



# AN0500

## Ameba-ZII Application Note

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### Abstract

Ameba-ZII is a high-integrated IC. Its features include 802.11 Wi-Fi, RF, Bluetooth and configurable GPIOs.

This manual introduces users how to develop Ameba-ZII, including SDK compiling and downloading image to Ameba-ZII.



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Though every effort has been made to ensure that this document is current and accurate, more information may have become available subsequent to the production of this guide.

## Revision History

| Revision | Release Date | Summary   |
|----------|--------------|---|
| 0.1      | 2018/11/27   | Initial draft   |
| 0.2      | 2019/01/09   | Add OTA part  |
| 0.3      | 2019/02/25   | Add EVB V2.0 build and image tool environment   |
| 0.4      | 2019/02/28   | Add How to enable secure boot & boot time   |
| 0.5      | 2019/03/01   | Add DEV_2V0 board user guide  |
| 0.6      | 2019/03/06   | Add trust zone project  |
| 0.7      | 2019/03/12   | Update OTA implementation method  |
| 0.8      | 2019/03/27   | Update TrustZone layout   |
| 0.9      | 2019/04/02   | Add How to generate flash image combines both firmware1 and firmware2   |
| 1.0      | 2019/04/22   | Add SDK Build Environment Setup, GCC Environment  |
| 1.1      | 2019/04/26   | Add Bluetooth section   |
| 1.2      | 2019/05/14   | Add Bluetooth 128-bit UUID configuration example  |
| 1.3      | 2019/05/15   | Update IAR trust zone project; Add trust zone project instruction under GCC environment; Update trust zone layout; Add troubleshooting chapter. |
| 1.4      | 2019/05/17   | Update OTA FW update behavior   |
| 1.5      | 2019/05/22   | Must use FT232 UART adapter to download code  |
| 1.6      | 2019/06/03   | Update TrustZone  |
| 1.7      | 2019/06/03   | Revise some explanations  |
| 1.8      | 2019/06/04   | Update instructions to build and flash in Ubuntu/Linux  |
| 1.9      | 2019/08/02   | Add pyOCD/DAPLink   |
| 1.10     | 2019/08/12   | Add SDK Architecture description  |
| 1.11     | 2019/08/15   | Refine pyOCD/DAPLink  |
| 1.12     | 2019/09/27   | Add note of WiFi BT coexistence   |
| 1.13     | 2019/10/02   | Improve visuality and explanation of document   |
| 1.14     | 2019/10/11   | Add GCC secure boot execution   |
| 1.15     | 2019/11/11   | Add Power Save and Efuse Chapters; Improve descriptions and content details; Fix the chapter quotation mismatch                                 |
| 1.16     | 2020/01/08   | Add trust zone project execution of secure boot and OTA   |
| 1.17     | 2020/02/14   | Add openOCD for Windows/Cygwin  |
| 1.18     | 2020/02/17   | Add OpenOCD for Ubuntu  |
| 1.19     | 2020/03/26   | Remove “module features” which user should refer to datasheet, because it may not be update to date in this application note.                   |

| Revision | Release Date | Summary  |
|----------|--------------|--|
| 1.20     | 2020/04/08   | Add BT Transmit Power  |
| 1.21     | 2020/04/21   | Add description in Force Old OTA section   |
| 1.22     | 2020/05/06   | Update write jtag key api description  |
| 1.23     | 2020/05/22   | Remove "UserAddr" from "Partition Record" in flash layout, because partition table doesn't record the address of User Data |
| 1.24     | 2020/06/05   | Add checksum description for OTA routine   |
| 1.25     | 2020/06/09   | Correct the description of serial number   |
| 1.26     | 2020/06/10   | Make serial number valid from 0x0 to 0xFFFFFFFF with new elf2bin tool  |
| 1.27     | 2020/09/09   | Update OpenOCD section   |
| 1.28     | 2020/09/15   | Update how to use PSRAM in GCC project   |
| 1.29     | 2020/10/20   | Add How to Debug in Secure Boot in IAR IDE   |
| 1.30     | 2020/11/13   | Update BT Examples; Modify Memory Usage; Add BT Default MAC Address section  |
| 1.31     | 2020/12/09   | Update OpenOCD setup on Windows OS   |
| 1.32     | 2021/03/31   | Add Cygwin version requirements for OpenOCD on Windows OS  |
| 1.33     | 2021/04/01   | Update OpenOCD section   |
| 1.34     | 2021/10/14   | Update system data layout  |
| 1.35     | 2022/06/30   | Update pyOCD setup on Linux and OpenOCD setup on Linux sections  |
| 1.36     | 2022/07/06   | Update pyOCD setup on Windows OS   |
| 1.37     | 2022/11/11   | Update Efuse section   |
| 1.38     | 2023/09/14   | Update eFuse section   |
| 1.39     | 2023/12/19   | Add fault message redirection section  |

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# 1 Demo Board User Guide

## 1.1 PCB Layout Overview

RTL8720C embedded on Ameba-ZII DEV demo board, which consists of various I/O interfaces. For the details of the HDK, please contact us for further reference.

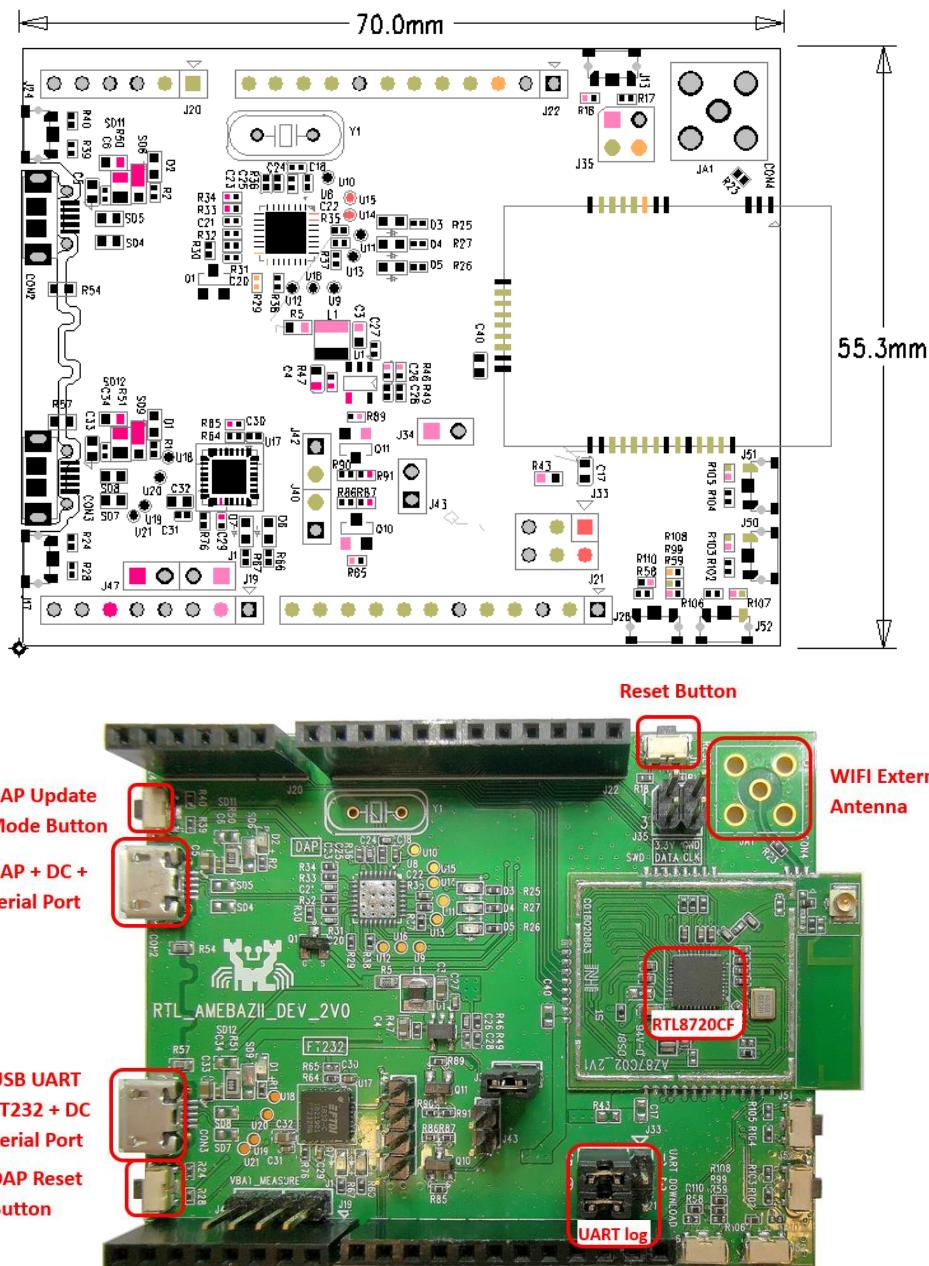


Figure 1-2 Ameba-ZII 2V0 Dev Board PCB Layout

## 1.2 Pin Mux Alternate Functions

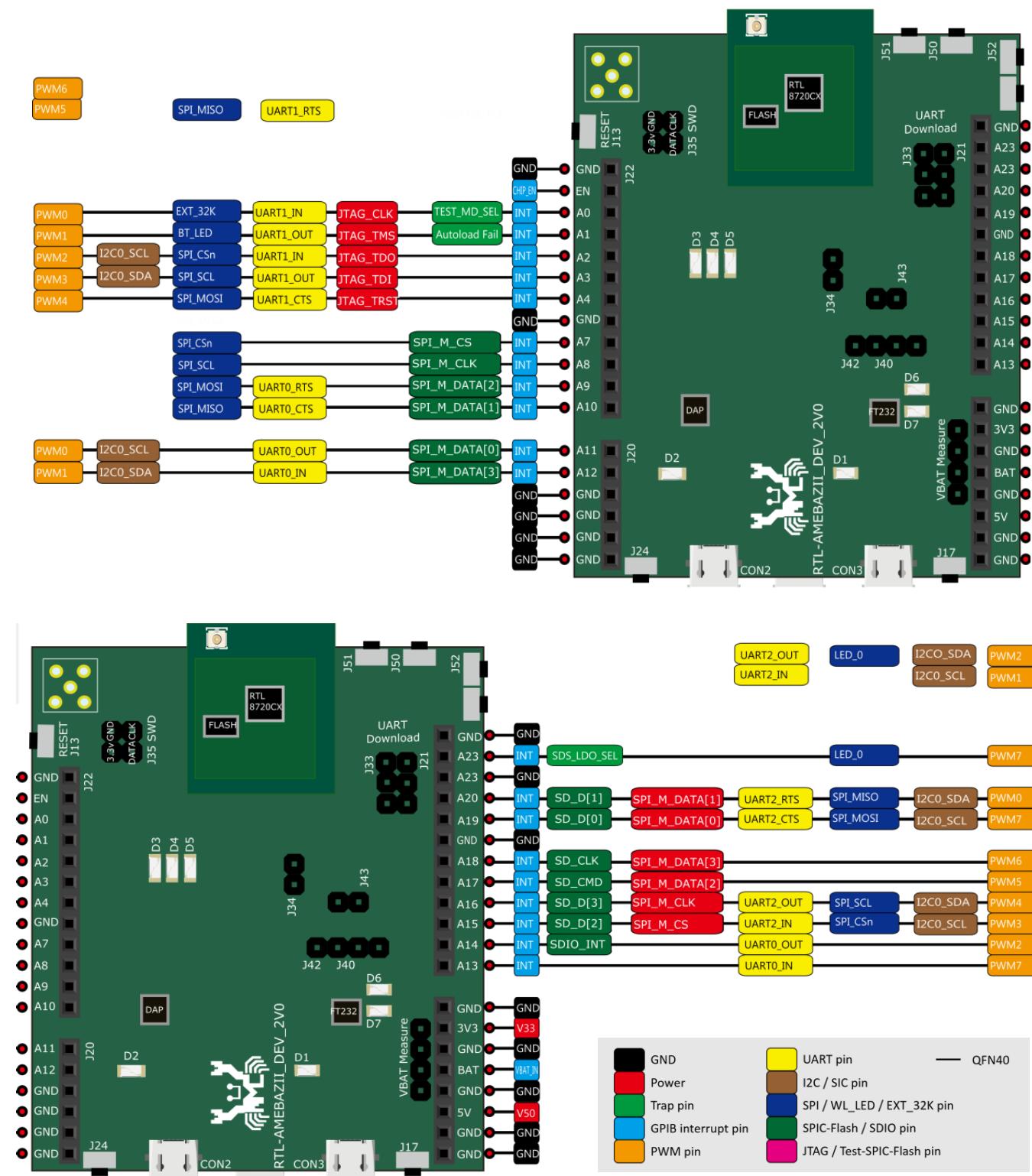
### 1.2.1 Pin Mux Table

| <i>Pin Name</i> | <i>SPIC-Flash/SDIO</i> | <i>JTAG</i> | <i>UART</i> | <i>SPI/WL_LED/EXT_32K</i> | <i>I2C</i> | <i>PWM</i> |
|-----------------|------------------------|-------------|-------------|---------------------------|------------|------------|
| <i>GPIOA_0</i>  |                        | JTAG_CLK    | UART1_IN    | EXT_32K                   |            | PWM[0]     |
| <i>GPIOA_1</i>  |                        | JTAG_TMS    | UART1_OUT   | BT_LED                    |            | PWM[1]     |
| <i>GPIOA_2</i>  |                        | JTAG_TDO    | UART1_IN    | SPI_CS <sub>n</sub>       | I2C_SCL    | PWM[2]     |
| <i>GPIOA_3</i>  |                        | JTAG_TDI    | UART1_OUT   | SPI_SCL                   | I2C_SDA    | PWM[3]     |
| <i>GPIOA_4</i>  |                        | JTAG_TRST   | UART1_CTS   | SPI_MOSI                  |            | PWM[4]     |
| <i>GPIOA_5</i>  |                        |             | UART1_RTS   | SPI_MISO                  |            | PWM[5]     |
| <i>GPIOA_6</i>  |                        |             |             |                           |            | PWM[6]     |
| <i>GPIOA_7</i>  | SPI_M_CS               |             |             | SPI_CS <sub>n</sub>       |            |            |
| <i>GPIOA_8</i>  | SPI_M_CLK              |             |             | SPI_SCL                   |            |            |
| <i>GPIOA_9</i>  | SPI_M_DATA[2]          |             | UART0_RTS   | SPI_MOSI                  |            |            |
| <i>GPIOA_10</i> | SPI_M_DATA[1]          |             | UART0_CTS   | SPI_MISO                  |            |            |
| <i>GPIOA_11</i> | SPI_M_DATA[0]          |             | UART0_OUT   |                           | I2C_SCL    | PWM[0]     |
| <i>GPIOA_12</i> | SPI_M_DATA[3]          |             | UART0_IN    |                           | I2C_SDA    | PWM[1]     |
| <i>GPIOA_13</i> |                        |             | UART0_IN    |                           |            | PWM[7]     |
| <i>GPIOA_14</i> | SDIO_INT               |             | UART0_OUT   |                           |            | PWM[2]     |
| <i>GPIOA_15</i> | SD_D[2]                |             | UART2_IN    | SPI_CS <sub>n</sub>       | I2C_SCL    | PWM[3]     |
| <i>GPIOA_16</i> | SD_D[3]                |             | UART2_OUT   | SPI_SCL                   | I2C_SDA    | PWM[4]     |
| <i>GPIOA_17</i> | SD_CMD                 |             |             |                           |            | PWM[5]     |
| <i>GPIOA_18</i> | SD_CLK                 |             |             |                           |            | PWM[6]     |
| <i>GPIOA_19</i> | SD_D[0]                |             | UART2_CTS   | SPI_MOSI                  | I2C_SCL    | PWM[7]     |
| <i>GPIOA_20</i> | SD_D[1]                |             | UART2_RTS   | SPI_MISO                  | I2C_SDA    | PWM[0]     |
| <i>GPIOA_21</i> |                        |             | UART2_IN    |                           | I2C_SCL    | PWM[1]     |
| <i>GPIOA_22</i> |                        |             | UART2_OUT   | LED_0                     | I2C_SDA    | PWM[2]     |
| <i>GPIOA_23</i> |                        |             |             | LED_0                     |            | PWM[7]     |

Table 1-1 GPIOA Pin MUX: DEV\_2V0 Board

**Note:** This table may not be up-to-date, please check the HDK and datasheet for more details.

## 1.2.2 Pin-Out Reference



**Figure 1-3 Pin Out Reference for DEV\_2V0**

## 2 SDK Architecture

Ameba-ZII SDK includes four folders: ‘component’, ‘doc’, ‘project’ and ‘tools’.

The architecture of SDK and descriptions of main folders are shown as below.

### 2.1 Component

| Sub-folders   |              | Description  |
|---------------|--------------|--|
| component     | Api          | <ul style="list-style-type: none"> <li>AT command</li> <li>Platform_stdlib.h: standard library header</li> <li>Wi-Fi driver interface</li> <li>Wi-Fi promisc mode interface</li> <li>Wi-Fi simple configuration</li> </ul> |
| common        | Application  | <ul style="list-style-type: none"> <li>Cloud services</li> <li>mqtt</li> </ul>   |
| api           | Bluetooth    | <ul style="list-style-type: none"> <li>Bluetooth driver</li> </ul>   |
| application   | Drivers      | <ul style="list-style-type: none"> <li>WLAN drivers</li> </ul>   |
| audio         | Example      | <ul style="list-style-type: none"> <li>Utility examples:<br/>wlan_fast_connect/ssl_download/fatfs...</li> </ul>  |
| bluetooth     | File_system  | <ul style="list-style-type: none"> <li>FATFS</li> <li>DCT</li> </ul>   |
| drivers       | Mbed         | <ul style="list-style-type: none"> <li>mbed API source code</li> </ul>   |
| example       | Media        | <ul style="list-style-type: none"> <li>multi-media framework</li> </ul>  |
| file_system   | Network      | <ul style="list-style-type: none"> <li>coap</li> <li>dhcp</li> <li>http</li> <li>lwip</li> <li>mDNS</li> <li>rtsp</li> <li>sntp</li> <li>ssl (MBEDTLS)</li> <li>tftp</li> <li>websocket</li> </ul>                         |
| graphic       | Utilities    | <ul style="list-style-type: none"> <li>cJSON</li> <li>http_client</li> <li>ssl_client</li> <li>tcpecho</li> <li>udpecho</li> <li>webserver/xml</li> </ul>  |
| mbed          | freertos     | FreeRTOS source code   |
| media         | os_dep       | <ul style="list-style-type: none"> <li>osdep_service.c: Realtek encapsulating interface for FreeRTOS</li> <li>osdep_service.h: Realtek encapsulating interface header</li> </ul>   |
| network       | App          | Monitor and shell  |
| test          | Cmsis        | cmsis style header file and startup file   |
| ui            | Fwlib        | HAL drivers and libraries  |
| utilities     | Mbed-drivers | Mbed API source code   |
| video         | Misc         | SDK libraries, IAR/GCC utilities...  |
| os            |              |  |
| cmsis_rtos    |              |  |
| customer_rtos |              |  |
| freertos      |              |  |
| os_dep        |              |  |
| system_view   |              |  |
| ucos2         |              |  |
| ucos3         |              |  |
| soc           |              |  |
| realtek       |              |  |
| 8710c         |              |  |
| app           |              |  |
| cmsis         |              |  |
| fwlib         |              |  |
| mbed-drivers  |              |  |
| misc          |              |  |

Figure 2-1 SDK architecture and description part 1

## 2.2 Doc, Project, Tools

| Folder  | Sub-folder                        | Description   |
|---------|-----------------------------------|---|
| DOC     | <b>AN0004</b>                     | Realtek low power Wi-Fi MP user guide                           |
|         | <b>AN0011</b>                     | Realtek WLAN simple configuration                               |
|         | <b>AN0012</b>                     | Realtek secure socket layer (SSL)                               |
|         | <b>AN0075</b>                     | Realtek Ameba-all at command v2.0                               |
|         | <b>AN0500</b>                     | Realtek Ameba-ZII application note                              |
| Project | <b>realtek_amebaz2_v0_example</b> | IAR/GCC project entry for AmebaZII                              |
|         | <b>\$/ EWARM-RELEASE</b>          | IAR projects  |
|         | <b>\$/~/Project_is.eww</b>        | IAR project for ignore secure (is, non TrustZone) configuration |
|         | <b>\$/~/Project_tz.eww</b>        | IAR project for TrustZone(tz) configuration                     |
|         | <b>\$/GCC-RELEASE</b>             | GCC projects  |
|         | <b>\$/~/application.is.mk</b>     | GCC project for Ignore Secure (is, non TrustZone) configuration |
|         | <b>\$/~/application.tz.mk</b>     | GCC project for TrustZone (tz) configuration                    |
| Tools   | <b>\$/example_sources</b>         | Examples for peripherals  |
|         | <b>Bluetooth</b>                  | APP for BT config   |
|         | <b>DownloadServer</b>             | OTA download TCP server   |
|         | <b>DownloadServer (HTTP)</b>      | OTA download HTTP server  |
|         | <b>pyOCD</b>                      | GDB server for DAPLink  |

Figure 2-2 SDK architecture and description part 2

## 3 SDK Build Environment Setup

### 3.1 Introduction

In this chapter, we will illustrate how to build Realtek WiFi SDK. We will start by explaining how to setup debugger on your computer for both **Windows OS** and **Linux OS**. Ameba-ZII uses **J-Link** Debugger and **DAPLink** debugger.

Then, we will illustrate how to connect **logUART** to the debuggers.

Lastly, we will explain how to setup development environment for your computer and how to process the compilation. The **IAR IDE** will be used for Windows OS and **GCC IDE** will be used for both Windows OS and Linux OS.

**Note:** For Windows OS, we use **Windows 7 64-bit** as our platform.

### 3.2 Debugger Settings

To download code or debug on Ameba-ZII, user needs to make sure the debugger is setup properly.

Ameba-ZII supports **J-Link** and **CMSIS-DAP** for code download and entering debugger mode. The settings are described below.

#### 3.2.1 J-Link Debugger

##### 3.2.1.1 Connection

Ameba-ZII supports J-Link debugger. you need to connect the **Serial Wire Debug (SWD)** connector of Ameba-ZII to J-Link debugger as shown below and then connect J-Link to PC. You can refer to section 1.2.2 for SWD pin definitions.

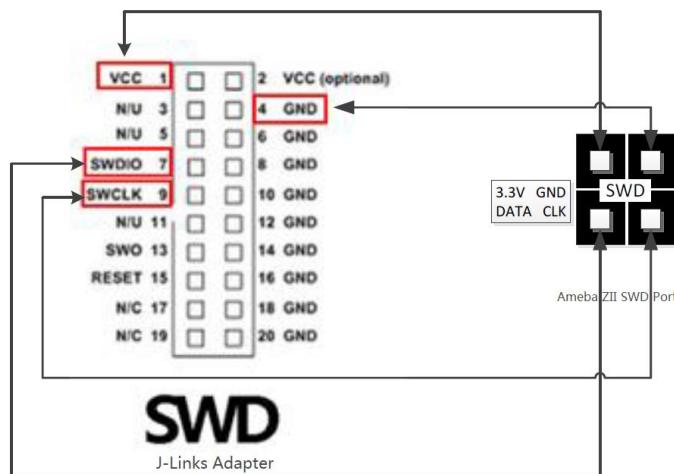


Figure 3-1 Connection between J-Link Adapter and Ameba-ZII SWD connector

**Note:**

1. To be able to debugger Ameba-ZII which is powered by Cortex-M33, user needs a J-Link debugger with the latest hardware version (Check [https://wiki.segger.com/Software\\_and\\_Hardware\\_Features\\_Overview](https://wiki.segger.com/Software_and_Hardware_Features_Overview) for details).
2. If you are using **Virtual Machine** as your platform, please make sure the USB connection setting between VM host and client is correct so that the VM client can detect the device.

### 3.2.1.2 Setups on Windows OS

To be able to use J-Link debugger, you need to firstly install J-Link GDB server.

Please check <http://www.segger.com> and download “J-Link Software and Documentation Pack” (<https://www.segger.com/downloads/jlink>).

**Note:** To support TrustZone feature, it's better to download the **latest version** of J-Link Software. Version 6.40 is used to prepare this document.

The process of is as follows:

**1. Install J-Link GDB server.**

Please check <http://www.segger.com> and download “J-Link Software and Documentation Pack” (<https://www.segger.com/downloads/jlink>).



Figure 3-2 J-Link Setup Interface

**2. Open installation location of ‘JLink\_V640’ and run “JLinkGDBServer.exe” to check connection.**

**3. Make sure the configuration is fine and click ‘OK’.**

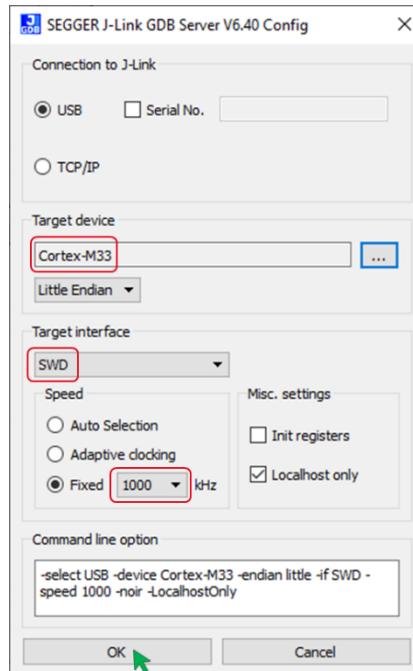


Figure 3-3 J-Link GDB server UI under Windows

4. Check if the below information is shown properly.

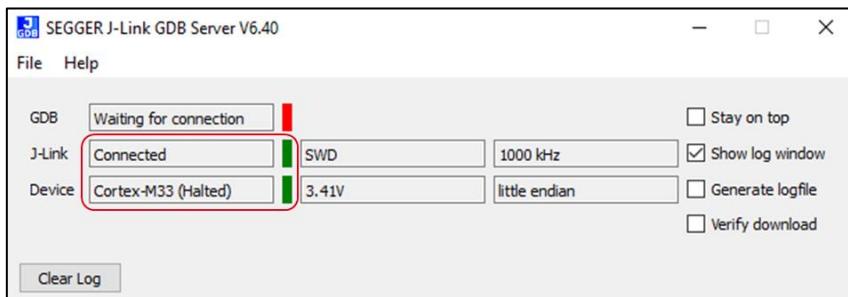


Figure 3-4 J-Link GDB server connect under Windows

**Note:** If J-Link GDB Server is unable to detect the device, try re-connecting the wires and re-open ‘JLinkGDBServer.exe’ may solve the problem.

### 3.2.1.3 Setups on Linux OS

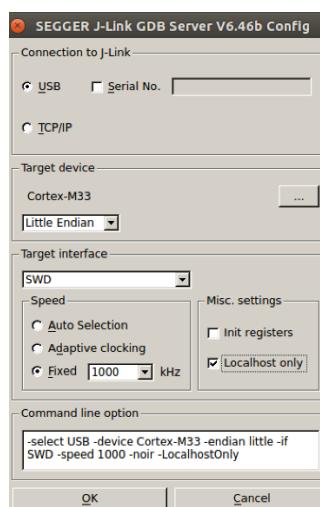
#### 3.2.1.3.1 Install J-Link Software on Ubuntu/Linux

- Download the latest JLink software for Ubuntu from the following link:  
<https://www.segger.com/downloads/jlink/#J-LinkSoftwareAndDocumentationPack>
- Install via the .DEB/ .RPM or TGZ file, the commands below are to install JLink through the .DEB file
  - “sudo dpkg -i JLink\_Linux\_V646b\_x86\_64.deb”
  - “sudo dpkg --install JLink\_Linux\_V646b\_x86\_64.deb”

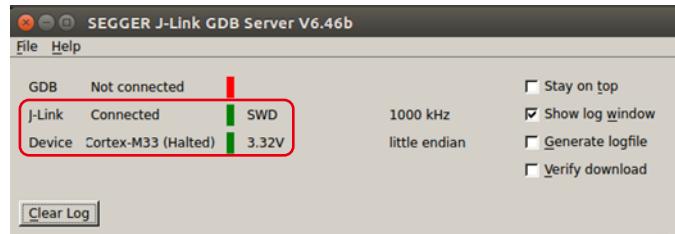
#### 3.2.1.3.2 Steps to Initiate JLinkGDBServer

If all steps mentioned in 3.2.1.2.1 have been followed, the JLink software as well as the JLink GDB server needs to be installed successfully. Before initiating the flash, follow the steps below to initiate the JLink GDB Server.

- Open a new terminal along with the terminal where the SDK is open.
- In the new terminal enter the command “sudo JLinkGDBServerExe”.
- Once this is done, the JLink GDB server config window will pop up as shown below.



4. The configurations to be selected are as shown above, to ensure proper connection please follow the configurations exactly as shown on the image and click “ok”.
5. If the connection is successful, the connection window should be as it is shown below.



6. Once connection is successful, please do not close the terminal from which the GDB server was started as this will result in the termination of the JLink GDB server program and in turn the flash will be a failure.

### 3.2.2 pyOCD/DAPLink

pyOCD (python On-Chip Debugger) provides open source Python library for programming and debugging Arm Cortex-M microcontrollers. pyOCD uses DAPLink as software project which enables programming and debugging application software on running on Arm Cortex CPUs. DAPLink enables developers with drag-and-drop programming and CMSIS-DAP (Cortex Microcontroller Software Interface Standard - Debug Access Port) based debugging. It runs on a secondary MCU that is attached to the JTAG port of the application MCU.

DAPLink can be downloaded from: <https://github.com/ARMmbed/DAPLink>

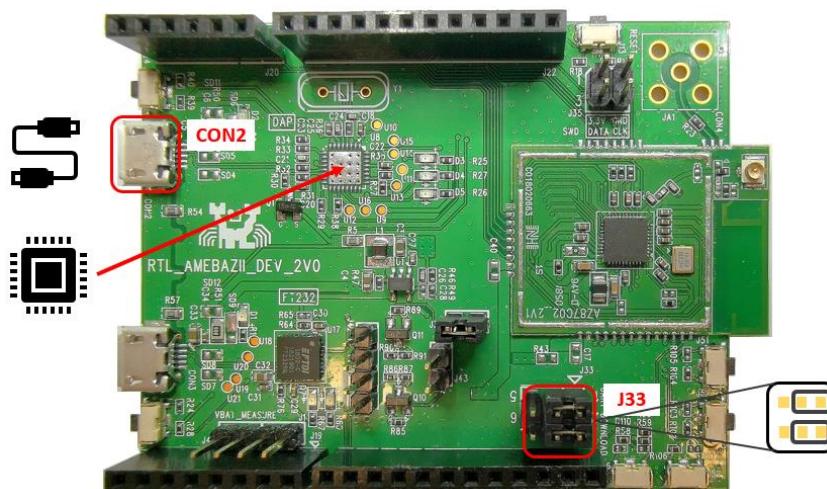
Please install modified version of pyOCD in Ameba-ZII SDK. It can be found in ‘tools/pyOCD’ of the SDK. **Official version cannot detect the amebaz2 board.**

Also, official pyOCD source code can be downloaded from: <https://github.com/mbedmicro/pyOCD>

#### 3.2.2.1 Connection

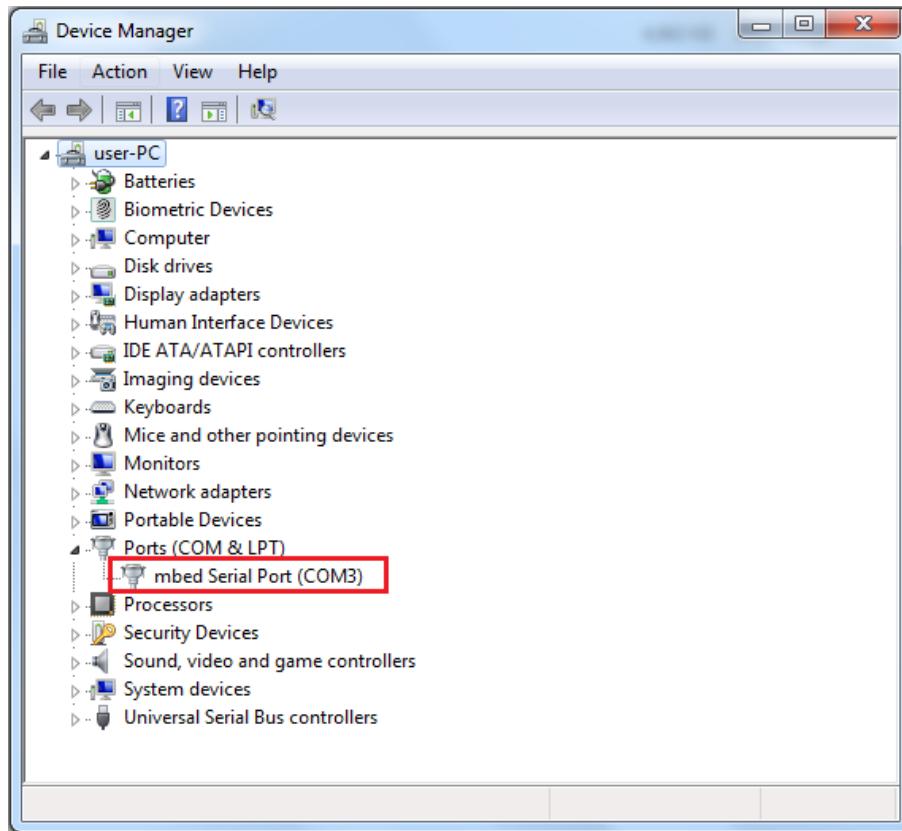
To use DAPLink you need to connect Ameba-ZII to PC via **CON2** and connect jumpers at **J33** as shown.

**Note:** You need to check whether the **DAP Chip** is mounted on the board.



The DAPLink debug probe also provides a USB serial port which can be bridged through to a TTL UART on the target system. The USB Serial port will appear on a Windows machine as a COM port, or on a Linux machine as a /dev/tty interface and on Mac OS as a /dev/usbmodem. While Linux and Mac OS don't require any drivers, Windows version older than Windows 10 will require a serial port driver which can be found in [http://os.mbed.com/media/downloads/drivers/mbedWinSerial\\_16466.exe](http://os.mbed.com/media/downloads/drivers/mbedWinSerial_16466.exe).

If Serial to USB driver has been installed and the board is connected to PC, there should be mbed Serial Port shown in Device Manager.



### 3.2.2.2 Setups on Windows OS

#### 1) Install with Python 2.X

- If Python 2.7 is not ready on your computer, please download and install **Python 2.7** from website: <https://www.python.org/downloads/release/python-2716/>

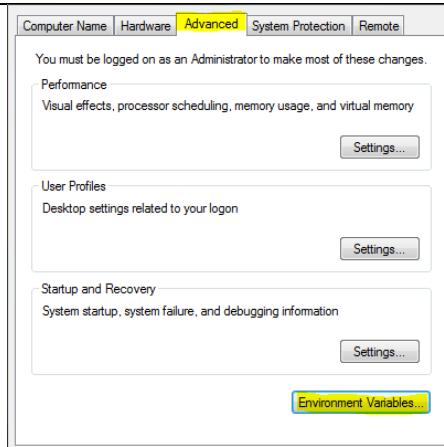
**Note:** Please choose **32-bit** version “Windows x86 MSI installer”.

- Setup **PATH** for Python 2.7:

In ‘Control Panel > System and Security > System’, click **Advanced system settings**.



Choose ‘**Advanced**’ tab and click ‘**Environment Variables**’.



Click Edit Path variable in **User variables** or **System variables**, then adding **Python 2.7 install path and scripts path** to Path variable.

For example, adding `C:\Python27` and `C:\Python27\Scripts` to Path variable.

```
C:\Python27
C:\Python27\Scripts
```

- c. Upgrade **pip** and install necessary packages in command window by following commands (Note: if there are multiply versions of python installed please specific its' path or add it to system variables when using cmd, e.g.  
`> python2.7 -m ...`)  
`> python -m pip install --upgrade pip`  
`> pip install pywinusb enum34 cmsis-pack-manager colorama intelhex intervaltree prettytable pyelftools`  
`pyyaml six`
- d. Install **pyOCD** in SDK folder '`tools/pyOCD/pyocd-0.21.1.dev35+dirty.win32.exe`'
- e. Install package to offer easy USB device communication in Python  
`> pip install pyusb`
- f. Attached HDK (DAPLink enabled) to computer then using command  
`> pyocd-gdbserver -p 2331`

If successfully detected, the following message will be shown:

```
$ pyocd-gdbserver -p 2331
0000398:WARNING:gdb_server:pyocd-gdbserver is deprecated; please use the new combined pyocd tool.
0000642:WARNING:mbed_board:Board ID 0857 is not recognized, using generic cortex_m target.
0000643:INFO:board:Target type is cortex_m
0000643:WARNING:board:Generic 'cortex_m' target type is selected; is this intentional? You will be able to debug but not program f
lash. To set the target type use the '--target' argument or 'target_override' option. Use 'pyocd list --targets' to see available
targets types.
0000676:INFO:dap:DP IDR = 0x6ba02477 (v2 rev6)
0000694:INFO:ap:AP#0 IDR = 0x84770001 (AHB-AP var0 rev8)
0000707:INFO:ap:AP#1 IDR = 0x54770002 (APB-AP var0 rev5)
0000727:INFO:rom_table:AP#0 ROM table #0 @ 0xe00f0f000 (designer=879 part=030)
0000738:INFO:rom_table:[0]<000e000:SCS-M33 class=9 designer=879 part=033 devtype=00 archid=2a04 devid=0:0:0>
0000746:INFO:rom_table:[1]<0001000:DWT class=9 designer=879 part=035 devtype=00 archid=1a02 devid=0:0:0>
0000753:INFO:rom_table:[2]<0002000:BPU class=9 designer=879 part=034 devtype=00 archid=1a03 devid=0:0:0>
0000763:WARNING:rom_table:Invalid coresight component, cidr=0x0
0000763:WARNING:rom_table:Warning: ROM table @ 0x80000000 has unexpected CIDR component class (0x0)
0000767:INFO:cortex_m_v8m:CPU implementer is Realtek.
0000770:INFO:cortex_m_v8m:CPU core #0 is Cortex-M33 r1p0 (security ext present)
0000780:INFO:dwrt:1 hardware breakpoints, 0 literal comparators
0000784:INFO:fpb:2 hardware breakpoints, 0 literal comparators
0000796:INFO:server:Serial server started on port 4444
0000797:INFO:gdbserver:GDB server started on port 2331
```

## 2) Install with Python 3.X

- a. If Python 3.10 is not ready on your computer, please download and install **Python 3.10** from website or Microsoft store:

<https://www.python.org/downloads/>

**Note:** Please choose **64-bit** version “Windows installer (64 bit)” as new version of cmsis\_pack\_manager don’t provide 32 bit libs for now.

b. Setup **PATH** for Python 3.10:

In ‘Control Panel > System and Security > System’, click **Advanced system settings**.

Choose ‘**Advanced**’ tab and click ‘**Environment Variables**’.

Click Edit Path variable in **User variables** or **System variables**, then adding **Python 3.10 install path** and **scripts path** to Path variable.

For example, adding *C:\Python310* and *C:\Python310\Scripts* to Path variable.

c. Upgrade **pip** and install necessary packages in command window by following commands (Note: if there are multiply versions of python installed please specific its' path or add it to system variables when using cmd, e.g. > path\to\python3.10.exe -m ... or > python3.10 -m ...)

> **python -m pip install --upgrade pip**

> **pip install pywinusb enum34 cmsis-pack-manager colorama intelhex intervaltree prettytable pyelftools pyyaml six**

d. Install **pyOCD** in SDK folder ‘*tools/pyOCD/pyocd-0.34.X.win-amd64.msi*

e. Install package to offer easy USB device communication in Python

> **pip install pyusb**

f. Attached HDK (DAPLink enabled) to computer then using command

> **python -m pyocd gdbserver -p 2331**

or

> **pyocd gdbserver -p 2331**

If successfully detected, the same message will be shown.

### 3.2.2.3 Setups on Linux OS

1) **Install through python2.X easy\_install**

a. Similar to windows, **Python 2.7** is required. If there is no Python 2.7 existed in Linux, please install Python 2.7.

If your Linux distribution is **Ubuntu**, please using following command:

> **sudo apt install python2.7**

b. Then install and upgrade pip and necessary packets

> **sudo apt install python-pip**

> **sudo python -m pip install --upgrade pip**

> **sudo pip install pyusb enum34 cmsis-pack-manager colorama intelhex intervaltree prettytable pyelftools pyyaml six**

c. Install pyOCD in SDK folder *tools/pyOCD/pyocd-0.21.1.dev36-py2.7.egg*

> **sudo python -m easy\_install tools/pyOCD/pyocd-0.21.1.dev36-py2.7.egg**

d. Attached HDK (DAPLink enabled) to computer then using command.

May need using sudo to have the hardware access privilege

> **sudo pyocd-gdbserver -p 2331**

- e. If successfully detected, the following message will be shown:

```
$ pyocd-gdbserver -p 2331
0000398:WARNING:gdb_server:pyocd-gdbserver is deprecated; please use the new combined pyocd tool.
0000642:WARNING:mbed_board:Board ID 0857 is not recognized, using generic cortex_m target.
0000643:INFO:board:Target type is cortex_m
0000643:WARNING:board:Generic 'cortex_m' target type is selected; is this intentional? You will be able to debug but not program f
lash. To set the target type use the '--target' argument or 'target_override' option. Use 'pyocd list --targets' to see available
targets types.
0000676:INFO:dap:DP IDR = 0x6ba02477 (v2 rev6)
0000694:INFO:ap:AP#0 IDR = 0xb4770001 (AHB-AP var0 rev8)
0000707:INFO:ap:AP#1 IDR = 0x54770002 (APB-AP var0 rev5)
0000727:INFO:rom_table:AP#0 ROM table #0 @ 0xe00ff000 (designer=879 part=030)
0000738:INFO:rom_table:[0]<000e000:SCS-M33 class=9 designer=879 part=033 devtype=00 archid=2a04 devid=0:0:0>
0000746:INFO:rom_table:[1]<0001000:DWT class=9 designer=879 part=035 devtype=00 archid=1a02 devid=0:0:0>
0000753:INFO:rom_table:[2]<0002000:BPU class=9 designer=879 part=034 devtype=00 archid=1a03 devid=0:0:0>
0000763:WARNING:rom_table:Invalid coresight component, cidr=0x0
0000763:WARNING:rom_table:Warning: ROM table @ 0x80000000 has unexpected CIDR component class (0x0)
0000767:INFO:cortex_m_v8m:CPU implementer is Realtek.
0000770:INFO:cortex_m_v8m:CPU core #0 is Cortex-M33 r1p0 (security ext present)
0000780:INFO:dwt:1 hardware watchpoints
0000784:INFO:fpb:2 hardware breakpoints, 0 literal comparators
0000796:INFO:server:Semihost server started on port 4444
0000797:INFO:gdbserver:GDB server started on port 2331
```

## 2) Install through python3.X pip

- a. As easy\_install is now deprecated from higher version of python, there is alternative way. If your Linux distribution is Ubuntu, please using following command:

> sudo apt install python3

Then install and upgrade pip and necessary packets

> sudo apt install python3-pip

> sudo python3 -m pip install --upgrade pip

- b. Install pyocd through pip local files:

> python3 -mpip install xxx/pyocd-0.34.X.tar.gz

- c. Update udev rules to change access permission

please follow the guides from <https://github.com/pyocd/pyOCD/tree/main/udev>

- d. Attached HDK (DAPLink enabled) to computer then using command.

> python3 -mpyocd gdbserver -p 2331

- e. If successfully detected, the same message above will be shown.

## 3.2.3 OpenOCD/DAPLink

The Open On-Chip Debugger (OpenOCD) aims to provide debugging, in-system programming and boundary-scan testing for embedded target devices.

### 3.2.3.1 Connection

It's the same as 3.2.2.1 .

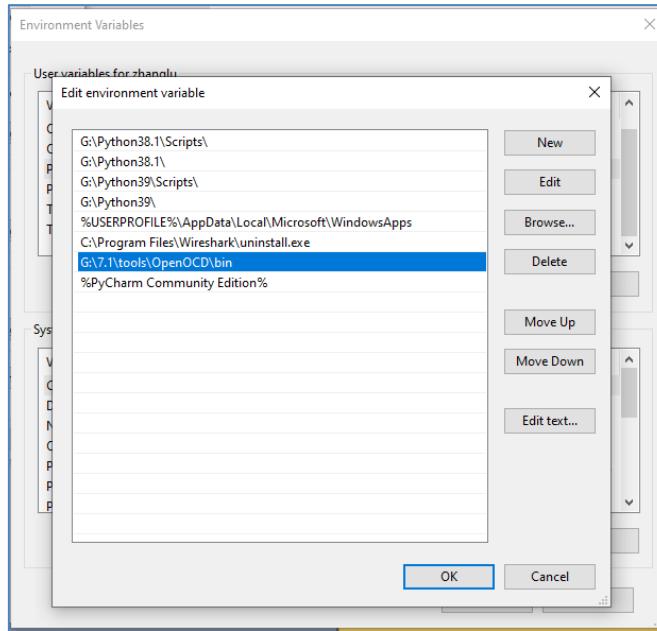
**Note: After downloading the image, user must close OpenOCD Debugger, then unplug and plug CON2 to reset the DAPLink before you reset the Ameba-ZII board, otherwise you will see below log when you reset the board.**

```
-- Rt18710c IoT Platform --
Chip VID: 5, Ver: 1
ROM Version: v2.1
Test Mode: boot_cfg1=0x0
Download Image over UART2[tx=16,rx=15] baud=115200
```

### 3.2.3.2 Setups on Windows OS

For Windows OS, the OpenOCD executive and dependencies are integrated into the SDK, under the *tools/OpenOCD* folder. There is no need to separately download the OpenOCD software.

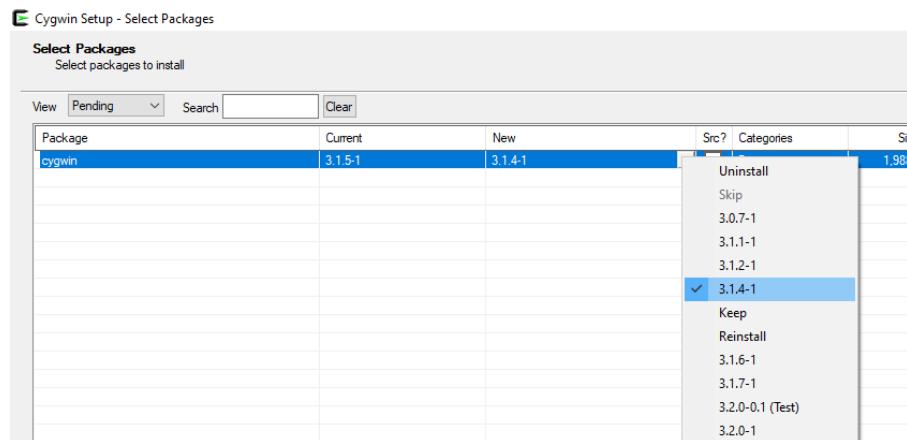
- User needs to add the *tools\OpenOCD\bin* path in the System Environment Variables Path (Control Panel -> System and Security -> System -> Advanced System Settings -> Advanced tab -> Environment Variables -> Path).



- Open Cygwin terminal (32-bit), directed to **GCC-RELEASE**
- Execute *./run\_openocd.sh* to open OpenOCD server

```
ample/GCC-RELEASE
$ ./run_openocd.sh
make[1]: Entering directory '/cygdrive/d/7.1forCommit/sdk/project/realtek_amebaz2_v0_example/GCC-RELEASE'
-----
Setup openocd
-----
cp -p ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_debug_openocd.txt ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_debug.txt
cp -p ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_flashloader.txt ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_flashloader.txt
make[1]: Leaving directory '/cygdrive/d/7.1forCommit/sdk/project/realtek_amebaz2_v0_example/GCC-RELEASE'
Try to search windows process
Open On-Chip Debugger 0.10.0
Licensed under GNU GPL v2
For bug reports, read
      http://openocd.org/doc/doxygen/bugs.html
Info : auto-selecting first available session transport "swd". To override use 'transport select <transport>'.
transport select swd
adapter speed: 500 kHz
adapter_nsrst_delay: 200
cortex_mx3 reset_config sysresetreq
Info : CMSIS-DAP: SWD Supported
Info : CMSIS-DAP: Interface Initialised (SWD)
Info : CMSIS-DAP: FW Version = 1.0
Info : SWCLK/TCK = 1 SWDIO/TMS = 1 TDI = 0 TDO = 0 nTRST = 0 nRESET = 1
Info : CMSIS-DAP: Interface ready
Info : clock speed 500 kHz
Info : SWD DPIDR 0x6ba02477
Info : security extensions detected
Info : rt18710c.cpu: hardware has 2 breakpoints, 1 watchpoints
target halted due to debug-request, current mode: Thread
xPSR: 0x01000000 pc: 0x00000a00 msp: 0x1003fa00
  TargetName      Type   Endian TapName        State
-----0* rt18710c.cpu cortex_mx3 little rt18710c.cpu    halted
```

Note: Errors such as “Error: Can't find openocd.cfg” may be encountered when running *./run\_openocd.sh* in Cygwin if the version of the Cygwin package installed is not 3.1.4-1. OpenOCD requires the cygwin1.dll to be from this version in order to run *./run\_openocd.sh* properly. If it is not on version 3.1.4-1, run the Cygwin setup file again and install version 3.1.4-1 of the Cygwin package when selecting the packages to install. Alternatively, the error can also be resolved by replacing the cygwin1.dll located in *cygwin/bin* with the version included in the *tools/OpenOCD/bin* folder.



- iv. Keep this OpenOCD server unclosed and open another Cygwin terminal for **debugging or downloading** via GDB

Alternatively, you can execute **run\_openocd.bat** batch file to open OpenOCD server. However, when using it for the first time, you need to manually setup the gdb server to openocd in Cygwin terminal before running **run\_openocd.bat**.

> make setup GDB\_SERVER=openocd

```
$ make setup GDB_SERVER=openocd
make[1]: Entering directory '/cygdrive/d/Projects/ameba/sdk/v7.1a/project/realtek_amebaz2_v0_example/GCC-RELEASE'
-----
Setup openocd
-----
cp -p ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_debug_openocd.txt ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_debug.txt
cp -p ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_flashloader_openocd.txt ../../component/soc/realtek/8710c/misc/gcc_utility/rtl_gdb_flashloader.txt
make[1]: Leaving directory '/cygdrive/d/Projects/ameba/sdk/v7.1a/project/realtek_amebaz2_v0_example/GCC-RELEASE'
```

> run\_openocd.bat

```

C:\> C:\WINDOWS\system32\cmd.exe
G:\7.1\project\realtek_amebaz2_v0_example\GCC-RELEASE>taskkill /F /IM openocd.exe
ERROR: The process "openocd.exe" not found.

G:\7.1\project\realtek_amebaz2_v0_example\GCC-RELEASE>openocd -s ..\..\..\component\soc\realtek\8710c\misc\gcc_utility\openocd -f amebaz2.cfg
Open On-Chip Debugger 0.10.0
Licensed under GNU GPL v2
For bug reports, read
    http://openocd.org/doc/doxygen/bugs.html
Info : auto-selecting first available session transport "swd". To override use 'transport select <transport>'.
adapter speed: 500 kHz
adapter_nsrst_delay: 200
cortex_mx3 reset_config sysresetreq
Info : CMSIS-DAP: SWD Supported
Info : CMSIS-DAP: Interface Initialised (SWD)
Info : CMSIS-DAP: FW Version = 1.0
Info : SWCLK/TCK = 1 SWDIO/TMS = 1 TDI = 0 TDO = 0 nTRST = 0 nRESET = 1
Info : CMSIS-DAP: Interface ready
Info : clock speed 500 kHz
Info : SWD DPIDR 0x6ba02477
Info : security extensions detected
Info : rtl8710c.cpu: hardware has 2 breakpoints, 1 watchpoints
target halted due to debug-request, current mode: Thread
xPSR: 0x01000000 pc: 0x00000000 msp: 0x1003fa00
----- TargetName      Type      Endian TapName      State -----
0* rtl8710c.cpu      cortex_mx3 little rtl8710c.cpu      halted

```

### 3.2.3.3 Setups on Linux OS

Here is the setup guide for compiling and installing the latest version OpenOCD from github source code. (below steps are verified under 16.04.1-Ubuntu and git://git.code.sf.net/p/openocd/code# 0a11537b3220749107f4ec78c76236ac8c9339d1.)

**Firstly**, we assume that you have access to root privileges, and you need to install some required packages. The packages include git, gcc build environment, usb-related libraries:

```
$ sudo apt-get install git build-essential g++ autotools-dev make libtool pkg-config autoconf automake texinfo libudev-dev libusb-1.0-0-dev libfox-1.6-dev
```

**Secondly**, we need to install HIDAPI library before OpenOCD. HIDAPI is a library which allows applications to interface with USB devices. You can refer <http://www.signal11.us/oss/hidapi/> for more information about it. To install it, we are going to clone the git project and compile it:

```
$ cd ~/
$ git clone https://github.com/signal11/hidapi.git or https://github.com/libusb/hidapi
$ cd hidapi/
$ ./bootstrap
$ ./configure
$ make
$ sudo make install
```

Note: Errors such as “configure.ac:16: error: AC\_CONFIG\_MACRO\_DIR can only be used once” caused by hidapi code, use <https://github.com/libusb/hidapi> to clone the latest version to avoid this issue.

After typing above commands, the HIDAPI should be installed. But we still need to add the location of the hid library into system PATH variable. For Ubuntu, please use an editor to open ~/.profile file:

```
$ vim ~/.profile
```

And at the bottom of .profile, please add the following line:

```
PATH="$HOME/bin:/usr/local/lib:$PATH"
```

```
# ~/.profile: executed by the command interpreter for login shells.
# This file is not read by bash(1), if ~/.bash_profile or ~/.bash_login
# exists.
# see /usr/share/doc/bash/examples/startup-files for examples.
# the files are located in the bash-doc package.

# the default umask is set in /etc/profile; for setting the umask
# for ssh logins, install and configure the libpam-umask package.
#umask 022

# if running bash
if [ -n "$BASH_VERSION" ]; then
    # include .bashrc if it exists
    if [ -f "$HOME/.bashrc" ]; then
        . "$HOME/.bashrc"
    fi
fi

# set PATH so it includes user's private bin if it exists
if [ -d "$HOME/bin" ] ; then
    PATH="$HOME/bin:$PATH"
fi

PATH="$HOME/bin:/usr/local/lib:$PATH"
```

To reload the PATH variable, you can use below command:

```
$ source ~/.profile
```

And you can use echo command to check the updated content of PATH variable:

```
$ echo $PATH
```

```
realtek@realtek-VirtualBox:~$ echo $PATH
/home/realtek/bin:/usr/local/lib:/usr/local/sbin:/usr/local/bin:/usr/usr/sbin:/usr/bin:/sbin:/bin:/usr/games
```

We also need to update our system shared library cache by following command:

```
$ sudo ldconfig
```

**Finally**, we are going to compile and install OpenOCD library after we installed HIDAPI:

```
$ cd ~/
$ git clone git://git.code.sf.net/p/openocd/code openocd-code
$ cd openocd-code/
$ ./bootstrap
```

Since we are using OpenOCD/CMSIS-DAP, we only enable its corresponding configuration:

```
$ ./configure --enable-cmsis-dap --disable-gccwarnings
$ make
$ sudo make install
```

At this point, we have installed the newest OpenOCD library and the OpenOCD/CMSIS-DAP connection should be able to work.

You can use -v command to check its version:

```
$ openocd -v
```

```
realtek123@ubuntu:~/sdk-ameba-v7.1d_v2/project/realtek_amebaz2_v0_example/GCC-RELEASE$ openocd -v
Open On-Chip Debugger 0.10.0+dev-01060-g0a11537 (2020-02-17-10:27)
Licensed under GNU GPL v2
For bug reports, read
  http://openocd.org/doc/doxygen/bugs.html
```

Here is another setup guide installing the latest version OpenOCD from official package management. (below steps are verified under 22.04.1-Ubuntu and openocd0.11.0.)

You can install openocd by:

```
$ sudo apt-get install openocd
```

Now if above steps are done successfully, you can run below command to start OpenOCD Debugger

```
$ sudo ./run_openocd.sh
```

If everything is fine, you will see below logs

```
realtek123@ubuntu:~/sdk-ameba-v7.1d_v2/project/realtek_amebaz2_v0_example/GCC-RELEASE$ sudo ./run_openocd.sh
Open On-Chip Debugger 0.10.0+dev-01060-g0a11537 (2020-02-17-10:27)
Licensed under GNU GPL v2
For bug reports, read
    http://openocd.org/doc/doxygen/bugs.html
Info : auto-selecting first available session transport "swd". To override use 'transport select <transport>'.
DEPRECATED! use 'adapter speed' not 'adapter_khz'
DEPRECATED! use 'adapter srst delay' not 'adapter_nsrst_delay'
cortex_m reset_config sysresetreq

Info : Listening on port 6666 for tcl connections
Info : Listening on port 4444 for telnet connections
Info : CMSIS-DAP: SWD Supported
Info : CMSIS-DAP: FW Version = 1.0
Info : CMSIS-DAP: Interface Initialised (SWD)
Info : SWCLK/TCK = 1 SWDIO/TMS = 0 TDI = 0 TDO = 0 nTRST = 0 nRESET = 1
Info : CMSIS-DAP: Interface ready
Info : clock speed 500 kHz
Info : SWD DPIDR 0x6ba02477
Info : rtl8710c.cpu: hardware has 2 breakpoints, 1 watchpoints
Info : rtl8710c.cpu: external reset detected
Info : Listening on port 3333 for gdb connections
```

But if you get below logs, please check your board connection.

```
realtek123@ubuntu:~/sdk-ameba-v7.1d_v2/project/realtek_amebaz2_v0_example/GCC-RELEASE$ sudo ./run_openocd.sh
[sudo] password for realtek123:
Open On-Chip Debugger 0.10.0+dev-01060-g0a11537 (2020-02-17-10:27)
Licensed under GNU GPL v2
For bug reports, read
    http://openocd.org/doc/doxygen/bugs.html
Info : auto-selecting first available session transport "swd". To override use 'transport select <transport>'.
DEPRECATED! use 'adapter speed' not 'adapter_khz'
DEPRECATED! use 'adapter srst delay' not 'adapter_nsrst_delay'
cortex_m reset_config sysresetreq

Info : Listening on port 6666 for tcl connections
Info : Listening on port 4444 for telnet connections
Error: unable to find CMSIS-DAP device
```

### 3.3 Log UART Settings

To be able to start development with the demo board, Log UART must be connected properly.

Different versions of EVBs have different connections.

#### 3.3.1 EVB v2.0

By default, UART2 (GPIOA\_15 / GPIOA\_16, check figure 1-3) is used as system log UART. User needs to connect jumpers to J33 for **CON3 (FT232)** or **CON2 (DAP)**.

##### 1) Connection to log UART via FT232 (CON3):

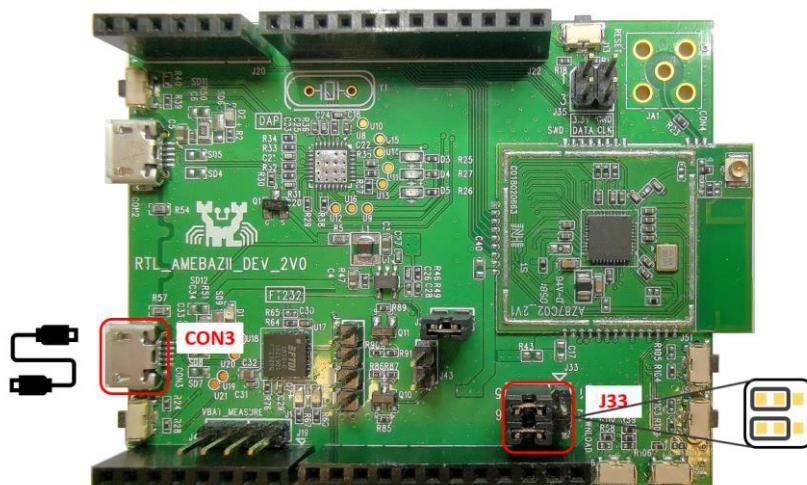


Figure 3-2 Log UART via FT232 on EVB V2.0

**2) Connection to log UART via DAP (CON2):**

**Note:** You need to check whether the **DAP Chip** is mounted on the board.

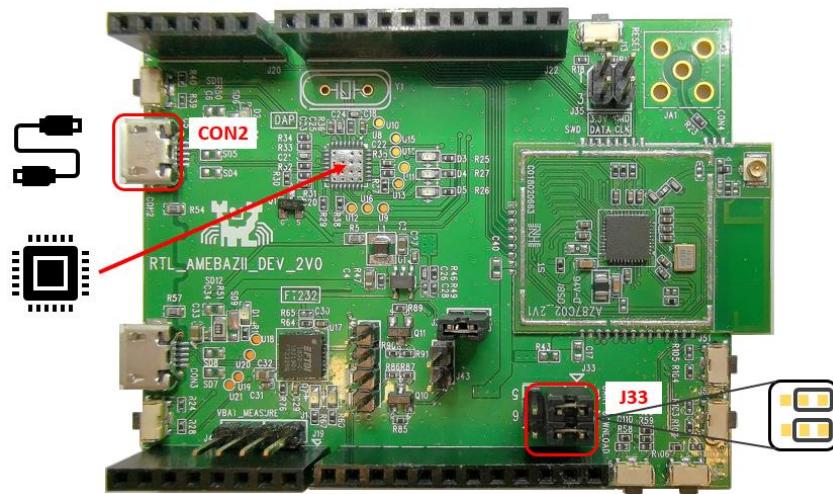


Figure 3-7 Log UART via DAP on EVB V2.0

## 3.4 IAR IDE Setup on Windows

The IAR IDE (integrated development environment) only supports Windows OS, this section is applicable for **Windows OS only**.

### 3.4.1 Install IAR IDE

IAR IDE provides the toolchain for Ameba-ZII. It allows users to write programs, compile and upload them to your board. Also, it supports step-by-step debug function.

User can visit the official website of **IAR Embedded Workbench** and install the IDE by following its instructions.

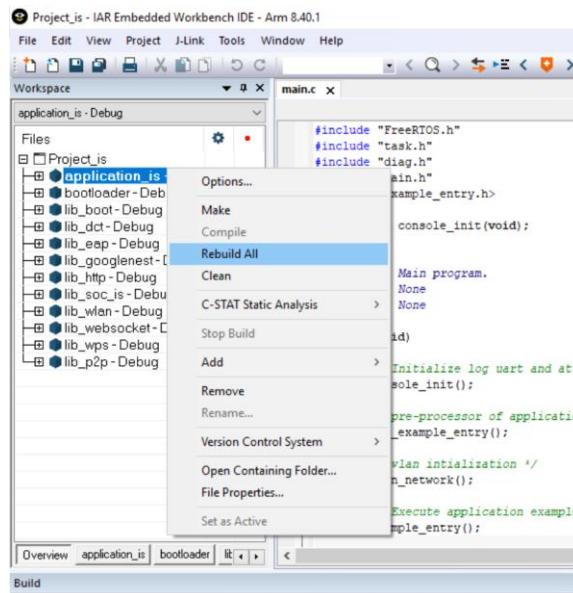
**Note:** Please use IAR version **8.30** or above.

### 3.4.2 Build Non-Trust Zone Project

Currently users can use **ignore secure mode**. ‘**project\_is.eww**’ (‘is’ means ignore secure) is the project without **TrustZone** configuration. This project is easier to develop and suit for first-time developer.

#### 3.4.2.1 Compilation

- 1) Open SDK/project/realtek\_amebaz2\_v0\_example/EWARM-RELEASE/Project\_is.eww.
- 2) Confirm ‘application\_is’ in Work Space, right click ‘application\_is’ and choose “**Rebuild All**” to compile.



- 3) Make sure there is no error after compile.

#### 3.4.2.2 Generate Image Binary

After compile, the images **partition.bin**, **bootloader.bin**, **firmware\_is.bin** and **flash\_is.bin** can be seen in the EWARM-RELEASE\Debug\Exe.

- 1) **partition.bin** stores partition table, recording the address of Boot image and firmware image;
- 2) **bootloader.bin** is bootloader image;
- 3) **firmware\_is.bin** is application image;
- 4) **flash\_is.bin** links partition.bin, bootloader.bin and firmware\_is.bin. Users need to choose flash\_is.bin when downloading the image to board by PG Tool.

### 3.4.2.3 Download

After a successfully compilation and ‘flash\_is.bin’ (ignore secure) is generated without error, user can either

- 1) Directly download the image binary on to demo board from IAR IDE (as below)

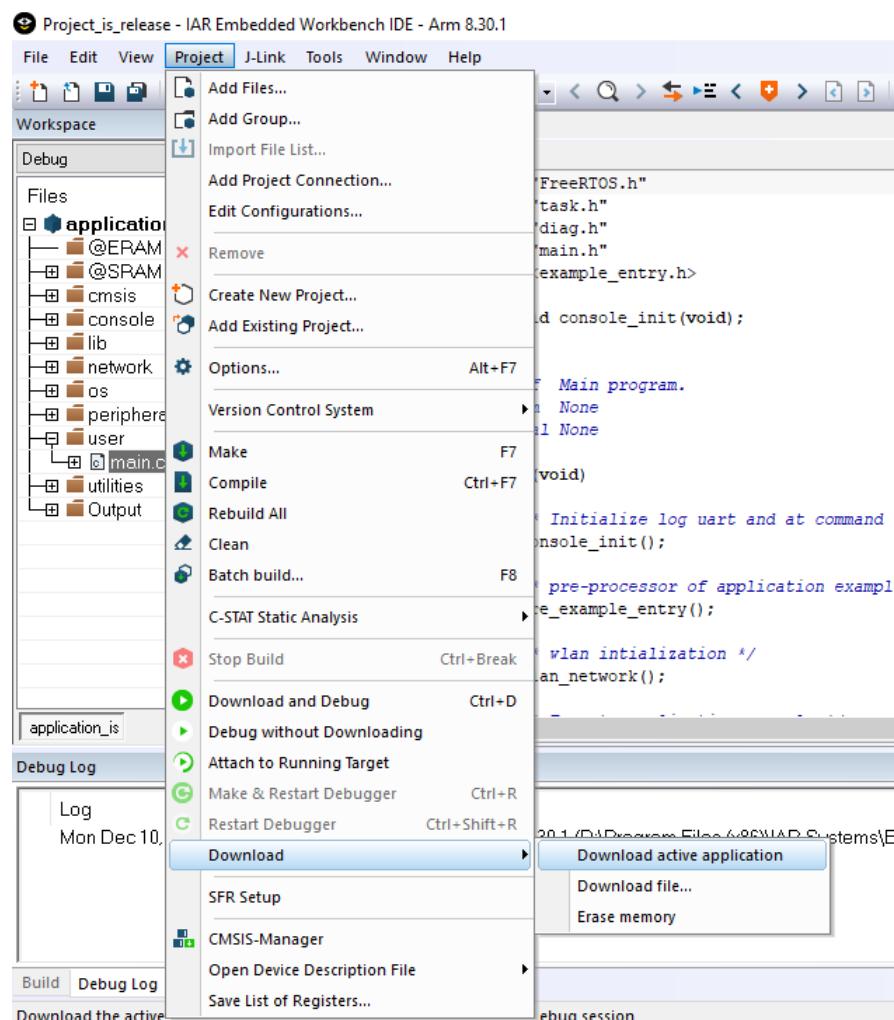


Figure 3-7 IAR download binary on flash

**Note:** Please ‘make’ the project first when some code is modified before download the bin file on the board, otherwise the download will fail and below logs will be shown.

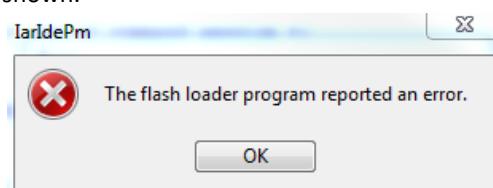


Figure 3-8 IAR download code on flash error message on IDE

```
Realtek Ameba-ZII Flash Loader Build @ 19:38:43, Nov 28 2018
DownloadingImage size <8b80980f> is invalid! Make sure the image is generated before the download
```

Figure 3-9 IAR download code on flash error message on Log UART

- 2) Or using the PG tool for Ameba-ZII (Will not be shown here, please check chapter Image Tool for details).

### 3.4.3 Build Trust Zone Project

If the project is building in **trust zone mode**, '**project\_tz.eww**' (tz means trust zone) is the project with trust zone configuration. The code can be decided as secure or not by putting the code to '**application\_s**' or '**application\_ns**'. Secure code can be executed by enabling **EXAMPLE\_TRUST\_ZONE** in **platform\_opts.h**.

#### 3.4.3.1 Compilation

- 1) Open SDK/project/realtek\_amebaz2\_v0\_example/EWARM-RELEASE/Project\_tz.eww.
- 2) Confirm '**application\_ns**' and '**application\_s**' are in Work Space.
- 3) Right click '**application\_s**' and click "**Rebuild All**" to compile '**application\_s**' first. If '**application\_s**' is compiled successfully, it will generate a file named '**application\_s\_import\_lib.o**' and the file will be put in "lib" folder of '**application\_ns**', shown in Figure 2-10.

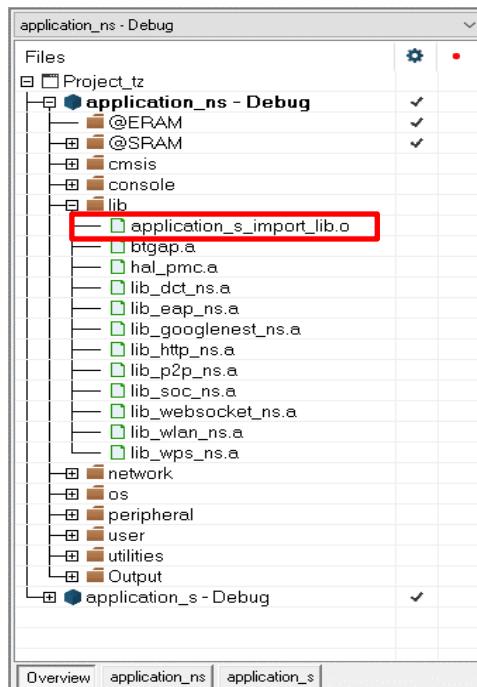


Figure 3-10 application\_s compile result

- 4) Make sure '**application\_s**' is compiled successfully and the file '**application\_s\_import\_lib.o**' has been put under "lib" in '**application\_ns**'.
- 5) Right click '**application\_ns**' and click "**Rebuild All**" to build '**application\_ns**'.
- 6) Make sure the '**application\_ns**' is compiled successfully.

#### 3.4.3.2 Generate Image Binary

After compile, the images **partition.bin**, **bootloader.bin**, **firmware\_tz.bin** and **flash\_tz.bin** can be seen in the **EWARM-RELEASE\Debug\Exe**.

- 1) **partition.bin** stores partition table, recording the address of Boot image and firmware image;
- 2) **bootloader.bin** is bootloader image;
- 3) **firmware\_tz.bin** is application image;
- 4) **flash\_tz.bin** links **partition.bin**, **bootloader.bin** and **firmware\_tz.bin**. Users need to choose **flash\_tz.bin** when downloading the image to board by PG Tool.

### 3.4.3.3 Download

After a successfully compilation and '**flash\_tz.bin**' is generated without error, user can either

- 1) Directly **download** the image binary on to demo board from IAR IDE (as below)

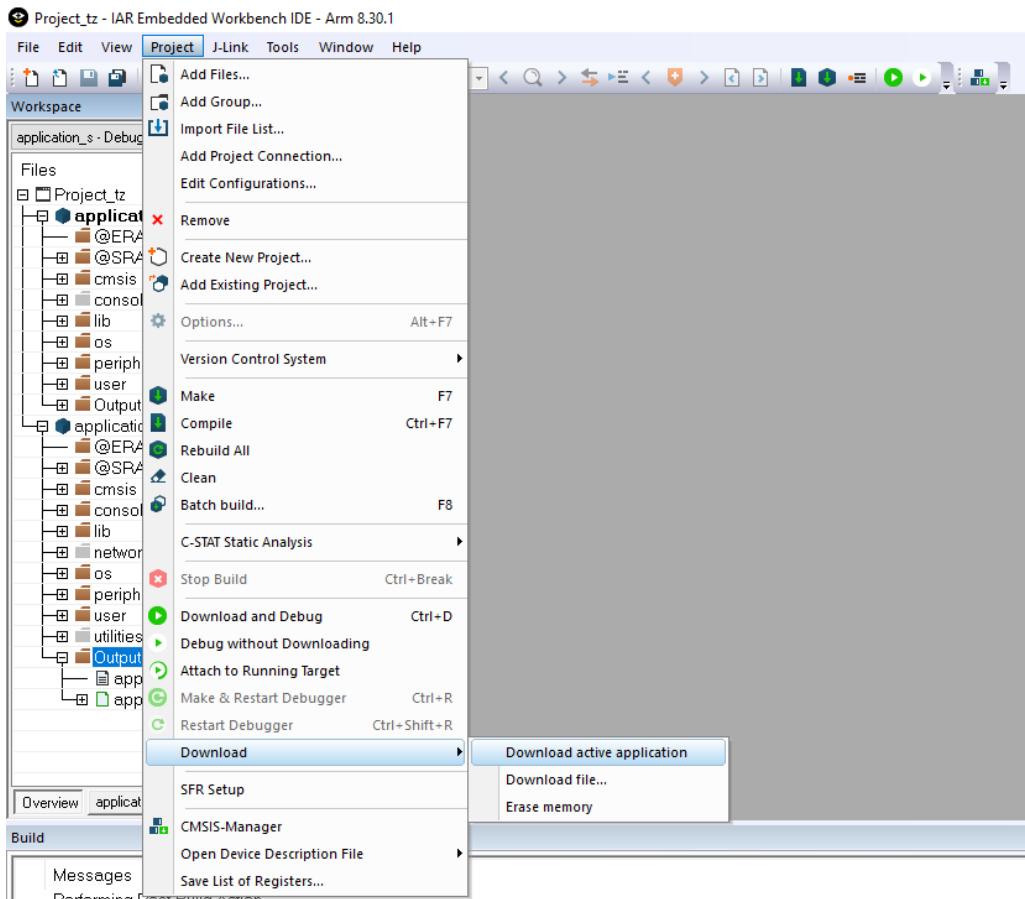


Figure 3-11 IAR download binary on flash

- 2) Or using the **PG tool** for Ameba-ZII (Will not be shown here, please check chapter Image Tool for details).

### 3.4.4 IAR Memory Configuration

The whole memory layout of Ameba-ZII can refer to chapter Memory Layout.

And there will be some extra configurations user needs to do if they want to put some code to certain memory region.

#### 3.4.4.1 Configure Memory from IAR IDE

In IAR Workspace, there are “@ERAM” and “@SRAM” group. “@ERAM” represents **external RAM**, which can be known as **PSRAM**. “@SRAM” represents **SRAM**. Except “@ERAM” and “@SRAM” group, the rest of read-only section (TEXT and RODATA) will be placed on **XIP**.

If users want to link a particular file into PSRAM (need to make sure that PSRAM is available), users can drag-and-drop the files into “@ERAM”. For example, “test.c” will be linked to PSRAM as the graph below. If users want to place specific source file into SRAM, users can drag-and-drop the files into “@SRAM”. For example, “flash\_api.c”, “flash\_fatfs.c”, “hal\_flash.c” is placed in SRAM as the graph below.

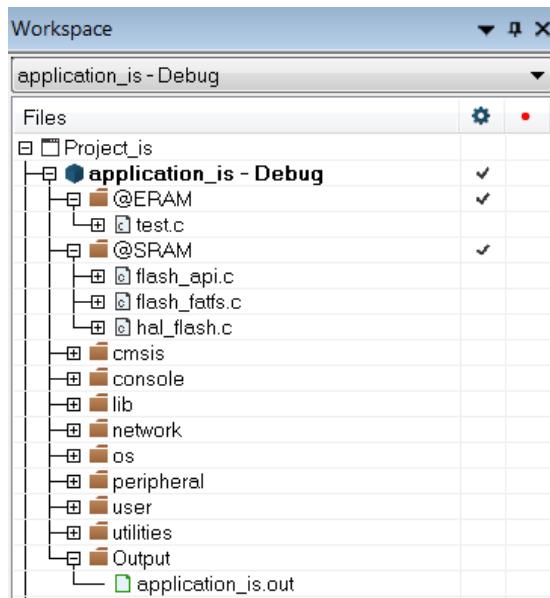


Figure 3-12 Overview of IAR Workspace

**Note:** There are some files which must NOT be linked to XIP section. Please keep the default settings of the IAR project if one doesn't know about this.

#### 3.4.4.2 Configure Memory from ICF File

IAR uses ICF (IAR Configuration File) to configure memory allocation so users can configure memory allocation by ICF file.

ICF file of Ameba-ZII locates: “SDK/project/realtek\_amebaz2\_v0\_example/EWARM-RELEASE/ application\_is.icf”

Open “application\_is.icf” with any text editor. There are some memory regions in it, which is:

- DTCM\_RAM\_region
- ERAM\_region
- XIP\_FLASH\_region

Users can reference IAR document if they don't know the format of ICF.

### 3.4.5 IAR Memory Overflow

In default, Ameba-ZII place read-only (TEXT and RODATA) section in XIP area. If XIP does not have enough space, it will show the errors as below while linking.

```
Error[Lp011]: section placement failed  
unable to allocate space for sections/blocks with a total estimated minimum size of 0x110'3e5e bytes  
(max align 0x8) in <[0x9b00'0140-0x9bff'ffff]> (total uncommitted space 0xff'fec0).
```

The solution is to either minimize the code or move the code to other memory region. Same rule applies to SRAM and PSRAM if it's available.

## 3.5 GCC IDE Setup on Windows (Using Cygwin)

### 3.5.1 Install Cygwin

**Cygwin** is a large collection of GNU and Open Source tools which provide the similar functionality as a Linux distribution on Windows. It provides the GCC toolchain for Ameba-ZII to compile projects.

User can visit the official website of Cygwin and install the software. Please use **Cygwin 32-bit** version.

**Note:**

- During the Cygwin installation, please install “**math**” “**bc: Arbitrary precision calculator language**”
- During the Cygwin installation, please install “**devel**” “**make: The GNU version of the ‘make’ utility**”

### 3.5.2 Build Non-Trust Zone Project

#### 3.5.2.1 Compile Project on Cygwin

- 1) Open “**Cygwin Terminal**”
- 2) Direct to compile path. Enter command “**cd /SDK/project/realtek\_amebaz2\_v0\_example/GCC-RELEASE**”
- 3) Clean up previous compilation files. Enter command “**make clean**”
- 4) Build all libraries and application. Enter command “**make all**”
- 5) Make sure there is no error after compile.

#### 3.5.2.2 Generate Image Binary

After compile, the images partition.bin, bootloader.bin, firmware\_is.bin and flash\_is.bin can be seen in different folders of \GCC-RELEASE.

- 1) **partition.bin** stores partition table, recording the address of Boot image and firmware image; located at folder \GCC-RELEASE;
- 2) **bootloader.bin** is bootloader image; located at folder \GCC-RELEASE\bootloader\Debug\bin;
- 3) **firmware\_is.bin** is application image; located at folder \GCC-RELEASE\application\_is\Debug\bin;
- 4) **flash\_is.bin** links partition.bin, bootloader.bin and firmware\_is.bin. Located at folder \GCC-RELEASE\application\_is\Debug\bin.

**Note:** Users need to choose ‘**flash\_is.bin**’ when downloading the image to board by **PG Tool**.

### 3.5.2.3 Download

After a successfully compilation and ‘**flash\_is.bin**’ is generated without error, user can either

- 1) Directly download the image binary on to demo board from Cygwin (as below)  
    Connect SWD to board and open “**JLinkGDBServer.exe**”. Please refer to Jlink debugger sector for SWD connection.  
    Enter command “**make flash**” at Cygwin.
- 2) Or using the **PG tool** for Ameba-ZII (Will not be shown here, please check chapter Image Tool for details).

## 3.5.3 Build Trust Zone Project

### 3.5.3.1 Compile

- 1) Open “**Cygwin Terminal**”.
- 2) Direct to compile path. Enter command “**cd /SDK /project/realtek\_amebaz2\_v0\_example/GCC-RELEASE**”.
- 3) Clean up previous compilation files. Enter command “**make clean**”.
- 4) Build all libraries and application. Enter command “**make tz**”.
- 5) Make sure there is no error after compile.

### 3.5.3.2 Generate Image Binary

After compile, the images partition.bin, bootloader.bin, firmware\_tz.bin and flash\_tz.bin can be seen in different folders of \GCC-RELEASE.

- 1) **partition.bin** stores partition table, recording the address of Boot image and firmware image; located at folder \GCC-RELEASE;
- 2) **bootloader.bin** is bootloader image; located at folder \GCC-RELEASE\bootloader\Debug\bin;
- 3) **firmware\_tz.bin** is application image; located at folder \GCC-RELEASE\application\_tz;
- 4) **flash\_tz.bin** links partition.bin, bootloader.bin and firmware\_tz.bin. Located at folder \GCC-RELEASE\application\_tz.

**Note:** Users need to choose ‘**flash\_tz.bin**’ when downloading the image to board by **PG Tool**.

### 3.5.3.3 Download

After a successfully compilation and ‘**flash\_tz.bin**’ is generated without error, user can either

- 1) Directly download the image binary on to demo board from **Cygwin** (as below)  
    Connect SWD to board and open “**JLinkGDBServer.exe**”. Please refer to ‘JLink section’ for SWD connection.  
    Enter command “**make setup GDB\_SERVER=jlink or pyocd**” to select GDB Server.  
    Enter command “**make flash\_tz**” at Cygwin.
- 2) Or using the **PG tool** for Ameba-ZII (Will not be shown here, please check chapter Image Tool for details).

### 3.5.3.4 Debug

After a successfully downloading, user can debug with pyOCD + DAPLink enabled HDK or using JLINKGDBServer + JLINK by following command:

“**make debug\_tz**”

**Note:** Before using “**make debug\_tz**”, “**make setup GDB\_SERVER=jlink or pyocd**” to select GDB Server is necessary.

### 3.5.4 GCC Memory Configuration

The whole memory layout of Ameba-ZII can refer to chapter Memory Layout.

There will be some extra configurations user needs to do if they want to put some code to certain memory region.

#### 3.5.4.1 Configure Memory from makefile

In application.is.mk, user can use below method to move object to DTCM\_RAM or PSRAM.

```
SRC_C += ../src/main.c

#SRAM
# -----
#@SRAM
SRAM_C += ../../component/common/mbed/targets/hal/rtl8710c/flash_api.c

#PSRAM
# -----
#@PSRAM
ERAM_C += ../../component/common/network/ssl/mbedtls-2.4.0/library/aesni.c
```

SRC\_C: in XIP by default

SRAM\_C: in DTCM\_RAM

ERAM\_C: in PSRAM

#### 3.5.4.2 Configure Memory from .ld File

Users can also configure memory allocation from .ld file.

The .ld file of Ameba-ZII locates at: "SDK/project/realtek\_amebaz2\_v0\_example/GCC-RELEASE/rtl8710c\_ram.ld"

Open "rtl8710c\_ram.ld" with any text editor. There are some memory regions in it, which are:

- DTCM\_RAM
- PSRAM
- XIP\_FLASH\_C
- XIP\_FLASH\_P

**Note:** Users can refer GCC document to understand the format of .ld file.

In .ld file, RODATA and (.text) are located in XIP section by default.

To put data or text in DTCM\_RAM, add prefix of sram section information in front of the object.

To put data or text in PSRAM, add prefix of psram section information in front of the object.

##### 3.5.4.2.1 Move text section of an object to DTCM\_RAM

```
.ram.code_text :
{
    ....
    /* Move text section of flash_api.c to DTCM_RAM */
    *flash_api*.o(.text*)
    ....
} > DTCM_RAM
```

### 3.5.4.2.2 Move text section of an object to PSRAM

```
.psram.code_text :  
{  
    .....  
    /* Move text section of aesni.c to PSRAM */  
    * aesni*.o(.text*)  
    .....  
} > PSRAM
```

### 3.5.4.2.3 Move text section of a library to PSRAM

```
.psram.code_text :  
{  
    .....  
    /* Move text section of lib_xxx.a to PSRAM, exclude object a/b/c */  
    *lib_xxx.a: (EXCLUDE_FILE (*a.o *b.o * c.o) .text*)  
    .....  
} > PSRAM
```

### 3.5.4.3 Configure Memory from C File

There are some section MACROS are already pre-defined in component/soc/Realtek/8710c/cmsis/rtl8710c/include/section\_config.h. User can use these MACROS to locate a specific function or variable to a specific memory location.

```
PSRAM_RODATA_SECTION  
const char user_pattern[12] = {  
    'H', 'e', 'l', 'l', 'o', '\0', 'W', 'o', 'r', 'l', 'd', '\0'  
};  
  
PSRAM_TEXT_SECTION  
void user_func (void)  
{  
    .....  
}
```

## 3.5.5 GCC Memory Overflow

By default, Ameba-ZII places read-only (TEXT and RODATA) section in the XIP area. If XIP does not have enough space, there will be memory overflow error. The **solution** is to either minimize the code or re-allocate the code to other memory region. Same rule applies to SRAM (DTCM\_RAM) and PSRAM (if it's available).

## 3.6 GCC Environment on Ubuntu/Linux

### 3.6.1 Verify Device Connections

Once the JLink software is installed, the connections to the ubuntu machine of the device need to be verified.

1. Ensure that the JLink debugger is connected to the target board and the USB device is connected to the Ubuntu/Linux machine.
2. Ensure that the micro-usb is connected to **CON3 (FT232)** and plugged into the Ubuntu/Linux machine via USB in order to receive serial logs.
3. To verify if both devices i.e. the JLink device and the device serial port have been detected properly we can use the “**lssub**” command to see list of devices as shown below:

```
parallels@ubuntu:~$ lssub
Bus 001 Device 009: ID 1366:0101 SEGGER J-Link PLUS
Bus 001 Device 005: ID 203a:ffffa
Bus 001 Device 004: ID 203a:ffffa
Bus 001 Device 003: ID 203a:ffffa
Bus 001 Device 002: ID 203a:ffff9
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 004 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 003 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 002 Device 002: ID 0403:6001 Future Technology Devices International, Ltd FT232 USB-Serial (UART) IC
Bus 002 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
parallels@ubuntu:~$
```

4. As you can see above the **SEGGER J-Link** and the **FT232 USB UART** device have been successfully detected.

### 3.6.2 Compile and Generate Binaries

1. Open the Ubuntu/Linux terminal.
2. Direct to compile path. Enter command “**cd /SDK /project/realtek\_amebaz2\_v0\_example/GCC-RELEASE**”
3. Clean up previous compilation files. Enter command “**make clean**”
4. Build all libraries and application. Enter command “**make all**”
5. Once the build is successful, you should be able to see the success logs as shown below.

```
[INFO] SECTION SET !!!!!
[INFO] 1d71e30 61d900 ffffffff
[INFO] Hash result: b7 d4 4a 60 a0 27 cf 09 6f ad d8 ba 03 d7 0c 55 01 15 9e fa bf 5d 28 db 09 30 2d 75 8a 42 9f f8
[INFO] PADDING TO 64B
[INFO]
[INFO] ././component/soc/realtek/8710c/misc/gcc_utility/elf2bin.linux      combine application_is/debug/bin/flash_is.bin PTAB=partition
[INFO] .bin,BOOT=bootloader/Debug/bin/bootloader.bin,FW1=application_is/Debug/bin/firmware_is.bin
PTAB ==> partition.bin
BOOT ==> bootloader/Debug/bin/bootloader.bin
FW1 ==> application_is/Debug/bin/firmware_is.bin
make[1]: Leaving directory '/home/parallels/sdk-ameba-v7.1a_rc4_gcc/project/realtek_amebaz2_v0_example/GCC-RELEASE'
parallels@ubuntu:~/sdk-ameba-v7.1a_rc4_gcc/project/realtek_amebaz2_v0_example/GCC-RELEASE$
```

### 3.6.3 Download and Flash Binaries

There are in-built scripts in the makefile that initiate download and flashing of the software via JLink. In order to flash successfully, the JLinkGDBServer needs to be initiated manually by the user and successful connection needs to be ensured. The JLink GDB server must be active and connected to the target before any type of flash action is taken. In order to start the JLink GDB server, follow the ‘**Steps to Initiate JLinkGDBServer**’ section.

#### 3.6.3.1 Initiate Flash Download

Once the JLink GDB server is set up as per the instructions given before, perform the following steps to initiate the flash download.

1. Proceed back to the previous terminal where the SDK was made, without closing the terminal from which GDB server is running
2. Run the command “**make setup GDB\_SERVER=jlink or pyocd**” to select GDB Server.
3. Run the command “**sudo make flash**”
4. If the flash download is successful, the following log will be printed

```
Flash Download done, exist  
A debugging session is active.  
Inferior 1 [Remote target] will be killed.  
Quit anyway? (y or n) [answered Y; input not from terminal]  
make[1]: Leaving directory '/home/parallels/sdk-ameba-v7.1a_rc4_gcc/project/realtek_amebazz_v0_example/GCC-RELEASE'  
parallels@ubuntu:~/sdk-ameba-v7.1a_rc4_gcc/project/realtek_amebazz_v0_example/GCC-RELEASE$ █
```

### 3.6.3.2 Debug

After a successfully downloading, user can debug with pyOCD + DAPLink enabled HDK or using JLINKGDBServer + JLINK by following command

“make debug\_tz”

Before using “make debug\_tz”, “make setup GDB\_SERVER=jlink or pyocd” to select GDB Server is necessary.

## 4 Image Tool

### 4.1 Introduction

This chapter introduces how to use Image Tool to generate and download images. As show in picture below, Image Tool has two menu pages:

- Download: used as image download server to transmit images to Ameba through UART.
- Generate: contact individual images and generate a composite image.

Please download the '**PG Tool Release Package**' and browse the image tool document '**UM0503**'.

**Note:** If you need to download code via external uart, must use **FT232** USB to connect UART dongle.

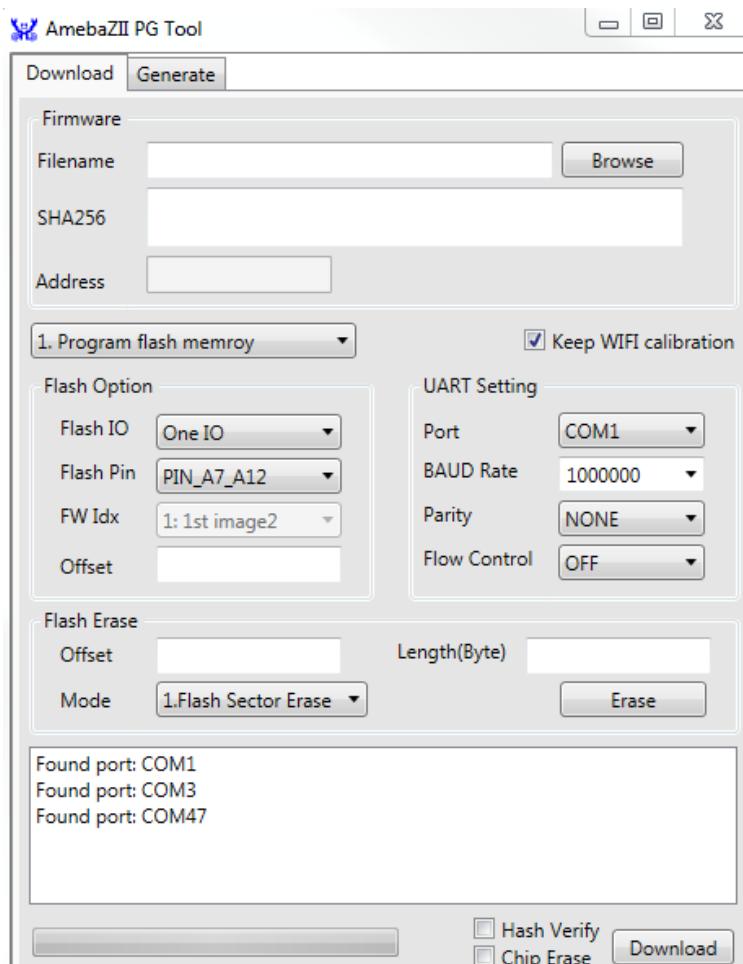


Figure 4-1 AmebaZII Image Tool UI

## 4.2 Environment Setup

### 4.2.1 Hardware Setup

#### 4.2.1.1 EVB V2.0

User needs to connect CON3 to user's PC via a Micro USB cable. Add jumpers for J34 and J33 (J33 is for log UART which has two jumpers) if there is no connection.

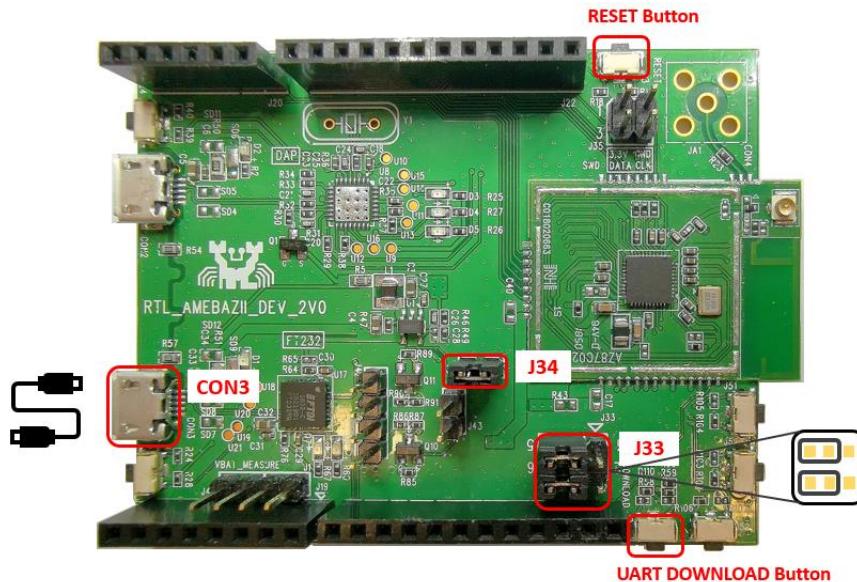


Figure 4-2 Ameba-ZII EVB V2.0 Hardware Setup

### 4.2.2 Software Setup

- Environment Requirements: EX. WinXP, Win 7 Above, Microsoft .NET Framework 3.5
- AmebaZII\_PGTool\_v1.0.1.exe

## 4.3 Image Download

User can download the image to demo board by following steps:

- 1) Trigger Ameba-ZII chip enter **UART download mode** by:
  - a. Press and hold the **UART DOWNLOAD** button then press the **RESET** button and release both buttons. And make sure the log UART is connected properly.
  - b. If the chip enters **download mode**, the below log should be shown on log UART console.

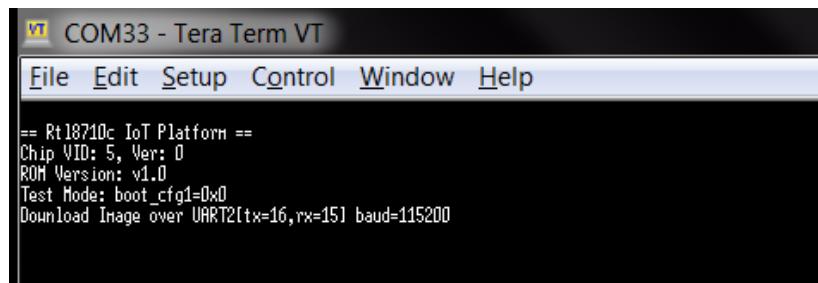
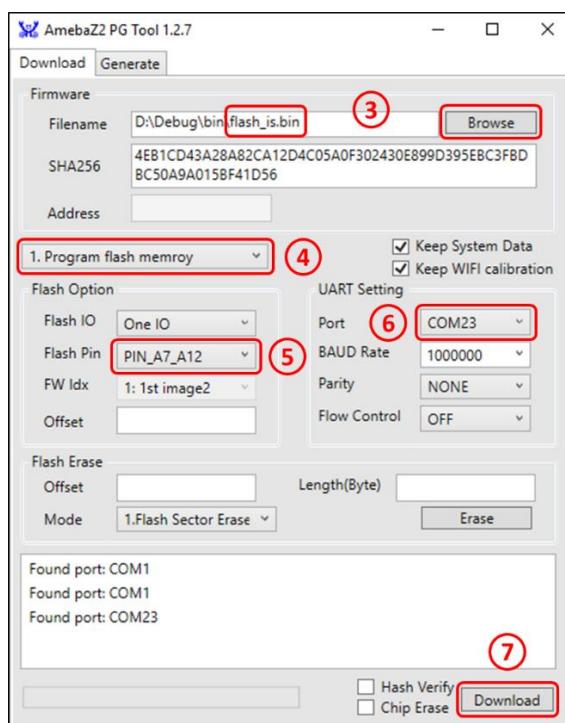


Figure 4-4 Ameba-ZII UART download mode

- c. After confirming it is in download mode, **remember to disconnect the log UART console before using Image Tool to download**, because the tool will also need to connect to this log UART port.

### 2) Open AmebaZ2 PG Tool



- 3) “Browse” to choose the image to be downloaded (flash\_xx.bin)

- 4) Choose “1. Program flash memory”

- 5) Choose correct “Flash Pin” according to the IC part number

| Flash Pin  | IC part number      |
|------------|---------------------|
| PIN_A7_A12 | RTL8710CX/RTL8720CM |
| PIN_B6_B12 | RTL8720CF           |

- 6) Choose the correct **UART port** (use **rescan** to update the port list)

- 7) Click “**Download**” to start downloading image. While downloading, the status will be shown on the left bar.

**Note:** It's recommended to use the default settings unless user is familiar with them.

## 5 Memory Layout

This chapter introduces the memory components in Ameba-ZII, including ROM, RAM, SRAM, PSRAM and Flash. Also, this chapter provides a guide for users to place their program to specific memory to fit user's requirement. However, some programs are fixed in specific memory and cannot be moved.

### 5.1 Memory Type

The size and configuration are as shown below

|              | Size(bytes) | Description  |
|--------------|-------------|--|
| <b>ROM</b>   | 384K        | Reserved   |
| <b>RAM</b>   | 256K        | Internal DTCM  |
| <b>PSRAM</b> | 4M          | MCM PSRAM, only available on RTL8720CM   |
| <b>XIP</b>   | 16M         | Execute in Place, section TEXT and RODATA, virtual address remapped by SCE (Secure Code Engine). Physical address of Flash starts from 0x98000000 which can refer to the datasheet for more details. |

Table 5-1 Size of Different Memories on Ameba-ZII

The graph of configuration on Ameba-ZII is as shown below:

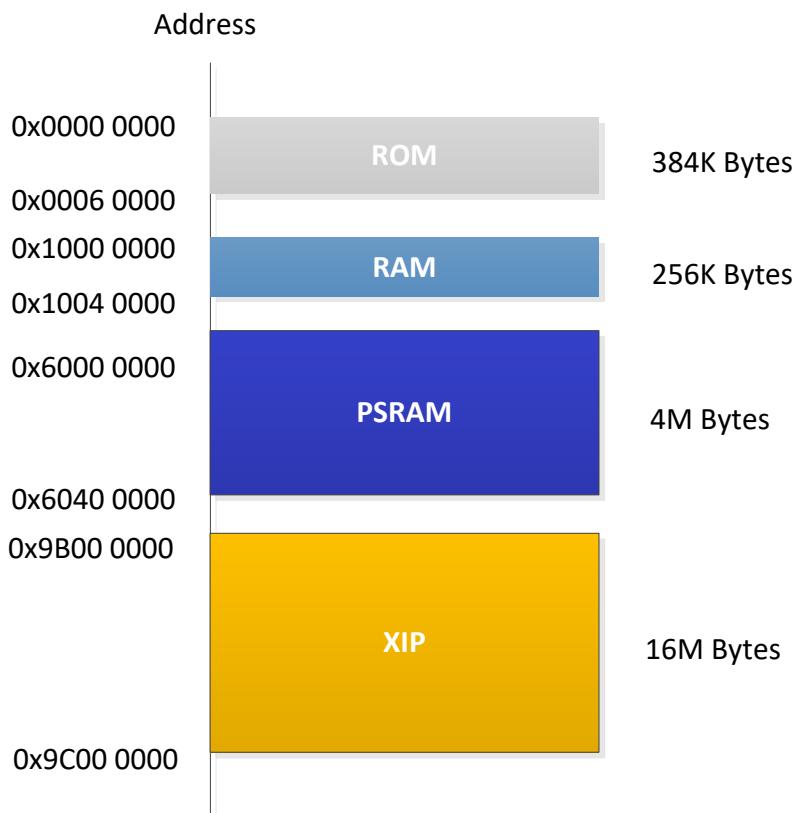


Figure 5-1 Address Allocation of Different Memories on Ameba-ZII

## 5.2 Flash Memory Layout

The default flash layout used in SDK is shown in below figure.

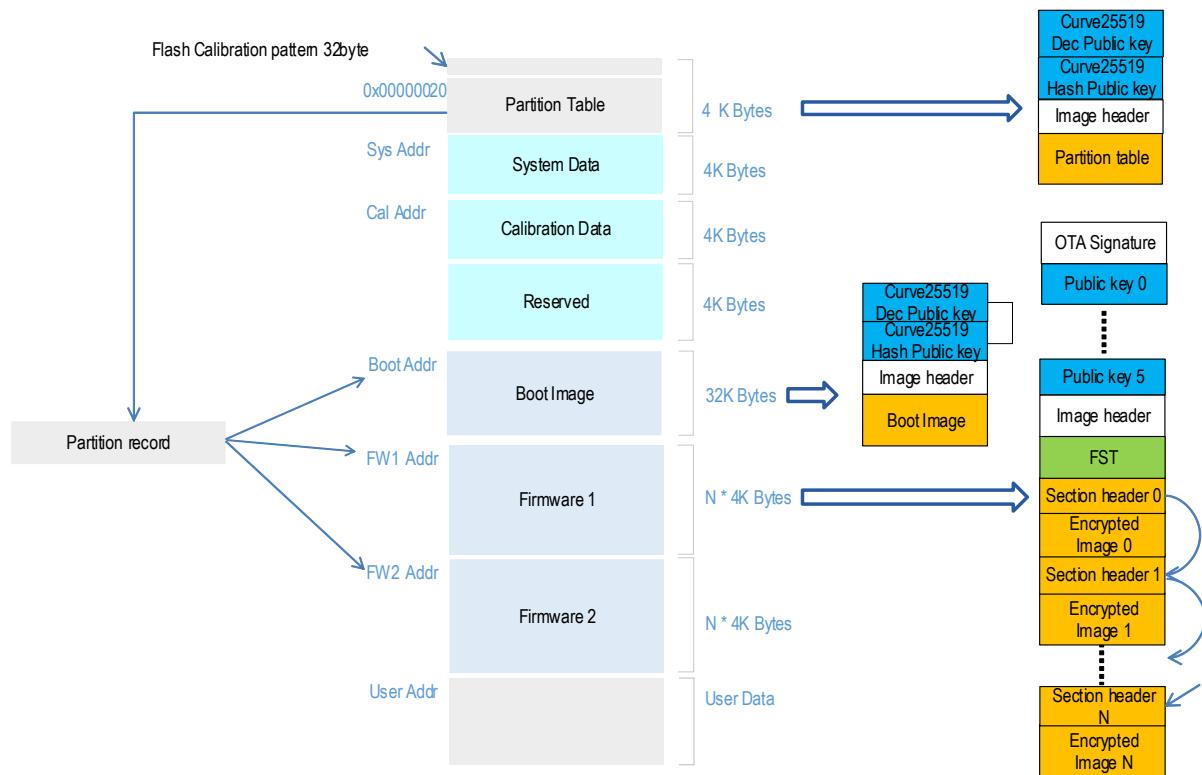


Figure 5-2 Flash memory layout

And the description of each block is listed in table below.

| Items            | Start Offset Address | Limit Offset Address            | Address adjustable | Size             | Description  | Mandatory |
|------------------|----------------------|---------------------------------|--------------------|------------------|--|-----------|
| Partition table  | 0x00000000           | 0x00001000-1                    | N                  | 4KB              | The first 32 bytes is flash calibration pattern. The actual partition table starts from 0x20 | Y         |
| System data      | 0x00001000           | 0x00002000-1                    | N                  | 4KB              | To store some system settings  | Y         |
| Calibration data | 0x00002000           | 0x00003000-1                    | N                  | 4KB              | RESERVED, user don't need to configure this portion  | Y         |
| Reserved         | 0x00003000           | 0x00004000-1                    | N                  | 4KB              | RESERVED, user don't need to configure this portion  | Y         |
| Boot image       | 0x00004000           | 0x0000C000-1                    | Y                  | 32KB             | Bootloader code/data   | Y         |
| Firmware 1       | 0x0000C000           | 0x0000C000 + $N * 4\text{KB}-1$ | Y                  | $N * 4\text{KB}$ | Application image  | Y         |

Table 5-2 Description of flash layout

## 5.2.1 Partition Table

### 5.2.1.1 The Layout of Partition Table

The partition table stores following information:

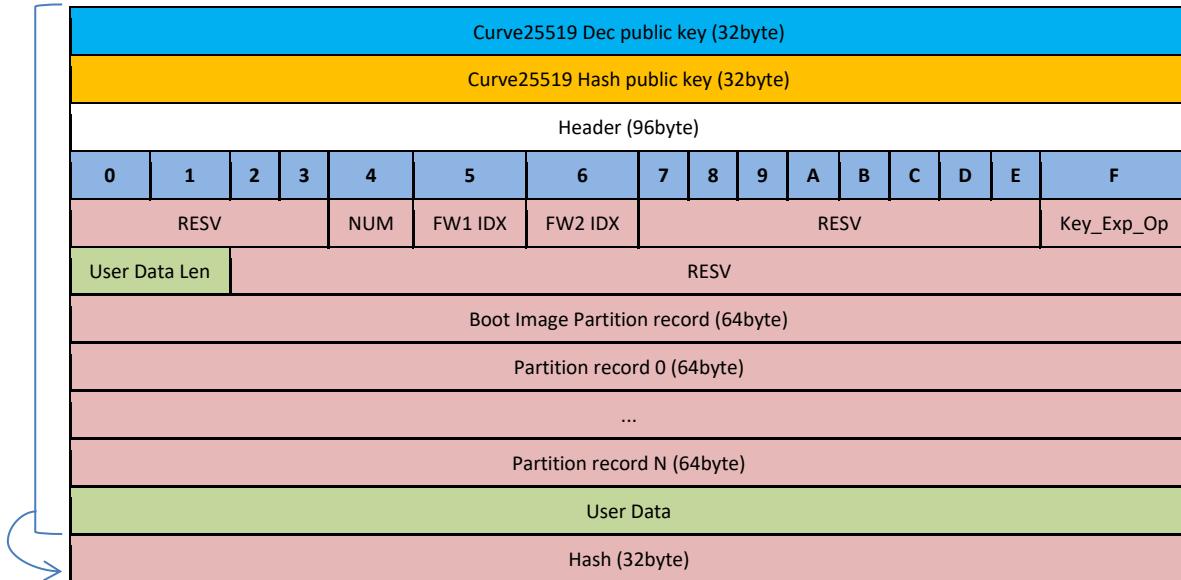


Table 5-3 The layout of Partition table

- **Curve25519 Dec public key:** the public key used to generate AES key to decrypt image
- **Curve25519 Hash public key:** the public key used to generate Hash key to validate the hash value
- **Header:** partition table image header
- Partition table image info
  - **NUM:** The record number in the partition table, not including “Boot Image Partition record”
  - **FW1/FW2 IDX:** FW1/FW2 Partition record index
  - **Key\_Exp\_Op [2:0]**
    - 1: Export AES keys of the latest FW
    - 2: Export AES keys for both FW1 & FW2
    - Other: Don’t export any AES to RAM code
- **User Data Len:** the length (in bytes) of user data
- Partition record x (includes boot image partition record)
 

|               |   |           |   |        |   |   |   |      |          |      |   |   |   |   |   |
|---------------|---|-----------|---|--------|---|---|---|------|----------|------|---|---|---|---|---|
| 0             | 1 | 2         | 3 | 4      | 5 | 6 | 7 | 8    | 9        | A    | B | C | D | E | F |
| Start address |   |           |   | Length |   |   |   | TYPE | DBG_SKIP | RESV |   |   |   |   |   |
| HKeyValid     |   | RESV [15] |   |        |   |   |   |      |          |      |   |   |   |   |   |
| Hash key      |   |           |   |        |   |   |   |      |          |      |   |   |   |   |   |
| Hash Key      |   |           |   |        |   |   |   |      |          |      |   |   |   |   |   |

  - **Start address:** the offset address on Flash for the image
  - **Length:** the length of the image, align to 4K
  - **TYPE:** type of the image (Pt=0/boot/sys/cal/user/fw1/fw2/resv)
  - **DBG\_SKIP:** skip download to ram from flash when debug mode is enabled
  - **HKeyValid:** indicates the Hash Key is valid (bit [0]! = 0) or not(bit [0] = 0)
  - **Hash key:** to do all firmware validation (from first byte to end)
- **User Data:** user secret data
- **Hash:** from the first byte of partition table to the end of user data (two public keys + Header + partition info + partition records + user data), calculated before encryption if the encryption is on

## 5.2.2 System Data

System data section is the one which stores some system settings, including OTA section, Flash section, Log UART section etc...

The size of system data section is 4KB.

| Offset            | 0x00                           | 0x04                                 | 0x08          | 0x0C |
|-------------------|--------------------------------|--------------------------------------|---------------|------|
| 0x00              | RSVD                           | RSVD                                 | Force old OTA | RSVD |
| 0x10              | RSVD                           | RSVD                                 | RSVD          | RSVD |
| 0x20              | WORD1: RSVD<br>WORD0: SPI Mode | WORD1: Flash Size<br>WORD0: Flash ID | RSVD          | RSVD |
| 0x30              | ULOG Baudrate                  | RSVD                                 | RSVD          | RSVD |
| 0x40<br>~<br>0x70 |                                | RSVD (SPIC calibration setting)      |               |      |
| ...               |                                | RSVD                                 |               |      |
| 0xFF0             |                                | BT Parameter Data                    |               |      |

Table 5-4 Layout of system data

### 5.2.2.1 OTA Section

| Offset | Bit    | Function      | Description   |
|--------|--------|---------------|---|
| 0x00   | [31:0] | RSVD          | RSVD  |
| 0x04   | [31:0] | RSVD          | RSVD  |
| 0x08   | [31:8] | RSVD          | RSVD  |
|        | [7:0]  | Force old OTA | Select GPIO to force booting from old OTA image. Available GPIO pins may vary from different Chip part number.<br>(GPIOA2~6, GPIOA13)<br>BIT[7]: active_state, 0 or 1<br>BIT[6]: RSVD<br>BIT[5]: port<br>BIT[4:0]: pin number |
| 0x0C   | [31:0] | RSVD          | RSVD  |

Table 5-5 Definition for OTA section in system data

#### 5.2.2.1.1 Force Old OTA

The platform provides a “Force old OTA” option to let user roll back to the previous OTA image by using a GPIO pin as trigger. Please note that if secure boot enabled, “key\_exp\_op” from *partition.json* need set as 2 to export both FW1 & FW2 AES key, to prevent boot fail when user try to roll back to previous image.

### 5.2.2.2 Flash Section

| Offset | Bit     | Function    | Description   |
|--------|---------|-------------|---|
| 0x20   | [31:16] | RSVD        | RSVD  |
|        | [15:0]  | SPI IO Mode | 0xFFFF: Quad IO mode<br>0x7FFF: Quad Output mode<br>0x3FFF: Dual IO mode<br>0x1FFF: Dual Output mode<br>0x0FFF: One IO mode |
| 0x24   | [31:16] | Flash Size  | 0xFFFF: 2MB<br>0x7FFF: 32MB<br>0x3FFF: 16MB<br>0x1FFF: 8MB<br>0x0FFF: 4MB<br>0x07FF: 2MB<br>0x03FF: 1MB                     |
|        | [15:0]  | Flash ID    | Use it only if the flash ID cannot get by flash ID cmd  |
| 0x28   | [31:0]  | RSVD        | RSVD  |
| 0x2C   | [31:0]  | RSVD        | RSVD  |

Table 5-6 Definition for Flash section in system data

### 5.2.2.3 Log UART Section

| Offset | Bit    | Function | Description                        |
|--------|--------|----------|------------------------------------|
| 0x30   | [31:0] | Baudrate | 0xFFFFFFFF: 115200<br>110~40000000 |
| 0x34   | [31:0] | RSVD     | RSVD                               |
| 0x38   | [31:0] | RSVD     | RSVD                               |
| 0x3C   | [31:0] | RSVD     | RSVD                               |

Table 5-7 Definition for Log UART section in system data

## 5.2.3 Boot Image

### 5.2.3.1 The Layout of Boot Image

The format of the boot image is as below:

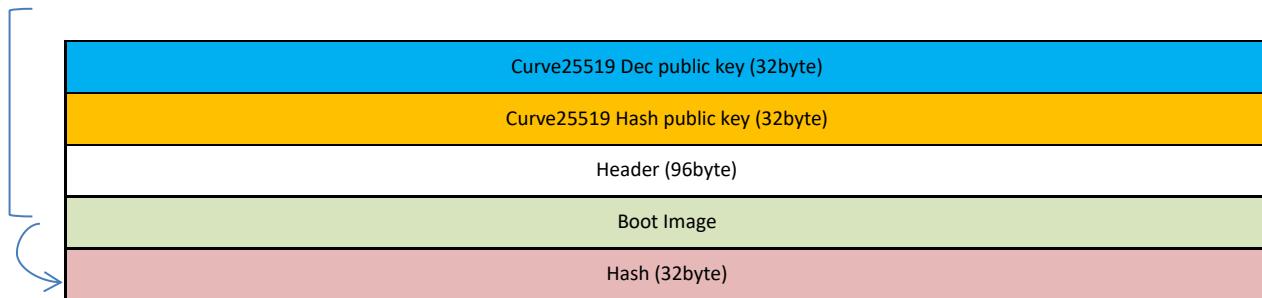


Table 5-8 The layout of boot image

- Curve25519 Dec public key: the public key used to generate AES key to decrypt image
- Curve25519 Hash public key: the public key used to generate Hash key to validate the hash value
- Header: boot image header
- Boot Image: boot image body (TEXT+DATA), will be padded with 0 to make its size is multiple of 32 bytes.
- Hash: two public keys + Header + Boot Image, calculated before encryption if image encryption is on

## 5.2.4 Firmware 1/Firmware 2

### 5.2.4.1 The Layout of Firmware Image

The format of the Firmware image is as below:



Table 5-9 The layout of firmware image

- **OTA signature:** The hash result of the 1<sup>st</sup> Image header “Sub FW Image 0 Header”
- **Public key 0 ~ 5:** Encryption key
  - key 0 is dedicated to enc/dec all “OTA signature/Header/FST”
  - key 1~5 are reserved
- **Sub-image x Header:** image header of FW sub-image x
- **Sub-image x FST:** Firmware Security Table of FW sub-image x
  - Each sub-image has image sections which have a section header and a section image body
- **Hash:** calculated with Encrypted FW image if image encryption is on
  - The 1<sup>st</sup> sub-image
    - From OTA Signature to the last image section, including all padding bytes
  - Other sub-image
    - From the sub image header to the last image section, including all padding bytes

### 5.2.4.2 How to Generate Flash Image Combines Both Firmware1 and Firmware2

There may be requirements need to generate flash image combines both firmware1 and firmware2. The default set of AmebaZ2 flash image contains partition table, boot image, and firmware1 image. In order to add firmware2 image to flash image, extra configurations need to be done.

- Prepare firmware2 image.

Please note that there is serial number needs to be customized for firmware2 image. Refer to “*7.4.2 Configuration for building OTA firmware*” for details of the serial number setting.

**Note:** that default serial number is “100”, any number larger than “100” will set firmware2 image as default for flash image otherwise firmware1 image is default.

Add firmware2 image at “project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE\Debug\Exe”

- Update “postbuild\_is.bat” for combines firmware1 and firmware2

Add “FW2=Debug\Exe\firmware2\_is.bin” after “FW1=Debug\Exe\firmware\_is.bin” at “component\soc\realtek\8710c\misc\iar\_utility\postbuild\_is.bat” refers the following table

```
::generate flash image, including partition + bootloader + firmware
%tooldir%\elf2bin.exe combine Debug/Exe/flash_is.bin
PTAB=Debug\Exe\partition.bin,BOOT=Debug\Exe\bootloader.bin,FW1=Debug\Exe\firmware_is.bin,FW2=Debug\Exe\firmware2_is.bin >> postbuild_is_log.txt
if not exist Debug\Exe\flash_is.bin (
    echo flash_is.bin isn't generated, check postbuild_is_log.txt
    echo flash_is.bin isn't generated > postbuild_is_error.txt
    goto error_exit
)
```

**Note:** that firmware2 image must have the same name as the code added in “postbuild\_is.bat”.

- Generate and download flash image

Please refer to “*3.4.2 Build Non-Trust Zone Project*” for generate flash image. The firmware1 image is auto generated when generating flash image. The generated image (“flash\_is.bin”) is the flash image combines both firmware1 and firmware2. Please note that the flash image is only downloadable by Image Tool. Refer to “*4.3 Image Download*” for details of using Image Tool downloading.

- Switch between firmware1 image and firmware2 image

To switch firmware1 image and firmware2 image please refer to ATCMD “ATSC” and “ATSR” which is detailed in “AN0075 Realtek Ameba-all at command v2.0.docx”.

## 5.3 SRAM Layout

The range of DTCM is from 0x10000000 to 0x10040000. The layout of this memory region is illustrated below.

Note: the layout may be changed according to actual application, please refer to the linker file for exact layout details.

|            |                     |
|------------|---------------------|
| 0x10000000 | Vector Table        |
| 0x100000A0 | Reserved for ROM    |
| 0x10000480 | RAM Entry Table     |
| 0x100004F0 | RAM Image Signature |
| 0x10000500 | Image2 RAM          |
| 0x10030000 | RAM Bootloader      |
| 0x1003EA00 | MSP                 |
| 0x1003FA00 | Reserved for ROM    |
| 0x1003FFFF |                     |

Table 5-10 AmebaZII DTCM (256KB) memory layout

| Items               | Start Offset Address | Limit Offset Address | Address adjustable | Size   | Description   | Mandatory |
|---------------------|----------------------|----------------------|--------------------|--------|---|-----------|
| Vector Table        | 0x10000000           | 0x100000A0 -1        | N                  | 160B   | The vector table  | Y         |
| Reserved for ROM    | 0x100000A0           | 0x10000480-1         | N                  | 992B   | Reserved for ROM code                                       | Y         |
| RAM Entry Table     | 0x10000480           | 0x100004F0-1         | N                  | 112B   | Entry function table of Image 2                             | Y         |
| RAM Image Signature | 0x100004F0           | 0x10000500-1         | N                  | 16B    | RTK pattern for RAM Image                                   | Y         |
| Image2 RAM          | 0x10000500           | 0x10030000-1         | Y                  | ~190KB | User application image (TEXT+DATA+BSS+HEAP)                 | Y         |
| RAM Bootloader      | 0x10030000           | 0x1003EA00-1         | N                  | ~58KB  | RAM boot image, will be recycled by Image2 for BSS and HEAP | Y         |
| MSP                 | 0x1003EA00           | 0x1003FA00-1         | Y                  | 4KB    | CPU main stack  | Y         |
| Reserved for ROM    | 0x1003FA00           | 0x1003FFFF           | N                  | 1535B  | Reserved for ROM(NS) code                                   | Y         |

Table 5-11 Description of RAM layout

## 5.4 TrustZone Memory Layout

By default, the memory is marked as secure, unless the address matches a region defined in SAU (Security Attribution Unit) which is used to define several memory regions as non-secure or NSC (Non-Secure Callable).

AmebaZII support 4 SAUs, and the regions are configured for ROM, RAM, PSRAM and XIP, which covers all memory units. The total region and boundary for RAM, PSRAM and XIP are configurable. Below is the default configuration of each SAU.

- **SAU 0:** 0x00019000 ~ 0x0005ffff as Non-Secure
  - ROM. The region is fixed and must not be modified.
- **SAU 1:** 0x10008000 ~ 0x4fffffff as Non-Secure
  - RAM.
- **SAU 2:** 0x60100000 ~ 0x9bfefeff as Non-Secure
  - PSRAM and XIP share SAU2. The start address of SAU2 must be located in PSRAM and the end address of SAU2 must be located in XIP
- **SAU 3:** 0x9bf00000 ~ 0x9bffff as Secure (NSC)
  - XIP. NSC is suggested to be located at the end (end is 0x9c00 0000)

Thus, if the TrustZone is enabled, the system memory layout will become as below.

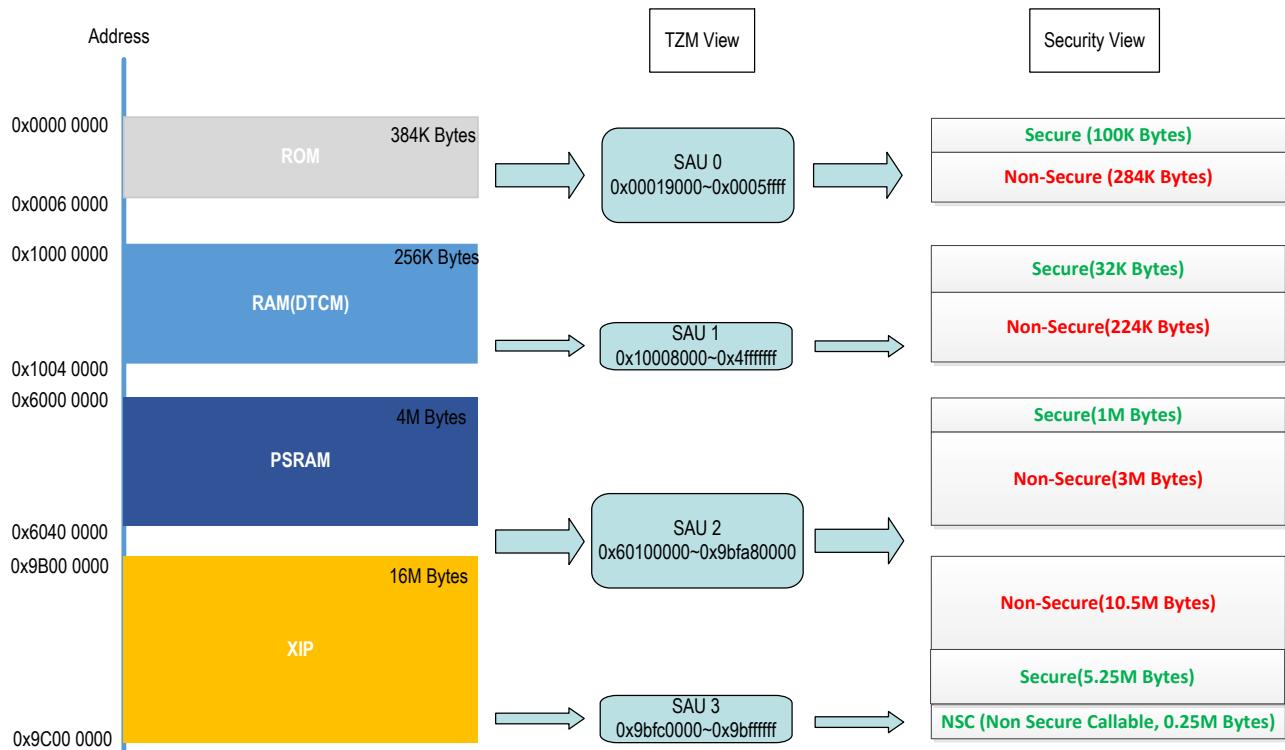


Figure 5-3 TrustZone Memory Layout

## 6 Boot Process

This chapter descripts the boot process of AmebaZII platform.

### 6.1 Boot Flow

While booting, the system will firstly load the **partition table** which has all image information, such as the image address, keys, user data etc... Then from the partition table, **boot image** will be loaded, and **firmware image** will be loaded at the end of the boot process.

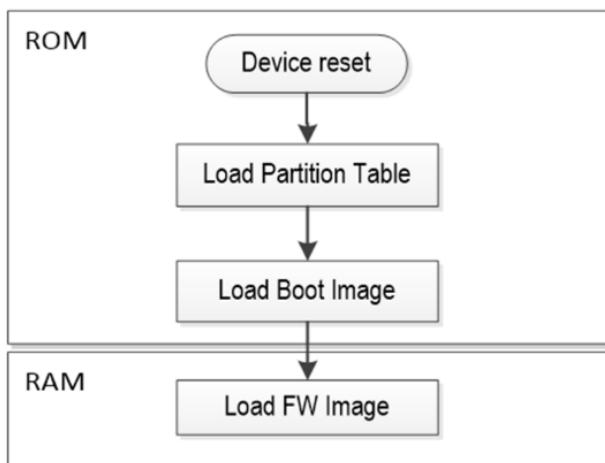


Figure 6-1 Overview of boot flow

### 6.2 Secure Boot

Secure boot aims at **firmware protection**, which prevents attackers from modifying or replacing firmware maliciously. When the chip is power on, the ROM security boot executes to check the validation of each image.

If the image is valid, then the authentication will be successful, which means the firmware is safe. And the subsequent process can be continued. Otherwise, the SoC will go into infinite loop.

## 6.2.1 Secure Boot Flow

While booting, the system will use the **encrypted private key** which locates in **super secure efuse**, and the **public key** which locates in **flash**, to generate AES keys and Hash keys, then use them to decrypt and verify each image.

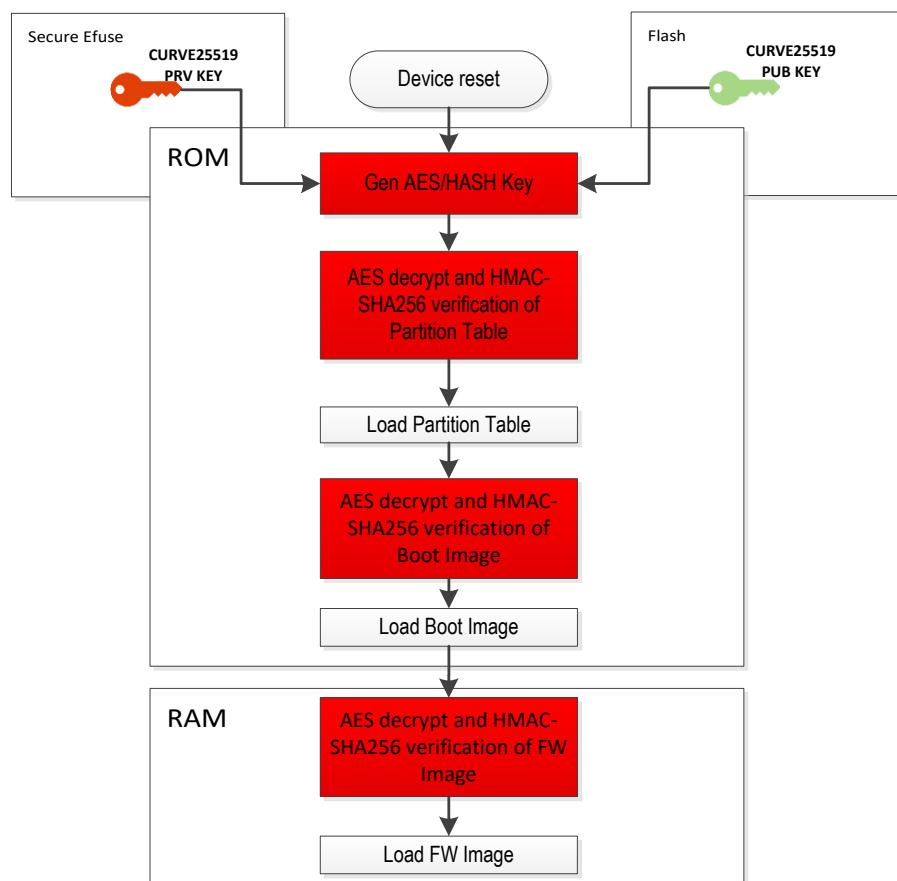


Figure 6-2 Secure boot flow

## 6.2.2 Partition Table and Boot Image Decryption Flow

Figure 6-3 illustrates the decryption flow of partition table and boot image in secure boot process.

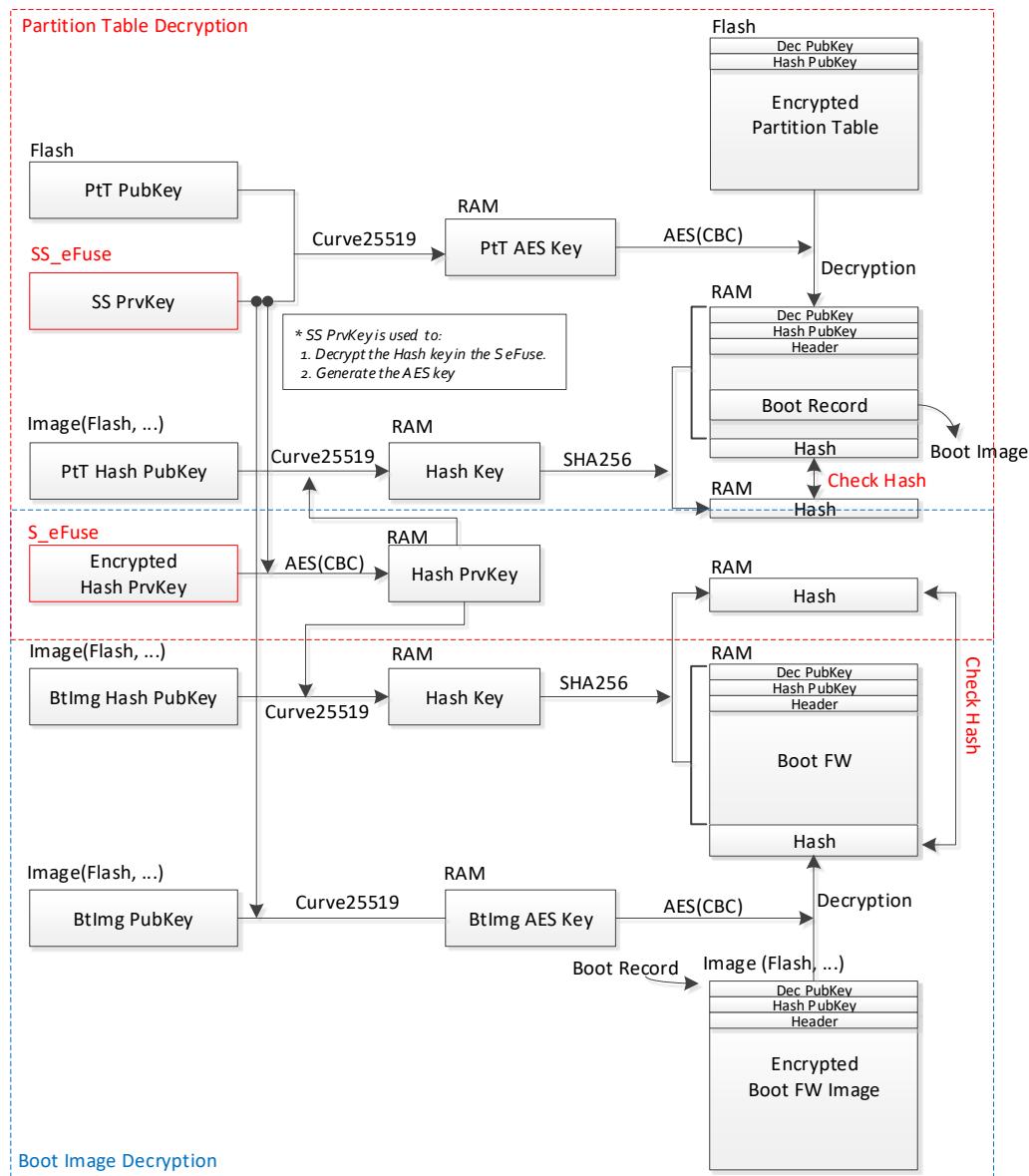


Figure 6-3 Partition table and boot image decryption flow

### 6.2.3 Secure Boot Use Scenario

Figure 6-4 illustrates the use scenario of secure boot in a real product development. Firstly, software developer needs to generate key pairs, and encrypt and hash the firmware properly. And when it comes to mass production, manufacturing facility will program the encrypted firmware along with a reference hash value on device, and program the private key in super secure efuse zone. While device boots up, it will use the super secure private key and public key to verify the hash value and decrypt each image. If case of any error or failure in the image validation process, the device won't boot.

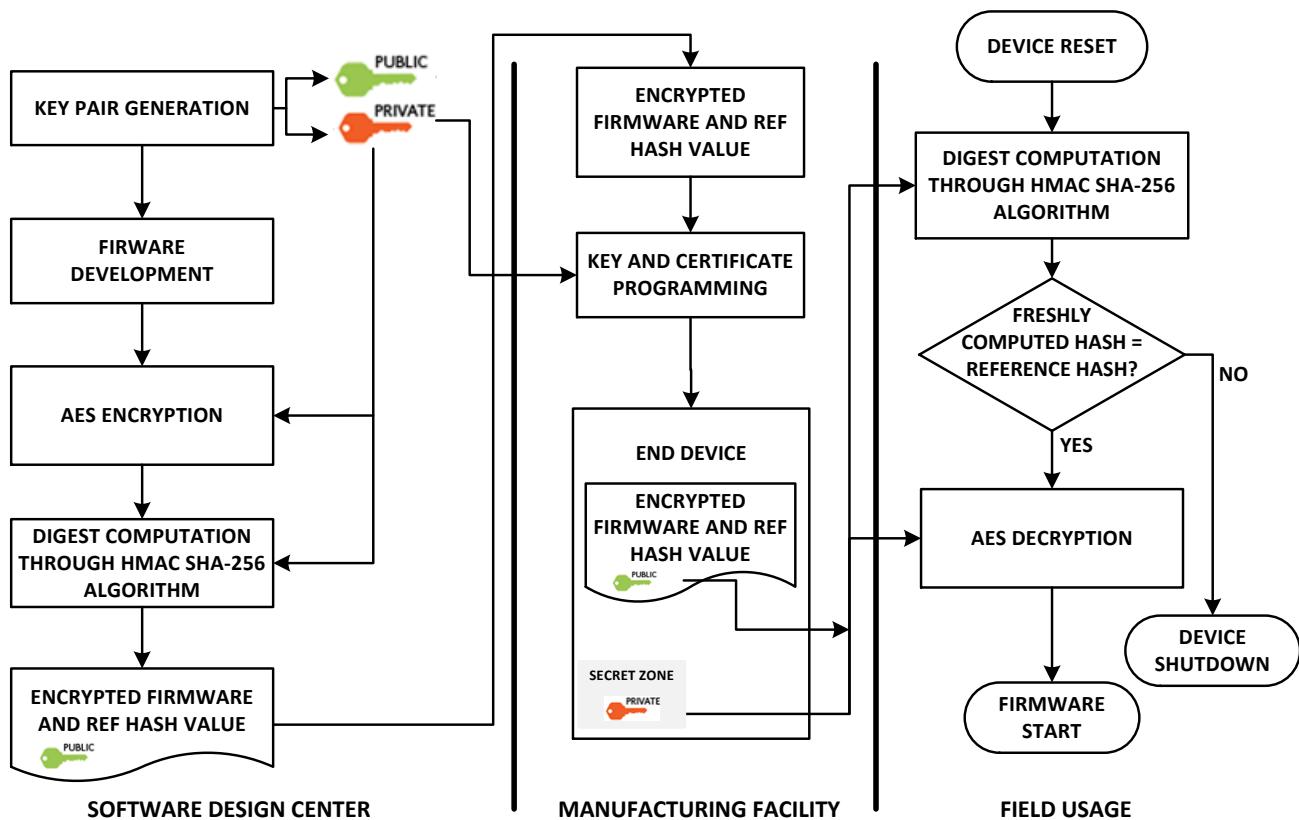


Figure 6-4 secure boot use scenario

## 6.2.4 How to Enable Secure Boot

This section shows how to enable the secure boot.

### 6.2.4.1 Keys Configuration

As mentioned above, while booting, the system will use the encryption private key which locates in super secure efuse, and the public key which locates in flash, to generate AES keys and Hash keys, then use them to decrypt and verify each image.

The super secure private key (named as “privkey\_enc”) and the encrypted hash private key (named as “privkey\_hash”) are configured in *keycfg.json* under *project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE\*.

What shows following is the default value. You can configure the keys by yourself in *keycfg.json*.

```
{
    "__comment_0":"configuration for private key, use auto to generate random key",
    "__comment_1":"private key maybe different from your desired input, program will modify first byte and last byte of key",
    "__comment_2":"to get actual private key, please open key.json after key generated.",
    "__comment_3":"hash private key in key.json will be encrypted",
    "privkey_enc":"000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F",
    "privkey_enc1":"auto",
    "privkey_hash":"000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F",
    "privkey_hash1":"auto"
}
```

### 6.2.4.2 Keys Programming in Efuse

After configuring the keys in *keycfg.json*, rebuild the whole project in IAR.

The *key.json* file under ‘*project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE\*’ will be updated after compiling. The “privkey\_enc” is the same with the “privkey\_enc” in *keycfg.json*, but the “privkey\_hash” has been changed after *Hash* algorithm.

```
{
    "__comment_EFUSE":"should keep these two key in safe place, or secure firmware protection is useless",
    "EFUSE":{
        "__comment_privkey_enc":"this key in EFUSE SUPER SECURE ZONE",

        "privkey_enc":"000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F",
        "__comment_privkey_hash":"this key in EFUSE SECURE ZONE, encrypted by upper key",

        "privkey_hash":"64A7433FCF027D19DDA4D446EEF8E78A22A8C33CB2C337C07366C040612EE0F2"
    },
    "TOOL":{
        "__comment_pubkey_enc":"public key for encryption",

        "pubkey_enc":"8F40C5ADB68F25624AE5B214EA767A6EC94D829D3D7B5E1AD1BA6F3E2138285F",
        "__comment_pubkey_hash":"public key for hash, only for partition table and bootloader",

        "pubkey_hash":"8F40C5ADB68F25624AE5B214EA767A6EC94D829D3D7B5E1AD1BA6F3E2138285F"
    }
}
```

“example\_secure\_boot.c” is an example provided for enabling secure boot. To write the keys to efuse, firstly, change CONFIG\_EXAMPLE\_SECURE\_BOOT to 1 in platform\_opts.h.

```
/*For secure boot example */
#define CONFIG_EXAMPLE_SECURE_BOOT 1
```

Secondly, modify the super secure key “susec\_key[]” and the secure key “sec\_key[]” to correspond with “privkey\_enc” and “privkey\_hash” in key.json file under *project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE\* in “example\_secure\_boot.c”. In another word, “susec\_key[]” should be the same with “privkey\_enc” in key.json, and “sec\_key[]” should be the same with “privkey\_hash” in key.json.

```
//these two keys are the same default keys used in SDK
const uint8_t susec_key[PRIV_KEY_LEN] = {
    0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
    0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F,
    0x10, 0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17,
    0x18, 0x19, 0x1A, 0x1B, 0x1C, 0x1D, 0x1E, 0x5F
};
const uint8_t sec_key[PRIV_KEY_LEN] = {
    0x64, 0xA7, 0x43, 0x3F, 0xCF, 0x02, 0x7D, 0x19,
    0xDD, 0xA4, 0xD4, 0x46, 0xEE, 0xF8, 0xE7, 0x8A,
    0x22, 0xA8, 0xC3, 0x3C, 0xB2, 0xC3, 0x37, 0xC0,
    0x73, 0x66, 0xC0, 0x40, 0x61, 0x2E, 0xE0, 0xF2
};
```

Thirdly, modify 0 to 1 to enable write super secure key function and write secure key function to write keys to efuse. What needs to be noted is, the efuse is one-time writable, please make sure the key is correct before programming in efuse.

```
// write SS key
memset(write_buf, 0xFF, PRIV_KEY_LEN);
if(1){ // fill your data
    for(i=0; i<PRIV_KEY_LEN; i++)
        write_buf[i] = susec_key[i];
}
if(1){ // write
    device_mutex_lock(RT_DEV_LOCK_EFUSE);
    ret = efuse_susec_key_write(write_buf);
    device_mutex_unlock(RT_DEV_LOCK_EFUSE);
    if(ret < 0){
        dbg_printf("efuse SS key: write address and length error\r\n");
        goto exit;
    }
    dbg_printf("\r\nWrite Done.\r\n");
}else{
    dbg_printf("\r\nPlease make sure the key is correct before programming in efuse.\r\n");
}
dbg_printf("\r\n");
// write S key
memset(write_buf, 0xFF, PRIV_KEY_LEN);
if(1){ // fill your data
    for(i=0; i<PRIV_KEY_LEN; i++)
        write_buf[i] = sec_key[i];
}
if(1){ // write
    device_mutex_lock(RT_DEV_LOCK_EFUSE);
```

```

ret = efuse_sec_key_write(write_buf, 0);
device_mutex_unlock(RT_DEV_LOCK_EFUSE);
if(ret < 0){
    dbg_printf("efuse S key: write address and length error\r\n");
    goto exit;
}
dbg_printf("\r\nWrite Done.\r\n");
}else{
    dbg_printf("\r\nPlease make sure the key is correct before programming in efuse.\r\n");
}
dbg_printf("\r\n");

```

The SS key locker can be enabled by changing 0 to 1 marked as yellow here. If the locker is enabled, the SS key turns to be unreadable forever. So, this configuration is irreversible, please do if only you are certain about SS key.

```

/*
Step 3: lock and protect the SS key from being read by CPU
*/
// lock SS key, make SS key unreadable forever.
// this configure is irreversible, so please do this only if you are certain about SS key
if(1){
    device_mutex_lock(RT_DEV_LOCK_EFUSE);
    ret = efuse_lock_susec_key();
    device_mutex_unlock(RT_DEV_LOCK_EFUSE);
    if(ret < 0){
        dbg_printf("efuse SS key lock error\r\n");
        goto exit;
    }
}

```

Enable secure boot by setting the flag to 1 in step 4. After enabling the secure boot, the device will only boot with encrypted image. The configure is also irreversible, so please do this if you are certain that the firmware image is encrypted and hashed with the correct SS key and S key.

```

/*
Step 4: enable the secure boot so that device will only boot with encrypted image
*/
// enable secure boot, make device boot only with correctly encrypted image
// this configure is irreversible, so please do this only if you are certain that the fw image is encrypted and
hashed with the correct SS key and S key
if(1){
    device_mutex_lock(RT_DEV_LOCK_EFUSE);
    ret = efuse_fw_verify_enable();
    device_mutex_unlock(RT_DEV_LOCK_EFUSE);
    if(ret < 0){
        dbg_printf("efuse secure boot enable error\r\n");
        goto exit;
    }
    device_mutex_lock(RT_DEV_LOCK_EFUSE);
    ret = efuse_fw_verify_check();
    device_mutex_unlock(RT_DEV_LOCK_EFUSE);
    if(ret)
        dbg_printf("secure boot is enabled!");
}

```

What needs to highlight is, the two sections above aim to write keys to efuse and enable secure boot. Before enabling secure boot, the Ameba-ZII is in non-secure boot mode, that means encrypted image cannot boot. So, till now, the application is built to enable secure boot. After enabling, encrypt the image and then the Ameba-ZII can boot with encrypted image.

### 6.2.4.3 Encrypt the Image

The 'boot/firmware 1/firmware 2' addresses are stored in partition records, defined in '*partition.json*' under '*project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE*'. The addresses can be modified if needed.

```
"boot":{  
    "start_addr" : "0x4000",  
    "length" : "0x8000",  
    "type": "BOOT",  
    "dbg_skip": false,  
    "hash_key":"FFFFFFFFFFFFFFF00000000000000000000000000000000"  
},  
"fw1":{  
    "start_addr" : "0x10000",  
    "length" : "0x80000",  
    "type": "FW1",  
    "dbg_skip": false,  
    "hash_key":"000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F"  
},  
"fw2":{  
    "start_addr" : "0x90000",  
    "length" : "0x80000",  
    "type": "FW2",  
    "dbg_skip": false,  
    "hash_key":"000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F"  
}
```

Ameba-ZII is defaulted as non-secure boot mode, secure boot asks encrypted firmware. The keys to enable firmware encryption are defined in '*amebaz2\_bootloader.json/amebaz2\_firmware\_is.json/amebaz2\_firmware\_tz.json*' under '*project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE*'. "*enc*" can be changed from *false* to *true* in following code to enable corresponding module encryption.

In *amebaz2\_bootloader.json*:

```
"PARTAB": {  
    "source":null,  
    "header":{  
        "next":null,  
        "__comment_type":"Support  
Type:PARTAB,BOOT,FWHS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",  
        "type":"PARTAB",  
        "enc":true,  
        "serial": 0  
    },  
    "list" : ["partab"],  
    "partab": {  
        "__comment_ptable":"move to partition.json",  
  
        "__comment_file":"TODO: use binary file directly",  
        "file": null  
    }  
},  
"BOOT": {  
    "source":"Debug/Exe/bootloader.out",  
    "header":{
```

```

        "next":null,
        "__comment_type":"Support
Type:PARTAB,BOOT,FWHS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type":"BOOT",
        "enc":true,
"user_key1":"AA0102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F",
        "serial": 0
    },
    "list" : ["sram"],
    "sram": {
        "__comment_option":"TODO: not ready",
        "option": null,

        "__comment_entry":"startup function table symbol",
        "entry":"gRamStartFun",

        "start": "RAM_FUNTAB$$Base",
        "end": "RAM_RODATA$$Limit",

        "__comment_file":"TODO: use binary file directly",
        "file": null
    }
}
}

```

For **ignore secure project**, need to modify *amebaz2\_firmware\_is.json*, “*enc*” also is set to **true** to encrypt the image. But what needs to be noted is, the “*enc*” in “*XIP\_FLASH\_P*” could not be set to **true** because this section is reserved for plain data.

```

"FWHS": {
    "source":"Debug/Exe/application_is.out",
    "header":{
        "next":null,
        "__comment_type":"Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type":"FWHS_S",
        "enc":true,
"user_key2":"BB0102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F",
        "__comment_pkey_idx":"assign by program, no need to configurate",
        "serial": 107
    },
    "FST":{
        "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
        "__comment_FST1": "validpat is used for section header validation",
        "__comment_FST2": "hash_en/enc_en?",
        "enc_algorithm":"cbc",
        "hash_algorithm":"sha256",
        "part_size":"4096",

        "__comment_validpat": "use auto or dedicated value",
        "validpat":"0001020304050607",
        "hash_en":true,
        "enc_en":true,
        "cipherkey":null,
        "cipheriv":null
    },
}
}

```

*"XIP\_FLASH\_C": {*

```
"source":"Debug/Exe/application_is.out",
"header":{

    "next":null,
    "__comment_type":"Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type":"XIP",
        "enc":true,
        "__comment_pkey_idx":"assign by program, no need to configurate",
        "serial": 0
    },
    "FST":{

        "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
        "__comment_FST1": "validpat is used for section header validation",
        "__comment_FST2": "hash_en/enc_en?",

"enc_algorithm":"cbc",
        "hash_algorithm":"sha256",
        "part_size":"4096",

        "__comment_validpat": "use auto or dedicated value",
        "validpat":"0001020304050607",
        "hash_en":true,
        "enc_en":true,
        "cipherkey":null,
        "cipheriv":null
    },
}

"XIP_FLASH_P": {
    "source":"Debug/Exe/application_is.out",
    "header":{

        "next":null,
        "__comment_type":"Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type":"XIP",
        "enc":false,
        "__comment_pkey_idx":"assign by program, no need to configurate",
        "serial": 0
    },
    "FST":{

        "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
        "__comment_FST1": "validpat is used for section header validation",
        "__comment_FST2": "hash_en/enc_en?",

"enc_algorithm":"cbc",
        "hash_algorithm":"sha256",
        "part_size":"4096",

        "__comment_validpat": "use auto or dedicated value",
        "validpat":"0001020304050607",
        "hash_en":true,
        "enc_en":false,
        "cipherkey":null,
        "cipheriv":null
    },
}
```

For **trust zone project**, need to modify *amebaz2\_firmware\_tz.json*, “enc” also is set to **true** to encrypt the image. But what needs to be noted is, the “enc” in “XIP\_S\_P” and “XIP\_NS\_P” could not be set to **true** because these sections are reserved for plain data.

```
{  
    "msg_level": 3,  
  
    "__comment__": "example key",  
    "000priv": "A0D6DAE7E062CA94CBB294BF896B9F68CF8438774256AC7403CA4FD9A1C9564F",  
    "000pub": "68513EF83E396B12BA059A900F36B6D31D11FE1C5D25EB8AA7C550307F9C2405",  
    "001priv": "882AA16C8C44A7760AA8C9AB22E3568C6FA16C2AFA4FOCEA29A10ABCD60E44F",  
    "001pub": "48AD23DDBDAC9E65719DB7D394D44D62820D19E50D68376774237E98D2305E6A",  
    "002priv": "58A3D915706835212260C22D628B336D13190B539714E3DB249D823CA5774453",  
    "002pub": "FD8D3F3E516D96186E10F07A64B24C7DE736826A24FAFE367E79F1FB2F1C832",  
    "003priv": "000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F",  
    "003pub": "8F40C5ADB68F25624AE5B214EA767A6EC94D829D3D7B5E1AD1BA6F3E2138285F",  
  
    "PROFILE": ["FIRMWARE"],  
    "FIRMWARE": {  
        "rand_pad": false,  
        "__comment_xip_pg_size": "XIP remapping page size/alignment setting: 0/1/2: 16K/32K/64K",  
        "xip_pg_size": 0,  
  
        "__comment_mode": "mode 0: bootloader and partition table, mode 1: firmware",  
        "mode": 1,  
        "file": "Debug/Exe/firmware_tz.bin",  
        "__comment_too_privkey": "if user want to fix key, can set private key here, if not, will use random key",  
  
        "privkey_enc": "A0D6DAE7E062CA94CBB294BF896B9F68CF8438774256AC7403CA4FD9A1C9564F",  
  
        "__comment_hash_key_src": "hash key from partition table FW1/FW2 (must match type in partition item)",  
        "hash_key_src": "FW1",  
  
        "__comment_images": "offset = null => cascade ( align to 64 ), should be zero if valid",  
        "images": [  
            {"img": "FWHS_S", "offset": "0x00"},  
            {"img": "FWHS_NSC", "offset": "0x00"},  
            {"img": "FWHS_NS", "offset": "0x00"},  
            {"img": "XIP_S_C", "offset": "0x00"},  
            {"img": "XIP_S_P", "offset": "0x00"},  
            {"img": "XIP_NS_C", "offset": "0x00"},  
            {"img": "XIP_NS_P", "offset": "0x00"}  
        ],  
        "FWHS_S": {  
            "source": "Debug/Exe/application_s.out",  
            "header": {  
                "next": null,  
                "__comment_type": "Support"  
            },  
            "type": "FWHS_S",  
            "enc": true,  
            "user_key2": "BB0102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F",  
            "__comment_pkey_idx": "assign by program, no need to configurate",  
            "serial": 100  
        },  
        "FST": {  
            "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",  
            "__comment_FST1": "validpat is used for section header validation",  
            "__comment_FST2": "hash_en/enc_en?",  
            "enc_algorithm": "cbc",  
            "type": "FST",  
            "header": {  
                "next": null,  
                "__comment_type": "Support"  
            },  
            "user_key2": "BB0102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F",  
            "__comment_pkey_idx": "assign by program, no need to configurate",  
            "serial": 100  
        }  
    }  
}
```

```
"hash_algorithm":"sha256",
"part_size":"4096",

"__comment_validpat": "use auto or dedicated value",
"validpat":"0001020304050607",
"hash_en":true,
"enc_en":true,
"cipherkey":null,
"cipheriv":null
},
"list" : ["sram","psram"],
"sram": {
    "secthdr":{
        "type": "SRAM"
    },
    "__comment_option": "TODO: not ready",
    "option": null,

    "__comment_entry": "startup function table symbol",
    "entry": "gRamStartFun",

    "sections":      ["FIRMWARE_FUNTAB*", "FIRMWARE_SIGN*",
"FWHS_NS*", "FIRMWARE_SRAM_RO*"], "FIRMWARE_SRAM_RW*"],
    "__comment_file": "TODO: use binary file directly",
    "file": null
},
"psram": {
    "secthdr":{
        "type": "PSRAM"
    },
    "__comment_option": "TODO: not ready",
    "option": null,

    "sections":      ["FIRMWARE_ERAM_RO*", "FIRMWARE_ERAM_RW*"],
    "__comment_file": "TODO: use binary file directly",
    "file": null
}
},
"FWHS_NS": {
    "source": "Debug/Exe/application_ns.out",
    "header": {
        "next":null,
        "__comment_type": "Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type": "FWHS_NS",
        "enc":true,
        "__comment_pkey_idx": "assign by program, no need to configurate",
        "serial": 0
    },
    "FST": {
        "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
        "__comment_FST1": "validpat is used for section header validation",
        "__comment_FST2": "hash_en/enc_en?",
        "enc_algorithm": "cbc",
        "hash_algorithm": "sha256",
        "part_size": "4096",

        "__comment_validpat": "use auto or dedicated value",
        "validpat": "0001020304050607",
    }
}
```

```
        "hash_en":true,
        "enc_en":true,
        "cipherkey":null,
        "cipheriv":null
    },
    "list" : ["sram","vector","psram"],
    "sram": {
        "secthdr":{
            "type": "SRAM"
        },
        "__comment_option":"TODO: not ready",
        "option": null,
        "__comment_entry":"startup function table symbol",
        "sections":      ["FIRMWARE_FUNTAB*", "FIRMWARE_SIGN*",
"FWIWARE_SRAM_RO*", "FWIWARE_SRAM_RW*"],
        "__comment_file":"TODO: use binary file directly",
        "file": null
    },
    "vector": {
        "secthdr":{
            "type": "SRAM"
        },
        "__comment_option":"TODO: not ready",
        "option": null,
        "sections":      ["FIRMWARE_VECTOR*"],
        "__comment_file":"TODO: use binary file directly",
        "file": null
    },
    "psram": {
        "secthdr":{
            "type": "PSRAM"
        },
        "__comment_option":"TODO: not ready",
        "option": null,
        "sections":      ["FIRMWARE_ERAM_RO*", "FIRMWARE_ERAM_RW*"],
        "__comment_file":"TODO: use binary file directly",
        "file": null
    }
},
"FWHS_NSC": {
    "source":"Debug/Exe/application_s.out",
    "header": {
        "next":null,
        "__comment_type":"Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type":"XIP",
        "enc":true,
        "__comment_pkey_idx":"assign by program, no need to configurate",
        "serial": 0
    },
    "FST": {
        "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
        "__comment_FST1": "validpat is used for section header validation",
        "__comment_FST2": "hash_en/enc_en?",
        "enc_algorithm":"cbc",
        "enc":true
    }
}
```

```
"hash_algorithm":"sha256",
"part_size":"4096",

"__comment_validpat": "use auto or dedicated value",
"validpat":"0001020304050607",
"hash_en":true,
"enc_en":true,
"cipherkey":null,
"cipheriv":null
},
"list" : ["nsc"],
"nsc": {
    "secthdr":{
        "type": "XIP",
        "xip_key": "A0D6DAE7E062CA94CBB294BF896B9F68",
        "xip_iv": "94879487948794879487948794879487"
    },
    "__comment_option": "TODO: not ready",
    "option": null,
    "__comment_entry": "XIP text, RO_data",
    "sections": ["FIRMWARE_NSC*"],
    "__comment_file": "TODO: use binary file directly",
    "file": null
}
},
"XIP_S_C": {
    "source": "Debug/Exe/application_s.out",
    "header": {
        "next":null,
        "__comment_type": "Support"
    }
},
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
"__comment_type": "Support",
"__comment_pkey_idx": "assign by program, no need to configurate",
"serial": 0
},
"FST": {
    "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
    "__comment_FST1": "validpat is used for section header validation",
    "__comment_FST2": "hash_en/enc_en?",
    "enc_algorithm": "cbc",
    "hash_algorithm": "sha256",
    "part_size": "4096",

    "__comment_validpat": "use auto or dedicated value",
    "validpat": "0001020304050607",
    "hash_en":true,
    "enc_en":true,
    "cipherkey":null,
    "cipheriv":null
},
"list" : ["xip"],
"xip": {
    "secthdr":{
        "type": "XIP",
        "xip_key": "A0D6DAE7E062CA94CBB294BF896B9F68",
        "xip_iv": "94879487948794879487948794879487"
    }
}
```

```
        },
        "__comment_option":"TODO: not ready",
        "option": null,
        "__comment_entry":"XIP text, RO_data",
        "sections": ["FIRMWARE_XIP_S_C*"],
        "__comment_file":"TODO: use binary file directly",
        "file": null
    },
},
"XIP_S_P": {
    "source":"Debug/Exe/application_s.out",
    "header": {
        "next":null,
        "__comment_type":"Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type":"XIP",
        "enc":false,
        "__comment_pkey_idx":"assign by program, no need to configurate",
        "serial": 0
    },
    "FST": {
        "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
        "__comment_FST1": "validpat is used for section header validation",
        "__comment_FST2": "hash_en/enc_en?",
        "enc_algorithm": "cbc",
        "hash_algorithm": "sha256",
        "part_size": "4096",
        "__comment_validpat": "use auto or dedicated value",
        "validpat": "0001020304050607",
        "hash_en": true,
        "enc_en": false,
        "cipherkey": null,
        "cipheriv": null
    },
    "list": ["xip"],
    "xip": {
        "secthdr": {
            "type": "XIP",
            "xip_key": "A0D6DAE7E062CA94CBB294BF896B9F68",
            "xip_iv": "94879487948794879487948794879487"
        },
        "__comment_option": "TODO: not ready",
        "option": null,
        "__comment_entry": "XIP text, RO_data",
        "sections": ["FIRMWARE_XIP_S_P*"],
        "__comment_file": "TODO: use binary file directly",
        "file": null
    }
},
"XIP_NS_C": {
    "source": "Debug/Exe/application_ns.out",
    "header": {
        "next":null,
```

```
    "__comment_type":"Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
    "type":"XIP",
    "enc":true,
    "__comment_pkey_idx":"assign by program, no need to configurate",
    "serial": 0
},
"FST":{
    "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
    "__comment_FST1": "validpat is used for section header validation",
    "__comment_FST2": "hash_en/enc_en?",
    "enc_algorithm":"cbc",
    "hash_algorithm":"sha256",
    "part_size":"4096",

    "__comment_validpat": "use auto or dedicated value",
    "validpat":"0001020304050607",
    "hash_en":true,
    "enc_en":true,
    "cipherkey":null,
    "cipheriv":null
},
"list" : ["xip"],
"xip": {
    "secthdr":{
        "type": "XIP",
        "xip_key": "A0D6DAE7E062CA94CBB294BF896B9F68",
        "xip_iv": "9487948794879487948794879487"
    },
    "__comment_option":"TODO: not ready",
    "option": null,

    "__comment_entry":"XIP text, RO_data",

    "sections":      ["FIRMWARE_XIP_C*"
],
    "__comment_file":"TODO: use binary file directly",
    "file": null
}
},
"XIP_NS_P": {
    "source":"Debug/Exe/application_ns.out",
    "header":{

        "next":null,
        "__comment_type":"Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",
        "type":"XIP",
        "enc":false,
        "__comment_pkey_idx":"assign by program, no need to configurate",
        "serial": 0
},
"FST":{
    "__comment_FST0": "enc_algorithm: cbc/ecb with cipher key",
    "__comment_FST1": "validpat is used for section header validation",
    "__comment_FST2": "hash_en/enc_en?",
    "enc_algorithm":"cbc",
    "hash_algorithm":"sha256",
    "part_size":"4096",
```

```
        " __comment_validpat": "use auto or dedicated value",
        "validpat": "0001020304050607",
        "hash_en": true,
        "enc_en": false,
        "cipherkey": null,
        "cipheriv": null
    },
    "list": ["xip"],
    "xip": {
        "secthdr": {
            "type": "XIP",
            "xip_key": "A0D6DAE7E062CA94CBB294BF896B9F68",
            "xip_iv": "94879487948794879487948794879487"
        },
        " __comment_option": "TODO: not ready",
        "option": null,
        " __comment_entry": "XIP text, RO_data",
        "sections": ["FIRMWARE_XIP_P*"]
    },
    " __comment_file": "TODO: use binary file directly",
    "file": null
}
}
```

#### **6.2.4.4 Open “secure\_bit”**

#### **6.2.4.4.1 IAR**

For ignore secure project, "secure\_bit" in postbuild\_is.bat under \component\soc\realtek\8710c\misc\iar\_utility needs to be set to 1.

```
%tooldir%\elf2bin.exe convert amebaz2_bootloader.json BOOTLOADER secure_bit=1 >> postbuild_is_log.txt
if not exist Debug\Exe\bootloader.bin (
    echo bootloader.bin isn't generated, check postbuild_is_log.txt
    echo bootloader.bin isn't generated > postbuild_is_error.txt
    pause
    exit 2 /b
)

::generate partition table
%tooldir%\elf2bin.exe convert amebaz2_bootloader.json PARTITIONTABLE secure_bit=1 >>
postbuild_is_log.txt
if not exist Debug\Exe\partition.bin (
    echo partition.bin isn't generated, check postbuild_is_log.txt
    echo partition.bin isn't generated > postbuild_is_error.txt
    pause
    exit 2 /b
)

::generate firmware image
if not exist amebaz2_firmware_is.json (
    echo amebaz2_firmware_is.json is missing
    echo amebaz2_firmware_is.json is missing > postbuild_is_error.txt
    pause
```

```

        exit 2 /b
)
%tooldir%\elf2bin.exe convert amebaz2_firmware_is.json FIRMWARE secure_bit=1 >> postbuild_is_log.txt
if not exist Debug\Exe\firmware_is.bin (
    echo firmware_is.bin isn't generated, check postbuild_is_log.txt
    echo firmware_is.bin isn't generated > postbuild_is_error.txt
    pause
    exit 2 /b
)

```

For **trust zone project**, “**secure\_bit**” in *postbuild\_tz.bat* under *\component\soc\realtek\8710c\misc\iar\_utility* needs to be set to 1.

```

%tooldir%\elf2bin.exe convert amebaz2_bootloader.json BOOTLOADER secure_bit=1 >>
postbuild_tz_log.txt
if not exist Debug\Exe\bootloader.bin (
    echo bootloader.bin isn't generated, check postbuild_tz_log.txt
    echo bootloader.bin isn't generated > postbuild_tz_error.txt
    goto error_exit
)

::generate partition table
%tooldir%\elf2bin.exe convert amebaz2_bootloader.json PARTITIONTABLE secure_bit=1 >>
postbuild_tz_log.txt
if not exist Debug\Exe\partition.bin (
    echo partition.bin isn't generated, check postbuild_tz_log.txt
    echo partition.bin isn't generated > postbuild_tz_error.txt
    goto error_exit
)

::generate firmware image
if not exist amebaz2_firmware_tz.json (
    echo amebaz2_firmware_tz.json is missing
    echo amebaz2_firmware_tz.json is missing > postbuild_tz_error.txt
    goto error_exit
)
%tooldir%\elf2bin.exe convert amebaz2_firmware_tz.json FIRMWARE secure_bit=1 >>
postbuild_tz_log.txt
if not exist Debug\Exe\firmware_tz.bin (
    echo firmware_tz.bin isn't generated, check postbuild_tz_log.txt
    echo firmware_tz.bin isn't generated > postbuild_tz_error.txt
    goto error_exit
)

```

#### 6.2.4.4.2 GCC

For **GCC compilation**, “**secure\_bit**” needs to be set to 1 in *application.is.mk* under *\project\realtek\_amebaz2\_v0\_example\GCC-RELEASE* for **ignore secure project**.

```

.PHONY: manipulate_images
manipulate_images:
    @echo =====
    @echo Image manipulating
    @echo =====
    cp $(AMEBAZ2_BOOTLOADERDIR)/bootloader.axf $(BOOT_BIN_DIR)/bootloader.axf
ifeq ($(findstring Linux, $(OS)), Linux)
    chmod 0774 $(ELF2BIN)
endif

```

```

$(ELF2BIN) keygen keycfg.json
$(ELF2BIN) convert amebaz2_bootloader.json BOOTLOADER secure_bit=1
$(ELF2BIN) convert amebaz2_bootloader.json PARTITIONTABLE secure_bit=1
$(ELF2BIN) convert amebaz2_firmware_is.json FIRMWARE secure_bit=1
$(ELF2BIN) combine $(BIN_DIR)/flash_is.bin
PTAB=partition.bin,BOOT=$(BOOT_BIN_DIR)/bootloader.bin,FW1=$(BIN_DIR)/firmware_is.bin

```

For **trust zone project**, “*secure\_bit*” needs to be set to 1 in application.tz.mk under `\project\realtek_amebaz2_v0_example\GCC-RELEASE`.

```

.PHONY: manipulate_images
manipulate_images: | application_tz
    @echo =====
    @echo Image manipulating
    @echo =====
    cp $(AMEBAZ2_BOOTLOADERDIR)/bootloader.axf $(BOOT_BIN_DIR)/bootloader.axf
ifeq ($(findstring Linux, $(OS)), Linux)
    chmod 0774 $(ELF2BIN)
endif
    $(ELF2BIN) keygen keycfg.json
    $(ELF2BIN) convert amebaz2_bootloader.json BOOTLOADER secure_bit=1
    $(ELF2BIN) convert amebaz2_bootloader.json PARTITIONTABLE secure_bit=1
    $(ELF2BIN) convert amebaz2_firmware_tz.json FIRMWARE secure_bit=1
    $(ELF2BIN) combine $(TARGET)/flash_tz.bin
PTAB=partition.bin,BOOT=$(BOOT_BIN_DIR)/bootloader.bin,FW1=$(TARGET)/firmware_tz.bin

```

#### 6.2.4.5 Secure Boot Execution

Set the “privkey\_enc” and “privkey\_hash” in `keycfg.json` as shown below, in this example, just change the last character of default value from F to 0.

```
{
    "__comment_0__": "configuration for private key, use auto to generate random key",
    "__comment_1__": "private key maybe different from your desired input, program will modify first byte and last byte of key",
    "__comment_2__": "to get actual private key, please open key.json after key generated.",
    "__comment_3__": "hash private key in key.json will be encrypted",
    "privkey_enc": "000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E50",
    "privkey_enc1": "auto",
    "privkey_hash": "000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E50",
    "privkey_hash1": "auto"
}
```

After rebuilding the project, the keys are updated in `key.json`.

```
{
    "__comment_EFUSE__": "should keep these two key in safe place, or secure firmware protection is useless",
    "EFUSE": {
        "__comment_privkey_enc": "this key in EFUSE SUPER SECURE ZONE",
        "privkey_enc": "000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E50",
        "__comment_privkey_hash": "this key in EFUSE SECURE ZONE, encrypted by upper key",
        "privkey_hash": "1C219D029C32C0744FBDAE9BC306D0CC57F02049217C3A94D8E105D5AA264A0"
    },
    "TOOL": {

```

```

    " __comment_pubkey_enc": "public key for encryption",
    "pubkey_enc": "B496A6CF209834D1F22C7FEA41172F5888F9540B069874F4700B411E77576E03",
        " __comment_pubkey_hash": "public key for hash, only for partition table and bootloader",
        "pubkey_hash": "B496A6CF209834D1F22C7FEA41172F5888F9540B069874F4700B411E77576E03"
    }
}

```

Set the flag CONFIG\_EXAMPLE\_SECURE\_BOOT to 1 in 'platform\_opts.h'.

```

/*For secure boot example */
#define CONFIG_EXAMPLE_SECURE_BOOT 1

```

Change the keys in 'example\_secure\_boot.c', make susec\_key[] equal to "privkey\_enc" and sec\_key[] equal to "privkey\_hash" in key.json.

```

//these two keys are the same default keys used in SDK
const uint8_t susec_key[PRIIV_KEY_LEN] = {
    0x00, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06, 0x07,
    0x08, 0x09, 0x0A, 0x0B, 0x0C, 0x0D, 0x0E, 0x0F,
    0x10, 0x11, 0x12, 0x13, 0x14, 0x15, 0x16, 0x17,
    0x18, 0x19, 0x1A, 0x1B, 0x1C, 0x1D, 0x1E, 0x50
};

const uint8_t sec_key[PRIIV_KEY_LEN] = {
    0x1C, 0x21, 0x9D, 0x02, 0x9C, 0x32, 0xC0, 0x74,
    0x4F, 0xBD, 0xAA, 0xE9, 0xBC, 0x30, 0x6D, 0x0C,
    0xC5, 0x7F, 0x02, 0x04, 0x92, 0x17, 0xC3, 0xA9,
    0x4D, 0x8E, 0x10, 0x5D, 0x5A, 0xA2, 0x64, 0xA0
};

```

Enable write SS key function, write S key function, lock SS key function and secure boot function by setting if condition as 1 (details are shown in section 6.2.4.2). Build the application and download it to Ameba-ZII to enable secure boot.

If secure boot is enabled successfully, the message will be:

```

#
efuse secure boot: Test Start
[0]      FF FF FF FF  FF FF FF FF
[8]      FF FF FF FF  FF FF FF FF
[16]     FF FF FF FF  FF FF FF FF
[24]     FF FF FF FF  FF FF FF FF

write Done.

[0]      00 01 02 03  04 05 06 07
[8]      08 09 0A 0B  0C 0D 0E 0F
[16]     10 11 12 13  14 15 16 17
[24]     18 19 1A 1B  1C 1D 1E 50
[0]      FF FF FF FF  FF FF FF FF
[8]      FF FF FF FF  FF FF FF FF
[16]     FF FF FF FF  FF FF FF FF
[24]     FF FF FF FF  FF FF FF FF

write Done.

[0]      1C 21 9D 02  9C 32 C0 74
[8]      4F BD AA E9  BC 30 6D 0C
[16]     C5 7F 02 04  92 17 C3 A9
[24]     4D 8E 10 5D  5A A2 64 A0
efuse secure boot keys: Test Done
eFuse Key Locked!! , Super-Secure Key Reading is Inhibited!!
secure boot is enabled!

```

Enabling secure boot successfully means only encrypted image can boot on this Ameba-ZII board.

To run your own application, you need to encrypt image by setting the “enc” as **true** in ‘amebaz2\_bootloader.json/amebaz2\_firmware\_is.json’ under *project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE\*’

Also, set “**secure\_bit=1**” in ‘postbuild\_is.bat’ under ‘component\soc\realtek\8710c\misc\iar\_utility’ (details are shown in section 6.2.4.4).

Finally, the Ameba-ZII board can run with encrypted image.

## 6.2.5 How to Debug in Secure Boot in IAR IDE

Once secure boot is successfully enabled, a super sec key is obtained. When trying to debug the program in IAR IDE, issue arises because of the default setup in IAR IDE. During debug, IAR IDE performs a CPU reset which clears the super sec key. When operation resume, the super sec key will be read again, resulting in boot failure because the super sec key can be read only once unless there is a power reset, or watchdog reset. This issue happens in both “Download and Debug” and “Debug without Downloading”. Thus, it is not recommendable to debug the program using these two methods.

**Note:** GCC SDK doesn't have this issue because it can be fully controlled by our GDB script.

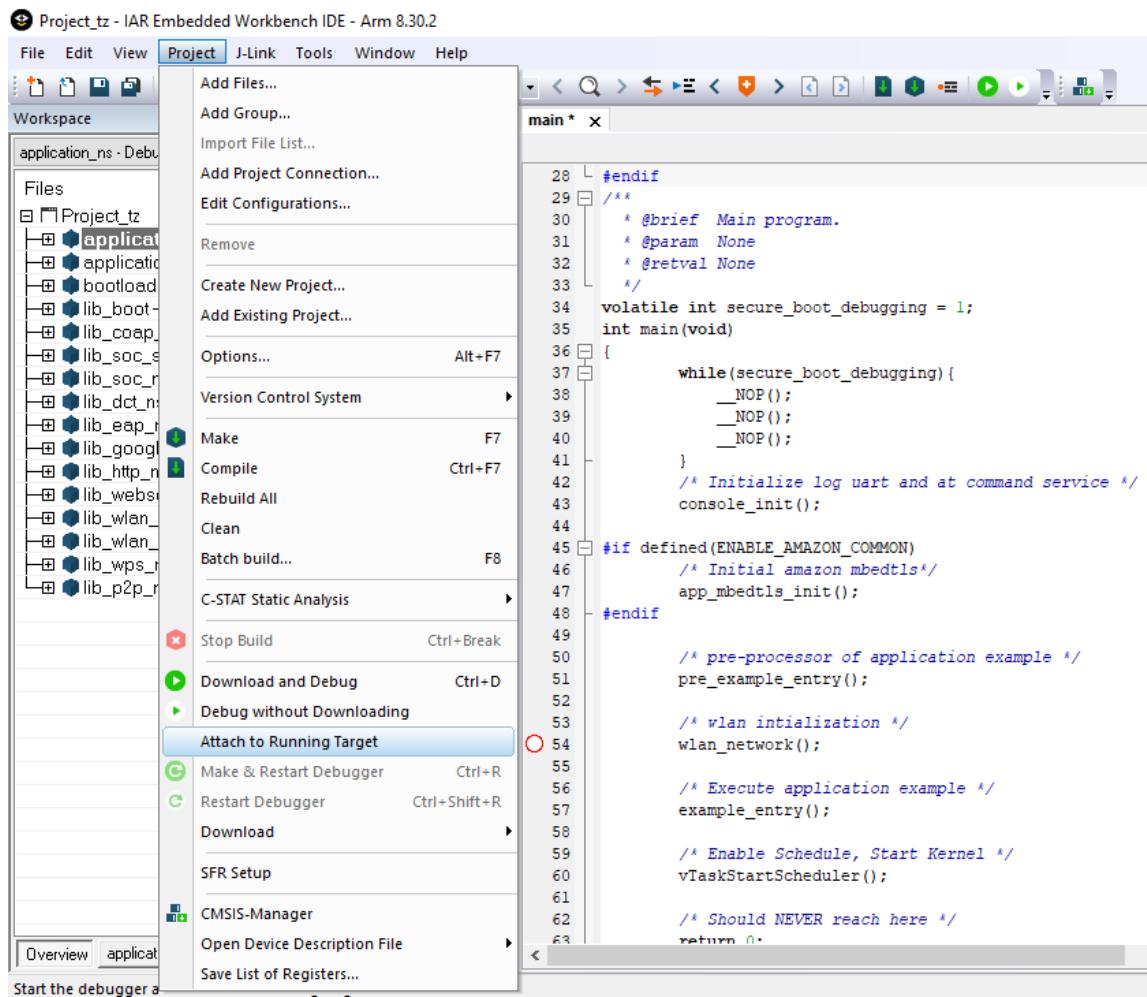
However, one alternative to debug the program is as follow:

Firstly, add this piece of code into main.c and make the project.

```
/**  
 * @brief Main program.  
 * @param None  
 * @retval None  
 */  
volatile int secure_boot_debugging = 1;  
int main(void)  
{  
    while(secure_boot_debugging){  
        __NOP();  
        __NOP();  
        __NOP();  
    }  
    /* Initialize log uart and at command service */  
    console_init();
```

Secondly, download the image binary on to the demo board from IAR IDE as shown in chapter 3.4.2.1.3. Afterwards, reset the demo board and you will observe that the program is halt before executing the main program in main.c.

Thirdly, debug the program using “Attach to Running Target” as shown below.



When everything mentioned above is completed, please follow the instructions below.

Stop the program with “Break” in the debug tab, and please add a breakpoint at “consol\_init()” in main.c. The breakpoint is used to ensure that the program will break right after the while loop, and to prevent the program to run to the end. Then, change the value of “secure\_boot\_debugging” to 0 in the Watch window to exit the while loop. Now, you can continue to debug the program.

**Note:** In situation where you want to reset the debugging process, please do not use the reset button under the debug tab. Instead, stop the debugging process, reset the demo board and debug using “Attach to Running Target” again.

## 7 Over-The-Air (OTA) Firmware Update

Over-the-air programming (OTA) provides a methodology to update device firmware remotely via TCP/IP network connection.

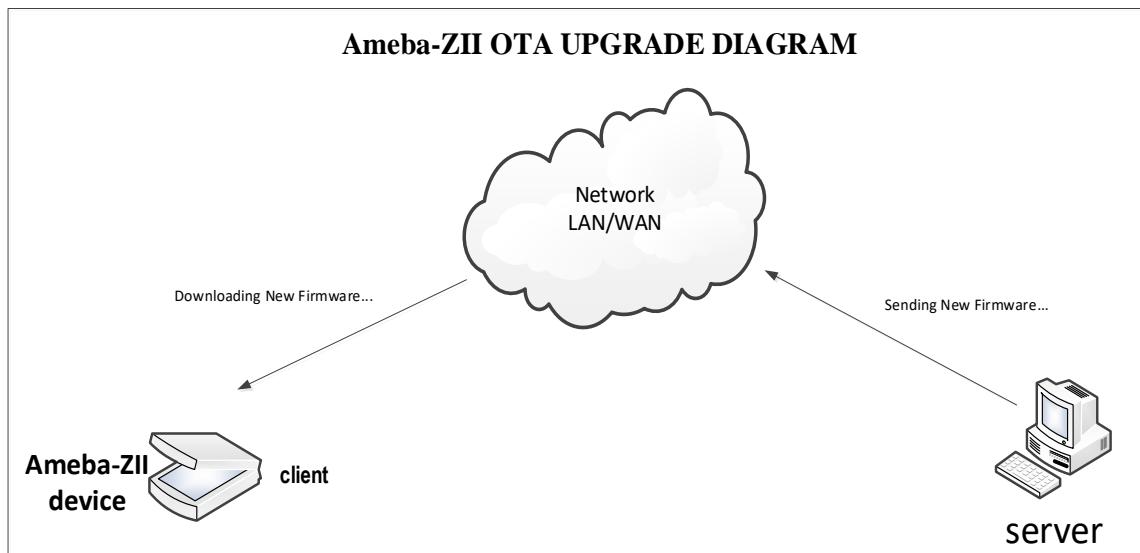


Figure 7-1 Methodology to Update Firmware via OTA

## 7.1 OTA Operation Flow

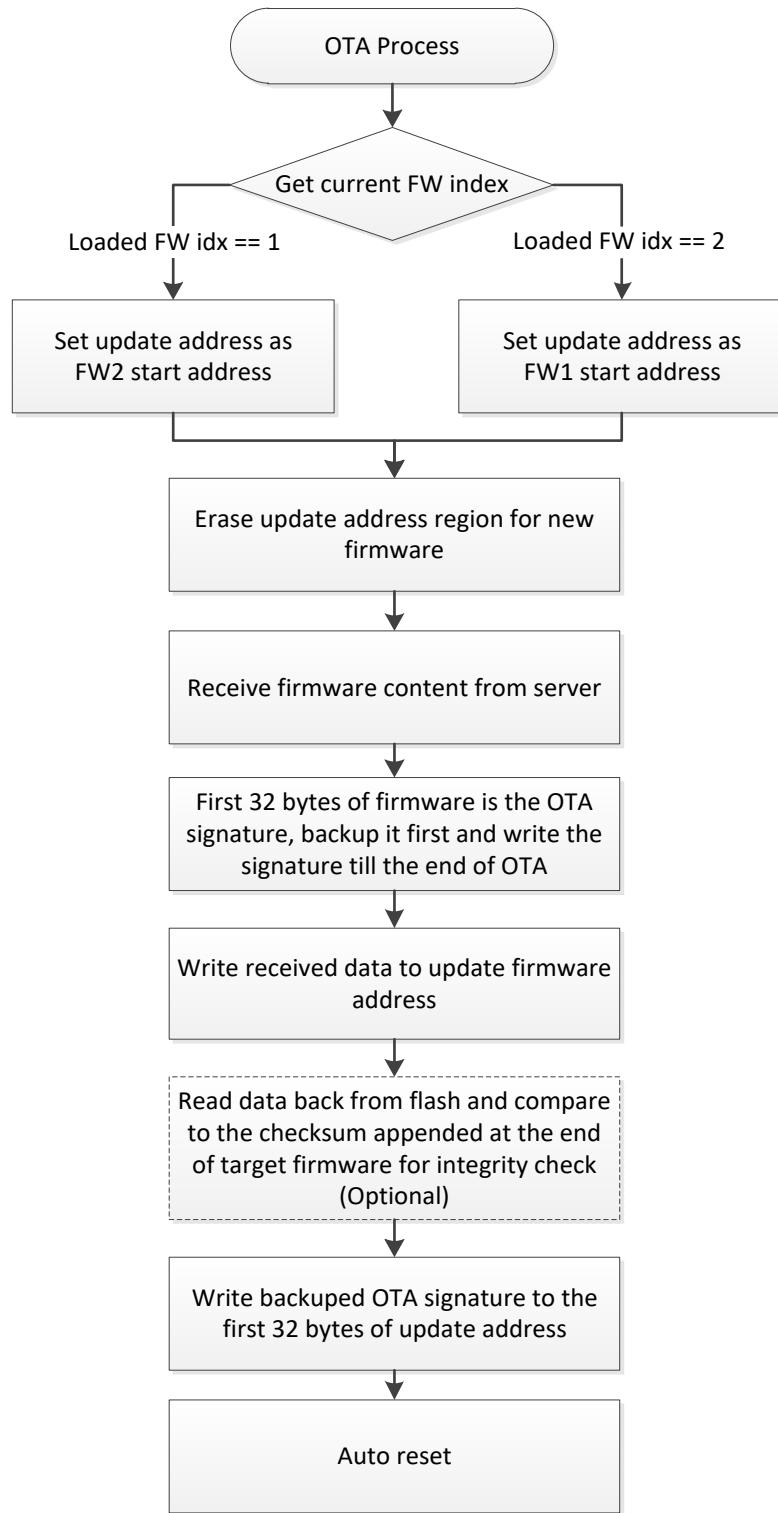


Figure 7-2 OTA Process Flow

As Table 5-9 described, the first 32 bytes of firmware image would be OTA signature, which is the hash result of the image header. During the step of “Write received data to update firmware address”, the 32 bytes OTA signature need set to 0xff, which is invalid signature. The correct OTA signature needs to be appended at the end of OTA process to prevent device booting from incomplete firmware.

## 7.2 OTA Checksum Mechanism

The 32 bytes OTA signature is used to notice the bootloader the overall OTA process is done without any network disconnection or re-boot during the OTA. However, this 32 bytes OTA signature cannot guarantee the content of firmware image is correct.

User can design a mechanism to calculate the hash of target OTA firmware for integrity check during the OTA update process. For the default OTA example in SDK, there is USE\_CHECKSUM option for this integrity check purpose. During image postbuild, SDK would append 4 bytes checksum at the end of firmware image. And when performing OTA routine, right after the firmware is downloaded and programmed into flash, it would read back all the programmed data from flash and compare with the checksum value from target firmware if USE\_CHECKSUM enabled. In such way, it can ensure the downloaded firmware is transferred completely and correct. For the detail implementation, please refer to OTA example *ota\_8710c.c* in SDK:

```
#define USE_CHECKSUM 1
```

Please note that this checksum mechanism in OTA example is added afterward. The original SDK might not have the logic for appending 4 bytes checksum value during postbuild process. Before user enable USE\_CHECKSUM in *ota\_8710c.c*, please make sure the target OTA firmware did have this 4 bytes checksum appended. Or the OTA procedure would always end in failure due to unmatched checksum value.

To check whether the postbuild generate CHECKSUM, please refer to below files.

IAR: (component\soc\realtek\8710c\misc\iar\_utility\postbuild\_is.bat or postbuild\_tz.bat)

```
%tooldir%\elf2bin.exe convert amebaz2_firmware_is.json FIRMWARE secure_bit=0 >>
postbuild_is_log.txt
if not exist Debug\Exe\firmware_is.bin (
    echo firmware_is.bin isn't generated, check postbuild_is_log.txt
    echo firmware_is.bin isn't generated > postbuild_is_error.txt
    goto error_exit
)

:: generate firmware ota image
%tooldir%\checksum.exe Debug\Exe\firmware_is.bin

::generate flash image, including partition + bootloader + firmware
%tooldir%\elf2bin.exe combine Debug/Exe/flash_is.bin
PTAB=Debug\Exe\partition.bin,BOOT=Debug\Exe\bootloader.bin,FW1=Debug\Exe\firmware_is.bin >>
postbuild_is_log.txt
if not exist Debug\Exe\flash_is.bin (
    echo flash_is.bin isn't generated, check postbuild_is_log.txt
    echo flash_is.bin isn't generated > postbuild_is_error.txt
    goto error_exit
)
```

GCC: (project\realtek\_amebaz2\_v0\_example\GCC-RELEASE\application.is.mk or application.tz.mk)

```
.PHONY: manipulate_images
```

```

manipulate_images: | application_is
@echo =====
@echo Image manipulating
@echo =====
cp ${AMEBAZ2_BOOTLOADERDIR}/bootloader.axf ${BOOT_BIN_DIR}/bootloader.axf
ifeq ($(findstring Linux, $(OS)), Linux)
    chmod 0774 $(ELF2BIN) $(CHKSUM)
endif
$(ELF2BIN) keygen keycfg.json
$(ELF2BIN) convert amebaz2_bootloader.json BOOTLOADER secure_bit=0
$(ELF2BIN) convert amebaz2_bootloader.json PARTITIONTABLE secure_bit=0
$(ELF2BIN) convert amebaz2_firmware_is.json FIRMWARE secure_bit=0
$(CHKSUM) $(BIN_DIR)/firmware_is.bin
$(ELF2BIN) combine $(BIN_DIR)/flash_is.bin
PTAB=partition.bin,BOOT=$(BOOT_BIN_DIR)/bootloader.bin,FW1=$(BIN_DIR)/firmware_is.bin

```

If postbuild does not generate CHECKSUM and ota\_8710.c does not check CHESKSUM: No influence

**If postbuild does not generate CHECKSUM and ota\_8710.c check CHECKSUM: OTA fail**

If postbuild generate CECHKSUM, and ota\_8710.c does not check CHECKSUM: No influence

If postbuild generate CHECKSUM, and ota\_8710.c check CHECSUM: OTA with integrity check

## 7.3 Boot Process Flow

Boot loader will select latest (based on serial number) updated firmware and load it.

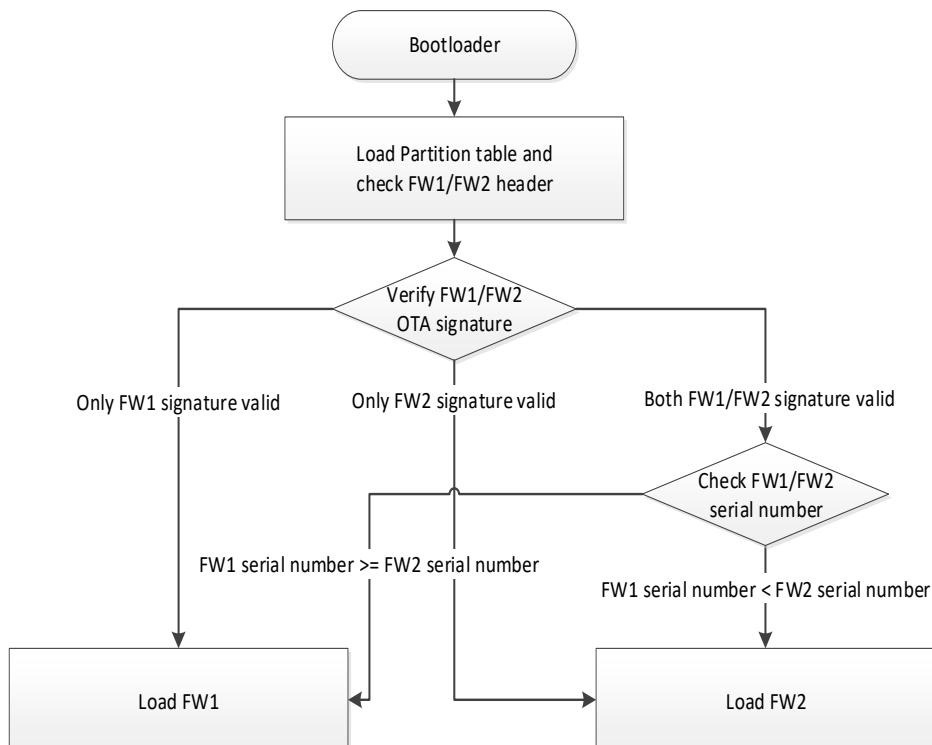


Figure 7-3 Boot Process Flow

## 7.4 Upgraded Partition

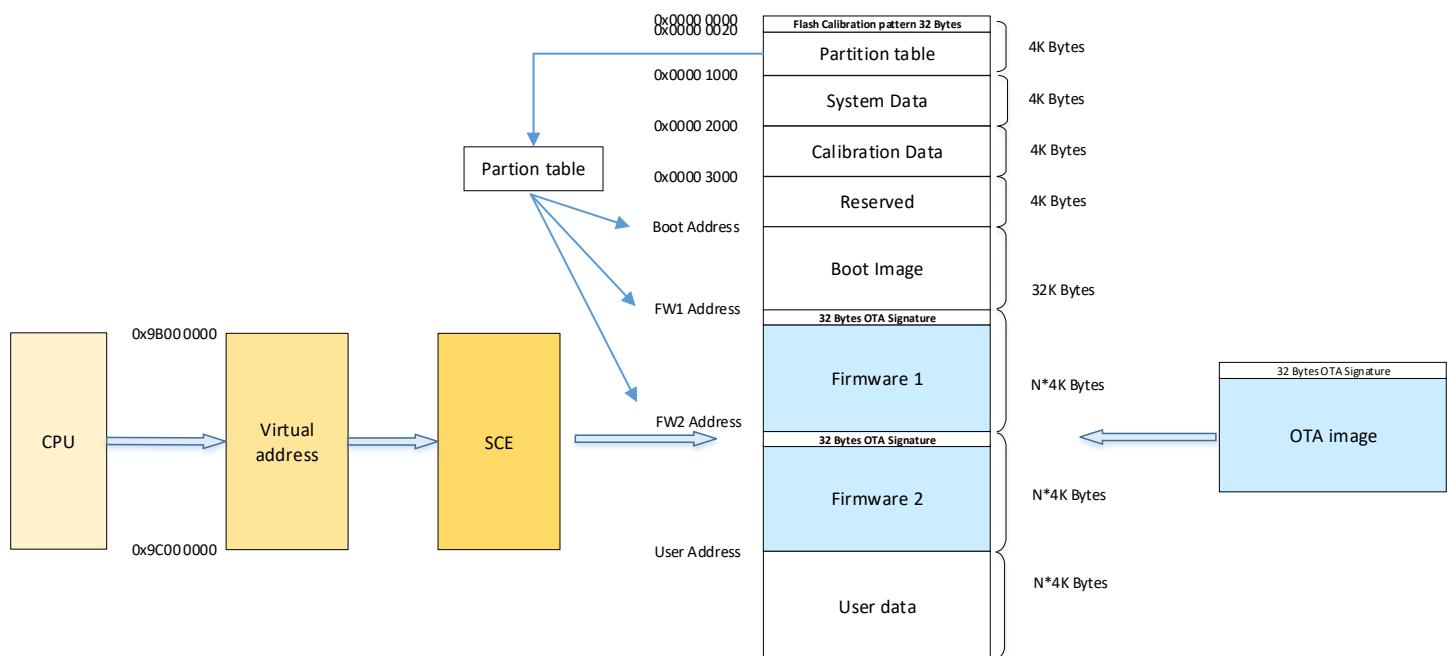


Figure 7-4 OTA update procedure

In Ameba-ZII OTA update procedure, **Firmware 1** and **Firmware 2** are swapped to each other.

The Firmware 1/Firmware 2 addresses are stored in partition records, defined in '**partition.json**' under '`project\realtek_amebaz2_v0_example\EWARM-RELEASE`'. Please adjust it according to your firmware size.

```
"fw1": {
    "start_addr" : "0x10000",
    "length" : "0x80000",
    "type": "FW1",
    "dbg_skip": false,
    "hash_key": "000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F"
},
"fw2": {
    "start_addr" : "0x90000",
    "length" : "0x80000",
    "type": "FW2",
    "dbg_skip": false,
    "hash_key": "000102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E5F"
}
```

## 7.5 Firmware Image Output

After building project source files in SDK, it would generate firmware as ‘firmware\_is.bin’, which is the OTA Firmware as mentioned earlier.

### 7.5.1 OTA Firmware Swap Behavior

When device executes OTA procedure, it would update the other OTA block, rather than the current running OTA block. The OTA firmware swap behavior should be looked like as below figure if the updated firmware keeps using newer serial number value.

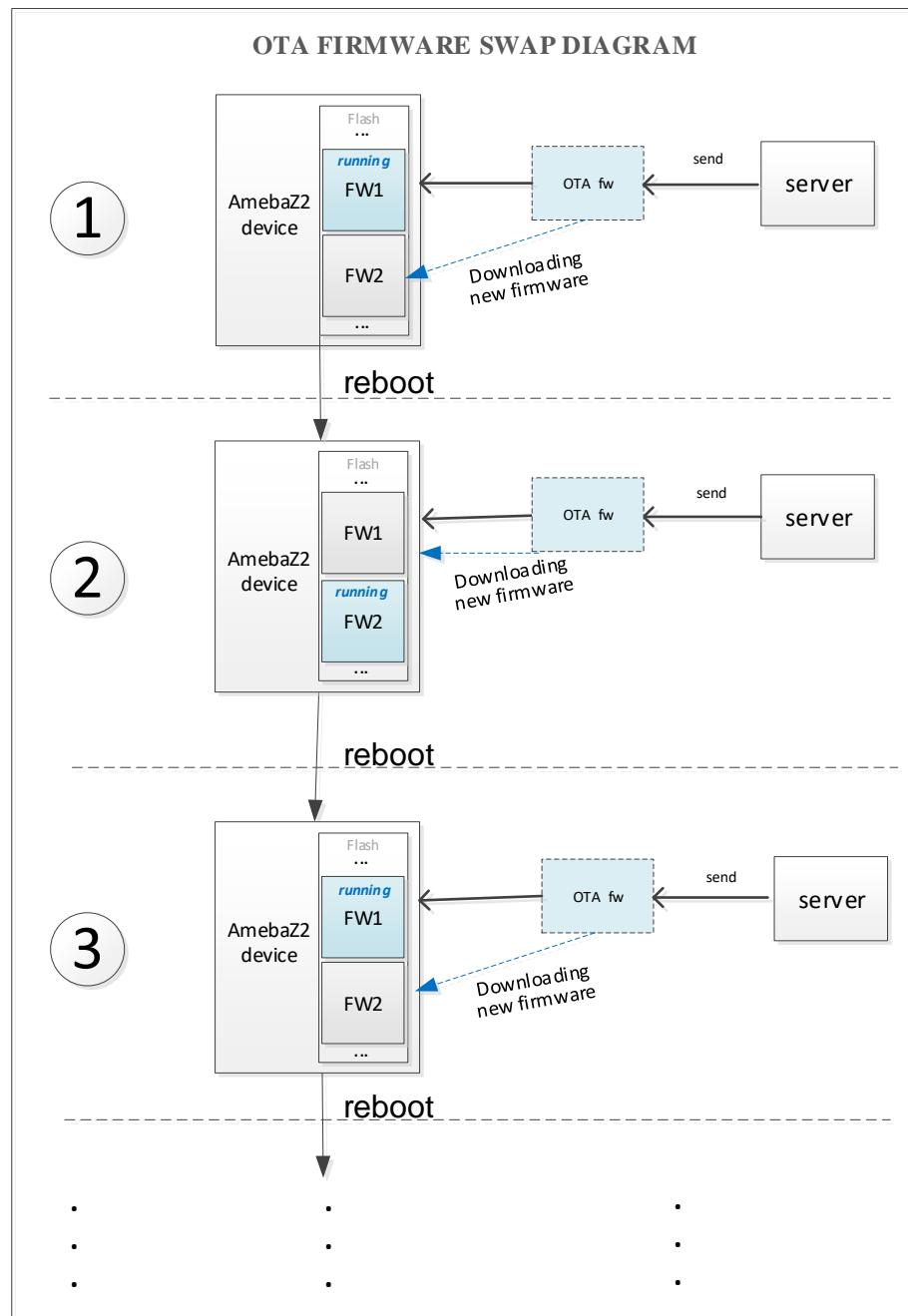


Figure 7-5 OTA Firmware SWAP Procedure

## 7.5.2 Configuration for Building OTA Firmware

Before building the project, the bootloader would check the serial number of OTA firmware to determine the boot sequence, the serial number of the OTA firmware need to be configured correctly before project build.

### 7.5.2.1 Serial Number

Ameba-ZII OTA use serial number to decide the boot sequence if the signature of firmware is valid. Hence before building the project, please make sure the serial number is correctly configured.

For **ignore secure project**, to set the serial number of a firmware, please follow below steps:

**Step 1:** The serial number setting of a firmware is as same as the serial number of its first image. You can check the images sequence in `project\realtek_amebaz2_v0_example\EWARM-RELEASE\amebaz2_firmware_is.json`.

```
"FIRMWARE":{  
    "images": [  
        {"img": "FWHS", "offset": "0x00"},  
        {"img": "XIP_FLASH_C", "offset": "0x00"},  
        {"img": "XIP_FLASH_P", "offset": "0x00"}  
    ]  
},
```

For this example, the FWHS is located at the top sequence. Hence it is the first image of this firmware.

**Step 2:** Modify the serial number setting of the first image. Take above figure for example, we need to modify the serial number of **“FWHS”**:

```
"FWHS": {  
    "source": "Debug/Exe/application_is.out",  
    "header": {  
        "next": null,  
        "__comment_type": "Support  
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,M0,CPFW",  
        "type": "FWHS_S",  
        "enc": false,  
  
        "user_key2": "BB0102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F",  
        "__comment_pkey_idx": "assign by program, no need to configurate",  
        "serial": 100  
    },
```

In new version of elf2bin tool, the Serial number is stored as 32-bit unsigned int in firmware header, valid range is from 0(0x0) ~ 4294967295(0xFFFFFFFF) and larger number means newer version. Please modify it according to your firmware version. If negative value is given to “serial”, it will become 0. If value larger than 0xFFFFFFFF is given, it will become 0xFFFFFFFF. Please make sure the elf2bin tool is below version or newer.

```
PS C:\Ameba\git_trunk\component\soc\realtek\8710c\misc\iar_utility> .\elf2bin.exe
Version: 1.0 Build: Jun 8 2020 14:56:25
USAGE : elf2bin convert <config.json> <profile_in_json> [option]
        convert function:
          Argument: config.json   : JSON config file for convert
          Argument: profile_in_json : Listed profile in JSON config
          Argument: option         : format arg1=val1,arg2=val2,...,argN=valN . can be ignore, if using default value
                                      : arg           | val           | comment
                                      : -----
                                      : secure_bit    | 0 or 1       | default value is 0
                                      : firmware_key  | curve or aes | default value is curve
: elf2bin keygen <config.json>
: elf2bin combine <output.bin> PTAB=partition.bin,BOOT=boot.bin,FW1=firmware.bin
  format : PARTITION_TYPE0=FILENAME0,...,PARTITION_TYPE0=FILENAME0
  PTAB is a special string for partition table
  BOOT/FW1/FW2 is partition type from definition in partition.json
```

**Important:** There was a limitation in old version of elf2bin tool. The valid number is from 0(0x0) to 2147483647(0x7FFFFFFF, INT\_MAX), if negative value is given to "serial", -2147483648 ~ -1 will be 2147483648(0x80000000) ~ 4294967295(0xFFFFFFFF) which will be even larger. Any version or build time which is older than below one has this limitation.

```
PS C:\Ameba\v7.1a\component\soc\realtek\8710c\misc\iar_utility> .\elf2bin.exe
Version: 1.0 Build: Dec 11 2019 17:05:18
USAGE : elf2bin convert <config.json> <profile_in_json> [option]
        convert function:
          Argument: config.json   : JSON config file for convert
          Argument: profile_in_json : Listed profile in JSON config
          Argument: option         : format arg1=val1,arg2=val2,...,argN=valN . can be ignore, if using default value
                                      : arg           | val           | comment
                                      : -----
                                      : secure_bit    | 0 or 1       | default value is 0
                                      : firmware_key  | curve or aes | default value is curve
: elf2bin keygen <config.json>
: elf2bin combine <output.bin> PTAB=partition.bin,BOOT=boot.bin,FW1=firmware.bin
  format : PARTITION_TYPE0=FILENAME0,...,PARTITION_TYPE0=FILENAME0
  PTAB is a special string for partition table
  BOOT/FW1/FW2 is partition type from definition in partition.json
```

**Step 3:** After building project source files in SDK, it should automatically generate *SDK\_folder/project/project\_name/EWARM-RELEASE/Debug/Exe/firmware\_is.bin*, which is the application of OTA Firmware. The serial information would also be included in this firmware.

For **trust zone project**, to set the serial number of a firmware, please follow below steps:

**Step 1:** The serial number setting of a firmware is as same as the serial number of its first image. You can check the images sequence in *project\realtek\_amebaz2\_v0\_example\EWARM-RELEASE\amebaz2\_firmware\_tz.json*.

```
"FIRMWARE":{
  "images": [
    {"img": "FWHS_S", "offset": "0x00"},  

    {"img": "FWHS_NSC", "offset": "0x00"},  

    {"img": "FWHS_NS", "offset": "0x00"},  

    {"img": "XIP_S_C", "offset": "0x00"},  

    {"img": "XIP_S_P", "offset": "0x00"},  

    {"img": "XIP_NS_C", "offset": "0x00"},  

    {"img": "XIP_NS_P", "offset": "0x00"}
  ]
},
```

For this example, the FWHS\_S is located at the top sequence. Hence it is the first image of this firmware.

**Step 2:** Modify the serial number setting of the first image. Take above figure for example, we need to modify the serial number of "FWHS\_S":

```
"FWHS_S": {
  "source": "Debug/Exe/application_s.out",
```

```

    "header": {
        "next": null,
        "__comment_type": "Support
Type:PARTAB,BOOT,FWHS_S,FWHS_NS,FWLS,ISP,VOE,WLN,DTCM,ITCM,SRAM,ERAM,XIP,MO,CPFW",
        "type": "FWHS_S",
        "enc": false,
        "user_key2": "BB0102030405060708090A0B0C0D0E0F101112131415161718191A1B1C1D1E1F",
        "__comment_pkey_idx": "assign by program, no need to configurate",
        "serial": 100
    },

```

**Step 3:** After building project source files in SDK, it should automatically generate */project/project\_name/EWARM-RELEASE/Debug/Exe/firmware\_tz.bin*, which is the application of OTA Firmware. The serial information would also be included in this firmware.

## 7.6 Implement OTA Over Wi-Fi

### 7.6.1 OTA Using Local Download Server Base on Socket

The example shows how device updates image from a local download server. The local download server send image to device based on network socket.

Make sure both device and PC are connecting to the same local network.

#### 7.6.1.1 Build OTA Application Image

##### Turn on OTA command

The flag defined in *\project\realtek\_amebaz2\_v0\_example\inc\platform\_opts.h*.

```
//on/off relative commands in log service
#define CONFIG_OTA_UPDATE 1
```

Download the firmware to Ameba-ZII board to execute OTA.

#### 7.6.1.2 Setup Local Download Server

**Step 1:** Build new firmware *firmware\_is.bin* and place it to *tools\DownloadServer* folder.

**Step 2:** Edit *start.bat* file: Port = 8082, file = *firmware\_is.bin*

```
@echo off
DownloadServer 8082 firmware_is.bin
set /p DUMMY=Press Enter to Continue ...
```

**Step 3:** Execute 'start.bat'.

```
c():checksum 0x202f57d
Listening on port (8082) to send firmware_is.bin (318592 bytes)

Waiting for client ...
```

#### 7.6.1.3 Execute OTA Procedure

After device connects to AP, enter command: **ATWO=IP[PORT]**. Please note that the device and your PC need under the same AP. The IP in ATWO command is the IP of your PC.

```
# ATWO=192.168.0.103[8082]
[ATWO] : _AT_WLAN_OTA_UPDATE
```

```
[MEM] After do cmd, available heap 92768

#
[update_ota_local_task] Update task start
[update_ota_prepare_addr] fw1 sn is 100, fw2 sn is 0
[update_ota_prepare_addr] NewFWAddr 00090000

[update_ota_local_task] Read info first
[update_ota_local_task] info 12 bytes
[update_ota_local_task] tx file size 0x4dc80
[update_ota_local_task] Current firmware index is 1

[update_ota_erase_upg_region] NewFWLen 318592
[update_ota_erase_upg_region] NewFWBlkSize 78 0x4e
[update_ota_local_task] Start to read data 318592 bytes
[update_ota_local_task] sig_backup for 32 bytes from index 0
.....
Read data finished

[update_ota_signature] Append OTA signature
[update_ota_signature] signature:
64 89 F2 09 0A 2A EC 7B 82 3F 1A 15 3C 92 00 66
98 6E 45 94 1E 1D 71 9C E0 E3 15 7A 7F 76 B1 89
[update_ota_local_task] Update task exit
[update_ota_local_task] Ready to reboot
== Rt18710c IOT Platform ==
```

Local download server success message:

```
c():checksum 0x202f57d
Listening on port (8082) to send firmware_is.bin (318592 bytes)

Waiting for client ...
Accept client connection from 192.168.0.108
Send checksum and file size first
Send checksum byte 12
Sending file...
.....
Total send 318592 bytes
Client Disconnected.
Waiting for client ...
```

After finishing downloading image, device will be auto-rebooted, and the bootloader will boot by the firmware with larger serial number.

## 7.6.2 OTA Using Local Download Server Based on HTTP

This example shows how device updates image from a local http download server. The local http download server will send the http response which data part is '**firmware\_is.bin**' after receiving the http request.

**Note:** Make sure both device and PC are connecting to the same local network.

### 7.6.2.1 Build OTA Application Image

#### Turn on OTA command

The flags defined in `\project\realtek_amebaz2_v0_example\inc\platform_opts.h` and `\component\soc\realtek\8710c\misc\platform\ota_8710c.h`.

```
/* platform_opts.h */
//on/off relative commands in log service
#define CONFIG_OTA_UPDATE 1

#define CONFIG_EXAMPLE_OTA_HTTP 1
```

```
/* ota_8710c.h */
#define HTTP_OTA_UPDATE
```

#### Define Server IP and PORT in example\_ota\_http.c file

(In `\component\common\example\ota_http\example_ota_http.c`)

```
#define PORT          8082
#define IP             "192.168.0.103"
#define RESOURCE      "firmware_is.bin"
```

**Download the firmware to Ameba-ZII board to execute OTA.**

#### Communication with Local HTTP download server

1. In `http_update_ota_task()`, after connecting with server, Ameba will send a HTTP request to server : "GET /RESOURCE HTTP/1.1\r\nHost: host\r\n\r\n".
2. The local HTTP download server will send the HTTP response after receiving the request. The response header contains the "Content-Length" which is the length of the `firmware_is.bin`. The response data part is just `firmware_is.bin`.
3. After Ameba receiving the HTTP response, it will parse the http response header to get the content length to judge if the receiving `firmware_is.bin` is completed.

### 7.6.2.2 Setup Local Http Download Server

**Step 1:** Build new firmware firmware\_is.bin and place to tools\DownloadServer(HTTP) folder.

**Step 2:** Edit start.bat file: Port = **8082**, file = **firmware\_is.bin**

```
@echo off  
DownloadServer 8082 firmware_is.bin  
set /p DUMMY=Press Enter to Continue ...
```

**Step 3:** Execute start.bat.

```
<Local HTTP Download Server>  
Listening on port (8082) to send firmware_is.bin (320256 bytes)  
Waiting for client ...
```

### 7.6.2.3 Execute OTA Procedure

Reboot the device and connect to AP, it should start the OTA update through HTTP protocol after 1 minute.

```
#  
#[update_ota_prepare_addr] fw1 sn is 100, fw2 sn is 0  
#[update_ota_prepare_addr] NewFWAddr 00090000  
  
[http_update_ota] Download new firmware begin, total size : 320256  
[http_update_ota] Current firmware index is 1  
[http_update_ota] fw size 320256, NewFWAddr 00090000  
  
[update_ota_erase_upg_region] NewFWLen 320256  
[update_ota_erase_upg_region] NewFwBlkSize 79 0x4f.  
[http_update_ota] sig_backup for 32 bytes from 0 index  
.....  
[http_update_ota] Download new firmware 320256 bytes completed  
[update_ota_signature] Append OTA signature  
[update_ota_signature] signature:  
 DD E9 FE 19 3B 15 79 99 8A 3C 84 FE 28 FB A2 13  
 53 0F DE 71 3B 7E 46 48 9F 9D 03 2C DB EB D3 B7  
[http_update_ota_task] Update task exit  
[http_update_ota_task] Ready to reboot  
== Rt18710c Iot Platform ==
```

Local download server success message:

```
<Local HTTP Download Server>  
Listening on port (8082) to send firmware_is.bin (320256 bytes)  
  
Waiting for client ...  
Accept client connection from 192.168.0.108  
Waiting for client's request...  
Receiving GET request, start sending file...  
.....  
Total send 320299 bytes  
Client Disconnected.  
Waiting for client ...
```

After finishing downloading image, device will be auto-rebooted, and the bootloader will load new firmware if it exists.

## 8 Power Save

### 8.1 Power Consumption Summary

The following table lists the power consumption of Ameba-ZII under 3.3V power supply.

#### Board Information:

- Board number: AMEBAZII\_DEV\_2V0
- Module number: AZ87CC1\_2V1
- Chip number: RTL8720\_CX
- FLASH is external, GPIO\_A7 to GPIO\_A12 is occupied for FLASH
- JTAG is enabled, GPIO\_A1 and GPIO\_A0 is occupied for JTAG
- log UART is GPIO\_A15 and GPIO\_A16

#### SVN version

- v7.1c

| Wakeup Source | Clock (Hz)     |      |              |     |            |      |
|---------------|----------------|------|--------------|-----|------------|------|
|               | 250k           | 4M   | 250k         | 4M  | 250k       | 4M   |
|               | DeepSleep (uA) |      | Standby (uA) |     | Sleep (uA) |      |
| Stimer        | 25.9           | 25.8 | 181          | 197 | 407        | 408  |
| GPIO_A2       | 301            | 302  | 458          | 471 | 684        | 702  |
| GPIO_A3       | 294            | 301  | 457          | 470 | 686        | 692  |
| GPIO_A4       | 303            | 301  | 458          | 470 | 684        | 686  |
| GPIO_A13      | 315            | 303  | 456          | 472 | 687        | 686  |
| GPIO_A14      | 301            | 300  | 454          | 469 | 679        | 680  |
| GPIO_A17      | 298            | 300  | 457          | 469 | 685        | 678  |
| GPIO_A18      | 301            | 301  | 456          | 468 | 682        | 683  |
| GPIO_A19      | 299            | 300  | 459          | 471 | 680        | 684  |
| GPIO_A20      | 302            | 300  | 457          | 473 | 681        | 680  |
| GPIO_A23      | 304            | 299  | 462          | 470 | 678        | 678  |
| UART_0        | NA             | NA   | 753          | 770 | 1036       | 1033 |
| Gtimer_0      | NA             | NA   | 677          | 689 | 942        | 948  |
| Gtimer_1      | NA             | NA   | 672          | 692 | 953        | 945  |
| Gtimer_2      | NA             | NA   | 678          | 692 | 945        | 944  |
| Gtimer_3      | NA             | NA   | 681          | 685 | 952        | 947  |
| Gtimer_4      | NA             | NA   | 679          | 692 | 947        | 948  |
| Gtimer_5      | NA             | NA   | 678          | 687 | 947        | 950  |
| Gtimer_6      | NA             | NA   | 680          | 688 | 950        | 945  |
| PWM_0 PA_20   | NA             | NA   | 703          | 714 | 970        | 966  |
| PWM_2 PA_2    | NA             | NA   | 689          | 715 | 967        | 965  |
| PWM_3 PA_3    | NA             | NA   | 699          | 712 | 968        | 967  |
| PWM_4 PA_4    | NA             | NA   | 695          | 710 | 971        | 970  |
| PWM_5 PA_17   | NA             | NA   | 706          | 713 | 974        | 968  |
| PWM_6 PA_18   | NA             | NA   | 702          | 717 | 970        | 969  |
| PWM_7 PA_13   | NA             | NA   | 694          | 709 | 972        | 971  |

## 9 eFuse

### 9.1 Introduction

eFuse belongs to One Time Programmable (OTP) technology, its default value is '1', and can only be changed from '1' to '0'. eFuse can be used to hold the individual and stable data such as key, calibration data, MAC address and specific setting.

The total size of physical eFuse is 512 bytes and divided into two parts by software. The first 256 bytes of physical eFuse are used for logical mapping, which can be mapped to logical eFuse by some algorithm and can be programmed multiple times. The remaining 256 bytes of the physical eFuse are defined by Realtek.

Logical eFuse program will program header and package, and the package is in word, so it takes at least three bytes a time. Software reserves one byte for isolation, so when the space of eFuse for logical mapping is less than four bytes, it cannot be programmed in any mode.

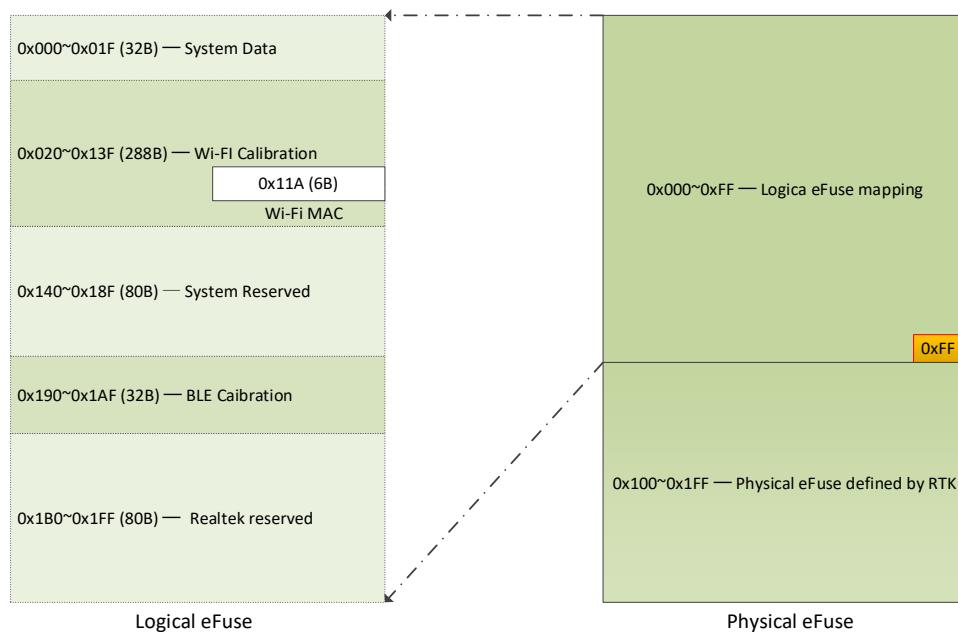


Fig 9-1 eFuse Diagram

### 9.2 Power Requirement

The power requirement of eFuse operation is listed in the Table 9-1 below.

| Supply Voltage (V) | Operation                      |
|--------------------|--------------------------------|
| 1.146              | Only read operation is allowed |
| 2.5                | Program eFuse                  |

Table 9-1 Operation under different voltage

**Note:** If you want to program eFuse, you must switch the power supply to 2.5V

## 9.3 eFuse Auto-load

eFuse can auto-load part of setting to control the circuit. eFuse auto-load is changed in word (two bytes). Under default condition, value of all the System Data bytes is 0xFF, and the System Configure Registers have its default values.

The way to change the value of System Configure Registers is as follows:

- In the logical eFuse, make sure that the third and fourth bytes of System Data area are written to 0x10 and 0x87 correctly.
- Program the corresponding bytes in word. If just programming in byte, another byte will load the eFuse default value 0xFF, which may make mistakes.
- Reboot the chip, and the System Configure Registers will load the new values.

## 9.4 Logical eFuse

### 9.4.1 Logical eFuse Layout

There is total 512 bytes logical eFuse in Ameba-ZII, as shown in the Table 9-2 below. Most of the logical eFuse space are reserved for extension, so the 512 bytes of logical eFuse can be easily mapped to 256 bytes of physical eFuse.

| Start Address | End Address | Description                   |
|---------------|-------------|-------------------------------|
| 0x000         | 0x01F       | System Data to be auto-loaded |
| 0x020         | 0x13C       | Wi-Fi Calibration data        |
| 0x140         | 0x18F       | System reserved               |
| 0x190         | 0x1AD       | Bluetooth Calibration data    |
| 0x1B0         | 0x1FF       | Realtek reserved              |

Table 9-2 Logical eFuse Layout

### 9.4.2 Wi-Fi 2.4G Power Index

The addresses and specifications of 2.4G power index are shown in Fig 9-2 and Fig 9-3.

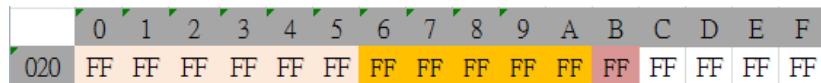


Fig 9-2 2.4G Wi-Fi power index address

| offset | name            | comment   |
|--------|-----------------|---|
| 20~25  | 2.4G CCK Index  | Path A CCK Power Index for Ch 1,2, Range 0~127,0.25dbm/step.<br>Path A CCK Power Index for Ch 3, 4, 5, Range 0~127,0.25dbm/step.<br>Path A CCK Power Index for Ch 6, 7,8, Range 0~127,0.25dbm/step.<br>Path A CCK Power Index for Ch 9, 10, 11, Range 0~127,0.25dbm/step.<br>Path A CCK Power Index for Ch 12, 13, Range 0~127,0.25dbm/step.<br>Path A CCK Power Index for Ch 14, Range 0~127,0.25dbm/step. |
|        | 2.4G BW40 Index | Path A 2G BW40-1S Power Index for Ch 1, 2, Range 0~127,0.25dbm/step.<br>Path A 2G BW40-1S Power Index for Ch 3, 4, 5, Range 0~127,0.25dbm/step.<br>Path A 2G BW40-1S Power Index for Ch 6, 7 ,8, Range 0~127,0.25dbm/step.<br>Path A 2G BW40-1S Power Index for Ch 9, 10, 11, Range 0~127,0.25dbm/step.<br>Path A 2G BW40-1S Power Index for Ch 12, 13, 14 Range 0~127,0.25dbm/step.                        |
|        | 2.4G Difference | Power Index Difference between BW20-1S and BW40-1S.<br>Bit[7:4]: Path A 2G Offset, Range -8~7,0.5dbm/step.<br>Power Index Difference between OFDM-1Tx and BW40-1S.<br>Bit[3:0]: Path A 2G Offset, Range -8~7,0.5dbm/step.   |
|        |                 |   |
|        |                 |   |
|        |                 |   |

Fig 9-3. 4G Wi-Fi power index specifications

### 9.4.3 Wi-Fi Channel Plan

The address of Wi-Fi channel plan is shown in Fig 9-4.

|     | 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | A  | B  | C  | D  | E  | F  |
|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 0C0 | FF |

Fig 9-4 Address of Wi-Fi channel plan

| eFuse | Name         | Bit   | Default | Comment   |
|-------|--------------|-------|---------|---|
| 0x0C8 | Channel Plan | [7]   | 0h      | <p>Software configure mode</p> <ul style="list-style-type: none"><li>• 0h: Enable software configure (refer to Channel Plane Domain Code)</li><li>• 1h: Disable software configure (cannot change Channel Plan Setting)</li></ul>   |
|       |              | [6:0] | 7Fh     | <p>Channel Plan</p> <ul style="list-style-type: none"><li>• 20h: 2G worldwide13, channel 1~13</li><li>• 21h: 2G Europe, channel 1~13</li><li>• 22h: 2G US, channel 1~11</li><li>• 23h: 2G Japan, channel 1~13,14</li><li>• 24h: 2G France, channel 10~13</li><li>• 2Ah: 2G US, channel 1~13</li><li>• 58h: 2G Japan, channel 1~13</li></ul> |

Frequently used country codes and the corresponding channel plans are listed in Table 9-3 and Table 9-4.

| Country   | Abbreviation | Enumeration Variable name        | Channel Plan |
|-----------|--------------|----------------------------------|--------------|
| America   | US           | RTW_COUNTRY_US                   | 0x76         |
| Australia | AS           | RTW_COUNTRY_AS                   | 0x2A         |
| Chile     | CL           | RTW_COUNTRY_CL                   | 0x2D         |
| China     | CN           | RTW_COUNTRY_CN                   | 0x48         |
| Europe    | EU           | RTW_COUNTRY_UA                   | 0x26         |
| Japan     | JP           | RTW_COUNTRY_JP                   | 0x27         |
| Mexico    | MX           | RTW_COUNTRY_MX                   | 0x4D         |
| Ukraine   | UA           | RTW_COUNTRY_UA                   | 0x35         |
| Default   | -            | RT_CHANNEL_DOMAIN_REALTEK_DEFINE | 0x7F         |

Table 9-3 Relationship between country code and channel plan

| Channel Plan | 2.4G Channel Definition | Channels                                      | Passive |
|--------------|-------------------------|---|---------|
| 0x76         | 2G_02                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | -       |
| 0x2A         | 2G_02                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | -       |
| 0x2D         | 2G_01                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | 12,13   |
| 0x48         | 2G_01                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | 12,13   |
| 0x26         | 2G_01                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | 12,13   |
| 0x27         | 2G_04                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 | -       |
| 0x4D         | 2G_02                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | -       |
| 0x35         | 2G_01                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | 12,13   |
| 0x7F         | 2G_01                   | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13     | 12,13   |

Table 9-4 2.4G channel map of the above channel plan

Note: Active scan channels are channel listed in table except the passive scan channels.

#### 9.4.4 Wi-Fi Crystal Calibration

The address of Wi-Fi crystal calibration is shown in Fig 9-5.



Fig 9-5 Crystal calibration address

| eFuse | Name                | Bit   | Default | Comment   |
|-------|---------------------|-------|---------|---|
| 0x0C9 | Crystal Calibration | [7]   | 0h      | <ul style="list-style-type: none"> <li>• Reserved</li> </ul>  |
|       |                     | [6:0] | 3Fh     | XTAL_K Value<br><ul style="list-style-type: none"> <li>• <math>X_i = X_o</math>, range 0~7Fh</li> </ul> |

#### 9.4.5 Wi-Fi Thermal Meter

The address of Thermal Meter is shown in Fig 9-6



Fig 9-6 Adress of Thermal Meter

| eFuse | Name | Bit | Default | Comment |
|-------|------|-----|---------|---------|
|-------|------|-----|---------|---------|

|       |               |       |     |   |  |
|-------|---------------|-------|-----|---|--|
| 0x0CA | Thermal Meter | [7:0] | 20h | Thermal Meter Default Value <ul style="list-style-type: none"> <li>System maker will calibrate a value and save it in EEPROM.</li> <li>Bit[7:0]: Thermal Meter Value</li> </ul> |  |
|-------|---------------|-------|-----|---|--|

## 9.4.6 Wi-Fi MAC Address

The Wi-Fi MAC address is shown in Fig 9-7.



Fig 9-7 MAC address

| eFuse | Bit    | Default      | Comment  |
|-------|--------|--------------|--|
| 0x0CA | [47:0] | FFFFFFFFFFFF | After the auto-load command or hardware reset, Ameba-ZII loads MAC addresses to MACID of the I/O registers |

## 9.4.7 BLE

| Address Offset | Bit    | Default       | Description   |
|----------------|--------|---------------|---|
| 190h ~ 0x195h  | [47:0] | FFFFFFFFFFFFh | BT address  |
| 196h           | [7:0]  | 08h           | Function Enable <ul style="list-style-type: none"> <li>Bit[7:0] : Default is 0x08.</li> <li>Bit[0] : Fix 0.</li> <li>Bit[1] : Tx gain K valid bit* .</li> <li>Bit[2] : Flatness K valid * .</li> <li>Bit[3] : Fix 1.</li> <li>Bit[7:4] : Fix 0.</li> </ul> <b>Note:</b> <ul style="list-style-type: none"> <li>After Tx gain K flow please remember to enable this bit which 0x196 will be 0xA.</li> <li>After Tx flatness K flow, please remember to enable this bit which 0x196 will be 0xC.</li> </ul> |
| 197h           | [7:0]  | FFh           | Bit[7:0] : Tx Gain K.<br>0.5dBm/step.<br><b>Note:</b> <ul style="list-style-type: none"> <li>It's reminded that customer need to write Tx Gain K value if Tx gain K valid bit is enabled.</li> </ul>  |
| 198h~199h      | [7:0]  | FFh           | Flatness K  |
| 19Ah~19Bh      | [7:0]  | FFh           | Reserved for Realtek  |
| 19Ch           | [7:0]  | 2Ah           | Max TX Gain LE1M  |
| 19Dh           | [7:0]  | FFh           | Reserved for Realtek  |
| 19Eh~19Fh      | [15:0] | FFFFh         | Reserved for Realtek  |
| 1A0h           | [7:0]  | FFh           | BT Thermal Meter  |
| 1A1h           | [7:0]  | FFh           | Logic map IQK/KOK valid bit <ul style="list-style-type: none"> <li>FF: Disable logic map IQK/KOK values</li> <li>FE: Enable logic map IQK/KOK values</li> </ul>   |

|           |        |          |                      |
|-----------|--------|----------|----------------------|
| 1A2h~1A5h | [31:0] | FFFFFFFh | Reserved for Realtek |
| 1A6h~1A9h | [31:0] | FFFFFFFh | Logic map IQK values |
| 1AAh~1ABh | [15:0] | FFFFh    | Logic map LOK values |

## 9.5 eFuse PG APIs

| Items         | API                        | Description                                  |
|---------------|----------------------------|--|
| Mbed API      | efuse_get_remaining_length | Get remaining efuse length                   |
|               | efuse_otp_read             | Read efuse OTP content                       |
|               | efuse_otp_write            | Write user's content to OTP efuse            |
|               | efuse_otp_chk              | Check user's content to OTP efuse            |
|               | efuse_disable_jtag         | Disable jtag                                 |
|               | efuse_disable_sec_jtag     | Disable secure jtag                          |
|               | efuse_disable_nonsec_jtag  | Disable nonsecure jtag                       |
|               | efuse_sec_key_write        | Write secure key to physical efuse           |
|               | efuse_susec_key_write      | Write super secure key to physical efuse     |
|               | efuse_s_jtag_key_write     | Write secure j-tag key to physical efuse     |
|               | efuse_ns_jtag_key_write    | Write non-secure j-tag key to physical efuse |
| Low Level API | efuse_logical_read         | Read efuse content on logical map            |
|               | efuse_logical_write        | Write user's content to efuse on logical map |
|               | efuse_fw_verify_enable     | To enable secure boot                        |
|               | efuse_fw_verify_check      | To check the secure boot is enabled or not   |

### 9.5.1 Mbed APIs

#### 9.5.1.1 efuse\_get\_remaining\_length

| Items        | Description  |
|--------------|--|
| Introduction | Get remaining efuse length   |
| Parameters   |  |
| Return       | <ul style="list-style-type: none"> <li>• remaining efuse length</li> </ul> |

#### 9.5.1.2 efuse\_otp\_read

| Items        | Description   |
|--------------|---|
| Introduction | Read efuse OTP content.   |
| Parameters   | <ul style="list-style-type: none"> <li>• address: Specifies the offset of the OTP.</li> <li>• len: Specifies the length of readback data.</li> <li>buf: Specified the address to save the readback data.</li> </ul> |
| Return       | <ul style="list-style-type: none"> <li>• 0: Success</li> <li>• -1: Failure</li> </ul>   |

#### 9.5.1.3 efuse\_otp\_write

| Items        | Description  |
|--------------|--|
| Introduction | Write user's content to OTP efuse  |
| Parameters   | <ul style="list-style-type: none"> <li>• address: Specifies the offset of the programmed OTP.</li> </ul> |

|        |   |
|--------|---|
|        | <ul style="list-style-type: none"> <li>• len: Specifies the data length of programmed data.</li> </ul> <p>buf: Specified the data to be programmed.</p> |
| Return | <ul style="list-style-type: none"> <li>• 0: Success</li> <li>• -1: Failure</li> </ul>   |

#### 9.5.1.4 efuse\_otp\_chk

| Items        | Description   |
|--------------|---|
| Introduction | Check user's content to OTP efuse   |
| Parameters   | <ul style="list-style-type: none"> <li>• buf: Specified the data to be programmed.</li> <li>• len: Specifies the data length of programmed data.</li> </ul> |
| Return       | <ul style="list-style-type: none"> <li>• 0: Success</li> <li>• -1: Failure</li> </ul>   |

#### 9.5.1.5 efuse\_disable\_jtag

| Items        | Description  |
|--------------|--|
| Introduction | Disable jtag   |
| Parameters   |  |
| Return       | <ul style="list-style-type: none"> <li>• 0: Success</li> </ul> |

#### 9.5.1.6 efuse\_disable\_sec\_jtag

| Items        | Description  |
|--------------|--|
| Introduction | Disable secure jtag  |
| Parameters   |  |
| Return       | <ul style="list-style-type: none"> <li>• 0: Success</li> </ul> |

#### 9.5.1.7 efuse\_disable\_nonsec\_jtag

| Items        | Description  |
|--------------|--|
| Introduction | Disable nonsecure jtag   |
| Parameters   |  |
| Return       | <ul style="list-style-type: none"> <li>• 0: Success</li> </ul> |

#### 9.5.1.8 efuse\_sec\_key\_write

| Items        | Description  |
|--------------|--|
| Introduction | Write secure key to efuse.   |
| Parameters   | <ul style="list-style-type: none"> <li>• buf: specified the 32-byte security key to be programmed.</li> <li>• key_num: select key number.</li> </ul> |
| Return       | <ul style="list-style-type: none"> <li>• 0 Success</li> <li>• -1 Failure</li> </ul>  |

#### 9.5.1.9 efuse\_susec\_key\_write

| Items | Description |
|-------|-------------|
|-------|-------------|

|              |   |
|--------------|---|
| Introduction | Write super secure key to efuse   |
| Parameters   | <ul style="list-style-type: none"> <li>buf: Specified the 32-byte super security key to be programmed.</li> </ul> |
| Return       | <ul style="list-style-type: none"> <li>0 Success</li> <li>-1 Failure</li> </ul>                                   |

### 9.5.1.10 efuse\_lock\_susec\_key

| Items        | Description   |
|--------------|---|
| Introduction | Lock super secure key   |
| Parameters   |   |
| Return       | <ul style="list-style-type: none"> <li>0 Success</li> <li>-1 Failure</li> </ul> |

### 9.5.1.11 efuse\_s\_jtag\_key\_write

| Items        | Description   |
|--------------|---|
| Introduction | Write secure j-tag key to efuse   |
| Parameters   | <ul style="list-style-type: none"> <li>buf: Specified the 16-byte S-JTAG key to be programmed.</li> </ul> |
| Return       | <ul style="list-style-type: none"> <li>Success</li> <li>-1 Failure</li> </ul>                             |

### 9.5.1.12 efuse\_ns\_jtag\_key\_write

| Items        | Description   |
|--------------|---|
| Introduction | Write non-secure j-tag key to efuse   |
| Parameters   | <ul style="list-style-type: none"> <li>buf: Specified the 16-byte S-JTAG key to be programmed.</li> </ul> |
| Return       | <ul style="list-style-type: none"> <li>Success</li> <li>-1 Failure</li> </ul>                             |

## 9.5.2 Low Level APIs

### 9.5.2.1 efuse\_logical\_read

| Items        | Description   |
|--------------|---|
| Introduction | Read efuse content on logical map   |
| Parameters   | <ul style="list-style-type: none"> <li>laddr: address on logical map</li> <li>size: size of wanted data</li> <li>pbuf: buffer of read data</li> </ul> |
| Return       | <ul style="list-style-type: none"> <li>return number of used bytes</li> </ul>   |

### 9.5.2.2 efuse\_logical\_write

| Items        | Description  |
|--------------|--|
| Introduction | Write user's content to efuse on logical map   |
| Parameters   | <ul style="list-style-type: none"> <li>addr: address on logical map</li> <li>cnts: how many bytes of data</li> </ul> |

|        |   |
|--------|---|
|        | <ul style="list-style-type: none"><li>• data: data need to be written</li></ul>     |
| Return | <ul style="list-style-type: none"><li>• 0 Success</li><li>• &lt;0 Failure</li></ul> |

### 9.5.2.3 efuse\_fw\_verify\_enable

|              |   |
|--------------|---|
| Introduction | To enable secure boot   |
| Parameters   |   |
| Return       | <ul style="list-style-type: none"><li>• 0 Success</li><li>• &lt;0 Failure</li></ul> |

### 9.5.2.4 efuse\_fw\_verify\_check

|              |   |
|--------------|---|
| Introduction | To check the secure boot is enabled or not                                      |
| Parameters   |   |
| Return       | <ul style="list-style-type: none"><li>• 1 Success</li><li>• 0 Failure</li></ul> |

## 10 Bluetooth

### 10.1 Features

Please refer to user manual '**UM0501 Realtek AmebaZ2 BLE Stack User Manual EN.pdf**' and '**UM0501 Realtek AmebaZ2 BLE Stack User Manual CN.pdf**'.

### 10.2 BT Wi-Fi Coexist

Since Wi-Fi and BT share same RF block, so make sure do not enable wifi power save when BT is enabled. When BT is enabled, `wifi_disable_powersave()` API will be called, and do not call `wifi_enable_powersave()` API when BT is on.

### 10.3 Memory Usage

Since Wi-Fi and BT share same RF block, so to enable BT, it is required to enable Wi-Fi. The following is the memory usage of Wi-Fi only and Wi-Fi + BT.

#### 10.3.1 Wi-Fi Only

- XIP code size: 436 KB
- SRAM used: 72 KB
- Available Heap Size: 122 KB

#### 10.3.2 Wi-Fi + BT

| BT examples                            | Code size<br>(XIP, Kbyte) | RAM size (Kbyte)<br>(Compare with Wi-Fi only) |           |                      |
|--|---------------------------|---|-----------|----------------------|
|  |                           | SRAM  | Heap Used | Total<br>(SRAM+Heap) |
| Example<br><code>ble_peripheral</code> | 569                       | + 3   | + 23      | + 26                 |
| Example<br><code>bt_central</code>     | 584                       | + 3   | + 25      | + 28                 |
| Example<br><code>ble_scatternet</code> | 598                       | + 4   | + 26      | + 30                 |
| Example<br><code>bt_beacon</code>      | 561                       | + 3   | + 22      | + 25                 |
| Example<br><code>bt_config</code>      | 570                       | + 3   | + 34      | + 37                 |

### 10.4 Examples

#### 10.4.1 `ble_peripheral`

This example shows how to create and run GATT service on GATT server.

##### 10.4.1.1 *Image Generation*

- (1) To run `ble_peripheral` example, turn on the following flags defined in  
`\project\realtek_amebaz2_v0_example\inc\platform_opts_bt.h`

|                   |   |
|-------------------|---|
| #define CONFIG_BT | 1 |
|-------------------|---|

```
#if CONFIG_BT
#define CONFIG_FTL_ENABLED
#define CONFIG_BT_CONFIG          0
#define CONFIG_BT_PERIPHERAL      1
#define CONFIG_BT_CENTRAL         0
#define CONFIG_BT_SCATTERNET      0
#define CONFIG_BT_BEACON          0
#define CONFIG_BT_MESH_PROVISIONER 0
#define CONFIG_BT_MESH_DEVICE      0
```

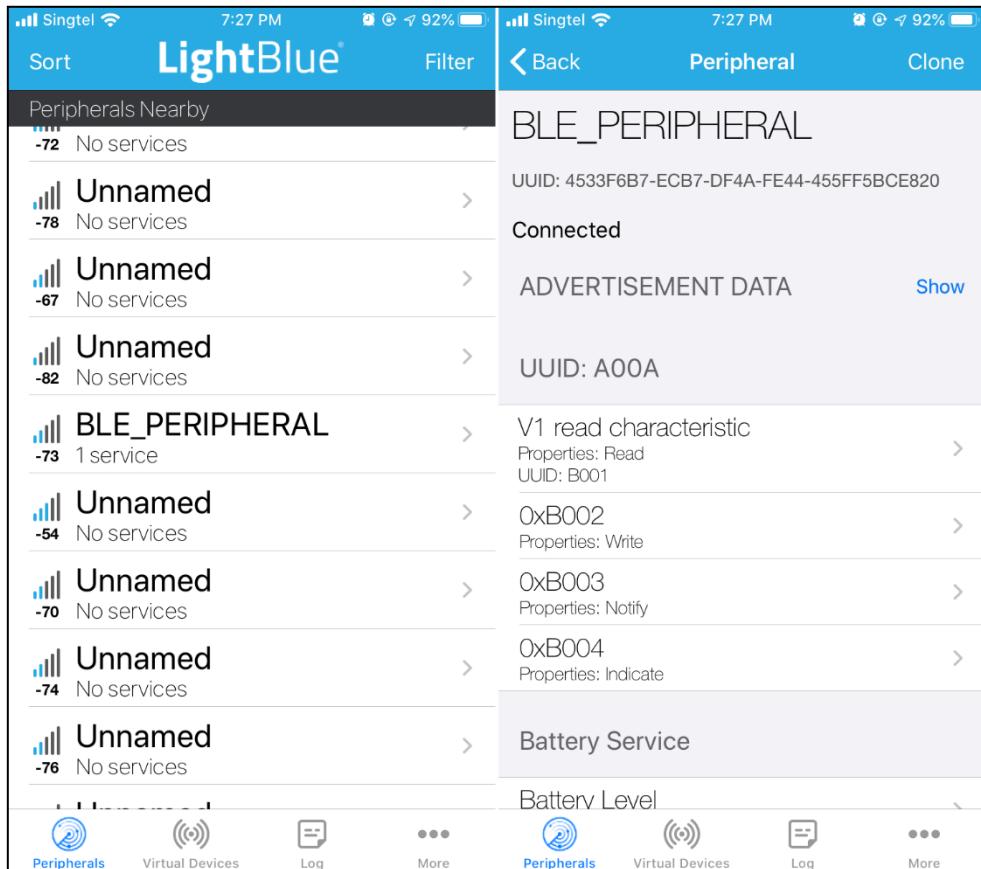
- (2) Build image and download image to your board.

#### 10.4.1.2 Test Procedure

- (1) After download image to your Ameba-ZII board, reset it. The default device name is BLE\_PERIPHERAL.
- (2) Download apps such as “LightBlue” or “nRF Connect” and use as GATT Client to connect it.
- (3) ATBp is an AT command for BT Peripheral. Using “ATBp=1” to initialize BT Peripheral stack, which can send advertising package out and scannable by other devices.

```
[BLE peripheral] GAP stack ready
GAP adv start
[MEM] After do cmd, available heap 88064
```

- (4) Search for BLE\_PERIPHERAL device and connect to it.



#### 10.4.2 ble\_central

This example shows how to discover service on GATT server.

### 10.4.2.1 Image Generation

- (1) To run ble\_central example, turn on the following flags defined in

\project\realtek\amebaz2\_v0\_example\inc\platform\_opts\_bt.h

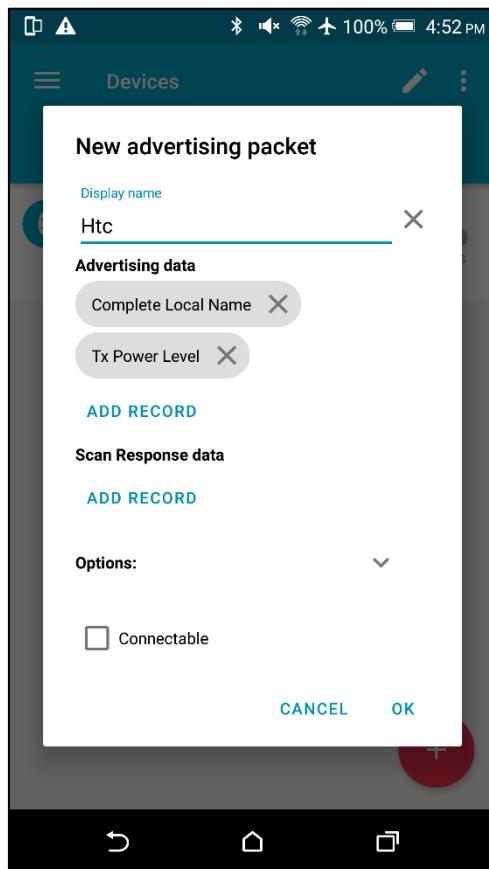
```
#define CONFIG_BT 1

#if CONFIG_BT
#define CONFIG_FTL_ENABLED
#define CONFIG_BT_CONFIG 0
#define CONFIG_BT_PERIPHERAL 0
#define CONFIG_BT_CENTRAL 1
#define CONFIG_BT_SCATTERNET 0
#define CONFIG_BT_BEACON 0
#define CONFIG_BT_MESH_PROVISIONER 0
#define CONFIG_BT_MESH_DEVICE 0
```

- (2) Build image and download image to your board.

### 10.4.2.2 Test Procedure

- (1) After download image to your Ameba-ZII board, reset it.
- (2) Download app “nRF Connect” and use as GATT Server to be connected.
- (3) Add new advertising packet and set its additional data.



- (4) ATBc is an AT command for BT Central. Using “ATBc=1” to turn BT Central stack ON.
- (5) Using “ATBS=1” to scan available BT devices nearby.
- (6) Using “ATBC=P/R, BLE\_BD\_ADDR” to connect to the device.

BT Central scan and connect log:

```
#ATBS=1
Start scan, scan_filter_policy = 0, scan_filter_duplicate = 1
[MEM] After do cmd, available heap 90360
```

```

# GAP scan start
ADVType | AddrType | BT_Addr
|rssi
NON_CONNECTABLE random 5e:3b:de:4e:96:38 -82
GAP_ADTYPE_FLAGS: 0x0
GAP_ADTYPE_LOCAL_NAME_XXX: HTC_E9pw
GAP_ADTYPE_POWER_LEVEL: 0x2
ADVType | AddrType | BT_Addr
|rssi
NON_CONNECTABLE random 5f:ee:5f:ce:06:1f -100
GAP_ADTYPE_MANUFACTURER_SPECIFIC: company_id 0x6, len 27
ADVType | AddrType | BT_Addr
|rssi
NON_CONNECTABLE random 03:af:5e:a9:3f:70 -92
GAP_ADTYPE_MANUFACTURER_SPECIFIC: company_id 0x6, len 27
#ATBS=0
Stop scan

[MEM] After do cmd, available heap 90360

# GAP scan stop
# ATBC=R,5e3bde4e9638

[MEM] After do cmd, available heap 86696

# cmd_con, DestAddr: 0x5E:0x3B:0xDE:0x4E:0x96:0x38

```

For more AT commands used for BT Central, please refer to user manual '**UM0201 Ameba Common BT Application User Manual EN.pdf**'.

### 10.4.3 ble\_scatternet

BLE Scatternet is the coexistence of BLE Central mode and BLE Peripheral mode. Once BLE Scatternet stack initialized, AT command of BLE Central and BLE Peripheral are available. This example shows how to turn BLE Scatternet on.

#### 10.4.3.1 Image Generation

- (1) To run ble\_central example, turn on the following flags defined in

`\project\realtek_amebaz2_v0_example\inc\platform_opts_bt.h`

```

#define CONFIG_BT 1

#if CONFIG_BT
#define CONFIG_FTL_ENABLED
#define CONFIG_BT_CONFIG 0
#define CONFIG_BT_PERIPHERAL 0
#define CONFIG_BT_CENTRAL 0
#define CONFIG_BT_SCATTERNET 1
#define CONFIG_BT_BEACON 0
#define CONFIG_BT_MESH_PROVISIONER 0
#define CONFIG_BT_MESH_DEVICE 0

```

- (2) Build image and download image to your board.

#### 10.4.3.2 Test Procedure

- (1) After download image to your Ameba-ZII board, reset it.
- (2) Using "ATBf=1" to turn BT Scatternet stack ON.
- (3) Once see the following message, you can continue input other AT command of BT Scatternet mode as well as BT Central mode and BT Peripheral mode.

```

START ADV!!
GAP adv start

```

For other AT commands used for BT Scatternet, please refer to '**UM0201 Ameba Common BT Application User Manual EN.pdf**'.

## 10.4.4 bt\_beacon

This example shows how to send BLE Beacons. Ameba-ZII provides two types of Beacon: Apple iBeacon and Radius Networks AltBeacons.

### 10.4.4.1 Image Generation

- (1) To run bt\_beacon example, turn on the following flags defined in `\project\realtek_amebaz2_v0_example\inc\platform_opts_bt.h`.

```
#define CONFIG_BT 1

#if CONFIG_BT
#define CONFIG_FTL_ENABLED
#define CONFIG_BT_CONFIG 0
#define CONFIG_BT_PERIPHERAL 0
#define CONFIG_BT_CENTRAL 0
#define CONFIG_BT_SCATTERNET 0
#define CONFIG_BT_BEACON 1
#define CONFIG_BT_MESH_PROVISIONER 0
#define CONFIG_BT_MESH_DEVICE 0
```

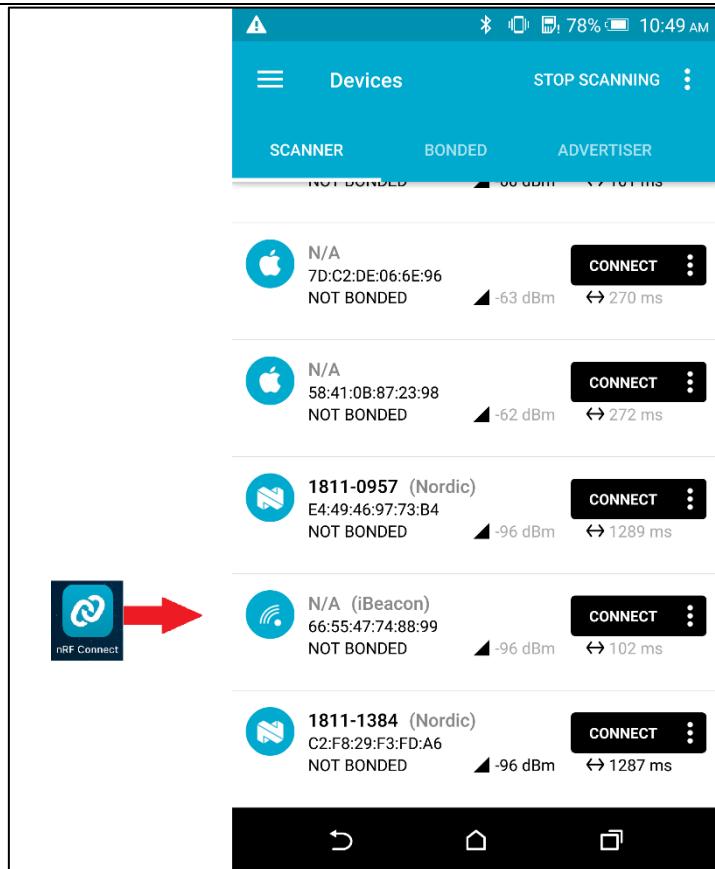
- (2) Build image and download image to your board.

### 10.4.4.2 Test Procedure

- (1) Choose beacon type by using “ATBJ=1,1” or “ATBJ=1,2” command.

```
# ATBJ
[ATBJ] Start BT I_Beacon: ATBJ=1,1
[ATBJ] Start BT Alt_Beacon: ATBJ=1,2
[ATBJ] Stop BT Beacon: ATBJ=0
```

- (2) You can use apps such as “Locate” on iOS, “LightBlue” or “nRF Connect” to observe beacons. “Locate” observe beacon by its adv UUID. Below screenshot is taken using Android “nRF Connect”.



## 10.4.5 bt\_config

BT Config provides a simple way for Wi-Fi device to associate to AP easily.

### 10.4.5.1 Image Generation

- To run bt\_config example, turn on the following flags defined in `\project\realtek\amebaz2_v0_example\inc\platform_opts_bt.h`.

```
#define CONFIG_BT 1
#define CONFIG_BT_CONFIG 1
#define CONFIG_BT_PERIPHERAL 0
#define CONFIG_BT_CENTRAL 0
#define CONFIG_BT_SCATTERNET 0
#define CONFIG_BT_BEACON 0
#define CONFIG_BT_MESH_PROVISIONER 0
#define CONFIG_BT_MESH_DEVICE 0
```

- Build image and download image to your board.

### 10.4.5.2 APP Installation

- The installation package is located at `\tools\bluetooth\BT Config` in SDK. You can install Android or iOS as your phone OS.



### 10.4.5.3 Test Procedure

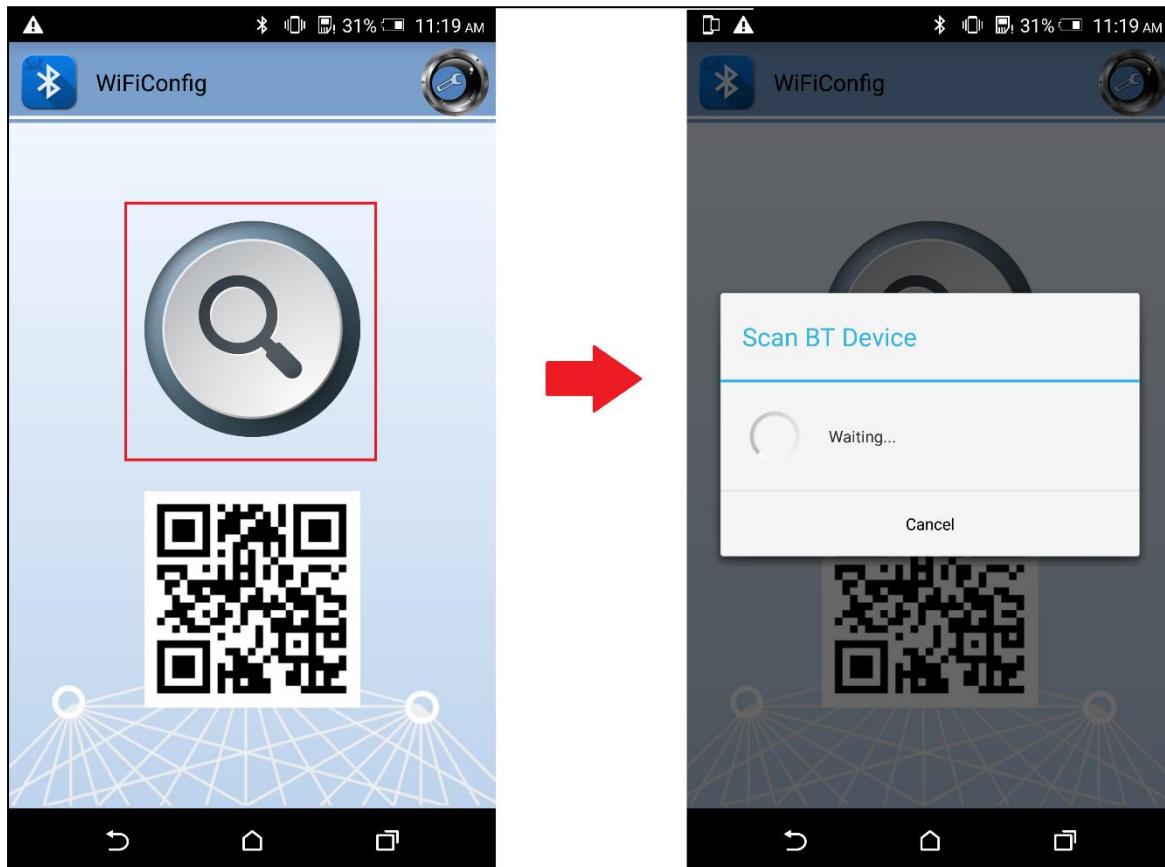
- (2) ATBB is an AT command for BT Config. Using "ATBB=1" to enter BT Config mode, which allows BT Config APP to discover and connect to AmebaZII. Reset your AmebaZII board, and input command "ATBB=1".
- (3) Once see the following message, you can open BT Config APP to associate AP.

BT Initialize and start adv log:

```
[BT Config wifi] BT Config wifi ready  
[BT Config wifi] ADV started
```

- (4) Click the BT config icon to launch it. Scan and connect with AmebaZII BT using BT Config app.

Display on BT config app:

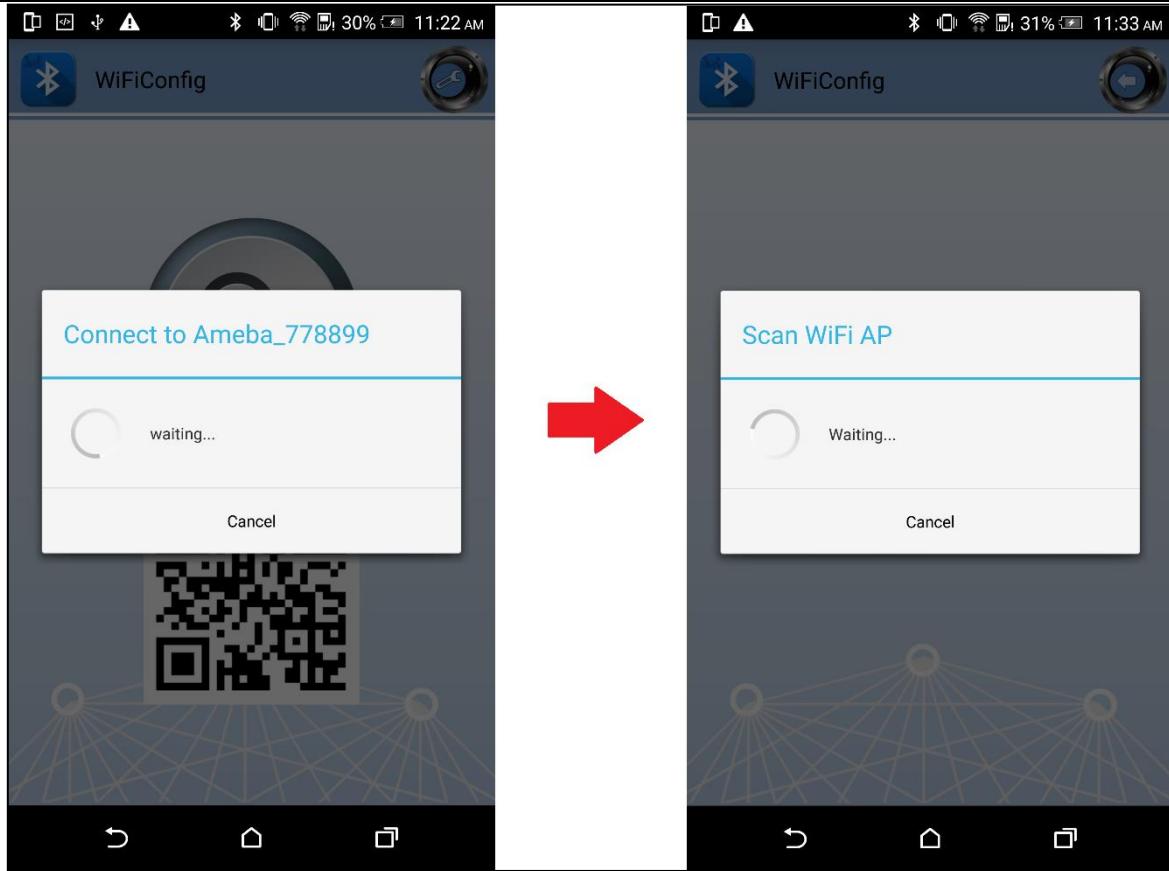


- (5) Once BT Config APP connected to AmebaZII, below log will be show. When connection is established AmebaZII will start searching for AP.

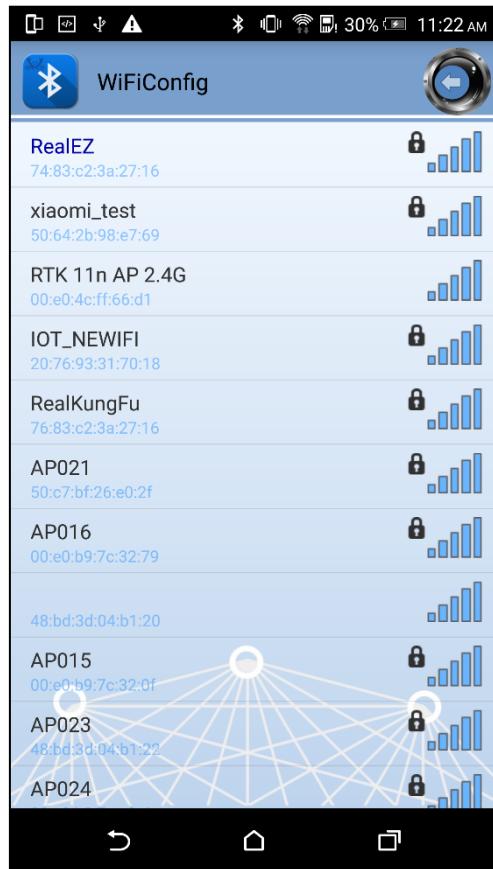
BT Connection log:

```
[BT Config wifi] Bluetooth Connection Established  
[BT Config wifi] Band Request  
[BT Config wifi] Scan Request  
[BT Config wifi] Scan 2.4G AP
```

Display on BT config app:



Scanned and reachable APs will be show on BT config app:

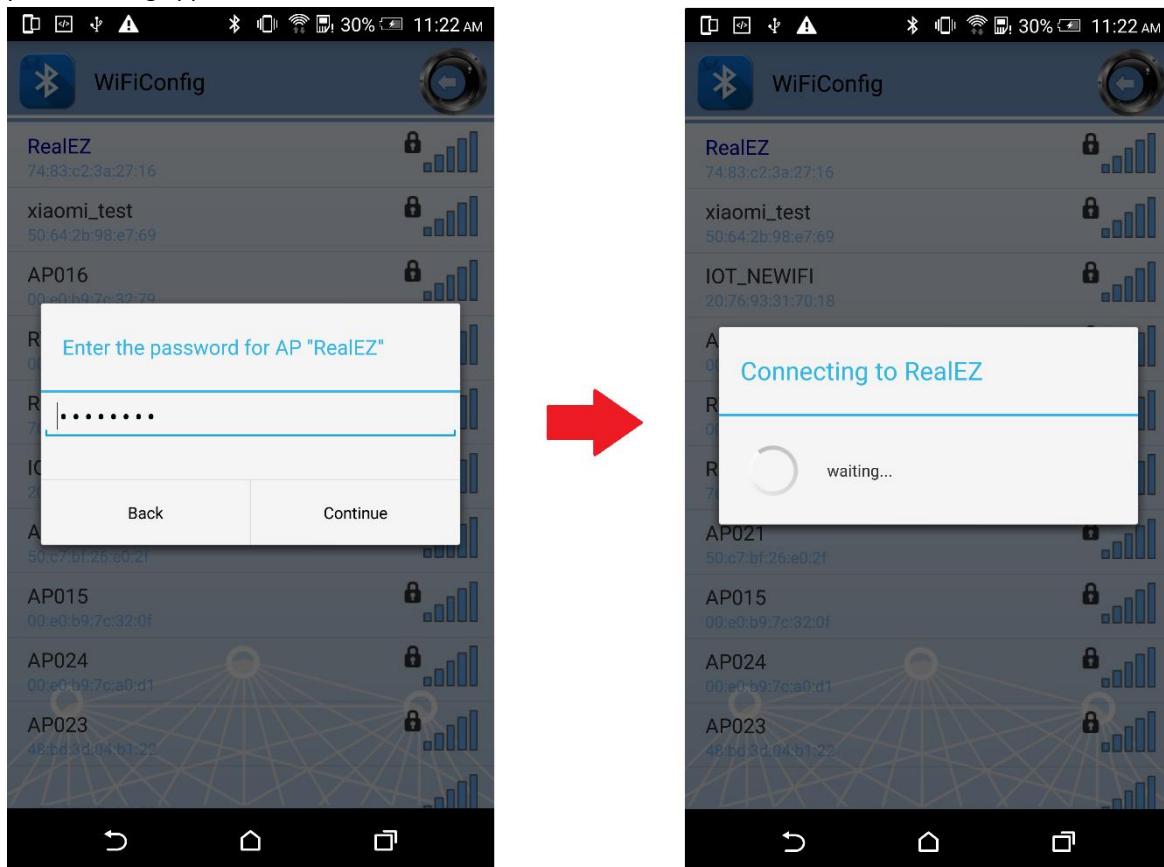


- (6) Select an AP to connect to and input password (if any).

## AP Connection log:

```
[BT Config Wifi] Connect Request  
[Driver]: set BSSID: 90:94:e4:c5:d3:f0  
  
[Driver]: set ssid [Test_ap]  
  
[Driver]: start auth to 90:94:e4:c5:d3:f0  
  
[Driver]: auth success, start assoc  
  
[Driver]: association success(res=7)  
  
[Driver]: set pairwise key to hw: alg:4(WEP40-1 WEP104-5 TKIP-2 AES-4)  
  
[Driver]: set group key to hw: alg:2(WEP40-1 WEP104-5 TKIP-2 AES-4)  
keyid:1  
  
[BT Config Wifi] Connected after 3458ms.  
  
Interface 0 IP address : 192.168.0.102  
[BT Config Wifi] Got IP after 3500ms.
```

## Display on BT config app:

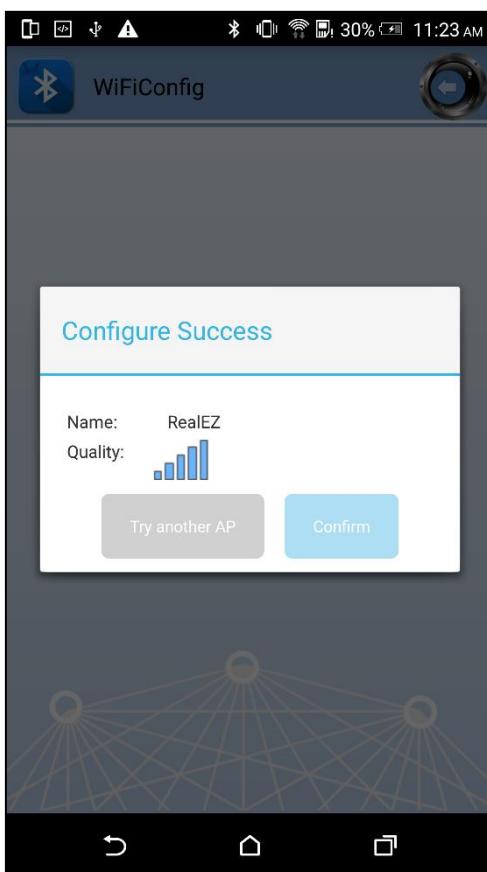


- (7) When AmebaZII is connected to an AP, user can confirm connection or select another AP. Click “Confirm” to confirm AP connection. Click “Try another AP” to go back to Wi-Fi scan list page and choose another AP to connect to. After confirming BT config result, Bluetooth connection is disconnected, AmebaZII becomes undetectable to BT Config APP.

BT Disconnect log:

```
[BT Config wifi] Bluetooth Connection Disconnected
[BT Config wifi] ADV started
[BT Config wifi] [BC_status_monitor] wifi connected, delete
BC_cmd_task and BC_status_monitor
[BT Config wifi] ADV stopped
```

Display on BT config app:



- (8) You can use “ATBB=1” to restart BT Config mode again.

| Command | Usage           |
|---------|-----------------|
| ATBB=1  | Start BT Config |
| ATBB=0  | Stop BT Config  |

**Note:** Enter BT Config mode will disconnect existing Wi-Fi connection.

Please refer to BT Config APP User Guide in \tools\bluetooth\BT Config for more details.

#### 10.4.6 128-bit UUID Configuration

This example shows how to configure BLE service with 128-bit UUID.

Modify service table as follow to configure BLE service with 128-bit UUID.

```
const uint8_t GATT_UUID128_CUSTOMIZED_PRIMARY_SERVICE [16] =
{0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77, 0x88, 0x99, 0xAA, 0xBB, 0xCC, 0xDD, 0xEE, 0xFF, 0x00};
#define GATT_UUID128_CUSTOMIZED_CHAR 0x01, 0x23, 0x45, 0x67, 0x89, 0x0A, 0xBC, 0xDE, 0xFF,
0x11, 0x22, 0x33, 0x44, 0x55, 0x66, 0x77,
```

```

static const T_ATTRIB_APPL customized_UUID128_service_tbl[] =
{
    {
        (ATTRIB_FLAG_VOID | ATTRIB_FLAG_LE),
        {
            LO_WORD(GATT_UUID_PRIMARY_SERVICE),
            HI_WORD(GATT_UUID_PRIMARY_SERVICE),
        },
        UUID_128BIT_SIZE,
        (void *) GATT_UUID128_CUSTOMIZED_PRIMARY_SERVICE,
        GATT_PERM_READ
    },
    {
        ATTRIB_FLAG_VALUE_INCL,
        {
            LO_WORD(GATT_UUID_CHARACTERISTIC),
            HI_WORD(GATT_UUID_CHARACTERISTIC),
            GATT_CHAR_PROP_READ | GATT_CHAR_PROP_WRITE,
        },
        1,
        NULL,
        GATT_PERM_READ
    },
    {
        ATTRIB_FLAG_VALUE_APPL | ATTRIB_FLAG_UUID_128BIT,
        {
            GATT_UUID128_CUSTOMIZED_CHAR
        },
        0,
        NULL,
        GATT_PERM_READ | GATT_PERM_WRITE
    },
};

};

```

## 10.5 BT Transmit Power

BT advertising transmit power can be changed during runtime.

The following is the API and the description for changing the advertising transmit power.

```

/**
 * @brief Set the advertising tx power for the device, or reset advertising tx power to default value.
Default power: 4.5dBm
*
* NOTE: This function can be called after @ref vendor_cmd_init is invoked.
*
* @param[in] option Set to 0.
* @param[in] tx_gain index for power level. NOTE: The following tx gain table may be changed in
future version.
    tx_gain  Power
    0x0D   -10 dBm
    0x21   0  dBm
    0x2A   4.5 dBm
*
* @retval GAP_CAUSE_SUCCESS Operation success.
* @retval GAP_CAUSE_SEND_REQ_FAILED Operation failure.
*
*/
#endif BT_VENDOR_CMD_ADV_TX_POWER_SUPPORT
T_GAP_CAUSE le_adv_set_tx_power(uint8_t option, uint8_t tx_gain);

```

```
#endif
```

**Note:** for this API to work, please call the API after advertising is enabled.

Please refer to *component\common\bluetooth\realtek\sdk\board\amebaz2\src\vendor\_cmd\ vendor\_cmd\_bt.h* for the complete description and example of usage case.

As stated in the description, the API only accepts three input variable values, 0x0D, 0x21 and 0x2A, which represent -10dBm, 0dBm and 4.5dBm respectively. These variables are not absolute values, they are offset values based on calibrated transmit powers during MP.

For example, in the default case BT transmit power is calibrated to 4.5dBm during MP. When the API is called with a pass in variable value of 0x21, the advertising transmit power at normal mode will be 0dBm. However, if BT transmit power is calibrated to 5.5dBm during MP and the API is called with a pass in variable value of 0x21, the actual advertising transmit power at normal mode will be 1dBm.

If board has not been calibrated, BT transmit power will follow the default case.

## 10.6 BT Default MAC Address

Bluetooth MAC address is stored in efuse. If Bluetooth MAC address in efuse is empty, default Bluetooth MAC address will be used. Default Bluetooth MAC is 0x99, 0x88, 0x77, 0x44, 0x55, 0x66.

Modify below array to change Bluetooth default MAC address, which defined in *component\common\bluetooth\realtek\sdk\board\amebaz2\src\hci.c*

```
unsigned char rtlbt_init_config[] =  
{  
    0x55, 0xab, 0x23, 0x87,  
    0x10, 0x00,  
    0x30, 0x00, 0x06, 0x99, 0x88, 0x77, 0x44, 0x55, 0x66, /* BT MAC address */  
    //0x0c, 0x00, 0x04, 0x1d, 0x70, 0x00, 0x00, /* Baudrate 115200 */  
    0x0c, 0x00, 0x04, 0x04, 0x50, 0xF7, 0x05, /* Baudrate 921600 */  
  
    0x18, 0x00, 0x01, 0x5c, /* flow control */  
    /*efuse about*/  
    0x94, 0x01, 0x06, 0x08, 0x00, 0x00, 0x00, 0x2e, 0x07,  
  
    0x9f, 0x01, 0x05, 0x2a, 0x2a, 0x2a, 0x2a, 0x50,  
  
    0xA4, 0x01, 0x04, 0xfe, 0xfe, 0xfe, 0xfe,  
};
```

**Note:** only the highlighted variables can be modified.

# 11 Troubleshooting

There may be issues while developing user applications. Hence, there are some troubleshooting methods that can be referring to.

## 11.1 Hard Fault

AmebaZ2 platform provides a detail back trace information when a hard fault exception happens. Please refer to the following approach to see the full back trace which will help debugging a lot.

### 11.1.1 IAR Environment

If you are using IAR IDE to develop, build project and then encounter a hard fault error. You need to install additional GCC toolchain in order to utilize '**arm-none-eabi-addr2line.exe**' to back trace hard fault error based on the generated back trace information.

#### 11.1.1.1 Download and Install GCC Toolchain for Windows

- 1). Please refer to the link and follow the step to download and install GCC toolchain for Windows.
  - a. <https://developer.arm.com/tools-and-software/open-source-software/developer-tools/gnu-toolchain/gnu-arm/downloads>
- 2). After installation, arm-none-eabi-addr2line.exe can be found in below folder.
  - a. \$INSTALL\_PATH/bin

#### 11.1.1.2 Trace Hard Fault

Please refer to the following example of tracing the hard fault.

```
S-Domain Fault Handler: msp=0x1003f998 psp=0x1002bf70 Tr=0xffffffff1
fault_id=2

Bus Fault:
SCB Configurable Fault Status Reg = 0x00000400

Bus Fault Status:
BusFault Address Reg is invalid(Asyn. BusFault)
Imprecise data bus error:
a data bus error has occurred, but the return address in the stack frame is
not related to the instruction that caused the error.

S-domain exception from Handler mode, Standard Stack Frame on S-MSP
Registers Saved to stack

Stacked:
R0  = 0x10018f60
R1  = 0x9b01b7d1
R2  = 0x00000000
R3  = 0x1001dee4
R4  = 0x10017860
R5  = 0x1002c02b
R6  = 0x0002ea5d
R7  = 0x0002f424
R8  = 0x00000000
R9  = 0x1002c02b
R10 = 0x9b801c5b
R11 = 0x1002c068
R12 = 0x00000000
LR  = 0x9b0465e1
PC  = 0x9b01b7d0
PSR = 0xa100001c

Current:
LR  = 0xffffffff1
MSP = 0x1003f9b8
PSP = 0x1002bf70
xPSR = 0xa0000005
CFSR = 0x000000400
HFSR = 0x000000000
```

```

DFSR = 0x00000000
MMFAR = 0x00000000
BFAR = 0x00000000
AFSR = 0x00000000
PriMask = 0x00000000
SVC priority: 0x00
PendSVC priority: 0xe0
Systick priority: 0xe0

MSP Data:
1003F9B8: 10018F60 9B01B7D1 00000000 1001DEE4
1003F9C8: 00000000 9B0465E1 9B01B7D0 A100001C
1003F9D8: 00000065 FFFFFFFD 00000000 100007C4
1003F9E8: 0000002D 0001869F 10008044 9B005959
1003F9F8: 9B0468B8 61000000 77CF8CC5 8B024015
1003FA08: 26384558 942D314C 0CEF815D 2AA0505C
1003FA18: CBB9C6F0 1847AA69 BE94F781 37E00DAD
1003FA28: CFE4C7DC 849BE050 2FFA91C4 89421B95
1003FA38: FABAC7E8 356CADA8 8DF7F0D3 B10E0054
1003FA48: D9F23435 E4AA8154 F6AE6C73 300910C2
1003FA58: C1E4AFA1 49208098 3F0E59BE B1B32F18
1003FA68: 3D179AF4 DC5894C0 8E33CD8C E0323486
1003FA78: A0FD56A3 AD4C2ACE B6571FF4 E94209D0
1003FA88: 1FF5FD14 B8960ACF 373E09F4 17819289
1003FA98: EF31AB8D 27F1EC18 529B29C4 E26100D0
1003FAA8: 7F3908FE 768860C0 9F7568AD 65D81576

PSP Data:
1002BF70: 1000E0B8 00000065 40040400 00000010
1002BF80: 00000000 0002EA69 000060D4 21000000
1002BF90: 0000000B 0002ECD3 0005F650 9B802D9C
1002BFA0: 1002BFE0 FFFFFFFF 1000DA78 00000001
1002BFB0: 00000000 00000000 1002C02A 00000000
1002BFC0: 00000000 00000000 00000000 00000000
1002BFD0: 00000001 FFFFFFFF FFFFFFFF 0000001A
1002BFE0: 00000300 00000000 00000000 00000000
1002BFF0: 00000000 00000000 00000000 00000000
1002C000: 00000000 00000000 00000000 00000000
1002C010: 00000000 00000000 00000000 00000000
1002C020: 00000000 00000000 0A310000 00000020
1002C030: 00000000 0002EB15 00000001 00000001
1002C040: 00000001 9B801C40 9B801C64 10007FB4
1002C050: 00000200 9B005F2F 1002C048 00000004
1002C060: 9B00AD61 00000001 00000200 1002C048

== NS Dump ==
CFSR_NS = 0x00000000
HFSR_NS = 0x00000000
DFSR_NS = 0x00000000
MMFAR_NS = 0x00000000
BFAR_NS = 0x00000000
AFSR_NS = 0x00000000
MSP_NS = 0x00000000
PSP_NS = 0x00000000
NS HardFault Status Reg = 0x00000000
SCB Configurable Fault Status Reg = 0x00000000

== Back Trace ==
msp=0x1003f9b8 psp=0x1002bf70
Main stack back trace:
top=0x1003fa00 lim=0x1003ea00
9b01b7d0 @ sp = 00000000
9b0465dd @ sp = 00000000
0001869b @ sp = 1003f9ec
9b005955 @ sp = 1003f9f4

Backtrace information may not correct! Use this command to get C source level
information:
arm-none-eabi-addr2line -e ELF_file -a -f 9b01b7d0 9b0465dd 0001869b 9b005955

```

User needs to check the last sentence of the hard fault (highlighted in yellow).

- 1). Open **CMD** window, go to the path of “**application\_is.debug.out**” which should be under /project/realtek\_amebaz2\_v0\_example/EWARM-RELEASE/Debug/Exe. (If for trust zone project, please replace “**application\_is**” by “**application\_tz**”.)
- 2). Use installed **arm-none-eabi-addr2line.exe** to get the back trace.

```
$INSTALL_PATH/bin/arm-none-eabi-addr2line.exe -e application_is.dbg.out -a -f 9b01b7d0 9b0465dd 0001869b 9b005955
```

The result will be

```
/cygdrive/d/v7.1a/project/realtek_amebaz2_v0_example/GCC-RELEASE/Debug/Exe  
$ /cygdrive/d/GNU Tools ARM Embedded/8 2018-q4-major/bin/arm-none-eabi-addr2line.exe -e application_is.dbg.out -a -f 9b01b7d0 9b0465dd 0001869b 9b005955  
0x9b01b7d0  
_freertos_up_sema_from_isr  
D:\v7.1a\component\os\freertos\freertos_service.c:139  
0x9b0465dd  
axi_bus_dma_Interrupt  
D:\v7.1a\component\common\drivers\wlan\realtek\src\hci\axi\axi_intf.c  
:205  
0x0001869b  
??  
?:0  
0x9b005955  
xPortStartScheduler  
D:\v7.1a\component\os\freertos\freertos_v10.0.1\Source\portable\IAR\ARM_RTL8710C/port.c:319
```

According to the result, user can trace the hard fault from **xPortStartScheduler -> axi\_bus\_dma\_Interrupt -> \_freertos\_up\_sema\_from\_isr**. The hard fault comes from **\_freertos\_up\_sema\_from\_isr()** that located in **D:\v7.1a\component\os\freertos\freertos\_service.c:139**.

## 11.1.2 GCC Environment

### 11.1.2.1 Install Cygwin

Please refer to section “3.5.1 Install Cygwin”.

### 11.1.2.2 Unzip Toolchain

- 1) Open “Cygwin Terminal”.
- 2) Direct to unzip path. Enter command “cd /SDK /project/realtek\_amebaz2\_v0\_example/GCC-RELEASE”.
- 3) Enter command “make toolchain” to unzip toolchain.

### 11.1.2.3 Trace Hard Fault

Please refer to the following example of tracing the hard fault.

```
S-Domain Fault Handler: msp=0x1003f998 psp=0x1002bf70 Tr=0xffffffff1  
fault_id=2  
  
Bus Fault:  
SCB Configurable Fault Status Reg = 0x00000400  
  
Bus Fault Status:  
BusFault Address Reg is invalid(Asyn. BusFault)  
Imprecise data bus error:  
a data bus error has occurred, but the return address in the stack frame  
is not related to the instruction that caused the error.  
  
S-domain exception from Handler mode, Standard Stack frame on S-MSP
```

## Registers Saved to stack

## Stacked:

R0 = 0x10018f60  
R1 = 0x9b01b7d1  
R2 = 0x00000000  
R3 = 0x1001dee4  
R4 = 0x10017860  
R5 = 0x1002c02b  
R6 = 0x0002ea5d  
R7 = 0x0002f424  
R8 = 0x00000000  
R9 = 0x1002c02b  
R10 = 0x9b801c5b  
R11 = 0x1002c068  
R12 = 0x00000000  
LR = 0x9b0465e1  
PC = 0x9b01b7d0  
PSR = 0xa100001c

## Current:

LR = 0xffffffff1  
MSP = 0x1003f9b8  
PSP = 0x1002bf70  
XPSR = 0xa0000005  
CFSR = 0x00000400  
HFSR = 0x00000000  
DFSR = 0x00000000  
MMFAR = 0x00000000  
BFAR = 0x00000000  
AFSR = 0x00000000  
PriMask = 0x00000000  
SVC priority: 0x00  
PendSVC priority: 0xe0  
Systick priority: 0xe0

## MSP Data:

|           |          |          |          |          |
|-----------|----------|----------|----------|----------|
| 1003F9B8: | 10018F60 | 9B01B7D1 | 00000000 | 1001DEE4 |
| 1003F9C8: | 00000000 | 9B0465E1 | 9B01B7D0 | A100001C |
| 1003F9D8: | 00000065 | FFFFFFF0 | 00000000 | 100007C4 |
| 1003F9E8: | 0000002D | 0001869F | 10008044 | 9B005959 |
| 1003F9F8: | 9B0468B8 | 61000000 | 77CF8CC5 | 8B024015 |
| 1003FA08: | 26384558 | 942D314C | 0CEF815D | 2AA0505C |
| 1003FA18: | CBB9C6F0 | 1847AA69 | BE94F781 | 37E00DAD |
| 1003FA28: | CFE4C7DC | 849BE050 | 2FFA91C4 | 89421B95 |
| 1003FA38: | FABAC7E8 | 356CADA8 | 8DF7F0D3 | B10E0054 |
| 1003FA48: | D9F23435 | E4AA8154 | F6AE6C73 | 300910C2 |
| 1003FA58: | C1E4AFA1 | 49208098 | 3F0E59BE | B1B32F18 |
| 1003FA68: | 3D179AF4 | DC5894C0 | 8E33CDBC | E0323486 |
| 1003FA78: | A0FD56A3 | AD4C2ACE | B6571FF4 | E94209D0 |
| 1003FA88: | 1FF5FD14 | B8960ACF | 373E09F4 | 17819289 |
| 1003FA98: | EF31AB8D | 27F1EC18 | 529B29C4 | E26100D0 |
| 1003FAA8: | 7F3908FE | 768860C0 | 9F7568AD | 65D81576 |

## PSP Data:

|           |          |            |            |          |
|-----------|----------|------------|------------|----------|
| 1002BF70: | 1000E0B8 | 00000065   | 40040400   | 00000010 |
| 1002BF80: | 00000000 | 0002EA69   | 000060D4   | 21000000 |
| 1002BF90: | 0000000B | 0002ECD3   | 0005F650   | 9B802D9C |
| 1002BFA0: | 1002BFE0 | FFFFFFFFFF | 1000DA78   | 00000001 |
| 1002BFB0: | 00000000 | 00000000   | 1002C02A   | 00000000 |
| 1002BFC0: | 00000000 | 00000000   | 00000000   | 00000000 |
| 1002BFD0: | 00000001 | FFFFFFFFFF | FFFFFFFFFF | 0000001A |

```

1002BFE0: 00000300 00000000 00000000 00000000
1002BFF0: 00000000 00000000 00000000 00000000
1002C000: 00000000 00000000 00000000 00000000
1002C010: 00000000 00000000 00000000 00000000
1002C020: 00000000 00000000 0A310000 00000020
1002C030: 00000000 0002EB15 00000001 00000001
1002C040: 00000001 9B801C40 9B801C64 10007FB4
1002C050: 00000200 9B005F2F 1002C048 00000004
1002C060: 9B00AD61 00000001 00000200 1002C048

== NS Dump ==
CFSR_NS = 0x00000000
HFSR_NS = 0x00000000
DFSR_NS = 0x00000000
MMFAR_NS = 0x00000000
BFAR_NS = 0x00000000
AFSR_NS = 0x00000000
MSP_NS = 0x00000000
PSP_NS = 0x00000000
NS HardFault Status Reg = 0x00000000
SCB Configurable Fault Status Reg = 0x00000000

== Back Trace ==
msp=0x1003f9b8 psp=0x1002bf70
Main stack back trace:
top=0x1003fa00 lim=0x1003ea00
9b01b7d0 @ sp = 00000000
9b0465dd @ sp = 00000000
0001869b @ sp = 1003f9ec
9b005955 @ sp = 1003f9f4

Backtrace information may not correct! Use this command to get C source
level information:
arm-none-eabi-addr2line -e ELF_file -a -f 9b01b7d0 9b0465dd 0001869b
9b005955

```

1) Use ‘cd’ command to direct to the path of ‘**application\_is.debug.axf**’ which under /project/realtek\_amebaz2\_v0\_example/GCC-RELEASE/application\_is/Debug/bin. (If for trust zone project, please replace “application\_is” by “application\_tz”.)

2) Use installed ‘**arm-none-eabi-addr2line.exe**’ to get the back trace.

```
$ /tools/arm-none-eabi-gcc/asdk/cygwin/newlib/bin/arm-none-eabi-addr2line.exe -e application_is.debug.axf -a -f 9b01b7d0
9b0465dd 0001869b 9b005955
```

The result will be:

```

/cygdrive/d/v7.1a/project/realtek_amebaz2_v0_example/GCC-
RELEASE/application_is/debug/bin
$ /cygdrive/d/v7.1a/tools/arm-none-eabi-gcc/asdk/cygwin/newlib/bin/arm-
none-eabi-addr2line.exe -e application_is.debug.axf -a -f 9b01b7d0
9b0465dd 0001869b 9b005955
0x9b01b7d0
_freertos_up_sema_from_isr
D:\v7.1a\component\os\freertos\freertos_service.c:139
0x9b0465dd
axi_bus_dma_Interrupt
D:\v7.1a\component\common\drivers\wlan\realtek\src\hci\axi\axi_intf.c:20
5

```

```
0x0001869b
??
??:0
0x9b005955
xPortStartScheduler
D:\v7.1a\component\os\freertos\freertos_v10.0.1\Source\portable\IAR\ARM_
RTL8710C\port.c:319
```

According to the result, user can trace the hard fault from `xPortStartScheduler -> axi_bus_dma_Interrupt -> _freertos_up_sema_from_isr`. The hard fault comes from `_freertos_up_sema_from_isr()` that located in `D:\v7.1a\component\os\freertos\freertos_service.c:139`.

## 11.2 Fault Message Redirection

The default configuration of the fault log was set to output exclusively through the UART port, and this brings limitations as it does not allow saving logs to alternative storage mediums.

To enable more flexible storage, fault message redirection was introduced. Users can save fault logs to any storage medium.

The Fault Message Redirection functions are as follow:

- `fault_handler_override()` is used to redeclare fault handler to utilize RAM code for fault triggering. It requires two callback functions, `fault_log()` and `bt_log()` to handle the logs obtained.
- `fault_log()` is the callback functions to handle fault event logs, which includes register and stack memory dump logs.
- `bt_log()` is the callback functions to handle stack backtrace logs.

The example code under “`/project/realtek_amebaz2_v0_example/inc/main_faultlog.c`” demonstrates how fault logs are saved into flash memory.

```
int main(void)
{
    /* Read last fault data and redeclare fault handler to use ram code */
    read_last_fault_log();
    fault_handler_override(fault_log, bt_log);

    /* Initialize log uart and at command service */
    console_init();

    ...
}
```

When a fault occurs, the log is saved to flash memory via `fault_log()` and `bt_log()`.

After the system restarts, the function `read_last_fault_log()` is called to retrieve the latest fault log from flash memory.

For detailed implementation guidance, users should refer to the `main_faultlog.c` file, which serves as a practical example of how to integrate these logging capabilities into their projects.