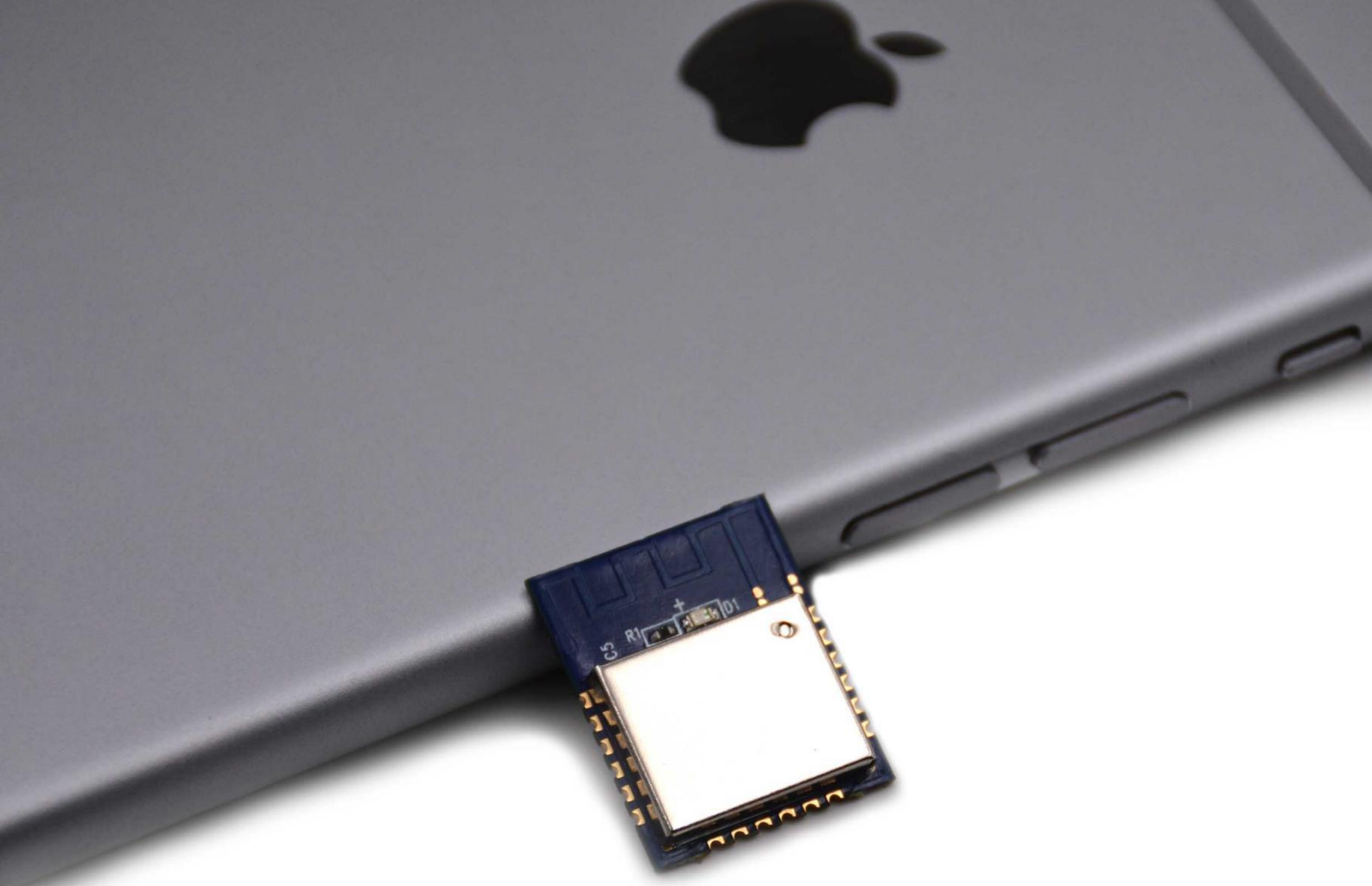

ESP8266 WiFi Module

Datasheet

Version 2.0

2016 / 9

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Amendment record

Time	Version	Specification
2016.09	V1.0	First release

Contents

1. Overview

ESP8266-S1 Wi-Fi module is a low consumption, high performance Wi-Fi network control module designed by Hysiry. It can meet the IoT application requirements in smart power grids, building automation, security and protection, smart home, remote health care etc.

The module's core processor ESP8266 integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor with smaller package size and 16 bit compact mode, main frequency support 80 MHz and 160 MHz, support RTOS, integrated Wi-Fi MAC / BB / RF / PA / LNA, on-board PCB antenna.

The module supports standard IEEE802.11 b / g / n protocol, a complete TCP / IP protocol stack.
Users can use the module to add networking capabilities to existing devices, but also to build an independent net work controller.

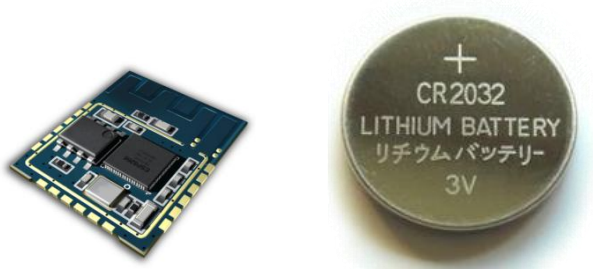


Figure -1.ESP8266-S1 Module

2. Main Features

2.1 System Diagram

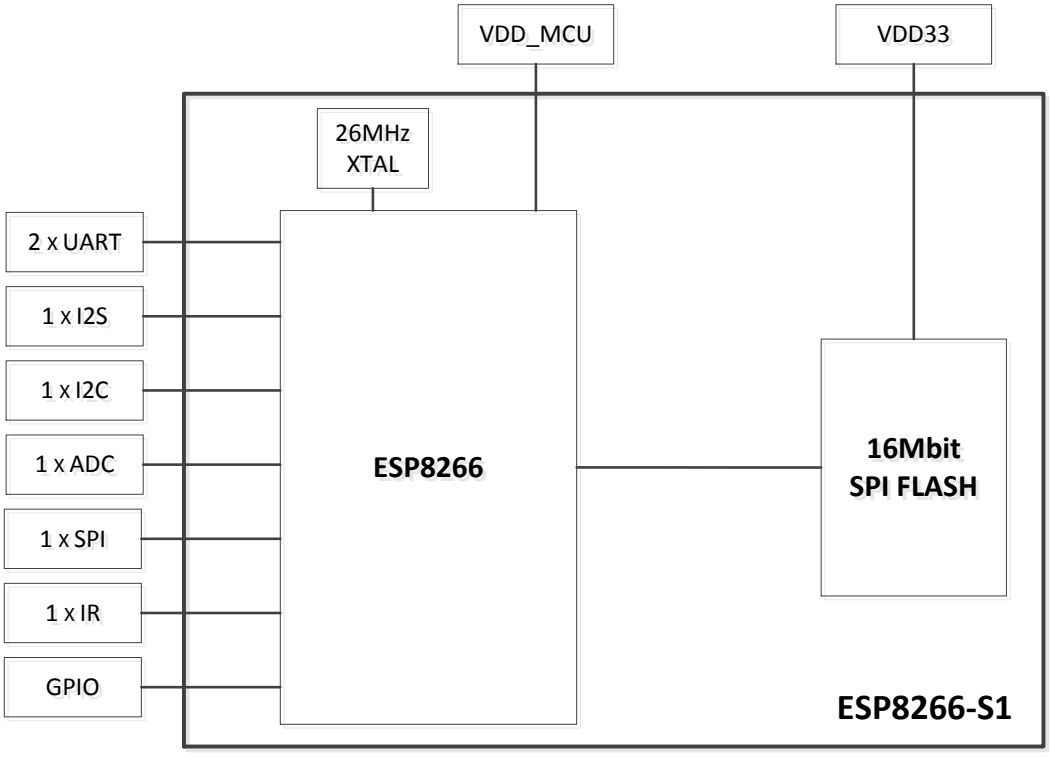


Figure -2. System Diagram

2.2 Hardware Specifications

- Operating Voltage: 3.3V（3.0 ~ 3.6V）
- Operating Temperature：-40 - 85°C
- CPU Tensilica L106
  - RAM 50KB（Available）
  - Flash 16 Mbit
- System
  - 802.11 b/g/n
  - Frequency range 2.4 GHz ~ 2.5 GHz（2400 M ~ 2483.5 M）
  - IntegratedTensilica L106 ultra-low power 32-bitmicro MCU, with 16-bit RSIC. The CPU clock speed is 80MHz. It can also reach a maximum value of 160MHz.
  - WIFI 2.4 GHz，supportWPA/WPA2
  - Supports UART、I2C、GPIO、PWM、SDIO、SPI、ADC、PWM、IR
  - Integrated 10 bit high precision ADC
  - Supports TCP、UDP、HTTP、FTP
  - Integrated TR switch, balun,LNA, Power amplifier and matching network
  - Integrated PLL, Regulator and power source management components, +20 dBm output power in 802.11b mode
  - Average working current80mA, <Deep sleep current < 20uA, Power down leakage current < 5uA
  - Rich interface on processor: SDIO 2.0, SPI, UARTl
  - Wake up ,build the connection and transmit packets in $< 2\text{ms}$
  - Standby power consumption < 1.0mW (DTIM3)
  - Support AT remote upgrades and cloud OTA upgrade
  - Support Station / SoftAP / SoftAP+Station operation modes
  - Ultra-Small 18.6mm * 15.0mm * 3.05mm

3. Pin description

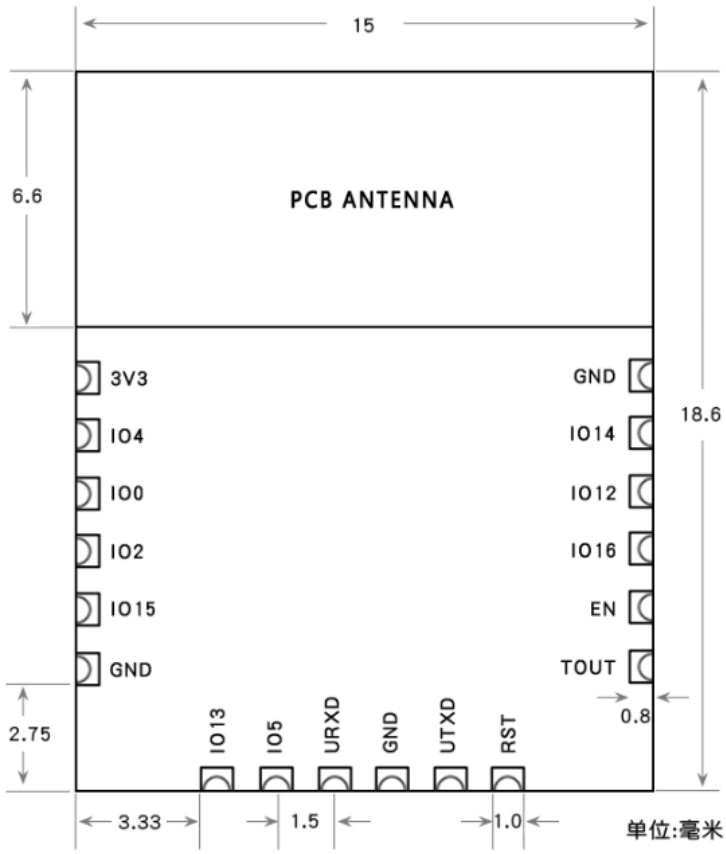


Figure -3. Pin description

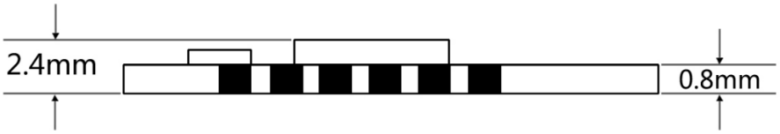


Figure -4.Module Size (Side View)

Figure -5.Module Size - shieldingcase (Side View)

Table -1. ESP8266-S1 Pin Definitions

No.	Pin Name	Functional Description
1	VCC	3.3 V power supply (VDD) **Note:**It is recommended the maximum output current a power supply provides be of 500 mA or above.
2	IO4	GPIO4
3	IO0	GPIO0 • UART download: pull down. • SDIO boot: don't-care.

4	IO2	GPIO2；UART1_TXD
5	IO15	GPIO15；MIDO； HSPICS；UART0_RTS
6	GND	Ground
7	IO13	GPIO13； HSPI_MOSI；UART0_CTS
8	IO5	GPIO5
9	URXD	UART0_RXD, receive end in UART download； GPIO3
10	GND	Ground
11	UTXD	UART0_TXD, transmit end in UART download, floating (internal pull-up) or pull up； GPIO1
12	RST	Reset
13	TOUT	Tests the power-supply voltage of VDD3P3 and the input power voltage of TOUT.These two functions cannot be used simultaneously.
14	EN	Chip enable pin (cannot be floating). Active high.
15	IO16	GPIO16； used for Deep-sleep wake-up when connected to RST pin.
16	IO12	GPIO12；HSPI_MISO
17	IO14	GPIO14；HSPI_CLK
18	GND	Ground

4. Functional Description

4.1 MCU

ESP8266EX contained in the ESP8266-S1 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.

4.2 Memory

4.2.1 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 ESP8266-S1.

4.2.2 SPI Flash

- ESP8266EX supports SPI flash. Theoretically speaking, ESP8266EX can support up to 16 MB SPI flash.
- ESP8266-S1 currently integrates 16 Mbit SPI flash memory. ESP8266-S1 supports these SPI modes: Standard SPI, DIO (Dual I/O), DOUT (Dual Output), QIO (Quad I/O) and QOUT (Quad Output).

4.3 Interface Description

Table -2. Interface Description

Interface	Pin	Functional Description
SPI	IO12(MISO),IO13(MOSI), IO14(CLK),IO15(CS)	S1 can control SPI Slave as a Master or communicate with Host MCU as a Slave. In overlap mode, S1 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 implemented via software programming. NEC coding, modulation, and demodulation are used by this interface. The frequency of modulated carrier signal is 38KHz.
ADC	TOUT	ESP8266EX integratesa 10-bit precision SARADC. ADC_IN interface is used to test the power supply voltage of VDD3P3(Pin 3 and Pin 4), as well as the input voltage of TOUT (Pin 6). It can be used in sensors application.
I2C	IO14(SCL), IO2(SDA) Any available GPIO(EXCEPT GPIO16)	Can connect to external sensor and display, etc.

UART	UART0: TXD(U0TXD),RXD(U0RXD) ,IO15(RTS),IO13(CTS)	Devices with UART interfaces can be connected **Download：** U0TXD+U0RXD or GPIO2+U0RXD **Communication：** (UART0):U0TXD,U0RXD,MTDO(U0RTS),MTCK(U0CTS) **Debug：** UART1_TXD(GPIO2)Can be used to print debugging information
	UART1: IO2(TXD)	By default, UART0 will output some printed information when the device is powered on and is booting up. If this issue exerts influence on some specific applications, users can exchange the inner pins of UART when initializing, that is to say, exchange U0TXD, U0RXD with U0RTS, U0CTS.
I2S	I2S input： IO12 (I2SI_DATA); IO13 (I2SI_BCK); IO14 (I2SI_WS);	Mainly used for audio capturing, processing and transmission
	I2S output: IO15 (I2SO_BCK); IO3 (I2SO_DATA); IO2 (I2SO_WS);	

5. Electrical Characteristic

5.1 Standby Power Consumption

Table -3. Standby Power Consumption

Mode	Status	Typical Value
Standby	Modem Sleep	15mA
	Light Sleep	0.9mA
	Deep Sleep	20uA
	Off	0.5uA
Working（Average）		80mA
Tx 801.11b，CCK 11Mbps，P OUT=+17 dBm		170mA
Tx 801.11g，OFDM 54Mbps，P OUT =+15 dBm		140mA
Tx 801.11n，MCS7，P OUT =+13 dBm		120mA
Rx 801.11b，1024 bytes packet length，-80 dBm		50mA
Rx 801.11g，1024 bytes packet length，-70 dBm		56mA
Rx 801.11n，1024 bytes packet length，-65 dBm		56mA

The following current consumption is based on 3.3V supply and 25°C ambient with internalregulators.Values are measured at antenna port without SAW filter. All the transmissionmeasurements valuesare based on 90% duty cycle, continuous transmission mode.

Table -4.Standby Power Consumption

Mode	Status	Typical Value				
Standby	Modem Sleep	15mA				
	Light Sleep	0.9mA				
	Deep Sleep	20uA				
	Off	0.5uA				
Power Save Mode (2.4G) (Low Power Listen disabled) [1]	DTIM period	Current Cons. (mA)	T1 (ms)	T2 (ms)	Tbeacon (ms)	T3 (ms)
	DTIM 1	1.2	2.01	0.36	0.99	0.39
	DTIM 3	0.9	1.99	0.32	1.06	0.41

①: Modem-Sleep requires the CPU to be working, as in PWM or I2S applications. According to802.11 standards (like U-APSD), it saves power to shut down the Wi-Fi Modem circuit whilemaintaining a Wi-Fi connection with no data transmission. E.g. in DTIM3, to maintain a sleep 300mswake 3ms cycle to receive AP's Beacon packages, the current is about 15mA.

②: During Light-Sleep, the CPU may be suspended in applications like Wi-Fi switch. Without datatransmission, the Wi-Fi Modem circuit can be turned off and CPU suspended to save poweraccording to the 802.11 standard (U-APSD). E.g. in DTIM3, to maintain a sleep 300ms-wake 3mscycle to receive AP's Beacon packages, the current is about 0.9mA.

③: Deep-Sleep does not require Wi-Fi connection to be maintained. For application with long timelags between data transmission, e.g. a temperature sensor that checks the temperature every 100s,sleep 300s and waking up to connect to the AP (taking about 0.3~1s), the overall average current isless than 1mA.

5.2 RF Performance

Table -5. 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	19.5	20.5	21.5	dBm

Sensitivity				
CCK，1Mbps	/	-98	/	dBm
CCK，11Mbps	/	-91	/	dBm
6Mbps（1/2 BPSK）	/	-93	/	dBm
54Mbps（3/4 64-QAM）	/	-75	/	dBm
HT20，MCS7（65Mbps，72.2Mbps）	/	-72	/	dBm
Adjacent channel rejection				
OFDM，6Mbps	/	37	/	dB
OFDM，54Mbps	/	21	/	dB
HT20，MCS0	/	37	/	dB
HT20，MCS7	/	20	/	dB

5.3 Digital Terminal Characteristics

Table -6. Digital Terminal Characteristics

Terminals	Symbol	Min	Max	Unit
Input logic level low	VIL	-0.3	0.25 VDD	V
Input logic level high	VIH	0.75 VDD	VDD + 0.3	V
Output logic level low	VOL	N	0.1 VDD	V
Output logic level high	VOL	0.8 VDD	N	V

5.4 Absolute Maximum Ratings

Table -7. Absolute Maximum Ratings

Rating	Condition	Value	Unit
Storage temperatue	/	-40 to 125	°C
Maximum soldering temperature	/	260	°C
Supply voltage	IPC/JEDEC J-STD-020	+3.0 to +3.6	V

5.5 Reflow Profile

Table -8. Reflow Profile

Indicator	Value
Ramp-up Rate (TS Max to TL)	3 °C /second max.
Prehea Temperature Min. (TS Min.) Temperature Typ. (TS Typ.) Temperature Min. (TS Max.) Time (TS)	 150°C 175°C 200°C 60 ~ 180 seconds
Ramp-up Rate (TL to TP)	3°C /second max
Time maintained above: Temperature (TL)/Time (TL)	270°C / 60 ~ 150 seconds
Peak temperature (TP)	260 °C max, for 10 seconds
Target Peak Temperature (TP Target)	260 °C + 0 / -5°C
Time within 5°C of actual Peak Temperature (TP)	20 ~ 40 seconds
TS max to TL (Ramp-down Rate)	6°C / second max.
Time 25°C to Peak Temperature (t)	8 minutes max.

6. Schematics

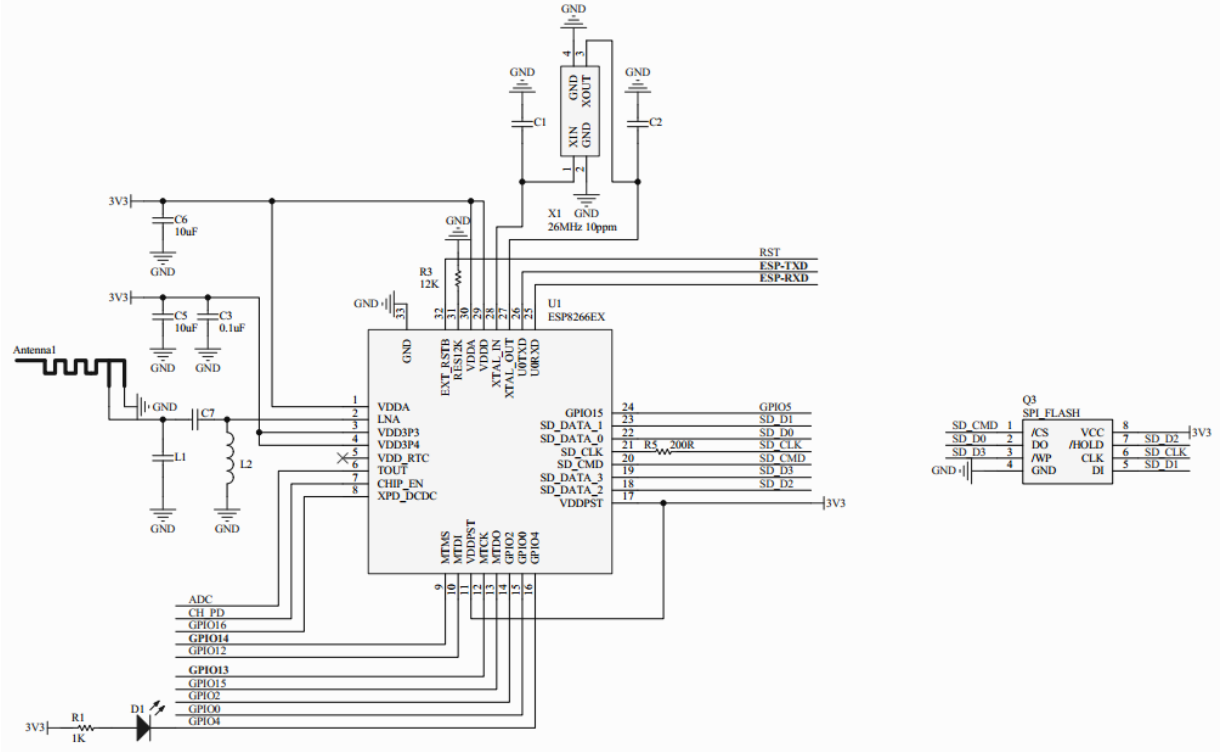


Figure -6. ESP8266-S1 Schematics

7. Minimum System Requirements

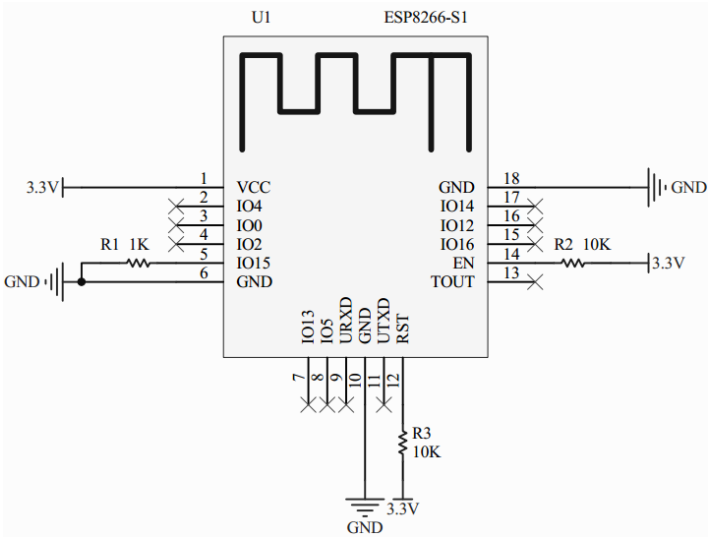
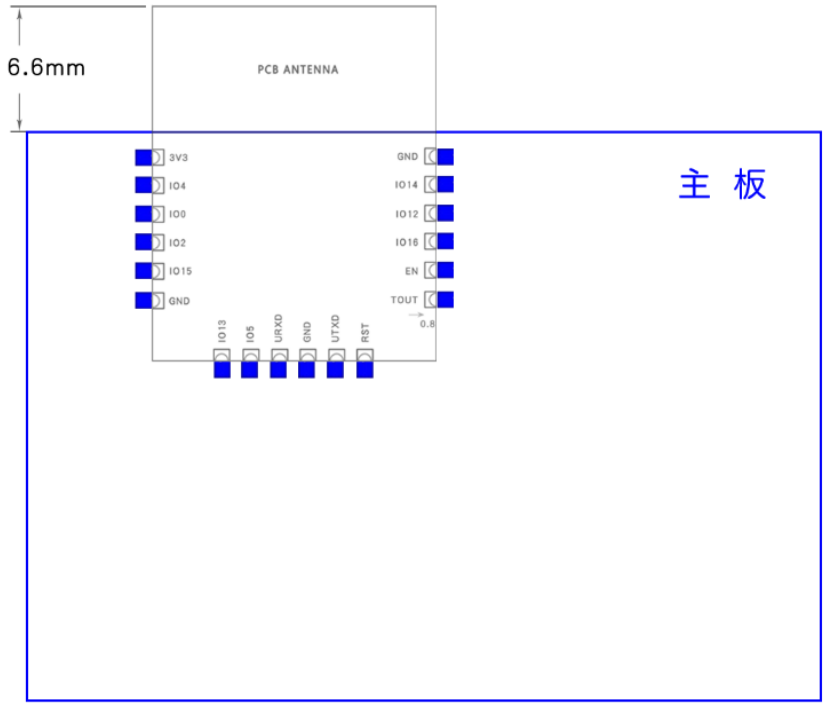


Figure -7. ESP8266-S1 minimum system

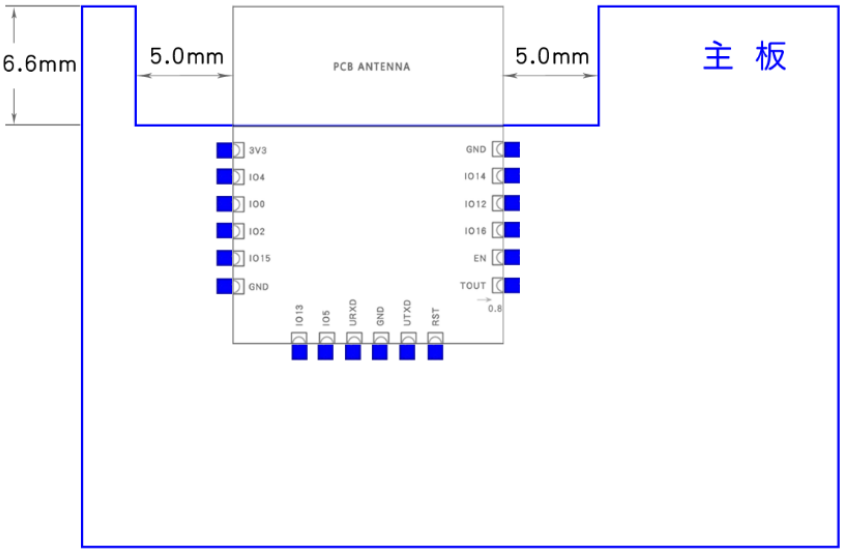
8. Module Placem

The ESP8266-S1 module is designed to be soldered to a host PCB. The placement of the module and antenna needs to adhere to our guidelines, in order to optimize the RF performance of the final product. This application note describes the recommended placement of the antenna on a host board to ensure optimal RF performance.

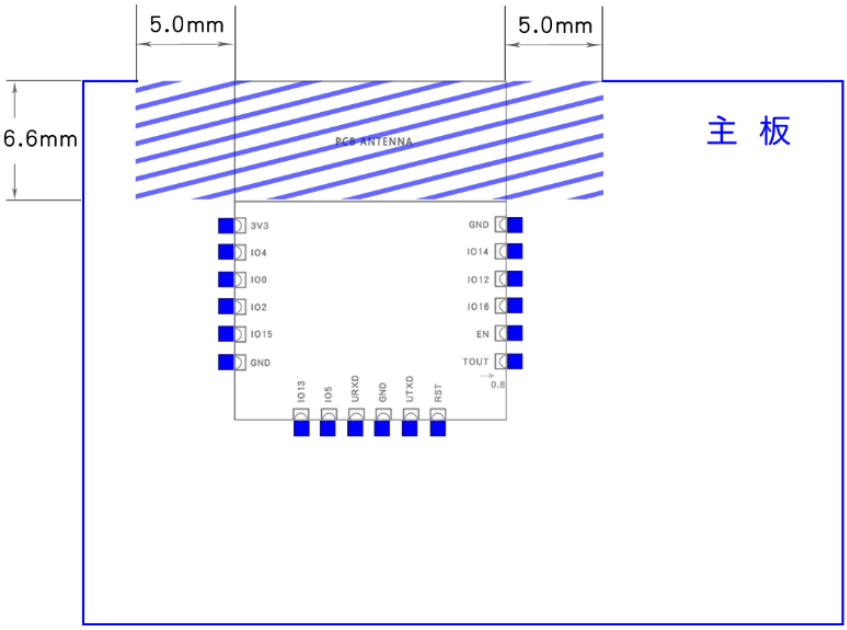
The PCB antenna used on ESP8266-S1 is a Meandered Inverted F Antenna (MIFA) for the 2.4G Wi-Fi band with an antenna gain. option 1 is used as a reference, and the measurements results show that option 2 and 3 have the best performances, while the other options are sub-optimal



Option 1. Placing at the edge withthe antenna outside of the host board



Option 3. Placing at the edge with clearance area



Option 3. Placing at the edge with no copper trace below the antenna

9. Switching noise control

ESP8266-S1 has high speed GPIO and peripheral interfaces which can create severe switching noise. In applications where power consumption and EMI profile are important, it is recommended that a series resistor of 10-100 ohms be placed with digital I/O. This limits overshoot during switching and results in smoother transitions. A series resistor may also protect from ESD to some extents.

10. Technical Support

E-mail：technical@hysiry.com

FCC Caution: Any changes or modifications not expressly
approved by the party responsible for compliance could 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.
This device and its antenna(s) must not be co-located or operating in conjunction
with any other antenna or transmitter.
15.105 Information to the user.
(b) For a Class B digital device or peripheral, the instructions furnished the
user shall include the following or similar statement, placed in a prominent
location in the text of the manual:
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.

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 and your bo dy.

Radiation Exposure Statement:
This equipment complies with FCC 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.
The module should not be installed and operated simultaneously with other radios except additional RF exposure was evaluated for simultaneously transmission.
The availability of some specific channels and/or operational frequency bands are country dependent and are firmware programmed at the factory to match the intended destination.
The firmware setting is not accessible by the end user.
The final end product must be labelled in a visible area with the following:
“Contains Transmitter Module **2AKBPESP8266**”