User Manual

DA16200 16600 Mass Production

UM-WI-011

Abstract

This User Manual explains how to setup production test in production.

Contents

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1 Terms and Definitions

EVB	Evaluation Board
GUI	Graphical User Interface
OTP	One Time Password
PLT	Production Line Tool
RF	Radio Frequency
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter

2 References

[1] DA16200, Datasheet, Renesas Electronics
[2] UM-WI-056, DA16200 DA16600 FreeRTOS Getting Started Guide, User Manual, Renesas Electronics
[3] UM-WI-004, DA16200 AT GUI Tool User Manual, User Manual, Renesas Electronics
[4] UM-WI-012, DA16200 SPI SFlash Downloader, User Manual, Renesas Electronics
[5] UM-WI-039, DA16200 DA16600 Multi Downloader, User Manual, Renesas Electronics
[6] UM-WI-046, DA16200 DA16600 FreeRTOS SDK Programmer Guide, User Manual, Renesas Electronics
[7] UM-WI-003, DA16200 DA16600 Host Interface and AT Command, User Manual, Renesas Electronics
[8] UM-B-041, SmartBond Production Line Tool, User Manual, Renesas Electronics

3 Overview

This document explains how to setup production tests for DA16200 and DA16600 in production, as well as the options and limitations that should be considered. Each procedure or the order introduced in this document can be omitted or changed according to production environment. Figure 1 shows recommended flow of the production test.

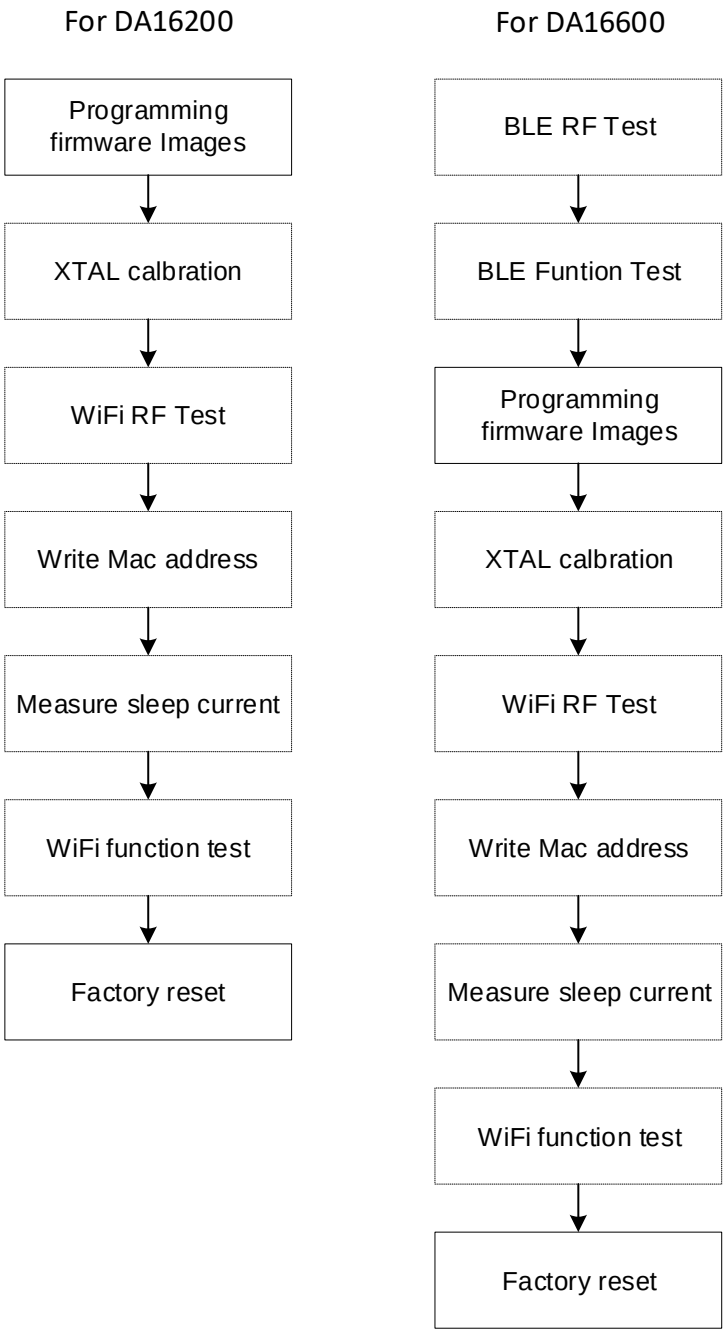


Figure 1: Flow of Production Test for DA16200/DA16600

NOTE
The flash should be empty when performing Bluetooth® LE test as Bluetooth® LE for DA16600 should be tested without firmware image.

4 Console Command and AT Command

Console commands on UART0 support programming firmware images, RF test, and writing value to OTP. AT commands are available for RF test, Wi-Fi function test and writing value to OTP over UART1 or 2. For DA16600, only UART2 is available, and UART1 is used for the GTL interface internally. The AT commands can be communicated using console terminal tools or AT GUI tool.

5 Programming Firmware Images

The first step is to program firmware images to serial flash memory over UART0 or SPI. For the address of each firmware images on the flash and how to program firmware images, see program firmware image section of the FreeRTOS Getting Started Guide, Ref. [2]. The programming firmware image can be done via SPI using GUI tool in Windows. For details, see the user manual Ref. [4].

After programming firmware images, NVRAM initialization can be done using the below console command.

```
[/DA16200] # nvram
[/DA16200/NVRAM] # nvedit erase sflash
[/DA16200/NVRAM] # nvedit clear
[/DA16200/NVRAM] # nvcfg update sflash
update, sflash completed
[/DA16200/NVRAM] # nvedit load sflash
nvedit, load complted
```

And the version of the programmed firmware image can be confirmed using the below console or AT command.

```
[/DA16200] # ver

        ******************************************************
        *             DA16200 SDK Information
        * ---------------------------------------------------
        *
        * - CPU Type        : Cortex-M4 (120 MHz)
        * - OS Type         : FreeRTOS 10.4.3
        * - Serial Flash    : 4 MB
        * - SDK Version     : V3.2.8.0 GEN-ATCMD
        * - F/W Version     : FRTOS-GEN01-01-f017bfdf51-006558
        * - F/W Build Time  : Aug 10 2023 13:44:35
        * - Boot Index      : 0
        *
        ******************************************************

[/DA16200] #                                                    Firmware for DA16200 FreeRTOS
```

NOTE
You can check the version information by using AT command as shown below.

Table 1: AT Command to Check Version

Command	Parameters	Description
AT+VER	(none)	Get version information. Response: +VER:<ThredX RTOS version>,< ThredX SLIB version> Response: +VER:<FreeRTOS RTOS version>

```
ate                                                 In order to see the AT command
Echo on
OK
AT+VER
```



```
+VER:FRTOS-GEN01-01-56c232799-004158                FreeRTOS verison

OK
```

An efficient way for production test using AT commands and programming firmware image for final product at the same time is to program both images to different regions in one step. DA16200 provides two regions of RTOS image. The running image can be changed using boot index which is stored in flash memory and can be changed by console command or AT command. The default value of the boot index is 0 for the first region. The following steps are how to program both images and proceed production test.

1. Program BOOT firmware image (bootloader).
2. Program RTOS firmware image for AT command to first region and firmware image for final product to the second region.
3. Initialize the NVRAM.
4. Production test.
5. After the step 4 is complete, change boot index to 1 for RTOS firmware image for final product.

How to create firmware images for AT command is described in Ref [7].

6 XTAL Calibration

The calibration TX power and temperature frequency for DA16200 are done during the ATE test. This section covers XTAL frequency calibration using AT GUI tool. The purpose of XTAL calibration is to match the desired tone for proper RF transmission and reception as shown below and Figure 2.

Register range is 0x00 ~ 0x7F, and there is about 2 kHz deviation per register code.

- Example: if Measured Tone is #1,

  Offset = Measured – Desired (2411994000-2412000000) = -6000, Offset value is < 0
  It needs to decrease Register value lower to move towards Desired Tone.

- Example: if Measured Tone is #2,

  Offset = Measured – Desired (2412006000-2412000000) = +6000, Offset value is > 0
  It needs to increase Register value higher to move towards Desired Tone.

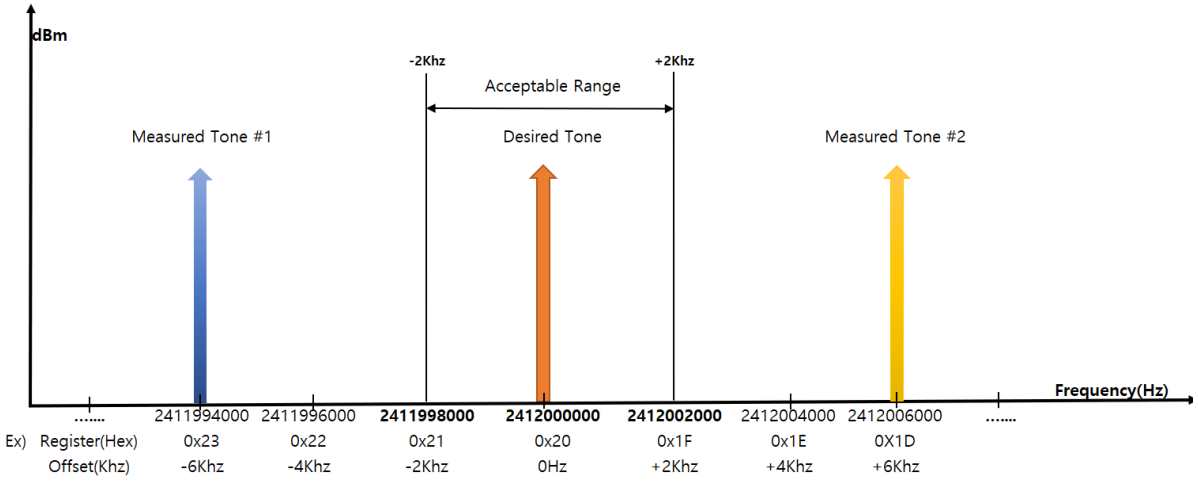


Figure 2: Offset in Frequency Domain

The procedure for XTAL calibration is:

1. Program firmware image for the AT command.
2. Run the TX test mode and Write default XTAL register with the below AT commands.
   a. AT+TMRFNOINIT=1 // Configure RF Test mode
   b. AT+RESTART // Restart DA16200 to enter RF Test mode
   c. AT+RFTESTSTART // RF Test start
   d. AT+RFCWTEST=2412,0,0 // CW Setting on Channel 1
   e. AT+XTALWR=3F // 0x3F is Center Register from 0x00 to 0x7F
3. Measure and calculate frequency offset.
   a. Offset = Measured Frequency (by Spectrum Analyzer) – Desire Tone Frequency (2412000000 Hz)
      i. Example:
         if Measured Frequency is 2412040000 Hz
         Offset = 2412040000 Hz – 2412000000 Hz= +40000 Hz
      ii. Example:
         if Measured Frequency is 2411960000 Hz
         Offset = 2411960000 Hz – 2412000000 Hz= -40000 Hz
   b. **Depending on the SDK version, Desire Tone might be 2413000000 Hz**
4. Calculate the starting XTAL register value.
   a. To reduce the calibration time in MP, it might be required to control the starting value.
   b. Starting XTAL register = Default XTAL register (0x3F) + offset/4000

(Frequency offset is expressed as a Decimal value, 40000/4000 = 10 (Dec) = 0x0A (Hex))

i. Example: if Offset is +40000 Hz > 0,
Starting XTAL Register = 0x3F + 0x0A = 0x49
Write 0x49 value should be written to the register. See the example below.
AT+XTALWR=49

c. Starting XTAL register = Default XTAL register - offset/4000

i. Example, if Offset is -40000 Hz < 0,
Starting XTAL Register = 0x3F - 0x0A = 0x35
Write 0x35 value should be written to the register. See the example below.
AT+XTALWR=35

5. If the offset is less than +2 kHz and greater than -2 kHz, the value is within the margin. If not, do the step 5 to change the XTAL register value. See the note below.

NOTE
Main Clock: 40 MHz, Recommend XTAL: +/- 20 ppm To make 2.4 GHz band, PLL uses 40 MHz main clock * 60. Additionally, **need to trim below 1 ppm to take temperature change into account** since XTAL has a deviation of +/- 20 ppm depending on temperature change. Therefore, Variation : 40000000 * 1/1000000 = 40 From an RF perspective, the value increases to 40 * 60 = 2400, which is 2400 Hz. As a result, it becomes -2.4 kHz ~ Center frequency ~ +2.4 kHz (400 Hz as a margin).

6. Check the offset sign.
When calculated, the offset value will have a plus (+) or minus (-) sign value.
If offset is plus (offset > 0), increase XTAL register. It can be increased < Max 0x7F (Dec : 127).

a. Example:

i. AT+XTALWR=50 (First time)
ii. AT+XTALWR=51 (Second time)
iii. AT+XTALWR=52 (Third time)

If offset is minus (offset < 0), decrease XTAL register. It can be decreased < Min 0x00 (Dec: 0).

b. Example:

i. AT+XTALWR=35 (First time)
ii. AT+XTALWR=34 (Second time)
iii. AT+XTALWR=33 (Third time)

7. Write the final value of XTAL register with AT command to OTP memory.
   - AT+UOTPWRASC=0428,1, <XTAL Register value>
   - Example: AT+UOTPWRASC=0428,1,33

DA16200 has two slots to store the XTAL offset in the OTP memory, see Table 2. To use AT command to write value at OTP address, address x 4 should be taken because address is 4-byte aligned address. For more details, see the **OTP Commands** section in the user manual, Ref. [7].

Table 2: XTAL Offset OTP Address

Slot	OTP Address	Address for AT Command	Size (Byte)
XTAL Offset #0	0x10A	428	2

Slot	OTP Address	Address for AT Command	Size (Byte)
XTAL Offset #1	0x10B	42c	2

Figure 3 shows the procedure of XTAL calibration.

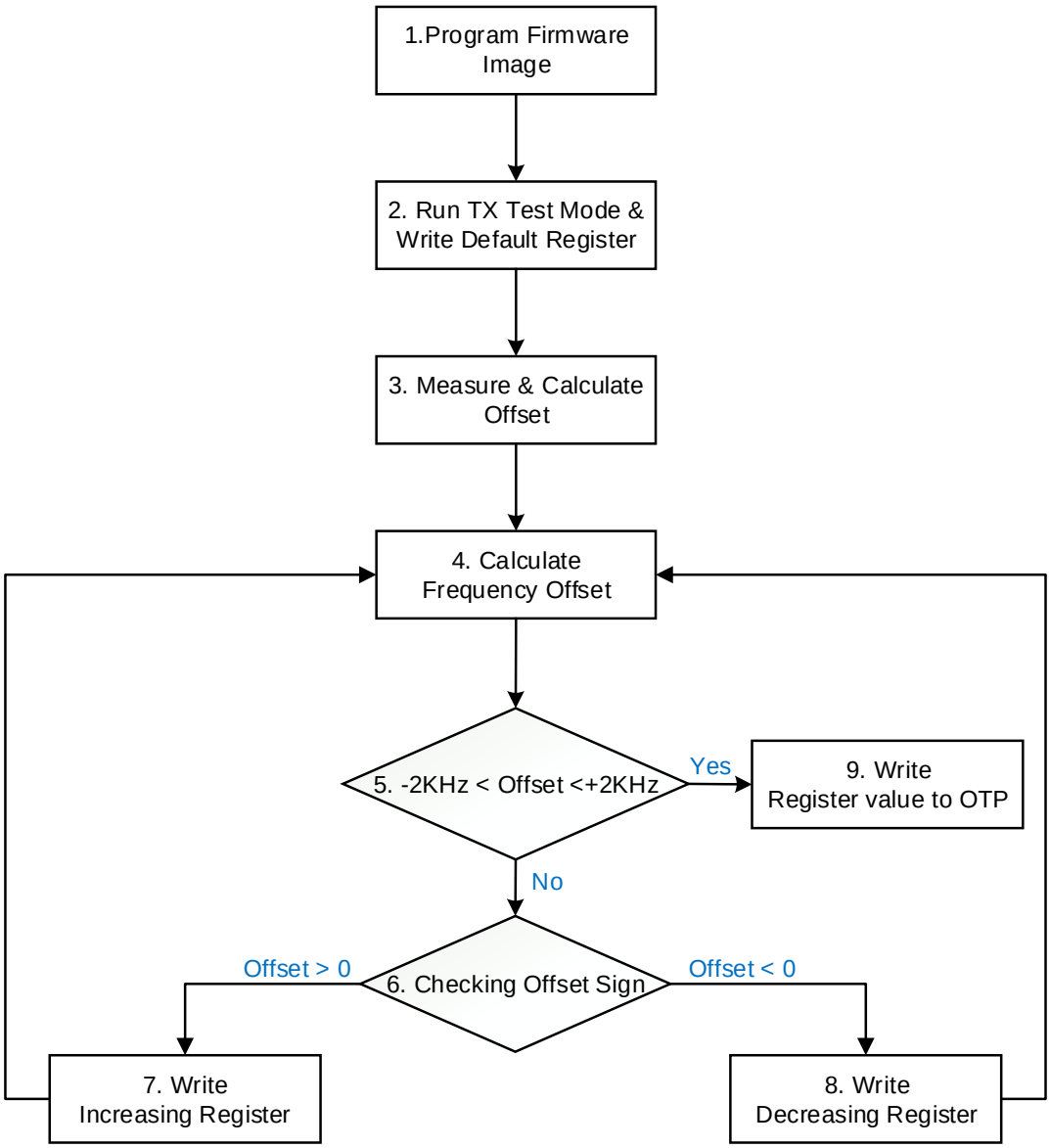


Figure 3: Procedure of XTAL Calibration

7 Wi-Fi RF Test

The TX/RX performance of DA16200 can be tested in the Certification Mode menu of the AT GUI tool. See Figure 4. For more information about AT commands, see the **RF Test Function Commands** section in the user manual Ref. [3].

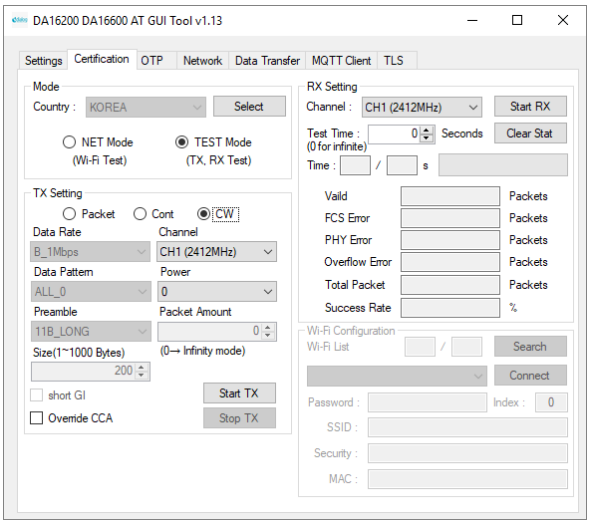


Figure 4: Certification Mode in AT GUI Tool

7.1 Test Parameter

Basic RF test parameters are listed in Table 3.

7.2 Test Channel

DA16200 supports up to channel 13, but Renesas highly recommends checking the performance at CH1 (2412 MHz), CH7 (2442 MHz) and CH13 (2472 MHz). To confirm the best performance of the product, it is recommended to check the test parameter of the Receiver and Transmitter mentioned in Table 3.

Table 3: RF Test Parameters

Test Parameter	802.11 B	802.11 G	802.11 N (HT20)
Tx	EVM	EVM	EVM
	Frequency Tolerance	Frequency Tolerance	Frequency Tolerance
	Output Power	Output Power	Output Power
	Data rate	Data rate	Data rate
	Symbol Clock Tolerance	Symbol Clock Tolerance	Symbol Clock Tolerance
	Tx Carrier Leakage	Tx Carrier Leakage	Tx Carrier Leakage
	Spectrum Emission Mask	Spectrum Emission Mask	Spectrum Emission Mask
Rx	Sensitivity	Sensitivity	Sensitivity

7.3 Test Command

Before RX/TX test, it is required to run AT commands as shown below first to initialize RF. See Table 4.

Table 4: RF AT Command

Command	Parameters	Description
AT+TMRFNOINIT=1	<0,1>	Set boot mode. 0: normal boot 1: RF test mode boot
AT+RESTART	(none)	If set the boot mode as RF test mode (AT+TMRFNOINIT=1), restart the DA16200 (AT+RESTART)
AT+RFTESTSTART	(none)	Start RF test mode.

7.4 TX Test

7.4.1 11B Mode

Table 5: 11B_1Mbps

Command	Description
AT+RFTX=2412,0,0,200,b1,0	11B 1 Mbps/Channel 1
AT+RFTXSTOP	Stop Tx
AT+RFTX=2442,0,0,200,b1,0	11B 1 Mbps/Channel 7
AT+RFTXSTOP	Stop Tx
AT+RFTX=2472,0,0,200,b1,0	11B 1 Mbps/Channel 13
AT+RFTXSTOP	Stop Tx

7.4.2 11G Mode

Table 6: 11G_54Mbps

Command	Description
AT+RFTX=2412,0,0,1000,g54,0	11G 54 Mbps/Channel 1
AT+RFTXSTOP	Stop Tx
AT+RFTX=2442,0,0,1000,g54,0	11G 54 Mbps/Channel 7
AT+RFTXSTOP	Stop Tx
AT+RFTX=2472,0,0,1000,g54,0	11G 54 Mbps/Channel 13
AT+RFTXSTOP	Stop Tx

7.4.3 11N Mode

Table 7: 11N_MCS7

Command	Description
AT+RFTX=2412,0,0,1000,n65,0	11N MCS7/Channel 1
AT+RFTXSTOP	Stop Tx
AT+RFTX=2442,0,0,1000,n65,0	11N MCS7/Channel 7
AT+RFTXSTOP	Stop Tx
AT+RFTX=2472,0,0,1000,n65,0	11N MCS7/Channel 13
AT+RFTXSTOP	Stop Tx

7.5 RX Test

For accurate RX measurement, measure lossless (Shield room or Anechoic chamber) conditions without external signal influence.

- Channel: Support CH1 ~ CH13
- Test Time: Maximum 3600s (Duration is 1 second fixed)
- RX Packet Rate: FCS + PHY + Overflow packet / Total packet = Error rate
  The error rate should not exceed 10 %.

8 Writing MAC Address

The MAC addresses written in the OTP memory is used for the WLAN0 interface (Station) MAC address and the next number is automatically designated as the WLAN1 (Soft AP) MAC address. For example, if `AA:BB:11:22:33:44` is written in the OTP memory, then WLAN0 has `AA:BB:11:22:33:44` and WLAN1 has `AA:BB:11:22:33:45`.

As each DA16200 chip consumes two MAC addresses, when writing a mac address to a DA16200 chip, the last byte of the mac address should be bigger **by 2** than the previous DA16200 chip in the production line.

For example, `AA:BB:11:22:33:44`, `AA:BB:11:22:33:46`, `AA:BB:11:22:33:48`. The last digit of the WLAN0 MAC address should be an even number.

The Mac address is already pre-programmed at the DA16200 chipset production stage. There are two ways to write the MAC address if required, AT GUI and Console.

8.1 AT GUI Tool

In AT GUI tool, write MAC addresses in OTP Mode. DA16200 provides 4 slots to store MAC addresses in the OTP memory. When a new MAC address is written, the previous slot should be invalidated. See Ref. [3].

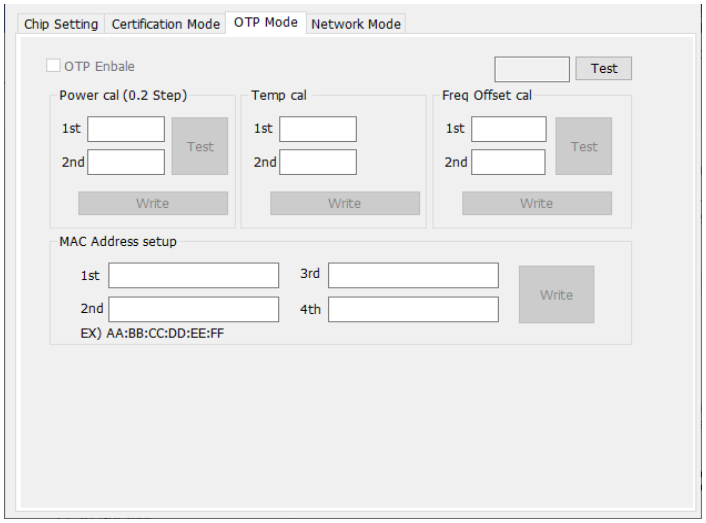


Figure 5: OTP Mode in AT GUI Tool

Table 8: AT Command for Writing/Reading MAC Address

Command	Parameters	Description
`AT+WFOTP`	<mac>	Write MAC address in the OTP memory. An old MAC address in the OTP will be invalidated if one exists. There are four mac address slots available in OTP. Thus, only a maximum of four MAC addresses are written in total at production. Response: `OK` or `ERROR` For example: `AT+WFOTP=EC:9F:0D:90:00:48` The last hex of <mac> should be an even number. The MAC address written in the OTP is used as WLAN0 MAC address and then WLAN's MAC+1 will be used as WLAN1 MAC address.

Command	Parameters	Description
AT+WFMAC	(none)	Get the current MAC address of the activated WLAN interface. DA16200 provides three types of MAC addresses (OTP MAC address, user MAC address and spoofing MAC address). The priority is OTP < User < Spoofing. Response: +WFMAC:<mac>

8.2 Console Command

Use command `setotpmac` as shown in the example code, to write the new MAC address to an empty slot. This command invalidates the previous slot and validates the new slot.

```
[/DA16200] # setotpmac AA:BB:11:22:33:44
```

Use command `getwlanmac` to check what the new MAC address is.

```
[/DA16200] # getwlanmac
MAC TYPE: OTP MAC
WLAN0 - AA:BB:11:22:33:44
WLAN1 - AA:BB:11:22:33:45
```

9 Wi-Fi Function Test

To test the basic Wi-Fi function (station and Soft AP), use the Network Mode menu in the AT GUI tool. For more information, see DA16200 AT GUI Tool User Manual, Ref. [3]. For related commands, see the **Network Function Commands** section in the user manual, Ref. [7].

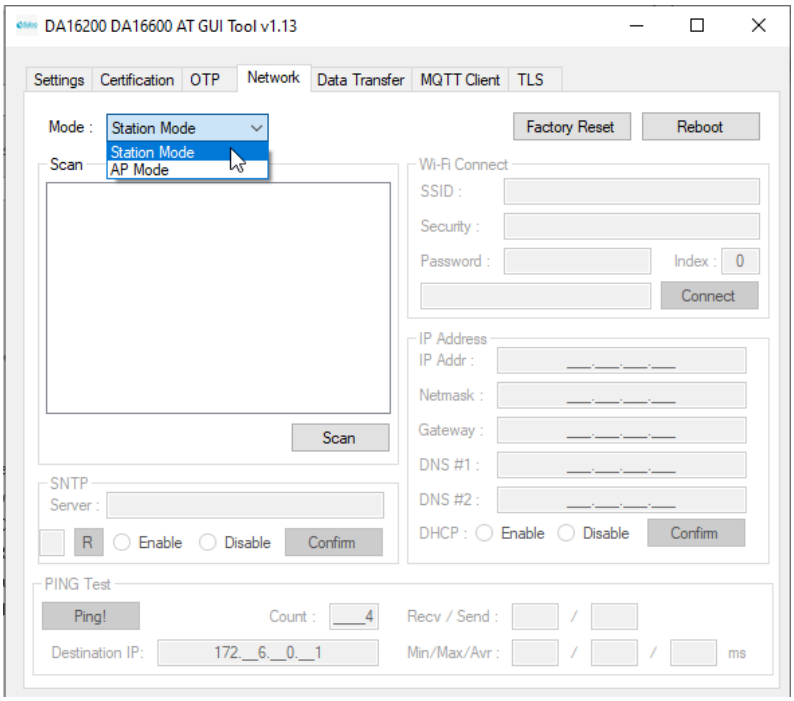


Figure 6: Network Mode in AT GUI Tool

10 Sleep Current Measurement

To detect any current leakage in the DA16200, measure the sleep current consumption. The following example code makes DA16200 go to sleep mode.

```
[/DA16200] # sys.hal
[/DA16200/SYS] # sleep [mode] [time]
Mode: sleep mode
2: Sleep mode 2.
3: Sleep mode 3.
Time: DA16200 wakes up after this time passes (second)
```

See the **Current Measurement** section in Ref. [2] about measuring current consumption.

11 Factory Reset

DA16200 should be initialized to the factory settings as multiple profiles may be written in the NVRAM during the production process. To erase all user NVRAM items, use the command code example below or AT commands in Table 9.

11.1 Console Command

```
[/DA16200] # factory
FACTORY RESET [N/y/?]y

Start Factory-Reset ...

Rebooting ....
```

11.2 AT Command

Table 9: AT Command for Factory Reset

Command	Parameters	Description
ATF	(none)	DA16200 factory reset.

12 Change Boot Index

The boot index can be changed by using console command `boot_idx`. Also, the SDK version and boot index can be confirmed during boot as shown below.

12.1 DA16200 Console Command

```
[/DA16200] # boot_idx 1                                          Moving the boot index from 0 to 1
[/DA16200] # reboot
       ******************************************************
        *             DA16200 SDK Information
        * ---------------------------------------------------
        *
        * - CPU Type        : Cortex-M4 (120 MHz)
        * - OS Type         : FreeRTOS 10.4.3
        * - Serial Flash    : 4 MB
        * - SDK Version     : V3.2.8.0 GEN
        * - F/W Version     : FRTOS-GEN01-01-f017bfdf51-006558
        * - F/W Build Time  : Aug 10 2023 13:44:35
        * - Boot Index      : 1                                  Need to check the boot index
        *
        ******************************************************
```

12.2 DA16600 Console Command

For DA16600, BLE firmware image is programmed from DA16200 to DA14531 during boot. Check whether the programming was successful through the logs below from DA16200.

```
        ******************************************************
        *             DA16600 SDK Information
        * ---------------------------------------------------
        *
        * - CPU Type        : Cortex-M4 (120 MHz)
        * - OS Type         : FreeRTOS 10.4.3
        * - Serial Flash    : 4 MB
        * - SDK Version     : V3.2.8.0 GEN-ATCMD
        * - F/W Version     : FRTOS-GEN01-01-f017bfdf51-006558
        * - F/W Build Time  : Aug 10 2023 14:09:33
        * - Boot Index      : 1                          Need to check the boot index
        *
        ******************************************************


gpio wakeup enable 00000402
[combo][iot_sensor]
   is_provisioned = 0
   is_sensor_started = 0
[combo] dpm_boot_type = 0


>>> UART1 : Clock=80000000, BaudRate=115200
>>> UART1 : DMA Enabled ...
[combo] BLE_BOOT_MODE_0
[combo] BLE FW VER to transfer ....
```

```
   >>> v_6.0.14.1114.3 (id=1) at bank_1
RTC switched to XTAL
combo] BLE FW transfer done                    Make sure to check this message "BLE FW Transfer done"


System Mode : Station Only (0)
>>> Start DA16X Supplicant ...
>>> DA16x Supp Ver2.7 - 2022_03
>>> MAC address (sta0) : d4:3d:39:11:5e:c6
>>> sta0 interface add OK
>>> Start STA mode...
by default, rf_meas_btcoex(1, 0, 0)

>>> UART2 : Clock=80000000, BaudRate=115200
>>> UART2 : DMA Enabled ...
<<< GAPM_DEVICE_READY_IND
IoT dev_name="DA16600-5EC6", len=12
[combo] Advertising...                         Make sure to check this message "Advertising..."
```

13 Bluetooth® LE Test

This section describes how to perform production test for Bluetooth® LE device on EVB for helping users to understand the test procedure in the final product.

13.1 SmartSnippets Tool

SmartSnippets™ Toolbox is provided with the Development Kit of Renesas's Bluetooth® LE chipset. The toolbox is a tool that helps Bluetooth® LE smart application developers test without expensive and bulky equipment. We recommend using this tool for Bluetooth® LE RF test.

To get the tool and user manuals, download it from Renesas website (https://www.renesas.com/us/en/products/wireless-connectivity/wi-fi/low-power-wi-fi).

- UM-B-083 SmartSnippets™ Toolbox
- For DA14531, the latest version is SmartSnippets Toolbox V5.0.16 for Windows OS

13.1.1 Install SmartSnippets Toolbox Windows

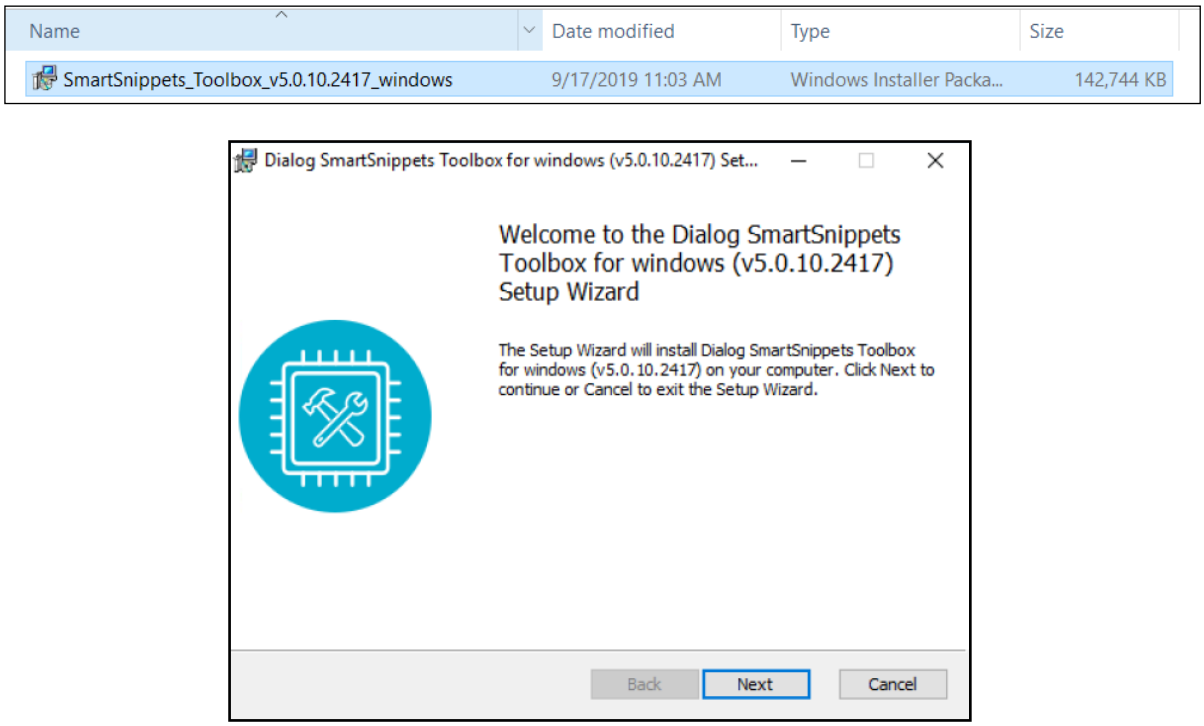


Figure 7: Installation Wizard of Smartsnippets_Toolbox v5.0.10.2417

13.1.2 Setup HW on EVB

We provide a SmartSnippets tool to check the RF performance of Bluetooth® LE DA14531 and it is required to check the board before the test. The board should be configured to connect UART in DA16600 EVB and change the RF path of DA14531. Figure 8 shows how to configure the DA16600 EVB.

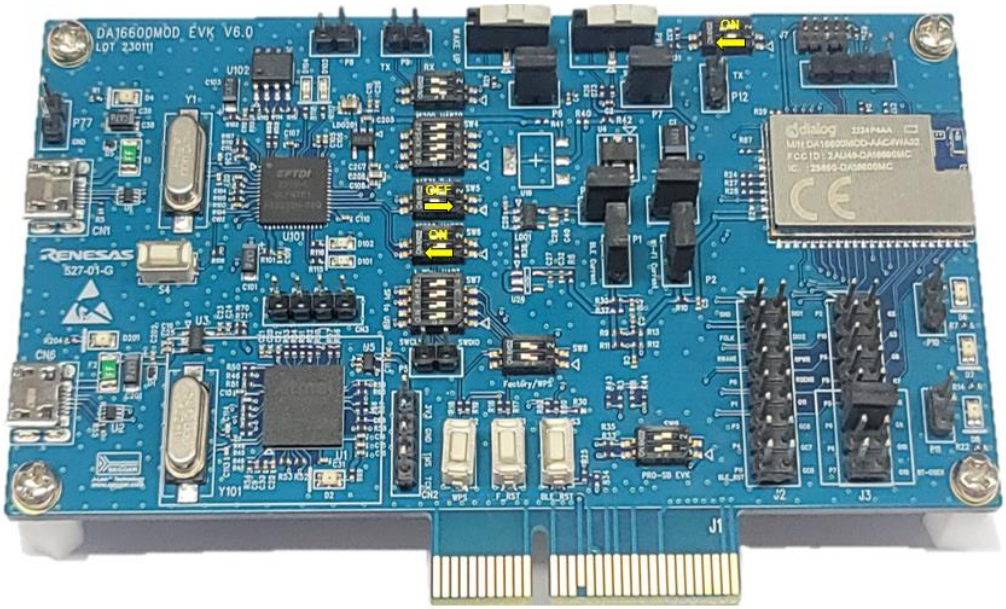


Figure 8: DA16600 EVB Setup for Bluetooth® LE Test

13.1.2.1 Erase Flash Content

Before Bluetooth® LE test, if the flash is not empty, run the following command to erase the flash content of the DA16600 module and go to `[MROM]` prompt by typing `reset` on the prompt:

- **[MROM] sflash erase 0 400000**

The flash should be empty and DA16200 does not download Bluetooth® LE image binary to DA14531 or it does not boot as no images in the flash.

13.1.2.2 DA14531 Reset

In DA16600, P0_0 for DA14531 reset is the Test Point. To use the SmartSnippets tool on the customer board, pin 43 (GPIOA1) of DA16600 must be pinned out.

Figure 9 shows a circuit configured for DA14531 reset in DA16600 EVB. Switch (S3) on the DA16600 board or the #10 in Figure 8 is the reset button during the test. When the reset is required, make sure to release the Switch (S3) quickly after pressing the button.

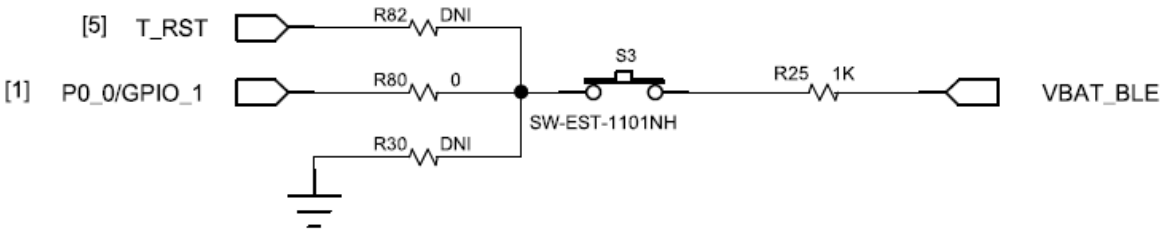


Figure 9: DA14531 Reset

13.1.2.3 DIP Switch Settings

For 1-wire (P0_5) UART to test RF performance of DA14531, turn on pin1 and 2 of SW6 to use UART and turn off pin 1 and 2 of SW5 as shown in Figure 10 and Figure 8.

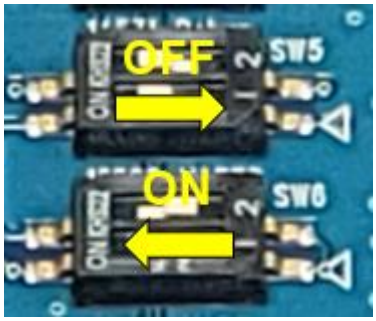


Figure 10: SW5 and SW6 Setup

SW10 can control RF switch. Turn on pin1 of SW10 to control RF switch to Bluetooth® LE RF path.

Figure 11: SW10 Setup

13.1.3 Run SmartSnippets Toolbox

The following is the procedure of the basic setup and test method using SmartSnippets.

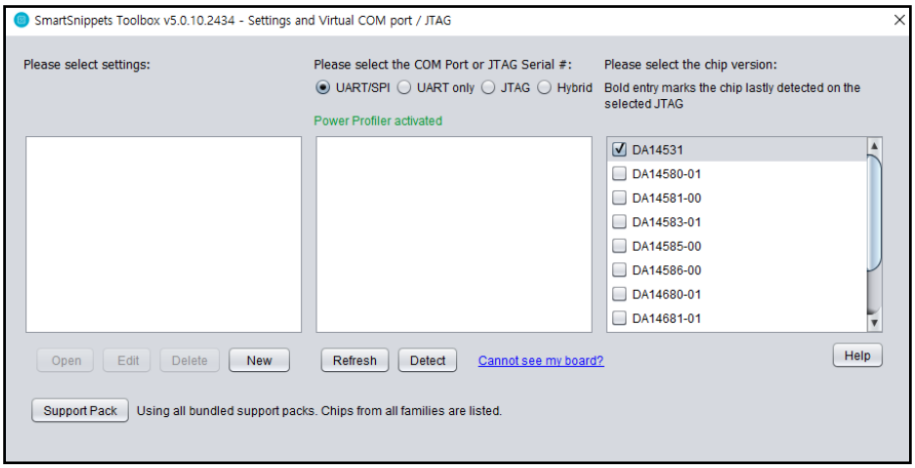


Figure 12: Initial Window of Smartsnippets_Toolbox

1. To create a new project with the DUT name, click **New** and specify the name. For example, for DA16600EVK, write DA16600.

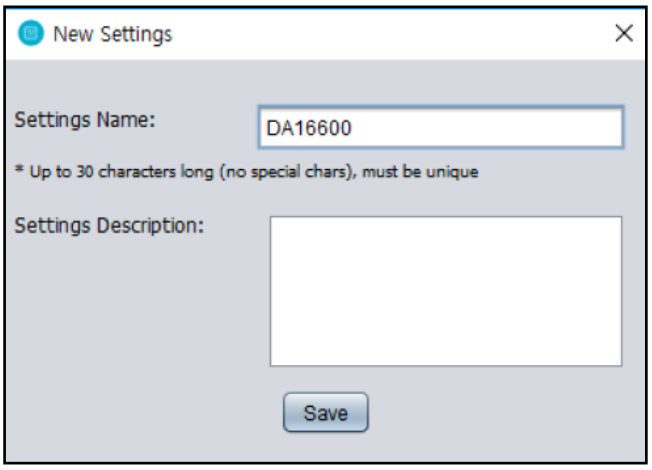


Figure 13: Create New Project with DUT Name

2. Click the **DA16600** name, choose the **DA14531-00** checkbox and select the **UART only** mode. Then, click **Refresh** to find the COM port of the DUT.

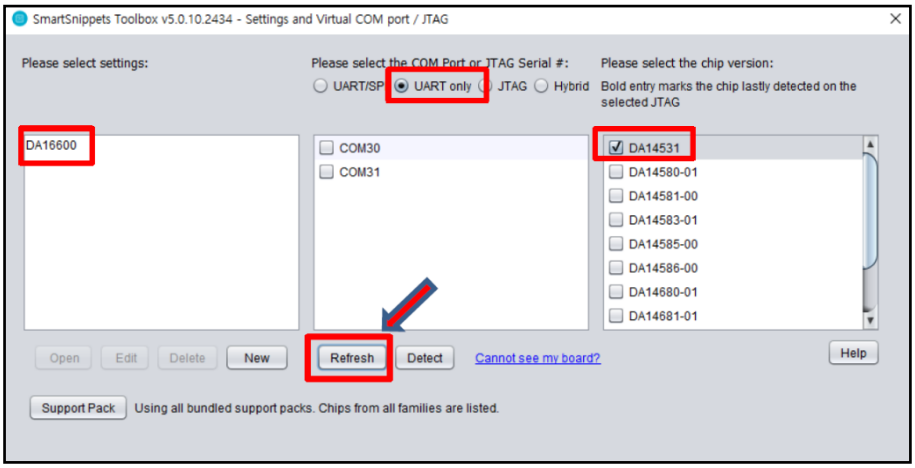


Figure 14: Find Connected COM Port with Refresh

3. Select the higher COM port out of the two that were created when the board is connected (non-Console COM port) and then click **Open**.

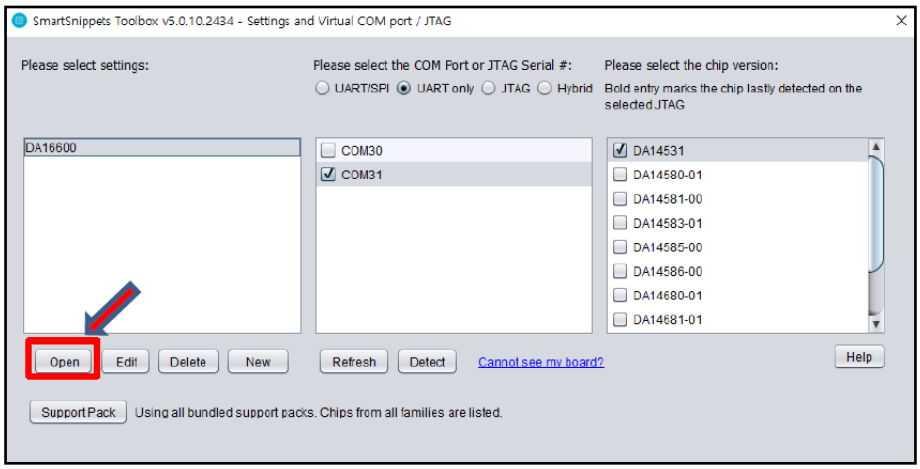


Figure 15: Open Project

4. Go to **Layout** > **Booter & Board Setup** and verify that the board setup is similar to Figure 16.

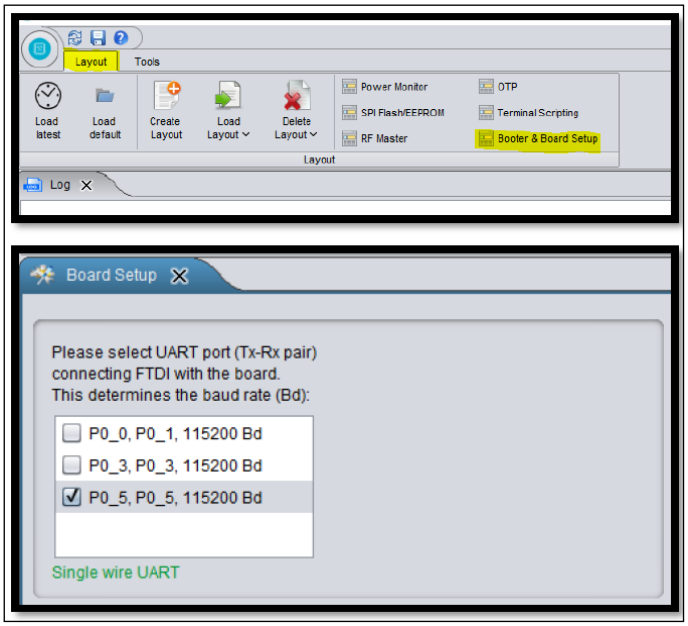


Figure 16: Verify Board Setup

5. Go to **Layout** > **RF master**. As shown in Figure 18, click **Browse** to download.

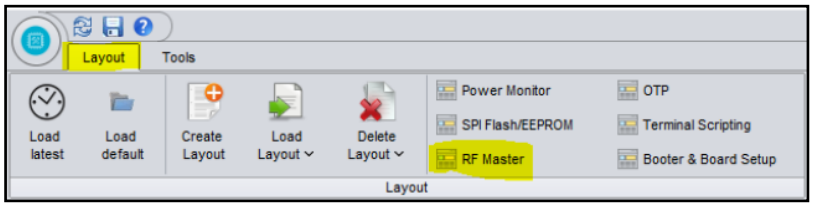


Figure 17: Select RF Master

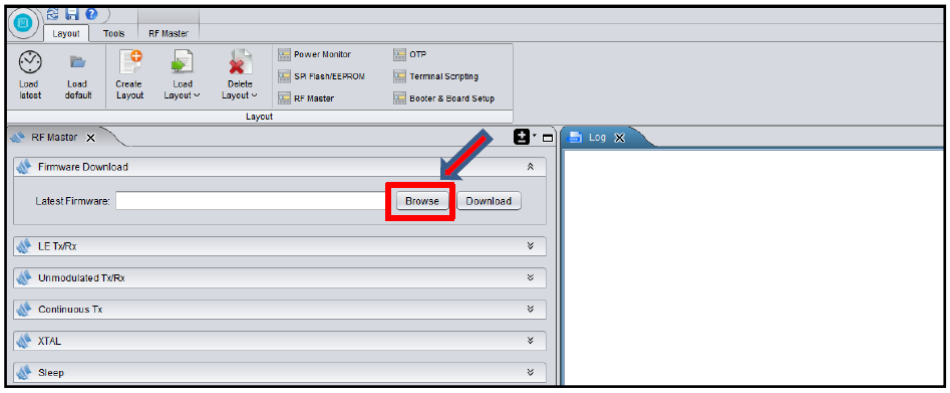


Figure 18: RF Master Window with Log

6. Select the binary file `prod_test_531_1wire_P05.bin` as shown in Figure 19. The pre-built `prod_test_531_1wire_P05.bin` located in DA14531 SDK of DA16600 SDK:
   `.\DA16200_DA16600_SDK_FreeRTOS_Manufacture_*\utility\combo\da14531_sdk_v_6.0.14.1114\6.0.14.1114\binaries\da14531\prod_test\`

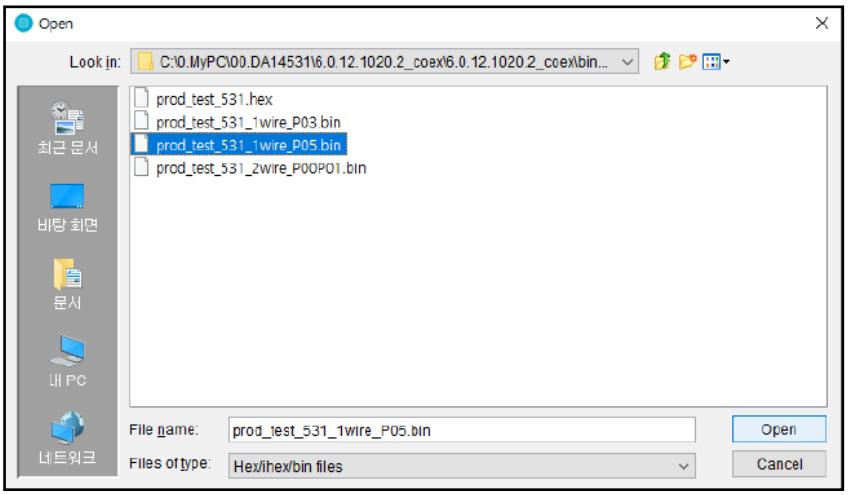


Figure 19: Select Binary File

7. Click **Download** and then **Reset HW** as shown in Figure 20, when the green text appears, click **Hardware Reset button - S3** in Figure 9 or #**15** in Figure 8. If “reset detected” does not displayed in the log box, make sure to release the S3 button quickly after clicking it.

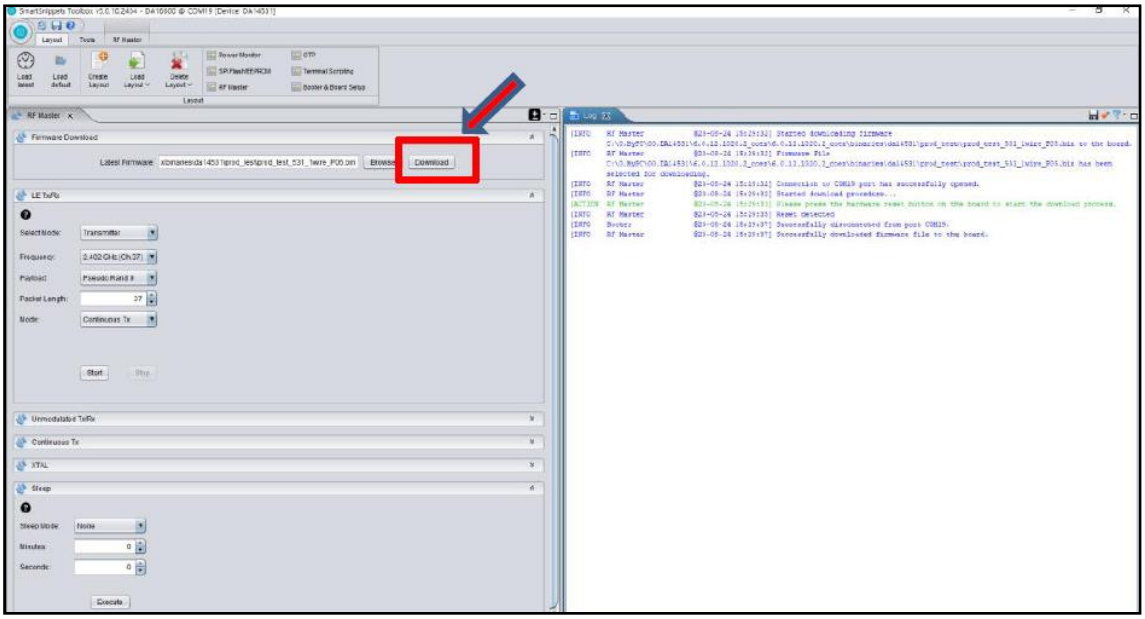


Figure 20: RF Master Log while Downloading Firmware and Reset

8. For continuous transmission, select **Continuous TX** (duty cycle close to 100 %). Set the correct frequency and click **Start**. The DUT will appear responding successfully to the command in the **Log** tab (response in green text). Click **Stop** to end the command.

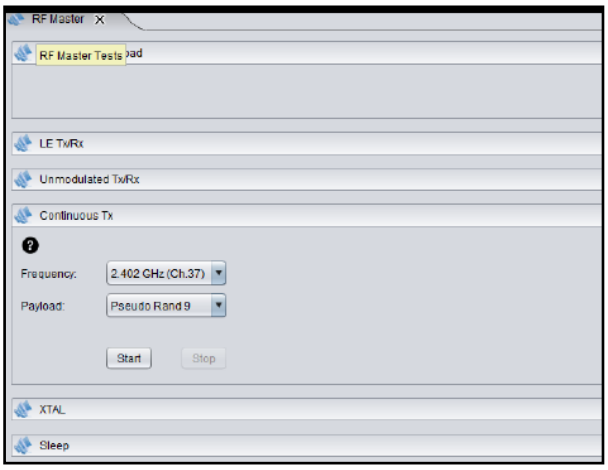


Figure 21: Continuous Setting

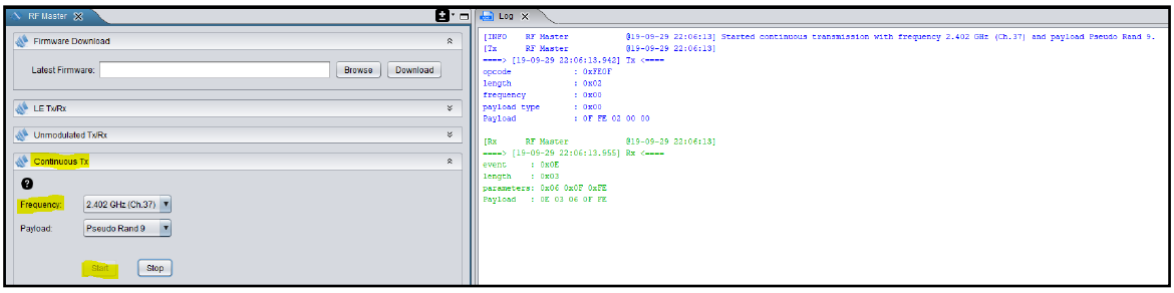


Figure 22: Continuous TX Command

9. For continuous reception, go to **LE TxRx** and select **Mode Receiver**. Set the correct frequency and click **Start**. The DUT will appear responding successfully to the command in the **Log** tab (response in green text). Click **Stop** to end the command.

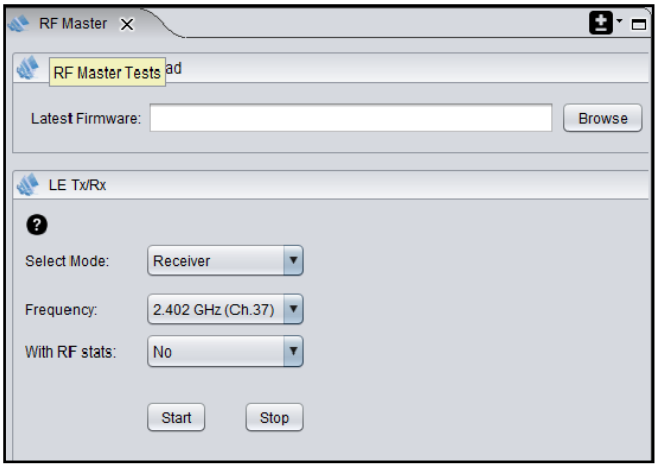


Figure 23: Select Mode for Rx

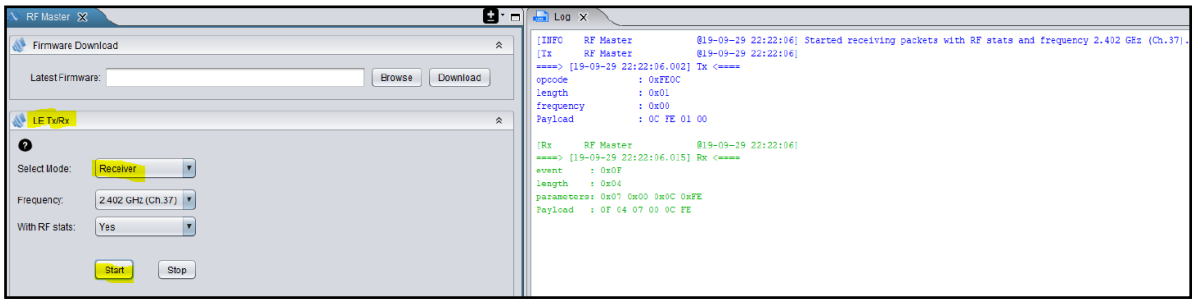


Figure 24: Continuous Reception Using LE Rx Command

13.2 Production Line Tool

By using the PLT, it is possible to test, calibrate, and load firmware for 16 different devices under test (DUTs) in parallel.

There is a Production tool that can perform a production test setup for the DA14531. This tool can be used to test all functions of Bluetooth® LE including XTAL Trim and to write the BD address into OTP.

For more information about using PLT, see Ref. [8].

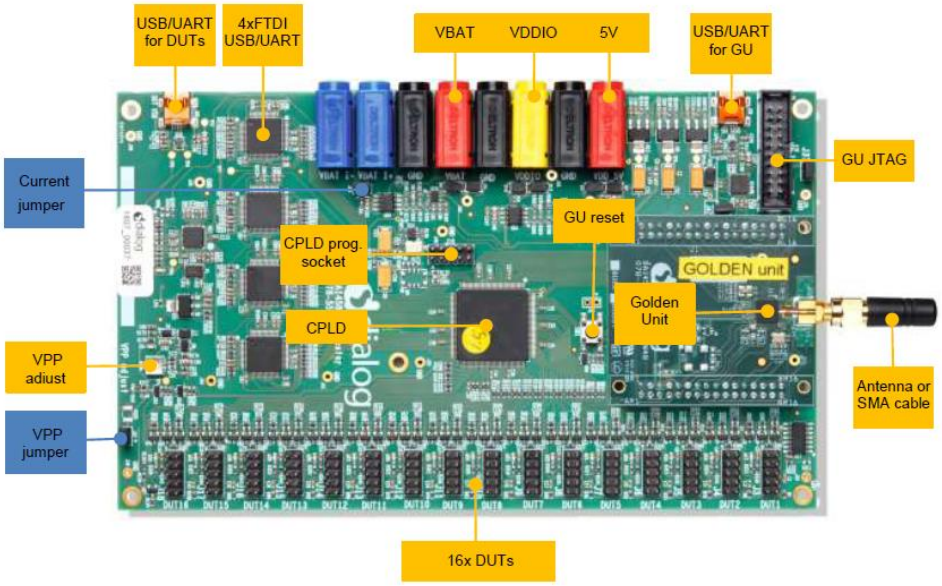


Figure 25**: Production Line Tool**

Appendix A RF Test with Console

The following describes how to check the Wi-Fi TX and RX RF performance using a UART debug port. There are two UARTs available on the DA16200 which can be used to check RF performance.

UART0 is used for debugging and checking Wi-Fi function by programming firmware images and using CLI commands.

A.1 Setup for RF Test

Console commands are normally undefined due to memory limitations and must be enabled to use console commands for performing RF tests through the debug port. See the SDK application note for enabling the console command interface for debugging.

To test using the DA16200 EVB, firmware image for AT command must be programmed. Prebuilt firmware images for AT command can be downloaded from the Renesas website (https://www.renesas.com/us/en/products/wireless-connectivity/wi-fi/low-power-wi-fi).

```
        ******************************************************
        *             DA16200 SDK Information
        * ---------------------------------------------------
        *
        * - CPU Type        : Cortex-M4 (120 MHz)
        * - OS Type         : FreeRTOS 10.4.3
        * - Serial Flash    : 4 MB
        * - SDK Version     : V3.2.8.0 GEN-ATCMD                    Need to check the image version
        * - F/W Version     : FRTOS-GEN01-01-f017bfdf51-006558
        * - F/W Build Time  : Aug 10 2023 13:44:35
        * - Boot Index      : 0
        *
        ******************************************************
```

For more detail on using CLI commands, see the getting started guide, Ref. [2]. List the available NVRAM commands by using the `?` or `Help` command.

Enter test mode using the `setenv NOINITWLAN 1` command and verify that the message "`!!! TEST MODE !!!`" is displayed.

NOTE
setenv NOINITWLAN 0 can be used to change to normal mode.

```
[/DA16200] # nvram                                          Enter the NVRAM
    Command-List is changed, "NVRAM"
[/DA16200/NVRAM] # setenv NOINITWLAN 1                      setenv NOINITWLAN 1 : Test mode
[/DA16200/NVRAM] # reboot                                   Needed reboot command

Wakeup source is 0x0
[dpm_init_retmemory] DPM INIT CONFIGURATION(1)


        ******************************************************
        *             DA16200 SDK Information
        * ---------------------------------------------------
        *
        * - CPU Type        : Cortex-M4 (120 MHz)
        * - OS Type         : FreeRTOS 10.4.3
        * - Serial Flash    : 4 MB
        * - SDK Version     : V3.2.8.0 GEN-ATCMD
        * - F/W Version     : FRTOS-GEN01-01-f017bfdf51-006558
        * - F/W Build Time  : Aug 10 2023 13:44:35
        * - Boot Index      : 0
        *
        ******************************************************

Fail to initialize WLAN. (step 1)
```



```
!!! TEST MODE !!!                                    setenv NOINITWLAN 1 : Test mode
>>> UART1 : Clock=80000000, BaudRate=115200
>>> UART1 : DMA Enabled ...
```

Before performing an RX test or TX test, the device must be initialized using the following commands:

```
[/DA16200] # lmac.tx.init                            Initializing to enable LMAC command
MAC init. OK
[/DA16200/LMAC.LMAC_TX] # start                      start command
START
[/DA16200/LMAC.LMAC_TX] #
```

NOTE
Once all tests are complete, the DA16200 must be returned to Wi-Fi operational mode by using the “Factory” command.

A.2 Commands for TX Test

A typical TX test environment is shown in Figure 26. TX power of the EVB can be measured using a signal analyzer. Accurate measurements are only possible using Conducted RF testing. Measuring RF with an antenna may show a significant difference in performance depending on the surrounding environment and the distance from the device, therefore it is recommended to perform the measurements using an RF cable connected to the U.FL connector on the module.

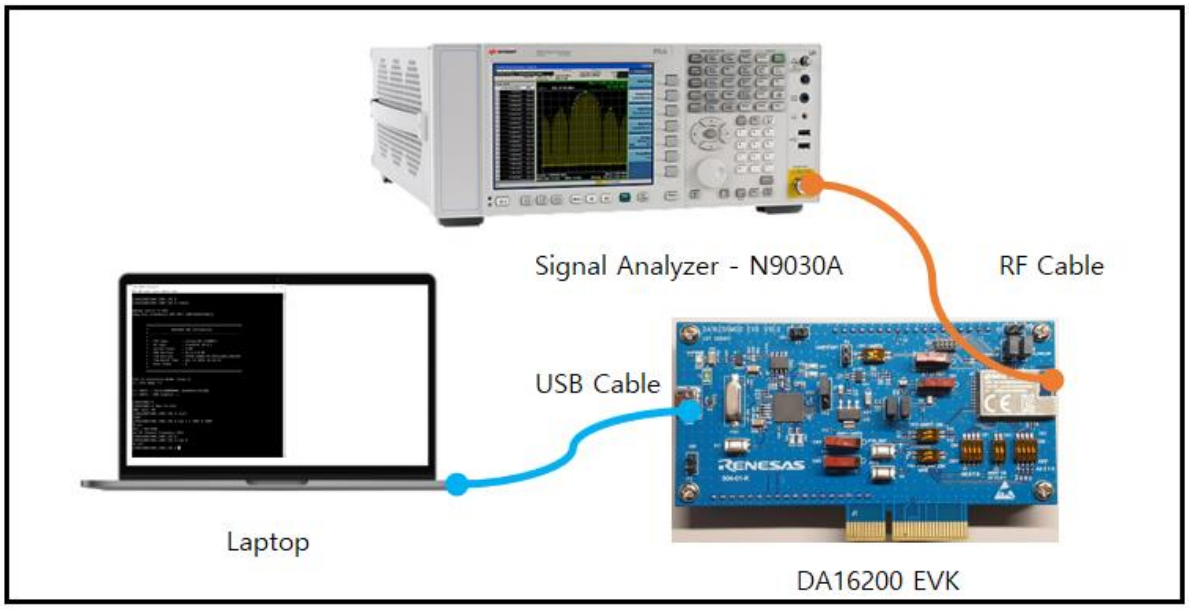


Figure 26: Setup for TX Test

```
[/DA16200] # lmac.tx.init
LMAC init. OK
[/DA16200/LMAC.LMAC_TX] # start
START
[/DA16200/LMAC.LMAC_TX] #
[/DA16200/LMAC.LMAC_TX] # txp 1 1 1007 0 1194                TX ON command
TX on.
desc = 0xc5d80
Set RF Channel Frequency 2412
[/DA16200/LMAC.LMAC_TX] # txp 0                              TX OFF command
TX off.
[/DA16200/LMAC.LMAC_TX] #
```


The following sequence is for TX signal generation:

1. Type `lmac` and `tx` to enter LMAC > TX command mode.
2. Type `init` and `start`.
3. Type `txp 1 [channel] [modulation type] [power level] [data length]` to generate the TX signal.
   - `Example 1) txp 1 1 400 0 32`
     - CH 1, 11B 1Mbps, Power level=0 (max power)
   - `Example 2) txp 1 11 1007 4 1194`
     - CH 11, 11N MCS7, Power grade=4

Depending on the Tx power, it has a gain about 0.8dB

At the end of the test, type `txp 0` which sets the TX signal to the off state. Otherwise, `txp 1` sets the TX signal to the on state. It is required to turn off the signal generation using `txp 0` before performing another test.

Here is an example of TX command for each Wi-Fi standards:

Modulation		Setting parameter	Duty cycle : 95%	For example		
			Data length	Duty cycle : 95%, power grade 3		
			Byte[Hex]	Channel 1	Channel 7	Channel 13
11b	1Mbps	400	32	txp 1 1 400 3 32	txp 1 7 400 3 32	txp 1 13 400 3 32
	2M	401	64	txp 1 1 401 3 64	txp 1 7 401 3 64	txp 1 13 401 3 64
	5.5M	402	12C	txp 1 1 402 3 12C	txp 1 7 402 3 12C	txp 1 13 402 3 12C
	11M	403	258	txp 1 1 403 3 258	txp 1 7 403 3 258	txp 1 13 403 3 258
11g	6M	404	1F4	txp 1 1 404 3 1F4	txp 1 7 404 3 1F4	txp 1 13 404 3 1F4
	9M	405	2BC	txp 1 1 405 3 2BC	txp 1 7 405 3 2BC	txp 1 13 405 3 2BC
	12M	406	3E8	txp 1 1 406 3 3E8	txp 1 7 406 3 3E8	txp 1 13 406 3 3E8
	18M	407	578	txp 1 1 407 3 578	txp 1 7 407 3 578	txp 1 13 407 3 578
	24M	408	708	txp 1 1 408 3 708	txp 1 7 408 3 708	txp 1 13 408 3 708
	36M	409	BB8	txp 1 1 409 3 BB8	txp 1 7 409 3 BB8	txp 1 13 409 3 BB8
	48M	40a	FA0	txp 1 1 40a 3 FA0	txp 1 7 40a 3 FA0	txp 1 13 40a 3 FA0
	54M	40b	FA0	txp 1 1 40b 3 FA0	txp 1 7 40b 3 FA0	txp 1 13 40b 3 FA0
11n	MCS0	1000	1F4	txp 1 1 1000 3 1F4	txp 1 7 1000 3 1F4	txp 1 13 1000 3 1F4
	MCS1	1001	3E8	txp 1 1 1001 3 3E8	txp 1 7 1001 3 3E8	txp 1 13 1001 3 3E8
	MCS2	1002	5DC	txp 1 1 1002 3 5DC	txp 1 7 1002 3 5DC	txp 1 13 1002 3 5DC
	MCS3	1003	7D0	txp 1 1 1003 3 7D0	txp 1 7 1003 3 7D0	txp 1 13 1003 3 7D0
	MCS4	1004	BB8	txp 1 1 1004 3 BB8	txp 1 7 1004 3 BB8	txp 1 13 1004 3 BB8
	MCS5	1005	FA0	txp 1 1 1005 3 FA0	txp 1 7 1005 3 FA0	txp 1 13 1005 3 FA0
	MCS6	1006	1194	txp 1 1 1006 3 1194	txp 1 7 1006 3 1194	txp 1 13 1006 3 1194
	MCS7	1007	1194	txp 1 1 1007 3 1194	txp 1 7 1007 3 1194	txp 1 13 1007 3 1194

Figure 27: Reference Table for TX Test

A.3 Commands for RX Test

For RX and conducted RF test, measurements should be performed without external signal interference. When checking the weak electric field signal such as 11b 1 Mbps mode, accurate measurement results may not be obtained if the measurement is not performed under shield room conditions.

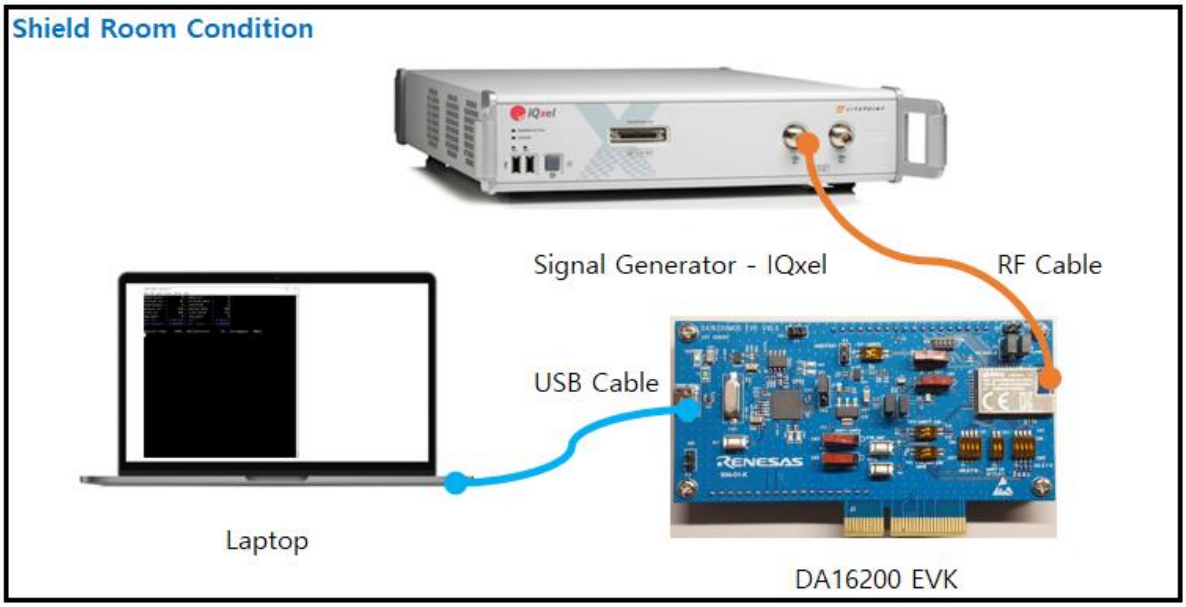


Figure 28: Setup for RX Test

The sequence of commands to initialize with mac layer is the same as for the TX test.

With `lmac.per` command, check the packet error rate of the signals received by DA16200.

Type `PER` on the console to stop receiving packets and end the test. This is known as RX test OFF.

`Lmac.per` : RX test On

`per` : RX test Off (Must be typed during RX test packet reception)

```
[/DA16200] #
[/DA16200] # lmac.tx.init
LMAC already initiated
[/DA16200/LMAC.LMAC_TX] # start
START
[/DA16200/LMAC.LMAC_TX] # lmac.per                    RX Test ON command
```

The PER for the signal received from the signal generator is displayed in the output generated by the `lmac.per` command as marked with the green box in the picture below. The error rate will be displayed based on how many packets have been received compared to the transmitted packets.

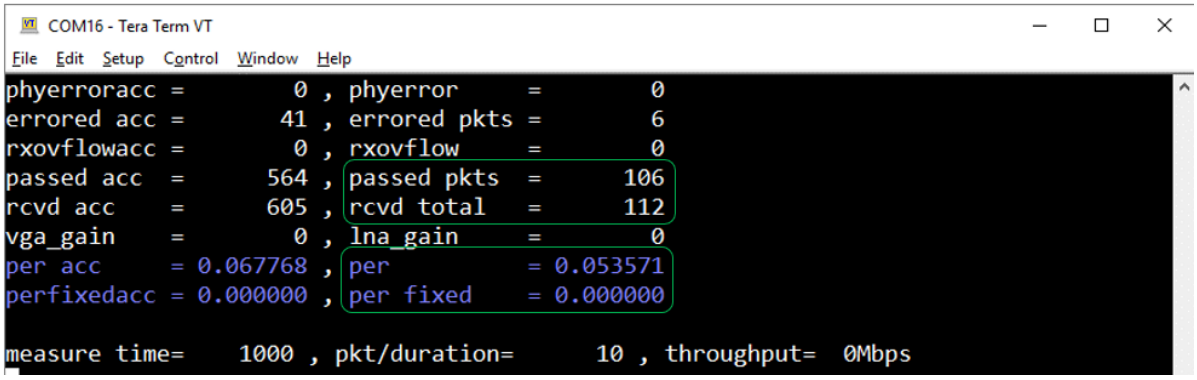


Figure 29: RX PER (Good)

The number of receivable packets per standard may vary. An error rate of less than 10% compared to send packets can be considered as a performance indicator.

Below is an error and it is displayed in red, but it is not a problem because the error rate is about 0.1%.

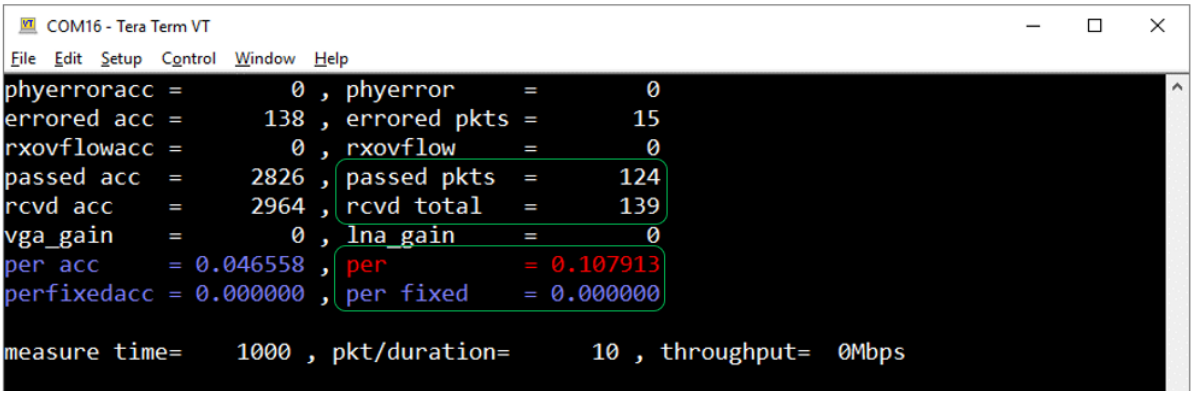


Figure 30: RX PER (Not Good)

Appendix B Configure DA16600 EVB 4v0 to Use AT Command via UART2

DA16600 supports AT command via the DA16200's UART. DA16200 supports 3 UARTs, and UART2 should be used for AT command UART0 is used for debug, and UART1 is used for communication between DA16200 and DA14531 on DA16600.

UART2 is not connected to FT2232H on EVB 4v0, thus additional manual modifications are required to use AT command via UART2. See the steps below.

The GPIO of UART1 or UART2 for AT command interface set in the DA16200, DA16600 Firmware image for AT command provided by default is assigned as follows:

- DA16200 Firmware image for AT command : UART1 – GPIOA_4, GPIOA_5
- DA16600 Firmware image for AT command: UART2 – GPIOC_6, GPIOC_7

B.1 Turn OFF Switch

UART1 is connected to FT2232H on the board, so the switch needs to be turned off first. To disconnect UART1 from FT2232H, SW3 and 5~8 of SW should be turned off. See Figure 31.

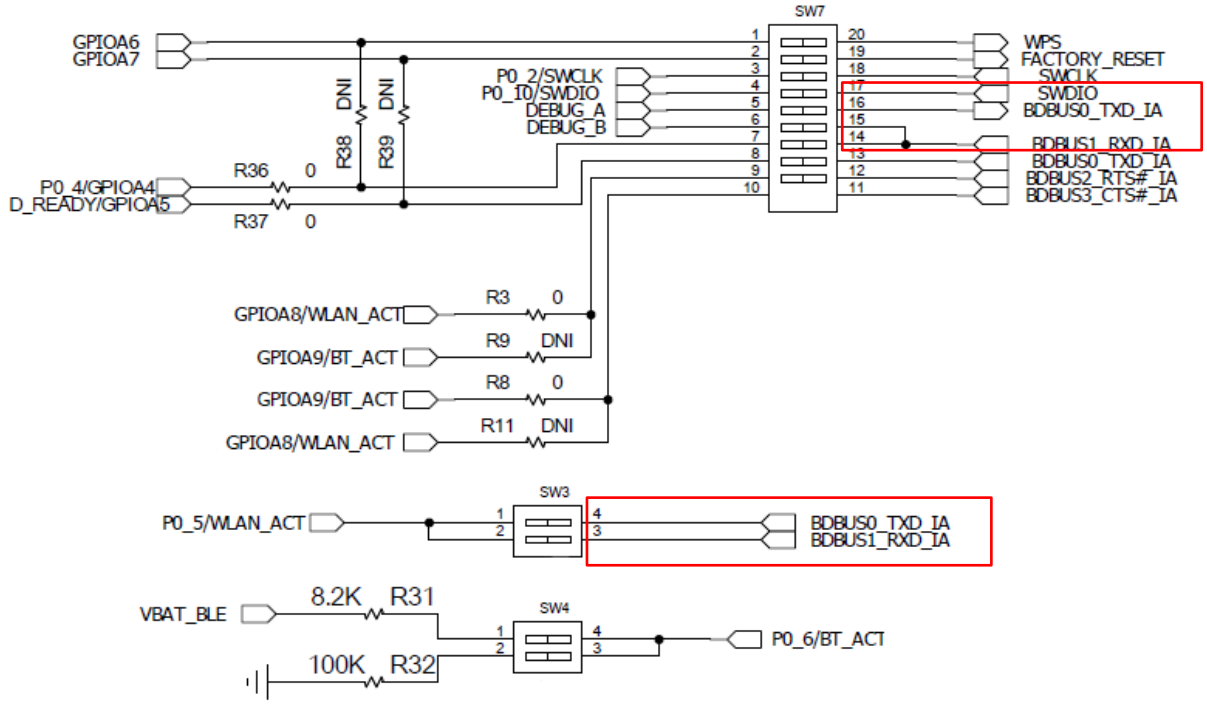
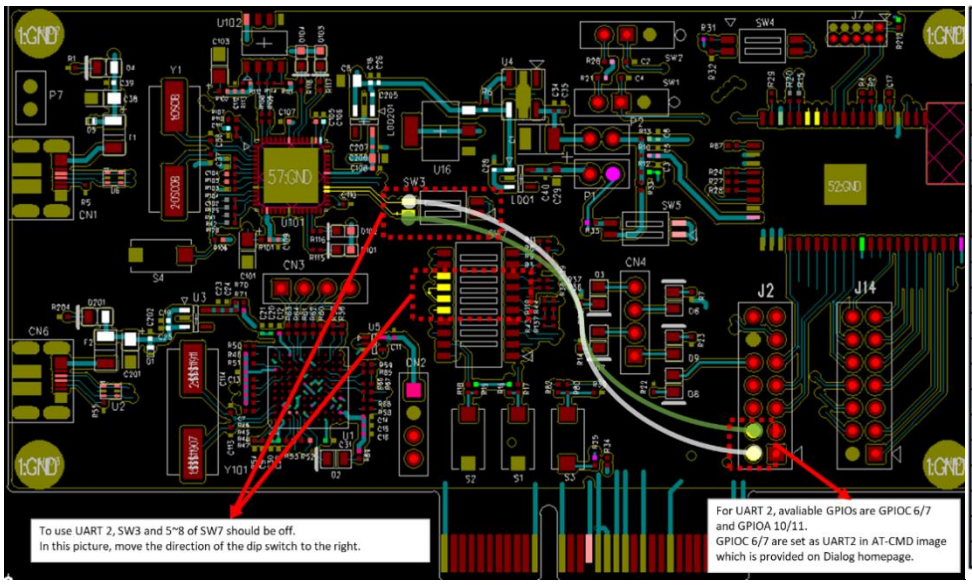


Figure 31: SW3 and SW7 UART1 Connection

B.2 Connect UART2 to FT2232H

UART2 is available with GPIOA10/11 or GPIOC6/7. See pin mux in Figure 32. GPIOC6/7 are set as UART2 in the DA16600 Manufacture image, so UART2 can be connected to FT2232H to use AT command. The image is available in Renesas website (https://www.renesas.com/us/en/products/wireless-connectivity/wi-fi/low-power-wi-fi).

GPIOC6/7 are 2/4 pins of J2 connector, connect the wires from SW3 to J2. See Figure 32.



Pin	UART2
TP	
TP	
GPIOA2	
GPIOA3	
TP	
TP	
GPIOA6	
GPIOA7	
GPIOA8	
GPIOA9	
GPIOA10	TXD
GPIOA11	RXD
TCLK/GPIOA15	
TMS	
UART_TXD	
UART_RXD	
GPIOC8	
GPIOC7	RXD
GPIOC6	TXD

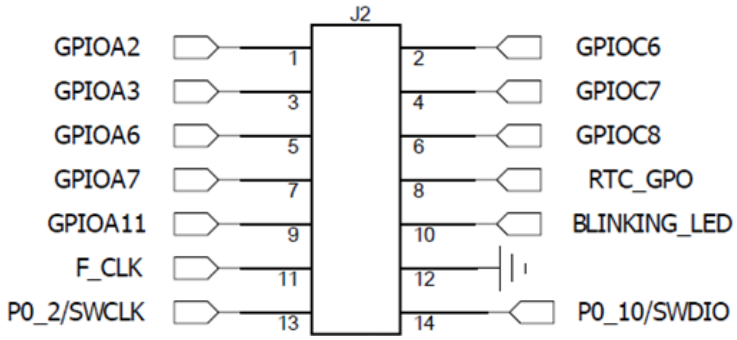


Figure 32: Connect UART2 to FT2232H

See Figure 33 for the picture of AT command connection via UART on EVB 4v0.

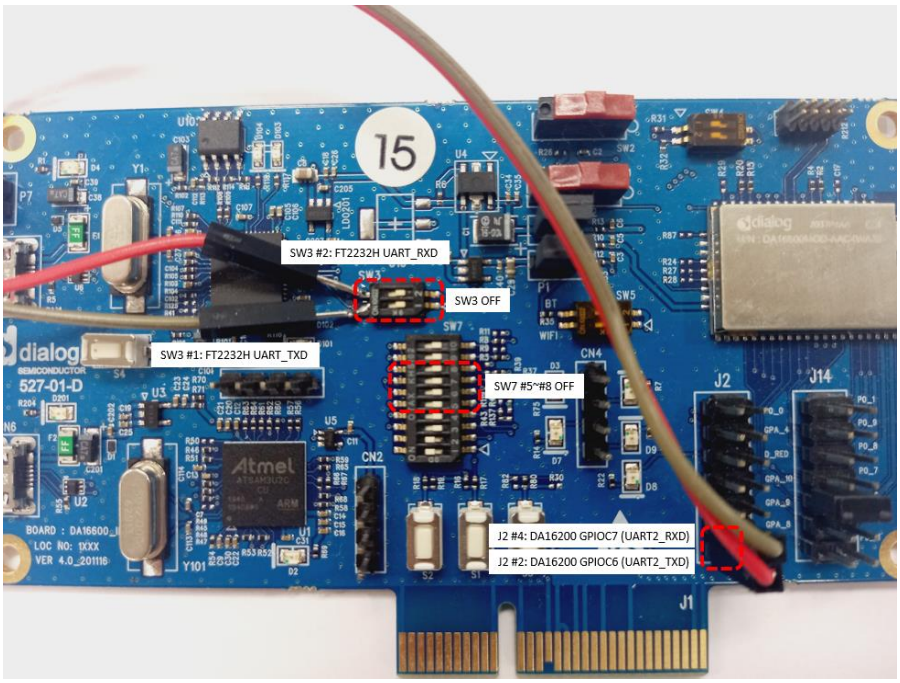


Figure 33: Setting for AT Command over UART2 on EVB 4v0

Revision History

Revision	Date	Description
2.0	Sep. 27, 2023	● Reorganized document according to sequence of production test ● Updated XTAL Calibration section
1.9	June 30, 2023	Updated the reference section
1.8	Jan. 12, 2023	● Updated descriptions in Writing MAC Address section ● Removed supporting channel 14
1.7	Aug. 16, 2022	● DA16600MOD Mass Production guide (UM-WI-054) merged into this document ● Removed Manufacture Image parts
1.6	Apr. 13, 2022	● Updated RF Test with Console section ● Updated reference section
1.5	Mar. 28, 2022	Updated logo, disclaimer, and copyright
1.4	Mar. 17, 2021	Added Note 1
1.3	Nov. 21, 2019	Finalized for publication
1.2	Nov. 18, 2019	● Editorial review ● Added description for OTP write command
1.1	Nov 12, 2019	● Added Download the AT command and General Images ● Added Change Boot Index section ● Error correction on Table 4
1.0	July 31, 2019	First Release

Status Definitions

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
APPROVED or unmarked	The content of this document has been approved for publication.

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