GigaDevice Semiconductor Inc.

GD32VW553 Certification Test Guidelines

Application Note
AN146

Revision 1.1

(Mar. 2024)

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1. Introduction

This test guideline is mainly used to give guidance to clients to test RF certification and regulatory performance of chips of GD32VW553 series. The certification regulations mainly refer to FCC, CE, and SRRC. Chapter 2 introduces software and hardware configuration of DUT (device under test). Chapter 3 and 4 introduce methods of testing Tx or Rx (transmitting or receiving) parameters in non-signaling mode in all certifications with RF test tool. Chapter 5 introduces methods of testing "Blocking" and "Adaptivity" parameters in signaling mode in CE certification with serial port command lines. Chapter 6 introduces frequently-asked questions and solutions. Chapter 7 is version history.

2. Test preparation

This chapter introduces preparation for certification tests, mainly including the building of DUT software and hardware platforms. DUT should have passed the RF calibration (That is, the RF calibration value, legal value, and other information have been correctly written into the chip Efuse).

2.1. Hardware configuration

Use the **GD development board** ***Figure 2-1. Reference connection of GD development board*** as an example for description:

1. UART&JLINK functions: The communication function of USB to UART and the firmware burning function of USB to JLINK are realized through the DAP chip circuit on the bottom board, and PC is connected to the USB port of the bottom board using a USB cable;
2. Serial port connection: Connect to the bottom board J5.2/4 (main chip UART PIN) and J5.1/3 (DAP UART PIN)) using a jumper cap respectively.
3. JLINK connection: Connect to the bottom board J4.2/4/6/8 (main chip JLINK PIN) and J4.1/3/5/7 (DAP JLINK PIN)) using a jumper cap respectively.
4. Configuration of the main chip mode:

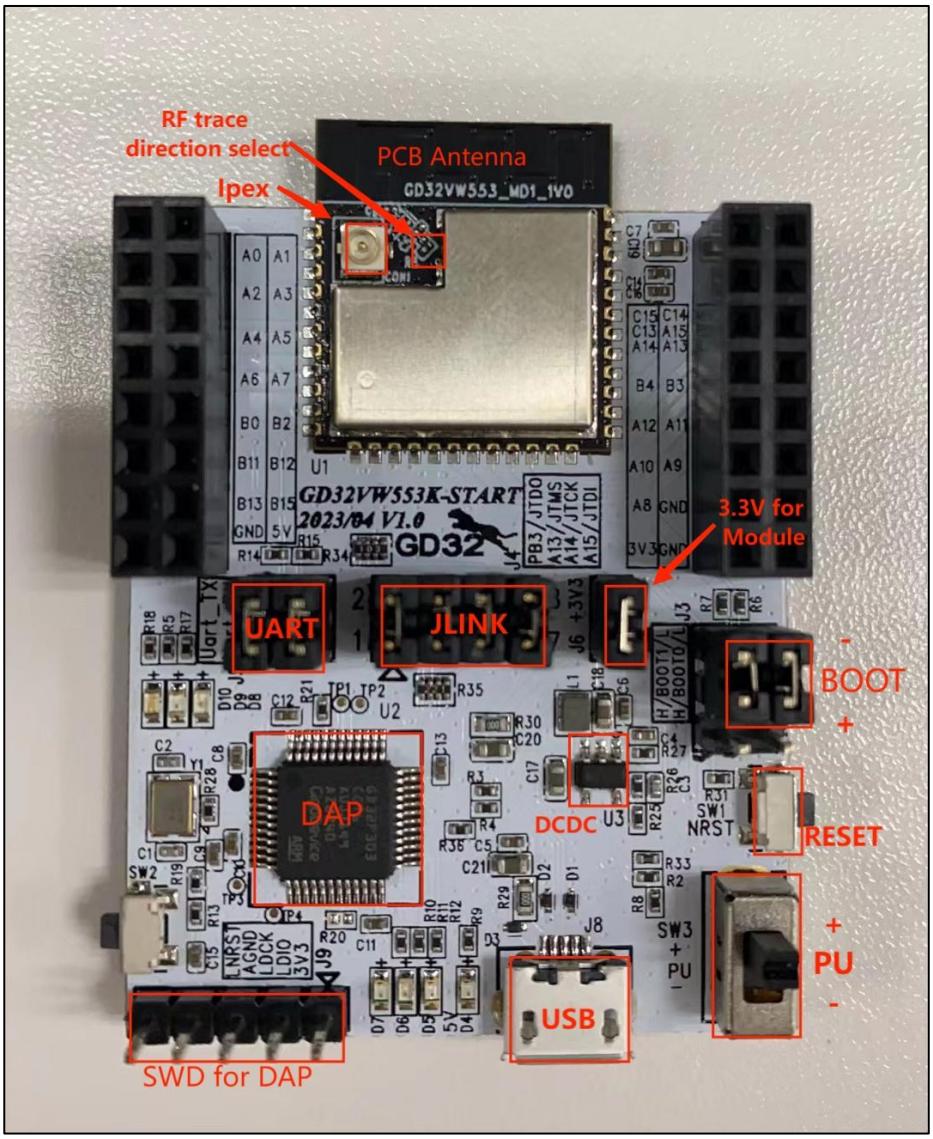
- "**BOOT0**" of PIN should be at low level (boot from flash), which is realized by connecting to bottom board J3.3 and J3.5.
- "**PU**" of PIN should be at high level, which is realized by setting the DIP switch "**SW3**" on the bottom board to the upper position.

5. Module antenna switching:

- Switch the position of the resistor by welding ***Figure 2-1. Reference connection of GD development board*** to select the RF signal path of DUT: When the left side of the resistor faces upward, the RF path leads to the PCB antenna and can only be used for radiation test; when the left side of the resistor faces downward, the RF path leads to the RF (Ipex) connector and is used for conduction test and external antenna radiation test. This document mainly targets **conduction test**.
- Connect the RF test socket of DUT and the RF port of the instrument using an Ipex- to-SMA cable.

6. Module power supply: The DC-DC circuit on the bottom board converts the 5 V power input from the USB port into a 3V3 output, and the 3V3 output is connected to the 3V3 pad of the module with the jumper cap "J6". Disconnect this jumper cap (from external 3V3 output to J6.2) to test the power consumption of the module.

Figure 2-1. Reference connection of GD development board



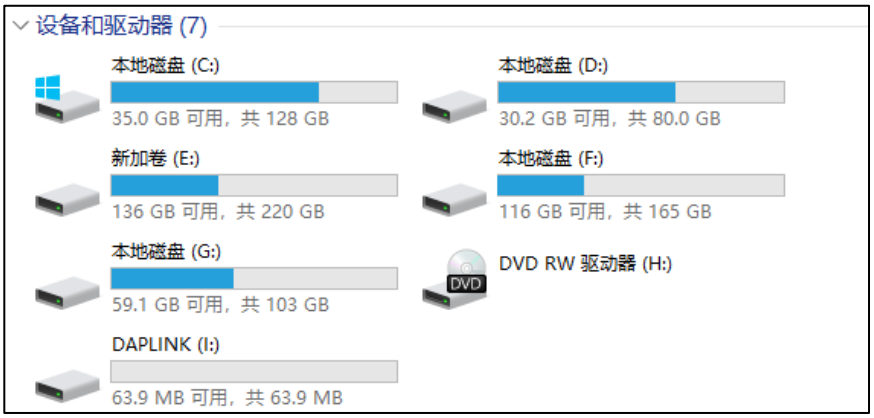
2.2. Software configuration

1. Drive installation: After the development board hardware and the test system are built, connect the two ends of the USB cable to the development board and PC respectively. First install the DAPLINK drive "**bedWinSerial_16466.rar**" on PC: After decompression, double-click the .exe file to start automatic installation. After installation, the serial port device and COM number ***Figure 2-2. Installation of serial port drive*** are displayed in the "Device Manager" on PC. It is recommended to install Windows 10/Windows 7 system on PC.

Figure 2-2. Installation of serial port drive

2. Firmware download: After the DAPLINK drive is installed, the new drive letter "DAPLINK" *Figure 2-3. DAPLINK folder* is displayed in the path of PC-"Explorer". For non-signaling test, directly "drag and drop" (or copy and paste) the test firmware named "rf_test" to this drive letter, wait for a while to achieve firmware burning, and click **Reset** to restart the chip. For signaling test, firmware named “wifi_signaling_test” or “ble_signaling_test” is used.

Figure 2-3. DAPLINK folder



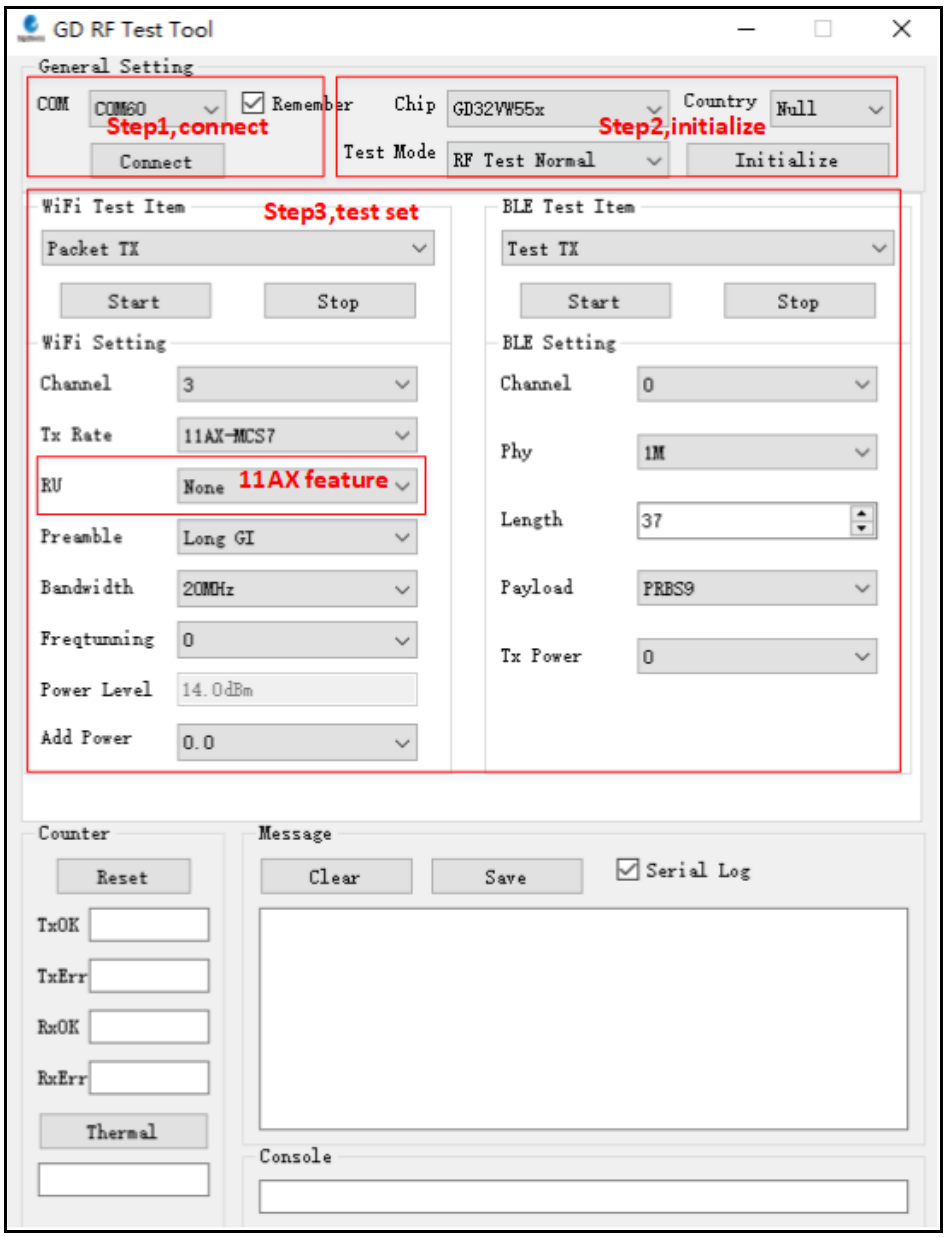
3. Non-signaling test - use RF tool

This chapter introduces how to test RF Tx and Rx parameters in non-signaling mode with the GD RF test tool.

3.1. Introduction to the tool

Figure 3-1. Description of tool functions shows the interface and functions of the first opened RF test tool "**GD RF Test Tool**" provided by GD (serial port not connected and chip not initialized).

Figure 3-1. Description of tool functions



3.2. Test mode setting

1. Serial port connection: Select the serial port number of DUT in the drop-down menu of **COM** on the tool interface, click **Connect**, and the text displayed on the button changes to **Disconnect**, which indicates that the serial port is successfully connected, and the **Freqtunning** bar displays the calibrated value. If the serial port connection fails, the log window will report the error.
2. Mode setting: Select "**GD32VW55X**" for "**Chip**". Select "**RF Test Normal**" for "**Test Mode**". Select the corresponding code for "**Country**", like "**FCC**" and "**CE**". Click "**Initialize**" and the button display text will be changed to "**De-initialize**", which indicates entering the test mode.
3. If the development board is restarted or replaced with another development board for test, repeat Steps 1 and 2. If "**Disconnect**" and "**De-initialize**" are displayed, continuously click each buttons twice to connect the serial port and initialize the chip mode again.

3.3. WiFi continuous packet sending test

This test item is defined as the modulated signal Tx with 100% duty, which is used to test the transmitted spectrum waveform and harmonic characteristics.

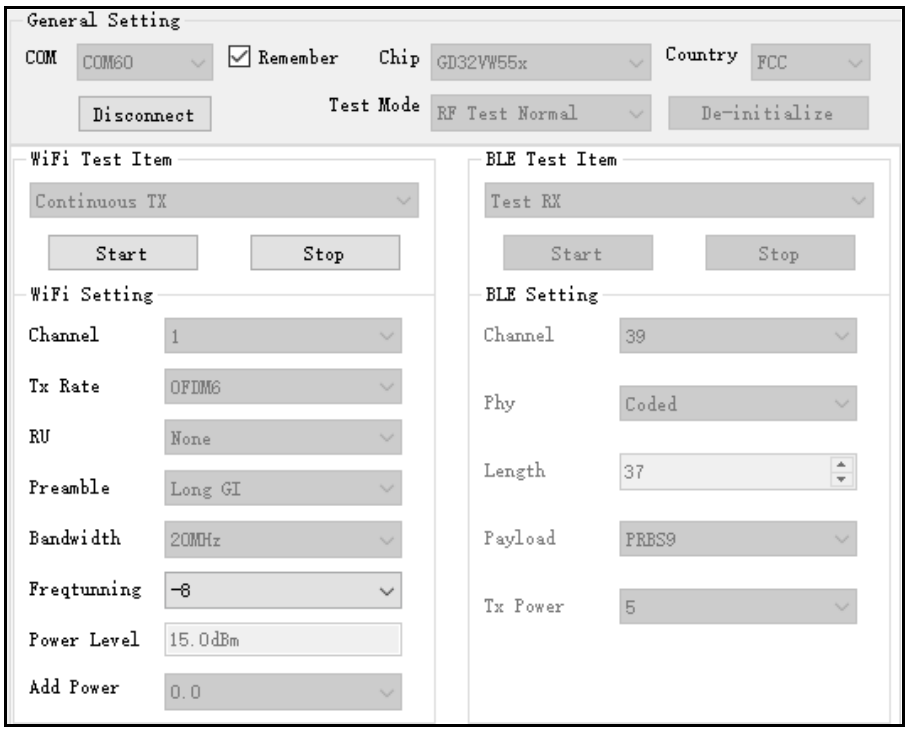
1. DUT setting: Set "**WiFi Test Item**" to "**Continuous TX**" on the tool interface. Set "**Channel**" and "**Rate**". Click "**Start**" and the "**Power Level**" field of the chip will display the default power (absolute dbm), recommended power for current channel and rate to pass certification. Tx TF signal starts.
2. Tx adjustment: To modify the power, first click '**Stop**" to stop Tx, modify the "**Add Power**" value in step units of 0.25 db, and click "**Start**". At this moment, refer to the following formula for the expected power:

   Expected power = default power ("**power level**" dbm value) + power adjustment value ("**Add Power**" db value)

3. Click "**Stop**" to end the test

As shown in ***Figure 3-2. Continuous TX Tool setting***, set **Country** to FCC, **Channel** to 1 (2,412 MHz), **Tx Rate** to 11G 6M, and **Power Level** to the default 15 dbm, and start Continuous TX.

Figure 3-2. Continuous TX Tool setting



3.4. WiFi receiving test

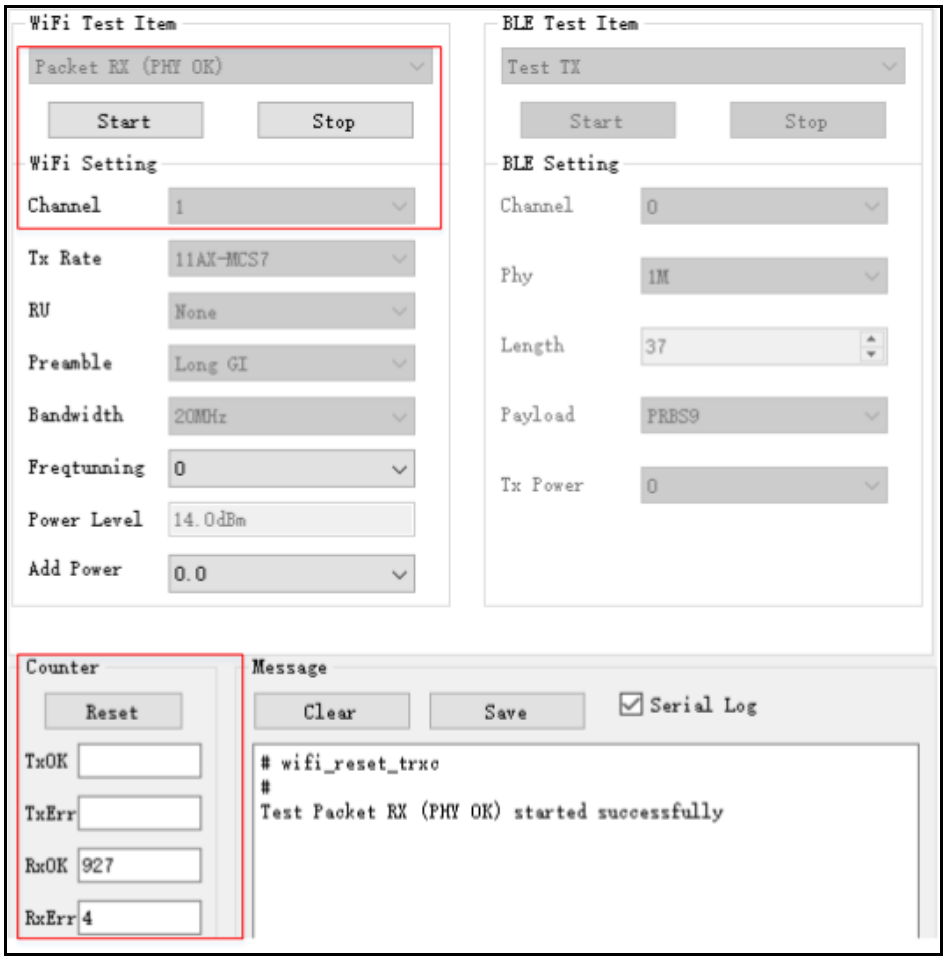
This test item is used to test the received packet error rate (RX PER), receiving sensitivity, and other parameters in a **shielded room environment** without any interference.

1. Set "**WiFi Test Item**" to "**Packet RX**" and set "**Channel**" and "**Bandwidth**".
2. Click "**Start**" and "**Reset**" to reset the counter.
3. At this moment, the instrument has not sent any packet. Observe the numbers shown in RxOK and RxErr at the lower left corner of the user interface for a few seconds to confirm that they are always empty, which indicates that the environment is "clean", and then set the packet sending of the instrument.
4. After the instrument has sent packets, record the result of the counter (number of RxOK packets) on the interface, and calculate PER according to the following formula: PER = (number of packets sent by the instrument – RxOK)/ number of packets sent by the instrument (11b rate PER≤8%， 11g/n rate PER≤10%, as specified in the Wi-Fi protocol).
5. If retesting is required, repeat Step 2-4.

It is generally recommended that the packet length and number of packets of the waveform of the Rx test instrument should be 1,024 bytes and 1000 respectively.

As shown in ***Figure 3-3. Packet RX Tool setting***, it means that Channel = 1 (2,412 MHz), Packet RX test started.

Figure 3-3. Packet RX Tool setting



3.5. BLE continuous packet sending test

This test item is defined as the modulated signal Tx with 100% duty, which is used to test the transmitted spectrum waveform and harmonic characteristics.

1. Set "**BLETest Item**" to "**Test TX Infinite**". Set "**Channel**", "**Phy**", "**Length**", and "**Payload**". Set "**TxPower**" to recommended value (FCC is 8, others is 6). Click "**Start**".
2. TX adjustment: To modify power, click "**Stop**" to stop Tx and then modify the "**Tx Power**" value. The field represents absolute dbm, like “5” for 5 dbm.
3. Test result: Click "**Stop**" to end the test

As shown in ***Figure 3-4. BLE Test TX Infinite Tool setting***, set **Country** to CE, **Channel** to 0 (2,402 MHz), **Phy** to 1M, **Payload** to "PRBS9", and **Tx Power** to 6 dbm, and start Test TX Infinite.

Figure 3-4. BLE Test TX Infinite Tool setting

3.6. BLE receiving test

This test item is used to test the received packet error rate (RX PER), receiving sensitivity, and other parameters in a **shielded room environment** without any interference.

1. Set "**WiFi Test Item**" to "**Packet RX**" and set "**Channel**" and "**Bandwidth**". Click "**Start**".
2. Set the instrument according to the above-mentioned parameters and send packets.
3. After the instrument ends, click "**Stop**". At this moment, the "**RXOK**" field will display the correct number of packets received.

As shown in ***Figure 3-5. Description of BLE receiving test commands***, set **Channel** to 39 (2,480MHz) and **Phy** to "Coded", and start Test RX.

Figure 3-5. Description of BLE receiving test commands

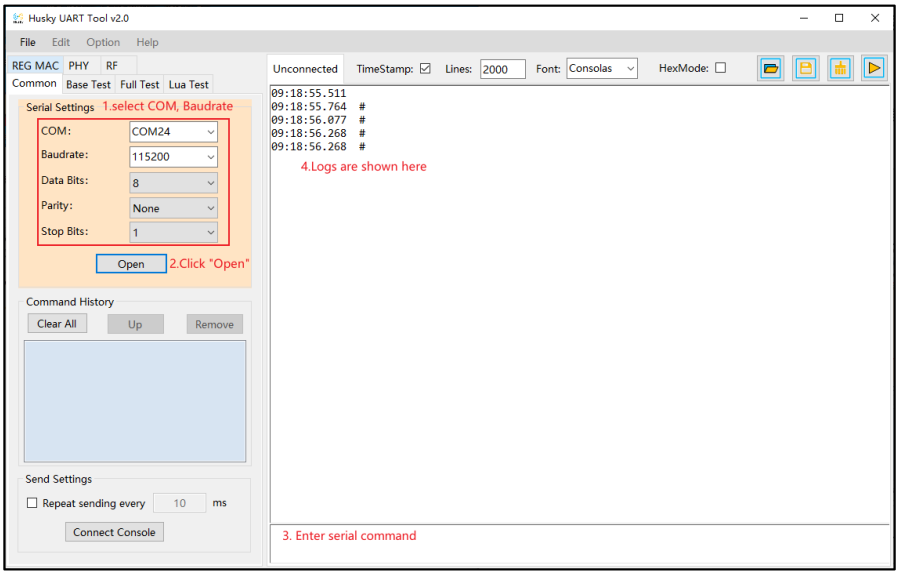
4. Non-signaling test – use serial port commands

This chapter introduces how to test RF Tx and Rx parameters in non-signaling mode with the serial port commands.

4.1. Serial port connection

1. Open the UART tool on PC (The serial port tool "**Husky Uart Tool**" provided by GD is recommended), click the drop-down menu of "**COM**", select the corresponding COM port of DUT, and the default serial port configuration is as shown in ***Figure 4-1. GD Serial Port Tool***:

Figure 4-1. GD Serial Port Tool



2. Click the button to connect the serial port. Press "**Reset**" at the side of the development board, and the serial port output box displays the log information, as shown in ***Figure 4-2. Serial port boot information***. At this moment, left-click in the serial port input box and press "**Enter**" on the keyboard, and the log displays "**#**":

Figure 4-2. Serial port boot information

```
# ALW: MBL: First print.
ALW: MBL: Boot from Image 0.
ALW: MBL: Validate Image 0 OK.
ALW: MBL: Jump to Main Image (0x0800a000).
Build date: 2024/01/08 17:08:03
This firmware is for WiFi & BLE rf test.
=== RF initialization finished ===
=== WiFi calibration done ===
BLE local addr: 76:BA:ED:21:00:5C, type 0x0
=== BLE Adapter enable complete ===
```

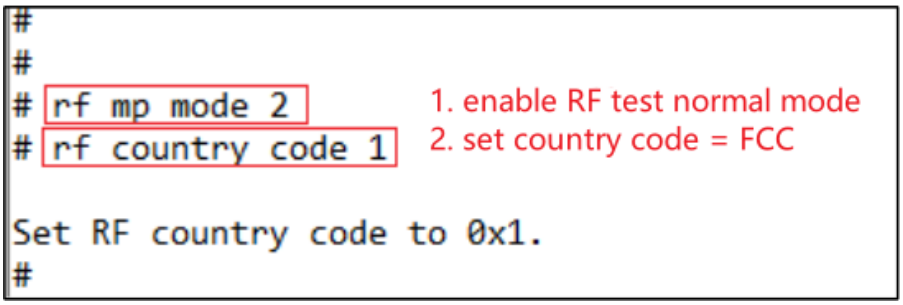
4.2. Test mode setting

- To set the RF Test Normal mode, enter the following command:
  - **rf_mp_mode 2**
- Set the certification mode:
  - **rf_country_code<code>**

Code=0/1/2/3/4 respectively represents Null/FCC/CE/TELEC/SRRC

An example is as shown in *Figure 4-3. RF test mode and country code setting*.

Figure 4-3. RF test mode and country code setting



4.3. WiFi continuous packet sending test

- To set the channel, enter the following command:
  - wifi_set_ch<channel>

  <Channel>: 20M, 1-14 (only the decimal system is supported). This may vary with different certification.
- To set **Tx Rate** and **Add Power** and start **Tx**, enter the following commands:
  - wifi_tx_cont<rate> [add power]

  <rate>: Refer to *Table 4-1. Correspondence between rate and index*.

  [add_power]: -16.0 to 16.0, range = 32 db, step = 0.25 db, for power adjustment

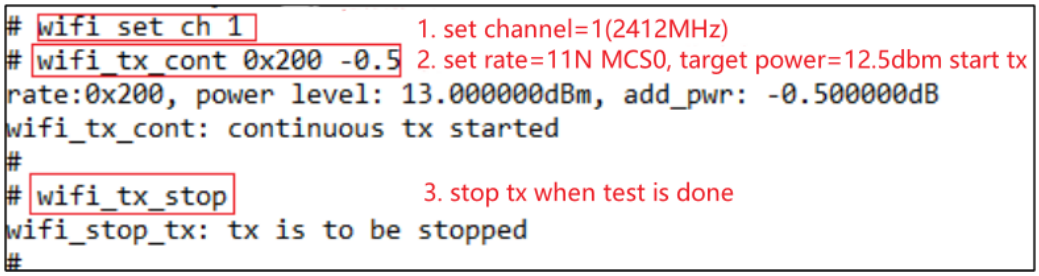
Table 4-1. Correspondence between rate and index

11B Rate	Index	11G Rate	Index	11N Rate	Index	11AX SU Rate	Index
1M	0x0	6M	0x4	MCS0	0x200	MCS0	0x500
2M	0x1	9M	0x5	MCS1	0x201	MCS1	0x501
5.5M	0x2	12M	0x6	MCS2	0x202	MCS2	0x502
11M	0x3	18M	0x7	MCS3	0x203	MCS3	0x503
		24M	0x8	MCS4	0x204	MCS4	0x504
		36M	0x9	MCS5	0x205	MCS5	0x505
		48M	0xa	MCS6	0x206	MCS6	0x506
		54M	0xb	MCS7	0x207	MCS7	0x507
						MCS8	0x508

MCS9	0x509

- To stop Tx when the test is completed or power adjustment is required, enter the following command. An example is shown in ***Figure 4-4. Description of continuous Tx test commands***.
  - **wifi_tx_stop**

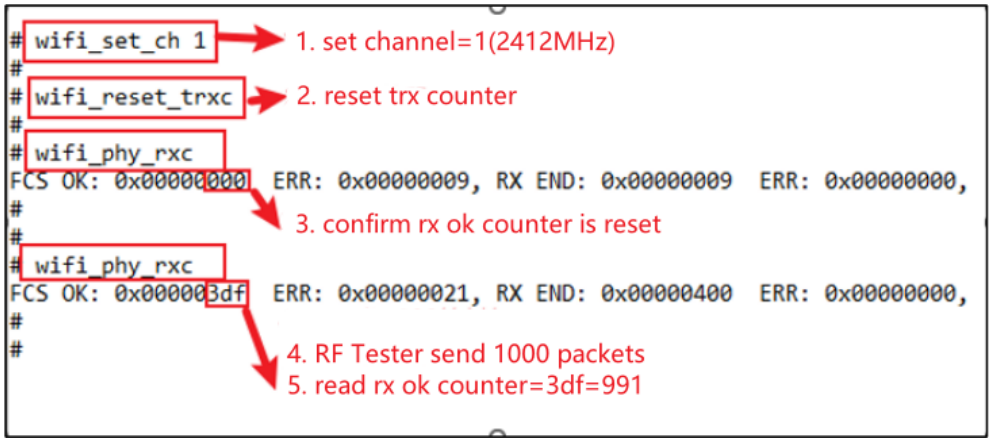
Figure 4-4. Description of continuous Tx test commands



4.4. WiFi receiving test

- Set the channel.
- Enter the following command to start the receiving test (namely clear the receiving counter).
  - **wifi_reset_trxc**
- Set the channel through the serial port and start Rx. At this moment, the instrument does not send packets. Determine whether the environment is clean through RxOK and RxErr counters. After the environment is confirmed to be clean, confirm the counters have been reset with the following command before setting the instrument to send packets, like 11G 6M, Power = -94 dbm, packet length = 1,024 bytes, number of packets = 1000.
  - **wifi_phy_rxc**
- After the instrument has sent packets, enter the command in Step 3 to obtain the number of packets received by the chip (number of RxOK and RxError packets. The reading is in hexadecimal system and needs to convert to decimal system.) and calculate the PER according to the following formula: PER = (number of packets sent by the instrument - number of RxOK packets)/ number of packets sent by the instrument.
- If retesting is required, repeat Steps 2-4. An example is as shown in ***Figure 4-5. Description of packet Rx test commands***. 0x3df = 991, PER = (1000 - 991)/1000 = 0.9%, which indicates that the test passes.

Figure 4-5. Description of packet Rx test commands



4.5. BLE continuous packet sending test

- Set parameters according to the following command and start the BLE discontinuous packet sending test
  - **ble_test_tx_infinite<channel><data length><pkt payload><phy><tx power level>**

Parameter definition

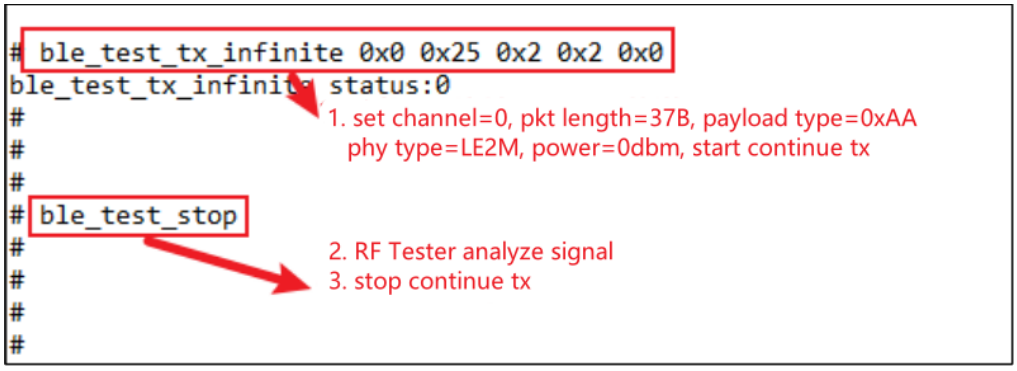
Table 4-2. Correspondence between rate and index

Name	Value and Meaning
channel	0X0 to 0x27 represents Channels 0-39
pkt length	0x0 to 0xFF represents 0B-255B
payload type	0X00/01/02/ represents PRBS9/F0F0/AAAA/.
payload type	0X01/02/03/04 represents 1M/2M/1Ms=8/1Ms=2
tx pow level	0x7E/7F represents min/max. 0X05 represents 5dbm/ 0xFF=-1dbm...

- The instrument starts to receive packets and demodulate.
- Stop BLE Tx
  - **ble_test_stop**

An example is as shown in ***Figure 4-6. Description of commands for BLE continuous packet sending test***.

Figure 4-6. Description of commands for BLE continuous packet sending test



4.6. BLE receiving test

- Set parameters according to the following command and start the BLE receiving test
  - **ble_test_rx<channel><phy>< modulation idx>**

  Usage: ble_test_rx<channel><phy><modulation idx>

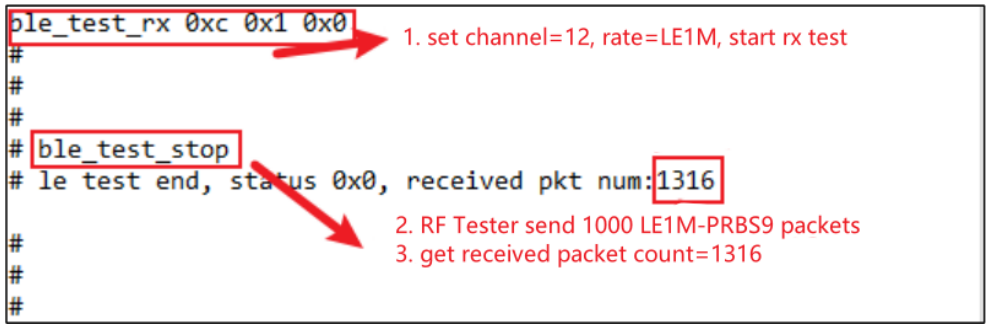
Parameter definition is shown in ***Table 4-3. CMDble_test_rx parameter description***.

Table 4-3. CMDble_test_rx parameter description

Name	Value and Meaning
channel	0X0 -27 represents Channels 0-39
phy	0X00/02/03 represents 1M/2M/ 1Mcoded
modulation idx	0X00/01 represents Standard/Stable

A specific example is as shown in ***Figure 4-7. Description of BLE receiving test commands***.

Figure 4-7. Description of BLE receiving test commands



5. Signaling test

This chapter introduces how to test "**Blocking**" and "**Adaptivity**" parameters in **signaling mode** with the serial port commands for CE certification. For the serial port connection method, Serial port connection see ***Serial port connection***.

Pay attention to the following points:

1. For WiFi, signaling test firmware should be programmed to DUT for connection with AP for test.
2. For BLE, DTM signaling test firmware should be programmed to DUT for communication with the instrument
3. For the above two tests, RF conductive connection is generally adopted for DUT and the instrument.

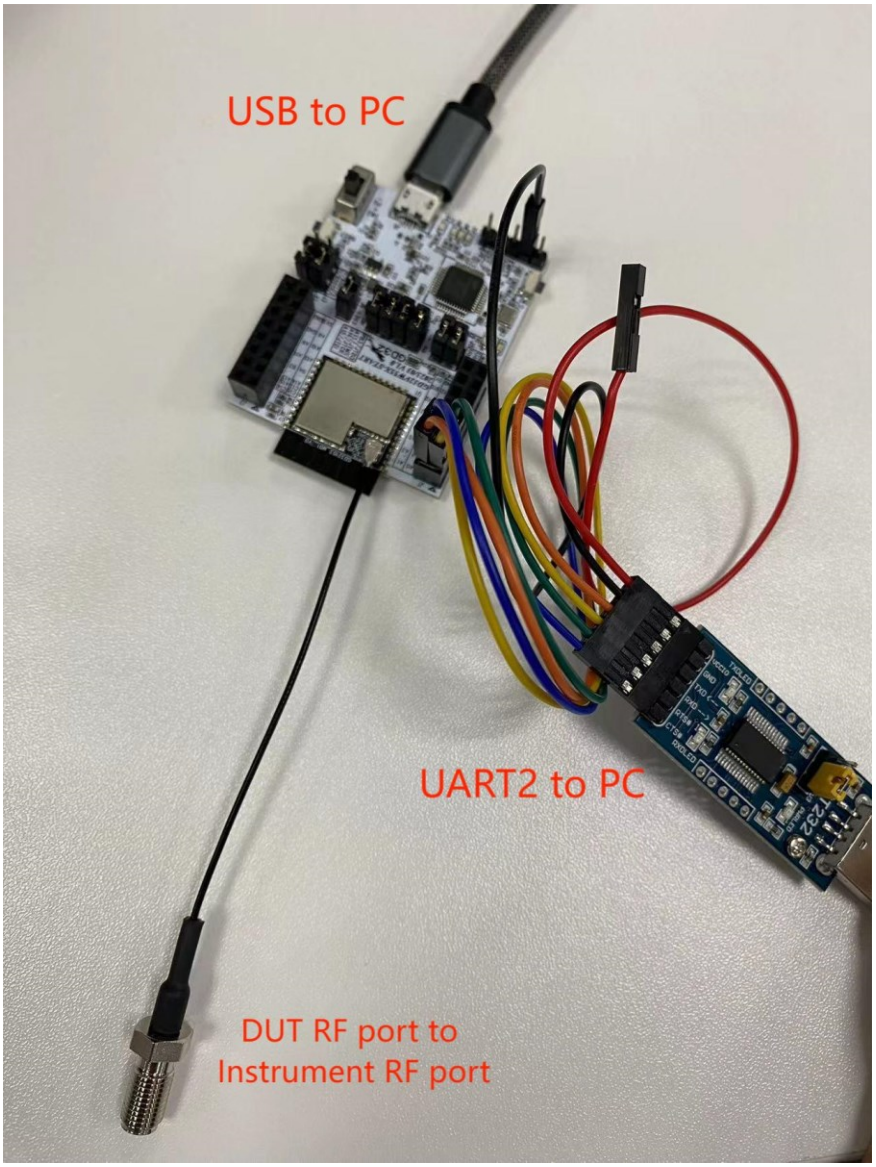
5.1. Preparations

In the "**Blocking**" and "**Adaptivity**" tests of WiFi, DUT is required to be connected to AP with the following serial port commands:

- Used to reset chips.
  - Reboot
- Used to scan AP in the environment and print information of AP on the serial port tool, like SSID and encryption methods.
  - wifi_scan
- Used to turn off the power-saving mechanism after connection to AP.
  - wifi_ps 0
- Used to connect DUT to the corresponding AP. <SSID> in the command is the SSID of the AP. [PASSWORD] is password of the AP. If encryption of the AP is open, [PASSWORD] is not required.
  - wifi_connect<SSID> [PASSWORD]
- Used to view connection details of DUT, like IP address of DUT.
  - wifi_status
- Used to set the chip and start TCP TX as described in ***Adaptivity test***. <ipaddr> parameter is IP address of server. <Port> parameter should be the same as the parameter of the command at server. <Interval> parameter is to set the log display interval. <length> is the size of sent packets over TCP in units of bytes. **For TCP test, it is recommended to use 1460.** <Time> is the data transmission time.
  - iperf3 -c <ipaddr> -l <length> -p <port> -i<interval> -t <time>

For "**Blocking**" test of BLE in DTM mode, the pins of the second serial port should be connected to the instrument through an external UART to USB board. The connection method of the second serial port is shown in ***Figure 5-1. Connection of the second serial port of DUT***.

Figure 5-1. Connection of the second serial port of DUT



The definition of the second serial port of DUT is listed in ***Table 5-1. Definition of the second serial port of DUT***.

Table 5-1. Definition of the second serial port of DUT

Pin of UART to USB board	Pin net name of DUT	Pin of DUT
GND	GND	J9.2
TXD	A1	J1.2
RXD	A0	J1.1
RTS	A2	J1.3
CTS	A3	J1.4

5.2. Blocking test

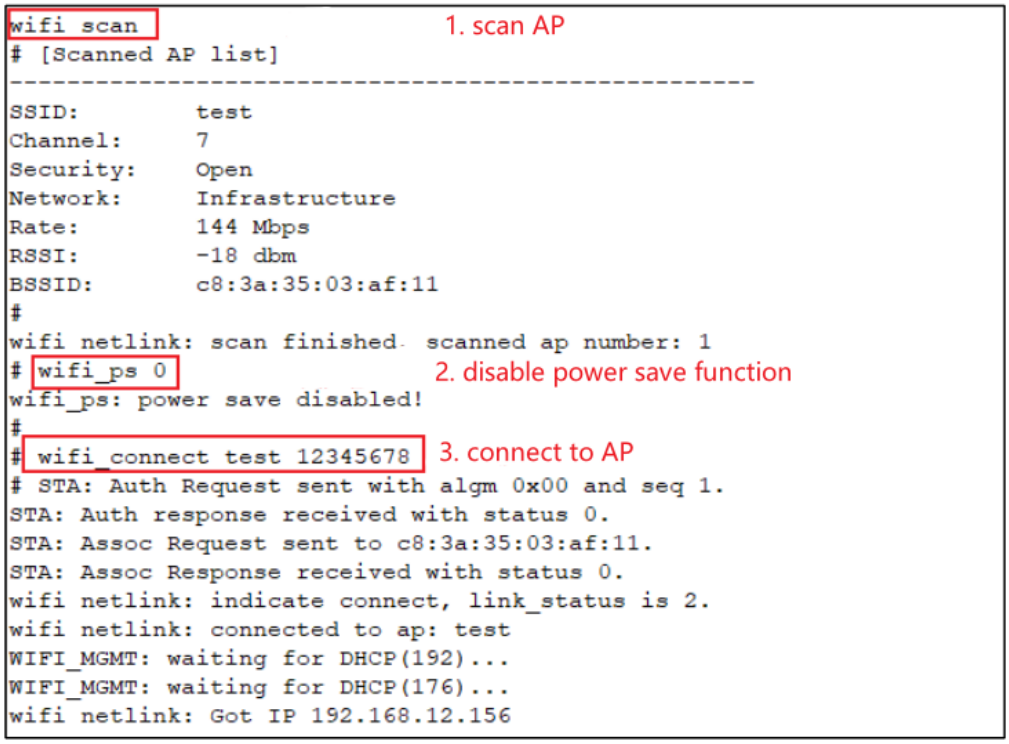
This item is one of CE certification. Certification laboratories usually use signaling tester like

CMW500.

For “Blocking” test of WiFi, the instrument is set to AP mode. After connecting DUT to the instrument, the instrument can control DUT to conduct RX test. Steps to set DUT is as follows:

- Reset the chip by entering the command at the serial port: "reboot".
- Scan AP by entering the command: "wifi_scan".
- Turn off the power-saving mechanism by entering the command: "wifi_ps 0".
- Connect to the specified AP by entering the command: "wifi_connect <SSID> [PASSWORD]".
- Confirm the connection status by entering the command: "wifi_status". The connection between DUT and AP is as shown in ***Figure 5-2. Connecting DUT to AP***.

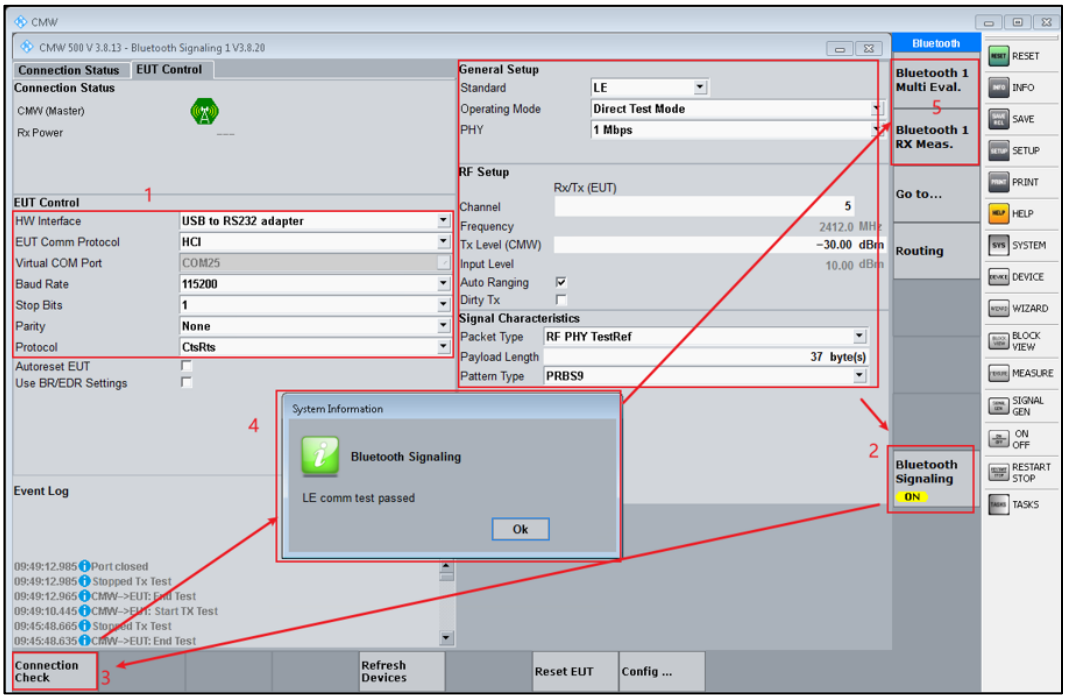
Figure 5-2. Connecting DUT to AP



For “**Blocking**” test of BLE, the steps are as follows:

- Set the instrument with reference to the options in two red boxes in ***Figure 5-3. Settings of CMW500 DTM***.
- Right-click “**Bluetooth Signaling”** in the lower right corner, and select **“On”.**
- Click “**Connection Check**" in the lower left corner.
- If “**LE comm test passed**” is displayed in the dialog box, it means successful connection. If connection failed, check whether the serial port cable of DUT is correctly connected and settings are correct in step 1.
- Click “**Multi Eval.**” or “**RX Meas.**” in the upper right corner to conduct transmitting or receiving test.

Figure 5-3. Settings of CMW500 DTM



5.3. Adaptivity test

This item is one of CE certification, which should be tested by WiFi in general. DUT needs to be connected to the AP of the certification laboratory and needs to conduct TCP TX. Test steps are as follows:

- Reset the chip at DUT by entering the command at the serial port: "reboot".
- Connect DUT to the specified AP by following the same steps as those in the previous section.
- Enter the command at the PC server in the laboratory: iperf3 -s -p yy -i 1. "yy" represents the port parameter.
- Conduct TCP TX at DUT by entering the command at the serial port: "iperf3 -c 192.168.xx.xx -l 1460 -p yy -i 1 -t 1000". "192.168.xx.xx" represents the server IP address. "yy" represents the port parameter and needs to be the same as that at the server.

DUT starts TCP TX, as shown in ***Figure 5-4. DUT TCP TX***.

Figure 5-4. DUT TCP TX

```
16:18:36.097  Iperf3: start iperf3 client!
16:18:36.100  # iperf3 client: Connecting to host 192.168.3.12, port 5002
16:18:36.149  iperf3 client: [  1] local 192.168.3.11 port 59712 connected to 192.168.3.12 port 5002
16:18:37.335  iperf3 client: [ ID] Interval           Transfer     Bandwidth
16:18:37.340  iperf3 client: [  1]   0.00-1.00   sec  2.55 MBytes  21.4 Mbits/sec
16:18:38.329  iperf3 client: [  1]   1.00-2.00   sec  2.75 MBytes  23.0 Mbits/sec
16:18:39.385  iperf3 client: [  1]   2.00-3.00   sec  2.79 MBytes  23.3 Mbits/sec
16:18:40.381  iperf3 client: [  1]   3.00-4.00   sec  2.97 MBytes  25.0 Mbits/sec
16:18:41.374  iperf3 client: [  1]   4.00-5.01   sec  3.29 MBytes  27.4 Mbits/sec
16:18:42.373  iperf3 client: [  1]   5.01-6.00   sec  2.63 MBytes  22.2 Mbits/sec
16:18:43.367  iperf3 client: [  1]   6.00-7.00   sec  2.35 MBytes  19.7 Mbits/sec
16:18:44.424  iperf3 client: [  1]   7.00-8.01   sec  2.85 MBytes  23.7 Mbits/sec
16:18:45.418  iperf3 client: [  1]   8.01-9.00   sec  3.08 MBytes  25.9 Mbits/sec
16:18:46.416  iperf3 client: [  1]   9.00-10.00  sec  3.26 MBytes  27.3 Mbits/sec
16:18:47.409  iperf3 client: [  1]  10.00-11.00  sec  3.31 MBytes  27.9 Mbits/sec
```

6. FAQ

- Q: For non-signaling tests, failure is displayed when the chip is initialized in the RF tool.
  A: Confirm whether the version of the firmware in DUT is the **RF test firmware "image-all-rf-test.bin"**. Use Husky Tool to confirm whether the serial port communication is correct, and whether the commands such as test mode setting are valid.

- Q: FCC radiated spurious emission parameter fails.
  A: Confirm whether the module shielding case is properly wielded.
  Confirm whether the country code values of the chip Efuse complies with the certification requirements. Otherwise, the default power might have a deviation.
  If harmonic fails, confirm whether the RF output matching circuit of the module has been tuned.

- Q: Low-frequency (< 1 Ghz) radiated spurious emission parameter fails.
  A: Check interference from the test environment.
  Check interference from PC, serial port, power supply base board, USB cable, and other sources.

- Q: Adaptivity parameter fails.
  A: Confirm whether the power-saving mode has been turned off in the chip.
  Adjust the attenuation added to the AP for test, which can't be too high.

7. Revision history

Table 7-1. Revision history is the version update history of this document.

Table 7-1. Revision history

Revision No.	Description	Date
1.0	Initial release	Nov.17.2023
1.1	Modify 2.2	Mar.1.2024

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