ESP RF Test Guide

Version 1.1
Espressif Systems

About This Document

This document mainly introduces to customers how to use EspRFTestTool to conduct an RF performance test.

Release Notes

Date	Version	Release Notes
2021.04	v1.0	Initial release.
2021.08	v1.1	Added instructions on ESP32-H2. Updated Section 4.3.

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1. Test Environment Diagram

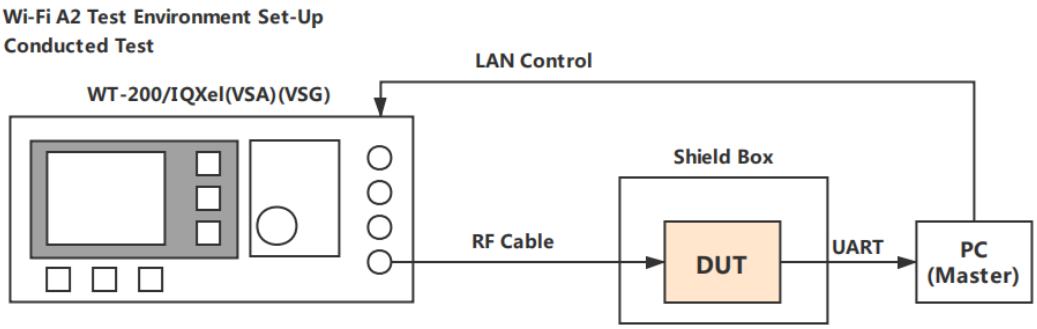

Figure 1-1. Environment Setup Diagram

- The DUT (device under test) is a hardware product based on ESP products, such as ESP32, ESP8266 and ESP32-C3.
- During testing, the PC runs EspRFTestTool and communicates with the DUT through the UART interface, by which configuration-related commands specific to different test modes are sent.
- An RF tester, such as WT-200 or IQXel, is used to test the RF performance of the DUT in different working modes.

2. Test Preparation

2.1. Hardware Connection

Table 2-1. Hardware Connection

Chip	Description
ESP8266 ESP8285	• Connect 3V3/CH_EN pins to the 3.3 V power supply • Connect RXD/TXD/GND pins to corresponding pins of a serial converter so that PC can communicate with DUT • Pull MTDO (GPIO15) low • Pull GPIO0 low to make DUT enter the downloading mode
ESP32 ESP32-S2 ESP32-S3	• Connect 3V3/CH_EN pins to the 3.3 V power supply • Connect RXD/TXD/GND pins to corresponding pins of a serial converter so that PC can communicate with DUT • Pull GPIO0 low to make DUT enter the downloading mode
ESP32-C3 ESP32-C6 ESP32-H2	• Connect 3V3/CH_EN pins to the 3.3 V power supply • Connect RXD/TXD/GND pins to corresponding pins of a serial converter so that PC can communicate with DUT • Pull GPIO9 low and GPIO8 high to make DUT enter the downloading mode
ESP-DevKitC Series	• Connect USB port to PC to start automatic downloading

2.2. Hardware Connection for Conduction Test

For modules with an I-PEX terminal, connect the RF cable to the terminal by moving the 0 ohm resistor during the conduction test.

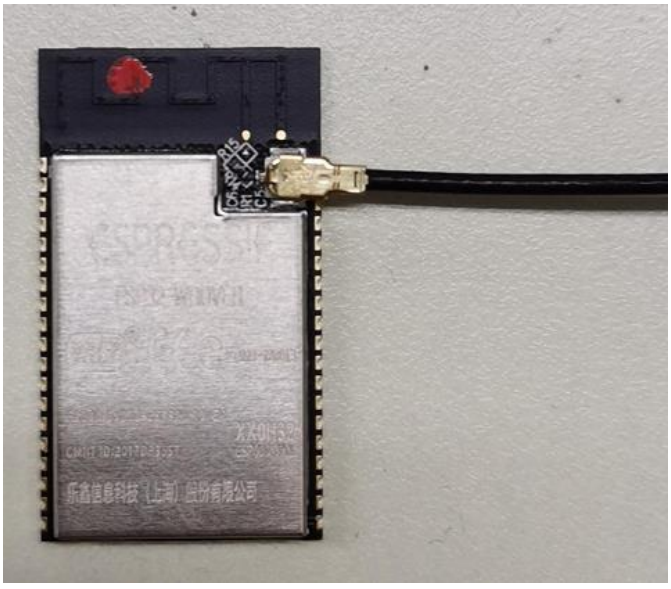

Figure 2-1. Conduction Test for IPEX Terminal

For modules with a single layer PCB on-board antenna, cut the trace to PCB antenna before soldering the RF cable to ensure the test data is accurate.

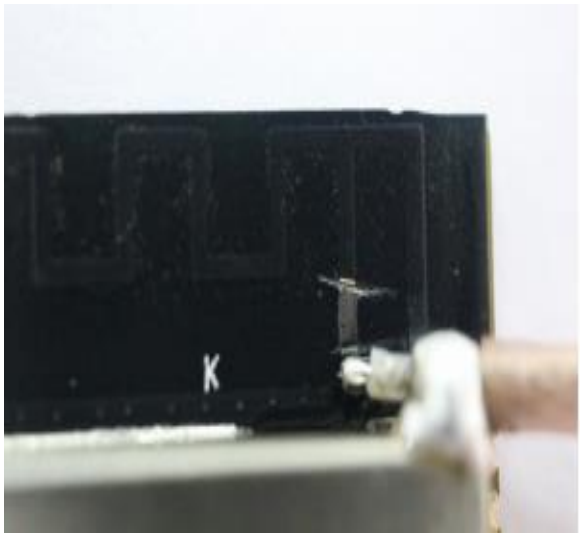

Figure 2-2. Conduction Test for PCB Onboard Antenna

2.3. Other Hardware

Table 2-2. Other Hardware

Item	Picture	Quantity	Description
ESP32/ESP8266 series of modules	Customer/ESP self-developed products	Depending on test requirements	The products that customers developed based on ESP32/ESP8266 series.
Serial Port Board		1	Serves as a USB converter that allows PC to communicate with DUT through the serial port on the board.
Micro-USB cable		1	Connects the serial port board to PC.
PC	--	1	Runs relevant software.
Wi-Fi Tester	--	1	Tests Wi-Fi performance parameters. Such as WT200/IQXel.

2.4. Software

Table 2-3. Software

Item	Description
CP210x_Windows_Drivers	USB-UART converter driver
EspRFTestTool	This tool integrates downloading and running of the test firmware, as well as sending of the configuration-related commands.

3. EspRFTestTool

3.1. Main Interface

As Figure 3-1 shows, the user interface of EspRFTestTool consists of five parts: Menu, Serial Port Configuration, Downloading Configuration, Test Configuration, and Log Information.

Figure 3-1. EspRFTestTool Main Interface

3.2. Function Overview

3.2.1. Menu

There are two menus: **Tool** and **Help**. The **Tool** Menu lists two options: **DownloadTool** and **PowerLimitTool**.

- **DownloadTool** is used to download test firmware into DUT. See *DownloadTool Instructions* for more information.
- **PowerLimitTool** is used to generate Phy Init Bins that are required for a specific or multiple mainstream certifications recognized by different countries or regions,

such as SRRC. Please refer to *ESP32-Series PowerLimitTool Instructions* for more information.

Under the **Help** Menu are **Tool Help**, **RF Test Help**, and **RF Certification Help**.

- **Tool Help**: Documentation on how to use the tools.
- **RF Test Help**: Documentation on RF Test.
- **RF Certification Help**: Documentation on certification tests.

3.2.2. Serial Port Configuration

The configuration options include chip type, COM port, baud rate, and the status of the serial port. The default baud rate for testing is 115200.

3.2.3. Download Configuration

It is used to download test firmware. See Section 4.1 for more information.

3.2.4. Test Configuration

There are four tabs: Wi-Fi Test, BT Test, Wi-Fi Adaptivity, and Manual.

- Wi-Fi Test: Wi-Fi TX or RX test. See Section 4.2 for more information.
- BT Test: Bluetooth TX or RX test. See Section 4.3 for more information.
- Wi-Fi Adaptivity: Adaptivity certification test. See Section 3.2 of *CE Certification Guide* for more information.
- Manual: Manual test.

3.2.5. Log Information

All the operating data is printed in this area as well as the module information. Customers can save or clear the log output.

4. RF Test

4.1. Download Instructions

Figure 4-1 shows the download interface of EspRFTestTool.

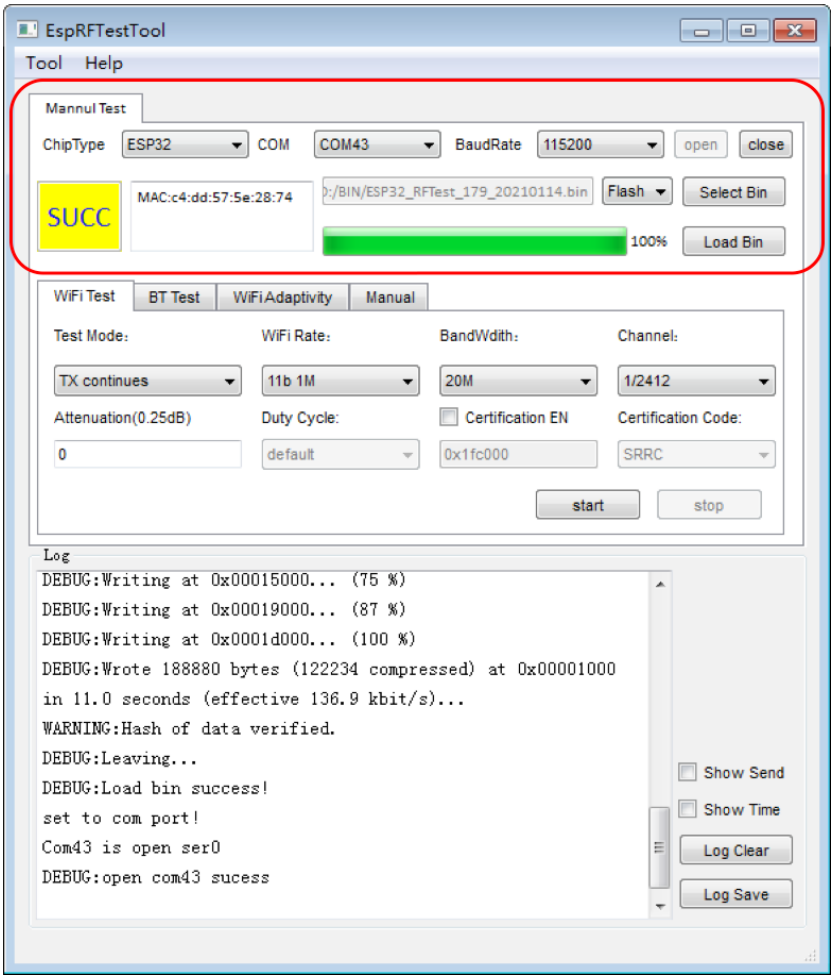

Figure 4-1. Download Configuration

4.1.1. Open EspRFTestTool

- **ChipType:** Select the corresponding chip type, such as ESP32 or ESP8266.
- **COM:** Select the corresponding COM port.
- **BaudRate:** Select the baud rate. Customers can configure it as needed while downloading firmware.
- **Serial Port Switch:** Click the **open** or **close** button to open or close the serial port.

4.1.2. Configure Firmware Download

- Download to “RAM” or “Flash”

  Click the “ RAM ” button to choose where to download firmware, either “RAM” or “Flash”. These two are different. If the bin file is downloaded to flash, you only

need to download it once. To run the downloaded file, you need to switch to Flash operation mode by floating GPIO0 and re-powering the DUT. If the bin file is downloaded to RAM, it will run immediately after the download process is completed. But the RAM program will be erased as soon as you reboot the DUT. You will have to download the bin file again.

- Select which firmware to download

  Click the "Select Bin" button to select which firmware to download from PC. Then, the name and path of the firmware will show up in the field near the button. Note that the test firmware for different chips is also different.

4.1.3. Download Status

- SYNC: The firmware is in sync.
- Load: The firmware is being downloaded.
- SUCC: The firmware has been downloaded successfully.
- Fail: The download failed.

4.1.4. Download Firmware

Load Bin: Click the **Load Bin** button to start the downloading process. When the green process bar shows 100%, and the status field displays the word "SUCC", the download is successful.

4.1.5. Log Output

After the download process is completed, float GPIO0 and re-power DUT to let it enter the normal working mode. Now you can start testing. You can use a serial tool to check whether the firmware is downloaded successfully. Figure 4-2 shows the log output of an ESP32 product after RF test firmware is downloaded into it.

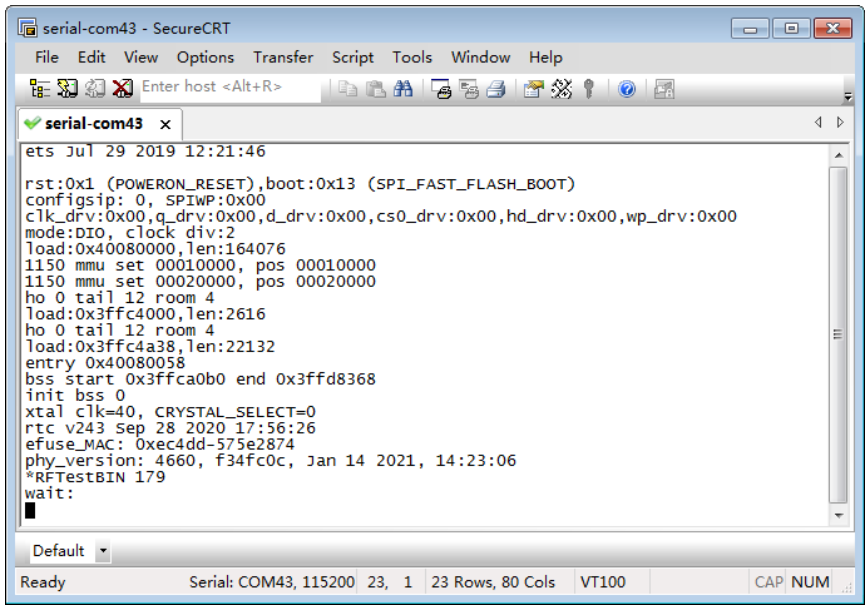

Figure 4-2. Log Information of ESP32 RF Test Firmware

4.2. Wi-Fi Performance Test

Figure 4-3 shows the Wi-Fi Test interface of EspRFTestTool.

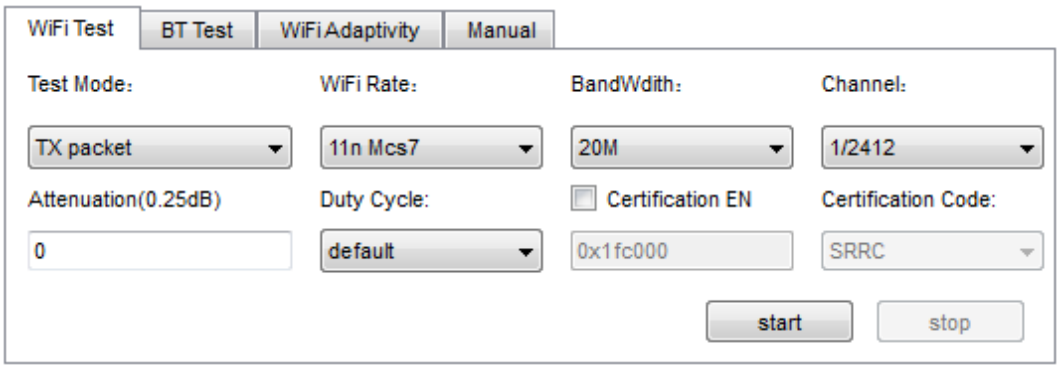

Figure 4-3. Wi-Fi Test Mode Interface

4.2.1. Wi-Fi Test

Test Mode options include:

- TX continues: Continuous TX mode, mainly used for certification tests.
- TX packet: Non-continuous TX mode, mainly used for TX performance tests.
- RX packet: RX packet mode, mainly used for RX performance tests.
- TX tone: Single carrier TX signals.

Wi-Fi Rate includes:

- RF test b/g/n packet rate.

BandWdith includes:

- 11n HT20, 20 M signal bandwidth.
- 11n HT40, 40 M signal bandwidth (applicable to ESP32 series only).

Channel:

- TX or RX channel.

Attenuation(0.25dB):

- Power attenuation.
- If power reduction is required for certifications, it can be achieved by filling in a value in the **Attenuation(0.25dB)** field. The default value is 0, which means no attenuation. 4 indicates an attenuation of 1 dB, 6 indicates 1.5 dB, 10 indicates 2.5 dB, and so on.

Duty Cycle:

- Support four configurations including 10%, 50%, 90%, and default.

Certification EN and **Certification Code**:

- Verify whether the power limit table is effective. See *ESP32-Series PowerLimitTool Instructions* for more information.

Select test parameters according to test requirements. Click **start** to start transmitting or receiving packets. Click **stop** to stop transmitting or receiving packets. Figure 4-4 shows the log information of Wi-Fi TX (left) and Wi-Fi RX (right).

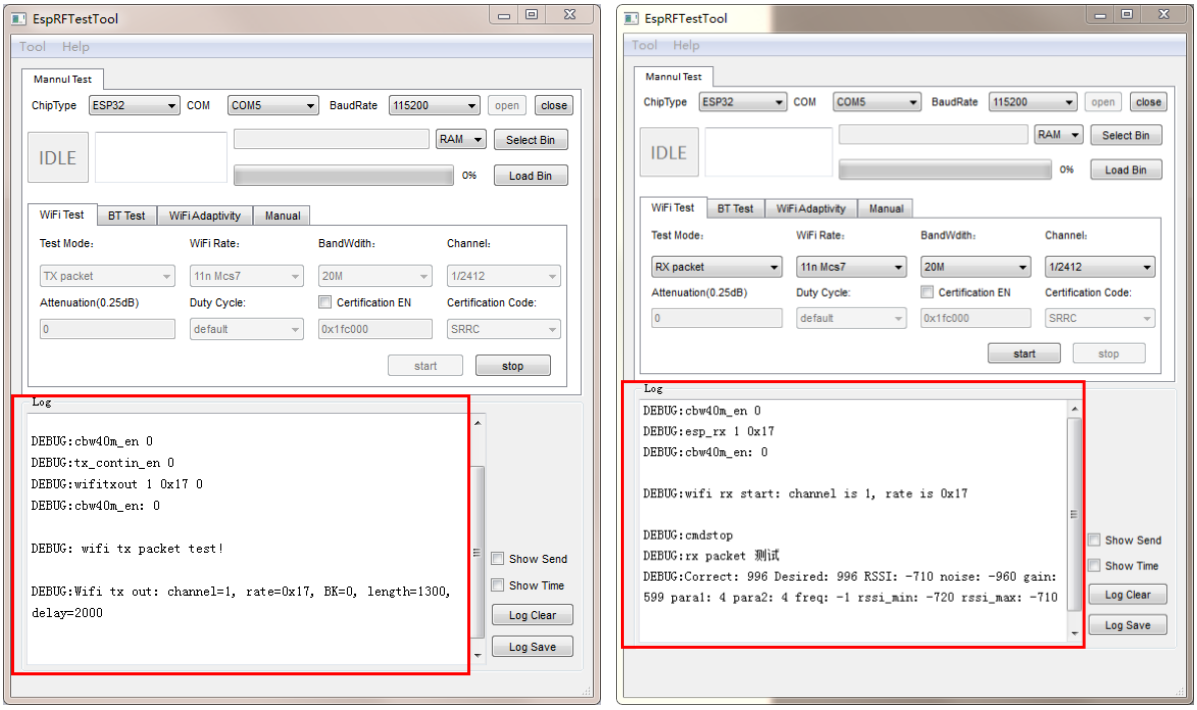

Figure 4-4. Log Information of Wi-Fi TX and RX

Wi-Fi TX log information:

- **cbw40m_en 0**: "0" means the signal bandwidth is 20 M; and "1" means 40 M.
- **wifitxout 1 0x17 0**: "1" means the channel is Channel 1. "0x17" means the test data rate is Mcs7.
- **Wifi tx out: channel=1, rate=0x17, BK=0, length=1300, delay=2000**: It means Wi-Fi TX is successful.

Wi-Fi RX log information:

When the equipment finishes receiving packets, click the "**stop**" button. The log shows as follows:

- **Correct: 996** means the total number of received packets.
- **Desired: 996** indicates the number of received packets at a specifically set data rate.
- **RSSI: -710** indicates the receiving signal strength. In this case, the signal strength is -71 dBm.

- Other log information is for developers to debug.

If you need to change test parameters while transmitting or receiving packets, click the **stop** button to stop the transmission or reception before making any changes. Then click **start** to start transmitting or receiving packets.

4.3. BT Performance Test

Figure 4-5 shows the BT Test interface. The firmware used for Bluetooth tests is the same as that for Wi-Fi tests. Click the **BT Test** tab in the Test Configuration area.

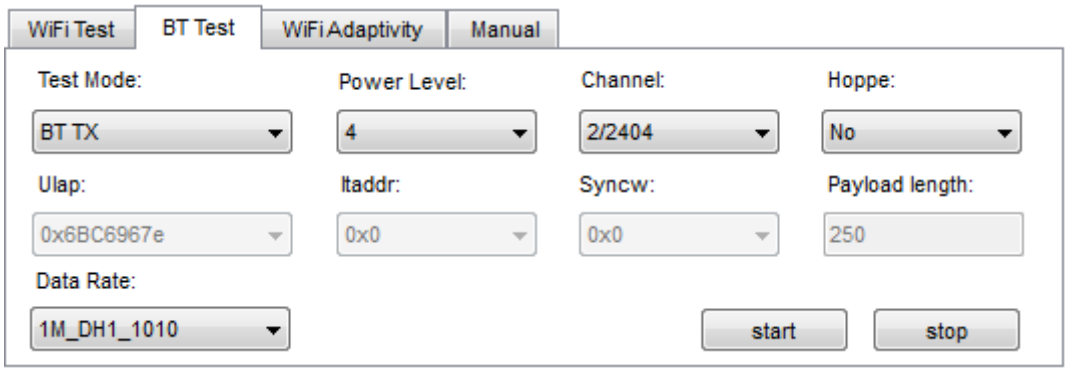

Figure 4-5. BT Test Mode Interface

4.3.1. BT Test

Test Mode options include:

- BT TX: Used for Classic Bluetooth TX tests.
- BT RX: Used for Classic Bluetooth RX tests.
- BLE TX: Used for Bluetooth LE TX tests.
- BLE RX: Used for Bluetooth LE RX tests.
- TX tone: Single carrier TX signals.

Power Level:

- TX power level.

Channel:

- TX or RX channel.

Data Rate:

- TX or RX data rate.

Other configurations can remain as default. Select test parameters according to the actual test requirements. Click **start** to start transmitting or receiving packets. Click **stop** to stop the transmission or reception. Figure 4-6 shows the log information of BT TX (left) and BT RX (right). Figure 4-7 shows the Bluetooth LE TX (left) and RX (right) log interfaces. Figure 4-8 shows the TX tone log interface.

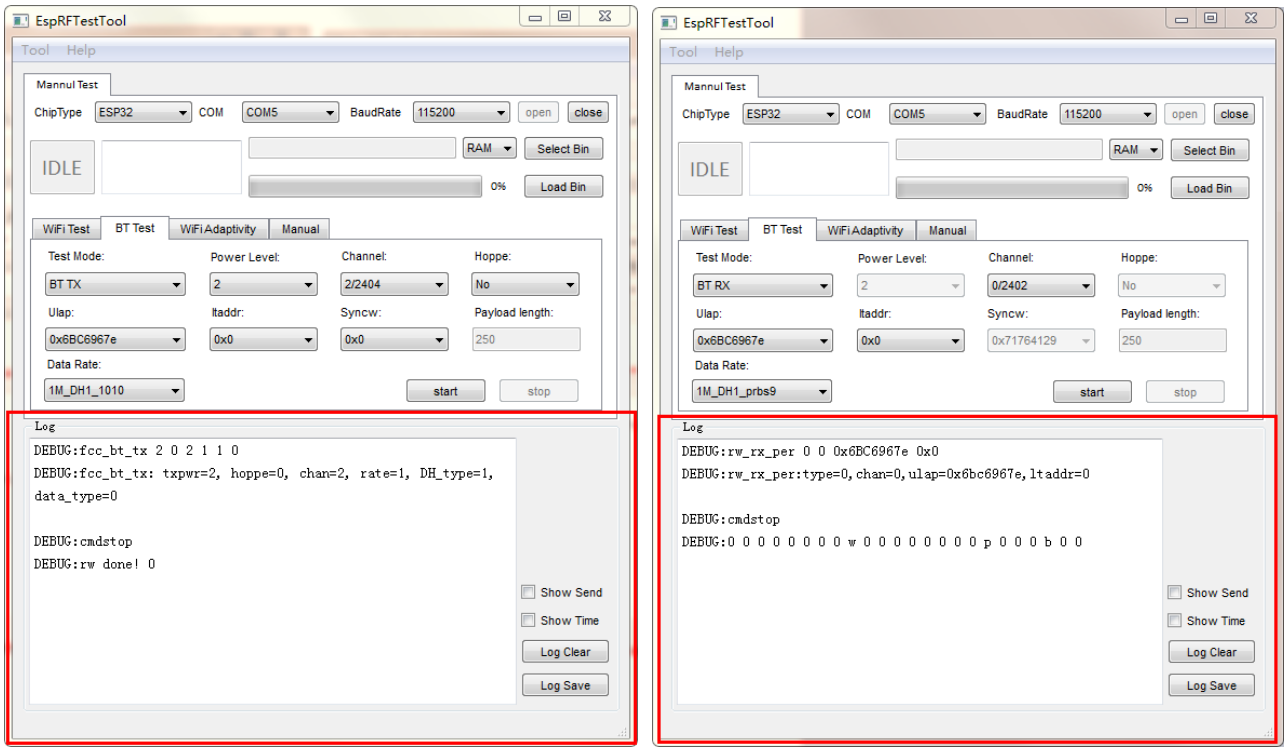

Figure 4-6. Log Information of BT TX and RX

BT TX log information:

- **fcc_bt_tx 2 0 2 1 1 0**: The BT TX test starts.
- **txpwr=2**: TX power level for the test.
- **hoppe=0**: Hopping is not supported.
- **chan=2**: TX/RX channel is Channel 2.
- **rate=1**: The test data rate is 1 M.
- **DH_type=1，data_type=0**: The packet type is DH1 and 1010.

BT RX log information:

rw_rx_per 0 0 0x6BC6967e 0x0: The BT RX test starts.

When the equipment finishes receiving packets, click the "**stop**" button. The log shows as follows:

0 0 0 0 0 0 0 0 0 0 w 0 0 0 0 0 0 0 0 0 p 0 0 0 b 0 0.

- The first parameter (based on hexadecimal system) indicates the total number of packets received this time.
- The second parameter (based on hexadecimal system) indicates the number of packets received of the corresponding speed at this time.
- The last parameter (based on hexadecimal system) indicates the number of bit errors.

- The second-to-last parameter (based on hexadecimal system) indicates the total number of the received bits at a certain data rate.

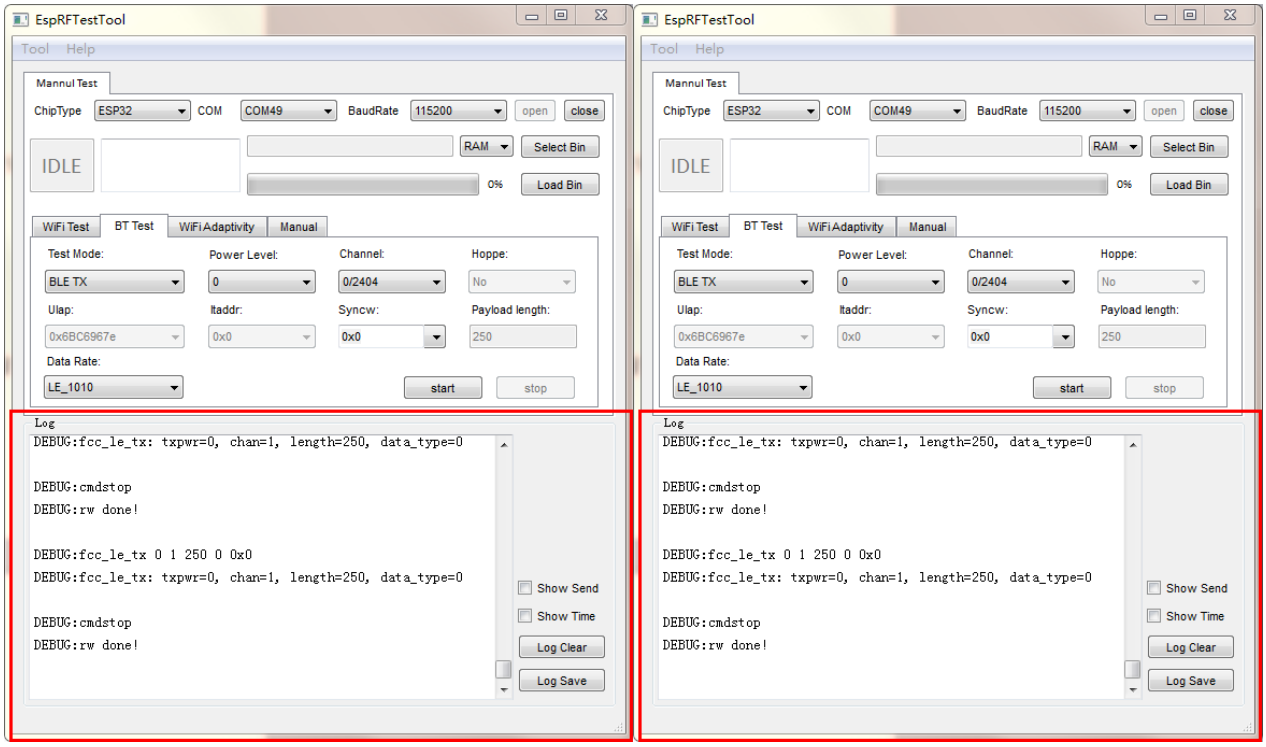

Figure 4-7. Log Information of Bluetooth LE TX and RX

Bluetooth LE TX log information:

- **fcc_le_tx 0 1 250 0 0x0**: The Bluetooth LE TX test starts.
- **txpwr=0**: TX power level for the test.
- **chan=1**: The channel is 1.
- **length=250**: payload length.
- **data_type=0**: data type. 0 means 1010; 1 means 00001111; 2 means prbs9.

Bluetooth LE RX log information:

rw_le_rx_per 0 0x0: The Bluetooth LE RX test starts.

When the equipment finishes receiving packets, click the "**stop**" button. The log shows as follows:

0 0 0 0 0 0 0 0 0 0 w 0 0 0 0 0 0 0 0 p 0 0 0

- The first parameter (based on hexadecimal system) indicates the total number of packets received this time.
- The second parameter (based on hexadecimal system) indicates the number of packets received of the corresponding speed at this time.
- The last parameter (based on hexadecimal system) indicates the number of bit errors.

- The second-to-last parameter (based on hexadecimal system) indicates the total number of the received bits at a certain data rate.

TX tone: single carrier signal

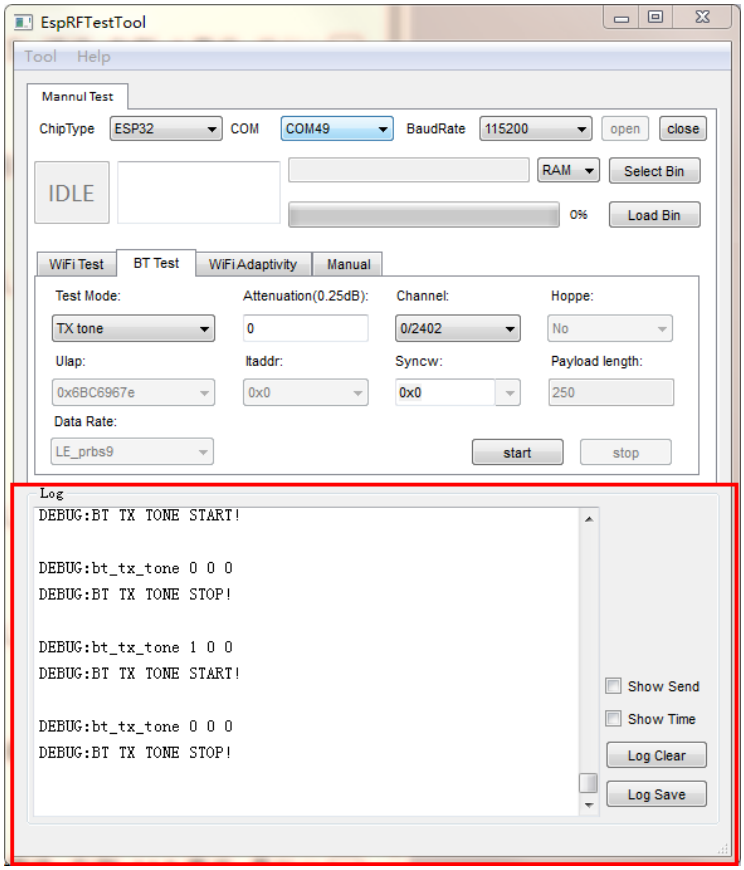

Figure 4-8. Log Information of TX tone

TX tone log information:

- **bt_tx_tone 1 0 0**: The TX tone test starts.
- The first single carrier transmits the enable signal. 1 means “transmit”, 0 means “stop transmit”.
- The second single carrier indicates the channel.
- The third single carrier indicates power attenuation. The unit is 0.25dB and 4 means an attenuation by 1dB.

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