



ESP-12S Specification

Version V1.0

Copyright ©2019

Disclaimer and Copyright Notice

The information contained herein, including any referenced URLs, is subject to change without notice.

This document is provided “as is” without warranty of any kind, express or implied, including but not limited to the warranties of merchantability, fitness for a particular purpose, or non-infringement. Furthermore, no warranty is given regarding proposals, specifications, or samples mentioned elsewhere. The publisher shall not be liable for any infringement of patent rights arising from the use of the information contained herein. This document does not grant, expressly or impliedly, by estoppel or otherwise, any license to intellectual property rights.

All test data presented herein are obtained from Ai-Thinker laboratories. Actual results may vary slightly.

Wi-Fi Alliance member logos are the property of the Wi-Fi Alliance.

All trade names, trademarks, and registered trademarks mentioned are the property of their respective owners.

Shenzhen Ai-Thinker Technology Co., Ltd. reserves the final right of interpretation of this document.

Notice

This manual may be updated due to product version upgrades or other reasons. Shenzhen Ai-Thinker Technology Co., Ltd. reserves the right to modify the content of this manual without prior notice or announcement. This manual is intended as a usage guide only. While Shenzhen Ai-Thinker Technology Co., Ltd. strives to provide accurate information, it makes no guarantee that the content is entirely free of errors. All statements, information, and recommendations contained herein do not constitute any express or implied warranty.

Document Revision History

Version	Date	Description of Changes	Authored by	Approved by
V0.9	2016-10-14	First edition	Yang Xiaofei	
V1.0	2019-10-30	Update data	Xie Yiji	

Contents

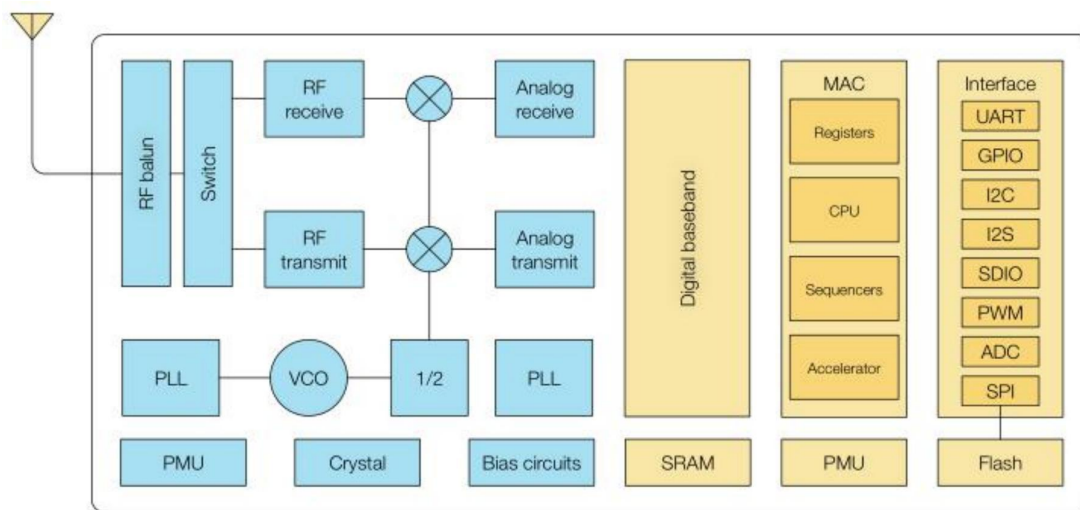
1 Product Overview	5
2 Electrical Parameters	8
3 Appearance and Dimensions	11
4 Pin Definition	12
5 Schematic Diagram	14
6 Design Guide	14
7 Reflow Soldering Profile	18
8 Packaging Information	19
9 Contact Information	20

1 Product Overview

The ESP-12S is a Wi-Fi module developed by Ai-Thinker Technology. Its core processor, ESP8285, integrates the industry-leading Tensilica L106 ultra-low-power 32-bit MCU in a compact package. It features a 16-bit reduced instruction mode, supports clock frequencies of 80 and 160 MHz, supports RTOS, and integrates Wi-Fi MAC/BB/RF/PA/LNA.

The ESP-12S Wi-Fi module supports the standard IEEE 802.11b/g/n protocol and a full TCP/IP protocol stack. Users can use this module to add networking capabilities to existing devices or to build standalone network controllers.

The ESP8285 is a high-performance wireless SoC, offering maximum utility at the lowest cost and providing limitless possibilities for embedding Wi-Fi functionality into other systems.



The ESP8285 features complete and self-contained Wi-Fi networking solution, allowing it to be used standalone or as a slave device integrated into a master MCU for operation. It comes with a built-in 2 MB Flash, featuring a simple external circuit design. The built-in high-speed cache memory helps to improve system performance and optimize the storage system.

Alternatively, the ESP8285 can function as a Wi-Fi adapter via SPI/SDIO or UART interfaces, making it applicable to designs based on any microcontroller.

With its powerful on-chip processing and storage capabilities, the ESP8285 can integrate sensors and other application-specific devices via its GPIO ports, significantly reducing the upfront development costs.

Features

- Complete 802.11b/g/n Wi-Fi SoC module
- Built-in ultra-low-power 32-bit Tensilica L106 MCU, supporting clock frequencies of 80 and 160 MHz, with RTOS support
- Built-in 1-channel 10-bit high-precision ADC
- Supports UART/GPIO/ADC/PWM/SPI/I2C interfaces
- Adopts SMD-16 package
- Integrates Wi-Fi MAC/BB/RF/PA/LNA
- Supports various sleep modes, with deep sleep current as low as 20 μ A
- Maximum UART baud rate up to 4 Mbps
- Embedded LwIP protocol stack
- Supports STA/AP/STA+AP operating modes
- Supports one-click network configuration for Android/iOS via Smart Config (APP) / AirKiss (WeChat)
- Supports local upgrade via UART and remote firmware upgrade (FOTA)
- Universal AT commands for quick start
- Supports secondary development; integrated Windows and Linux development environments

Main Parameters

Table 1 Main Parameters Specifications

Model	ESP-12S
Package	SMD-16
Dimensions	24*16*3 (± 0.2) mm
Antenna Type	On-board PCB antenna
Frequency Range	2400–2483.5 MHz
Operating Temperature	-40–105 °C
Storage Conditions	-40–125 °C, < 90% RH
Power Supply Range	Supply voltage: 3.0–3.6 V, supply current: >500 mA
Supported Interfaces	UART/GPIO/ADC/PWM/SPI/I2C
Available I/Os	9
UART Baud Rate	Supports 110–4608000 bps, default 115200 bps
Security	WEP/WPA-PSK/WPA2-PSK
SPI Flash	Default 16 Mbit
Certification	FCC, CE, RoHS, SRRC

2 Electrical Parameters

Electrical Characteristics

Parameter		Condition	Min	Typ	Max	Unit
Supply Voltage		VDD	3.0	3.3	3.6	V
I/O	V_{IL}/V_{IH}	-	-0.3/0.75VIO	-	0.25VIO/3.6	V
	V_{OL}/V_{OH}	-	N/0.8VIO	-	0.1VIO/N	V
	I_{MAX}	-	-	-	12	mA

RF Performance

Description	Typ	Unit
Frequency Range	2400–2483.5	MHz
Output Power		
11n mode, PA output power	13±2	dBm
11g mode, PA output power	14±2	dBm
11b mode, PA output power	16±2	dBm
Receiver Sensitivity		
CCK, 1 Mbps	<=-90	dBm
CCK, 11 Mbps	<=-85	dBm
6 Mbps (1/2 BPSK)	<=-88	dBm
54 Mbps (3/4 64-QAM)	<=-70	dBm
HT20 (MCS7)	<=-67	dBm

Power Consumption

The following power consumption data is measured based on a 3.3 V power supply, an ambient temperature of 25 °C, and using an internal voltage regulator.

- All measurements are performed at the antenna interface without a SAW filter.
- All transmission data is measured under continuous transmission mode with a 90% duty cycle.

Mode	Min	Typ	Max	Unit
TX 802.11b, CCK 11 Mbps, POUT=+17 dBm	-	170	-	mA
TX 802.11g, OFDM 54 Mbps, POUT=+15 dBm	-	140	-	mA
TX 802.11n, MCS7, POUT =+13 dBm	-	120	-	mA
RX 802.11b, Packet Length 1024 bytes, -80 dBm	-	50	-	mA
RX 802.11g, Packet Length 1024 bytes, -70 dBm	-	56	-	mA
RX 802.11n, Packet Length 1024 bytes, -65 dBm	-	56	-	mA
Modem-sleep ^①	-	20	-	mA
Light-sleep ^②	-	2	-	mA
Deep-sleep ^③	-	20	-	μA
Power Off	-	0.5	-	μA

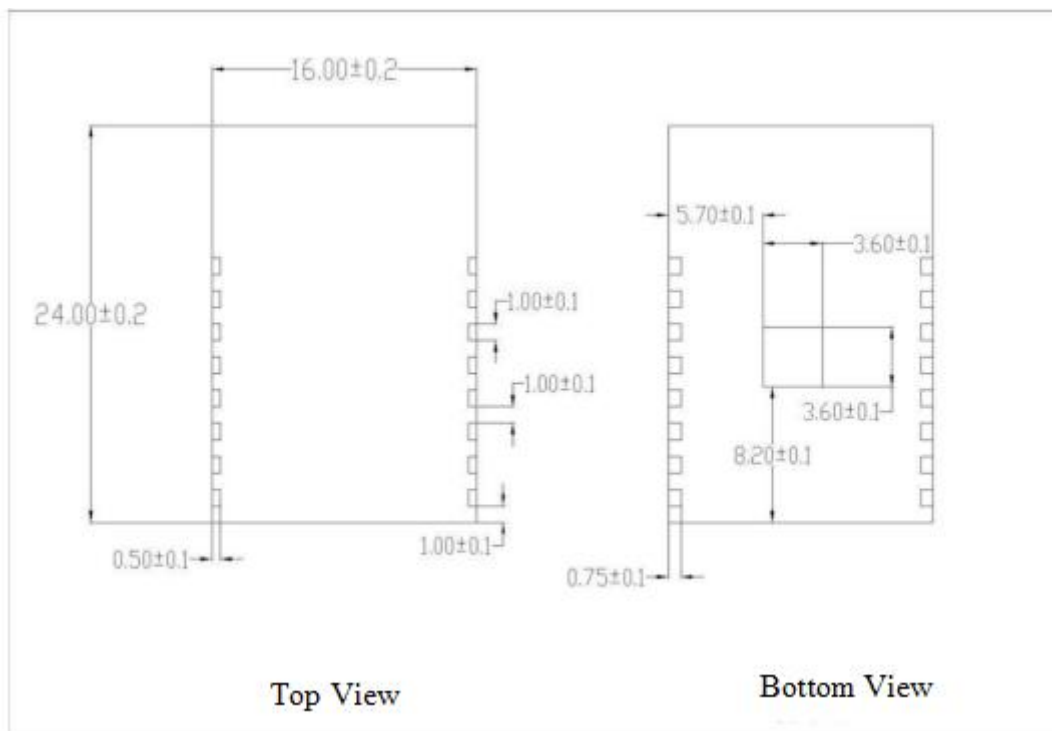
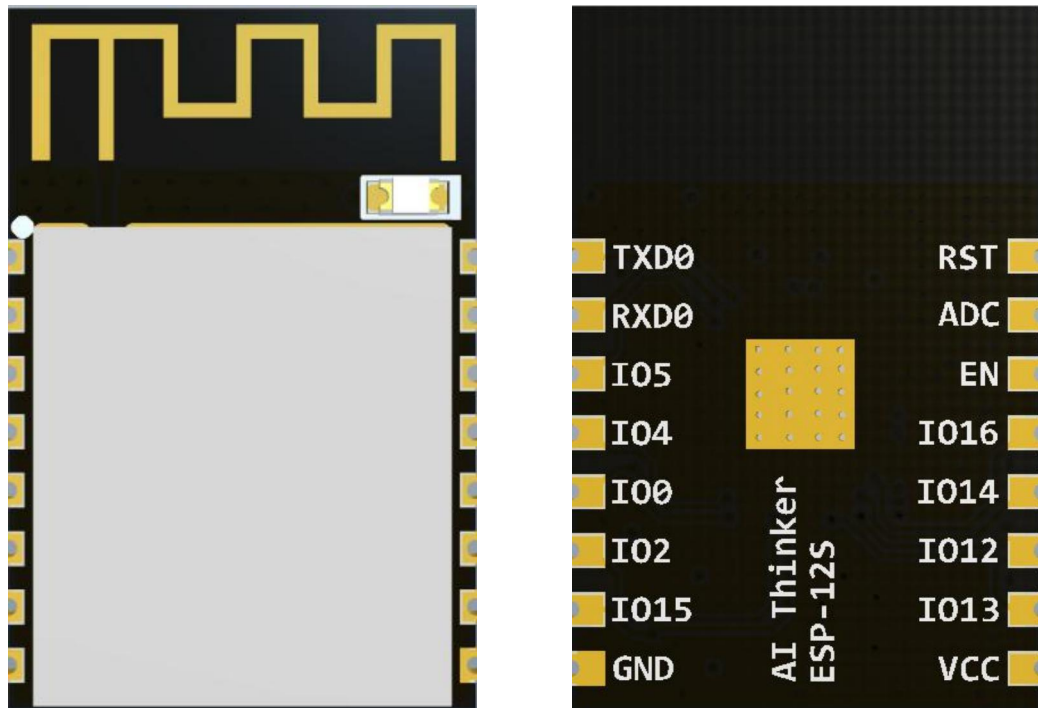
Instructions:

- Modem-sleep is used for applications requiring the CPU to remain active, such as PWM or I2S applications. While maintaining a Wi-Fi connection, if there is no data transmission, the Wi-Fi modem circuit can be turned off according to the 802.11 standard (e.g., U-APSD) to save power. For example, during DTIM3, every 300 ms of sleep, the system wakes up for 3 ms to receive the AP's Beacon packets, resulting in an overall average current of approximately 20 mA.
- Light-sleep is used for applications where the CPU can be paused, such as Wi-Fi switches. While maintaining a Wi-Fi connection, if there is no data transmission, the Wi-Fi modem circuit can be turned off according to the 802.11 standard (e.g., U-APSD) to save power. For example, during DTIM3, every 300 ms of sleep, the

system wakes up for 3 ms to receive the AP's Beacon packets, resulting in an overall average current of approximately 2 mA.

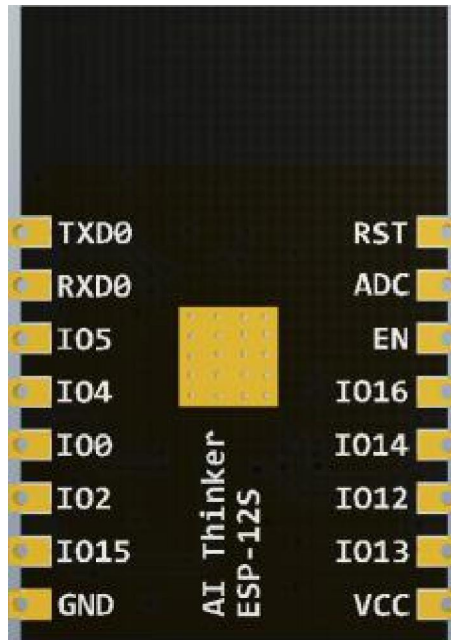
- Deep-sleep is used for applications that do not require constant Wi-Fi connection and only transmit data packets infrequently, such as temperature sensors that take measurements every 100 seconds. For example, after waking up every 300 seconds, it takes 0.3 to 1 seconds to connect to the AP and send data, so the overall average current can be much less than 1 mA. The current value of 20 μ A is measured at 2.5 V.

3 Appearance and Dimensions



4 Pin Definition

The ESP-12S module exposes a total of 16 pins, as shown in the pin diagram. The pin function definition table provides the detailed interface specifications.



ESP-12S Pin Diagram

Pin Function Definition Table

Pin No.	Name	Function Description
1	RST	Reset pin, active low
2	ADC	A/D conversion result, input voltage range: 0–1 V, value range: 0–1024
3	EN	Chip enable, active high
4	IO16	GPIO16; can be used for deep sleep wake-up when connected to the RST pin
5	IO14	GPIO14/ HSPI_CLK/IR_T/IC_SCL/I2SI_WS
6	IO12	GPIO12/ HSPI_MISO
7	IO13	GPIO13/HSPI_MOSI/UART0_CTS
8	VCC	3.3 V VDD; external power supply output current is recommended to be above 500 mA

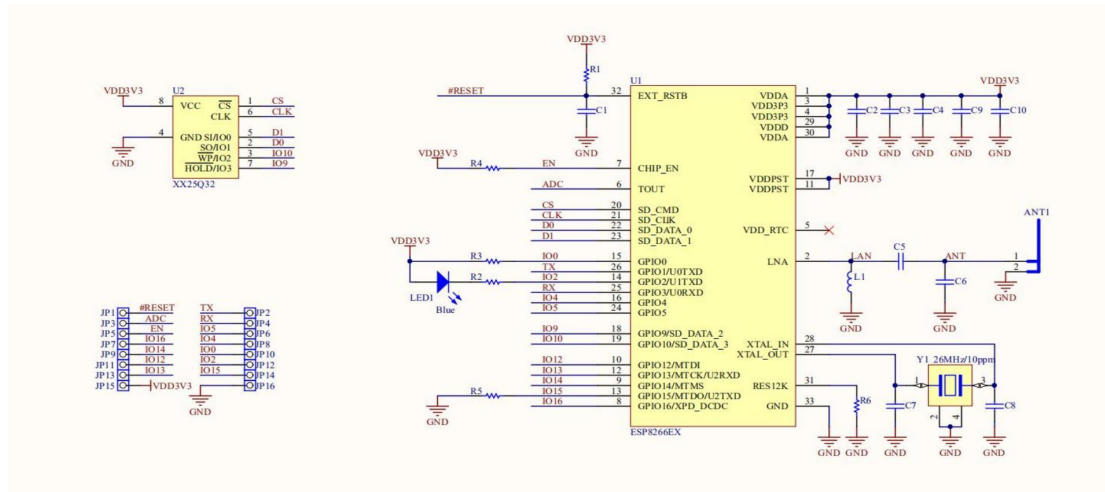
9	GND	Ground
10	IO15	GPIO15/I2SO_BCK/HSPICS/UART0_RTS
11	IO2	GPIO2/UART1_TXD/I2C_SDA/I2SO_WS
12	IO0	GPIO0; download mode: externally pulled low, run mode: floating or externally pulled high
13	IO4	GPIO4
14	IO5	GPIO5/IR_R
15	RXD	UART0_RXD/GPIO3/I2SO_DATA
16	TXD	UART0_TXD/GPIO1

Module Boot Mode Description Table

Mode	CH_PD(EN)	RST	GPIO15	GPIO0	GPIO2	TXD0
Download Mode	High	High	Low	Low	High	High
Run Mode	High	High	Low	High	High	High

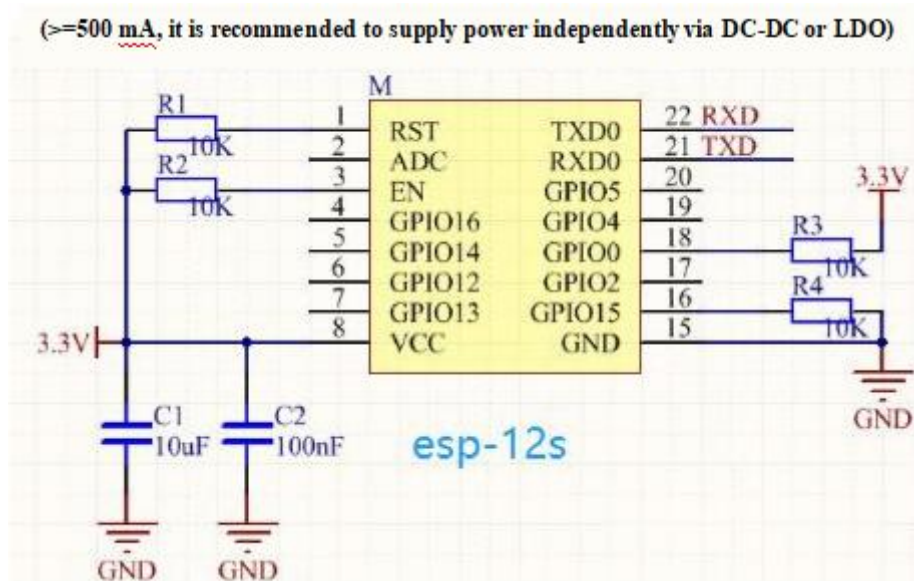
Note: Some pins have been internally pulled up; please refer to the schematic diagram.

5 Schematic Diagram



6 Design Guide

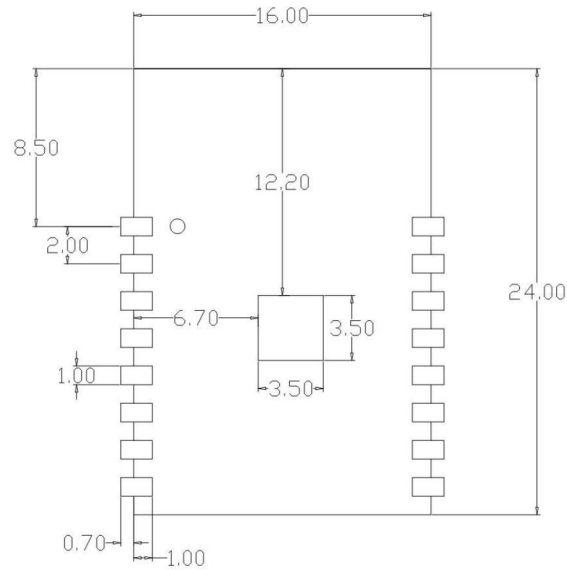
1. Application Circuit



Note:

- (1) For the module's peripheral circuits, GPIO0 must be pulled up to VCC, and GPIO15 must be pulled down to GND.
- (2) Both the EN pin and the RST pin must be pulled up to VCC.

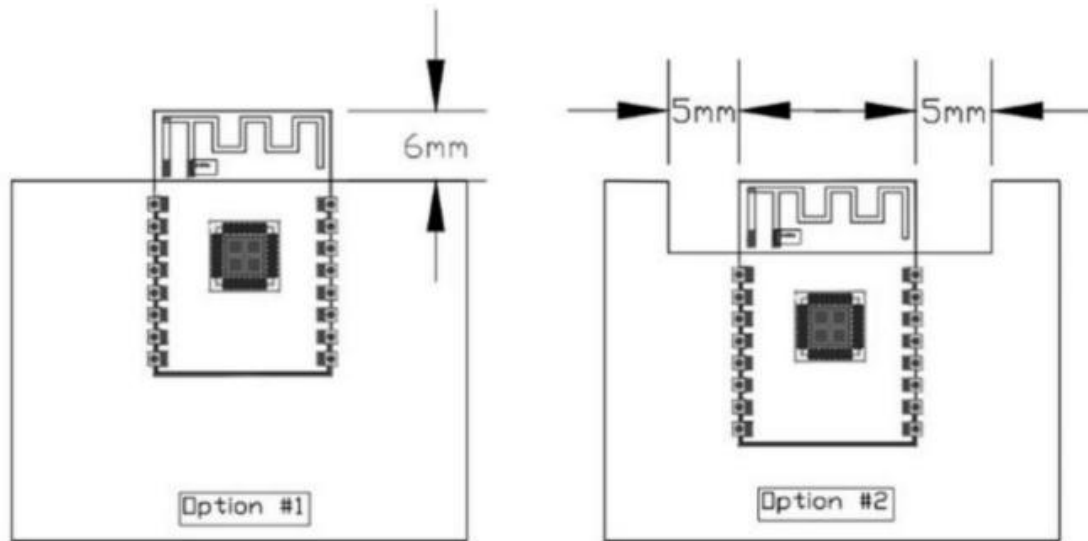
2. Recommended PCB Footprint Dimensions



Note: This diagram shows the package outline of the ESP-12S module. It is recommended to design the PCB board according to this diagram to ensure the module can work properly on the PCB. When designing the solder pads, it is important to note that the solder pads on the PCB should not be designed to be retracted relative to the corresponding module solder pads. However, if the PCB solder pads are expanded relative to the module solder pads, it will not affect the use of the module.

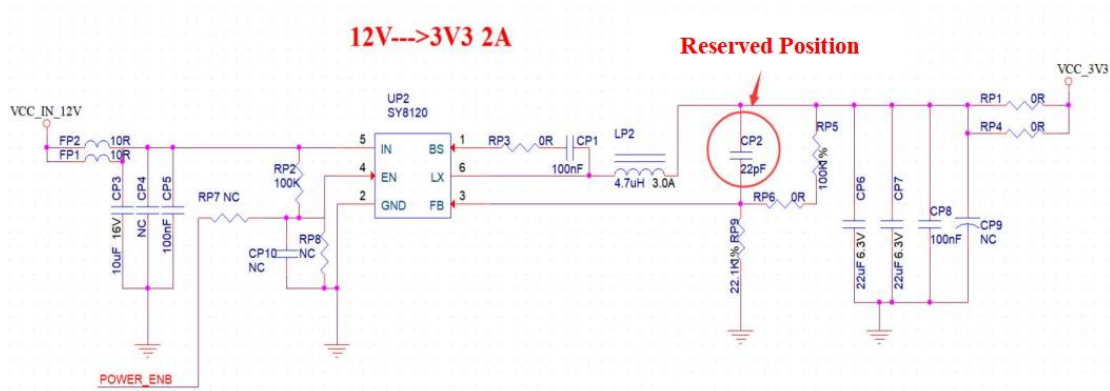
3. Antenna Layout Requirements

- (1) For the installation position on the mainboard, the following two options are recommended:
 - **Option 1:** Place the module at the edge of the mainboard, with the antenna area extending beyond the mainboard edge.
 - **Option 2:** Place the module at the edge of the main board, and cut out a clearance area in the mainboard edge at the antenna position.
- (2) To ensure optimal antenna performance of the onboard antenna, metal objects must not be placed near the antenna, and the antenna should be kept away from high-frequency devices.



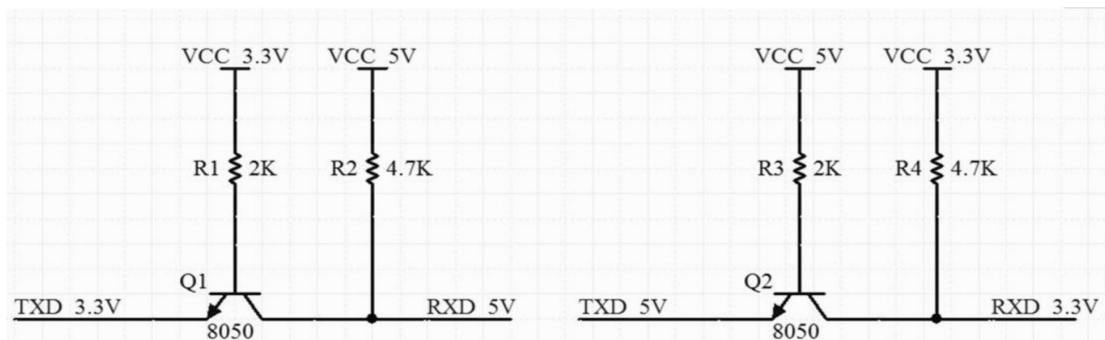
4. Power Supply

- (1) A 3.3 V voltage is recommended, with a peak current of at least 500 mA.
- (2) An LDO power supply is recommended; if using DC-DC, it is advised to control ripple within 30 mV.
- (3) For the DC-DC power supply circuit, it is recommended to reserve space for a dynamic response capacitor, which can optimize output ripple under significant load variations.
- (4) ESD protection devices are recommended to be added to the 3.3 V power interface.



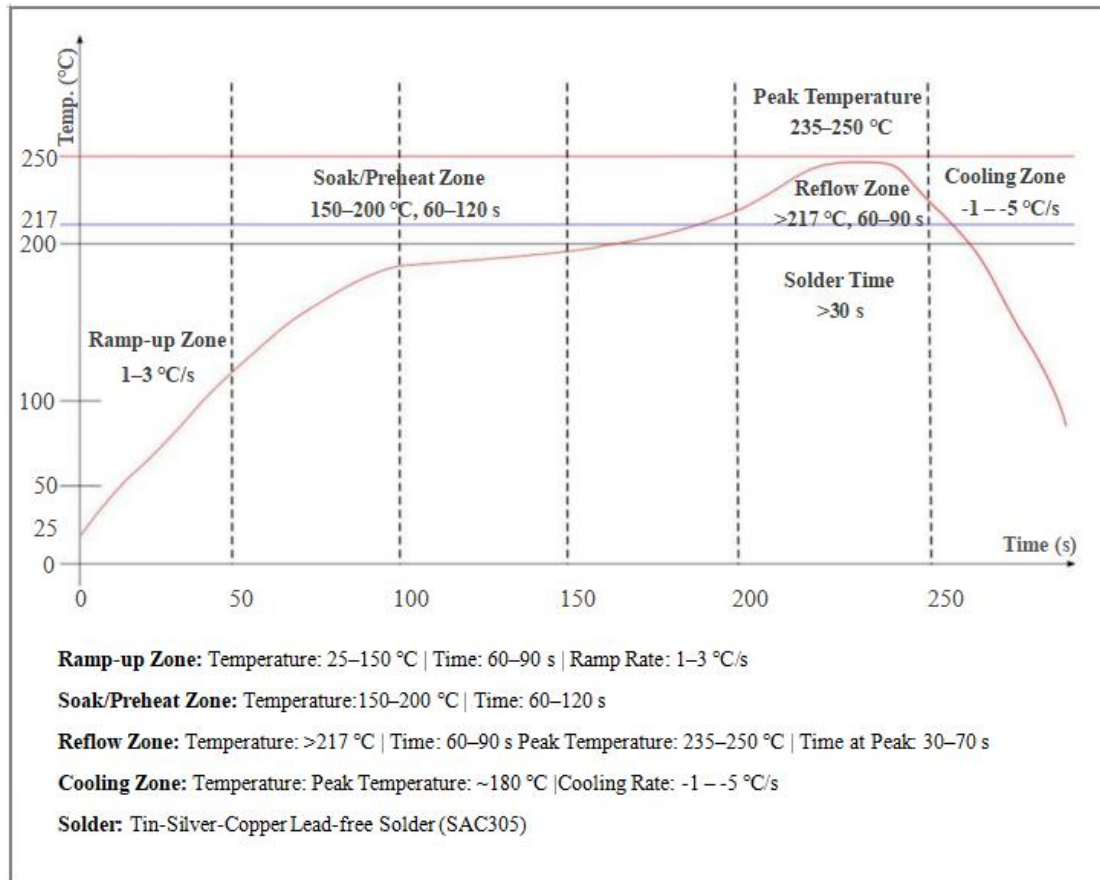
5. GPIO

- (1) Some I/O pins are exposed on the module periphery. To use these I/O pins, it is recommended to connect a 10-100 Ω resistor in series on each I/O pin. This helps suppress overshoot, stabilize signal levels, and benefits both EMI (Electromagnetic Interference) and ESD (Electrostatic Discharge) protection.
- (2) The pull-up/pull-down configuration for specific I/O pins must follow the guidelines in the specification, as it affects the module's boot configuration.
- (3) The module's I/O pins operate at 3.3 V. If the IO voltage level of the main controller and the module do not match, a level-shifting circuit must be added.
- (4) If an I/O pin is directly connected to a peripheral interface or pin headers, it is recommended to reserve space for an ESD protection device near the connector on the IO trace.



Level-shifting Circuit

7 Reflow Soldering Profile



8 Packaging Information

As shown in the figure below, ESP-12S is packaged in tape and reel.



9 Contact Information

Official Website: <https://www.ai-thinker.com>

Develop DOCS: <https://docs.ai-thinker.com>

Official Forum: <http://bbs.ai-thinker.com>

Sample Purchase: <https://anxinke.taobao.com>

Business Cooperation: sales@aithinker.com

Technical Support: support@aithinker.com



Company Address: Room 410, Block C, Huafeng Smart Innovation Port, Gusu Xixiang, Bao'an District, Shenzhen City, Guangdong Province, China

Contact Hotline: 0755-29162996