ESP32-C2module
Datasheet

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
12 GPIOs
On-board PCB antenna

ESP32-C2 module

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-C1 module_datasheet_en.pdf

1.1 Features

CPU and On-Chip Memory

- ESP8684H2 or ESP8684H4 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 *ESP8684-C1 module 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/RXA-MPDU,TX/RXA-MSDU
- Immediate Block ACK
- Fragmentation and defragmentation
- Transmit opportunity (TXOP)
- Automatic Beacon monitoring (hardware TSF)
- 3 x 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
- 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

- GPIO, SPI, UART, I2C, LED PWM controller, general DMA controller, temperature sensor, SAR ADC, timers and watchdog

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 Description

ESP8684-C1 module 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-C1 module can be vertically soldered to a PCB board via wave soldering. The module has 8 available GPIOs.

ESP8684-C1 module comes with a PCB antenna.

The series comparison for ESP8684-C1 module is as follows:

Table 1: ESP8684-C1 module Series Comparison

Ordering Code	In-Package flash	Ambient Temp.[1] (°C)	Size[2] (mm)
ESP8684-C1 module -H2	2 MB	-40 ~105	15.0x17.3x2.8
ESP8684-C1 module -H4	4 MB		

[1] Ambient temperature specifies the recommended temperature range ofthe environment immediately outside the Espressif module.

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

The ESP8684H2 chip and the ESP8684H4 chip fall into the same category, namely ESP8684 chip series. ESP8684 integrates a rich set of peripherals including UART, I2C, LED PWM controller, general DMA controller, temperature sensor, and SAR ADC etc.

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

1.3 Applications

- Smart Home
  - -Light control
  - -Smart button
  - -Smart plug
  - -Indoor positioning
- Industrial Automation
  - -Industrial robot
  - -Industrial field bus
- Consumer Electronics
  - -Smart watch and bracelet
  - -Over-the-top (OTT) devices
  - -Logger toys and proximity sensing toys
- Health Care
  - -Health monitor
  - -Baby monitor
- Smart Agriculture
  - -Smart greenhouse
  - -Smart irrigation
  - -Agriculture robot
- Retail and Catering
  - -POS machines
  - -Service robot

• Generic Low-power loT Sensor Hubs

• Generic Low-power IoT Data Loggers

Contents

List of Tables

3.2 Pin Description

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

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
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, UOTXD
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: out put; 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.

3.3 Strapping Pins

Note:

The content below is excerpted from Section Strapping Pins in *ESP8684 Series Datasheet*. For the strapping pin mapping between the chip and modules, please refer to Chapter 5 *Module Schematics*.

ESP8684 series has two strapping pins:

- GPIO8
- GPIO9

Software can read the values of GPIO8 and GPIO9 from GPIO_STRAPPING field in GPIO_STRAP_REG register. For register description, please refer to Section GPIO Matrix Register Summary in *ESP8684 Technical Reference Manual*.

During the chip's 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.

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

To change the strapping bit values, you can apply the external pull-down/pull-up resistances, or use the host MCU's GPIOs to control the voltage level of these pins when powering on ESP8684.

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

Table 4 lists detailed booting configurations of the strapping pins.

Table 4: Strapping Pins

Booting Mode [1]			
Pin	Default	SPI Boot	Download Boot
GPIO8	N/A	Don't care	1
GPIO9	Internal weak pull-up	1	0
Enabling/Disabling ROM Messages Print During Booting			
Pin	Default	Functionality	
GPIO8	N/A	When the value of eFuse field EFUSE_UART_PRINT_CONTROL is 0 (default), print is enabled and not controlled by GPIO8. 1, if GPIO8 is 0, print is enabled; if GPIO8 is1, it is disabled. 2, if GPIO8 is 0, print is disabled; if GPIO8 is1,it is enabled. 3, print is disabled and not controlled by GPIO8.	

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

Figure 3 shows the setup and hold times for the strapping pins before and after the CHIP_EN signal goes high. Details about the parameters are listed in Table 5.

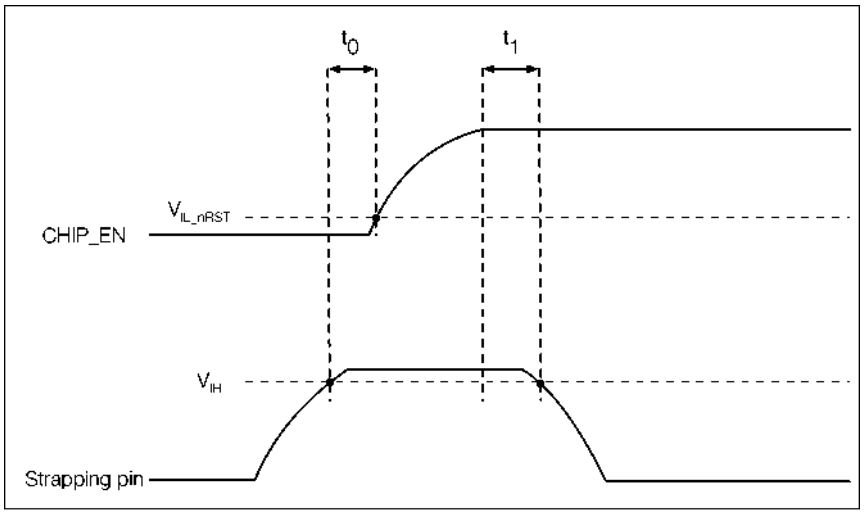

Figure 3: Setup and Hold Times for the Strapping Pins

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

Parameter	Description	Min (ms)
to	Setup time before CHIP EN goes from low to high	0
ti	Hold time after CHIP EN 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 Table 6 *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under Table 7 *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
IVDD	Current delivered by external power supply	0.5	—	—	A
TA	Operating ambient temperature	-40	—	105	°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
VIH	High-level input voltage	0.75 x VDD[1]	—	VDD[1]+ 0.3	V
VIL	Low-level input voltage	-0.3	—	0.25 x VDD[1]	V
\IH	High-level input current	—	—	50	nA
IIL	Low-level input current	—	—	50	nA
VOH [2]	High-level output voltage	0.8 x VDD[1]	—	—	V
VOL[2]	Low-level output voltage	—	—	0.1 x VDD[1]	V
I_{OH}	High-level source current (VDD1= 3.3 V *VOH* >= 2.64 *M* PAD DRIVER = 3)	—	40	—	mA
IOL	Low-level sink current (VDD1= 3.3 V VOL = 0.495 *M* PAD DRIVER = 3)	—	28	—	mA
RPU	Pull-up resistor	—	45	—	kQ
RPD	Pull-down resistor	—	45	—	kQ

$V_{IH\ nRST}$	Chip reset release voltage	0.75 x VDD[1]	—	VDD[1]+ 0.3	V
$V_{IL\ nRST}$	Chip reset voltage	-0.3	—	0.25 x 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.

4.4 Current Consumption Characteristics

Owing to the use of advanced power-management technologies, the module can switch between different power modes.

For details on different power modes, please refer to Section *Low-Power Management* in *ESP8684 Series Datasheet*.

Reminder to DZY: link to datasheet when it is published.

Table 9: 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, MCS7, @18dBm	260
	RX	802.11b/g/n, HT20	65

[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 in RX mode are for cases where the peripherals are disabled and the CPU idle.

Table 10: Current Consumption in Low-Power Modes

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

Table 11: Current Consumption in Modem-sleep Mode

Work mode	Frequency (MHz)	Description	Typ[1] (mA)	Typ[2] (mA)
Modem-sleep[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] Current consumption when all peripheral clocks are **disabled**.

[2] Current consumption when all peripheral clocks are **enabled**. In practice, the current consumption might be different depending on which peripherals are enabled.

[3] In Modem-sleep mode, Wi-Fi is clock gated, and the current 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.

4.5 Wi-Fi Radio

4.5.1 Wi-Fi RF Standards

Table12: Wi-Fi RF Standards

Name	Description
Center frequency range of operating channel[1]	2412 ~2484 MHz
Wi-Fi wireless standard	IEEE 802.11b/g/n
Data rate (20 MHz)	11b: 1,2, 5.5 and 11 Mbps 11g: 6, 9, 12, 18, 24, 36, 48, 54 Mbps 11n: MCS 0-7, 72.2 Mbps (Max)
Antenna type	PCB antenna

[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 Wi-Fi RF Transmitter (TX) Specifications

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

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

Rate	Min (dBm)	Np (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, MCS0	_	20	_
802.11n, HT20, MCS7	_	18	_

Table14: TX EVM Test

Rate	Min (dB)	Typ (dB)	SL[1] (dB)
802.11b, 1 Mbps, @21 dBm	_	-24	-10
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, MCS0, @20 dBm	_	-25	-5
802.11n, HT20, MCS7, @18dBm	_	-31	-27

[1] SL stands for standard limit value.

4.5.3 Wi-Fi RF Receiver (RX) Specifications

Table 15: RX Sensitivity

Rate	Min (dBm)	NP (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, MCS0	_	-93.0	_
802.11n, HT20, MCS 1	_	-91.0	_
802.11n, HT20, MCS2	_	-88.0	_
802.11n, HT20, MCS3	_	-85.0	_
802.11n, HT20, MCS4	_	-82.0	_
802.11n, HT20, MCS5	_	-75.0	_
802.11n, HT20, MCS6	_	-76.0	_
802.11n, HT20, MCS7	_	-74.0	_

Table 16: Maximum RX Level

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

Table 17: RX Adjacent Channel Rejection

Rate	Min (dB)	Typ (dB)	Max (dB)
802.11b, 1 Mbps	_	35	_
802.11b, 11 Mbps	_	35	_

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Table 17 - cont'd from previous page

Rate	Min (dB)	Typ (dB)	Max (dB)
802.11g, 6 Mbps		31	_
802.11g, 54 Mbps		20	_
802.11n, HT20, MCS0	_	16	_
802.11n, HT20, MCS7	_	25	_

4.6 Bluetooth LE Radio

4.6.1 Bluetooth LE RF Transmitter (TX) Specifications

Table 18: Transmitter General Characteristics

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

Table 19: Transmitter Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0±2 MHz	—	-32.0	—	dBm
	F = F0±3 MHz	_	-38.0	_	dBm
	F = F0±>3 MHz	_	-41.0	_	dBm
Modulation characteristics	△ f 1avg	_	249.0	_	kHz
	△ f 2max	_	246.0	_	kHz
	△ f 2avg/^ f 1avg	_	1.1	_	_
Carrier frequency offset	MaX |fn|n=Q, 1, 2, ..k	_	2.0	_	kHz
Carrier frequency drift	MaX |fQ — fn|n=2, 3, 4, ..k	—	1.0	—	kHz
	Max |fo — fi|	_	0.5	_	kHz
	MaX |fn — fn—5 |n=6, 7, 8, ..k	—	1.0	—	kHz

Table 20: 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	△ f 1avg	—	498.0	—	kHz
	△ f 2max	_	589.0	_	kHz
	△ f 2avg/^ f 1avg	_	1.2	—	—
Carrier frequency offset	MaX |fn|n=Q, 1, 2, ..k	_	1.0	—	kHz

Cont'd on next page

Table 20 - cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
Carrier frequency drift	MaX $f_{n\n=2, 3, 4, ..k}$		3.0	_	kHz
	Max \fo — fi\		2.4	_	kHz
	MaX \f$_n$ — f$_n$—5\n=6, 7, 8, ..*k*	_	1.2	—	kHz

Table 21: 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	△f1avg	—	248.0	—	kHz
	△ f 】max	—	224.0	—	kHz
Carrier frequency offset	MaX \f$_n$\n=0, 1, 2, ..*k*	—	0.5	—	kHz
Carrier frequency drift	MaX \f$_0$ - f$_n$\n=1, 2, 3, ..*k*	—	0.7	—	kHz
	Max \fo — f3\	—	0.2	—	kHz
	MaX \f$_n$ — f$_n$—3\n=7, 8, 9, ..*k*	—	0.7	—	kHz

Table 22: 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	△ f 2avg	—	273.0	—	kHz
	△ f 2maX	—	243.0	—	kHz
Carrier frequency offset	MaX \f$_n$\n=0, 1, 2, ..*k*	—	0.5	—	kHz
Carrier frequency drift	MaX \f^0 - fn\n=1, 2, 3, ..*k*	—	0.7	—	kHz
	MaX \fo — f3\	—	0.7	—	kHz
	MaX \f$_n$ — f$_n$—3\n=7, 8, 9, ..*k*	—	0.2	—	kHz

4.6.2 Bluetooth LE RF Receiver (RX) Specifications

Table 23: Receiver Characteristics - Bluetooth LE 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-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

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Table 23 - cont'd from previous page

Parameter	Description	Min	Typ	Max	Unit
	F > F0 + 3 MHz(1)	—	—	—	dB
	F < F0-3MHz	—	—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 24: 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 — 6MHz	—	—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 25: 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

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	—	-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 < F0-3MHz	—	-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 26: 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 < F0-3MHz	—	-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 MH

7 Physical Dimensions and PCB Land Pattern

7.1 Physical Dimensions

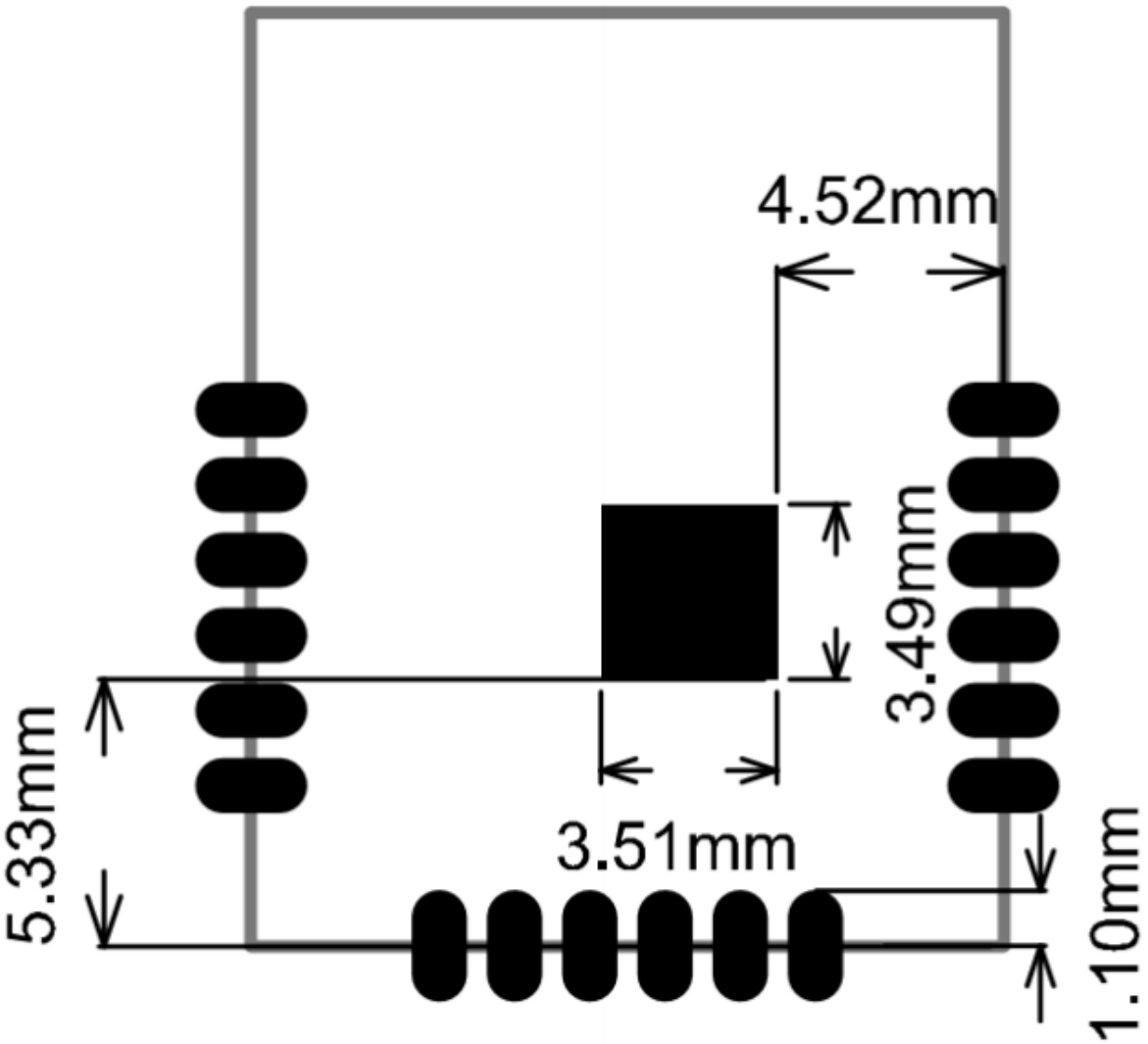


Figure 6: Physical Dimensions

Note:
For information about tape, reel, and product marking, please refer to *EspressifModule Packaging Information*.

7.2 Recommended 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*.

Figure -4-1 Module Size (reverse projection view)

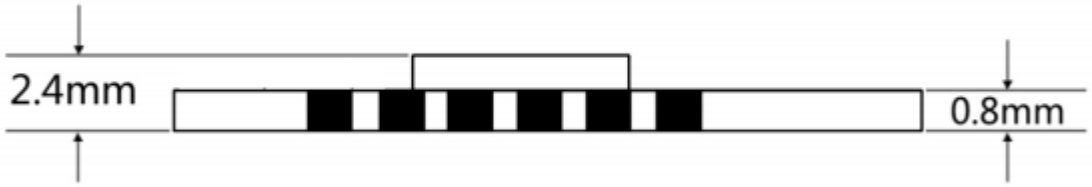


Figure -5 Module Size (Side View)

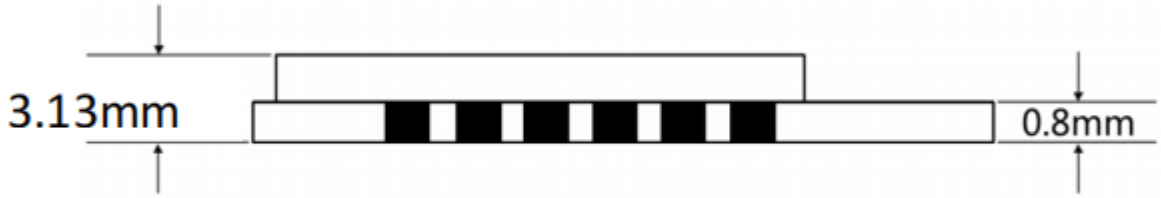


Figure -6 Module Size - shieldingcase (Side View)

the source files for module with Autodesk Viewer.

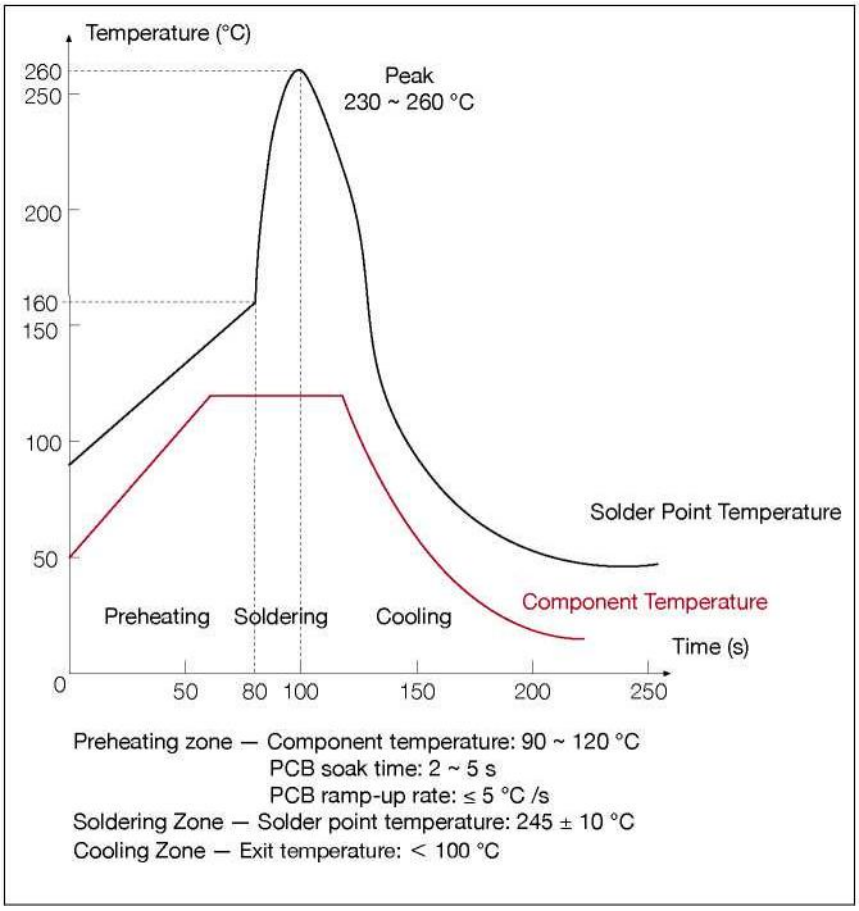
8.1 Storage Conditions

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 Soldering Profil



- 8.3.1 Wave Profile

Figure 8: Wave Soldering Profile

8.4 Ultrasonic Vibration

Avoid exposing Espressif modules to vibration from ultrasonic equipment, such as ultrasonic welders or ultrasonic cleaners. This vibration may induce resonance in the in-module crystal and lead to its malfunction or even failure. As a consequence, the module may stop working or its performance may deteriorate.

FCC MODULAR APPROVAL INFORMATION EXAMPLES for Manual

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference.
(2) This device must accept any interference received, including interference that may cause undesired operation.

CAUTION: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

OEM INTEGRATION INSTRUCTIONS:
This device is intended only for OEM integrators under the following conditions:

The module must be installed in the host equipment such that 20cm is maintained between the antenna and users, and the transmitter module may not be co-located with any other transmitter or antenna. The module shall be only used with the internal on-board antenna that has been originally tested and certified with this module. External antennas are not supported. As long as these 3 conditions above are met, further transmitter test will not be required.

However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.). The end-product may need Verification testing, Declaration of Conformity testing, a Permissive Class II Change or new Certification. Please involve a FCC certification specialist in order to determine what will be exactly applicable for the end-product.

Validity of using the module certification:
In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization for this module in combination with the host equipment is no longer considered valid and the FCC ID of the module cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization. In such cases, please involve a FCC certification specialist in order to determine if a Permissive Class II Change or new Certification is required.

Upgrade Firmware:
The software provided for firmware upgrade will not be capable to affect any RF parameters as certified for the FCC for this module, in order to prevent compliance issues.

End product labeling:
This transmitter module is authorized only for use in device where the antenna may be installed such that 20cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: “Contains FCC ID: 2AVENESP32-C2”.

Information that must be placed in the end user manual:

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual.

“CAUTION : Exposure to Radio Frequency Radiation.
Antenna shall be mounted in such a manner to minimize the potential for human contact during normal operation. The antenna should not be contacted during operation to avoid the possibility of exceeding the FCC radio frequency exposure limit.

Requirement per KDB996369 D03

2.2 List of applicable FCC rules

List the FCC rules that are applicable to the modular transmitter. These are the rules that specifically establish the bands of operation, the power, spurious emissions, and operating fundamental frequencies. DO NOT list compliance to unintentional-radiator rules (Part 15 Subpart B) since that is not a condition of a module grant that is extended to a host manufacturer. See also Section 2.10 below concerning the need to notify host manufacturers that further testing is required.3

Explanation: This module meets the requirements of FCC part 15C(15.247).

2.3 Summarize the specific operational use conditions

Describe use conditions that are applicable to the modular transmitter, including for example any limits on antennas, etc. For example, if point-to-point antennas are used that require reduction in power or compensation for cable loss, then this information must be in the instructions. If the use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer's instruction manual. In addition, certain information may also be needed, such as peak gain per frequency band and minimum gain, specifically for master devices in 5 GHz DFS bands.

Explanation: The EUT has a PCB Antenna, and the antenna use a permanently attached antenna which is not replaceable.

2.4 Limited module procedures

If a modular transmitter is approved as a "limited module," then the module manufacturer is responsible for approving the host environment that the limited module is used with. The manufacturer of a limited module must describe, both in the filing and in the installation instructions, the alternative means that the limited module manufacturer uses to verify that the host meets the necessary requirements to satisfy the module limiting conditions. A limited module manufacturer has the flexibility to define its alternative method to address the conditions that limit the initial approval, such as: shielding, minimum signaling amplitude, buffered modulation/data inputs, or power supply regulation. The alternative method could include that the limited module manufacturer reviews detailed test data or host designs prior to giving the host manufacturer approval.

This limited module procedure is also applicable for RF exposure evaluation when it is necessary to demonstrate compliance in a specific host. The module manufacturer must state how control of the product into which the modular transmitter will be installed will be maintained such that full compliance of the product is always ensured. For additional hosts other than the specific host originally granted with a limited module, a Class II permissive change is required on the module grant to register the additional host as a specific host also approved with the module.

Explanation: The module is not a limited module.

2.5 Trace antenna designs

For a modular transmitter with trace antenna designs, see the guidance in Question 11 of KDB Publication 996369 D02 FAQ – Modules for Micro-Strip Antennas and traces. The integration information shall include for the TCB review the integration instructions for the following aspects:

layout of trace design, parts list (BOM), antenna, connectors, and isolation requirements.

a) Information that includes permitted variances (e.g., trace boundary limits, thickness, length, width, shape(s), dielectric constant, and impedance as applicable for each type of antenna);

b) Each design shall be considered a different type (e.g., antenna length in multiple(s) of frequency, the wavelength, and antenna shape (traces in phase) can affect antenna gain and must be considered);

c) The parameters shall be provided in a manner permitting host manufacturers to design the printed circuit (PC) board layout;

d) Appropriate parts by manufacturer and specifications;

e) Test procedures for design verification; and

f) Production test procedures for ensuring compliance.

The module grantee shall provide a notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

Explanation: Yes, The module with trace antenna designs, and This manual has been shown the layout of trace design, antenna, connectors, and isolation requirements.

2.6 RF exposure considerations

It is essential for module grantees to clearly and explicitly state the RF exposure conditions that permit a host product manufacturer to use the module. Two types of instructions are required for RF exposure information: (1) to the host product manufacturer, to define the application conditions (mobile, portable – xx cm from a person's body); and (2) additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).

Explanation: This module complies with FCC RF radiation exposure limits set forth for an uncontrolled environment, This equipment should be installed and operated with a minimum distance of 20cm between the radiator and your body." This module is designed to comply with the FCC statement, FCC ID is: 2AVENESP32-C2.

2.7 Antennas

A list of antennas included in the application for certification must be provided in the instructions. For modular transmitters approved as limited modules, all applicable professional installer instructions must be included as part of the information to the host product manufacturer. The antenna list shall also identify the antenna types (monopole, PIFA, dipole, etc. (note that for example an "omni-directional antenna" is not considered to be a specific "antenna type")).

For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product. The module manufacturers shall provide a list of acceptable unique connectors.

Explanation: The EUT has a Chip Antenna, and the antenna use a permanently attached antenna which is unique.

2.8 Label and compliance information

Grantees are responsible for the continued compliance of their modules to the FCC rules. This includes advising host product manufacturers that they need to provide a physical or e-label stating "Contains FCC ID" with their finished product. See Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748.

Explanation: The host system using this module, should have label in a visible area indicated the following texts: "Contains FCC ID: 2AVENESP32-C2"

2.9 Information on test modes and additional testing requirements5

Additional guidance for testing host products is given in KDB Publication 996369 D04 Module Integration Guide. Test modes should take into consideration different operational conditions for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.

The grantee should provide information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host.

Grantees can increase the utility of their modular transmitters by providing special means, modes, or instructions that simulates or characterizes a connection by enabling a transmitter. This can greatly simplify a host manufacturer's determination that a module as installed in a host complies with FCC requirements.

Explanation: Top band can increase the utility of our modular transmitters by providing instructions that simulates or characterizes a connection by enabling a transmitter.

2.10 Additional testing, Part 15 Subpart B disclaimer

The grantee should include a statement that the modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Explanation: The module without unintentional-radiator digital circuity, so the module does not require an evaluation by FCC Part 15 Subpart B. The host shoule be evaluated by the FCC Subpart B.