ESPC5-12

Product Specification

2.4&5 GHz Wi-Fi 6 & BLE5.0 & 802.15.4 Coexistence Module

Version: 1.0 Date: July.05, 2025

Features

- General
  - Chip: ESP32-C5HF4
  - Module Size:16mm x 24mm x 3mm
  - RISC-V single-core microprocessor 240MHz
  - 320KB ROM
  - 384KB HP SRAM+16KB LP SRAM
- Wi-Fi Features
  - Wi-Fi 2.4&5 GHz, 1T1R
  - IEEE 802.11 b/g/n/ax-compliant
  - Center frequency range of operating channel: 2412 ~ 2484 MHz, 5180 ~ 5885MHz
  - 1T1R mode with data rate up to 150 Mbps
  - 20&40 MHz bandwidth (11ac 20MHz only)
  - TX/RX A-MPDU, TX/RX A-MSDU
  - Immediate Block ACK
  - 802.11 mc FTM
- Bluetooth Features
  - Bluetooth® 5 (LE), Bluetooth mesh
  - Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
  - Advertising extensions
  - Multiple advertisement sets
  - Channel selection algorithm #2
  - LE Power Control
- IEEE 802.15.4
  - Compliant with IEEE 802.15.4-2015 protocol
  - OQPSK PHY in 2.4 GHz band
  - Data rate: 250 Kbps
  - Thread 1.3
  - ZigBee 3.0
- Peripheral Interfaces
  - GPIO * 19;
  - I2C;
  - I2S;
  - SDIO;
  - CAN FD;
  - SPI;
  - EN;
  - MCPWM;
  - ADC;
  - LED PWM;
- Working Temperature: -40℃~125℃

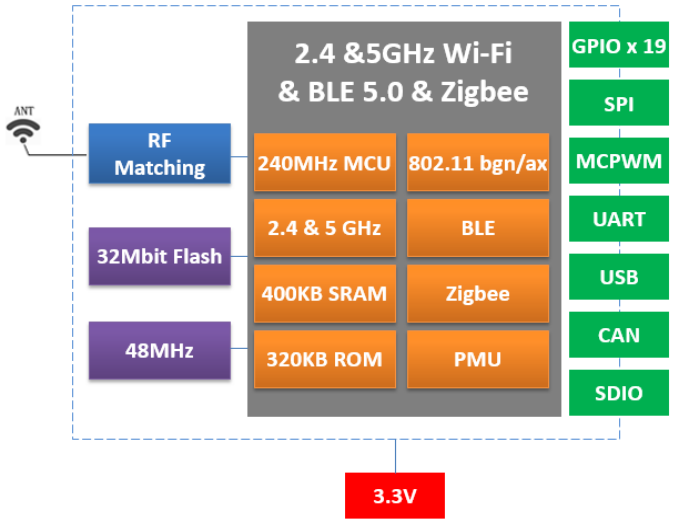
Applications

- Serial transparent transmission;
- Wi-Fi prober;
- Smart power plug/Smart LED light/Smart home;
- Camera product;
- Sensor networks;
- Over-the-top (OTT) devices;
- Wireless location system beacon;
- Industrial field bus;

Module Type

Name	Flash	PSRAM	Antenna
ESPC5-12-H4	32M bit	-	PCB

Module Structure



Update Record

Date	Version	Update
2025-07-05	V1.0	First released

Table of Contents

1. Introduction

ESPC5-12 Wi-Fi6 2.4G&5 GHz and BLE coexistence Module is a highly integrated single-chip low power 802.11b/g/n/ax Wireless LAN (WLAN) network controller. It combines a 240MHz CPU, WLAN MAC, a 1T1R capable WLAN baseband, RF, and Bluetooth in a single chip. It also provides a bunch of configurable GPIO, which are configured as digital peripherals for different applications and control usage.

ESPC5-12 integrates rich peripherals, including SPI, parallel IO, ADC, UART, I2C, I2S, RMT (TX/RX), LED pulse width modulation, USB serial port, JTAG controller, MCPWM, SDIO2.0 slave controller, GDMA, Twai ®controller, on-chip JTAG debugging function, event task matrix. And up to 19 GPIO and so on.

ESPC5-12 includes an IEEE Standard 802.15.4 subsystem that integrates PHY and MAC layer. It supports various software stacks including Thread, ZigBee, Matter, HomeKit, MQTT and so on.

ESPC5-12 module uses ESP32-C5 as Wi-Fi and BLE coexistence SOC chip.

ESPC5-12 module integrates internal memories for complete Wi-Fi protocol functions. The embedded memory configuration also provides convenient application developments.

ESPC5-12 module supports the standard IEEE802.11 b/g/n/ax protocol and the complete TCP/IP protocol stack. User can use it to add the Wi-Fi function for the installed devices, and also can be viewed as an independent network controller.

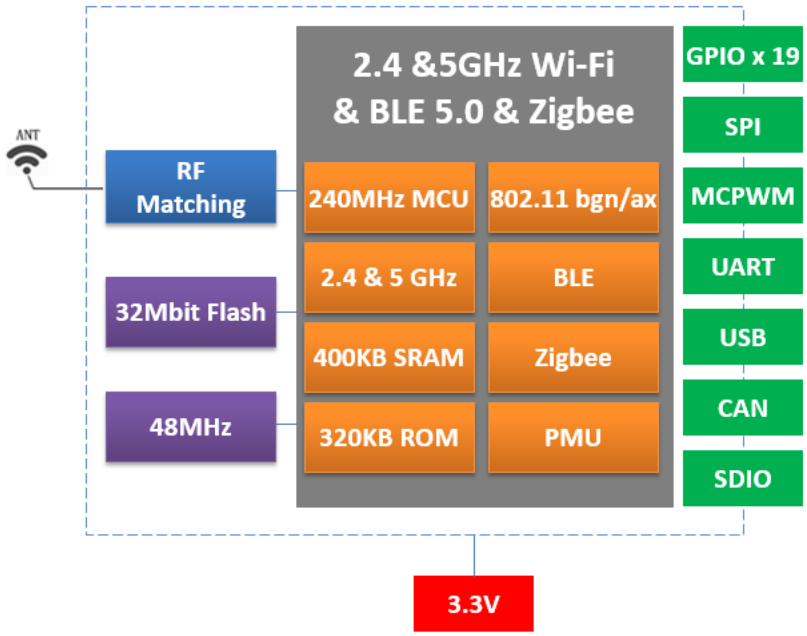


Fig.1.1 ESPC5-12 Module Structure

Technical parameters for ESPC5-12 are listed as follows.

Table.1.1 ESPC5-12 Parameters

Type	Item	Parameter
Wi-Fi 2.4G	Frequency	2.4G~2.5G (2412M~2484M) | IEEE 802.11 b/g/n
	Transmit power	802.11b: +18 dBm
		802.11g: +16 dBm
		802.11n: +16 dBm
		802.11ax: +14 dBm
	Receiver sensitivity	802.11b: -99 dBm (11Mbps)
		802.11g: -78 dBm（54Mbps）
		802.11n: -91 dBm（MCS7, HT20）
		802.11n: -73 dBm（MCS7, HT40）
		802.11ax: -69 dBm（MCS9, HE20）
	EVM	-25dB @802.11b,11Mbps @18dBm
		-29dB @802.11g,54Mbps @16dBm
		-30dB @802.11n, HT20, MCS7 @15dBm
		-31dB @802.11n, HT40, MCS7 @15dBm
		-34dB @802.11ax, HE20, MCS9 @14dBm
	Antenna	PCB Antenna
Wi-Fi 5G	Frequency	5G (5180 ~5885 MHz) | IEEE 802.11a/n/ac/ax
	Transmit power	802.11a: +17.5 dBm (6Mbps)
		802.11n: +17 dBm (HT40, MCS0)
		802.11ac: +17 dBm (VHT20, MCS0)
		802.11ax: +16.5dBm (HE20, MCS0)
	Receiver sensitivity	802.11a: -94.5 dBm (6Mbps)
		802.11n: -91.5 dBm（HT40, MCS0）
		802.11ac: -94.5 dBm（VHT20, MCS0）
		802.11ax: -94 dBm（HE20, MCS0）
	EVM	-27.3dB@802.11a, 6Mbps@17.5dBm
		-27dB@802.11n, HT40, MCS0@16dBm
		-28dB@802.11ac, VHT20, MCS0@17.5dBm
		-27dB@802.11ax, HE20, MCS0@17dBm
	Antenna	PCB Antenna

BLE	RF power control range	-15~20dBm （2402 ~ 2480 MHz）
IEEE 802.15.4	RF power control range	-15~20dBm （2405 ~ 2480 MHz）
Hardware	CPU	RISC-V 32-bit single-core processor 240MHz
	Interface	UART/SDIO/SPI/I2C/GPIO/USB
	Working voltage	3.3V
	Working temperature	-40°C ~ 125°C
	Environment temperature	-40°C ~ 125°C
	Shape	16mm x 24mm x 3mm
Software	Wi-Fi working mode	STA, Soft-AP and sniffer modes
	Security mode	GCMP, CCMP, TKIP, WAPI, WEP, BIP.WPA2, WPA3
	Update firmware	UART Download/USB Download
	Software develops	ESP IDF
	Network protocol	IPv4, TCP/UDP/HTTP/FTP/MQTT

2. Interface Definition

ESPC5-12 Wi-Fi & BLE module interface definition is shown as below。

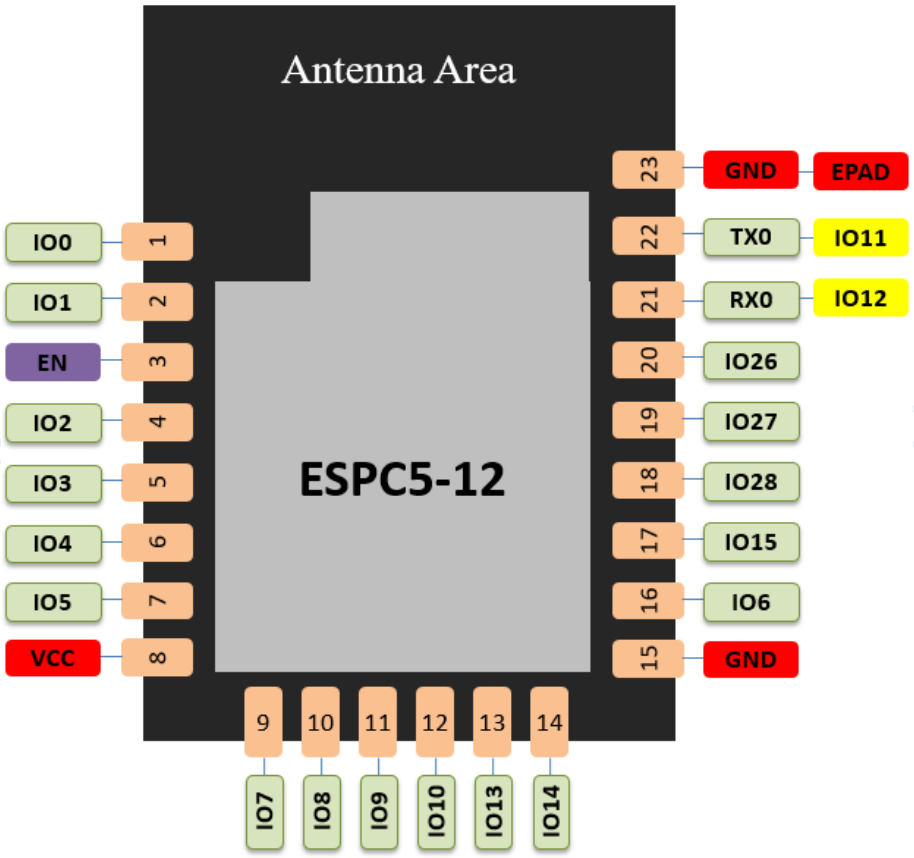


Fig.2.1 ESPC5-12 Pins Definition（Top view）

Working modes and pins functions are shown in Table 2.1.

Table.2.1Working Mode

Mode	IO28 Voltage Level
UART Download Mode	LOW
Flash Boot Mode	HIGH (Default)

Table.2.2 Pins Function Definition

Num.	Pin Name	Type	Function
1	IO0	I/O/T	GPIO0, XTAL_32K_P, LP_GPIO0, LP_UART_DTRN
2	IO1	I/O/T	GPIO1, XTAL_32K_N, LP_GPIO1, LP_UART_DSRN, ADC1_CH0
3	EN	I	Chip enable; Internal Pull-up. HIGH: enable the chip

4	IO2	I/O/T	MTMS, GPIO2, LP_GPIO2, LP_UART_RTSN, LP_I2C_SDA, ADC1_CH1, FSPIQ
5	IO3	I/O/T	MTDI, GPIO3, LP_GPIO3, LP_UART_CTSN, LP_I2C_SCL, ADC1_CH2
6	IO4	I/O/T	MTCK, GPIO4, LP_GPIO4, LP_UART_RXD, ADC1_CH3, FSPIHD
7	IO5	I/O/T	MTDO, GPIO5, LP_GPIO5, LP_UART_TXD, ADC1_CH4, FSPIWP
8	3V3	P	Power supply
9	IO7	I/O/T	GPIO7, LP_GPIO7, FSPID, SDIO_DATA1
10	IO8	I/O/T	GPIO8, PAD_COMP0, SDIO_DATA0
11	IO9	I/O/T	GPIO9, PAD_COMP1, SDIO_CLK
12	IO10	I/O/T	GPIO10, FSPICS0, SDIO_CMD
13	IO13	I/O/T	GPIO13, USB_D-, SDIO_DATA3
14	IO14	I/O/T	GPIO14, USB_D+, SDIO_DATA2
15	GND	P	Ground
16	IO6	I/O/T	GPIO6, LP_GPIO6, ADC1_CH5, FSPICLK
17	IO15	I/O/T	SPICS1, GPIO15
18	IO28	I/O/T	GPIO28
19	IO27	I/O/T	GPIO27
20	IO26	I/O/T	GPIO26
21	RX0	I/O/T	U0RXD, GPIO12
22	TX0	I/O/T	U0TXD, GPIO11
23	EPAD	P	GND, used to improve EVM

3. Size and Layout

Size for ESPC5-12 can be shown as follows.

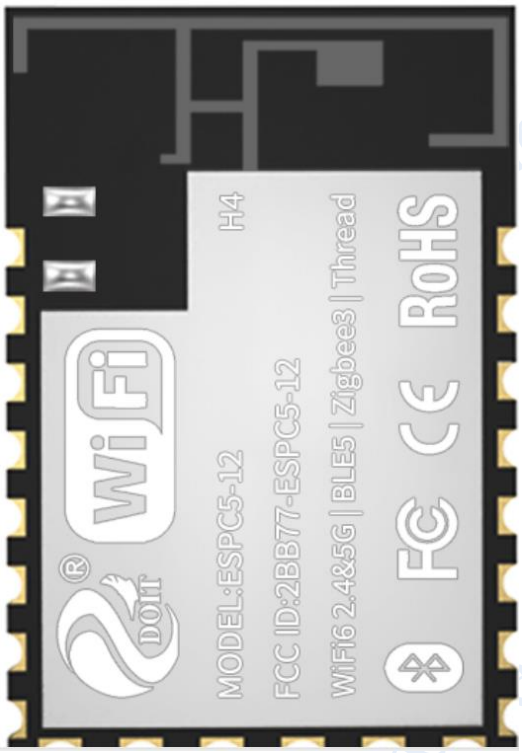
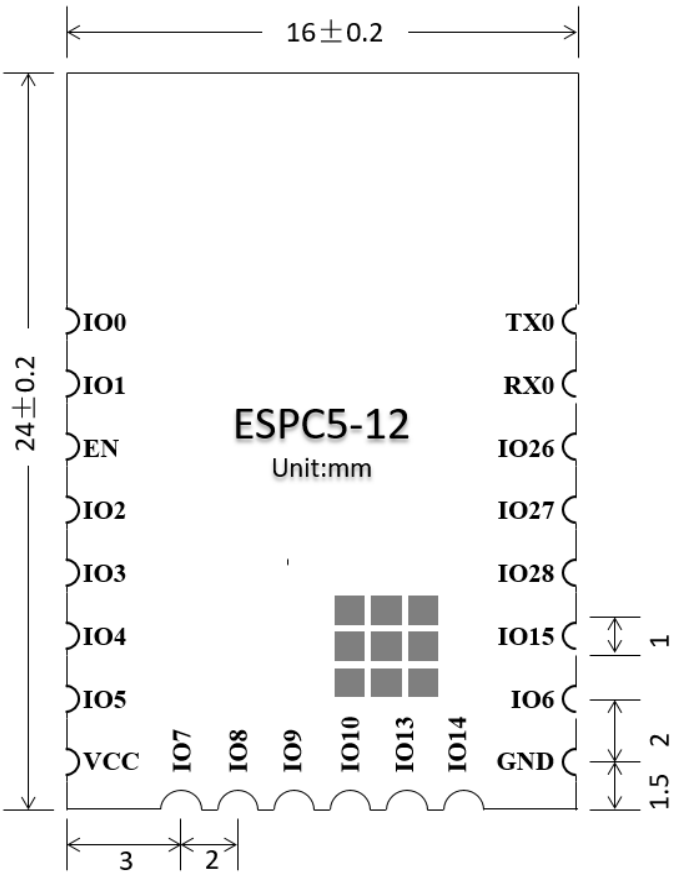


Fig.3.1 Shape for ESPC5-12



(a) （Top view）

(b) Side View

Fig.3.2 Size for ESPC5-12

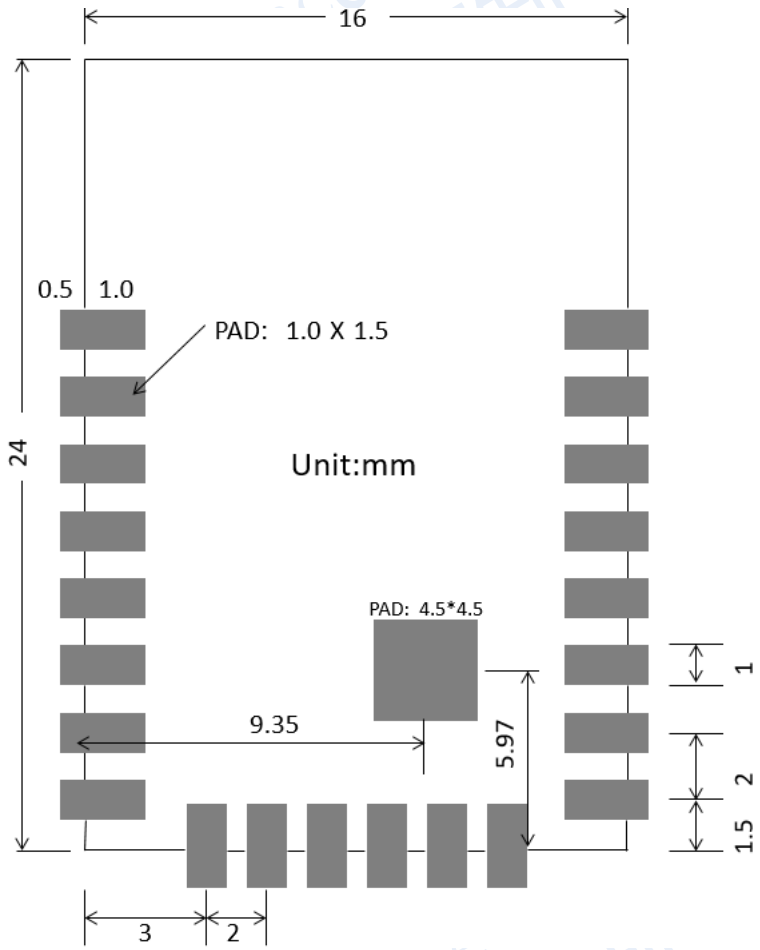


Fig. 3.3 PCB Layout for ESPC5-12（Top view）

4. Electronica Characteristics

Table.4.1 Electronica Characteristics

Parameters		Condition	Min	Classical	Max	Unit
Store Temperature		-	-40	Normal	105	℃
Sold Temperature		IPC/JEDEC J-STD-020	-	-	260	℃
Working Voltage		-	3.0	3.3	3.6	V
I/O/T	V_{IL}	-	-0.3	-	0.25*VDD	V
	V_{IH}	-	0.75*VDD	-	VDD+0.3	
	V_{OL}	-	-	-	0.1*VDD	

V_{OH}	-	0.8*VDD	-	-	
Electrostatic Release Quantity (Human model)	TAMB=25℃	-	-	2	KV
Electrostatic Release Quantity (Machine model)	TAMB=25℃	-	-	0.5	KV

5. Power Consumption

The following power consumption data were measured under the conditions of a 3.3 V power supply and an ambient temperature of 25 °

Table.5.1 2.4GHz Power Consumption @Active mode

Parameters	Min	Classical	Max	Unit
RX 11 b/g/n, HT20	-	-	95	mA
RX 11n, HT40	-	-	104	mA
RX 11ax, HE20	-	-	95	mA
TX 11b, 1Mbps @18dBm	-	-	338	mA
TX 11g, 54Mbps @15dBm	-	-	273	mA
TX 11n, HT20, MCS7 @15dBm	-	-	273	mA
TX 11n, HT40, MCS7 @15dBm	-	-	265	mA
TX 11ax, HE20, MCS9 @14dBm	-	-	251	mA

Table.5.2 5GHz Power Consumption @Active mode

Parameters	Min	Classical	Max	Unit
RX 11 a/n, HT20	-	-	122	mA
RX 11n, HT40	-	-	129	mA
RX 11ac, VHT20	-	-	121	mA
RX 11ax, HE20	-	-	123	mA
TX 11a, 6Mbps @17dBm	-	-	398	mA
TX 11n, HT20, MCS7 @14dBm	-	-	364	mA
TX 11n, HT40, MCS7@14dBm	-	-	361	mA
TX 11ac, VHT40, MCS7@14dBm	-	-	364	mA
TX 11ax, HE20, MCS7,@14dBm	-	-	365	mA

Table.5.3 Power Consumption @Other mode

Parameters	Min	Classical	Max	Unit
Modem-sleep @240MHz	-	18	-	mA
Modem-sleep @80MHz	-	12	-	mA
Light-sleep	-	0.25	-	uA
Deep-sleep	-	0.012	-	uA
Power off, CHIP_PU is set to low level	-	0.002	-	uA

The peak current consumption of ESPC5-12 exceed 500mA when the module start work (RF calibration work consumes maximum current). Therefore, the recommended power supply is no less than 500mA.

Note:

1. Active Mode: CPU and RF are all turned on.

2. Modem-sleep Mode: CPU is turned on. RF and baseband are turned off, but the communication is still connected.

3. Light-sleep Mode: CPU is turned off. RTC/external interrupt/MAC can wake up the chip. The communication is still connected.

4. Deep-sleep Mode: Only RTC is turned on.

6. 2.4GHz Wi-Fi RF Characteristics

The data in the following table is gotten when voltage is 3.3V in the indoor temperature environment.

Table.6.1 2.4GHz Wi-Fi TX Characteristics @ EVM satisfied 802.11 standard

Parameters	Min	Classical	Max	Unit
Input frequency	2412	-	2484	MHz
802.11b,1Mbps	-	18	-	dBm
802.11g,6Mbps	-	17.1	-	dBm
802.11n, HT20,MCS7	-	15.3	-	dBm
802.11n, HT40,MCS7	-	14.2	-	dBm
802.11ax, HE20,MCS0	-	17.1	-	dBm
802.11ax,HE20,MCS9	-	13.3	-	dBm

Table.6.2 2.4GHz Wi-Fi RX Sensitivity

Parameters	Min	Classical	Max	Unit
802.11b,1Mbps	-	-99	-	dBm
802.11b,11Mbps	-	-89	-	dBm
802.11g,6Mbps	-	-94	-	dBm
802.11g,54Mbps	-	-77	-	dBm
802.11n,HT20,MCS0	-	-93	-	dBm
802.11n,HT20,MCS7	-	-75	-	dBm
802.11n,HT40,MCS0	-	-91	-	dBm
802.11n,HT40,MCS7	-	-73	-	dBm
802.11ax, HE20, MCS0		-94		dBm
802.11ax, HE20, MCS9		-69		dBm

Table.6.3 2.4GHz Wi-Fi RX Characteristics

Parameters	Min	Classical	Max	Unit
ADJ Channel Rejection @11b, 1Mbps	-	41	-	dB
ADJ Channel Rejection @11b, 11Mbps	-	40	-	dB
ADJ Channel Rejection @11g, 6Mbps	-	37	-	dB
ADJ Channel Rejection @11g, 54Mbps	-	17	-	dB
ADJ Channel Rejection @11n,HT20,MCS0	-	34	-	dB
ADJ Channel Rejection @11n,HT20,MCS7	-	16	-	dB
ADJ Channel Rejection @11n,HT40,MCS0	-	24	-	dB
ADJ Channel Rejection @11n,HT40,MCS7	-	13	-	dB
ADJ Channel Rejection @11ax,HE20,MCS0	-	38	-	dB
ADJ Channel Rejection @11ax,HE20,MCS9	-	12	-	dB

7. 5GHz Wi-Fi RF Characteristics

The data in the following table is gotten when voltage is 3.3V in the indoor temperature environment.

Table.7.1 5GHz Wi-Fi TX Characteristics @ EVM satisfied 802.11 standard

Parameters	Min	Classical	Max	Unit

Input frequency	5180	-	5885	MHz
802.11a,6Mbps	-	17.8	-	dBm
802.11n,HT20,MCS0	-	17.1	-	dBm
802.11n,HT20,MCS7	-	15.7	-	dBm
802.11n,HT40,MCS0	-	16.8	-	dBm
802.11n,HT40,MCS7	-	15.0	-	dBm
802.11ac,VHT20,MCS0	-	17.3	-	dBm
802.11ac,VHT20,MCS7	-	15.8	-	dBm
802.11ax,HE20,MCS0	-	17.4	-	dBm
802.11ax,HE20,MCS7	-	15.3	-	dBm

Table.7.2 5GHz Wi-Fi RX Sensitivity

Parameters	Min	Classical	Max	Unit
802.11a,6Mbps	-	-94	-	dBm
802.11a,54Mbps	-	-77	-	dBm
802.11n,HT20,MCS0	-	-94	-	dBm
802.11n,HT20,MCS7	-	-75	-	dBm
802.11n,HT40,MCS0	-	-91	-	dBm
802.11n,HT40,MCS7	-	-73	-	dBm
802.11ac,VHT20,MCS0	-	-94	-	dBm
802.11ac,VHT20,MCS7	-	-75	-	dBm
802.11ax, HE20, MCS0		-94		dBm
802.11ax, HE20, MCS7		-75		dBm

Table.7.3 5GHz Wi-Fi RX Characteristics

Parameters	Min	Classical	Max	Unit
ADJ Channel Rejection @11a, 6Mbps	-	29	-	dB
ADJ Channel Rejection @11a, 54Mbps	-	9	-	dB
ADJ Channel Rejection @11n,HT20,MCS0	-	26	-	dB
ADJ Channel Rejection @11n,HT20,MCS7	-	8	-	dB

ADJ Channel Rejection @11n,HT40,MCS0	-	29	-	dB
ADJ Channel Rejection @11n,HT40,MCS7	-	11	-	dB
ADJ Channel Rejection @11n,VHT20,MCS0	-	25	-	dB
ADJ Channel Rejection @11n,VHT20,MCS7	-	6	-	dB
ADJ Channel Rejection @11ax,HE20,MCS0	-	25	-	dB
ADJ Channel Rejection @11ax,HE20,MCS7	-	6	-	dB

8. Bluetooth LE Radio

Table.8.1 TX Transmitter General Characteristics（Bluetooth Radio 2402 ~ 2480 MHz）

Parameters	Min	Classical	Max	Unit
RF power control range	-15	4	18	dBm
ADJ channel Transmit Power @F-F0±2MHz	-	-33	-	dBm
ADJ channel Transmit Power @F-F0±3MHz	-	-40	-	dBm
ADJ channel Transmit Power @F-F0±>3MHz	-	-45	-	kHz
△f1avg	-	250	-	kHz
△f2max	255	-	-	kHz
△f1avg/△f2max	-	0.98	-	-

Table.8.2 RX Transmitter General Characteristics（Bluetooth Radio 2402 ~ 2480 MHz）

Parameters		Min	Classical	Max	Unit
BLE	Sensitivity @30.8% PER	-	-98.5	-	dBm
	Maximum received signal @30.8% PER	0	5	-	dBm
	Co-channel C/I	-	9	-	dB

9. 802.15.4 Radio

Table.9.1 TX Transmitter General Characteristics（802.15.4 Radio 2405 ~ 2480 MHz）250 Kbps

Parameters	Min	Classical	Max	Unit
RF transmit power range	-15	4	18	dBm
EVM	-	4.0%	-	-

Table.9.2 RX Transmitter General Characteristics（802.15.4 Radio 2405 ~ 2480 MHz）250 Kbps

Parameters		Description	Min	Classical	Max	Unit
Sensitivity @1% PER		-	-	-103	-	dBm
Maximum received signal @1% PER		-	-	5	-	dBm
Relative jamming level	Adjacent channel	F = F0 + 5 MHz	-	28	-	dB
		F = F0 -5 MHz	-	32	-	dB
	Adjacent channel	F = F0 + 10 MHz	-	48	-	dB
		F = F0 -10 MHz	-	53	-	dB

10. Recommended Sold Temperature Curve

(1) Reflow Times <= 2 times (Max.)

(2) Max Rising Slope: 3℃/sec

(3) Max Falling Slope: -3℃/sec

(4) Over 217℃ Time: 60~120sec

(5) Peak Temp:240℃~250℃

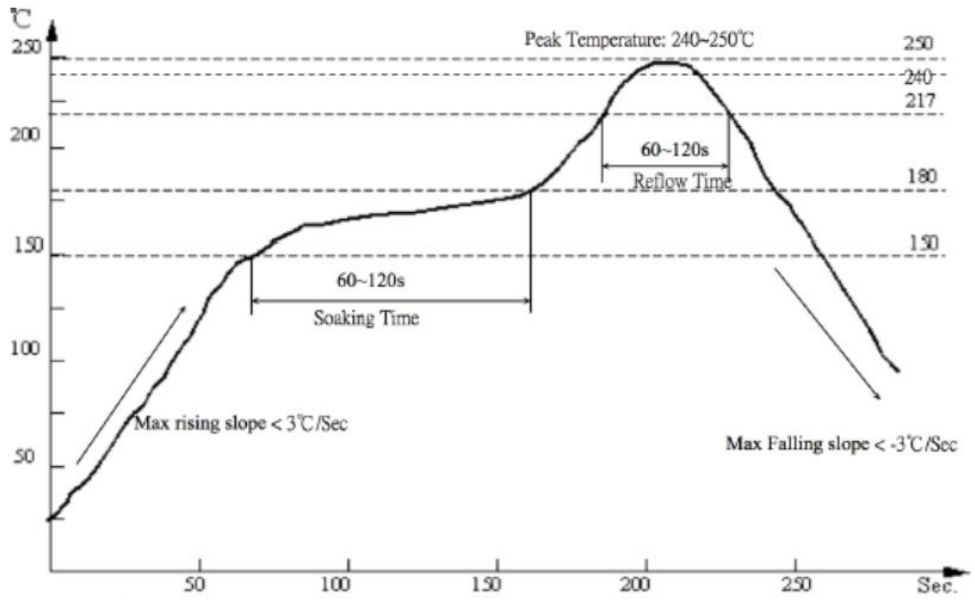


Fig.10.1 Recommended Reflow Profile

11. Minimum User System

This module can work just at 3.3V voltage condition:

Note:

(1) The working voltage for module is DC 3.3V;

(2) The max current from IO of this module is 40mA;

(3) Wi-Fi module is at download mode: IO28 is LOW level, then module reset to power;

(4) Wi-Fi module is connected to RXD of the other MCU, and TXD is connected to RXD of the other MCU.

12. Recommended Layout Design

ESPC5-12 module can be sold on PCB board directly. For the high RF performance for the device, please notice the placement of the module. There are three ways to use the module for Wi-Fi Module with PCB antenna.

Solution 1: optical solution. The Wi-Fi module is placed on the side of the board, and the antennas are all exposed, and there is no metal material around the antenna, including wires, metal casings, weight plates, and the like.

Solution 2: sub-optical solution. The Wi-Fi module is placed on the side of the board, and the antenna below is hollowed out. There is a gap of not less than 5 mm reserved with the PCB, and there is no metal material around the antenna, including wires, metal casings, weight plates, and the like.

Solution 3: The Wi-Fi module is placed on the side of the board, and the PCB area under the antenna is empty, and copper cannot be laid.

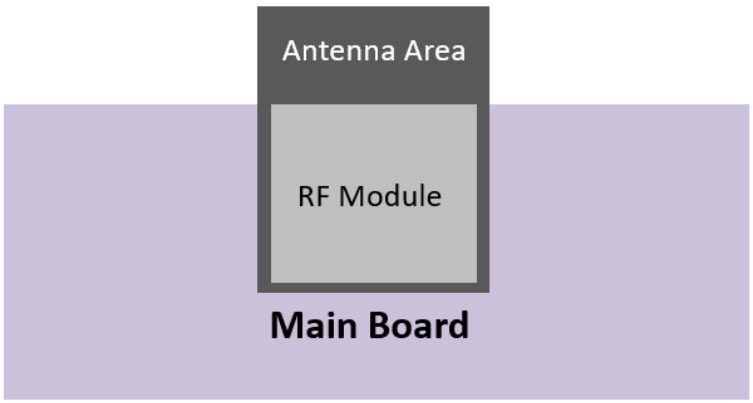


Fig.12.1 Solution 1

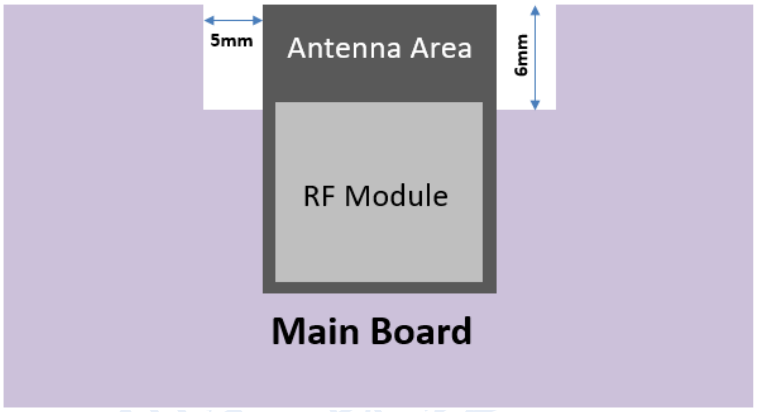


Fig.12.2 Solution 2

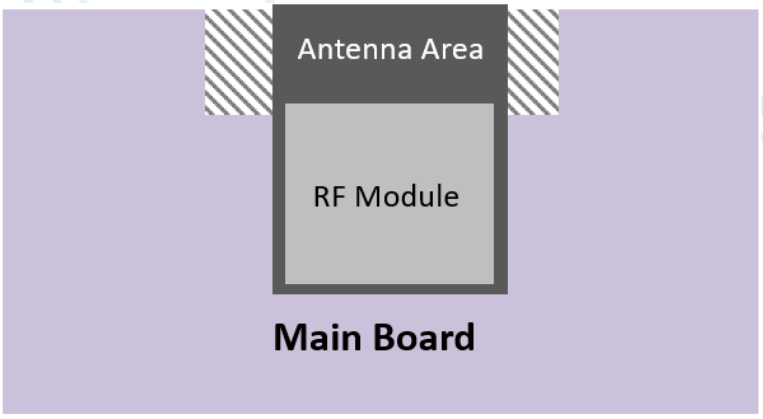


Fig.12.3 Solution 3

13. Peripheral Design Suggestion

Wi-Fi module is already integrated into high-speed GPIO and Peripheral interface, which may be generated the switch noise. If there is a high request for the power consumption and EMI characteristics, it is suggested to connect a serial 10~100 ohm resistance, which can suppress overshoot when switching power supply, and can smooth signal. At the same time, it also can prevent electrostatic discharge (ESD).

14. Product Handling

14.1 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.

14.2 Electrostatic Discharge (ESD)

• Human body model (HBM): ±2000 V

• Charged-device model (CDM): ±500 V

15. Packing Instruction

The product is packed in a tray, as shown in the following figure.

The size of the single box is: 340 x 360 x 60mm, and 800 pieces module is in the box. And the outer box size is 355 x 375 x 325mm, including 5 single box which include 4000 pieces module.

Fig.15.1 Module Package

Appendix: Module Schematic