



Rafael RT58x BLE SDK

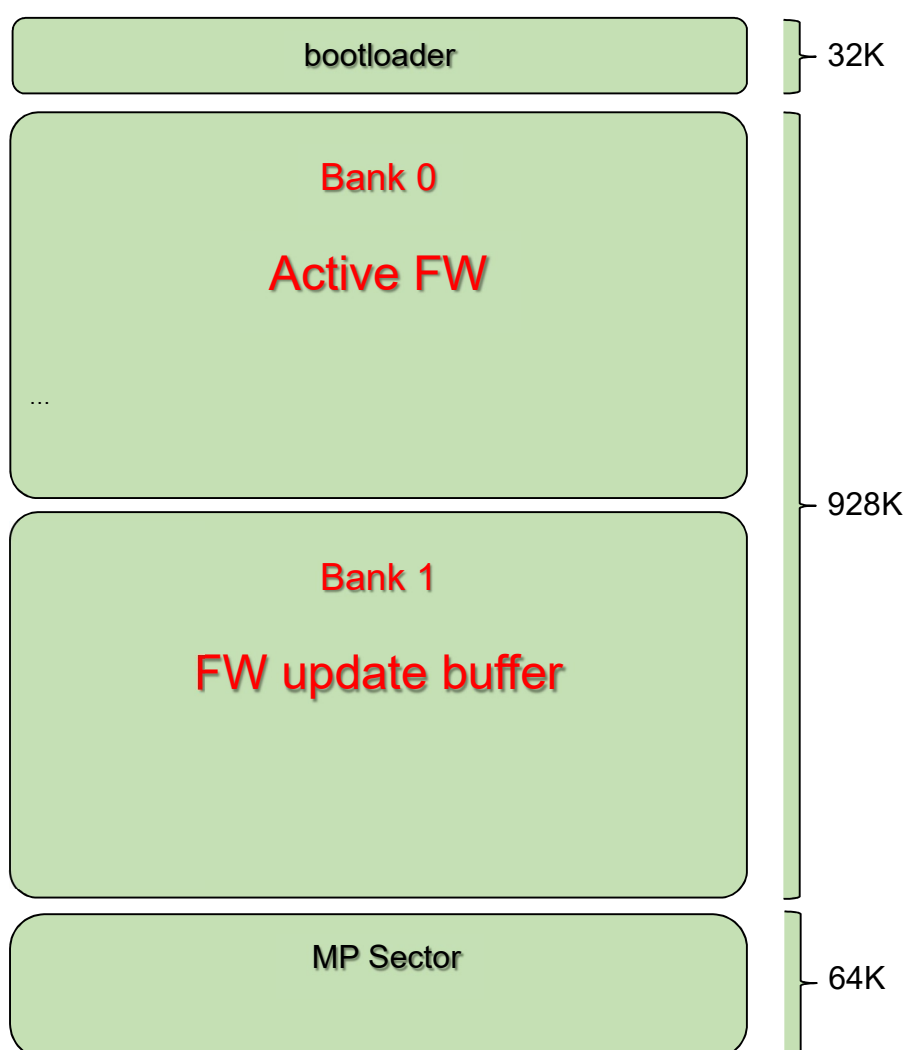
OTA Guide V1.3

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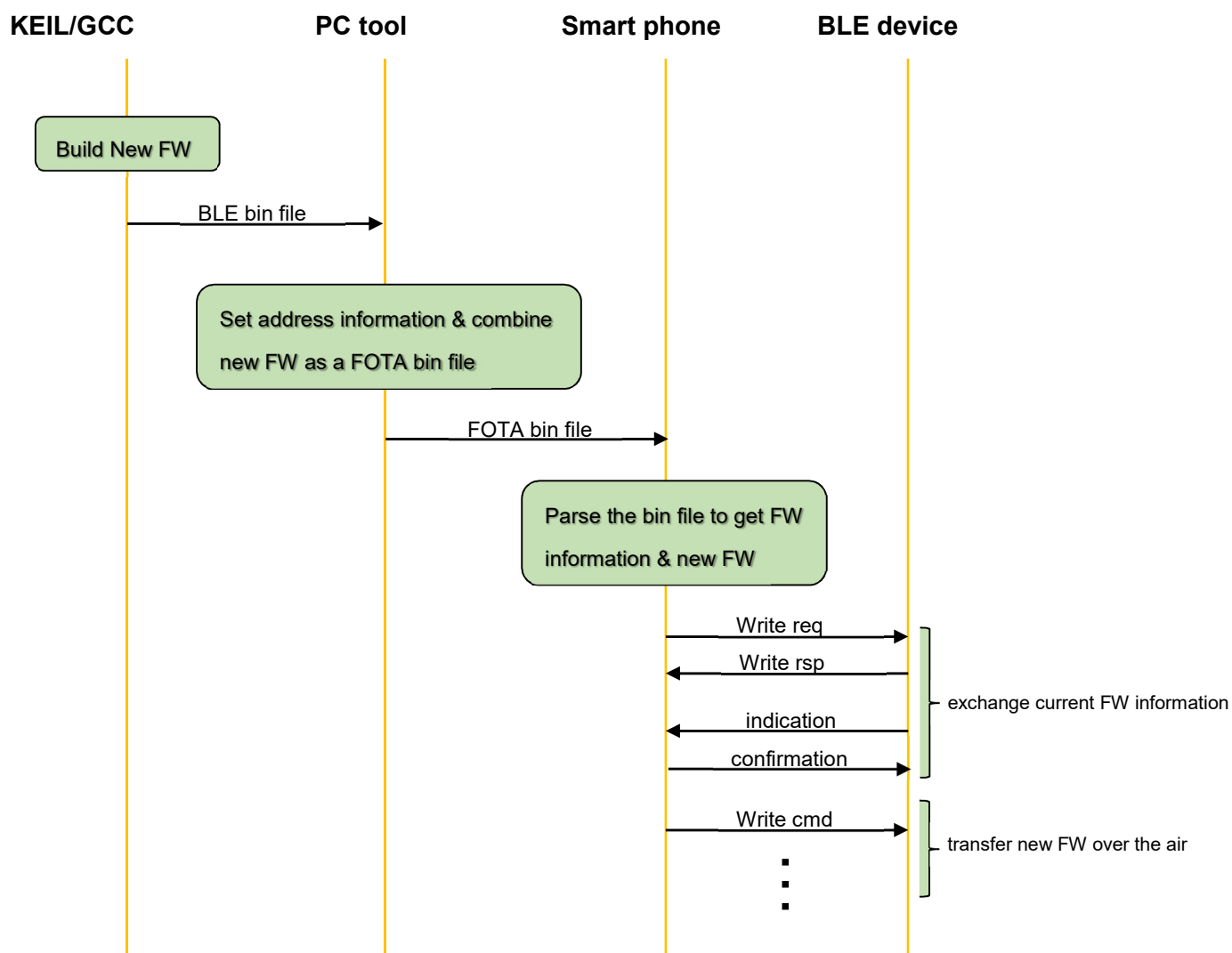
1. Overview

RT58x BLE SDK utilizes dual-bank flash to perform firmware over-the-air (FOTA) updates to ensure a valid image is activated. Bank 0 of the dual-bank flash is configured as an active FW block and Bank 1 is configured as the FW update buffer.



A complete FOTA update is accomplished via the following steps:

- Build new FW using KEIL/GCC.
- Use the PC tool to combine new FW and system information into a FOTA bin file.
- Load the FOTA bin file into smart phone and use the FOTA APP to parse the system information and FW.
- Query system information of the BLE device and make a decision whether or not to update the FW.



2. Running FOTA Update Demo

Confirm BLE device support the functionality of FOTA update, which means the bootloader & FOTA update service already programmed

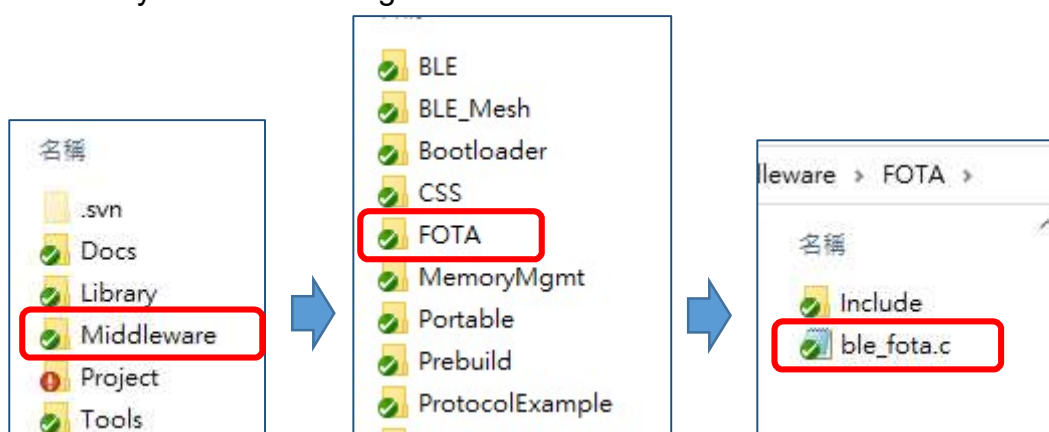
Build new **BLE bin** file with new BLE system information (ex: *FW version*)

Load new **BLE bin** file into the PC tool and key-in the address information. The PC tool will combine the info as a **FOTA bin** file

Use mobile app to query the current *FW version* of the BLE device and decode the *FW version* of the **FOTA bin** file to determine whether or not to perform an over-the-air update process

2.1 Build the BLE bin file with BLE System information

BLE System information is set by array systeminfo [] which is defined in “ble_fota.c” file with 16-byte maximum length.



```
const sys_information_t systeminfo =  
{  
    {"VerGet"},          /* Specific string for FOTA tool to search sy  
    {"sys ver 0001"}     /* An example of current system information,  
};
```

The string "VerGet" is defined for PC tool to search system information, in the code base should not appear second string like this.

2.2 Using the IOT Evaluation Tool to Get FOTA bin File

After open the IOT evaluation tool, click the icon "FOTA" to go to the page "FOTA update tool".



In FOTA update tool, follows these steps to get FOTA bin file

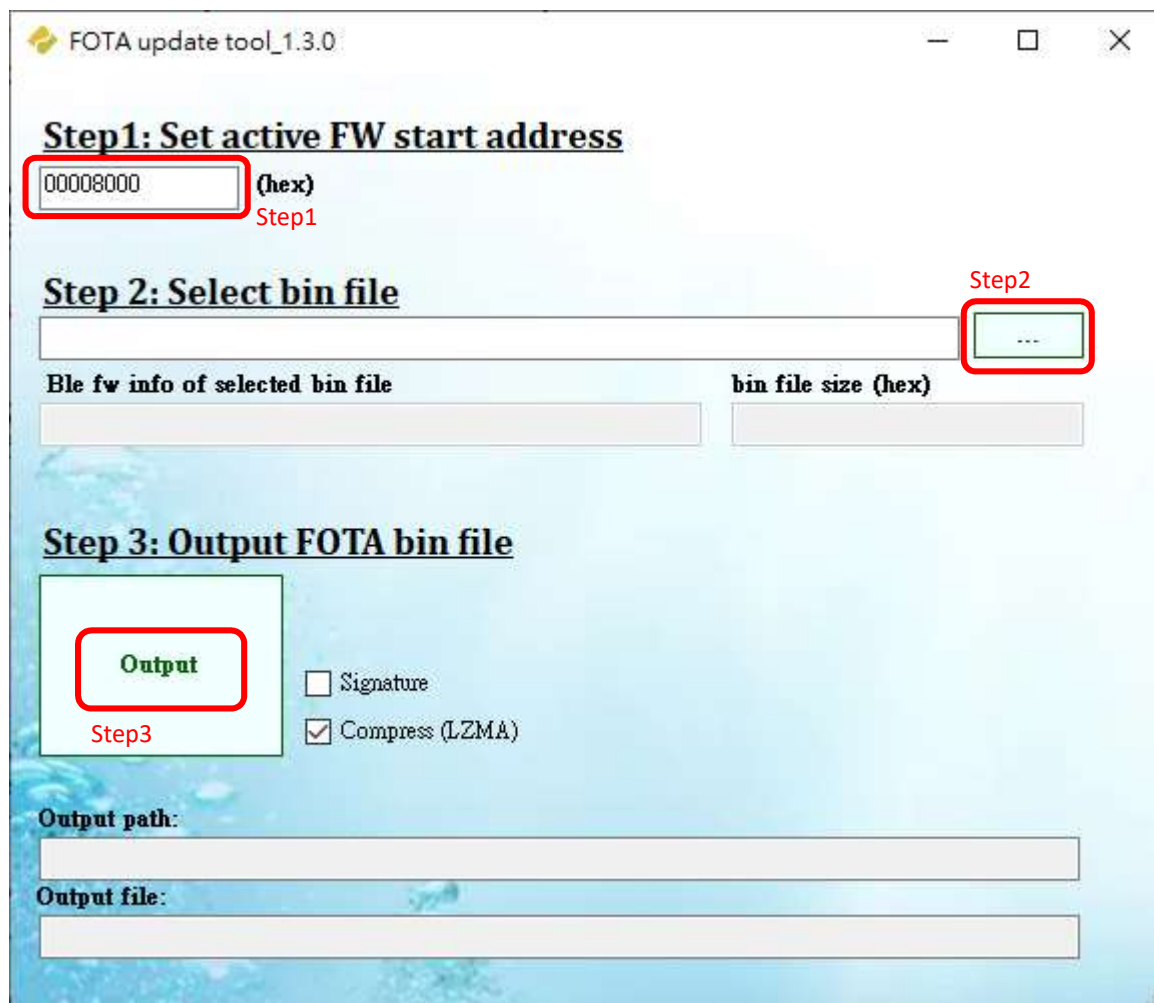
2.2.1 Normal Mode

Step 1: Set active FW start address, default value is 0x8000, Usually, user don't have to change the value.

Step 2: Select the bin file that already built by KEIL/GCC.

Step 3: Click the "Output" button to output a new FOTA bin file.

[Note that after SDK version 1.3.0, it is recommended to check the "Compress(LZMA)" option.]



The screenshot shows the 'FOTA update tool_1.3.0' window. It is divided into three main sections:

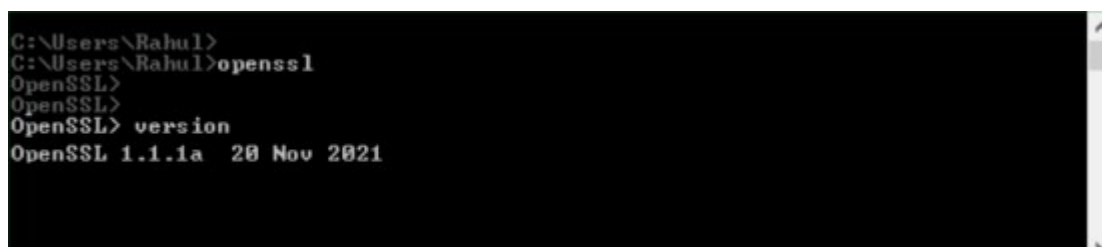
- Step 1: Set active FW start address**: A text box contains '00008000' with '(hex)' to its right. A red box highlights the text box, and 'Step1' is written in red below it.
- Step 2: Select bin file**: A file selection field is shown with a red box around the '...' button. 'Step2' is written in red above the button. Below this are two fields: 'Ble fw info of selected bin file' and 'bin file size (hex)', both currently empty.
- Step 3: Output FOTA bin file**: A green 'Output' button is highlighted with a red box, with 'Step3' written in red below it. To the right of the button are two checkboxes: 'Signature' (unchecked) and 'Compress (LZMA)' (checked). Below these are two more fields: 'Output path:' and 'Output file:', both currently empty.

2.2.2 Security Boot Mode

OpenSSL is an open-source command line tool that is commonly used to generate private keys, create CSRs, install your SSL/TLS certificate, and identify certificate information. Security Boot option is a quick way to implement these function with openssl.exe. This user guide will help you understand the most common OpenSSL commands and how to use them. Security Boot option is created with c sharp and will generate ECDSA digital signature and verify signature by this software, the following third-party packages are required:

<https://www.microsoft.com/en-us/download/confirmation.aspx?id=30679>

- Download OpenSSL Binary
 - i. Download the latest OpenSSL windows installer file. Click the below link to visit OpenSSL download page:
<http://slproweb.com/products/Win32OpenSSL.html>
 - ii. Open a command prompt on your system and type “openssl” to open OpenSSL prompt. After that type version to get the installed OpenSSL version on your system (as shown in Figure 2.1).

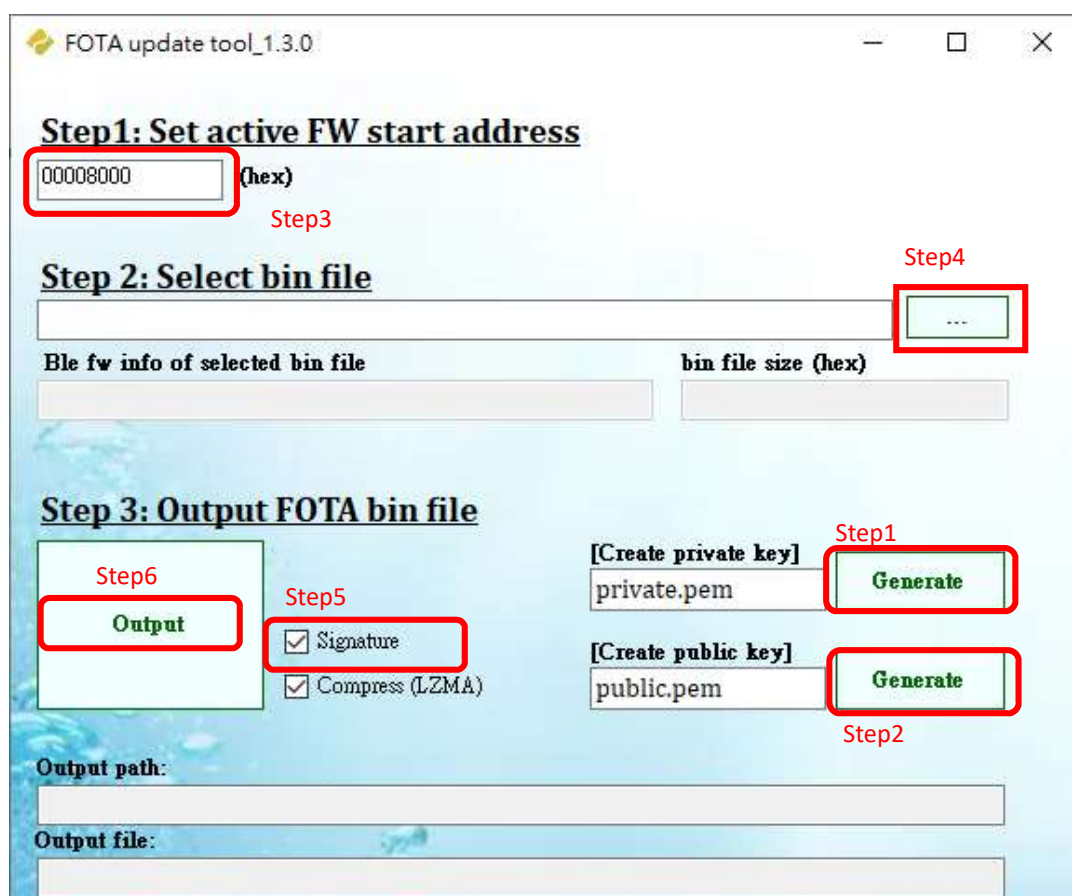


```

C:\Users\Rahul>
C:\Users\Rahul>openssl
OpenSSL>
OpenSSL>
OpenSSL> version
OpenSSL 1.1.1a  20 Nov 2021
  
```

Figure 2.1 OpenSSL version

- Using SHA-256 Algorithm with ECDSA
 - i. Elliptic Curve Digital Signature Algorithm, or ECDSA, is one of the more complex public key cryptography encryption algorithms. ECDSA is used for asymmetric encryption and decryption, as well as for signing and verifying. ECDSA provides the same level of security as RSA but it does so while using much shorter key lengths. Therefore, for longer keys, ECDSA will take considerably more time to crack through brute-forcing attacks.
 - ii. Advantages of using ECDSA to RSA:
 - ECDSA requires much shorter keys to provide the same level of security.
 - ECDSA has quick process of signing and verification.
 - ECDSA has much better performance compared to RSA by shorter key lengths
 - ECDSA is in compliance with the modern requirements of industry.
- Tool architecture



FOTA update tool_1.3.0

Step1: Set active FW start address
 (hex) Step3

Step 2: Select bin file Step4

Ble fw info of selected bin file **bin file size (hex)**

Step 3: Output FOTA bin file

Step6 Step5

☒ Signature ☒ Compress (LZMA)

[Create private key] Step1

[Create public key] Step2

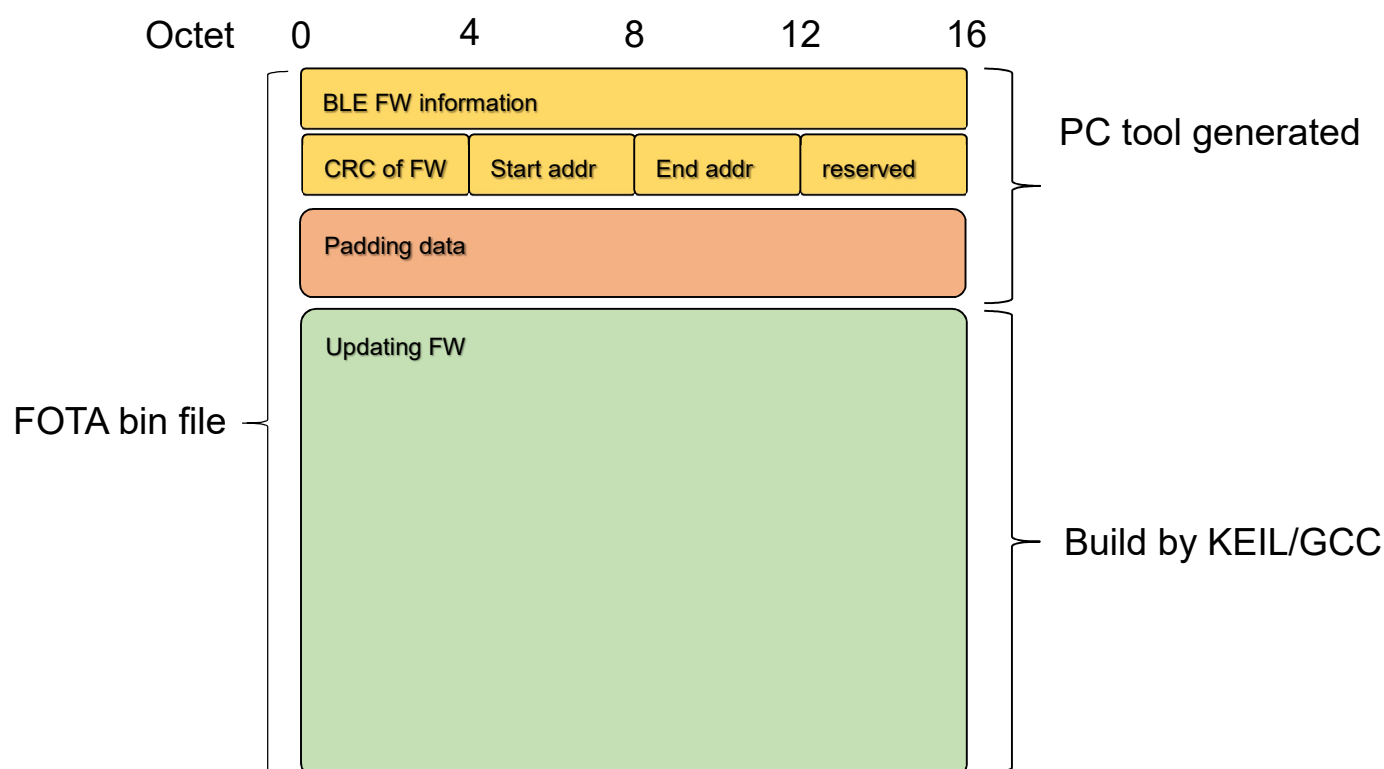
Output path:

Output file:

Figure 2.2 Security Boot Tool architecture

- i. Figure 2.2 draws the Security Boot architecture diagram. Following step-by-step instructions, users can easily operate Security Boot.
- ii. Generate Public and Private Keys with openssl.exe.
 Step 1: Type in private key filename such as "private.pem" and click "GENERATE" button to generate private key.
 Step 2: Proceed to the next step, type in public key filename such as "public.pem" and click "GENERATE" button to generate public key. Meanwhile, tool also will generate an output file named "public.der", which is a public key certificate in .der format with OpenSSL.
- iii. Generate and verify a signature with openssl.exe.
 Step 3: Set active FW start address, default value is 0x8000, Usually, user don't have to change the value. When selecting "bootloader.bin", this value will be ignored
 Step 4: Select digest of document to sign, such as "bootloader.bin".
 Step 5: Check the "signature" option.
 Step 6: Pressing "Output" button, tool will parse the data of signature and write to end of file and output the file location information in "Output path" and "Output file".
 [Note that the "bootloader.bin" file cannot check the "Compress(LZMA)" option.]

PC tool generates 32byte of information. The information is saved to the front of FOTA bin file. PC tool also insert padding data behind the information. Padding data size equals to “active FW start address”, default is 0x8000. Updating FW is allocated after padding data.



2.2.3 Complete Steps To Operate Security Boot Mode

The following is an operation example:

We have prepared 3 files:

Index	bin file name	generate tools	Remark
1	bootloader.bin	KEIL or GCC	bootloader
2	TRSP_FOTA_Periph_0001.bin	KEIL or GCC	Application bin case 1
3	TRSP_FOTA_Periph_0002.bin	KEIL or GCC	Application bin case 2

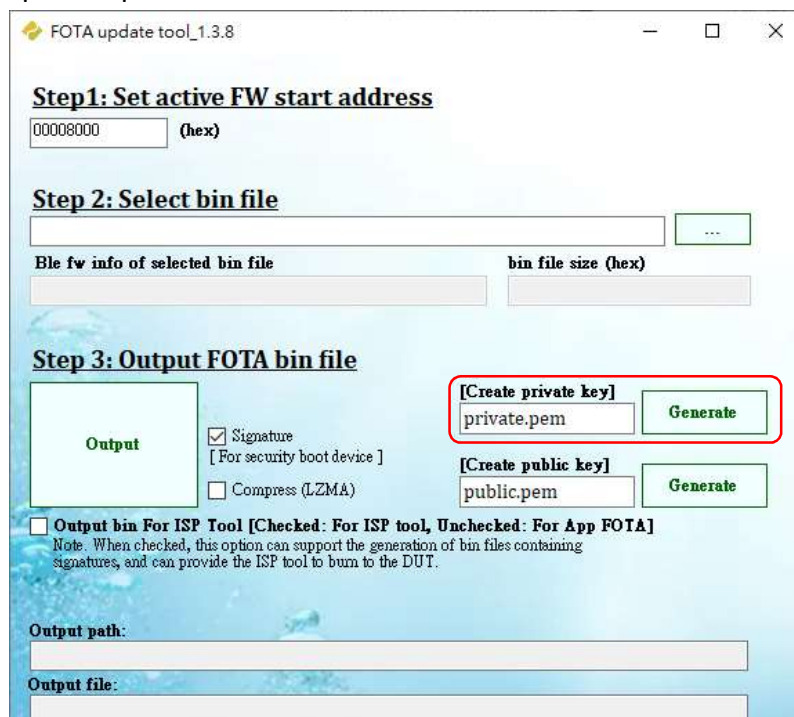
We need to generate the following files through the FOTA tool.

Index	bin file name	generate tools	Remark
4	private.pem	FOTA	Private Key

5	public.pem	FOTA	Public Key
6	bootloader_Signature.bin	FOTA	Bootloader bin containing the signature is provided to the ISP tool.
7	TRSP_FOTA_Periph_0001_Signature_ISP.bin	FOTA	Application bin case 1 containing the signature is provided to the ISP tool.
8	TRSP_FOTA_Periph_0001_Signature_FOTA.bin	FOTA	Application bin case 1 contains the signature bin and is provided to APP do
9	TRSP_FOTA_Periph_0002_Signature_FOTA.bin	FOTA	Application bin case 2 contains the signature bin and is provided to the App for FOTA use.

Please note that before generating Index 6 to 9 files, you must first generate "private.pem" and "public.pem" files [the two file locations are in the same folder as the executable program IoT_EVALUATION_TOOL.exe].

- **Index 4.** Generate "private.pem" file



FOTA update tool_1.3.8

Step 1: Set active FW start address
 (hex)

Step 2: Select bin file
 ...
 Ble fw info of selected bin file bin file size (hex)

Step 3: Output FOTA bin file

Output

☒ Signature [For security boot device]
☐ Compress (LZMA)

[Create private key]
 Generate

[Create public key]
 Generate

☐ **Output bin For ISP Tool** [Checked: For ISP tool, Unchecked: For App FOTA]
 Note: When checked, this option can support the generation of bin files containing signatures, and can provide the ISP tool to burn to the DUT.

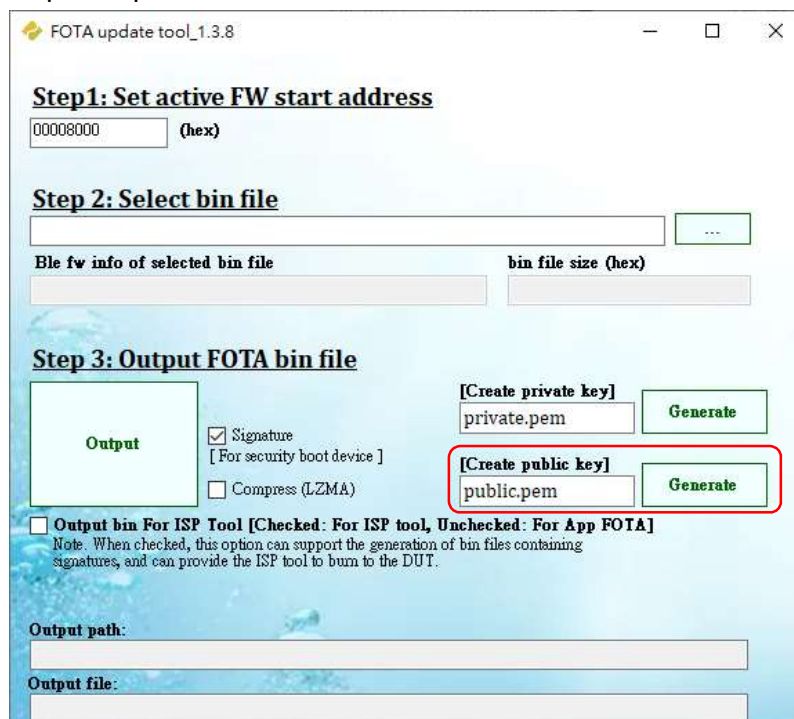
Output path:

Output file:

After clicking "Generate", you will see the private.pem file in the folder [same path as the

executable program].

- **Index 5.** Generate “public.pem” file



FOTA update tool_1.3.8

Step 1: Set active FW start address
 (hex)

Step 2: Select bin file
 ...

Ble fw info of selected bin file **bin file size (hex)**

Step 3: Output FOTA bin file

Output ☒ Signature [For security boot device]
☐ Compress (LZMA)

[Create private key]
 Generate

[Create public key]
 Generate

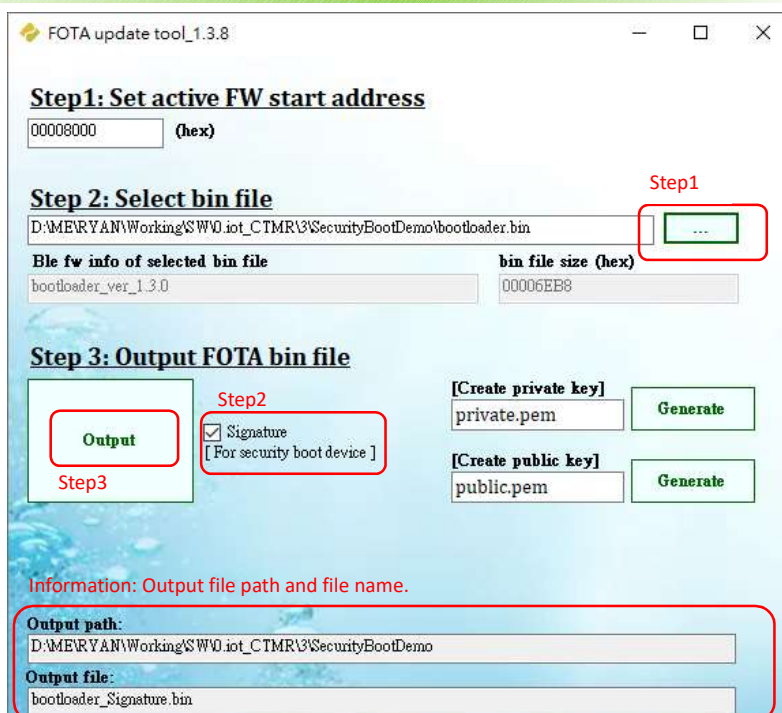
☐ **Output bin For ISP Tool** [Checked: For ISP tool, Unchecked: For App FOTA]
 Note. When checked, this option can support the generation of bin files containing signatures, and can provide the ISP tool to burn to the DUT.

Output path:

Output file:

After clicking "Generate", you will see the private.pem file in the folder [same path as the executable program].

- **Index 6.** Generate “bootloader_Signature.bin” file



FOTA update tool_1.3.8

Step1: Set active FW start address
 (hex)

Step 2: Select bin file
 ... Step1

Ble fw info of selected bin file
 bootloader_ver_1.3.0

bin file size (hex)
 00006EB8

Step 3: Output FOTA bin file

Output Step3

☒ **Signature**
 [For security boot device] Step2

☐ **Compress (LZMA)**

[Create private key]
 Generate

[Create public key]
 Generate

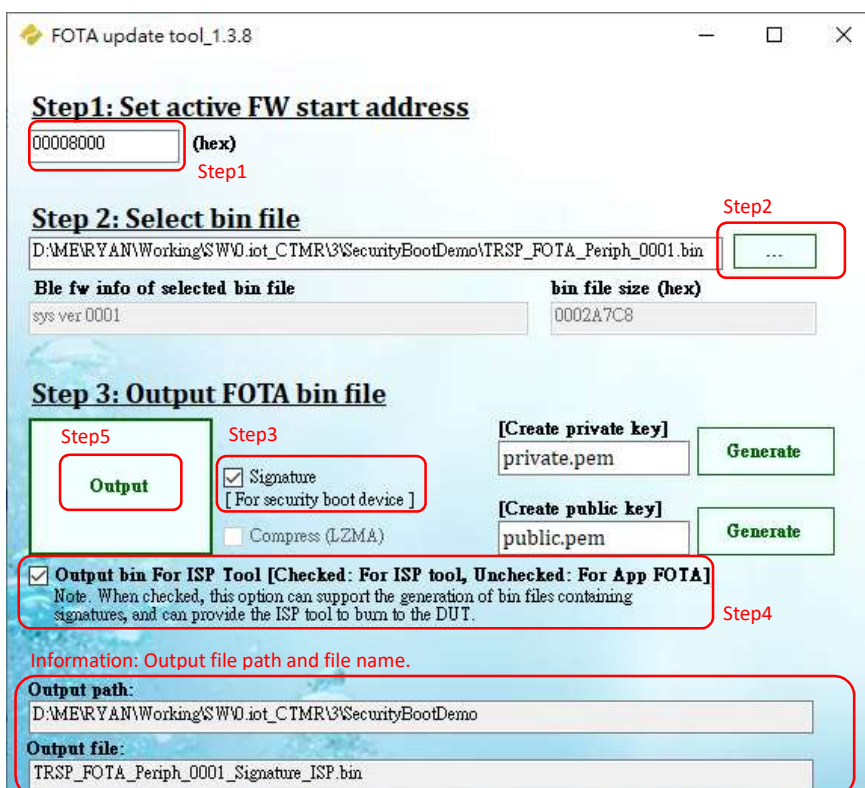
Information: Output file path and file name.

Output path:

Output file:

This file contains the signature bootloader.bin, which is required for security mode.

- **Index 7.** Generate "TRSP_FOTA_Periph_0001_Signature_ISP.bin" file



FOTA update tool_1.3.8

Step1: Set active FW start address
 (hex) Step1

Step 2: Select bin file
 ... Step2

Ble fw info of selected bin file
 sys ver 0001

bin file size (hex)
 0002A7C8

Step 3: Output FOTA bin file

Output Step5

☒ **Signature**
 [For security boot device] Step3

☐ **Compress (LZMA)**

[Create private key]
 Generate

[Create public key]
 Generate

☒ **Output bin For ISP Tool [Checked: For ISP tool, Unchecked: For App FOTA]**
 Note: When checked, this option can support the generation of bin files containing signatures, and can provide the ISP tool to burn to the DUT. Step4

Information: Output file path and file name.

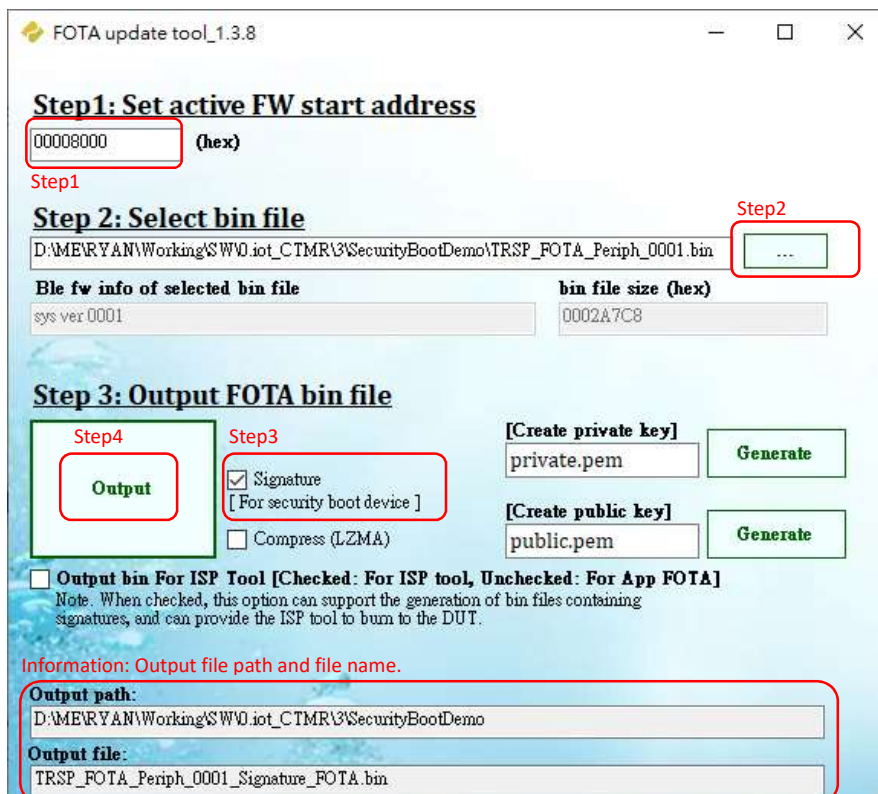
Output path:

Output file:

Please note that in Step 3, this application bin file must have "Signature" checked.

Please note that in Step 4 this application bin file must have "Output bin For ISP Tool" **checked**.

- **Index 8.** Generate "TRSP_FOTA_Periph_0001_Signature_FOTA.bin" file



FOTA update tool_1.3.8

Step1: Set active FW start address
 (hex)

Step2: Select bin file

Ble fw info of selected bin file
 sys ver 0001

bin file size (hex)

Step3: Output FOTA bin file

Step4:

Step3: ☒ Signature [For security boot device]
☐ Compress (LZMA)

[Create private key]

[Create public key]

☐ **Output bin For ISP Tool** [Checked: For ISP tool, Unchecked: For App FOTA]
 Note: When checked, this option can support the generation of bin files containing signatures, and can provide the ISP tool to burn to the DUT.

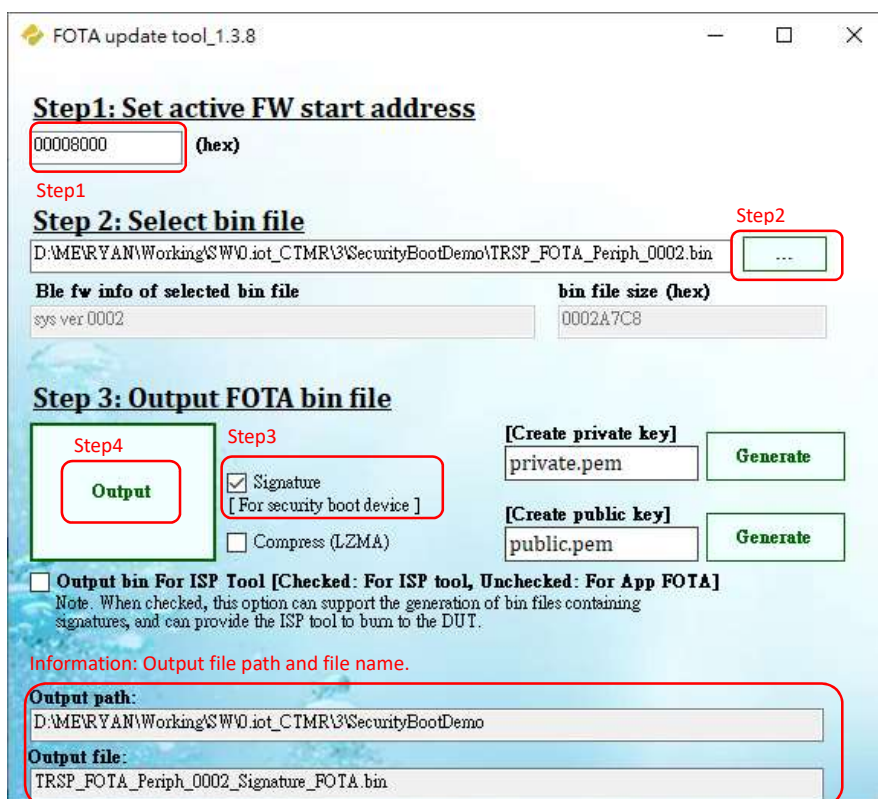
Information: Output file path and file name.

Output path:

Output file:

Please note that in Step 3, this application bin file must have "Signature" **checked**.

- **Index 9.** Generate "TRSP_FOTA_Periph_0002_Signature_FOTA.bin" file



FOTA update tool_1.3.8

Step1: Set active FW start address
 (hex)

Step2: Select bin file

Ble fw info of selected bin file
 sys ver: 0002

bin file size (hex)

Step3: Output FOTA bin file

Step4: Output

Step3:
☒ Signature [For security boot device]
☐ Compress (LZMA)

[Create private key]

[Create public key]

☐ **Output bin For ISP Tool** [Checked: For ISP tool, Unchecked: For App FOTA]
 Note: When checked, this option can support the generation of bin files containing signatures, and can provide the ISP tool to burn to the DUT.

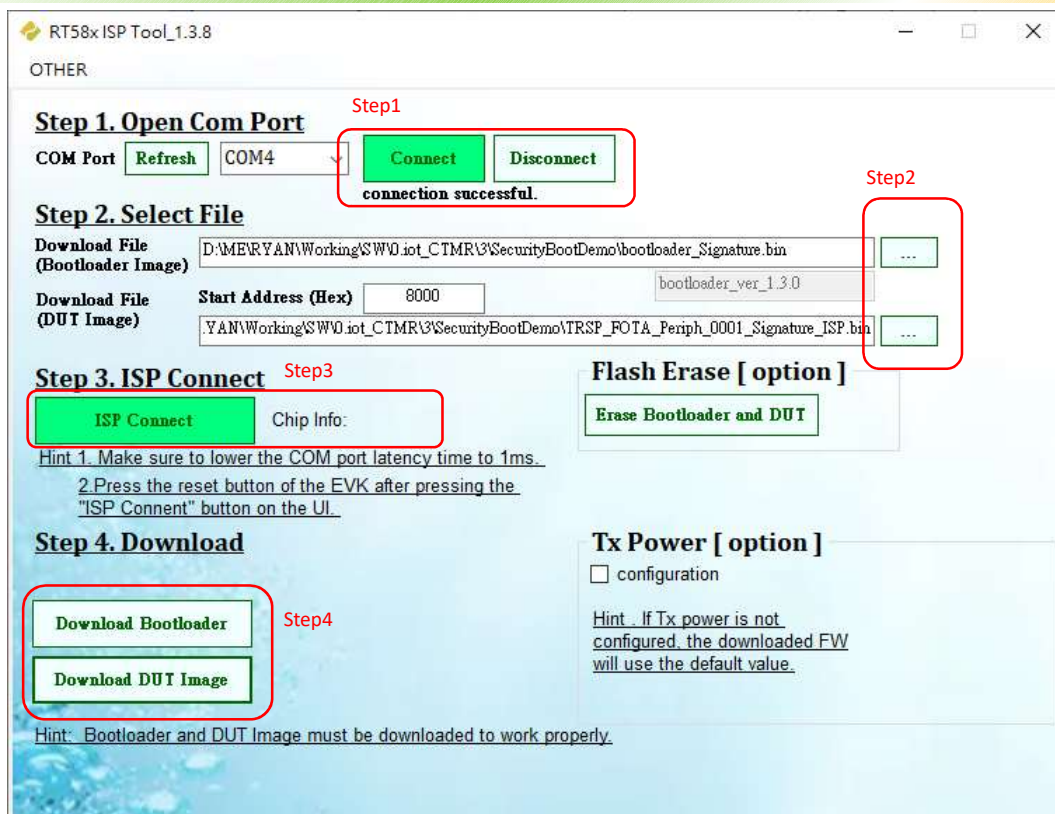
Information: Output file path and file name.

Output path:

Output file:

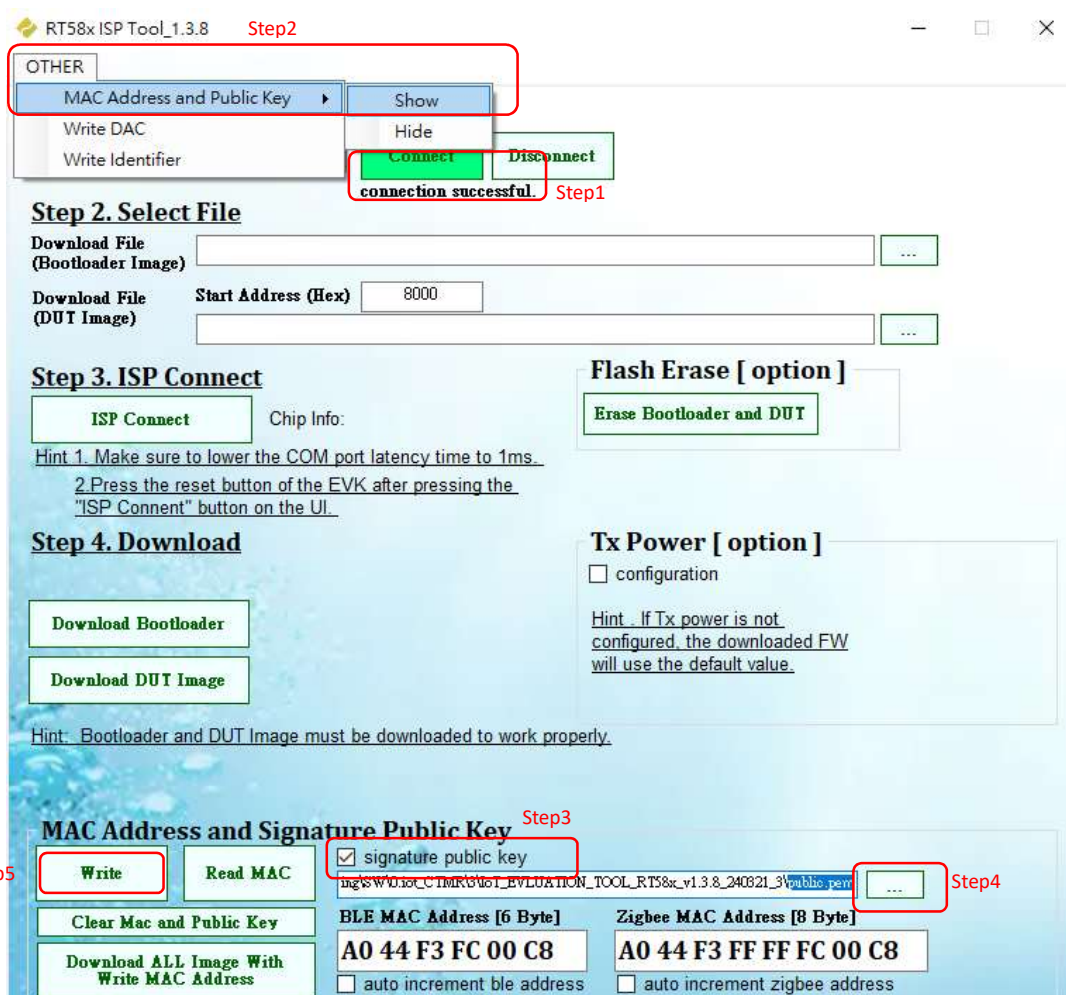
Please note that in Step 3, this application bin file must have "Signature" **checked**.

- Let the DUT work in Security mode.
 1. Download "bootloader_Signature.bin" and "TRSP_FOTA_Periph_0001_Signature_ISP.bin" to the DUT using the ISP tool.



These steps are the same as for standard ISP downloads, just make sure the file you choose contains a signature.

2. Write "public.pem" to the DUT's security page.



RT58x ISP Tool_1.3.8 Step2

OTHER

MAC Address and Public Key ▸ Show Hide

Write DAC

Write Identifier

Connect Disconnect

connection successful Step1

Step 2. Select File

Download File (Bootloader Image) ...

Download File (DUT Image) Start Address (Hex) 8000 ...

Step 3. ISP Connect

ISP Connect Chip Info:

Flash Erase [option]

Erase Bootloader and DUT

Hint 1. Make sure to lower the COM port latency time to 1ms.

2. Press the reset button of the EVK after pressing the "ISP Connect" button on the UI.

Step 4. Download

Download Bootloader

Download DUT Image

Hint: Bootloader and DUT Image must be downloaded to work properly.

MAC Address and Signature Public Key

Step3

signature public key

Step4

Step5

Write Read MAC

Clear Mac and Public Key

Download ALL Image With Write MAC Address

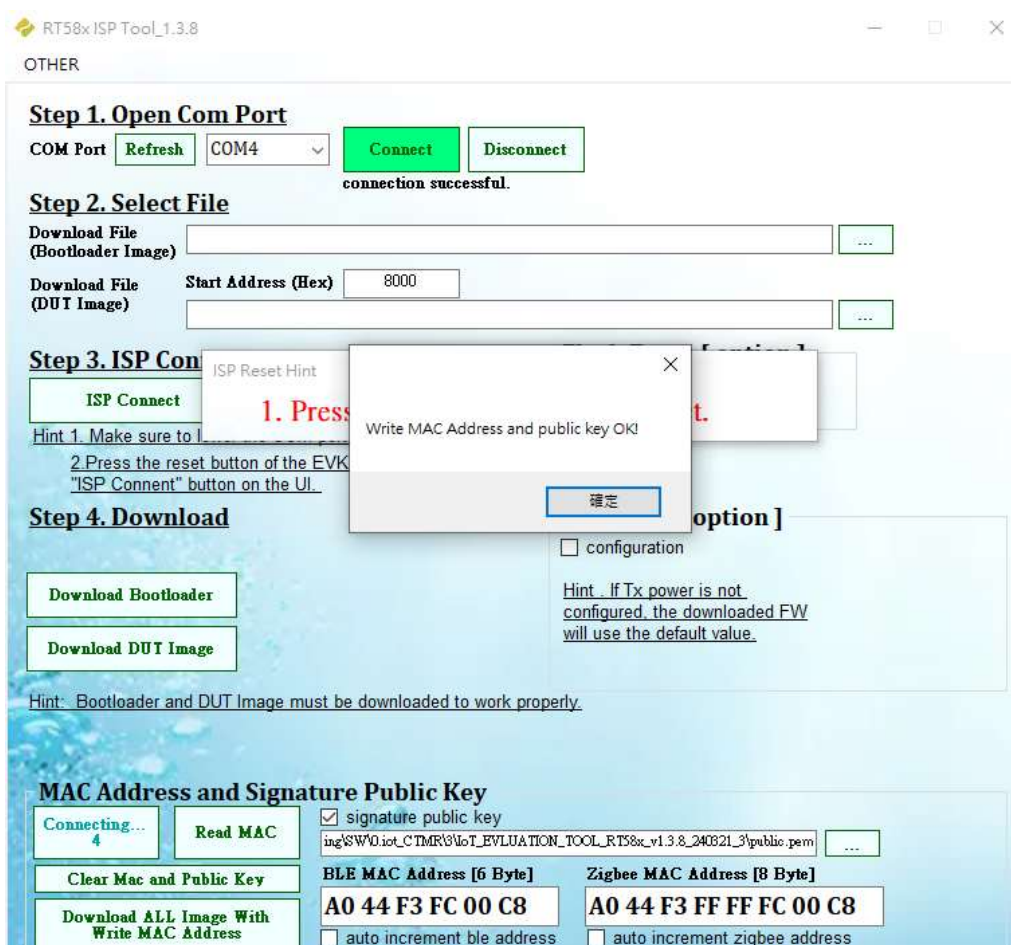
BLE MAC Address [6 Byte] A0 44 F3 FC 00 C8

Zigbee MAC Address [8 Byte] A0 44 F3 FF FF FC 00 C8

auto increment ble address auto increment zigbee address

This step is very important. When the user writes the correct public key[public.pem] into the security page in this way, the DUT will enter the security mode and check whether the public key is correct every time it is restarted.

Please note that in step 5, when you press the Write button, you must press the reset button of the DUT within 7 seconds to enter the ISP connect mode. When entering this mode, the public key will be written. If the writing is successful, "write MAC address and public key OK" will be displayed. As shown below.

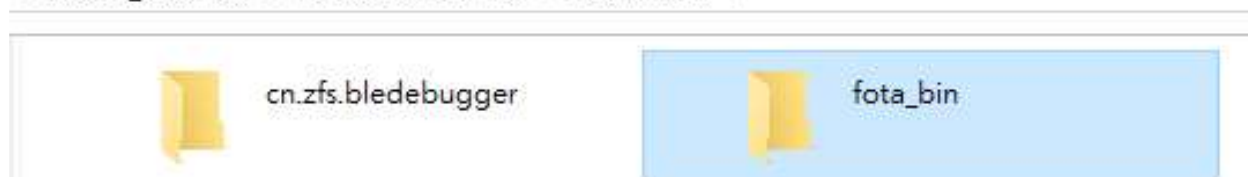


At this point, the DUT has completed security mode setting. You can use the FOTA function of the APP to transfer TRSP_FOTA_Periph_0002_Signature_FOTA.bin to the DUT, and it should be updated successfully. If you send a bin file without a signature, the update will fail.

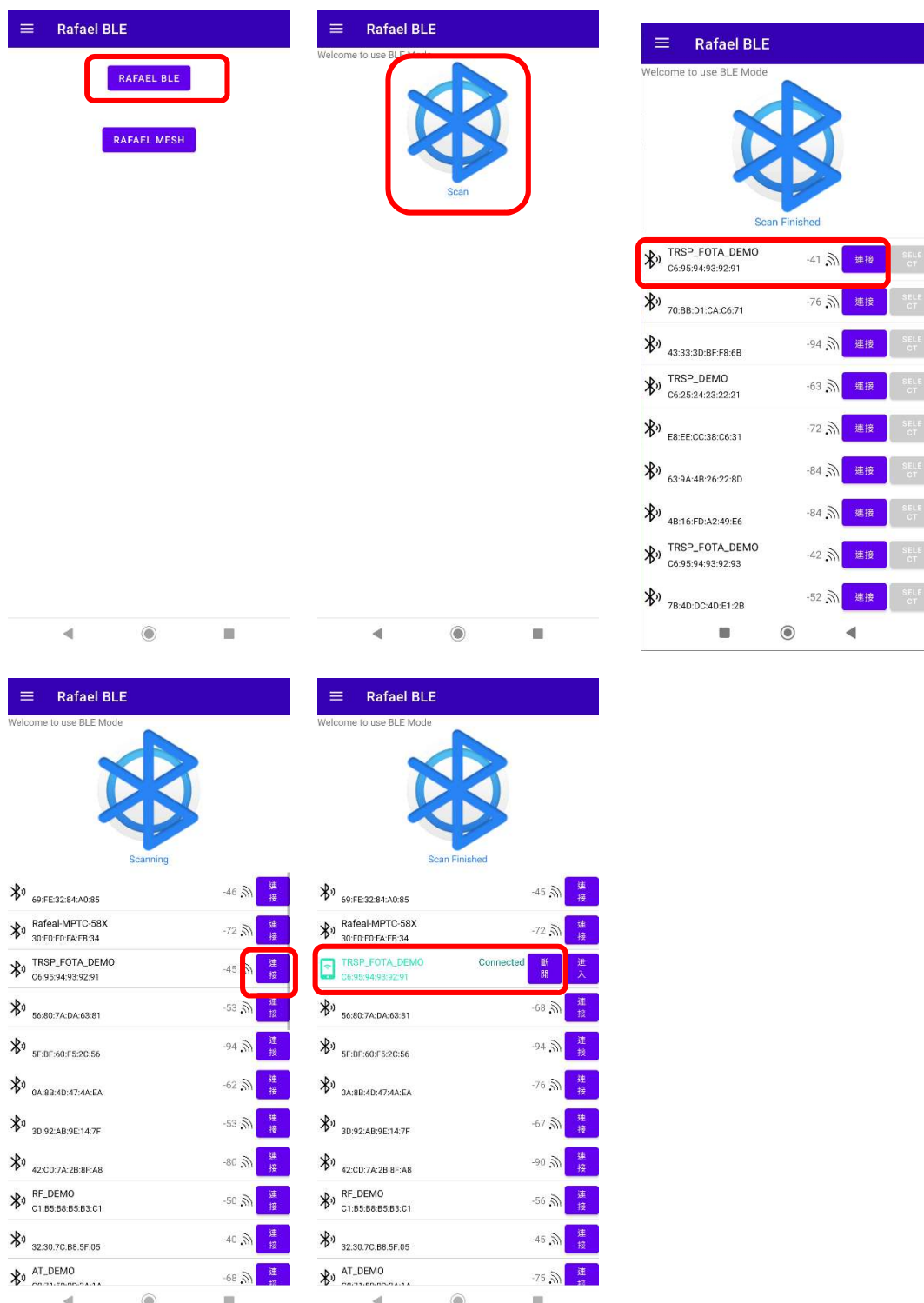
2.3 Start the FOTA Update by Using Mobile App

After generating the FOTA bin file, put it into specific folder “fota_bin” of smart phone (folder path: download/fota_bin).

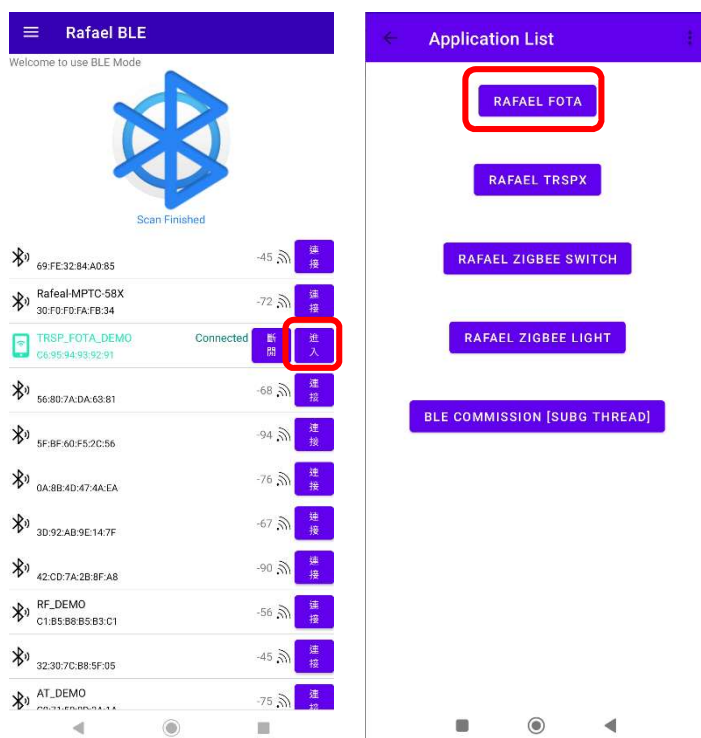
➤ ASUS_X00TDB ➤ 内部共用儲存空間 ➤ Download ➤



Install and open the mobile app “Rafael BLE” to scan and connect BLE device.



Once BLE device successfully connect, enter application list to find FOTA update page and pairing with BLE device.



At FOTA update page,

Step1: select FOTA bin file by button **SELECT BIN**

Step2: click the **CHECK VERSION** button, mobile app will parse FOTA bin file to get system information and query BLE device's system information.

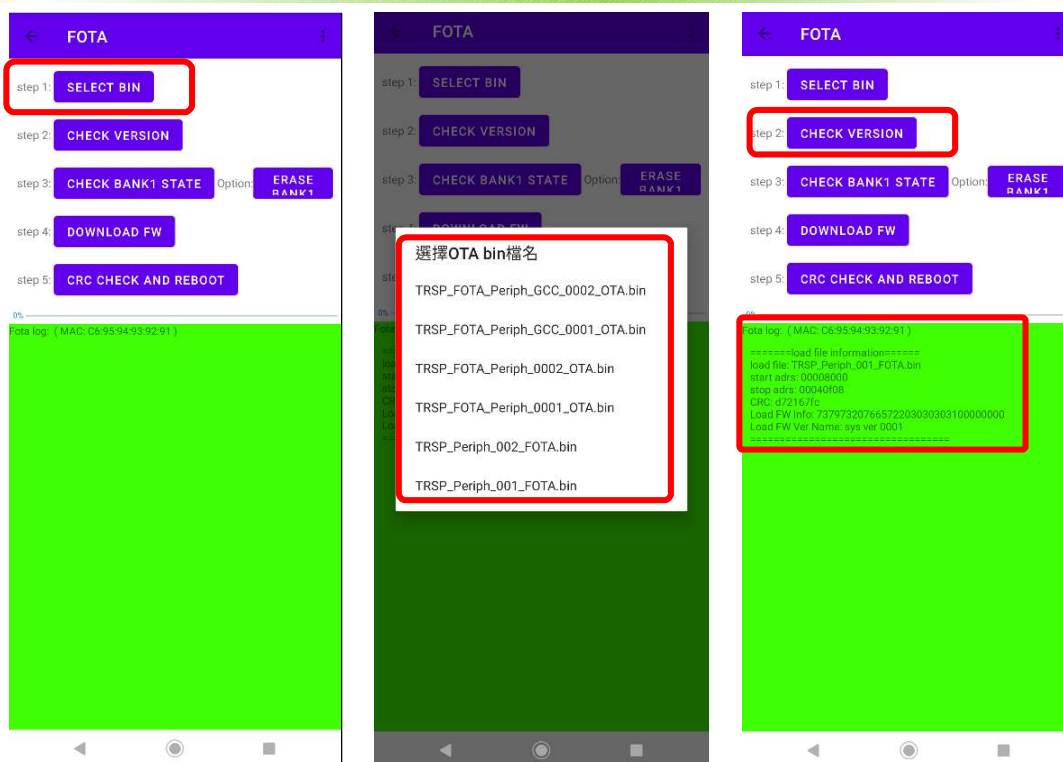
Step3: click the **CHECK BANK1 STATE** button to check updating FW buffer of device and APP the will check the transmission type is a resume one or new one.

※ Note that If previous incomplete update FW found in FW updating buffer, and FW mismatch with new updating FW. mobile APP will send erase command to device. Otherwise, mobile APP will resume the transmission from last abort address.

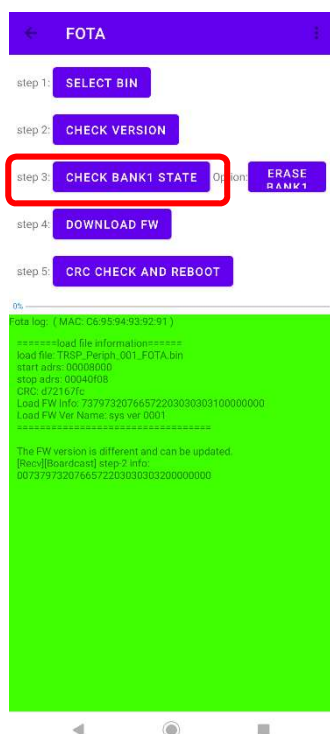
Step4: click button **DOWNLOAD FW** to start FW updating over the air.

Step5: Signal device to update new FW and reboot.

Step 1 & 2:

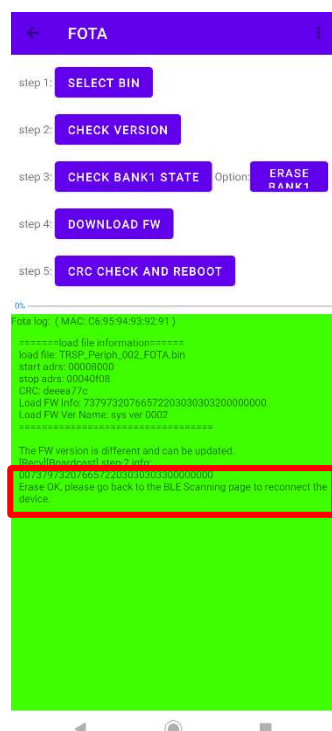


Step 3 check FW buffer status

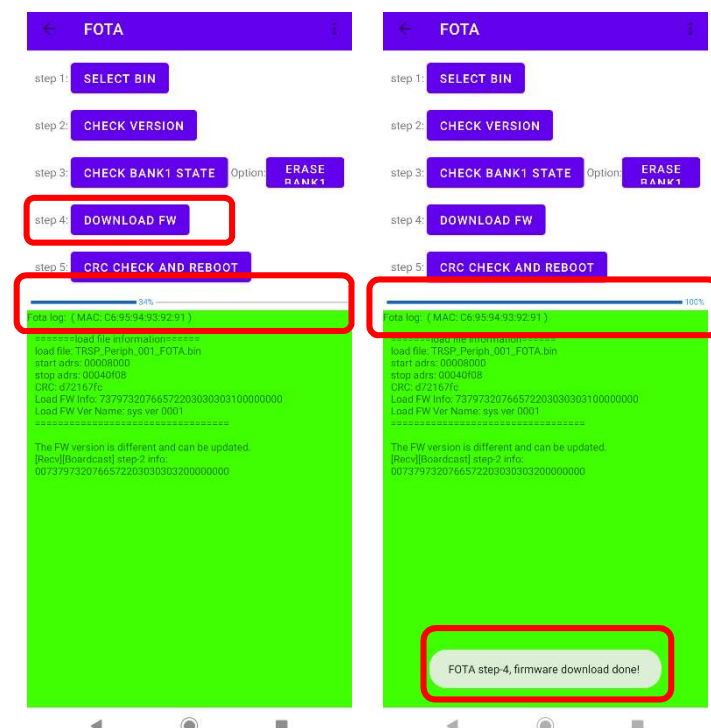


Step 3-1 (optional) mobile APP will send erase command for the buffer to device, after

erase command send, please go back to BLE scanning page to reconnect device and start from step 1



Step 4: start send FW to device App shows the progress bar and log information.



Step 5: check device get FW completely and reboot device to update new FW



2.4 Start the FOTA update for multi-device by using Mobile App


When FOTA is required for multiple devices, you can follow the steps below to simplify excessive manual steps.

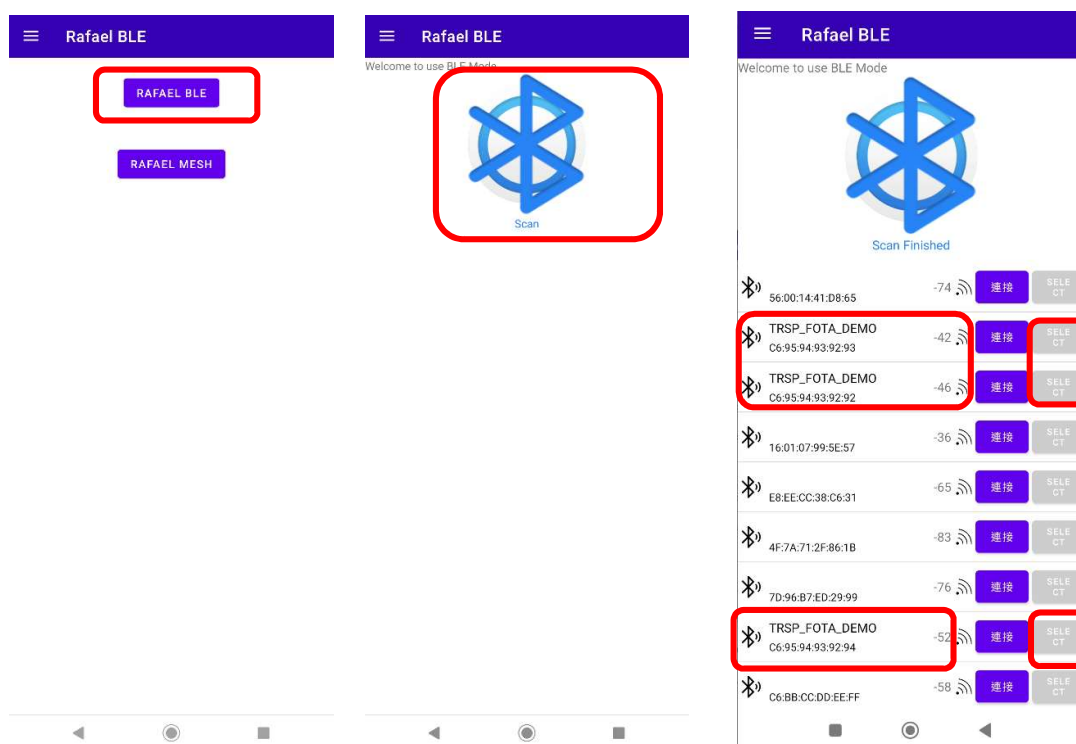
After generating the FOTA bin file, put it into specific folder “fota_bin” of smart phone (folder path: download/fota_bin).

> ASUS_X00TDB > 内部共用儲存空間 > Download >

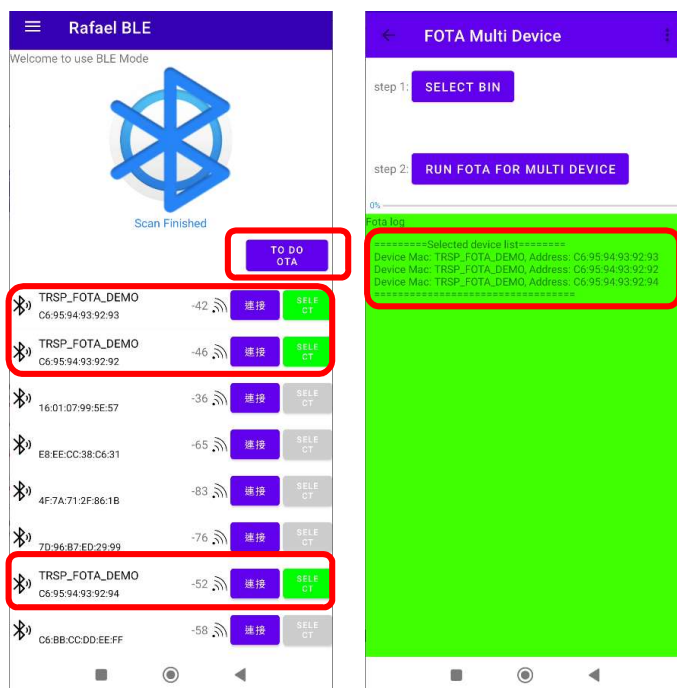


Install and open the mobile app “Rafael BLE” to scan and select BLE device.

Note that no connection is required here, so you need to use the  Button to select the device for OTA.



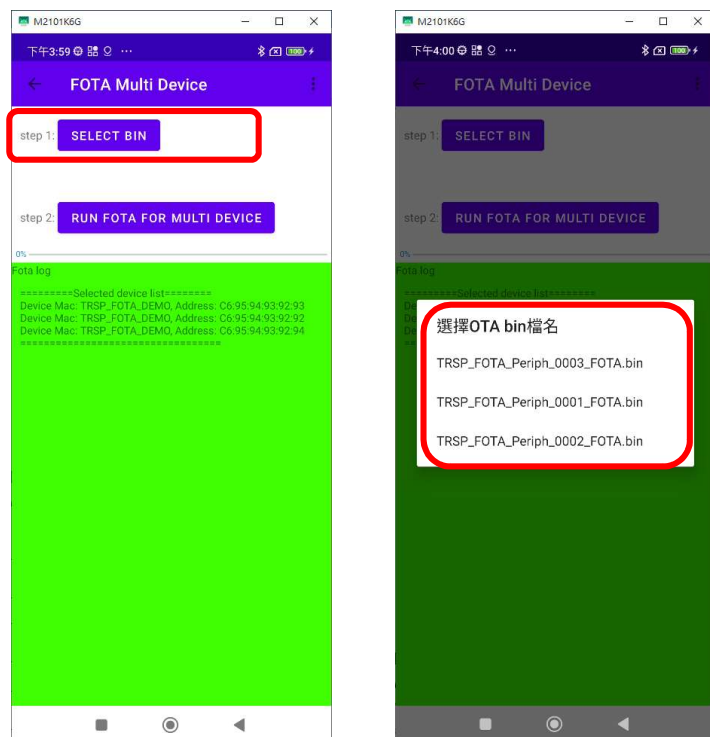
When more than one device is selected, the "TO DO OTA" button will be displayed on the UI. After the user selects the device that needs OTA, then press the "TO DO OTA" button to enter the OTA for multi-device UI. After entering the UI screen, the Log will display the device name and MAC selected by the user for re-confirmation. If they do not match, they can return to the scanning screen and select again.



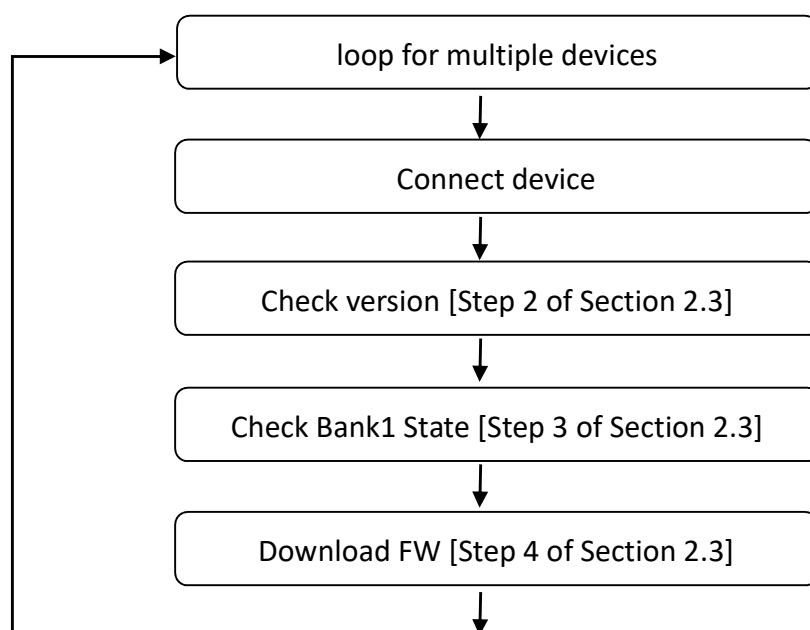
At FOTA Multi device update page,

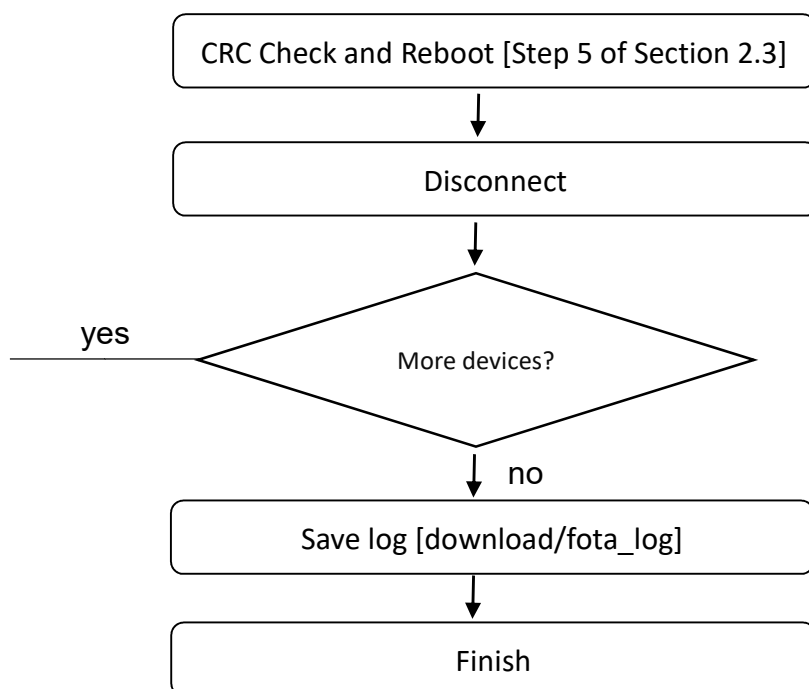
Step1: select FOTA bin file by button

SELECT BIN



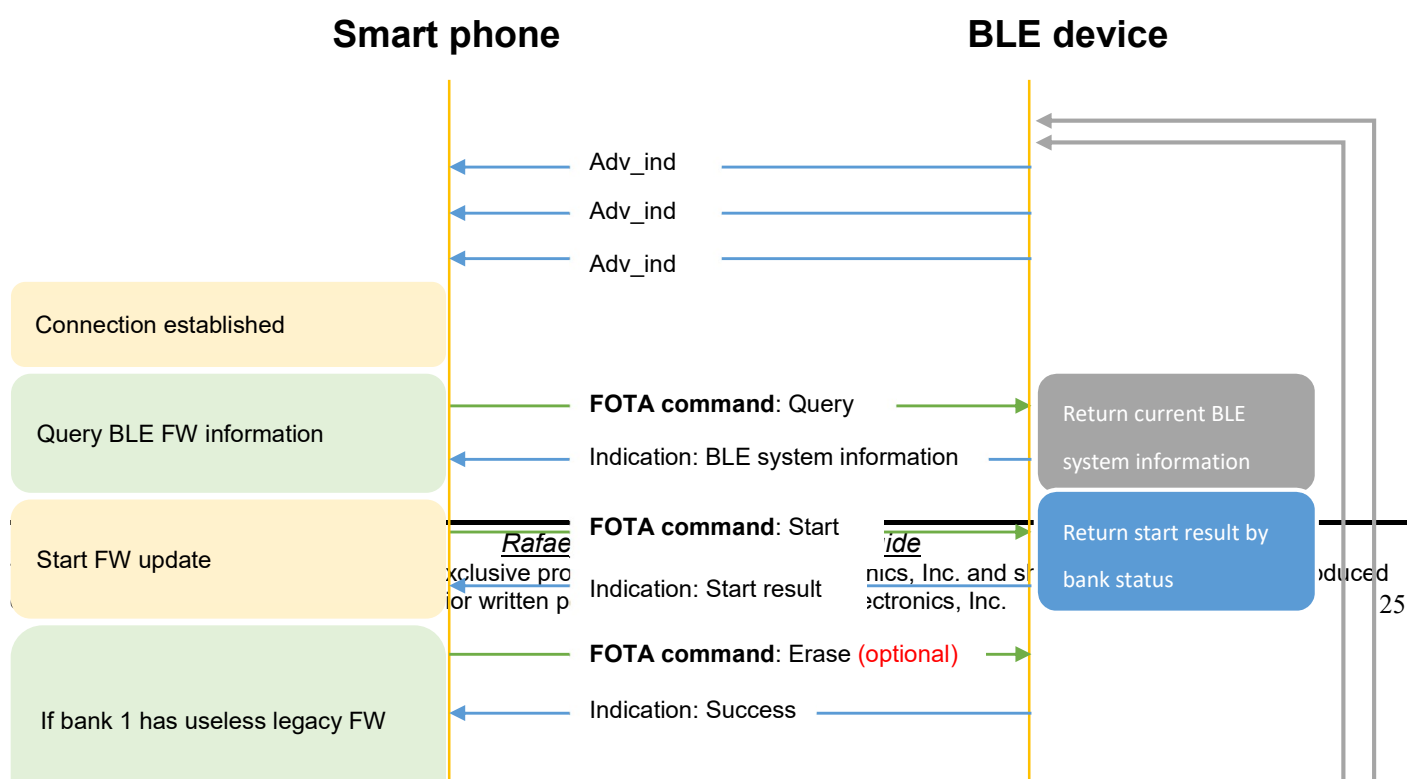
Step2: click the **RUN FOTA FOR MULTI DEVICE** button, these devices will perform steps 2 to 5 introduced in Chapter 2.3, as shown in the flow chart below.

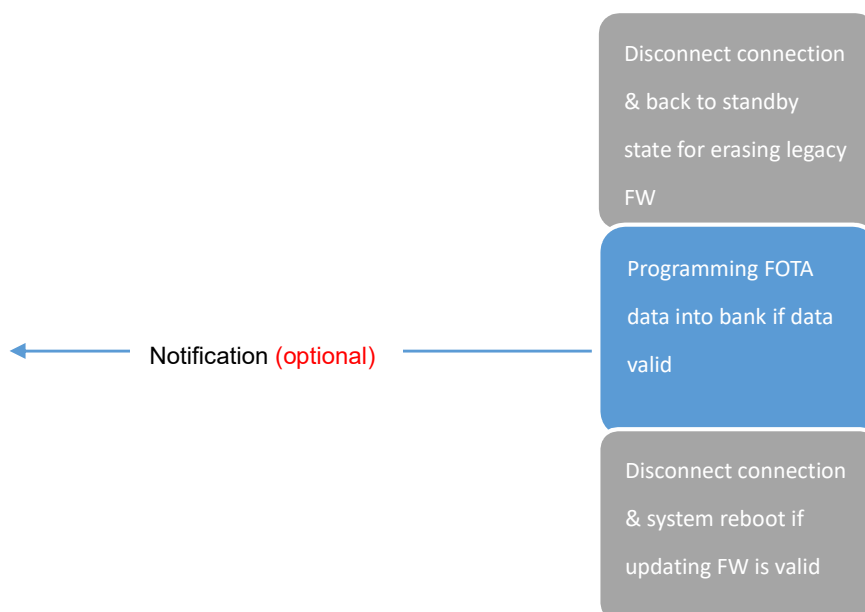




3. FOTA Communication Flow

After the BLE device is paired with a smart phone, the complete FOTA update handshake flow proceeds as shown below:





From the handshake flow, you can find that there were two major functions **FOTA command** and **FOTA data** to handle FOTA update procedure. These two functions defined in the file "ble_fota.c":

```
void ble_fota_cmd(uint8_t host_id, uint8_t length, uint8_t *p_data);
```

```
void ble_fota_data(uint8_t host_id, uint8_t length, uint8_t *p_data);
```

3.1 FOTA command

FOTA commands were parsed by function "ble_fota_cmd()".

```
void ble_fota_cmd(uint8_t host_id, uint8_t length, uint8_t *p_data);
```

The first byte of command payload contains command ID and each command ID may contain different information behind. We defined four kind of commands here:

1. **Query**: Query device current system information.

octets	1
parameter	Command ID (0x00)

2. **Start**: Start FW upgrade, this command contains new FW length and CRC.

octets	1	4	4	4	1
parameter	Command ID (0x01)	FW length	FW CRC	Notify interval	FW info

3. **Erase:** Terminated the connection and erasing legacy FW and information.

octets	1
parameter	Command ID (0x02)

4. **Apply:** Apply the new FW if device receiving FW length and CRC matched with FOTA command "Start".

octets	1	4
parameter	Command ID (0x03)	Bank0 address

Note: command "Erase" sends only when device report that there are legacy FW in bank 1 and smart phone confirmed this FW was not match with updating FW. You can find the upon definitions in the file "ble_fota.h".

```
#define OTA_CMD_QUERY           0x00 /* Query current system information */
#define OTA_CMD_START           0x01 /* Start FW OTA update */
#define OTA_CMD_ERASE           0x02 /* Erase legacy FW */
#define OTA_CMD_APPLY           0x03 /* FW transmission completed, apply new FW */
```

When device received FOTA command, an indication with error code will return to smart phone to decide how to continue the FOTA procedure. These error codes were also defined in "ble_fota.h" file:

```
typedef uint8_t OtaErrCode;
#define OTA_ERR_CODE_NO_ERR      0x00 /* Command success */
#define OTA_ERR_CODE_CMD_ERR     0x01 /* Unsupported command ID */
#define OTA_ERR_CODE_ALREADY_START 0x02 /* FOTA procedure already start */
#define OTA_ERR_CODE_UPDATE_NOT_START 0x03 /* FOTA procedure was not start */
#define OTA_ERR_CODE_FLASH_ERASE_ERR 0x04 /* Flash erase fail */
#define OTA_ERR_CODE_FW_CRC_ERR  0x05 /* Receiving FW's CRC incorrect */
#define OTA_ERR_CODE_FW_LEN_ERR  0x06 /* Receiving FW's length incorrect */
#define OTA_ERR_CODE_OUT_OF_BANK_SIZE 0x07 /* Updating FW's length larger than bank size */
```

1. **No error:** Command success.

octets	1
parameter	Error code (0x00)

2. **Command error:** Unsupported command ID.

octets	1
parameter	Error code (0x01)

3. **Already start:** FOTA procedure already start.

octets	1	4	4	3
parameter	Error code (0x02)	Updating FW length	Updating FW CRC	Updating FW next expect address

4. **Update not start:** FOTA procedure not start yet.

octets	1
parameter	Error code (0x03)

5. **Flash erase error:** Bank flash erase fail.

octets	1
parameter	Error code (0x04)

6. **FW CRC error:** Receiving FW's CRC is incorrect.

octets	1
parameter	Error code (0x05)

7. **FW length error:** Receiving FW's length is incorrect.

octets	1
parameter	Error code (0x06)

8. **Out of bank size:** Updating FW's length larger than bank size.

octets	1	3
parameter	Error code (0x07)	Current FW bank size

3.2 FOTA data

The function “ble_fota_data()” is implemented to handle FOTA data.

```
void ble_fota_data(uint8_t host_id, uint8_t length, uint8_t *p_data);
```

First 4 bytes of data payload is data header which contains the FOTA data programming address (3 bytes) and length (1byte).

octets	3	1	Variable
parameter	Data programming address	Data programming length	Data

If there were invalid data header, device will send notification to response it. Hence, for ideal FOTA data transmission, there were not any notification send from device unless smart phone had configure periodic notification. The notification reason is contained in the first byte of notification packet and you can find the definition in the “ble_fota.h” file as follows:

```
/*Notification reasons for FOTA data*/
typedef uint8_t OtaNotify;
#define OTA_DATA_NOTIFY_PERIODIC          0x00 /* Periodic notification, the notify interval */
#define OTA_DATA_NOTIFY_TIMEOUT           0x01 /* FOTA data was not received in a specific interval */
#define OTA_DATA_NOTIFY_ADDRESS_UNEXPECTED 0x02 /* Received FOTA data's address was not continuous */
#define OTA_DATA_NOTIFY_LEN_ERROR         0x03 /* Received FOTA data length incorrect */
#define OTA_DATA_NOTIFY_TOTAL_LEN_ERR     0x04 /* Total received FOTA data length is larger than expected */
#define OTA_DATA_NOTIFY_ADDRESS_ERR       0x05 /* Received FOTA data's address is larger than expected */
#define OTA_DATA_NOTIFY_NOT_START         0x06 /* FOTA data received but FOTA procedure was not started */
#define OTA_DATA_NOTIFY_NONE              0xFF /* No notification needs to send */
```

1. **Periodic:** Periodic notification, the notify interval set from FOTA start command.

octets	1	3
parameter	Notify reason (0x00)	Updating FW next expect address

2. **Timeout:** FOTA data was not received in a specific interval.

octets	1	3
parameter	Notify reason (0x01)	Updating FW next expect address

3. **Address unexpected:** Received FOTA data's address was not continuously.

octets	1	3
parameter	Notify reason (0x02)	Updating FW next expect address

4. **Length error:** Received FOTA data length incorrect.

octets	1	1
parameter	Notify reason (0x03)	Received FOTA data length

5. **Total length error:** Total received FOTA data length is larger than bank size.

octets	1	3
parameter	Notify reason (0x04)	Total Receiving FOTA data length

6. **Address error:** Received FOTA data's address is larger than bank size.

octets	1
parameter	Notify reason (0x05)

7. **Not start:** FOTA data received but FOTA procedure was not start.

octets	1
parameter	Notify reason (0x06)

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Revision History

Revision	Description	Owner	Date
1.0	Initial version	Nat	2022/2/9
1.1	Add Security Boot Mode description.	Ryan	2022/12/13

1.2	FOTA for multi device.	Ryan	2023/12/08
1.3	Complete Steps To Operate Security Boot Mode	Ryan	2024/03/22

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