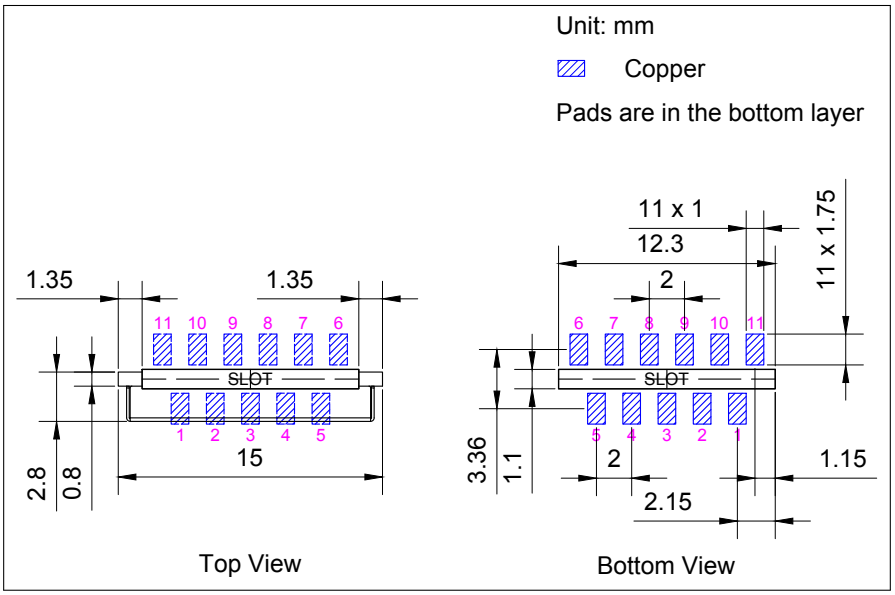

Figure 7: Recommended PCB Land Pattern

11.2 Module Placement for PCB Design

If module-on-board design is adopted, attention should be paid while positioning the module on the base board. The interference of the base board on the module's antenna performance should be minimized.

For details about module placement for PCB design, please refer to *ESP8684 Hardware Design Guidelines* > Section *Positioning a Module on a Base Board*.

12 Product Handling

12.1 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.

12.2 Electrostatic Discharge (ESD)

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

12.3 Wave Profile

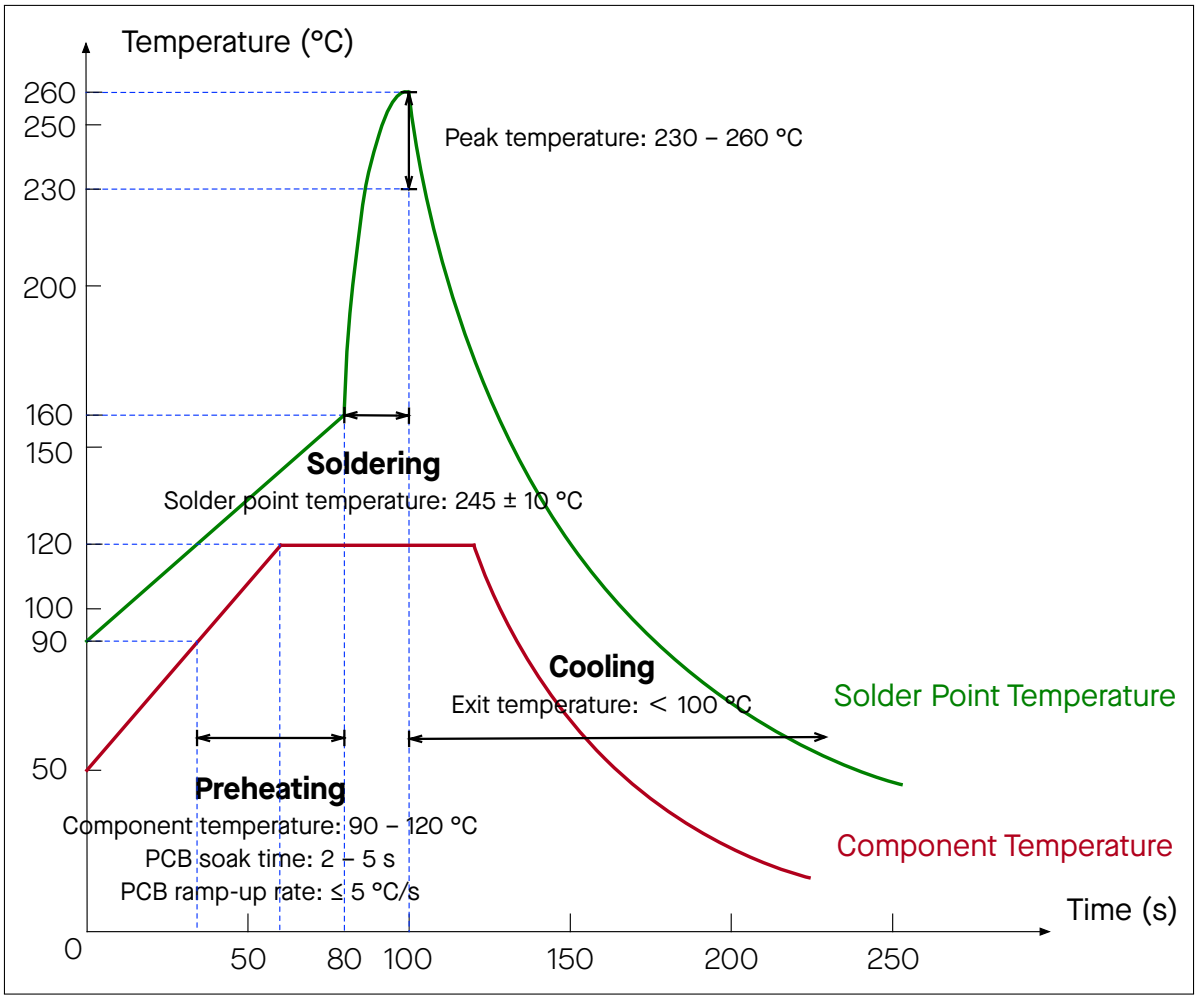

Figure 8: Wave Soldering Profile

12.4 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**.

Related Documentation and Resources

Related Documentation

- ESP8684 Series Datasheet – Specifications of the ESP8684 hardware.
- ESP8684 Technical Reference Manual – Detailed information on how to use the ESP8684 memory and peripherals.
- ESP8684 Hardware Design Guidelines – Guidelines on how to integrate the ESP8684 into your hardware product.
- ESP8684 Series SoC Errata – Descriptions of known errors in ESP8684 series of SoCs.
- *Certificates*
  https://espressif.com/en/support/documents/certificates
- *ESP8684 Product/Process Change Notifications (PCN)*
  https://espressif.com/en/support/documents/pcns?keys=ESP8684
- *Documentation Updates and Update Notification Subscription*
  https://espressif.com/en/support/download/documents

Developer Zone

- ESP-IDF Programming Guide for ESP8684 – 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

- *ESP8684 Series SoCs* – Browse through all ESP8684 SoCs.
  https://espressif.com/en/products/socs?id=ESP8684
- *ESP8684 Series Modules* – Browse through all ESP8684-based modules.
  https://espressif.com/en/products/modules?id=ESP8684
- *ESP8684 Series DevKits* – Browse through all ESP8684-based devkits.
  https://espressif.com/en/products/devkits?id=ESP8684
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  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
2025-03-14	v1.1	Updated Table 15 *Wi-Fi RF Transmitter (TX) Specifications* and Table 16 *Wi-Fi RF Transmitter (TX) Specifications*
2025-01-20	v1.0	• Table 1 *Series Comparison*: – Update the Ordering Code from ESP8684-WROOM-03-H2 to ESP8684-WROOM-03-H2X – Update the Ordering Code from ESP8684-WROOM-03-H4 to ESP8684-WROOM-03-H4X
2024-12-23	v0.9	• In Chapter 1 *Module Overview*, renamed 1.2 *Description* to 1.2 *Series Comparison* • In Chapter 3.1 *Pin Layout*, Add annotations to the antenna keepout zone • Improved the structure, formatting, and wording in: – Chapter 4 *Boot Configurations* (use to be Section 3.3 *Strapping Pins*) – Chapter 6 *Electrical Characteristics* and 7 *RF Characteristics* (used to be Chapter 4 *Electrical Characteristics*) – Chapter 10 *Module Dimensions* and 11 *PCB Layout Recommendations* (used to be Chapter 7 *Physical Dimensions and PCB Land Pattern*) • Added Chapter 5 *Peripherals* • Added Chapter 11.2 *Module Placement for PCB Design*
2024-01-09	v0.8	Added an item about Bluetooth 5.3 certification in Section 1.1 *Features*.
2023-06-25	v0.7	• Updated 3.1 *Pin Layout* • Updated 2 *Pin Description* • Updated 8 *Module Schematics* • Updated 9 *Peripheral Schematics* • Updated 10 *Module Dimensions*
2022-12-27	v0.6	Added a note to table 2 *Pin Description*
2022-08-22	v0.5	Preliminary release
2022-04-15	v0.1	Draft

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