ESP8266 SDK

Getting Started Guide

Version 2.7

About This Guide

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

Chapter	Title	Content
Chapter 1	Overview	Introduction to the overall procedure of using the SDK, and familiarization with the HDK, FW and toolkit of the ESP8266.
Chapter 2	Preparing the Hardware	Hardware configuration and setup for programming, illustrated with two examples, ESP-LAUNCHER and ESP-WROOM-02.
Chapter 3	Preparing the Software	Presentation of the non-OS SDK and RTOS SDK. Information on the tools for compiling the SDK and downloading the firmware.
Chapter 4	Flash Maps	Addresses and layout specifications for downloading the firmware to flash memory. Explanation of the OTA and non-OTA firmware.
Chapter 5	Compiling the SDK	Introductions on how to compiling the SDK using the relevant tools.
Chapter 6	Downloading the Firmware	Introductions on how to download the firmware with download tools.
Appendix A	Configuring ISSI & MXIC Flash QIO Mode	Introduction to ISSI & MXIC Flash QIO mode.
Appendix B	Learning Resources	List of ESP8266-related must-read documents and must-have resources.

Release Notes

Date	Version	Release notes
2016.04	V2.0	First release.
2016.07	V2.1	Added MXIC Flash QIO mode； Modified the default value of byte 112 to 0.
2016.07	V2.2	Updated Section 3.3.1.
2016.08	V2.3	Updated the Baidu link in Section 3.3.1.
2016.10	V2.4	Updated the flash address of ***eagle.irom0.text.bin*** in Section 4.1.1.
2016.11	V2.5	Added Appendix B—Learning Resources.
2017.01	V2.6	Modified the default value of byte 113 to 0 in Table 6-6. Added two Github links of RTOS and non-OS SDK sample code in Appendix B.2—Must-Have Resources.
2017.02	V2.7	Updated sections 3.1 and 3.2; Updated the link for the OVA image file in section 3.3.1; Updated Section 5.1.2.

Table of Contents

1. Overview

1.1. Procedure Overview

Figure 1-1 shows the overall procedure of the SDK compilation.

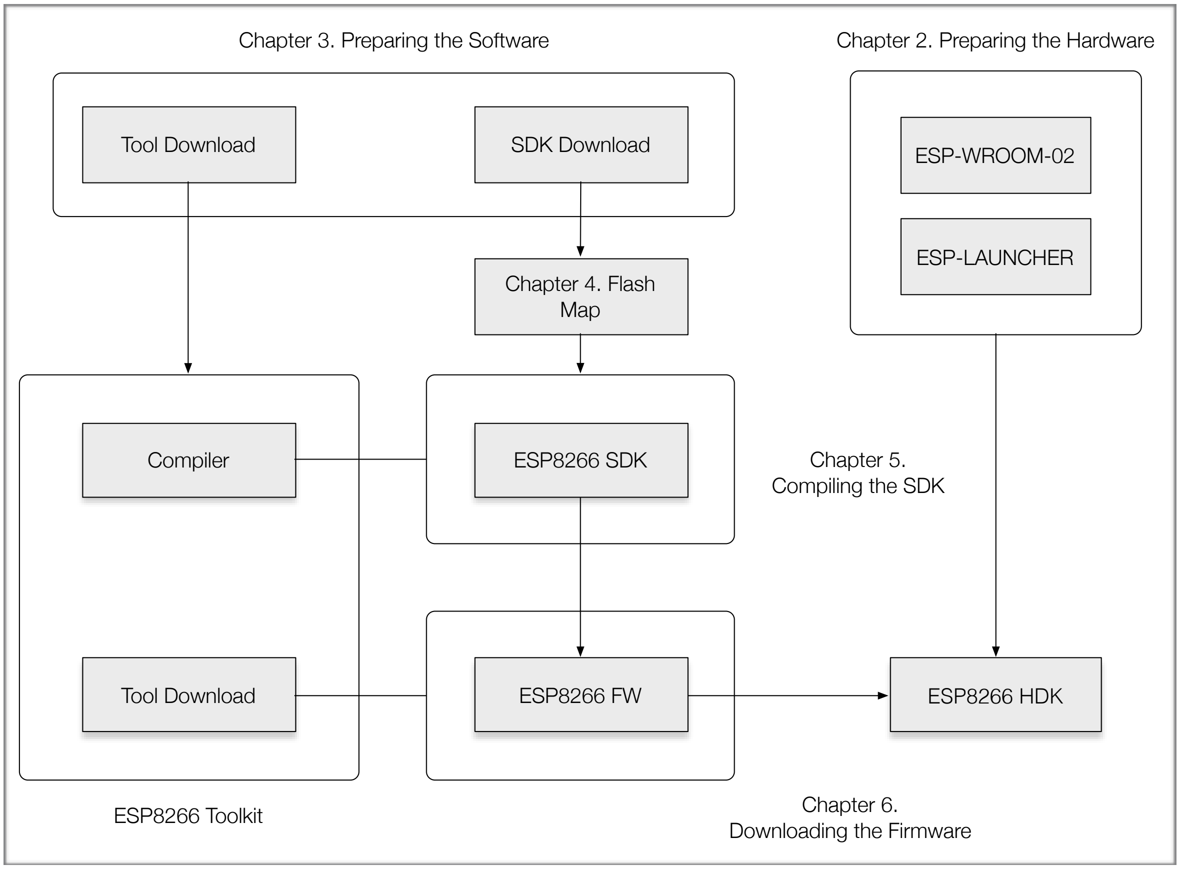


Figure 1-1 Procedure Overview

1.2. ESP8266 HDK

The ESP8266 HDK (Hardware Development Kit) includes the chip—ESP8266EX, the module—ESP-WROOM-02 and the development board—ESP-LAUNCHER. Users can download the pre-compiled firmware using ESP-WROOM-02 or ESP-LAUNCHER.

📖 ***Notes:***

- *If users use other development boards or modules that integrate ESP8266EX, please use the development firmware provided by the corresponding manufacturers.*
- *If users would like to purchase ESP-WROOM-02 or ESP-LAUNCHER, please visit Espressif's official online store at: https://espressif.taobao.com.*

1.3. ESP8266 SDK

The ESP8266 Software Development Kit (SDK) is an Internet of Things (IoT) application development platform developed by Espressif for developers. It includes such examples of application development as Smart Lights and Smart Plugs.

Depending on whether they are based on an operating system (OS), SDKs can be categorized into two types: Non-OS SDK and RTOS SDK.

1.3.1. Non-OS SDK

Non-OS SDK is not based on an operating system. It supports the compilation of IOT_Demo and AT commands. Non-OS SDK uses timers and callbacks as the main way to perform various functions such as nested events and functions triggered by certain conditions. Non-OS SDK uses the espconn network interface; users need to develop their software according to usage rules of the espconn interface.

1.3.2. RTOS SDK

RTOS SDK is based on FreeRTOS, open-source software development on Github.

- The FreeRTOS SDK is based on FreeRTOS , a multi-tasking OS. Users can use standard interfaces to realize resource management, recycling operations, execution delays, inter-task messaging and synchronization, and other task-oriented process design approaches. For the specifics of interface methods, please refer to the official website of FreeRTOS or USING THE FreeRTOS REAL TIME KERNEL—A Practical Guide
- The network operation interface in RTOS SDK is the standard lwIP API. RTOS SDK provides a package which enables a BSD Socket API interface. Users can directly use the socket API to develop software applications; and port to ESP8266 other applications from other platforms using the socket API, effectively reducing the learning costs arising from switching platforms.
- RTOS SDK introduces cJSON library whose functions make it easier to parse JSON packets.
- RTOS is compatible with non-OS SDK in Wi-Fi interfaces, SmartConfig interfaces, Sniffer related interfaces, system interfaces, timer interfaces, FOTA interfaces and peripheral driver interfaces, but does not support AT implementation.

1.4. ESP8266 FW

ESP8266 FW (Firmware) has been provided in binary format files (.BIN) that can be downloaded directly to the HDK. Users can choose between Over-The-Air (OTA) and non-OTA firmware. For detailed information, please refer to Table 1-1.

Table 1-1. ESP8266 FW

Binaries	Compulsory or optional	Description	Non-OTA	OTA
master_device_key.bin	Optional	Users can apply for it from Espressif Cloud to get Espressif Cloud service.	✔	✔
esp_init_data_default.bin	Compulsory	Default system parameters provided in SDK.	✔	✔
blank.bin	Compulsory	Default system parameters provided in SDK.	✔	✔
eagle.flash.bin	Compulsory	Main program compiled from SDK.	✔	✘
eagle.irom0text.bin	Compulsory	Main program compiled from SDK.	✔	✘
user1.bin	Compulsory for first usage.	Main program compiled from SDK.	✘	✔
user2.bin	Used in firmware upgrade.	Main program compiled from SDK.	✘	✔

Notes:

- *For the contents of SDK, please refer to Chapter 3, "Preparing the Software".*
- *For SDK compilation, please refer to Chapter 5, "Compiling the SDK".*
- *For the addresses of binaries in the flash, please refer to Chapter 4, "Flash Maps".*

1.5. ESP8266 Toolkit

1.5.1. Compiler

Linux OS is required to compile the ESP8266 SDK. When using Windows OS, we recommend VirtualBox as the virtual machine for ESP8266. In order to simplify the compilation procedure, we have installed the compiling tools on the virtual machine. Users can directly compile the ESP8266 SDK by importing the ESP8266 compiler (OVA image) into the virtual machine.

1.5.2. Firmware Download Tool

The ESP8266 DOWNLOAD TOOL is the official firmware download tool developed by Espressif. Users can download multiple binaries to the SPI Flash of the ESP8266 mother board (ESP-LAUNCHER or ESP-WROOM-02) at the same time according to the actual compilation mode and flash size.

1.5.3. Serial Port Debug Tool

The serial port debug tool can be used to directly communicate with the ESP8266 module over a standard RS-232 port. For PCs that do not have a physical serial port, a virtual com port (USB-to-serial converter) can be used.

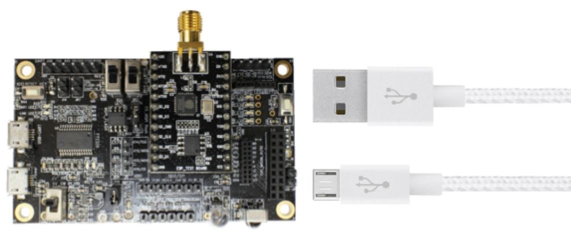
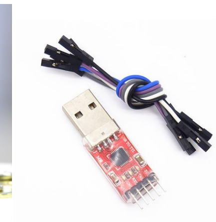
Users may directly input commands into the terminal and view or record responses in real time.

> 📖 ***Note:***
>
> *We recommend CoolTerm (for Windows and Mac OS) and Minicom (for Linux OS) as the serial port debug tool.*

2. Preparing the Hardware

Depending on whether the ESP-LAUNCHER or the ESP-WROOM-02 is used, users will need either of the hardware mentioned in Table 2-1 below:

Table 2-1. Hardware Preparations

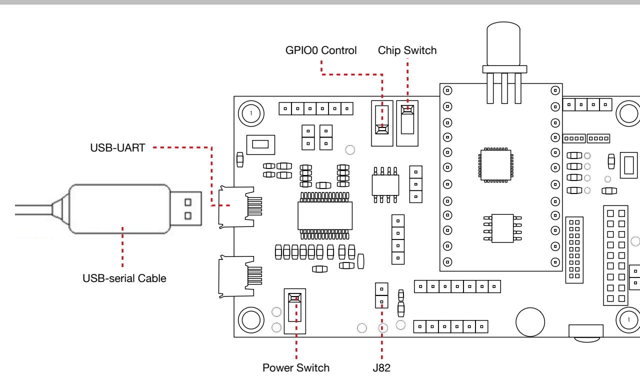
ESP-LAUNCHER		ESP-WROOM-02
• 1 × ESP-LAUNCHER • 1 × USB cable		• 1 × ESP-WROOM-02 • 1 × USB-to-TTL converter (FT232R recommended) • 6 × Dupont lines • 1 × soldering tool suite
	OR	 
1 × PC with pre-installed Windows OS		

⚠️ **Notice:**

The ESP8266 Wi-Fi module needs a 3.3V power supply and may draw a minimum current of 500 mA.

2.1. ESP-LAUNCHER

1. Connect PC to the USB-UART interface of ESP-LAUNCHER using the USB cable.
2. Set ESP-LAUNCHER to download mode.

Steps	Result
• Slide Power Switch towards the outer side as the figure on the right 👉 shows. • Slide `GPIO0` Control towards the inner side to enable ESP-LAUNCHER's download mode. ⚠️ ***Notice:*** *J82 must be shorted by a jumper, otherwise code cannot be downloaded to the board.*	

3. Connect the USB-to-TTL converter to the PC.

> 📖 ***Note:***
>
> *Make sure that the proper driver for the USB-to-TTL converter is installed and recognized by the PC.*

4. Power on ESP-LAUNCHER by sliding the Power Switch towards the inner side.
5. Power on the chip by sliding the Chip Switch towards the outer side.
6. Download firmware to flash with the ESP8266 DOWNLOAD TOOL.

> 📖 ***Note:***
>
> *On how to download firmware, please refer to Chapter 4, "Flash Map" and Chapter 6, "Downloading the Firmware".*

7. After downloading, slide the `GPIO0` Control towards the outer side to enable ESP-LAUNCHER's working mode.
8. Power on the chip again with the Chip Switch and the chip will read and run programs from the flash.

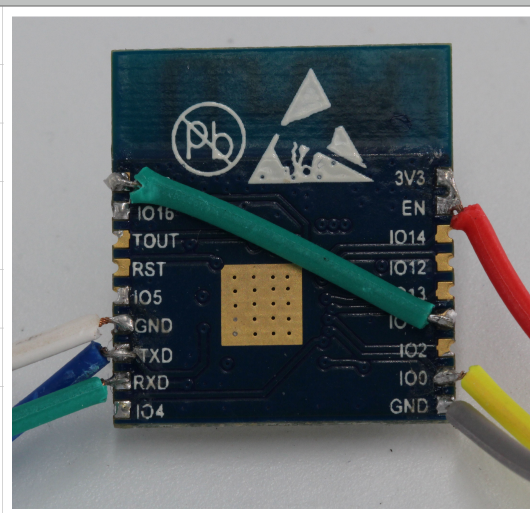
— — END

For more information on the ESP-LAUNCHER hardware, please refer to ESP8266 System Description.

2.2. ESP-WROOM-02

1. Lead out the pins of the ESP-WROOM-02, as shown in Table 2-2.

Table 2-2. ESP-WROOM-02 Pins

Pin	Pin status	Figure
`EN`	Pull up	
`3V3`	3.3V power supply (VDD)	
`IO15`	Pull down	
`IO0`	UART download: pull down; Flash boot: floating/pull up	
`GND`	GND	
`RXD`	Receive-end in UART download	
`TXD`	Transmit-end in UART download; floating/pull up	

2. Connect ESP-WROOM-02 to the USB-to-TTL converter, using Dupont lines, as shown in Figure 2-1.

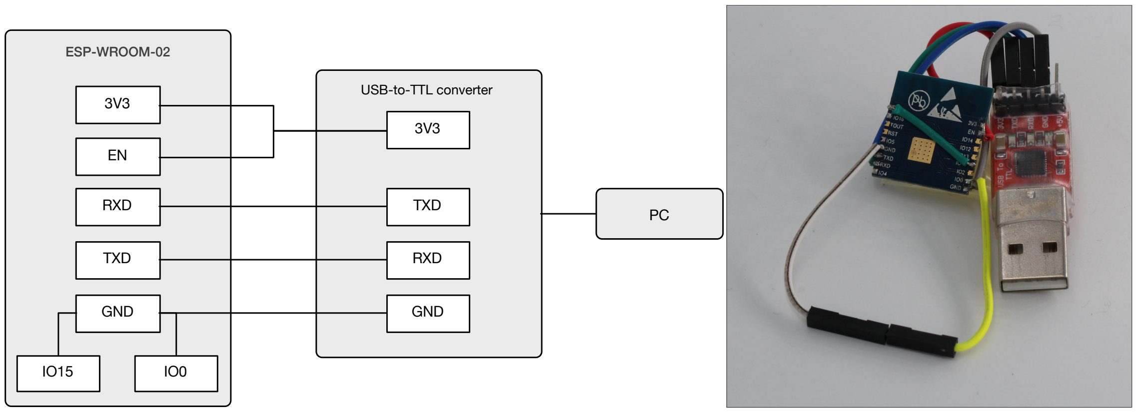


Figure 2-1. ESP-WROOM-02 Download Mode

3. Connect the USB-to-TTL converter to the PC.
4. Download firmware to flash with the ESP8266 DOWNLOAD TOOL.

> 📖 ***Note:***
>
> *On how to download firmware, please refer to Chapter 4, "Flash Maps" and Chapter 6, "Downloading the Firmware".*

5. After downloading, switch ESP-WROOM-02 to working mode.
   Set `IO0` as floating or pull-up.
6. Power on ESP-LAUNCHER again and the chip will read and run programs from the flash.

— — END

> 📖 ***Notes:***
>
> - `IO0` *is an internal pull-up pin.*
> - *For more information on ESP-WROOM-02 hardware, please refer to [ESP8266 System Description]() and [ESP-WROOM-02 Datasheet]().*

3. Preparing the Software

3.1. Non-OS SDK

Users can download the non-OS SDK (including application examples) from: http://www.espressif.com/en/support/download/sdks-demos?keys=&field_type_tid%5B%5D=14.

Figure 3-1 shows the directory structure of the non-OS SDK.

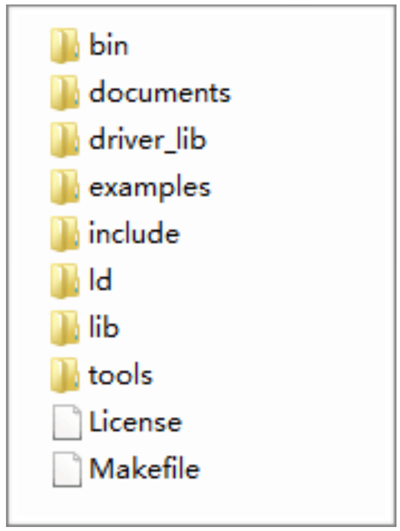


Figure 3-1. Non-OS SDK Directory Structure

- ***bin***: compiled binaries to be downloaded directly into the flash.
- ***documents***: SDK-related documents or links.
- ***driver_lib***: library files that drive peripherals, such as UART, I2C and GPIO.
- ***examples***: sample codes for secondary development, for example, IoT Demo.
- ***include***: header files pre-installed in SDK. The files contain relevant API functions and other macro definitions. Users do not need to modify them.
- ***ld***: linker scripts. We suggest users not modifying them without any specific reasons.
- ***lib***: library files provided in SDK.
- ***tools***: tools needed for compiling binaries. Users do not need to modify them.

3.2. RTOS SDK

Users can download RTOS SDK and its application examples (ESP8266_IOT_PLATFORM) from:

- RTOS SDK
  https://github.com/espressif/ESP8266_RTOS_SDK

- ESP8266_IOT_PLATFORM
  https://github.com/espressif/ESP8266_IOT_PLATFORM

Table 3-2 shows the directory structure of the RTOS SDK.

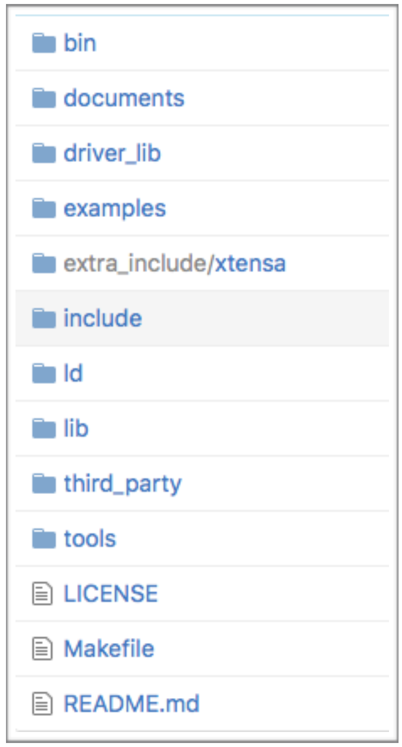


Figure 3-2. RTOS SDK Directory Structure

- ***bin***: boot and initialization firmware.
- ***documents***: ESP8266_RTOS_SDK files.
- ***driver_lib***: sample codes of drivers.
- ***examples***: sample codes for Espressif's application programs.
  - ***openssl_demo***: sample codes of the openssl API function.
  - ***project_template***: sample codes of project templates.
  - ***smart_config***: sample codes of SmartConfig.
  - ***spiffs_test***: sample codes of the spiffs file system function.
  - ***websocket_demo***: sample codes of web socket.
- ***include***: header files of ESP8266_RTOS_SDK, including software interfaces and macro functions for users to use.
- ***ld***: link files used when compiling; users do not need to modify them.
- ***lib***: library file of ESP8266_RTOS_SDK.
- ***third_party***: third-party library of Espressif's open-source codes, currently including free RTOS, JSON, lwIP, mbedTLS, noPoll, OpenSSL, spiffs, and SSL.
- ***tools***: tools needed for compiling binaries; users do not need to modify them.

3.3. ESP8266 Toolkit

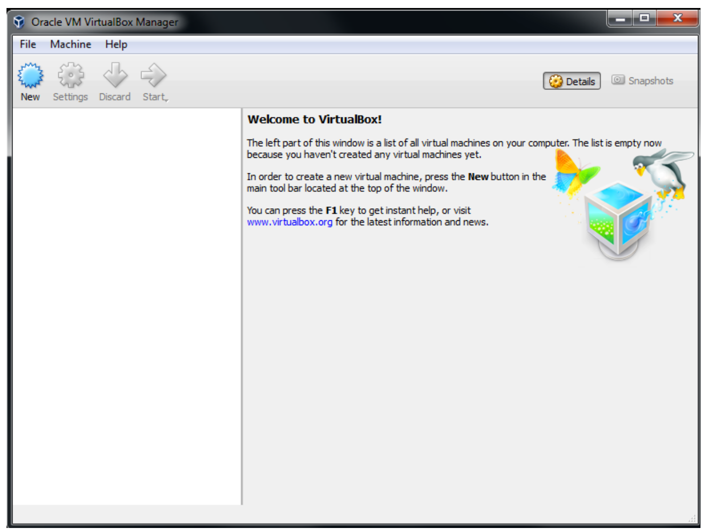
3.3.1. Compiler

Please download VirtualBox from: https://www.virtualbox.org/wiki/Downloads.

> 📖 ***Note:***
>
> *Please choose the right version of VirtualBox according to the host machine's OS.*

Please download the compiler ***ESP8266_lubuntu_20141021.ova*** from:

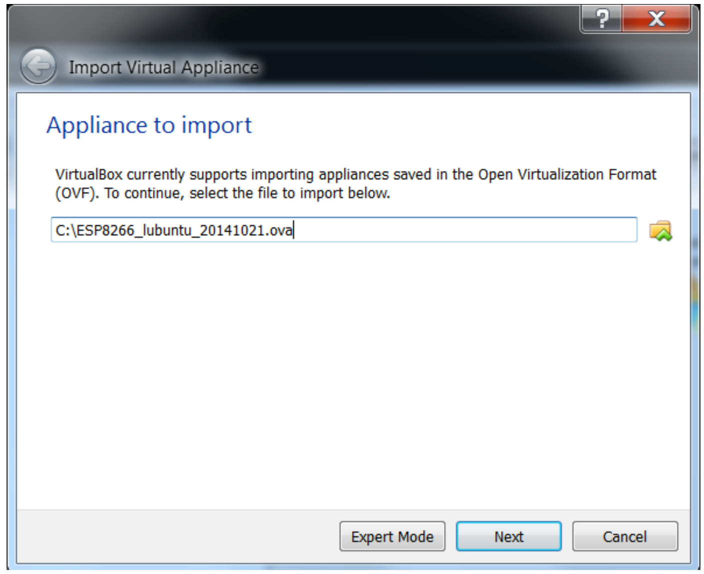
http://downloads.espressif.com/FB/ESP8266_GCC.zip

Steps	Results
1. Start Windows OS and install the virtual machine.	
• Double-click ***VirtualBox-5.0.16-105871-Win.exe*** and install VirtualBox. 📖 ***Note:*** *VirtualBox has different versions. We are using Windows V.5.0.16 as an example.* • Double-click ***Oracle VM VirtualBox.exe*** to run the program, and the system will show the main menu 👉 . 💬 ***Tip:*** *The ESP8266 virtual machine takes up much space (memory). Please reserve enough space for it.*	
2. Import the image file.	

<table>
<tr><th>Steps</th><th>Results</th></tr>
<tr><td>

- Select ***File > Import Appliance***, and a dialog box will show up .
- Select the image file to import, for example, ***C:\ESP8266_lubuntu_20141021.ova***, and click ***Next***.
- Click ***Import*** to confirm the settings.

</td><td>



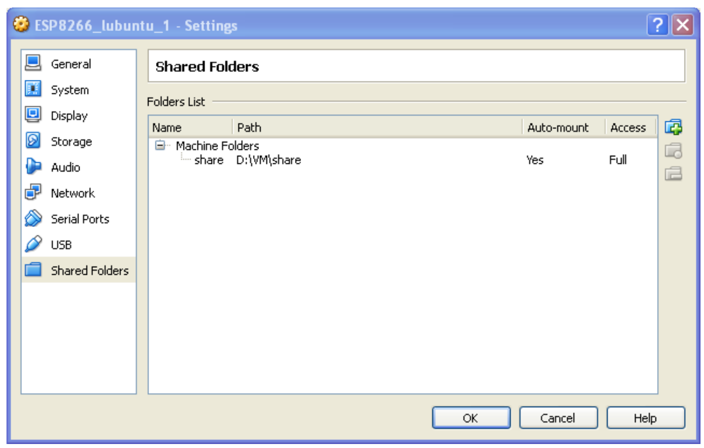
</td></tr>
<tr><td colspan="2">

3. Create a shared folder.

</td></tr>
<tr><td>

- Create a new folder named ***D:\VM\share***.
- Select ***Machine > Settings > Shared Folders…***, and a dialog box will show up .
- Select the shared folder in ***Machine Folders***, for example, ***D:\VM\share***.

</td><td>



</td></tr>
<tr><td colspan="2">

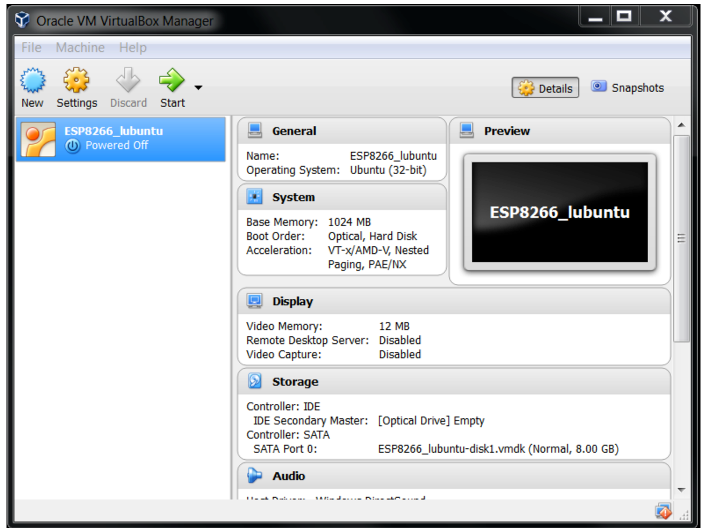
4. Run the virtual machine.

</td></tr>
</table>

<table>
<tr><th>Steps</th><th>Results</th></tr>
<tr><td>

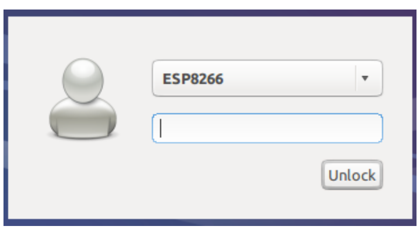
- After importing, a virtual machine named ***ESP8266_lubuntu*** shows up 👉.
- Double-click ***ESP8266_lubuntu*** or ***Start*** to run the virtual machine.

</td><td>

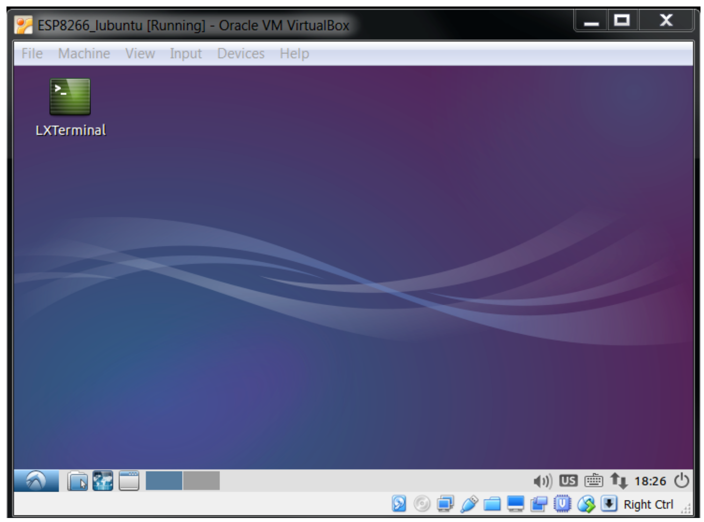


</td></tr>
<tr><td>

- The system shows the ESP8266 virtual machine 👉.
- If a dialog box like the one below 👇 shows up, please enter the password: ***espressif***.



</td><td>



</td></tr>
</table>

3.3.2. Firmware Download Tool

Please download the ESP8266 DOWNLOAD TOOL from:

http://www.espressif.com/support/download/other-tools.

4. Flash Maps

This chapter provides the flash maps for OTA firmware and non-OTA firmware in flash memories with a different capacity. Users can modify the map as needed.

Figure 4-1 shows the flash maps for the two different types of firmware.

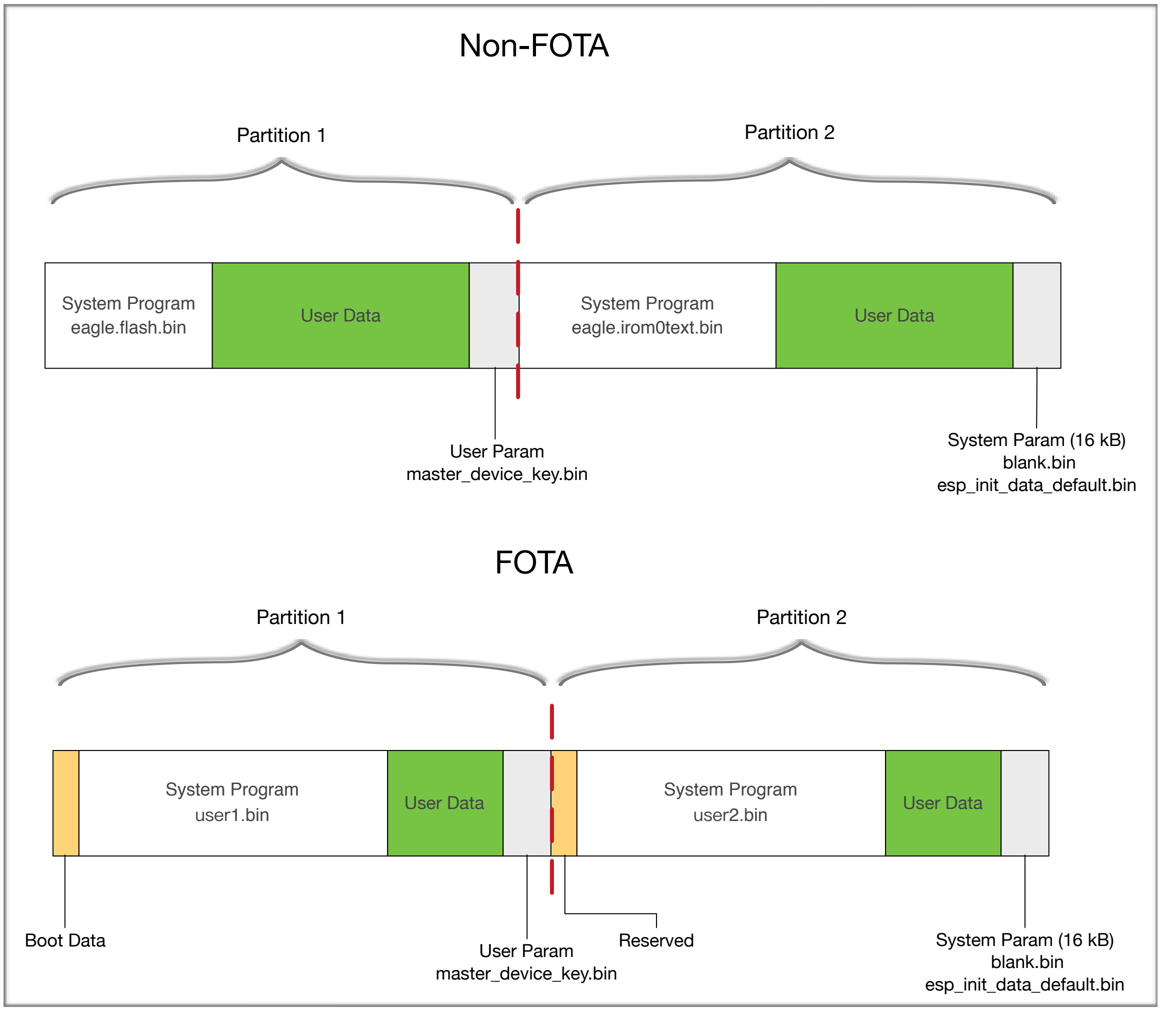


Figure 4-1. Flash Maps

> 📖 ***Note:***
>
> *For ESP8266 firmware, please refer to Section 1.3, "ESP8266 FW".*

- ***System Program***: this area stores the firmware necessary for the system to run.
- ***User Data***: If system data do not take up all the flash memory, the remaining area can be used to store user data.
- ***User Param***: Users can define the address. In IOT_Demo, the four sectors starting from 0x3C000 are defined as the user parameter area. Users can define any available address for this area.

  - *master_device_key.bin*: In IOT_Demo, it is located in the third sector of user parameter area.
- ***System Param***: this area contains the last four sectors of the flash.
  - *blank.bin*: the download address is the second-to-last sector in the flash.
  - *esp_init_data_default.bin*: the download address is the fourth-to-last sector of flash.
- ***Boot Data***: It is located in Partition 1 of OTA firmware, and stores OTA-related data.
- ***Reserved***: It is a reserved area in Partition 2 of OTA firmware, corresponding to the ***Boot data*** area in Partition 1 of OTA firmware.

> 📖 ***Notes:***
> - *Each sector of the flash is 4 KB.*
> - *For detailed download addresses, please refer to the following sections..*

4.1. Non-OTA

4.1.1. Flash Map

For flash memories with different capacity levels, the storage space of ***eagle.irom0text.bin*** is limited. Users can change the limit by modifying ***ESP8266_NONOS_SDK/ld/eagle.app.v6.ld***.

Users can modify the `len` field in `irom0_0_seg`, as shown in Figure 4-2 (red rectangle).

The location of ***irom0.text*** varies across different versions of SDK. Users must consult the ***eagle.app.v6.ld*** file and ensure that they are downloading ***eagle.irom0.text.bin*** to the correct offset in the flash. The address in the blue rectangle marks the location of ***eagle.irom0.text.bin*** in the flash.

```
MEMORY
{
  dport0_0_seg :                        org = 0x3FF00000, len = 0x10
  dram0_0_seg :                         org = 0x3FFE8000, len = 0x14000
  iram1_0_seg :                         org = 0x40100000, len = 0x8000
  irom0_0_seg :                         org = 0x40210000, len = 0x5C000
}
```

Figure 4-2. Location for *irom0.text*

Table 4-1 shows the storage limits of *eagle.irom0text.bin* with different `len` values.

Table 4-1. Non-OTA Flash Map (unit: KB)

Flash capacity	eagle.flash.bin	eagle.irom0text.bin	User data	len	User/System Param
512	≤ 64	≤ 240	≥ 176	0x3C000	16
1024	≤ 64	≤ 752	≥ 176	0xBC000	16

Flash capacity	eagle.flash.bin	eagle.irom0text.bin	User data	len	User/System Param
2048	≤ 64	≤ 768	≥ 176	0xC0000	16
4096	≤ 64	≤ 768	≥ 176	0xC0000	16

> **Note:**
> *ESP8266 presently only supports a System Param area of up to 1024 KB.*

4.1.2. Download Addresses

Table 4-2 lists the download addresses for non-OTA firmware.

Table 4-2. Download Address for Non-OTA Firmware (unit: KB)

Binaries	Download addresses in flash with different capacities			
	512	1024	2048	4096
master_device_key.bin	0x3E000			
esp_init_data_default.bin	0x7C000	0xFC000	0x1FC000	0x3FC000
blank.bin	0x7E000	0xFE000	0x1FE000	0x3FE000
eagle.flash.bin	0x00000			
eagle.irom0text.bin	0x10000			

4.2. OTA Firmware

4.2.1. Flash Map

Table 4-3 lists the download addresses for the OTA firmware.

Table 4-3. OTA Flash Map (unit: KB)

Flash capacity	boot	user1.bin	user2.bin	User/System Param	User data
512	4	≤ 236	≤ 236	16	≥ 0
1024	4	≤ 492	≤ 492	16	≥ 0
2048 (Partition 1 = 512)	4	≤ 492	≤ 492	16	≥ 1024
2048 (Partition 1 = 1024)	4	≤ 1004	≤ 1004	16	≥ 0
4096 (Partition 1 = 512)	4	≤ 492	≤ 492	16	≥ 3072
4096 (Partition 1 = 1024)	4	≤ 1004	≤ 1004	16	≥ 2048

4.2.2. Download Addresses

Table 4-4 lists the download addresses for the OTA firmware.

Table 4-4. Download Addresses for OTA Firmware (unit: KB)

Binaries	Download addresses in flash with different capacities					
	512	1024	2048		4096	
			512+512	1024+1024	512+512	1024+1024
master_device_key.bin	0x3E000	0x7E000	0x7E000	0xFE000	0x7E000	0xFE000
esp_init_data_default.bin	0x7C000	0xFC000	0x1FC000		0x3FC000	
blank.bin	0x7E000	0xFE000	0x1FE000		0x3FE000	
boot.bin	0x00000					
user1.bin	0x01000					
user2.bin	0x41000	0x81000	0x81000	0x101000	0x81000	0x101000

📖 ***Notes:***

- *For OTA firmware, users do not need to download* ***user2.bin,*** *but upgrade the firmware via the cloud server.*
- *For details on the functional description of OTA firmware, please refer to ESP8266 FOTA Guide.*

5. Compiling the SDK

> **Notes:**
> - *This chapter demonstrates how to compile the SDK by taking **ESP8266_NONOS_SDK/examples/IoT_Demo** as an example.*
> - ***IoT_Demo** defines three types of devices, i.e., LIGHT_DEVICE, PLUG_DEVICE and SENSOR_DEVICE in **examples>IoT_Demo/include/user_config.h**. Users can only configure one device at a time. The default device for configuration is LIGHT_DEVICE.*

5.1. Preparations

5.1.1. Modifying SDK Files

> **Note:**
> *Users need to modify the SDK files if using the OTA firmware.*

1. Start Windows OS.
2. Modify files in ***ESP8266_NONOS_SDK/examples/IoT_Demo/include*** according to the flash map.
    - Modify `#define PRIV_PARAM_START_SEC` in ***user_light.h*** and ***user_plug.h***.

```
/* NOTICE !!! ---this is for 512KB spi flash.*/
/* You can change to other sector if you use other size spi flash. */
/* Refer to the documentation about OTA support and flash mapping*/
#define PRIV_PARAM_START_SEC          0x3C
#define PRIV_PARAM_SAVE     0
```

    - Modify `#define ESP_PARAM_START_SEC` in ***user_esp_platform.h***.

```
/* NOTICE---this is for 512KB spi flash.
 * you can change to other sector if you use other size spi flash. */
#define ESP_PARAM_START_SEC          0x3D
```

Table 5-1 lists the modified values.

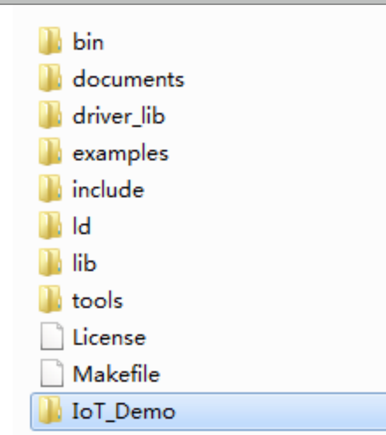
Table 5-1. Modify the Field Values in the "include" File (unit: kB)

Default value (512)	Modified values					
	512	1024	2048 (512+512)	2048 (1024+1024)	4096 (512+512)	4096 (1024+1024)
0x3C	-	0x7C	0x7C	0xFC	0x7C	0xFC
0x3D	-	0x7D	0x7D	0xFD	0x7D	0xFD

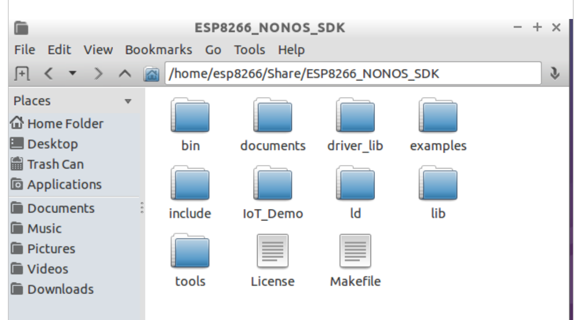
> 📖 ***Note:***
>
> *Users need not modify the SDK files if using a 512-KB flash.*

5.1.2. Downloading SDK Files

1. Start Linux OS.
2. Run LXTerminal on the desktop of the virtual machine.
3. Copy the files to be compiled to the shared folder.

Steps	Results
• Copy ***ESP8266_NONOS_SDK*** folder to the shared directory, for example, ***C:\VM\share***. • Copy ***IoT_Demo*** folder to ***C:\VM\share \ESP8266_NONOS_SDK***, as shown in the figure on the right 👉.	

4. Download shared directory.

Steps	Results
• Execute `./mount.sh`. • Input the password: ***espressif***. Downloading shared files is completed. • Open the shared directory ***ESP8266_NONOS_SDK*** in the virtual machine and confirm whether the download has been successful. - If successful, the directory contains such files as those in the figure on the right 👉. - If not, the directory will be empty, and users will need to go over this step again.	

> ⚠️ ***Notice:***
>
> *If users use the RTOS SDK, please continue with the following steps; if use the non-OS SDK, please skip Step 5.*

5. Set the variable PATH to point to SDK and binaries.

```
export SDK_PATH=~/Share/ESP8266_RTOS_SDK
export BIN_PATH=~/Share/ESP8266_RTOS_SDK/bin
```

> 📖 ***Note:***
> *Users can add it to **.bashrc** file, otherwise Step 5 needs to be repeated each time the compiler is restarted.*

5.2. Compilation

5.2.1. Compile ESP8266_NONOS_SDK_v0.9.5 and Later Versions

1. Switch to the ***/Share/ESP8266_NONOS_SDK/IoT_Demo*** directory in the terminal.

```
cd /home/esp8266/Share/ESP8266_NONOS_SDK/IoT_Demo
./gen_misc.sh
```

The system shows the following information:

```
gen_misc.sh version 20150511
Please follow below steps(1-5) to generate specific bin(s):
```

2. Select the required options as shown in Figure 5-1.

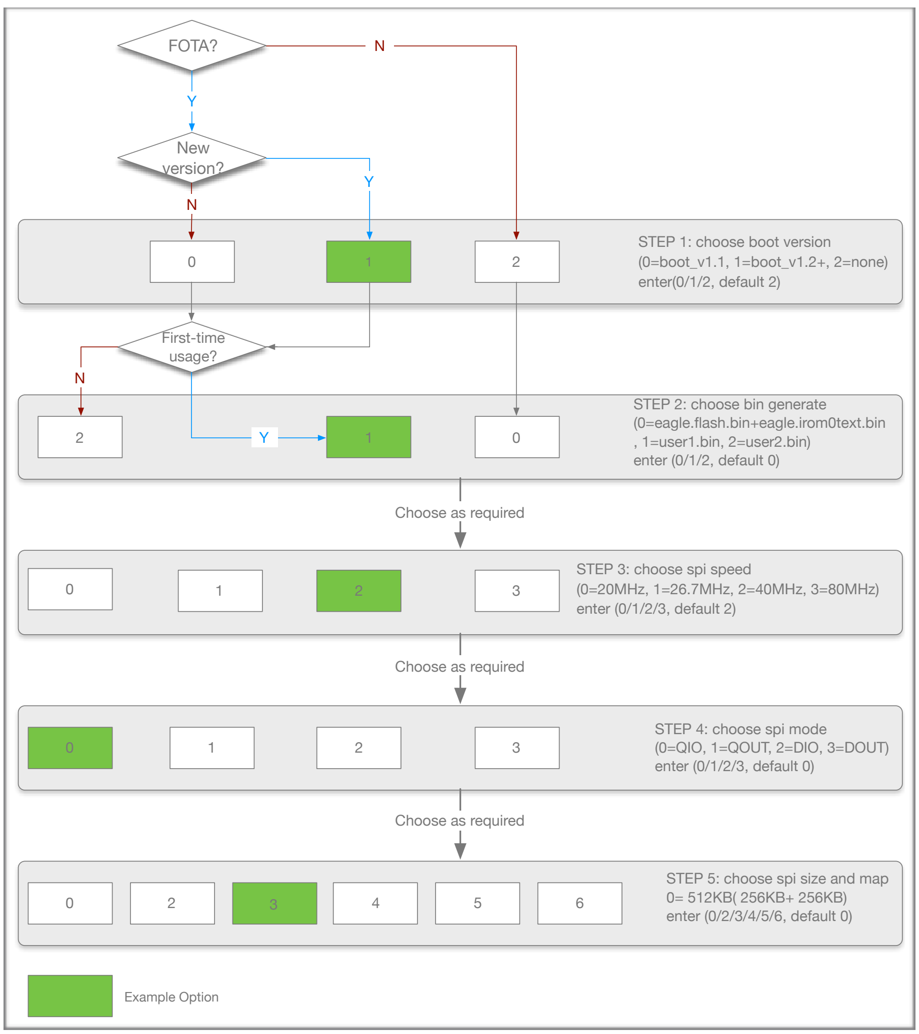


Figure 5-1. Compile SDK

> **Notes:**
> - *The sample options are marked in green. Users can select the right options as needed.*
> - *For OTA and non-OTA firmware, please refer to Section 1.4, "ESP8266 FW".*
> - *Only sdk_v1.1.0 + boot 1.4 + flash download tool_v1.2 and higher versions support options 5 and 6 in Step 5.*
> - *After compiling **user1.bin**, execute `make clean` first to clear the temporary files generated by the last compilation, and then compile **user2.bin**.*
> - *For the flash map in Step 5, please refer to Chapter 4, "Flash Maps".*

3. After compilation, the generated binaries and the addresses in flash are shown as follows:

```
Generate user1.2048.new.3.bin successfully in folder bin/upgrade.

boot.bin------------>0x00000

user1.2048.new.3.bin--->0xSupport boot_v1.2 and +

01000

!!!
```

> **Note:**
> *Users can open the **/home/esp8266/Share/ESP8266_NONOS_SDK/bin** directory and check the compiled binaries.*

— — END

5.2.2. ESP8266_NONOS_SDK_v0.9.4 and Earlier Versions

For ESP8266_NONOS_SDK_v0.9.4 and previous versions, the compilation process is as follows:

1. Execute `./gen_misc_plus.sh 1` to generate ***user1.bin*** under the ***/ESP8266_NONOS_SDK/bin/upgrade*** path.
2. Execute `make clean` to clear previous compilation data.
3. Execute `./gen_misc_plus.sh 2` to generate ***user2.bin*** under the ***/ESP8266_NONOS_SDK/bin/upgrade*** path.

> **Note:**
> *ESP8266_NONOS_SDK_v0.7 and earlier are non-OTA firmware.*

6. Downloading the Firmware

6.1. Download Procedure

1. Start Windows OS.
2. Double-click ***ESP_DOWNLOAD_TOOL.exe*** to open Flash tool.

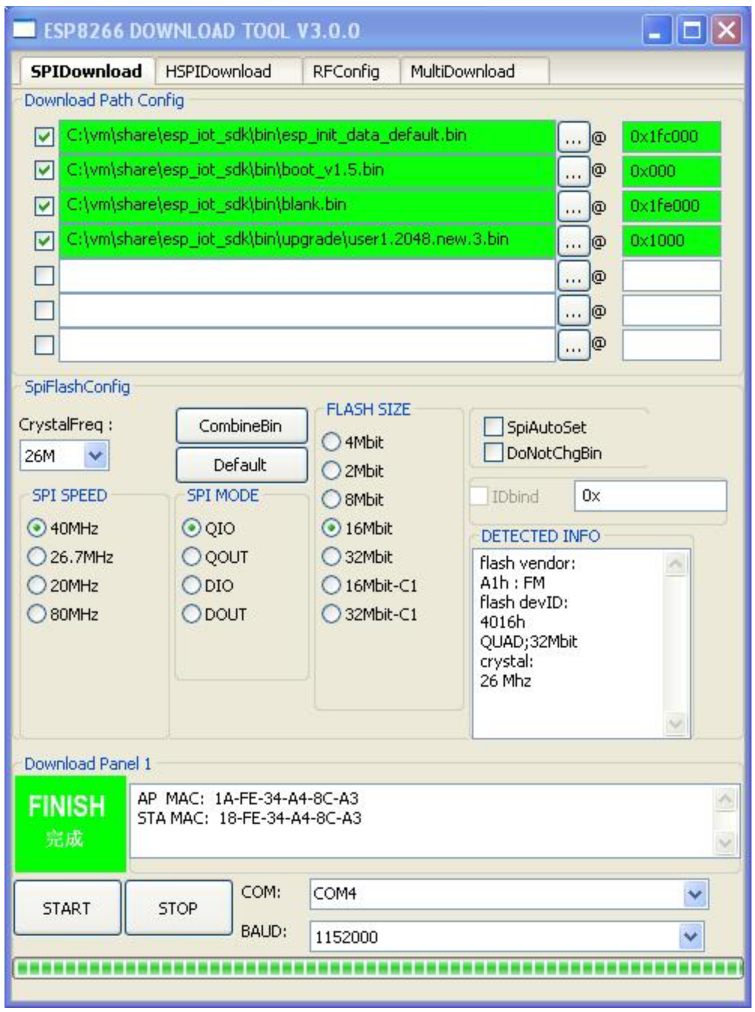


Figure 6-1. ESP8266 DOWNLOAD TOOL—SPIDownload

SPIDownload	For SPI Flash download.
HSPIDownload	For HSPI Flash download.
RFConfig	RF initialization Configuration.
MutiDownload	For multi-mother boards download.

3. Double-click ... in ***Download Path Config*** panel to select the binaries to be downloaded. Set the corresponding download addresses in ***ADDR***.
4. Configure SPIDownload.

> 📖 ***Note:***
> *The binaries to be downloaded and the corresponding addresses vary with different SPI Flash sizes and actual demands. For details, please refer to Chapter 4, "Flash Maps".*

Table 6-1. SPIDownload Configuration

Items	Description
SPI FLASH CONFIG	
CrystalFreq	Select the crystal frequency according to the crystal oscillator used.
CombineBin	Combine the selected binaries into ***target.bin*** with the address 0x0000.
Default	Set the SPI Flash to the default value.
SPI SPEED	Select SPI read/write speed with the maximum value of 80 MHz.
SPI MODE	Select SPI mode according to the SPI Flash used. If the flash is Dual SPI, select ***DIO*** or ***DOUT***. If the flash is Quad SPI, select ***DIO*** or ***DOUT***. ⚠️ ***Notice:*** *If ISSI Flash is used, please refer to Appendix, "Configure ISSI & MXIC Flash QIO Mode".*
FLASH SIZE	Select the flash size according to the flash type. 📖 ***Note:*** ***16Mbit-C1*** *refers to 1024+1024 flash map and* ***32Mbit-C1*** *1024+1024 flash map as well.*
SpiAutoSet	We recommend not checking ***SpiAutoSet***, but configuring the flash manually as needed. If users select ***SpiAutoSet***, the binaries will be downloaded according to the default flash map. The flash map of 16 Mbit and 32 Mbit will be 512 KByte + 512 KByte.
DoNotChgBin	• If users select ***DoNotChgBin***, the flash working frequency, mode, and flash map will be based on the configuration when compiling. • If users do not select ***DoNotChgBin***, the flash working frequency, mode, and flash map will be defined by the final configuration of the compiler.
Download Panel	
START	Click ***START*** to start download. When the download completes, ***FINISH*** will appear in the green area on the left.
STOP	Click ***STOP*** to stop download.
MAC Address	If download is successful, the system will show the MAC addresses of ESP8266 STA and ESP8266 AP.
COM PORT	Select the actual COM port of ESP8266.

Items	Description
SPI FLASH CONFIG	
BAUDRATE	Select the baud rate of downloading. The default value is 115200.

5. After downloading, turn `GPIO0` Control on ESP-LAUNCHER to the outer side and power the board on to enable the working mode.

6.2. Check Log File

After downloading firmware, users can check the log printed in the terminal by using the serial port debug tool.

Users need to configure the settings of the serial port debug tool, as follows:

Table 6-2. Serial Port Debug Tool Configuration

Items	Configuration Description
Protocol	Serial port.
Port number	Set the port number according to the connected device.
Baud rate	The baud rate at which the device is running, related to the crystal oscillator. • 69120 (24 M crystal oscillator) • 74880 (26 M crystal oscillator) • 115200 (40 M crystal oscillator) The ESP8266 AT example supports the baud rate of 115200 by default. Users cannot modify it. The ESP8266 IOT Demo example supports the baud rate of 74880. Users can modify it.
Data bit	8
Calibration	None.
Flow control	None.

6.2.1. ESP8266 IOT Demo

If users download ESP8266 IOT Demo firmware, the system in working mode will show the initialization information including the SDK version, etc. “Finish” means the firmware works properly.

```
SDK version:X.X.X(e67da894)

IOT VERSION = v1.0.5t45772(a)

reset reason: 0

PWM version: 00000003

mode: sta(18:fe:34:a4:8c:a3) + softAP(1a:fe:34:a4:8c:a3)
```

```
add if0
add if1
dhcp server start:(ip:192.168.4.1,mask:255.255.255.0,gw:192.168.4.1)
bcn 100
finish
```

6.2.2. ESP8266 AT

If users download the ESP8266 AT firmware, or the default firmware in ESP-LAUNCHER or ESP-WROOM-02, the system in working mode will display "Ready" at the end. Input command "AT" in the terminal and the system will return "OK", which means that the firmware works properly.

📖 ***Notes:***

- The baud rate in AT firmware is configured as 115200 manually, however, the default baud rate of ESP8266 is 74880, due to this discrepancy, the system initialization information will be displayed as mojibake. It is a normal phenomenon as long as the system shows "Ready" at the end.
- For more information on AT commands, please refer to *ESP8266 AT Instruction Set*.

6.3. Configuration of RF initialization (Optional)

Before downloading binaries to flash, users can modify the RF initialization settings in the ***RF InitConfig*** tab. The newly-generated ***esp_init_data_setting.bin*** can be downloaded to the flash instead of ***esp_init_data_default.bin***. Users can configure both the options and the parameters of the RF settings.

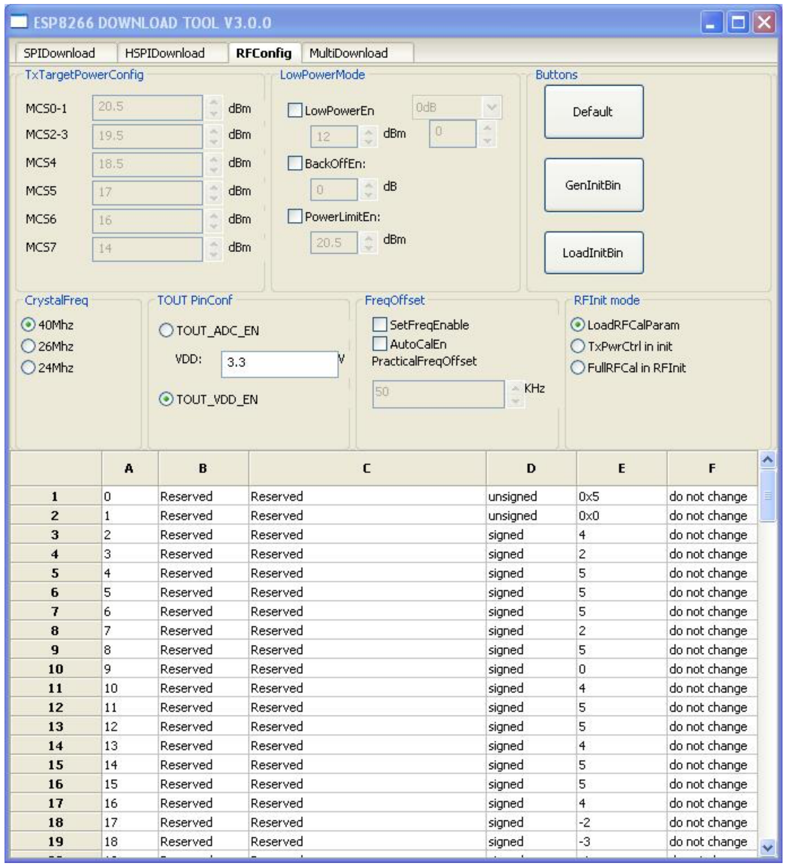


Figure 6-2. ESP8266 DOWNLOAD TOOL - RF InitConfig

6.3.1. Configuration of RF InitConfig Options

RF InitConfig options are listed in the upper part of Figure 6-2. Please refer to Table 6-3 for a description of this configuration.

Table 6-3. Configuration of RF InitConfig Options

Items	Description
TxTargetPowerConfig	Users need not configure this. It varies with the options in LowPowerMode.
LowPowerMode	Configure the low power mode as required. • *LowPowerEn*: enable low power mode, set a power value for all data rates. • *PowerLimtEn*: set a limit for output power. • *BackOffEn*: set backoff value for each data rate. 📖 ***Note:*** *Users cannot configure LowPowerEn and PowerLimtEn at the same time.*
CrystalFreq	Select the crystal oscillator frequency according to the crystal oscillator used. 📖 ***Note:*** *If a different option is selected when downloading, it will override this configuration.*

Items	Description
TOUT PinConf	Configure the TOUT pin according to the actual TOUT pin status. We recommend the default value. • *TOUT_ADC_EN*: When the TOUT pin connects to an external circuit, measure the external voltage (0V - 1V) through the internal ADC. • *TOUT_VDD_EN*: When TOUT pin is left floating, measure VDD33 voltage through uint16 system_get_vdd33(void). ⚠ ***Notice:*** • *Users cannot configure TOUT_ADC_EN and TOUT_VDD_EN at the same time.* • *When users use TOUT_ADC_EN, they need to input the actual voltage on VDD3P3 pin 3 and pin 4.*
FreqOffset	• *SetFreqEnable*: Set the frequency offset manually. - *PracticalFreqOffset*: the option is valid when selecting *SetFreqEnable*. • *AutoCalEn*: Set the frequency offset automatically.
RFInt mode	Users can select the RF initialization mode: • *LoadRFCalParam*: During the RF initialization, RF data are loaded directly from the flash without any calibration. It takes about 2 ms and the least initial current. • *TxPwrCtrl in init*: During the RF initialization, only Tx Power calibration will be performed, and other data are loaded from flash. It takes about 20 ms and small initial current. • *FullRFCal in RFInit*: All calibrations are performed during the RF initialization. It takes 200 ms and large initial current.

6.3.2. Configuration of RF InitConfig Parameters

RF InitConfig parameters are listed in the lower part of Figure 6-2. The description of parameters' configuration is shown in Table 6-4.

Table 6-4. Configuration of RF InitConfig Parameters

Items	Description
A	The byte in ***esp_init_data_setting.bin*** (0 ~ 127 byte). For example, A = 0 represents Byte 0 in ***esp_init_data_setting.bin***.
B	The item name. Users cannot modify it if marked as Reserved.
C	The item name. Users cannot modify it if marked as Reserved.
D	Data types of configuration items, including unsigned and signed data types.
E	The hexadecimal value of a configuration item.

⚠ ***Notice:***

Please do not modify the parameters marked as Reserved.

The following section introduces how to modify the 112 ~ 114 byte parameters. Figure 6-3 shows the initial configuration.

A	B	C	D	E	F
112	tx_param42	freq_correct_en	unsigned	0	bit[0]:0->do not correct fre
113	tx_param43	force_freq_offset	unsigned	0	signed, unit is 8khz
114	tx_param44	rf_cal_use_flash	unsigned	0	0: RF init no RF CAL, using

Figure 6-3. 112 ～ 114 Byte Parameters

Modify the RF Initialization Parameters

Byte 114 is used to control THE RF initialization when ESP8266 is powered on. Table 6-5 provides the parameter configuration.

📖 ***Note:***

Supported by ESP8266_NONOS_SDK_V1.5.3 and ESP8266_RTOS_SDK_V1.3.0 and higher.

Table 6-5. Modify RF Initialization Parameters

Option	Description
byte 114 = 0	Only a VDD33 calibration is performed during the RF initialization. It takes about 2 ms and the least initial current.
byte 114 = 1	The default value is 1. VDD33 and TX power calibrations are performed during the RF initialization. It takes about 18 ms and small initial current.
byte 114 = 2	The same as when “ byte 114 = 0”.
byte 114 = 3	All calibrations are performed during the RF initialization. It takes about 200 ms and large initial current.

Correct Frequency Offset

Byte 112 and byte 113 relate to the frequency offset correction. Table 6-6 provides the parameter configuration.

📖 ***Note:***

Supported by ESP8266_NONOS_SDK_V1.4.0 and ESP8266_RTOS_SDK_V1.3.0 and higher.

Table 6-6. Options for Frequency Offset Correction

Option	Description
The default value of byte 112 is 0.	
bit 0	This bit is of the highest priority. • bit 0 = 0: frequency offset cannot be corrected. • bit 0 = 1: frequency offset can be corrected.

Option	Description
	The default value of byte 112 is 0.
bit 1	When value = 0, it means that the bbpll is 168 M. Both positive and negative frequency offsets can be corrected. However, this may effect the digital peripheral performance and, therefore, it is not recommended. When value = 1, it means that the bbpll is 160 M. Only the positive frequency offset can be corrected.
{bit 3， bit 2}	When value = 0, it means that the chip will track and correct the frequency offset automatically. The initial correction value is 0. When value = 1, it means that the chip is manually programmed to change the frequency offset to that of byte 113, so the chip will not track and correct the frequency offset automatically. When value = 2, it means that the chip will track and correct the frequency offset automatically. The initial correction value is that of byte 113.
	The default value of byte 113 is 0.
113 byte	It is the value when the frequency offset is corrected manually or the initial correction value in frequency tracking. The data type is sign int8, in multiples of 8 kHz.

6.3.3. Configuration Examples

The configuration of bytes 112 and 113 depends depends on users' specific needs. We provide some examples below:

1. **The module works at ambient temperature, and needs no correction of the frequency offset.**
   - Set byte 112 = 0, byte 113 = 0.
2. **The module works at ambient temperature and needs no automatic tracking and correction of the frequency offset; yet the frequency offset is large. In this case, a manual correction of the frequency offset is recommended.**
   - If the frequency offset is +160 KHz (at ambient temperature), users can set byte 112 = 0x07, byte 113 = (256 - 160/8) = 236 = 0xEC.
   - If the frequency offset is -160 KHz (at ambient temperature), users can set byte 112 = 0x05, byte 113 = 160/8 = 20 = 0x14. This may effect the digital peripheral performance, so we do not recommend it.
3. **Applications, such as smart lights, work at a wide temperature range of -40 °C to 125 °C, and need to track and correct the frequency offset automatically. The frequency offset at ambient temperature is small, so the initial offset correction value is not needed.**
   - Set byte 112 = 0x03, byte 113 = 0.

4. **Applications, such as smart lights, work at a wide temperature range of -40 °C to 125 °C, and need to track and correct the frequency offset automatically. The frequency offset at ambient temperature is large, so the initial offset correction value is needed.**
   - If the frequency offset is +160 kHz (at ambient temperature), users can set byte 112 = 0x0B, byte 113 = (256 - 160/8) = 236 = 0xEC.
   - If the frequency offset is -160 kHz (at ambient temperature), users can set byte 112 = 0x09, byte 113 = 160/8 = 20 = 0x14. But this may effect the digital peripheral performance and needs substantive tests, so we do not recommend it.

We recommend Example 3.

When the configuration of RF initialization is done, click ***GenInitBin*** button to generate

esp_init_data_setting.bin.

In addition, users can click ***Default*** button to set the value of frequency offset to default, or click ***LoadInitBin*** button to import a binary file for configuration.

A. Appendix—Configuring ISSI & MXIC Flash QIO Mode

> ⚠️ ***Notice:***
> *Choose DIO or DOUT mode when downloading, otherwise errors may occur. There is no need to modify binaries in DIO or DOUT mode.*

When using QIO mode of ISSI flash or MXIC flash, users need to modify the first two bytes in ***blank.bin***, as shown in Table A-1. During initialization, ESP8266 will automatically check the first two bytes and switch to QIO mode to read ISSI_FLASH or MXIC_FLASH. The structure of ***blank.bin*** is shown below:

```
strcut boot_hdr{
    char user_bin:2;     //low_bit
    char boot_status:1;
    char to_qio:1;
    char reverse:4;
    char version:5;      //low bit
    char test_pass_flag:1;
    char test_start_flag:1;
    char enhance_boot_flag:1;
}
```

Table A-1. blank.bin Configuration

Option	Description
Without secondary boot loader	Modify `to_qio` to 0.
With secondary boot loader	Modify `use_bin` to 0 and `to_qio` to 0, as well. Modify `version` according to the current boot version. ***Example***: If users use the secondary ***boot_v1.5.bin***, please modify the first two bytes FF FF to F4 E5.

B. Appendix—Learning Resources

B.1. Must-Read Documents

- *ESP8266EX Datasheet*

  Description: This document introduces the specifications of ESP8266EX, including an overview of the features, protocols, technical parameters and applications. It also describes the pin layout, as well as major functional modules integrated in ESP8266EX (CPU, flash and memory, clock, radio, Wi-Fi, and low-power management). Additionally, it provides descriptions of peripheral interfaces integrated on ESP8266EX, lists the electrical data of ESP8266EX and illustrates the package details of ESP8266EX.
- *ESP8266 Hardware Resources*

  Description: This zip package includes the manufacturing specifications of the ESP8266 board and its modules, manufacturing BOM and schematics.
- *ESP8266 Non-OS SDK IoT_Demo Guide*

  Description: This documents provides simple demo implementations of three types of smart devices: Smart Light, Smart Power Plug, and Sensor Device. It also introduces the readers to curl toolkits, functions in LAN and WAN.
- *ESP8266 RTOS SDK Programming Guide*

  Description: This document provides sample codes based on ESP8266_RTOS_SDK, including basic examples, networking protocol examples and advanced examples.
- *ESP8266 AT Command Examples*

  Description: This document introduces some specific examples of how to use 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.
- *ESP8266 Non-OS SDK API Reference*

  Description: This document lists ESP8266_NONOS_SDK APIs, provides an overview of ESP8266_NONOS_SDK and introduces the readers to system APIs, TCP/UDP APIs, mesh APIs, application specific APIs, definitions and data structures, and APIs for peripheral interfacing.
- *ESP8266 RTOS SDK API Reference*

Description: This document lists ESP8266_RTOS_SDK APIs, including functions for Wi-Fi related APIs, boot APIs, etc.

- *FAQ*

B.2. Must-Have Resources

- *ESP8266 SDKs*

  Description: This webpage provides links to the latest version of ESP8266 SDK and the older ones.
- *RTOS Sample Code*

  Description: This webpage provides the sample code for the commonly used functions.
- *Non-OS Sample Code*

  Description: This webpage provides the sample code for the commonly used functions.
- *ESP8266 Tools*

  Description: This webpage 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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