



# **Espressif IOT SDK User Manual**

**Version 1.5**

**Espressif Systems IOT Team  
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# 1.

# Preambles

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This manual introduces the setting up of toolchain, and codes for ESP8266-based SDK for Internet of Things.

More information can be found at Espressif's BBS: <http://bbs.espressif.com/>

The user starter guide can be found at: <http://bbs.espressif.com/viewforum.php?f=21>



## 2. Development Tools

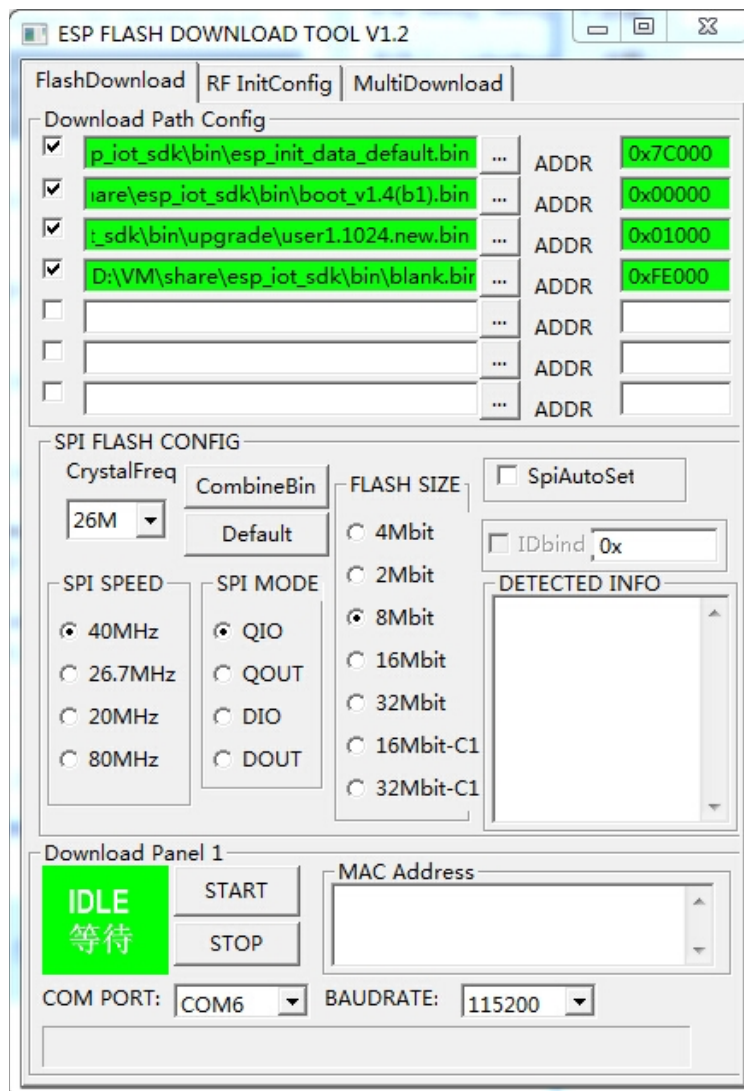
### 2.1. Download Tools: FLASH\_DOWNLOAD\_TOOLS

Espressif Systems official flash download tool "ESP\_FLASH\_DOWNLOAD\_TOOL" to download firmware into Flash.

Download : <http://bbs.espressif.com/viewtopic.php?f=57&t=433>

Users can burn several bin files altogether in one time, and download several complied \*.bin files in one time into the SPI Flash on the ESP8266 motherboard.

Steps of using **ESP\_FLASH\_DOWNLOAD\_TOOL**:





1. Bin-Select Area: Choose bins to burn, and burn them in corresponding address.
2. SPI FLASH CONFIG: Set config of SPI flash. "**CombineBin**" merges all bins selected above to one (**target.bin**). "**Default**" resets the config of SPI Flash to the default config.
3. Mac Address: MAC address of ESP8266.

Also set the jumper on the motherboard as **MTDO:0, GPIO0:0, GPIO2:1**; this causes the chip to enter the download mode. Steps are as follows:

- See the green boxes in the picture below, select the bin files to be burned → fill in the path → check burning options.
- Set COM port and baud rate.
- Click "START" to start downloading.
- After the downloading, disconnect the power for the motherboard, and change the jumper into operation mode. Re-connect the power for operation.

Set the jumper on the motherboard as **MTDO:0, GPIO0:1, GPIO2:1** for operation mode.

PS: Please disconnect the power when setting the jumper.

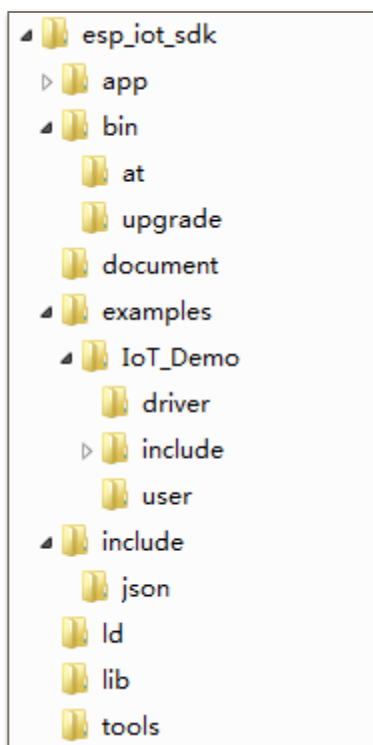
## 2.2. Serial Port Tool

The default baud rate of ESP8266 module is 74880.

## 3. SDK Software Package

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All header files, library files and compilation files needed for secondary development are included in the SDK software package. See the picture below for directory structure:



### Detailed description:

- The "app" directory is the main working directory, we need to copy source codes to this directory to compile.
- "bin" folder stores the bin files downloaded into the Flash:
  - ▶ "at" folder stores the bin files that support AT instructions provided by Espressif Systems;
  - ▶ "upgrade" folder stores the bin files generated by compilation, which support FOTA;
  - ▶ "bin" folder root stores the bin files generated by compilation, which don't support FOTA, and it also supports other bin files provided by Espressif Systems.
- "examples" folder stores SDK examples, and we need to copy source codes here (all files in the IoT\_Demo folder) to "app" folder;



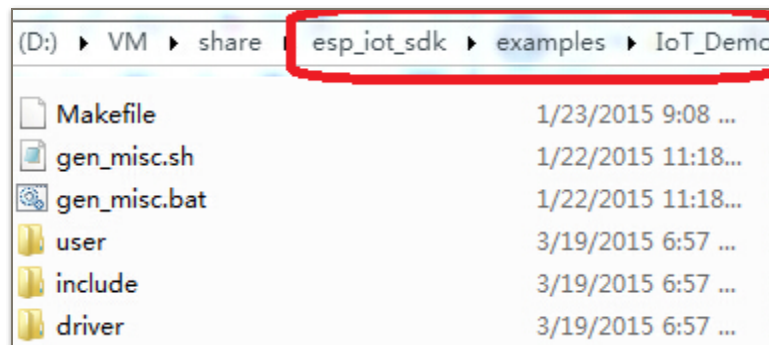


- "`include`" folder stores the header files pre-installed in the SDK, which may include relevant API functions and other macro definitions. Users can use them directly and do not need to change anything;
- "`ld`" folder stores the files needed for SDK software link. Users can use them directly and do not need to change anything;
- "`lib`" folder stores the library files needed for SDK compilation;
- "`tools`" folder stores the tools needed for generating bin files. Users can use them directly and do not need to change anything.

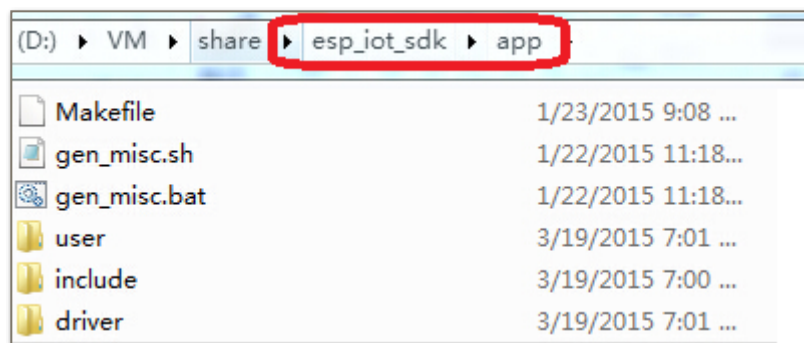


## 4. Compilation

When compiling, please remember to copy the sub-folders in the `esp_iot_sdk/examples/IOT_Demo` to `esp_iot_sdk/app`.



Copy all files in the picture above to `esp_iot_sdk/app` to compile.



### 4.1. Compilation for Version 0.9.5 SDK and After

With the release of `esp_iot_sdk_v0.9.5`, the compile process was simplified with a script in the APP folder.

Compile : `./gen_misc.sh`

```
esp8266@esp8266-VirtualBox:~/Share/esp_iot_sdk/app$ ./gen_misc.sh
Please follow below steps(1-5) to generate specific bin(s):
STEP 1: choose boot version(0=boot_v1.1, 1=boot_v1.2+, 2=none)
enter(0/1/2, default 2):
```

Then follow the tips and steps.



STEP 1 : boot version	
0	boot_v1.1, old version boot, support FOTA ( firmware upgrade through Wi-Fi )
1	boot_v1.2+, new version boot, always recommend to use the latest boot.bin, support FOTA
2	none boot, generate <code>eagle.flash.bin</code> and <code>eagle.irom0text.bin</code> , don't support FOTA
STEP 2 : bin generated	
0	input 2 in STEP 1, generate <code>eagle.flash.bin</code> and <code>eagle.irom0text.bin</code> , don't support FOTA
1	input 0 or 1 in STEP 1, generate <code>user1.bin</code> , support FOTA
2	input 0 or 1 in STEP 1, generate <code>user2.bin</code> , support FOTA
STEP 3 : SPI flash configuration ( SPI speed )	
0	SPI speed 20MHz, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
1	SPI speed 26.7MHz, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
2	SPI speed 40MHz, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
3	SPI speed 80MHz, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
STEP 4 : SPI flash configuration ( SPI mode )	
0	QIO, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
1	QOUT, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
2	DIO, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
3	DOUT, according to your actual SPI flash, set same configuration while downloading by ESP flash download tool.
STEP 5 : SPI flash configuration ( SPI flash size & map )	
0	flash size 512KB, flash map of program area is 256KB + 256KB
2	flash size 1024KB, flash map of program area is 512KB + 512KB
3	flash size 2048KB, only the first 1024KB is program area, flash map of program area is 512KB + 512KB



4	flash size 4096KB, only the first 1024KB is program area, flash map of program area is 512KB + 512KB
5	flash size 2048KB, flash map of program area is 1024KB + 1024KB Only supported by sdk_v1.1.0 + boot 1.4 + flash download tool_v1.2 and later version
6	

Notice,

- `none boot` : generate `eagle.flash.bin` and `eagle.irom0text.bin` which do not support FOTA.
- `boot_v1.1` & `boot_v1.2` : we recommend you to use the latest boot; choosing boot in compilation will get `user1.bin` or `user2.bin` which support FOTA (firmware upgrade through WiFi)
- After compiling `user1.bin`, please call `make clean` first to clean up the temporary files generated by last compilation, then compile `user2.bin`.
- Compilation succeeds: it shows the address for the bins to be written to. For example:

```
eagle.app.v6.flash.bin----->addr:0x00000
eagle.app.v6.irom0text.bin----->addr:0x40000
!!!
esp8266@esp8266-VirtualBox:~/Share/esp_iot_sdk/app$
```

Or

```
Generate user1.512.old.bin successully in folder bin/upgrade.
Support boot_v1.1 and +
user1.512.old.bin----->addr:0x1000
!!!
esp8266@esp8266-VirtualBox:~/Share/esp_iot_sdk/app$
```

## 4.2. Compilation for Version 0.9.5 SDK and After

For `esp_iot_sdk_v0.9.4` and before, FW does not support upgrade through WiFi compiled by `./gen_misc.sh`.

FW support upgrade through WiFi (FOTA) compiled as:

- (1) Run `./gen_misc_plus.sh 1` to generate `user1.bin` at `/esp_iot_sdk/bin/upgrade`
- (2) Run `make clean` to clean up the temporary files generated by last compilation
- (3) Run `./gen_misc_plus.sh 2` to generate `user2.bin` at `/esp_iot_sdk/bin/upgrade`

Notes:

- 1) Please refer to document "**Firmware update through cloud server**" for details about FOTA.
- 2) `esp_iot_sdk_v0.7` and previous versions do not support FOTA.
- 3) `esp_iot_sdk_v0.8` and later versions support cloud update and are compatible with previous compilation and burning methods.



## 5. Flash Map

Different settings of STEP 1 and STEP 5 in compilation leads to different flash size and flash map.

Notes

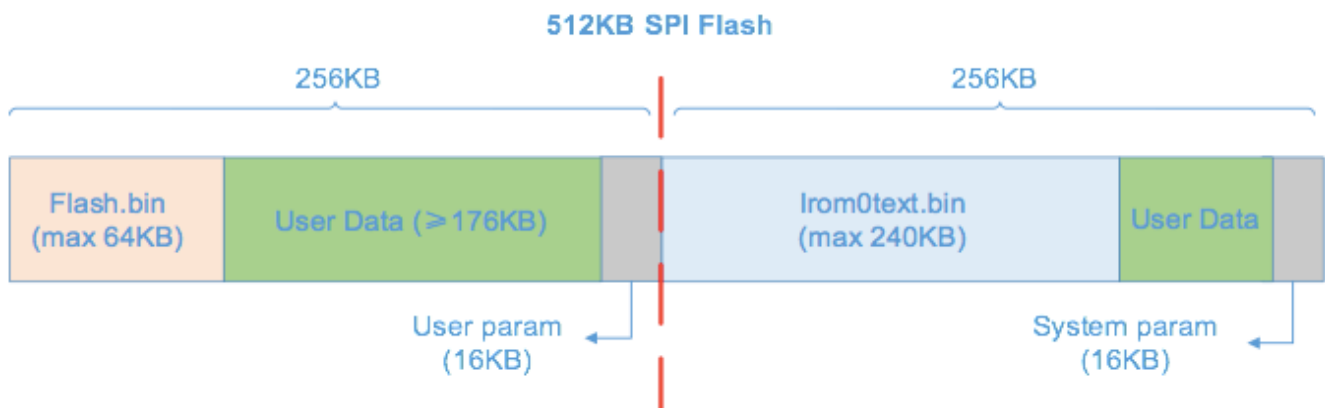
- System param (system parameter area) is always the last 16KB of flash.
- User param is the user parameter area used by Espressif demo code ( IOT\_Demo or AT ). If users develop their own application, user data can be saved in any flash area available.
- User Data area ( green area in pictures below ) means the flash area that may be available, if program area doesn't reach the maximum size, remaining area can be used to save user data.

### 5.1. none boot - don't support upgrade through WiFi

Choose 2 none boot in STEP 1 of compilation to generate `eagle.flash.bin` ( hereinafter called `flash.bin` ) and `eagle.irom0text.bin` ( hereinafter called `irom0text.bin` ). Then choose different flash map in STEP 5 according to your actual SPI flash.

#### 1. 512KB flash

If choose 2 none boot in STEP 1, choose 0 512KB in STEP 5, the flash map will be as below



- User Data area: if program area ( `flash.bin` and `irom0text.bin` ) doesn't fill up flash, the remaining area can be used to store user data.
- `irom0text.bin` default to be less than 200KB ; for 512KB flash, user can revise ld file for compilation, to make the maximum size of `irom0text.bin` to be  $256 - 16 = 240$  KB
- In "`eagle.app.v6.ld`" ( `\esp_iot_sdk\ld` ), "len" of "`irom0_0_seg`" means the maximum size of `irom0text.bin` . For 512KB flash, it can be revised to `0x3C000` at most, the maximum size of `irom0text.bin` is 240 KB.



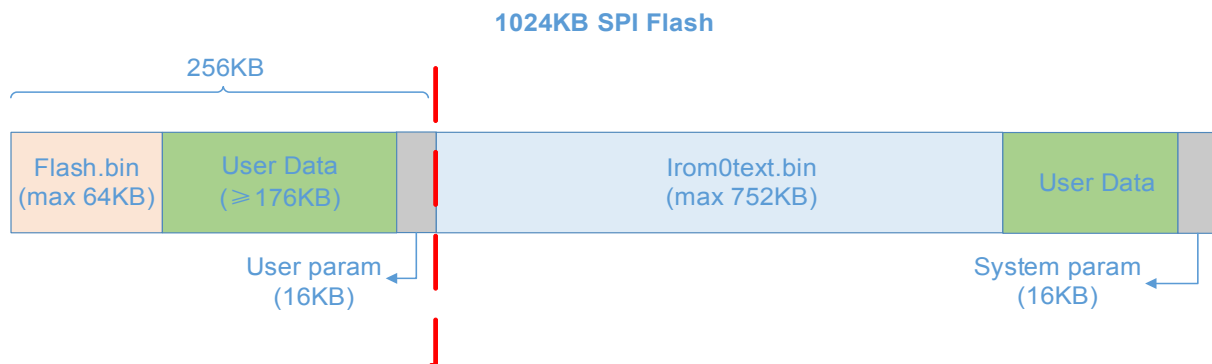
```

MEMORY
{
    dport0_0_seg :          org = 0x3FF00000, len = 0x10
    dram0_0_seg :          org = 0x3FFE8000, len = 0x14000
    iraml_0_seg :          org = 0x40100000, len = 0x8000
    irom0_0_seg :          org = 0x40240000, len = 0x32000
}

```

## 2. 1024KB flash

If choose 2 none boot in STEP 1, choose 2 1024KB in STEP 5, flash map will be as below



- User Data area: if program area ( `flash.bin` and `irom0text.bin` ) doesn't fill up flash, the remaining area can be used to store user data.
- `irom0text.bin` default to be less than 200KB ; for 1024KB flash, user can revise ld file for compilation, to make the maximum size of `irom0text.bin` to be  $1024 - 256 - 16 = 752$  KB
- In "`eagle.app.v6.ld`" ( `\esp_iot_sdk\ld` ), "len" of "`irom0_0_seg`" means the maximum size of `irom0text.bin`. For 1024KB flash, it can be revised to `0xBC000` at most, the maximum size of `irom0text.bin` is 752 KB.

```

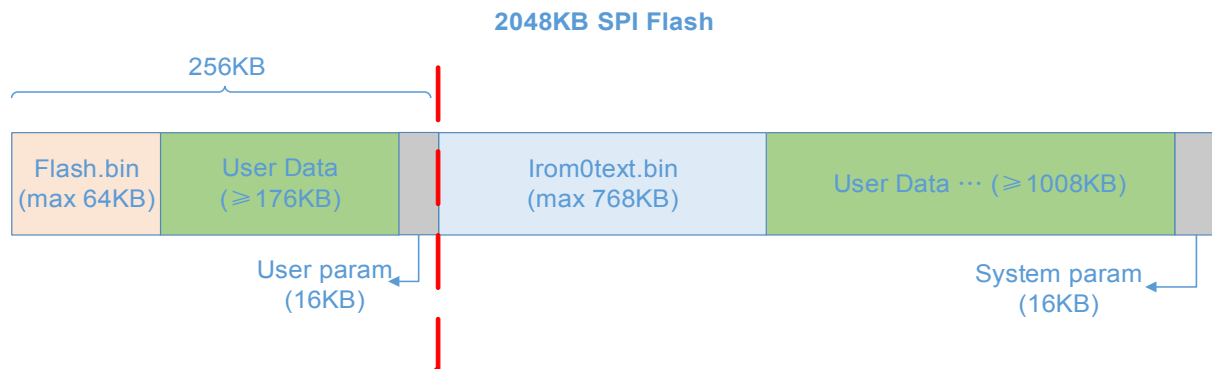
MEMORY
{
    dport0_0_seg :          org = 0x3FF00000, len = 0x10
    dram0_0_seg :          org = 0x3FFE8000, len = 0x14000
    iraml_0_seg :          org = 0x40100000, len = 0x8000
    irom0_0_seg :          org = 0x40240000, len = 0x32000
}

```



### 3. 2048KB flash

If choose 2 none boot in STEP 1, choose 3 2048KB in STEP 5, flash map will be as below



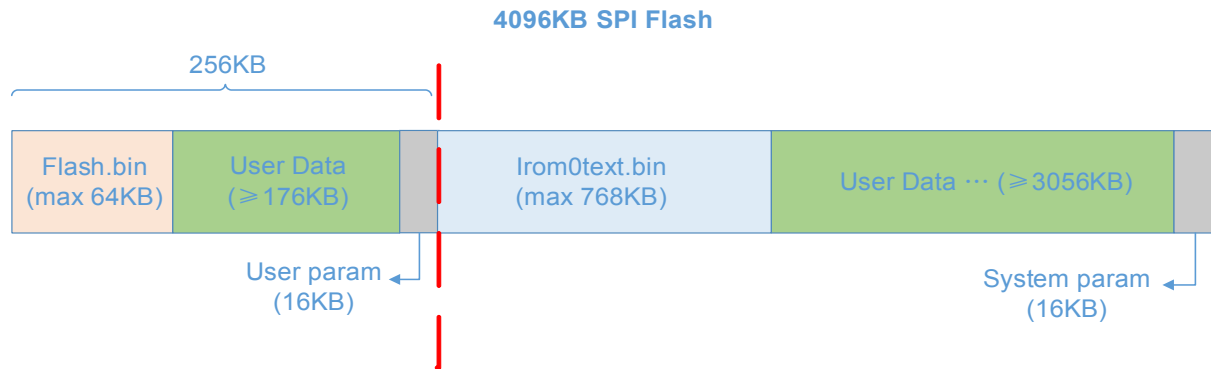
- User Data area: if program area ( `flash.bin` and `irom0text.bin` ) doesn't fill up flash, the remaining area can be used to store user data.
- `irom0text.bin` default to be less than 200KB ; Only the first 1024KB can be program area now, so for 2048KB flash, user can revise ld file for compilation, to make the maximum size of `irom0text.bin` to be  $1024 - 256 = 768$  KB
- In "`eagle.app.v6.ld`" ( `\esp_iot_sdk\ld` ), "len" of "`irom0_0_seg`" means the maximum size of `irom0text.bin`. For 2048KB flash, it can be revised to `0xC0000` at most, the maximum size of `irom0text.bin` is 768 KB.

```
MEMORY
{
    dport0_0_seg :                org = 0x3FF00000, len = 0x10
    dram0_0_seg :                 org = 0x3FFE8000, len = 0x14000
    iraml_0_seg :                 org = 0x40100000, len = 0x8000
    irom0_0_seg :                 org = 0x40240000, len = 0x32000
}
```



#### 4. 4096KB flash

If choose 2 none boot in STEP 1, choose 4 4096KB in STEP 5, flash map will be as below



- User Data area: if program area ( `flash.bin` and `irom0text.bin` ) doesn't fill up flash, the remaining area can be used to store user data.
- `irom0text.bin` default to be less than 200KB ; Only the first 1024KB can be program area now, so for 4096KB flash, user can revise ld file for compilation, to make the maximum size of `irom0text.bin` to be  $1024 - 256 = 768$  KB
- In "`eagle.app.v6.ld`" ( `\esp_iot_sdk\ld` ), "`len`" of "`irom0_0_seg`" means the maximum size of `irom0text.bin`. For 4096KB flash, it can be revised to `0xC0000` at most, the maximum size of `irom0text.bin` is 768 KB.

```
MEMORY
{
    dport0_0_seg :                org = 0x3FF00000, len = 0x10
    dram0_0_seg :                 org = 0x3FFE8000, len = 0x14000
    iraml_0_seg :                 org = 0x40100000, len = 0x8000
    irom0_0_seg :                 org = 0x40240000, len = 0x32000
}
```





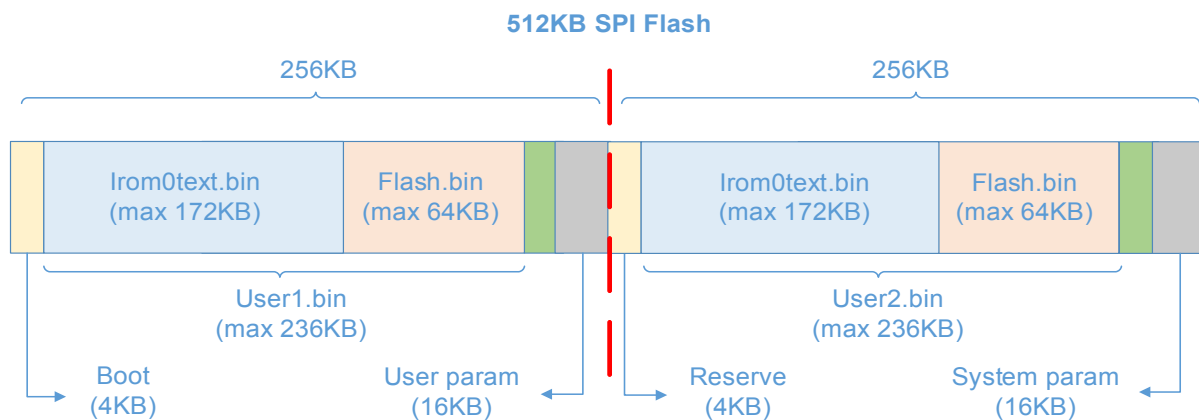
## 5.2. with boot - support upgrade through WiFi (FOTA)

Choose **1 boot\_v1.2+** in **STEP 1** to support FOTA, generate **user1.bin** and **user2.bin**. Then choose different flash map in **STEP 5** according to your actual SPI flash.

- After generating **user1.bin**, call **make clean** first to clean the temporary files, then compile again to generate **user2.bin**
- boot\_v1.1** is an old version boot, compilation and downloading are the same as **boot\_v1.2+**, we recommend you to use the latest version of **boot.bin**.
- User Data area ( green area in pictures below ) means the flash area that may be available, if program area ( **user1.bin** and **user2.bin** ) doesn't reach the maximum size, remaining area can be used to save user data.

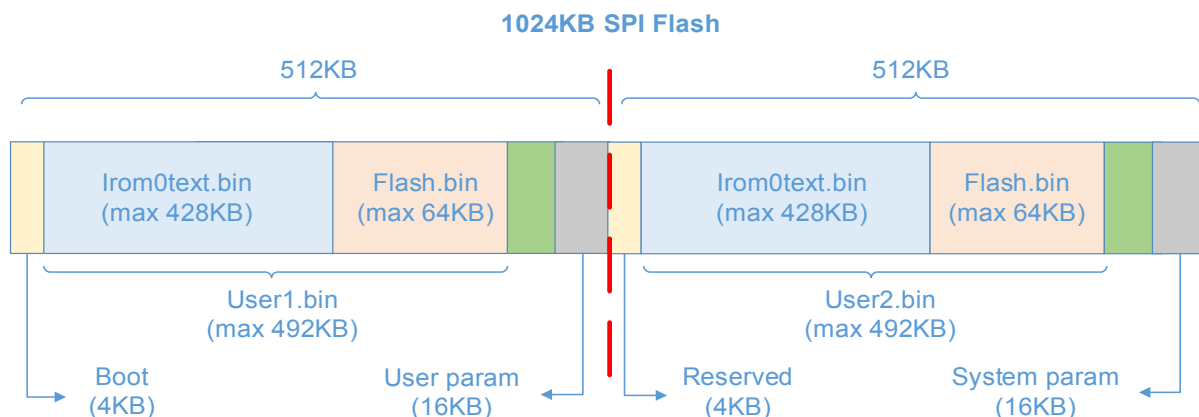
### 1. 512KB flash

If choose **1 boot\_v1.2+** in **STEP 1**, choose **0 512KB** in **STEP 5**, flash map will be as below



### 2. 1024KB flash

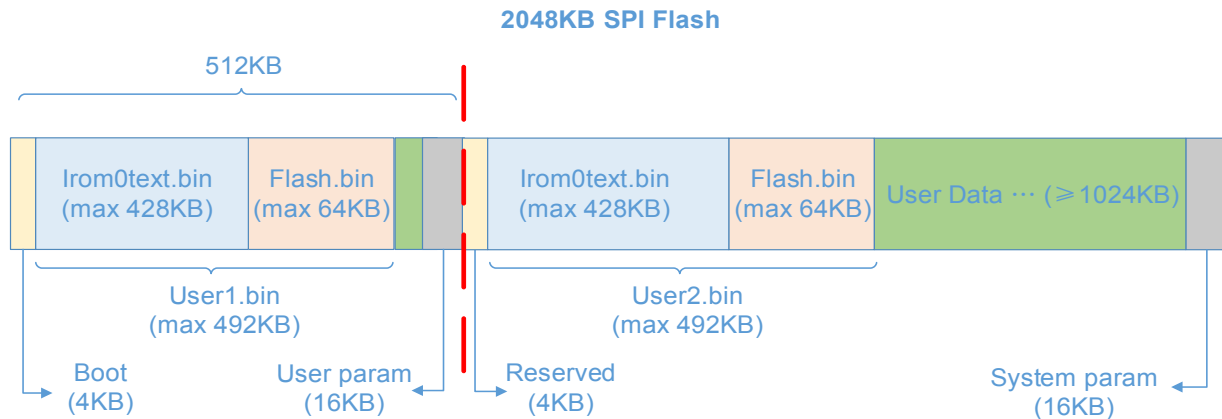
If choose **1 boot\_v1.2+** in **STEP 1**, choose **2 1024KB** in **STEP 5**, flash map will be as below



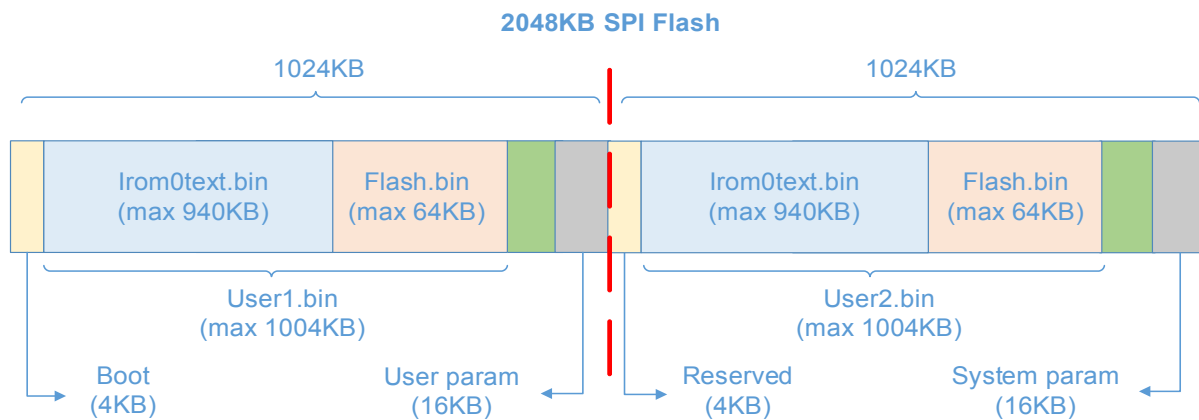


### 3. 2048KB flash

If choose 1 `boot_v1.2+` in STEP 1, choose 3 2048KB in STEP 5, only the first 1024KB is the program area ( 512KB + 512KB ), and the flash map will be as below



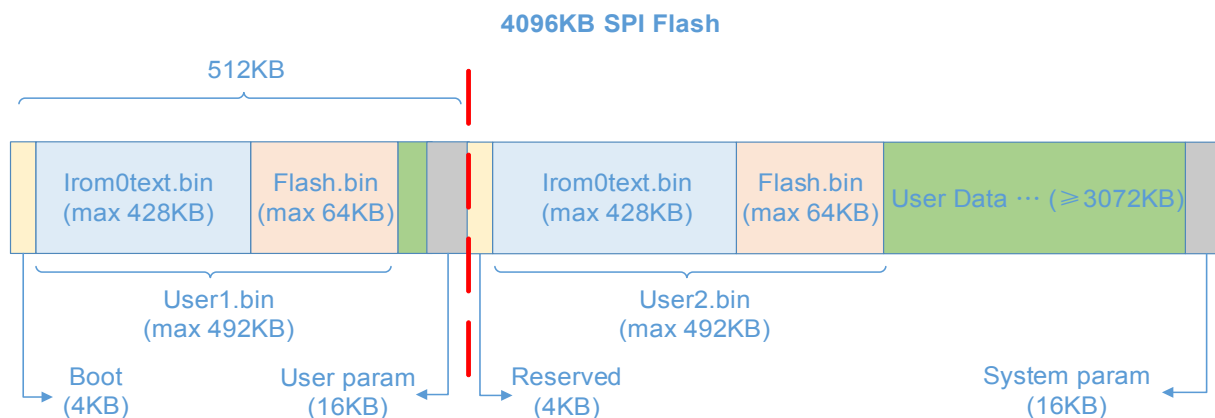
If choose 1 `boot_v1.2+` in STEP 1, choose 5 2048KB in STEP 5 (only supported by sdk\_v1.1.0 + boot v1.4 + flash download tool v1.2 and later version), the program area is 1024KB + 1024KB, and the flash map will be as below



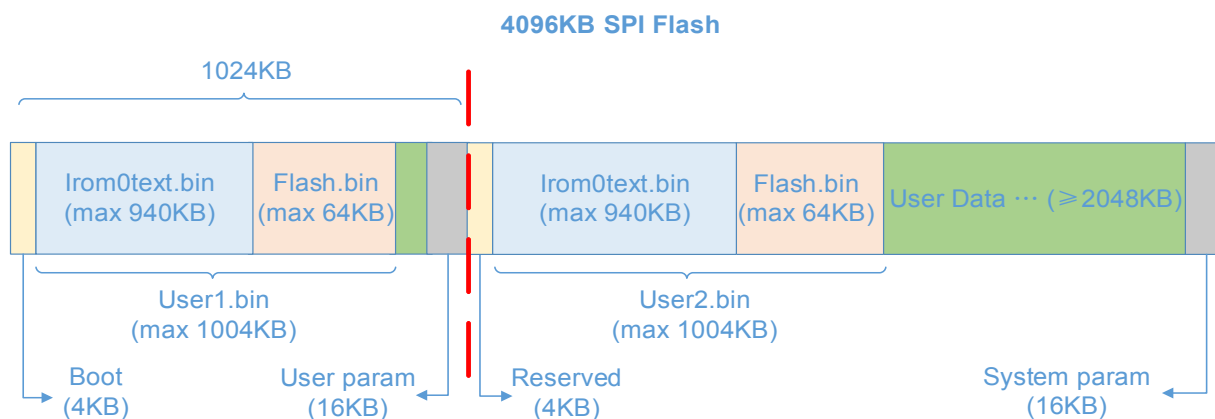


#### 4. 4096KB flash

If choose 1 `boot_v1.2+` in STEP 1, choose 4 4096KB in STEP 5, only the first 1024KB is the program area ( 512KB + 512KB ), and the flash map will be as below



If choose 1 `boot_v1.2+` in STEP 1, choose 6 4096KB in STEP 5 (only supported by sdk\_v1.1.0 + boot 1.4 + flash download tool v1.2 and later version), the first 2048KB is the program area (1024KB + 1024KB), and the flash map will be as below



## 6. Writing Image Into Flash

According to compiling method and flash size, we can choose one of the following ways to write the image to the flash device.

Note:

- Flash system parameter area is the last 4 sectors of flash, 4K Bytes per sector, so it's the last 16KB of flash;
- Flash user parameter area depends on user-defined application; in IOT\_Demo which uses 512KB flash as example, user parameter area is 4 sectors starting from `0x3C000`
- `master_device_key.bin` is needed if you are using Espressif Cloud, otherwise it need not to burn into Flash; it is only necessary for initial write-in and revision of `master_device_key`; in IOT\_Demo, `master_device_key` is in the third sector of user parameter area.
- `blank.bin` as initialization, which should be written to the last but one in flash;
- `esp_init_data_default.bin` stores default RF parameter values and which should be written to the forth sector from the end of flash;
- IoT\_Demo in ESP8266\_NONOS\_SDK is using 512 KB Flash map by default, more details in documentation "2B-ESP8266\_SDK\_IOT\_Demo".

### 6.1. Don't Support Cloud Update (FOTA)

#### 1. 512KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service
<b>esp_init_data_default.bin</b>	0x7C000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0x7E000	Stores default system parameter values, provided in SDK
<b>eagle.flash.bin</b>	0x00000	Compiled by the steps described above
<b>eagle.irom0text.bin</b>	0x40000	Compiled by the steps described above



## 2. 1024KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service
<b>esp_init_data_default.bin</b>	0xFC000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0xFE000	Stores default system parameter values, provided in SDK
<b>eagle.flash.bin</b>	0x00000	Compiled by the steps described above
<b>eagle.irom0text.bin</b>	0x40000	Compiled by the steps described above

## 3. 2048KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service
<b>esp_init_data_default.bin</b>	0x1FC000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0x1FE000	Stores default system parameter values, provided in SDK
<b>eagle.flash.bin</b>	0x00000	Compiled by the steps described above
<b>eagle.irom0text.bin</b>	0x40000	Compiled by the steps described above

## 4. 4096KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service
<b>esp_init_data_default.bin</b>	0x3FC000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0x3FE000	Stores default system parameter values, provided in SDK
<b>eagle.flash.bin</b>	0x00000	Compiled by the steps described above
<b>eagle.irom0text.bin</b>	0x40000	Compiled by the steps described above



## 6.2. Version that supports Cloud Update (FOTA)

Note:

- `User2.bin` doesn't need to be burned into Flash, it can be downloaded through WiFi (FOTA)

### 1. 512KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service
<b>esp_init_data_default.bin</b>	0x7C000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0x7E000	Stores default system parameter values, provided in SDK
<b>boot.bin</b>	0x00000	Boot loader, provided in SDK, we recommend users to use the latest version
<b>user1.bin</b>	0x01000	Compiled by the steps described above
<b>user2.bin</b>	0x41000	Compiled by the steps described above, doesn't need to be burned into flash, can be download ed through WiFi as upgrade

### 2. 1024KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000 (Recommend to revise)	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service; to be written into the third sector of flash user parameter area which is 0x3E000 in IOT_Demo, can be changed by user. If you use 1024KB flash, we recommend you to change it to 0x7E000, refer to BBS <a href="http://bbs.espressif.com/viewtopic.php?f=10&amp;t=305">http://bbs.espressif.com/viewtopic.php?f=10&amp;t=305</a>
<b>esp_init_data_default.bin</b>	0xFC000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0xFE000	Stores default system parameter values, provided in SDK
<b>boot.bin</b>	0x00000	Boot loader, provided in SDK, we recommend you to use the latest version
<b>user1.bin</b>	0x01000	Compiled by the steps described above
<b>user2.bin</b>	0x81000	Compiled by the steps described above, doesn't need to be burned into flash, can be download ed through WiFi as upgrade



### 3. 2048KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service; to be written into the third sector of flash user parameter area which is 0x3E000 in IOT_Demo, can be changed by user. If choose 3 in STEP 5, please change it to 0x7E000, refer to BBS <a href="http://bbs.espressif.com/viewtopic.php?f=10&amp;t=305">http://bbs.espressif.com/viewtopic.php?f=10&amp;t=305</a> If choose 5 in STEP 5, change it to 0xFE000, and burn it into 0xFE000.
<b>esp_init_data_default.bin</b>	0x1FC000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0x1FE000	Stores default system parameter values, provided in SDK
<b>boot.bin</b>	0x00000	Boot loader, provided in SDK, we recommend you to use the latest version
<b>user1.bin</b>	0x01000	Compiled by the steps described above
<b>user2.bin</b>	0x81000	Compiled by the steps described above, need not to be burned into flash, can be download through WiFi as upgrade

### 4. 4096KB Flash

bin	Address	Description
<b>master_device_key.bin</b>	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service; to be written into the third sector of flash user parameter area which is 0x3E000 in IOT_Demo, can be changed by user. If choose 4 in STEP 5, please change it to 0x7E000, refer to BBS <a href="http://bbs.espressif.com/viewtopic.php?f=10&amp;t=305">http://bbs.espressif.com/viewtopic.php?f=10&amp;t=305</a> If choose 6 in STEP 5, change it to 0xFE000, and burn it into 0xFE000.
<b>esp_init_data_default.bin</b>	0x3FC000	Stores default RF parameter values, provided in SDK
<b>blank.bin</b>	0x3FE000	Stores default system parameter values, provided in SDK
<b>boot.bin</b>	0x00000	Boot loader, provided in SDK, we recommend you to use the latest version
<b>user1.bin</b>	0x01000	Compiled by the steps described above
<b>user2.bin</b>	0x81000	Compiled by the steps described above, doesn't need to be burned into flash, can be downloaded through WiFi as upgrade



# 7.

# Appendix

Since **esp\_iot\_sdk\_v1.4.0**, users can configure RF initialization when ESP8266 is powered on by set the byte 114 of esp\_init\_data\_default.bin (0~127 byte):

- 114 byte default to be 0 : RF only calibrate VDD33 during initialization which will take about 2 ms with lowest power consumption.
- 114 byte set to be 1 : RF calibrate VDD33 and TX power which will take about 18 ms with a lower power consumption.
- 114 byte set to be 2 : RF only calibrate VDD33 during initialization which will take about 2 ms with lowest power consumption. The same as option 0.
- 114 byte set to be 3 : RF will do the whole calibration which will take about 200 ms with a higher power consumption.



(1) Click "RF InitConfig" in tool "ESP FLASH DOWNLOAD TOOL\_v2.3"

	A	B	C	D	E
109	108	Reserved	Reserved	unsigned	0
110	109	Reserved	Reserved	unsigned	0
111	110	Reserved	Reserved	unsigned	0
112	111	Reserved	Reserved	unsigned	0
113	112	tx_param42	freq_correct_en	unsigned	3
114	113	tx_param43	force_freq_offset	unsigned	0
115	114	tx_param44	rf_cal_use_flash	unsigned	1
116	115	Reserved	Reserved	unsigned	0





- (2) The table at the bottom is the configuration of esp\_init\_data\_default.bin (0~127 byte). And the "RFInit mode" is used to set the RF initialization. For example, select the "TxPwrCtrl in init", the byte 114 will change to be 1 as shown in the picture above.
- (3) Click "GenInitBin" to generate a new bin "esp\_init\_data\_setting.bin", and download it into Flash to replace esp\_init\_data\_default.bin to use the new RF configuration.

 esp_init_data_setting.bin	8/7/2015 1:45 PM	VLC media file (....	1 KB
 ESP8266_RF_init.xls	5/7/2015 5:15 PM	Microsoft Excel ...	48 KB