ESP-WROOM-S2
Datasheet

About This Guide

This document introduces users to the specifications of ESP-WROOM-S2 hardware, including the following topics.

Chapter	Title	Subject
Chapter 1	Overview	Introduction to ESP-WROOM-S2, including dimensions and specifications.
Chapter 2	Pin Description	Introduction to pin layout and the relevant description.
Chapter 3	Functional Description	Description of the major functional modules and protocols applied on ESP-WROOM-S2, including CPU, flash, memory and interfaces.
Chapter 4	Electrical Characteristics	Electrical data of ESP-WROOM-S2.
Chapter 5	FCC Warning	

Release Notes

Date	Version	Release notes
2016.06	V1.0	First release.
2016.08	V1.1	Updated the operating temperature range; Added NCC Wi-Fi standard; Updated Section 3.4 Interface Description.

Table of Contents

1.   Overview

Espressif provides the SMD module - ESP-WROOM-S2 that integrates ESP8266EX. The module has received various adjustments to achieve better RF performance. We recommend using ESP-WROOM-S2 for tests or for further development.

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

The module size is 16 mm x 23 mm x 3 mm (see Figure 1-1). The flash used on this module is a 2 MB SPI flash connected to HSPI, with the package size of SOP 8-150 mil. The gain of the on-board PCB antenna is 2 dBi.

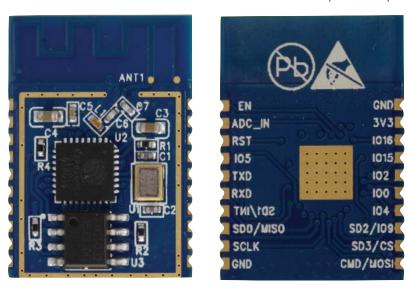The ESP-WROOM-S2 works as the SDIO/SPI slave with the SPI speed of up to 8 Mbps.

Figure 1-1. ESP-WROOM-S2 Module

Table 1-1. ESP-WROOM-S2 Specifications

Categories	Items	Specifications
Wi-Fi	Standards	FCC
	Wi-Fi protocols	802.11 b/g/n20
	Frequency range	2412MHz ~ 2462MHz
	Peripheral interface	UART/I2C/GPIO/PWM/SDIO/SPI/IR Remote Control/ADC
		GPIO/PWM

Categories	Items	Specifications
Hardware	Operating voltage	3.0V ~ 3.6V
	Operating current	Average: 80 mA
	Operating temperature range	-40°C ~ 85°C
	Storage temperature	-40°C ~ 85°C
	Package size	16 mm x 23 mm x 3 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 burn firmware via host
	Software development	Supports Cloud Server Development SDK for secondary development
	Network protocols	IPv4, TCP/UDP/HTTP/FTP
	User configuration	AT Instruction Set, Cloud Server, Android/iOS App

📖 *Note:*

ESP-WROOM-S2 with high temperature range option (-40°C ~ 125°C) is available for custom order.

2. Pin Description
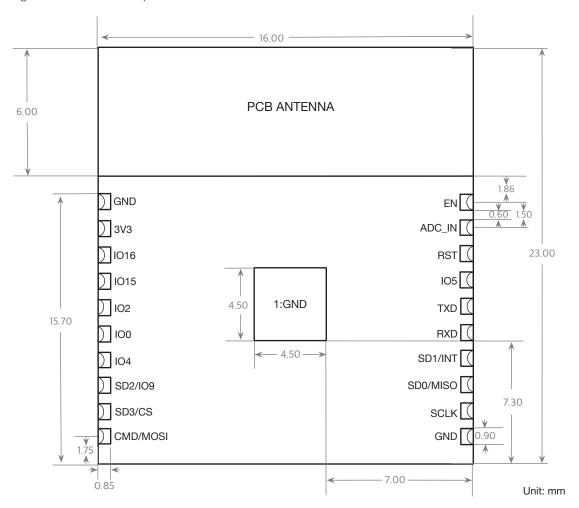
Figure 2-1 shows the pin distribution of the SMD Module.

Figure 2-1. Top View of The ESP-WROOM-S2

Table 2-1. ESP-WROOM-S2 Dimensions

Length	Width	Height	PAD size (bottom)	Pin Pitch
16 mm	23 mm	3 mm	0.9 mm x 0.85 mm	1.5 mm

ESP-WROOM-S2 has 20 pins, please see the pin definitions in Table 2-2.

Table 2-2. ESP-WROOM-S2 Pin Definitions

No.	Pin Name	Functional Description
1	GND	Ground
2	3V3	3.3 V power supply (VDD) 📖 **Note:** *It is recommended the maximum output current a power supply provides be of 500 mA or above.*
3	IO16	GPIO16; used for Deep-sleep wake-up when connected to RST pin.
4	IO15	HSPICS • UART download: pull down. • SDIO boot: floating (internal pull-up) or pull up.
5	IO2	GPIO2; UART1_TXD • UART download: pull down. • SDIO boot: don't-care.
6	IO0	GPIO0 • UART download: pull down. • SDIO boot: don't-care.
7	IO4	GPIO4
8	SD2/IO9	SD_D2 (Series resistor: 100 ~ 200 Ω, 10 k pull-up resistor); GPIO9
9	SD3/CS	SD_D3 (Series resistor: 100 ~ 200 Ω, 10 k pull-up resistor); SLAVE_ SPI_CS
10	CMD/MOSI	SD_CMD (Series resistor: 100 ~ 200 Ω, 10 k pull-up resistor); SLAVE_ SPI_MOSI
11	GND	Ground
12	SCLK	SD_CLK (Series resistor: 100 ~ 200 Ω); SLAVE_ SPI_CLK
13	SD0/MISO	SD_D0 (Series resistor: 100 ~ 200 Ω, 10 k pull-up resistor); SLAVE_ SPI_MISO
14	SD1/INT	SD_D1 (Series resistor: 100 ~ 200 Ω, 10 k pull-up resistor); SLAVE_ SPI_INT
15	RXD	UART0_RXD, receive end in UART download; GPIO3
16	TXD	UART0_TXD, transmit end in UART download, floating (internal pull-up) or pull up; GPIO1
17	IO5	GPIO5
18	RST	Reset
19	ADC_IN	Tests the power-supply voltage of VDD3P3 and the input power voltage of TOUT. These two functions cannot be used simultaneously.
20	EN	Chip enable pin (cannot be floating). Active high.

3. Functional Description

3.1. MCU

ESP8266EX contained in the ESP-WROOM-S2 integrates Tensilica L106 32-bit micro controller (MCU) and a 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 application. The MCU can work in conjunction with the other parts of the chip through the following interfaces.

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

3.2. Memory

3.2.1. Internal SRAM and ROM

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

According to our current version of SDK, SRAM space available to users is assigned as below.

- RAM size < 50 kB, that is, when ESP8266EX is working in Station mode and connects to the router, available space in Heap + Data sector is around 50 kB.
- There is no programmable ROM in ESP8266EX, therefore, user program must be stored in the SPI flash integrated into the ESP-WROOM-S2.

3.2.2. SPI Flash

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

ESP-WROOM-S2 currently integrates 2 MB SPI flash memory. ESP-WROOM-S2 supports these SPI modes: Standard SPI, DIO (Dual I/O), DOUT (Dual Output), QIO (Quad I/O) and QOUT (Quad Output).

> ⚠️ *Notice:*
>
> *Please use the most updated download tool and configure **SPI MODE** in the download tool as **DIO** or **DOUT**.*

3.3. Crystal Oscillator

ESP-WROOM-S2 uses 26 MHz crystal oscillator. The accuracy of the crystal oscillator should be ±10 PPM, and the operating temperature range is -20°C to 85°C.

When using the download tool, please note to select the right crystal oscillator type. 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 and adjustment on 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.

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 inductance nearby.

3.4. Interface Description

Table 3-1. Interface Description

Interface	Pin	Functional Description
SPI	GPIO12/13/14/15 or GPIO6/7/8/11	S2 can control SPI Slave as a Master or communicate with Host MCU as a Slave. In overlap mode, S2 can share the SPI interface with Flash, shifted by different CS signals.
PWM	Any available GPIO (EXCEPT GPIO16)	Currently the demo provides 4 PWM channels (users can extend to 6 channels). PWM interface can realize the control of LED lights, buzzers, relays, electronic machines, etc.
IR	Any available GPIO (EXCEPT GPIO16)	The functionality of infrared remote control interface can be realized via software programming. The interface uses NEC coding, modulation, and demodulation. The frequency of modulated carrier signal is 38 kHz.
ADC	TOUT	Tests the power supply voltage of VDD3P3 (Pin 3 and Pin 4) and the input power voltage of TOUT (Pin 6). However, these two functions cannot be used simultaneously. This interface is typically used in sensors.
I2C	Any available GPIO (EXCEPT GPIO16)	Connects to external sensors and display screens, etc.
UART	UART0: TXD(U0TXD), RXD(U0RXD) UART1: IO2(TXD)	Communicates with UART device. Downloading: U0TXD + U0RXD or GPIO2 + U0RXD Communicating (UART0): U0TXD, U0RXD Debugging: UART1_TXD (GPIO2) can be used to print debugging information.

4. Electrical Characteristics

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

4.1. Absolute Maximum Ratings

Table 4-1. Absolute Maximum Ratings

Rating	Condition	Value	Unit
Storage temperatue	-	-40 ~ 125	℃
Maximum soldering temperature	-	260	℃
Supply voltage	IPC/JEDEC J-STD-020	3.0 ~ 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	125	℃
Supply voltage	VDD	3.0	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	-	50	-	ohm
Input reflection	-	-	-10	dB
PA output power at 72.2 Mbps	15.5	16.5	17.5	dBm
PA output power in 11b mode	16	17	**18**	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	-	2462	MHz
Input impedance	-	50	-	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	16	17	**18**	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 3.3 V 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 802.11n20, 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 802.11n20, 1024 bytes packet length , 65 dBm	-	56	-	mA
Modem-Sleep①	-	15	-	mA
Light-Sleep②	-	0.9	-	mA
Deep-Sleep③	-	10	-	μA
Power Off	-	0.5	-	μA

🔖 *Notes:*

① *Modem-Sleep* is used when applications require CPU to be working, such as PWM or I2S applications. In the scenarios where Wi-Fi connectivity is maintained and data transmission is not required, 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 the scenarios where Wi-Fi connectivity is maintained and data transmission is not required, 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 and only transmit data with long time lags, e.g., a temperature sensor that measures temperature every 100 s. For example, when ESP8266EX sleeps for 300 s then wakes up to connect to AP (taking about 0.3 ~ 1 s), the overall average current consumption is far less than 1 mA.

4.7. Reflow Profile

Table 4-7. Reflow Profile

Indicator	Value
Ramp-up Rate (T_S Max to T_L)	3°C/second max.
Preheat	
Temperature Min. (T_S Min.)	150°C
Temperature Typ. (T_S Typ.)	175°C
Temperature Min. (T_S Max.)	200°C
Time (T_S)	60 ~ 180 seconds
Ramp-up Rate (T_L to T_P)	3°C/second max.
Time maintained above: Temperature (T_L)/Time (T_L)	217°C/60 ~ 150 seconds
Peak temperature (T_P)	260°C max, for 10 seconds
Target Peak Temperature (T_P Target)	260°C + 0/-5°C
Time within 5°C of actual Peak Temperature (T_P)	20 ~ 40 seconds
T_S max to T_L (Ramp-down Rate)	6°C/second max.
Time 25°C to Peak Temperature (t)	8 minutes max.

5. FCC Warning

Any Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the 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 Label Instructions:

The outside of final products that contains this module device must display a label referring to the enclosed module. This exterior label can use wording such as: "Contains Transmitter Module
FCC ID: 2AC7Z-ESPWROOMS2" or "Contains FCC ID: 2AC7Z-ESPWROOMS2" Any similar wording that expresses the same meaning may be used.

FCC Radiation Exposure Statement:

To satisfy FCC RF Exposure requirements for this transmission devices, a separation distance of 20cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.