# 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 Characteristics | Electrical data of ESP-WROOM-02. |
| Chapter 5 | Schematics | ESP-WROOM-02 schematics and peripheral schematics. |
| Chapter 6 | Dimensions | Figure of ESP-WROOM-02 dimensions. |
| Appendix A | Learning Resources | ESP8266-related must-read documents and must-have resources. |

## 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.<br>• 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.<br>• Updated Figure 2-1. |
| 2016.08 | V1.1 | Updated the operating temperature range. |
| 2016.11 | V1.2 | • Added Appendix—Learning Resources.<br>• Added "ESP-WROOM-02 Peripheral Schematics" in Chapter 5. |
| 2016.11 | V2.0 | • Added Section 4.8 "Electrostatic Discharge".<br>• Updated Figure 5-1. ESP-WROOM-02 Schematics. |
| 2016.12 | V2.1 | • Changed the minimum working voltage from 3.0V to 2.5V.<br>• 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;<br>• Changed the input impedance value in Table 4-4 and 4-5 from 50Ω to 39+j6 Ω;<br>• Added Figure 4-1 Reflow Profile. |
| 2017.09 | V2.4 | • Added Documentation Change Notification and the official link for downloading Product Certifications;<br>• Updated the supply voltage to 2.7 V ~ 3.6 V;<br>• Updated the storage temperature and the operating temperature to -20°C ~ 70°C;<br>• Updated Figure 2-1 ESP-WROOM-02 Pin Layout and added a note to it;<br>• Updated Chapter 4: Collated electrical-characteristics-related data into Table 4-1; collated Wi-Fi-radio-related data into Table 4-2 and updated the output power parameters;<br>• Updated Chapter 5 Schematics and added a note;<br>• Added Chapter 6 Dimensions.<br>• Deleted Appendix B—Notices. |

## Documentation Change Notification

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# 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±0.2) mm x (20±0.2) mm x (3±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.
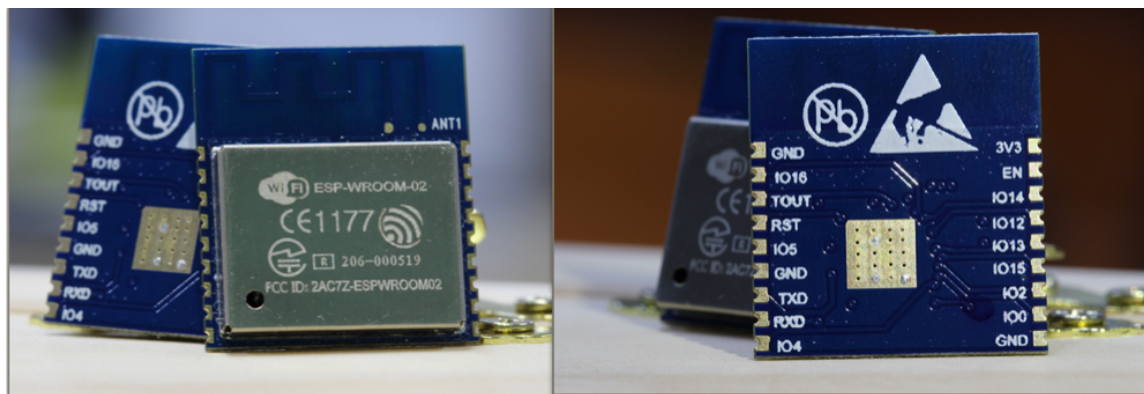


Figure 1-1. ESP-WROOM-02 Module

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 | 2.7V ~ 3.6V |
| | Operating current | Average: 80 mA |
| | Minimum current delivered by power supply | 500 mA |
| | Operating temperature range | -20°C ~ 70°C |

| Categories | Items | Specifications |
|---|---|---|
| | Storage temperature | -20°C ~ 70°C |
| | Package size | (18±0.2) mm x (20±0.2) mm x (3±0.15) mm |
| | 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
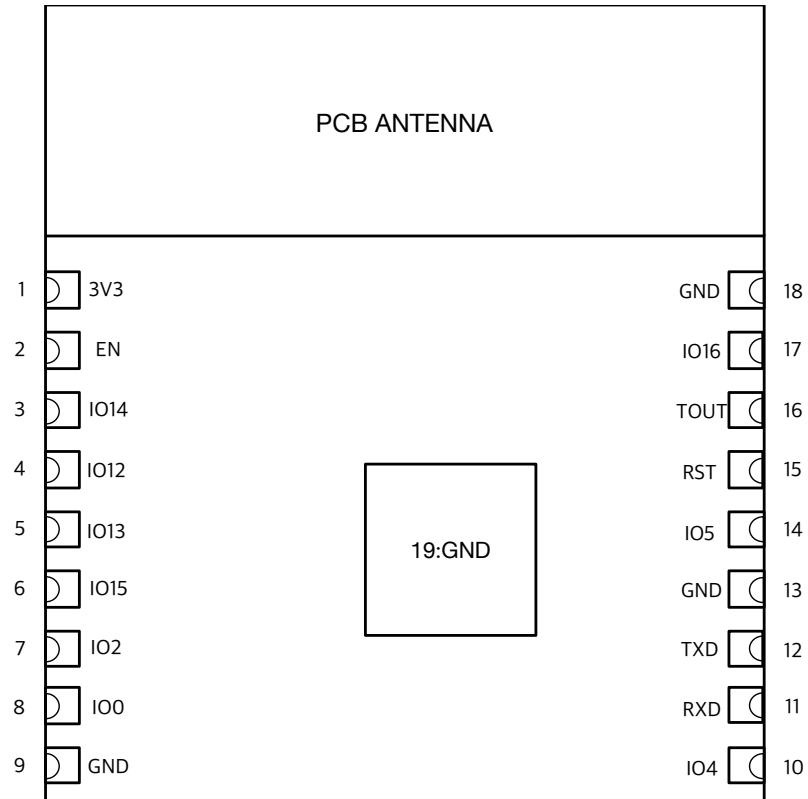
Figure 2-1 shows the pin distribution of the ESP-WROOM-02.



**Figure 2-1. ESP-WROOM-02 Pin Layout**

ESP-WROOM-02 has 18 pins. Please see the pin definitions in Table 2-1.

**Table 2-1. 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 |

| No. | Pin Name | Functional Description |
|---|---|---|
| 6 | IO15 | GPIO15; MTDO; HSPICS; UART0_RTS<br>Pull down. |
| 7 | IO2 | GPIO2; UART1_TXD<br>Floating (internal pull-up) or pull up. |
| 8 | IO0 | GPIO0<br>• UART download: pull down.<br>• Flash boot: floating or pull up. |
| 9 | GND | GND |
| 10 | IO4 | GPIO4 |
| 11 | RXD | UART0_RXD, receive end in UART download;<br>GPIO3 |
| 12 | TXD | UART0_TXD, transmit end in UART download, floating or pull up;<br>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.

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.    Electrical Characteristics

Table 4-1. Electrical Characteristics

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Storage temperatue | - | -20 | Normal | 70 | ℃ |
| Operating temperature | - | -20 | 20 | 70 | ℃ |
| Maximum soldering temperature (Condition: IPC/JEDEC J-STD-020) | - | - | - | 260 | ℃ |
| Supply voltage | VDD | 2.7 | 3.3 | 3.6 | V |
| 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 | $V_{OL}$ | - | - | 0.1 VDD | V |
| Output logic level high | $V_{OH}$ | 0.8 VDD | - | - | V |

## 4.2.    Wi-Fi Radio

Table 4-2. Wi-Fi Radio Characteristics

| Description | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Input frequency | 2400 | - | 2483.5 | MHz |
| Input impedance | - | 39+j6 | - | Ω |
| Input reflection | - | - | -10 | dB |
| **Output Power** | | | | |
| PA output power at 72.2 Mbps | 13 | 14 | 15 | dBm |
| PA output power in 11b mode | 19.5 | 20 | 20.5 | dBm |
| **Sensitivity** | | | | |
| CCK, 1 Mbps | - | -98 | - | dBm |

4. Electrical Characteristics

| Description | Min | Typ | Max | Unit |
|---|---|---|---|---|
| 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 |

## 4.3.  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 4-3. 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.

# 4.4. Reflow Profile
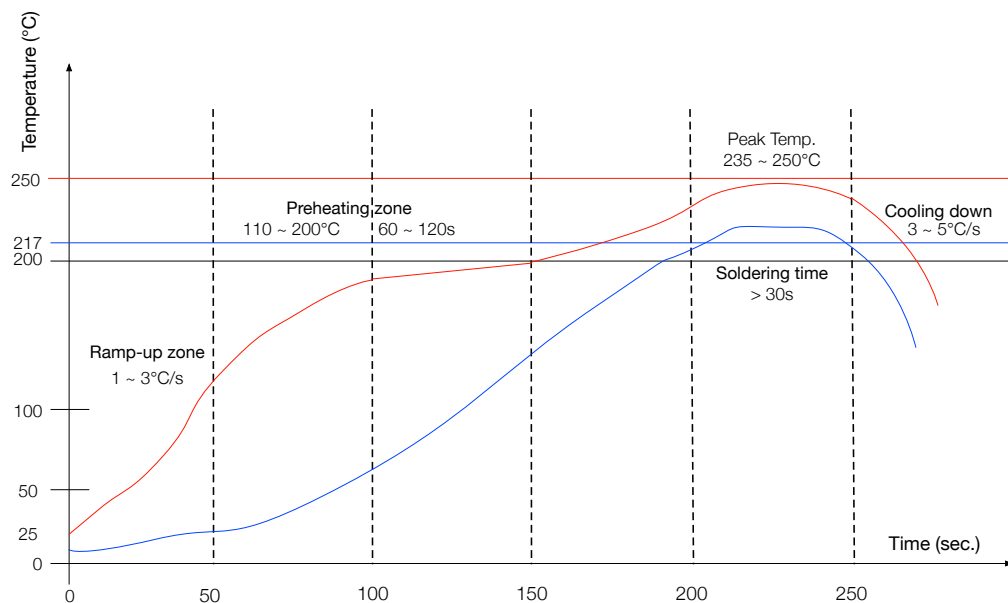


Ramp-up zone (升温区): Temp. <150°C, Time 60 ~ 90s, Ramp-up rate 1 ~ 3°C/s.
Preheating zone (预热恒温区): Temp. 150 ~ 200°C, Time 60 ~ 120s, Ramp-up rate 0.3 ~ 0.8°C/s.
Reflow soldering zone (回流焊接区): Peak Temp. 235 ~ 250°C ( <245°C recommended), Time 30 ~ 70s.
Cooling down zone (冷却区): Temp. 217 ~ 170°C, Ramp-down 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**

## 4.5. Electrostatic Discharge

Table 4-4. Electrostatic Discharge Parameters

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

# 5. Schematics
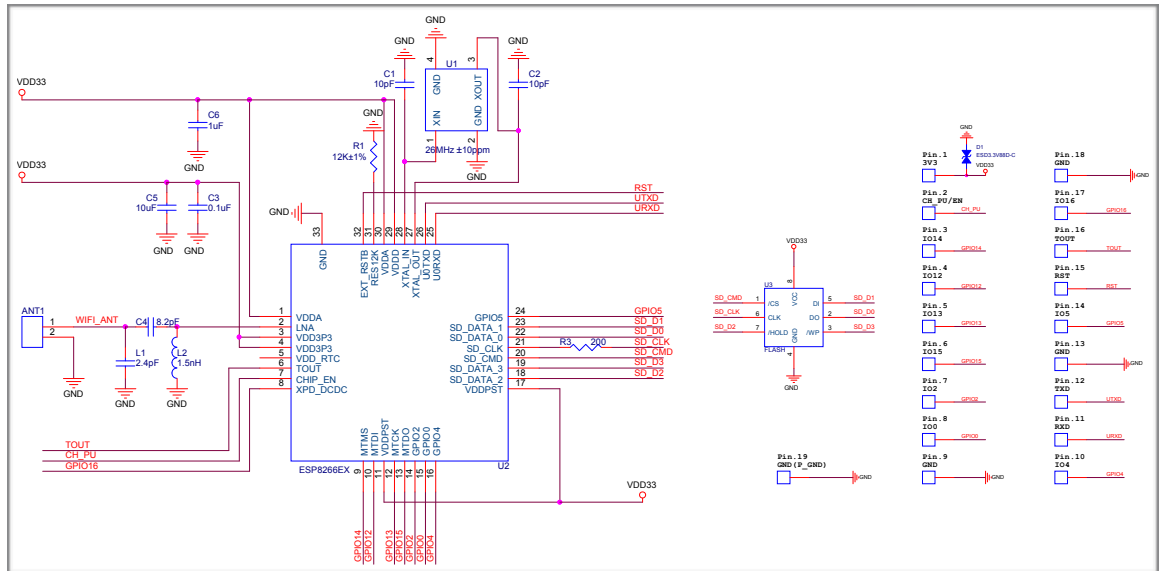


Figure 5-1. ESP-WROOM-02 Schematics
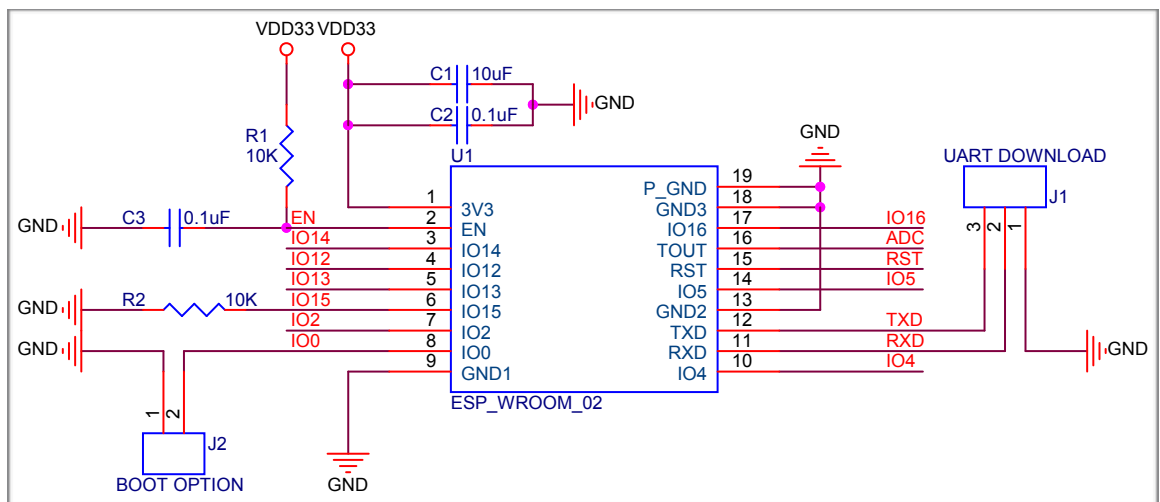


Figure 5-2. ESP-WROOM-02 Peripheral Schematics

📖 **Note:**

*It is recommended that users do not solder Pad 19 to the base board.*

# 6. Dimensions
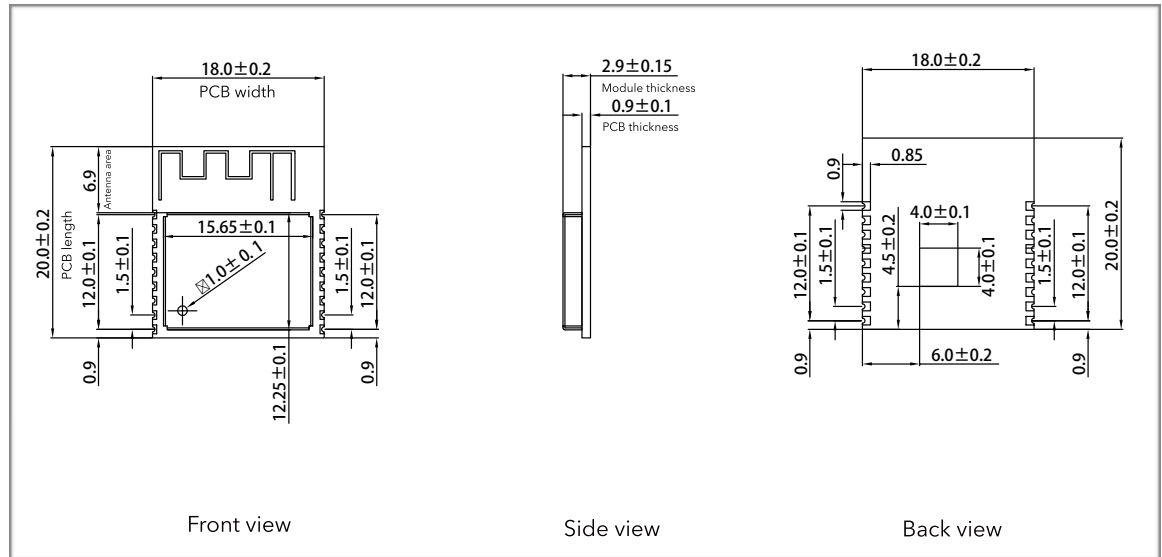


**Figure 6-1. Dimensions of ESP-WROOM-02**

# 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*

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