ESP-WROOM-02

Datasheet

About This Guide

This document provides introduction to the specifications of ESP-WROOM-02 hardware, including the following topics:

Chapter	Title	Subject
Chapter 1	Overview	Introduction to ESP-WROOM-02, including dimensions and specifications.
Chapter 2	Pin Definition	Pin layout followed by the relevant description.
Chapter 3	Functional Description	Description of major functional modules integrated on ESP-WROOM-02, including CPU, flash, memory and interfaces.
Chapter 4	Electrical Characteristic	Electrical data of ESP-WROOM-02.
Chapter 5	Schematics	ESP-WROOM-02 schematics and peripheral schematics.
Appendix A	Learning Resources	ESP8266-related must-read documents and must-have resources.
Appendix B	Notices	FCC/CE/IC/KCC compliance statements.

Release Notes

Date	Version	Release notes
2015.12	V0.5	First release.
2016.01	V0.6	Updated Section 3.2.2.
2016.02	V0.7	Added Appendix—Notices. Updated Chapter 1.
2016.04	V0.8	Updated the flash size and PAD (bottom) size.
2016.06	V0.9	Updated the flash size.
2016.06	V1.0	Added Appendix—Notices—B.5. Updated Figure 2-1.
2016.08	V1.1	Updated the operating temperature range.
2016.11	V1.2	Added Appendix—Learning Resources. Added "ESP-WROOM-02 Peripheral Schematics" in Chapter 5.
2016.11	V2.0	Added Section 4.8 "Electrostatic Discharge". Updated Figure 5-1. ESP-WROOM-02 Schematics.
2016.12	V2.1	Changed the minimum working voltage from 3.0V to 2.5V. Changed the power consumption during Deep-sleep from 10 μA to 20 μA.

Date	Version	Release notes
2017.02	V2.2	Changed the maximum operating temperature of crystal oscillator from 85°C to 70°C, and added the description about the storage temperature range of crystal oscillator in Section 3.3.
2017.04	V2.3	Added the module's dimensional tolerance; Changed the input impedance value in Table 4-4 and 4-5 from 50Ω to 39+j6 Ω; Added Figure 4-1 Reflow Profile.

Table of Contents

1. Overview

Espressif provides the SMD module—ESP-WROOM-02 that integrates ESP8266EX. The module has been adjusted to get the best RF performance. We recommend using ESP-WROOM-02 for tests or for further development.

> 📖 **Note:**
>
> *For more information on ESP8266EX, please refer to ESP8266EX Datasheet.*

The module size is 18 mm (±0.2 mm) x 20 mm (±0.2 mm) x 3 mm (±0.15 mm). The type of flash used on this module is an SPI flash with a package size of SOP 8-150 mil. The gain of the on-board PCB antenna is 2 dBi.
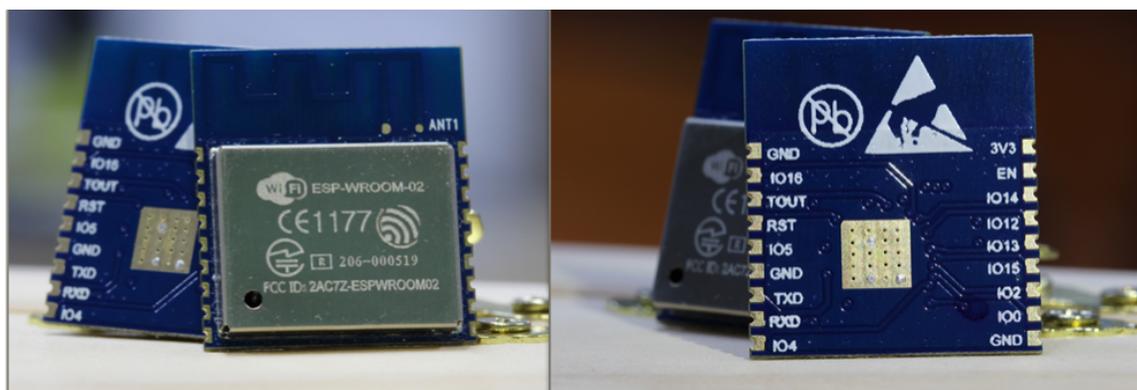

Figure 1-1. ESP-WROOM-02 Module

Table 1-1. ESP-WROOM-02 Specifications

Categories	Items	Specifications
Wi-Fi	Standards	FCC/CE/TELEC/KCC/SRRC/IC/NCC
	Wi-Fi protocols	802.11 b/g/n
	Frequency range	2.4 GHz ~ 2.5 GHz (2400M ~ 2483.5M)
Hardware	Peripheral interface	UART/HSPI/I2C/I2S/IR Remote Control
		GPIO/PWM
	Operating voltage	2.5V ~ 3.6V
	Operating current	Average: 80 mA
	Operating temperature range	-40°C ~ 85°C
	Storage temperature	-40°C ~ 85°C
	Package size	18 mm (±0.2 mm) x 20 mm (±0.2 mm) x 3 mm (±0.15 mm)

Categories	Items	Specifications
	External interface	-
Software	Wi-Fi mode	Station/SoftAP/SoftAP + Station
	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware upgrade	UART Download/OTA (via network)/Download and write firmware via host
	Software development	Supports Cloud Server Development/SDK for custom firmware development
	Network protocols	IPv4, TCP/UDP/HTTP/FTP
	User configuration	AT Instruction Set, Cloud Server, Android/iOS app

📖 **Note:**

ESP-WROOM-02 with high temperature range option (-40°C ~ 125°C) is available for custom order.

2. Pin Description

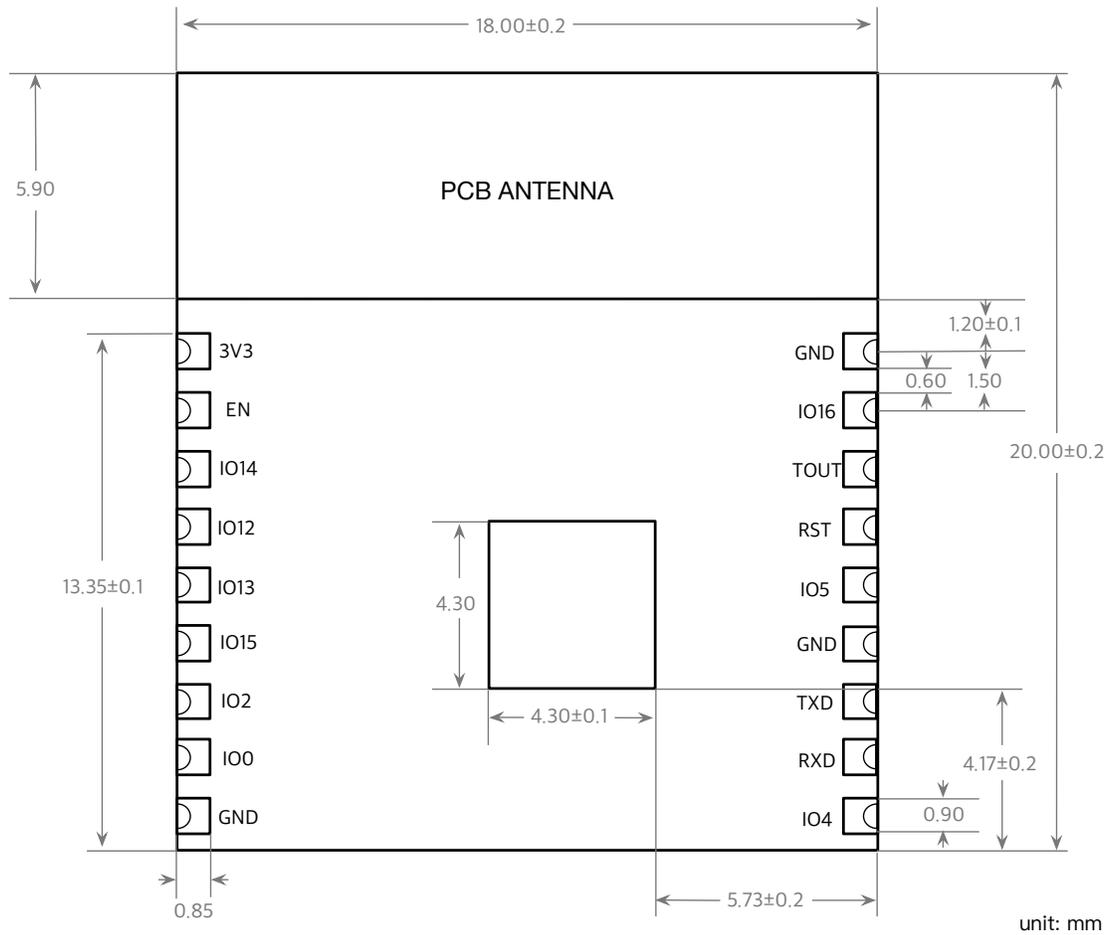Figure 2-1 shows the pin distribution of the ESP-WROOM-02.

Figure 2-1. Top view of The ESP-WROOM-02

Table 2-1. ESP-WROOM-02 Dimensions

Length	Width	Height	PAD Size (Bottom)	Pin Pitch
18 mm ± 0.2 mm	20 mm ± 0.2 mm	3 mm ± 0.15 mm	0.9 mm x 0.85 mm	1.5 mm

ESP-WROOM-02 has 18 pins. Please see the pin definitions in Table 2-2.

Table 2-2. ESP-WROOM-02 Pin Definitions

No.	Pin Name	Functional Description
1	3V3	3.3V power supply (VDD) 📖 *Note:* *It is recommended the maximum output current a power supply provides be of 500 mA or above.*
2	EN	Chip enable pin. Active high.
3	IO14	GPIO14; HSPI_CLK
4	IO12	GPIO12; HSPI_MISO
5	IO13	GPIO13; HSPI_MOSI; UART0_CTS
6	IO15	GPIO15; MTDO; HSPICS; UART0_RTS Pull down.
7	IO2	GPIO2; UART1_TXD Floating (internal pull-up) or pull up.
8	IO0	GPIO0 • UART download: pull down. • Flash boot: floating or pull up.
9	GND	GND
10	IO4	GPIO4
11	RXD	UART0_RXD, receive end in UART download; GPIO3
12	TXD	UART0_TXD, transmit end in UART download, floating or pull up; GPIO1
13	GND	GND
14	IO5	GPIO5
15	RST	Reset
16	TOUT	It can be used to test the power-supply voltage of VDD3P3 (Pin3 and Pin4) and the input power voltage of TOUT (Pin6). These two functions cannot be used simultaneously.
17	IO16	GPIO16; used for Deep-sleep wake-up when connected to RST pin.
18	GND	GND

3.   Functional Description

3.1.   MCU

ESP8266EX integrates the Tensilica L106 32-bit microcontroller (MCU) and ultra-low-power 16-bit RSIC. The CPU clock speed is 80 MHz and can reach a maximum value of 160 MHz. The system can readily run a Real Time Operating System (RTOS). Currently, the Wi-Fi stack only takes up 20% of CPU time. The remaining CPU time (80% of total MIPS) can be used for user applications. The CPU can interface through:

- Programmable RAM/ROM interfaces (iBus) that connect to memory controller and can access the external flash.
- Data RAM interface (dBus) that connects to the memory controller.
- AHB interface that accesses the register.

3.2.   Memory

3.2.1.   Internal SRAM and ROM

ESP8266EX Wi-Fi SoC integrates the memory controller and memory units including ROM and SRAM. MCU can access the memory units through iBus, dBus, and AHB interfaces. All memory units can be accessed upon request. A memory arbiter determines the running sequence in the arrival order of requests.

According to our current version of SDK, the SRAM space available to users is assigned as follows:

- RAM size < 50 kB, that is, when ESP8266EX is working in Station mode and connects to the router, available space in the Heap + Data sector is around 50 kB.
- There is no programmable ROM in ESP8266EX, therefore, the user program must be stored in an external SPI flash.

3.2.2.   SPI Flash

ESP8266EX supports SPI flash. Theoretically speaking, ESP8266EX can support an up-to-16-MB SPI flash.

ESP-WROOM-02 currently integrates a 2-MB SPI flash. ESP-WROOM-02 supports these SPI modes: Standard SPI, DIO (Dual I/O), DOUT (Dual Output), QIO (Quad I/O) and QOUT (Quad Output).

3.3. Crystal Oscillator

ESP-WROOM-02 uses a 26-MHz crystal oscillator. The accuracy of the crystal oscillator should be ±10 PPM. The operating temperature range is -20°C to 70°C; and the storage temperature range is -40°C to 85°C.

When using the download tool, please select the right type of crystal oscillator. In circuit design, capacitors C1 and C2 which connect to the earth are added to the input and output terminals of the crystal oscillator respectively. The values of the two capacitors can be flexible, ranging from 6 pF to 22 pF, however, the specific capacitive values depend on further testing of, and adjustment to, the overall performance of the whole circuit. Normally, the capacitive values of C1 and C2 are within 10 pF for the 26-MHz crystal oscillator.

The crystal oscillator should be placed as close to the XTAL pins as possible (without the traces being too long). It is good practice to add high density ground vias around the clock trace for great insulation.

There should be no vias on the input and output traces, which means the traces cannot cross layers.

Place the input and output bypass capacitors on the near left or right side of the chip. Do not place them on the traces.

Do not route high-frequency digital signal lines in the four-layer board. It is best not to route any signal line under the crystal oscillator. The larger the copper area on the top layer is, the better. As crystal oscillator is a sensitive component, do not place magnetic components such as high current inductor nearby.

3.4. Interface Description

Table 3-1. Interface Description

Interface	Pin	Functional Description
HSPI	IO12 (MISO), IO13 (MOSI), IO14 (CLK), IO15 (CS)	Connects to SPI Flash, display screen, and MCU.
PWM	IO12 (R), IO15 (G),IO13 (B)	Currently the PWM interface has four channels, but users can extend it to eight channels. PWM interface can realize the control of LED lights, buzzers, relays, electronic machines, etc.
IR	IO14 (IR_T), IO5 (IR_R)	The functionality of the infrared remote control interface can be realized via software programming. The interface uses NEC coding, modulation, and demodulation. The frequency of the modulated carrier signal is 38 kHz.
ADC	TOUT	Tests the power supply voltage of VDD3P3 (Pin3 and Pin4) and the input power voltage of TOUT (Pin6). However, these two functions cannot be used simultaneously. This interface is typically used in sensors.
I2C	IO14 (SCL), IO2 (SDA)	Connects to external sensors and display screens, etc.

Interface	Pin	Functional Description
UART	UART0: TXD (U0TXD), RXD (U0RXD), IO15 (RTS), IO13 (CTS) UART1: IO2 (TXD)	Communicates with the UART device. Downloading: U0TXD + U0RXD or GPIO2 + U0RXD Communicating: (UART0): U0TXD, U0RXD, MTDO (U0RTS), MTCK (U0CTS) Debugging: UART1_TXD (GPIO2) can be used to print debugging information. By default, UART0 will output some printed information when you power on ESP8266EX. If this issue influences some specific applications, users can exchange the inner pins of UART when initializing ESP8266EX, that is, exchange U0TXD and U0RXD with U0RTS and U0CTS. Users can connect MTDO and MTCK to the serial port of the external MCU to realize the communication.
I2S	I2S input: IO12 (I2SI_DATA) ; IO13 (I2SI_BCK); IO14 (I2SI_WS); I2S output: IO15 (I2SO_BCK); IO3 (I2SO_DATA); IO2 (I2SO_WS).	Collects, processes and transmits audio data.

4. Electrical Characteristics

> 📖 *Note:*
>
> *Unless otherwise specified, measurements are based on VDD = 3.3V, TA = 25℃.*

4.1. Absolute Maximum Ratings

Table 4-1. Absolute Maximum Ratings

Rating	Condition	Value	Unit
Storage temperatue	-	-40 ~ 85	℃
Maximum soldering temperature	-	260	℃
Supply voltage	IPC/JEDEC J-STD-020	2.5 ~ 3.6	V

4.2. Recommended Operating Conditions

Table 4-2. Recommended Operating Conditions

Operating condition	Symbol	Min	Typ	Max	Unit
Operating temperature	-	-40	20	85	℃
Supply voltage	VDD	2.5	3.3	3.6	V

4.3. Digital Terminal Characteristics

Table 4-3. Digital Terminal Characteristics

Terminals	Symbol	Min	Typ	Max	Unit
Input logic level low	V_{IL}	-0.3	-	0.25 VDD	V
Input logic level high	V_{IH}	0.75 VDD	-	VDD + 0.3	V
Output logic level low	V_{OL}	N	-	0.1 VDD	V
Output logic level high	V_{OH}	0.8 VDD	-	N	V

4.4.   RF Performance

Table 4-4. RF Performance

Description	Min	Typ	Max	Unit
Input frequency	2400	-	2483.5	MHz
Input impedance	-	39+j6	-	Ω
Input reflection	-	-	-10	dB
PA output power at 72.2 Mbps	15.5	16.5	17.5	dBm
PA output power in 11b mode	19.5	20.5	21.5	dBm
Sensitivity				
CCK, 1 Mbps	-	-98	-	dBm
CCK, 11 Mbps	-	-91	-	dBm
6 Mbps (1/2 BPSK)	-	-93	-	dBm
54 Mbps (3/4 64-QAM)	-	-75	-	dBm
HT20, MCS7 (65 Mbps, 72.2 Mbps)	-	-72	-	dBm
Adjacent channel rejection				
OFDM, 6 Mbps	-	37	-	dB
OFDM, 54 Mbps	-	21	-	dB
HT20, MCS0	-	37	-	dB
HT20, MCS7	-	20	-	dB

4.5.   Sensitivity

Table 4-5. Sensitivity

Parameters	Min	Typ	Max	Unit
Input frequency	2412	-	2484	MHz
Input impedance	-	39+j6	-	Ω
Input reflection	-	-	-10	dB
PA output power at 72.2 Mbps	15.5	16.5	17.5	dBm
PA output power in 11b mode	19.5	20.5	21.5	dBm
Sensitivity				
DSSS, 1 Mbps	-	-98	-	dBm

Parameters	Min	Typ	Max	Unit
CCK, 11 Mbps	-	-91	-	dBm
6 Mbps (1/2 BPSK)	-	-93	-	dBm
54 Mbps (3/4 64-QAM)	-	-75	-	dBm
HT20, MCS7 (65 Mbps, 72.2 Mbps)	-	-72	-	dBm
Adjacent channel rejection				
OFDM, 6 Mbps	-	37	-	dB
OFDM, 54 Mbps	-	21	-	dB
HT20, MCS0	-	37	-	dB
HT20, MCS7	-	20	-	dB

4.6. Power Consumption

The following power consumption data were obtained from the tests with a 3.3V power supply and a voltage stabilizer, in 25°C ambient temperature.

- All tests were performed at the antenna port without SAW filter.
- All data are based on 90% duty cycle in continuous transmission mode.

Table 4-6. Power Consumption

Modes	Min	Typ	Max	Unit
Tx 802.11b, CCK 11 Mbps, P_{OUT} = +17 dBm	-	170	-	mA
Tx 802.11g, OFDM 54 Mbps, P_{OUT} = +15 dBm	-	140	-	mA
Tx 802.11n, MCS7, P_{OUT} = +13 dBm	-	120	-	mA
Rx 802.11b, 1024 bytes packet length , -80 dBm	-	50	-	mA
Rx 802.11g, 1024 bytes packet length , -70 dBm	-	56	-	mA
Rx 802.11n, 1024 bytes packet length , -65 dBm	-	56	-	mA
Modem-sleep①	-	15	-	mA
Light-sleep②	-	0.9	-	mA
Deep-sleep③	-	20	-	µA
Power Off	-	0.5	-	µA

📖 **Notes:**

① **Modem-sleep** is used when such applications as PWM or I2S require the CPU to be working. In cases where Wi-Fi connectivity is maintained and data transmission is not required, the Wi-Fi Modem circuit can be shut down to save power, according to 802.11 standards (such as U-APSD). For example, in DTIM3, when ESP8266EX sleeps for 300 ms and wakes up for 3 ms to receive Beacon packages from AP, the overall average current consumption is about 15 mA.

② **Light-sleep** is used for applications whose CPU may be suspended, such as Wi-Fi switch. In cases where Wi-Fi connectivity is maintained and data transmission is not required, the Wi-Fi Modem circuit and CPU can be shut down to save power, according to 802.11 standards (such as U-APSD). For example, in DTIM3, when ESP8266EX sleeps for 300 ms and wakes up for 3 ms to receive Beacon packages from AP, the overall average current consumption is about 0.9 mA.

③ **Deep-sleep** is for applications that do not require Wi-Fi connectivity but only transmit data over long time lags, e.g., a temperature sensor that measures temperature every 100s. For example, when ESP8266EX sleeps for 300s then wakes up to connect to AP (taking about 0.3 ~ 1s), the overall average current consumption is far less than 1 mA. The current consumption of 20 µA was obtained at the voltage of 2.5V.

4.7. Reflow Profile
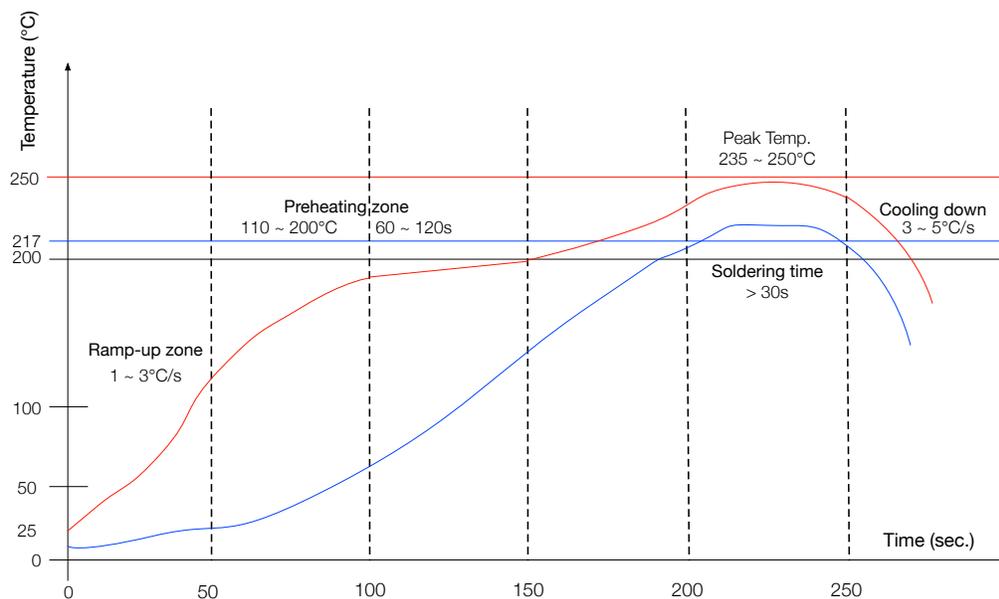
Ramp-up zone (升温区): Temp. <150°C, Time 60 ~ 90s, Ramp-up rate 1 ~ 3°C/s.
Preheating zone (预热恒温区): Temp. 150 ~ 200°C, Time 60 ~ 120s, Ramp-up rate 0.3 ~ 0.8°C/s.
Reflow soldering zone (回流焊接区): Peak Temp. 235 ~ 250°C (<245°C recommended), Time 30 ~ 70s.
Cooling down zone (冷却区): Temp. 217 ~ 170°C, Ramp-down rate 3 ~ 5°C/s.
Sn&Ag&Cu Lead-free solder (SAC305)/焊料为锡银铜合金无铅焊料

Figure 4-1. ESP-WROOM-02 Reflow Profile

4.8. Electrostatic Discharge

Table 4-7. Electrostatic Discharge Parameters

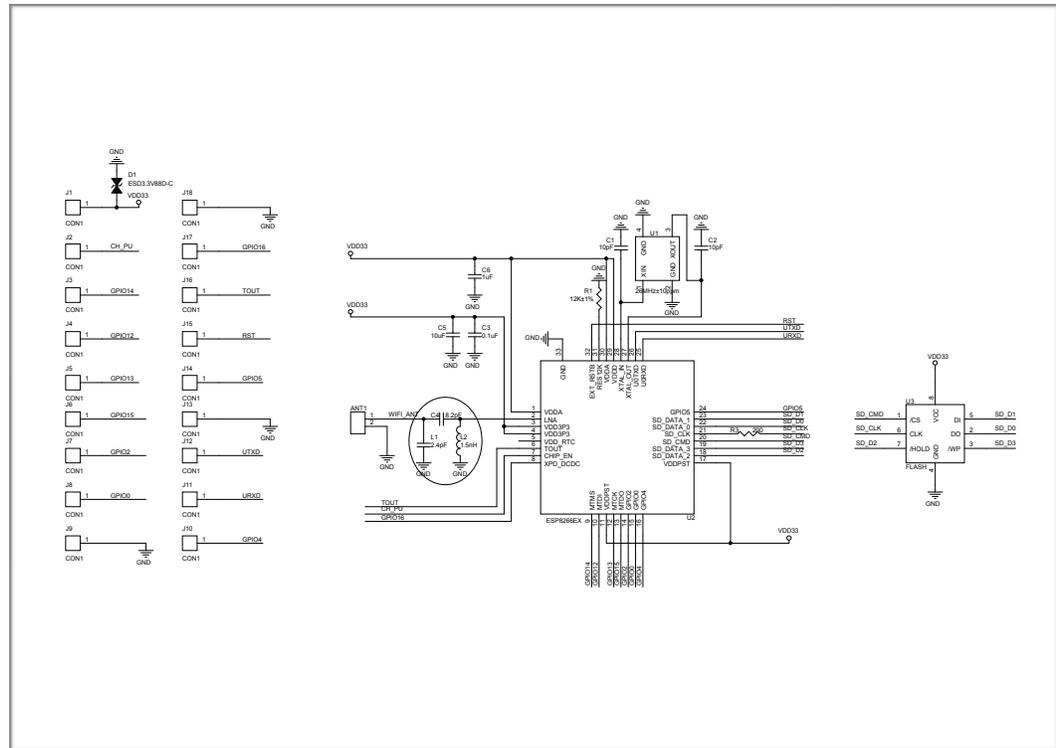| Name	Symbol	Reference	Level	Max	Unit
Electrostatic Discharge (Human - Body Model)	V_{ESD} (HBM)	Temperature: 23 ± 5°C Based on ANSI/ESDA/JEDEC JS - 001 - 2014	2	2000	V
Electrostatic Discharge (Charged - Device Model)	V_{ESD} (CDM)	Temperature: 23 ± 5°C Based on JEDEC EIA/JESD22 - C101F	C2	500	

5. Schematics

Figure 5-1. ESP-WROOM-02 Schematics
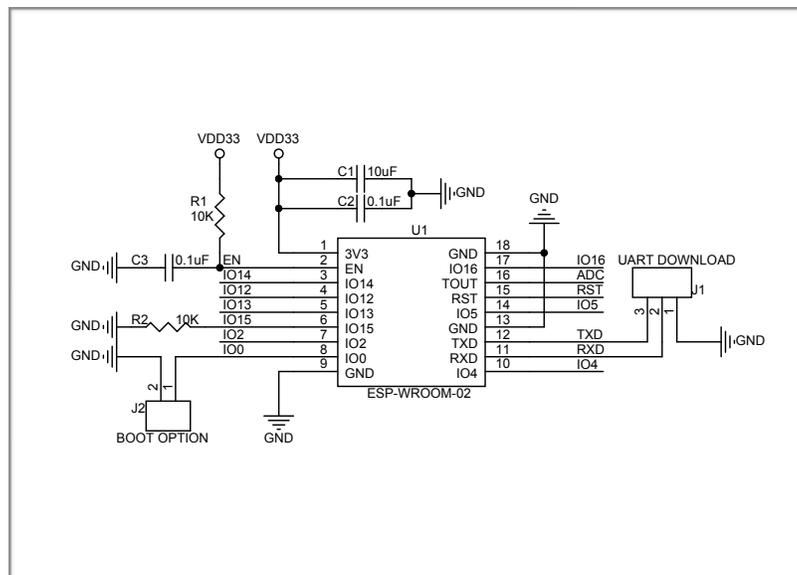
Figure 5-2. ESP-WROOM-02 Peripheral Schematics

A. Appendix—Learning Resources

A.1. Must-Read Documents

- *ESP8266 Quick Start Guide*

  Description: This document is a quick user guide to getting started with ESP8266. It includes an introduction to the ESP-LAUNCHER, how to download firmware on to the board and run it, how to compile the AT application, structure and the debugging method of RTOS SDK. Basic documentation and other related resources for the ESP8266 are also provided.

- *ESP8266 SDK Getting Started Guide*

  Description: This document takes ESP-LAUNCHER and ESP-WROOM-02 as examples to introduce how to use ESP8266 SDK. The contents include preparations before compilation, SDK compilation and firmware download.

- *ESP-WROOM-02 PCB Design and Module Placement Guide*

  Description: The ESP-WROOM-02 module is designed to be soldered to a host PCB. This document compares six different placements of the antenna on a host board and provides notes on designing PCB.

- *ESP8266 Hardware Resources*

  Description: This zip package includes manufacturing specifications of the ESP8266 board and the modules, manufacturing BOM and schematics.

- *ESP8266 AT Command Examples*

  Description: This document introduces some specific examples of using Espressif AT commands, including single connection as a TCP Client, UDP transmission and transparent transmission, and multiple connection as a TCP server.

- *ESP8266 AT Instruction Set*

  Description: This document provides lists of AT commands based on ESP8266_NONOS_SDK, including user-defined AT commands, basic AT commands, Wi-Fi AT commands and TCP/IP-related AT commands. It also introduces the downloading of AT firmware into flash.

- *TCP/UDP UART Passthrough Test Demonstration*

  Description: This guide is intended to help users run a TCP & UDP passthrough test on the ESP8266 IoT platform.

- *FAQ*

A.2. Must-Have Resources

- *ESP8266 SDKs*

  Description: This website page provides links to the latest version of ESP8266 SDK and the older ones.

- *ESP8266 Tools*

  Description: This website page provides links to the ESP8266 flash download tools and ESP8266 performance evaluation tools.

- *ESP8266 APK*
- *ESP8266 Certification and Test Guide*
- *ESP8266 BBS*
- *ESP8266 Resources*

B.   Appendix—Notices

B.1. Federal Communications Commission (FCC) Declaration of Conformity

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 the 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.

Any changes or modifications to this equipment not expressly approved by Espressif may cause harmful interference and void the user's authority to operate this equipment.

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, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

B.2. EC Declaration of Conformity

This equipment can be used in member states of the European Union once the corresponding administrative license is obtained.

Espressif, as manufacturer of the product ESP-WROOM-02, declares that the said product complies with the essential requirements established in Article 3 of the Council of Europe Directive 1999/5/ CE, dated 9th March, 1999.

B.3. Industry Canada (IC) Compliance Notice

B.3.1. IC RSS warning

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes:

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

B.3.2. **IC Radiation Exposure Statement**

This equipment complies with IC RF radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

This equipment should be installed and operated with minimum distance 20cm between the radiator& your body.

Any changes or modifications not expressly approved by Espressif responsible for compliance could void the user's authority to operate the equipment.

B.4. Korea Communications Commission (KCC) Statement

인증받은자의 상호: ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD

제품명 / 모델명:특정소출력 무선기기(무선데이타통신시스템용 무선기기 / ESP-WROOM-02

제조자 및 제조국가: ESPRESSIF SYSTEMS (SHANGHAI) PTE LTD / China

제조년월:2016.02

인증번호:MSIP-CRM-es5- ESP-WROOM-02

해당 무선설비는 운용 중 전파혼신 가능성이 있음

해당 무선설비는 전파혼신 가능 성이 있으므로 인명안전과 관련된 서비스는 할 수 없음

B.5. Radio Transmission Equipment Type Approval Certificate

In accordance with the provisions on the Radio Regulations of the People's Republic of China, the following radio transmission equipment, after examination, conforms to the provisions with its CMIIT ID: 2016DP3252

Date of Issue: 2016.06.15

Equipment Name: 2.4GHz无线局域网模块

Equipment Type: ESP-WROOM-02

Espressif IOT Team

www.espressif.com