Espressif IOT SDK User Manual

Version 1.4

Espressif Systems IOT Team

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1. Preambles

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

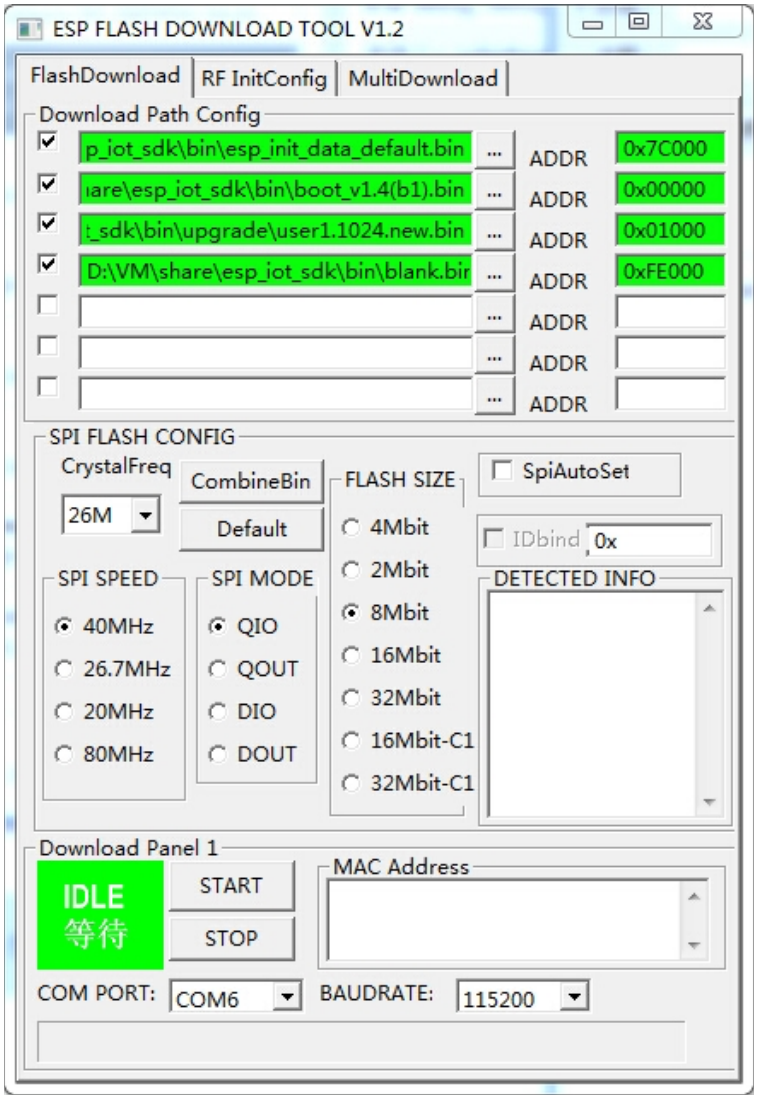
2.1. Download Tools: FLASH_DOWNLOAD_TOOLS

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.

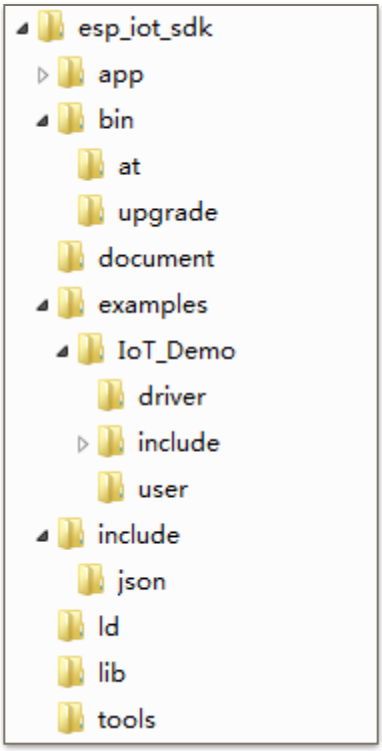
PS: Please disconnect the power when setting the jumper.

2.2. Serial Port Tool

The default baud rate of ESP8266 module is 74880.

3. SDK Software Package

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:



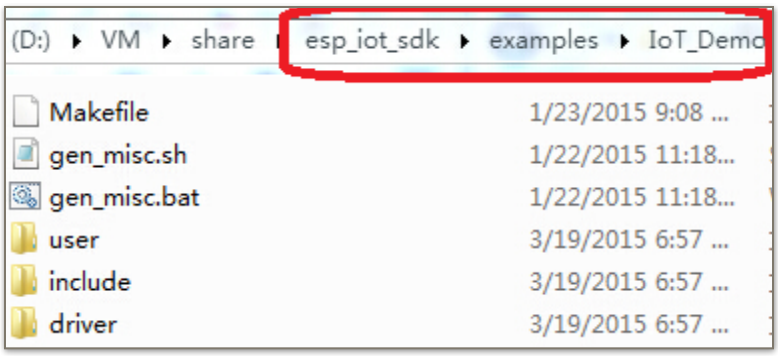
Detailed description:

- 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;

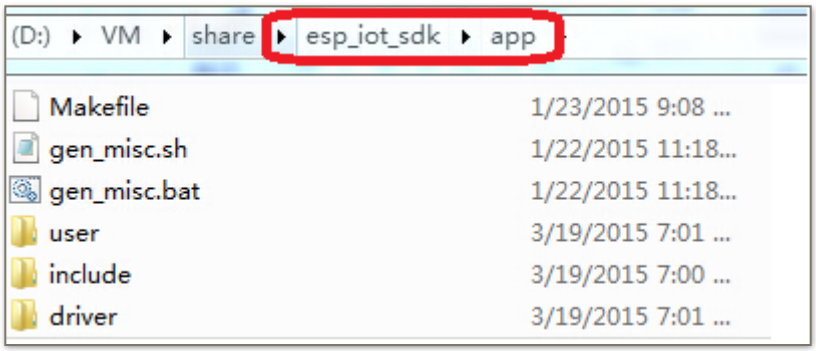
- "include" folder stores the header files pre-installed in the SDK, which may include relevant API functions and other macro definitions. Users can use them directly and do not need to change anything;
- "ld" folder stores the files needed for SDK software link. Users can use them directly and do not 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 `eagle.flash.bin` and `eagle.irom0text.bin`, don't support FOTA
STEP 2 : bin generated	
0	input 2 in STEP 1, generate `eagle.flash.bin` and `eagle.irom0text.bin`, don't support FOTA
1	input 0 or 1 in STEP 1, generate `user1.bin`, support FOTA
2	input 0 or 1 in STEP 1, generate `user2.bin`, 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

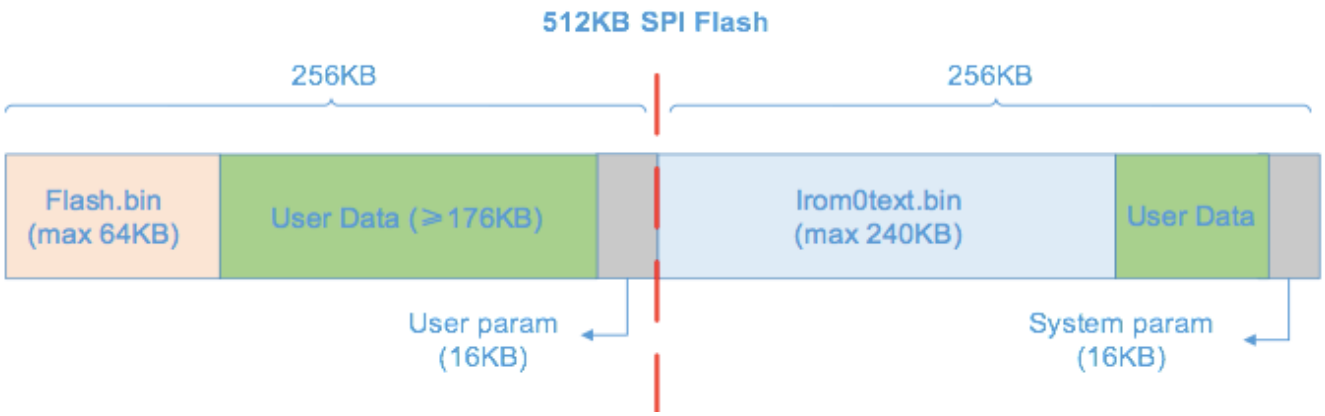
- System param (system parameter area) is always the last 16KB of flash.
- User param is the user parameter area used by Espressif demo code (IOT_Demo or AT). If users develop their own application, user data can be saved in any flash area available.
- User Data area (green area in pictures below) means 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

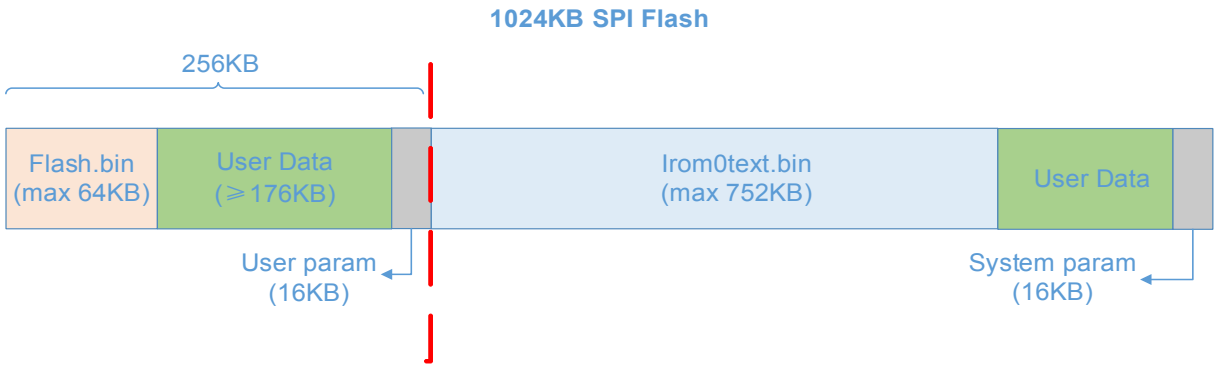


- User Data area: if program area (`flash.bin` and `irom0text.bin`) doesn't fill up flash, the remaining area can be used to store user data.
- `irom0text.bin` default to be less than 200KB ; for 512KB flash, user can revise ld file for compilation, to make the maximum size of `irom0text.bin` to be 256 – 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
  iram1_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

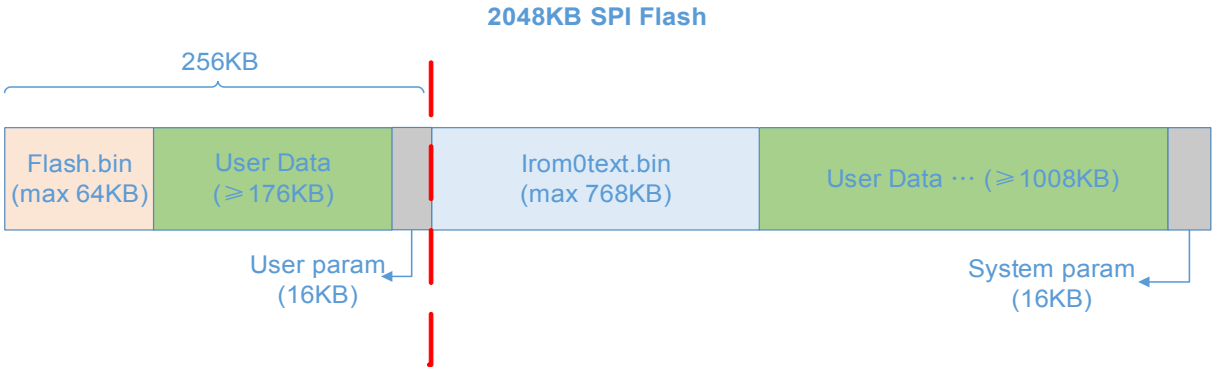


- User Data area: if program area (`flash.bin` and `irom0text.bin`) doesn't fill up flash, the remaining area can be used to store user data.
- `irom0text.bin` default to be less than 200KB ; for 1024KB flash, user can revise ld file for compilation, to make the maximum size of `irom0text.bin` to be 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
  iram1_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

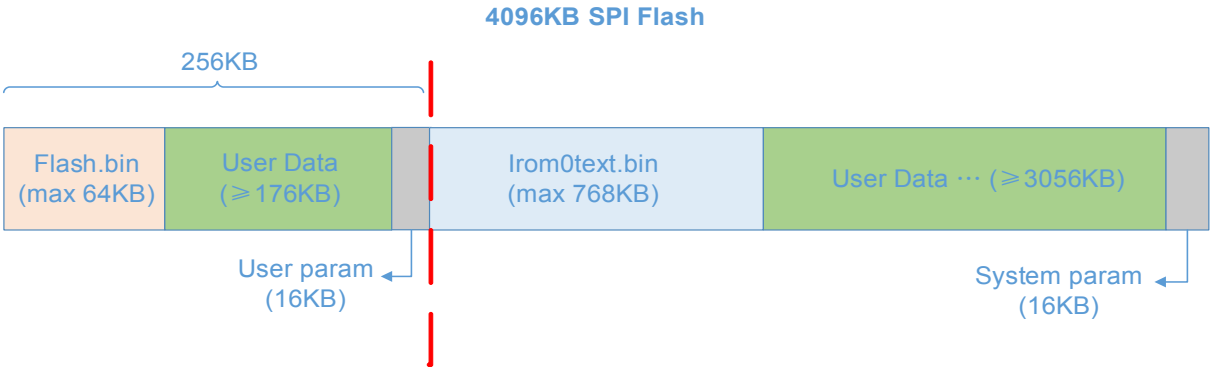


- User Data area: if program area (`flash.bin` and `irom0text.bin`) doesn't fill up flash, the remaining area can be used to store user data.
- `irom0text.bin` default to be less than 200KB ; Only the first 1024KB can be program area now, so for 2048KB flash, user can revise ld file for compilation, 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
  iram1_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
  iram1_0_seg :                   org = 0x40100000, len = 0x8000
  irom0_0_seg :                   org = 0x40240000, len = 0x32000
}
```

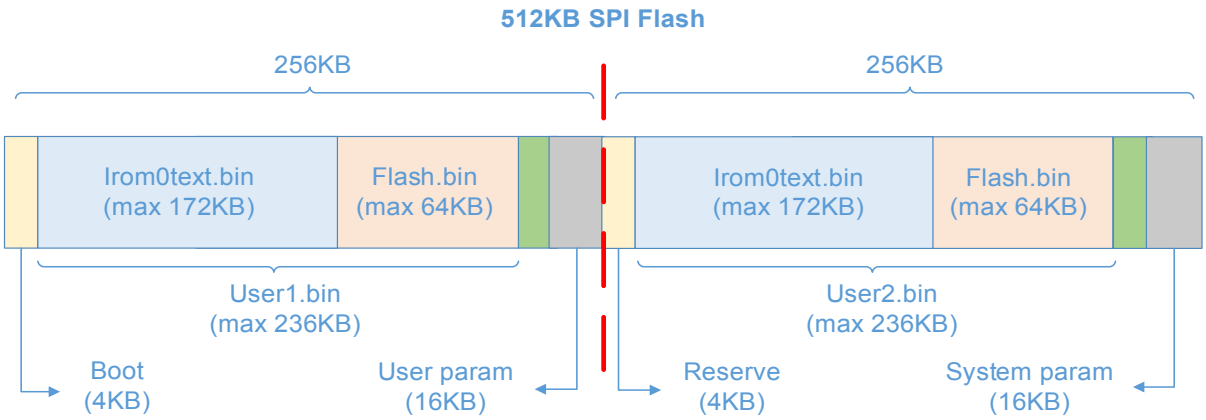
5.2. with boot - support upgrade through WiFi (FOTA)

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.

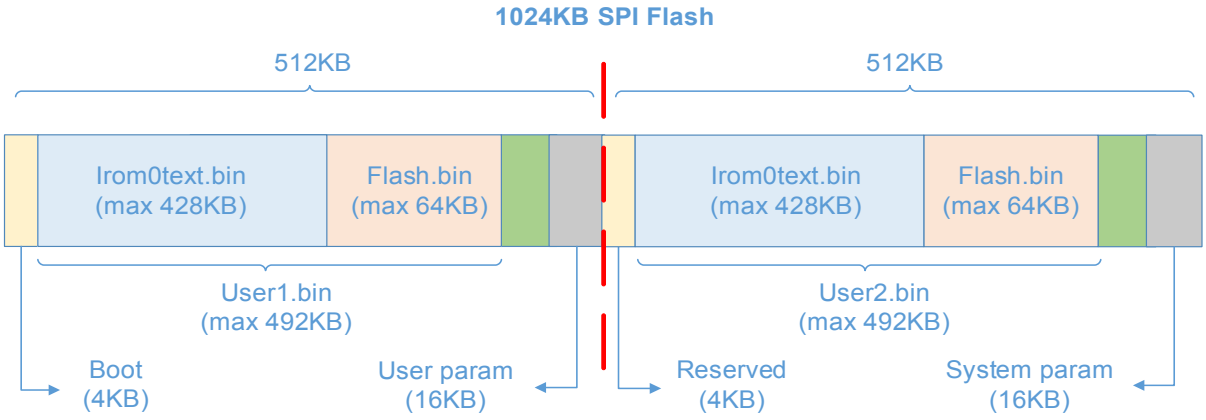
1. 512KB flash

If choose `1 boot_v1.2+` in `STEP 1`, choose `0 512KB` in `STEP 5`, flash map will be as below



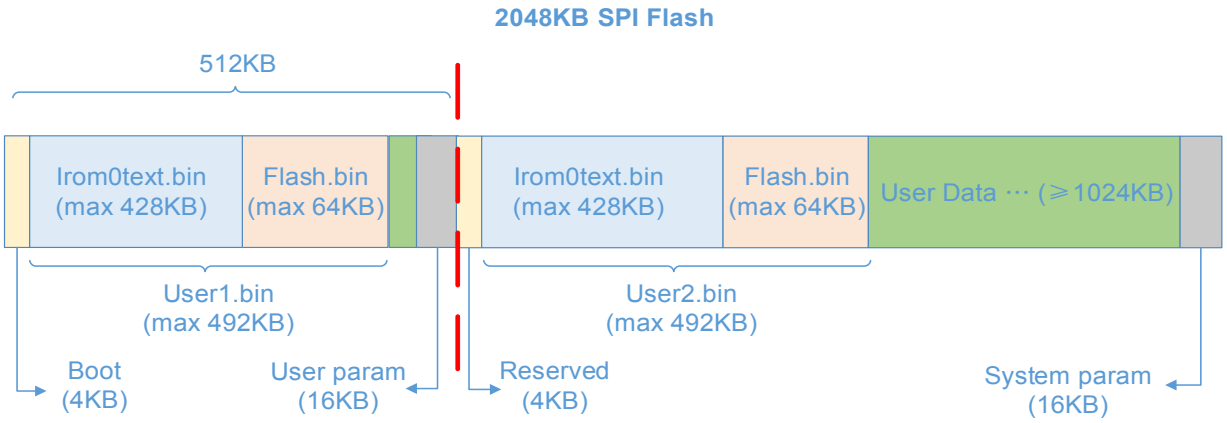
2. 1024KB flash

If choose `1 boot_v1.2+` in `STEP 1`, choose `2 1024KB` in `STEP 5`, flash map will be as below

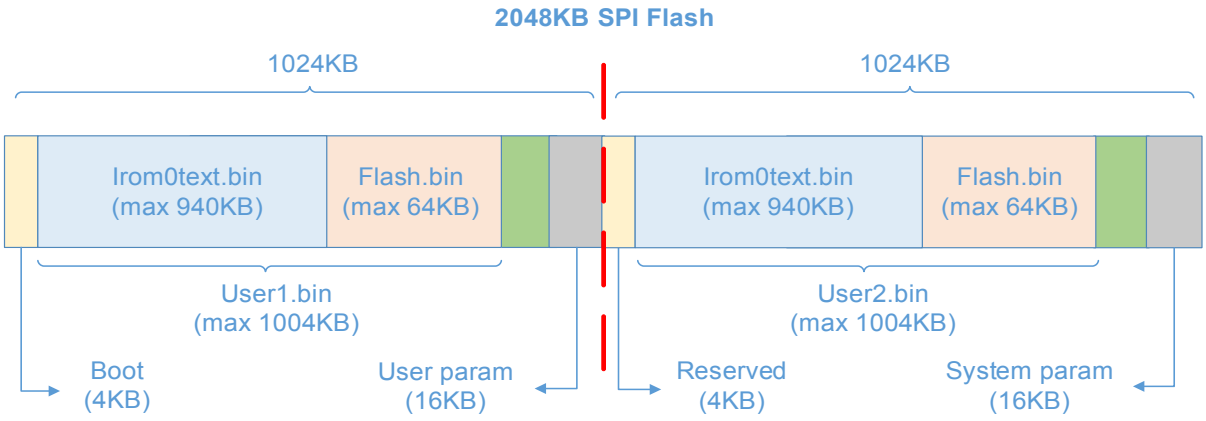


3. 2048KB flash

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

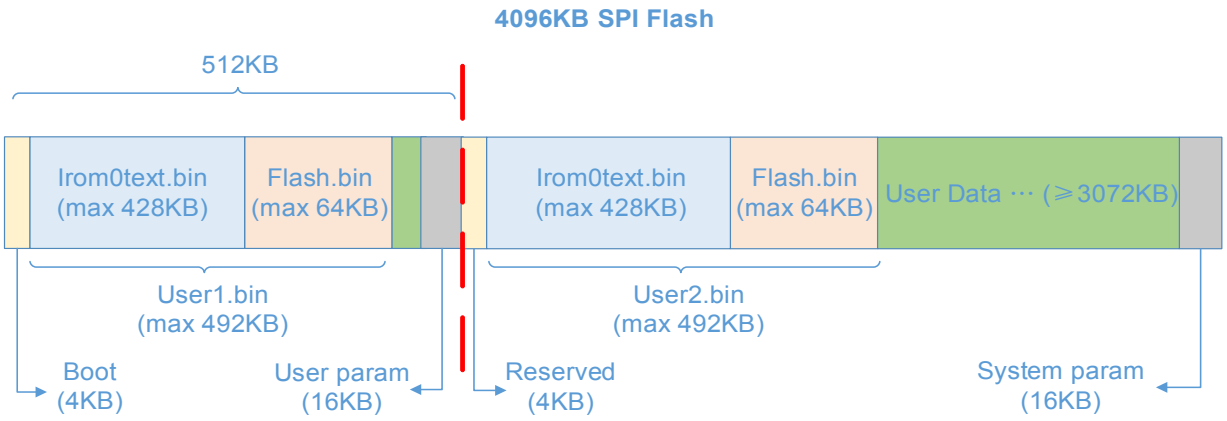


If choose `1 boot_v1.2+` in `STEP 1`, choose `5 2048KB` in `STEP 5` (only supported by sdk_v1.1.0 + boot v1.4 + flash download tool v1.2 and later version), the program area is 1024KB + 1024KB, and the flash map will be as below

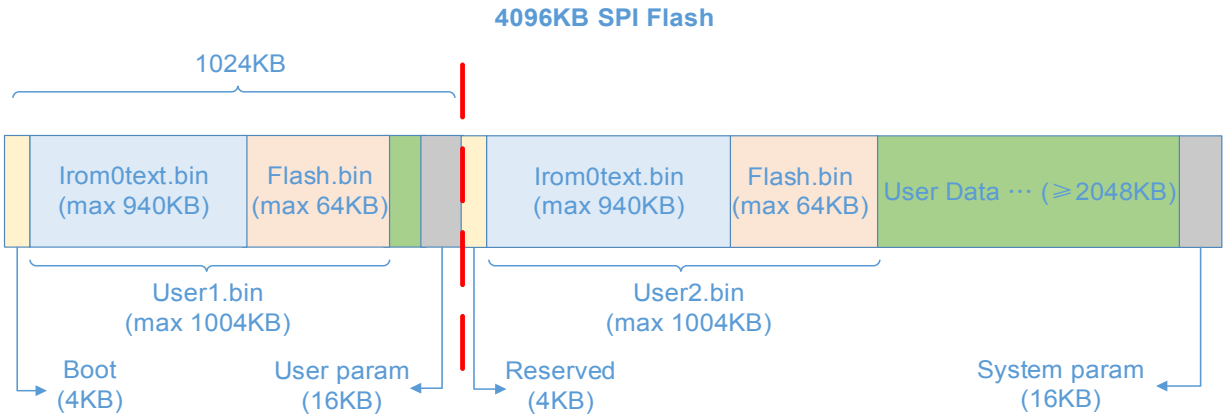


4. 4096KB flash

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;
- As for how to use 1MB or larger flash, please refer to BBS : http://bbs.espressif.com/viewtopic.php?f=10&t=305

6.1. Don't Support Cloud Update (FOTA)

1. 512KB Flash

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

2. 1024KB Flash

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

3. 2048KB Flash

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

4. 4096KB Flash

bin	Address	Description
master_device_key.bin	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service
esp_init_data_default.bin	0x3FC000	Stores default RF parameter values, provided in SDK
blank.bin	0x3FE000	Stores default system parameter values, provided in SDK
eagle.flash.bin	0x00000	Compiled by the steps described above
eagle.irom0text.bin	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
master_device_key.bin	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service
esp_init_data_default.bin	0x7C000	Stores default RF parameter values, provided in SDK
blank.bin	0x7E000	Stores default system parameter values, provided in SDK
boot.bin	0x00000	Boot loader, provided in SDK, we recommend users to use the latest version
user1.bin	0x01000	Compiled by the steps described above
user2.bin	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
master_device_key.bin	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 http://bbs.espressif.com/viewtopic.php?f=10&t=305
esp_init_data_default.bin	0xFC000	Stores default RF parameter values, provided in SDK
blank.bin	0xFE000	Stores default system parameter values, provided in SDK
boot.bin	0x00000	Boot loader, provided in SDK, we recommend you to use the latest version
user1.bin	0x01000	Compiled by the steps described above
user2.bin	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
master_device_key.bin	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 http://bbs.espressif.com/viewtopic.php?f=10&t=305 If choose 5 in STEP 5, change it to 0xFE000, and burn it into 0xFE000.
esp_init_data_default.bin	0x1FC000	Stores default RF parameter values, provided in SDK
blank.bin	0x1FE000	Stores default system parameter values, provided in SDK
boot.bin	0x00000	Boot loader, provided in SDK, we recommend you to use the latest version
user1.bin	0x01000	Compiled by the steps described above
user2.bin	0x81000	Compiled by the steps described above, need not to be burned into flash, can be download through WiFi as upgrade

4. 4096KB Flash

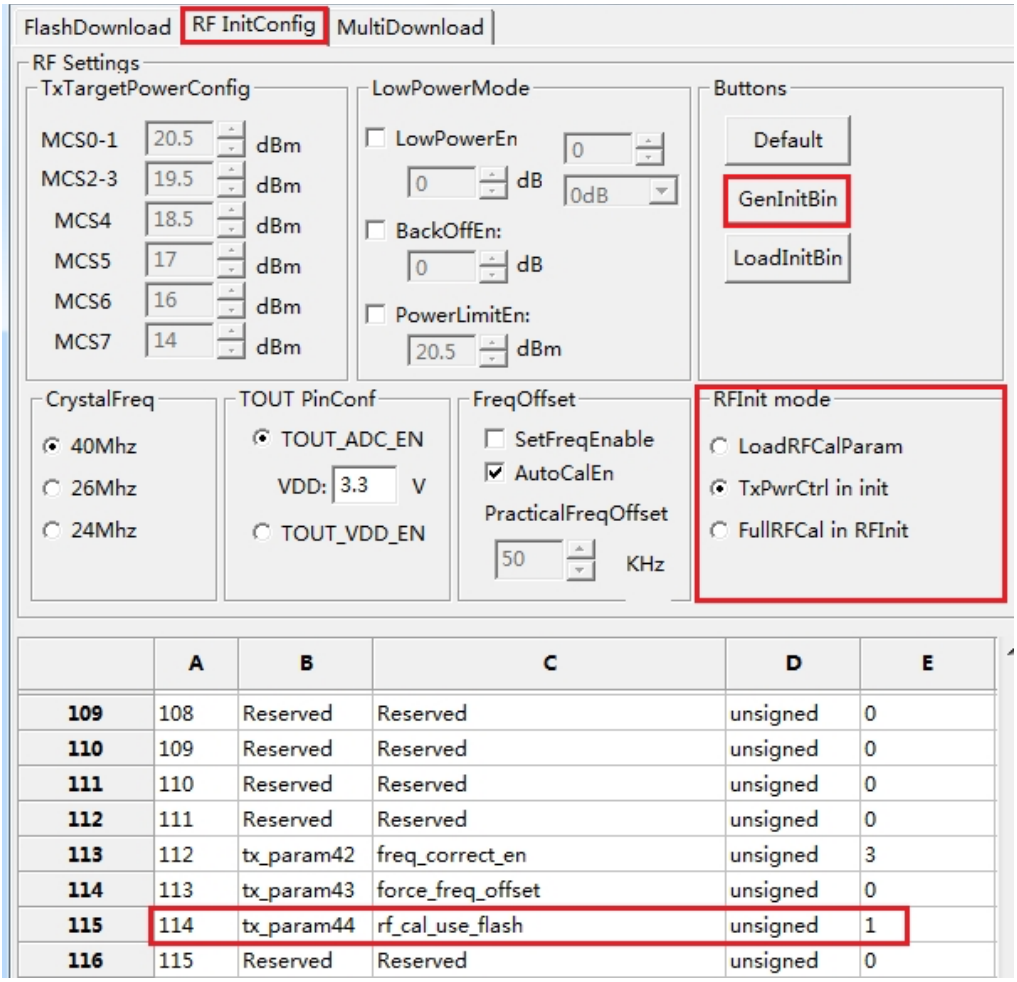
bin	Address	Description
master_device_key.bin	0x3E000	Obtained from Espressif Cloud by users themselves to get Espressif Cloud service; to be written into the third sector of flash user parameter area which is 0x3E000 in IOT_Demo, can be changed by user. If choose 4 in STEP 5, please change it to 0x7E000,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