ESP32-Series PowerLimitTool

Instructions

Version 1.0
Espressif Systems

About This Document

This document provides users with technical information about Phy Init Bin.

Release Notes

Date	Version	Release Notes
2021.04.13	V1.0	Initial release.

Documentation Change Notification

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Certification

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1. Introduction to PowerLimitTool

1.1. Tool Interface

In the main interface of EspRFTestTool, click on the Tool menu and select PowerLimitTool from the drop-down list to open it, as shown in Figure 1-1.

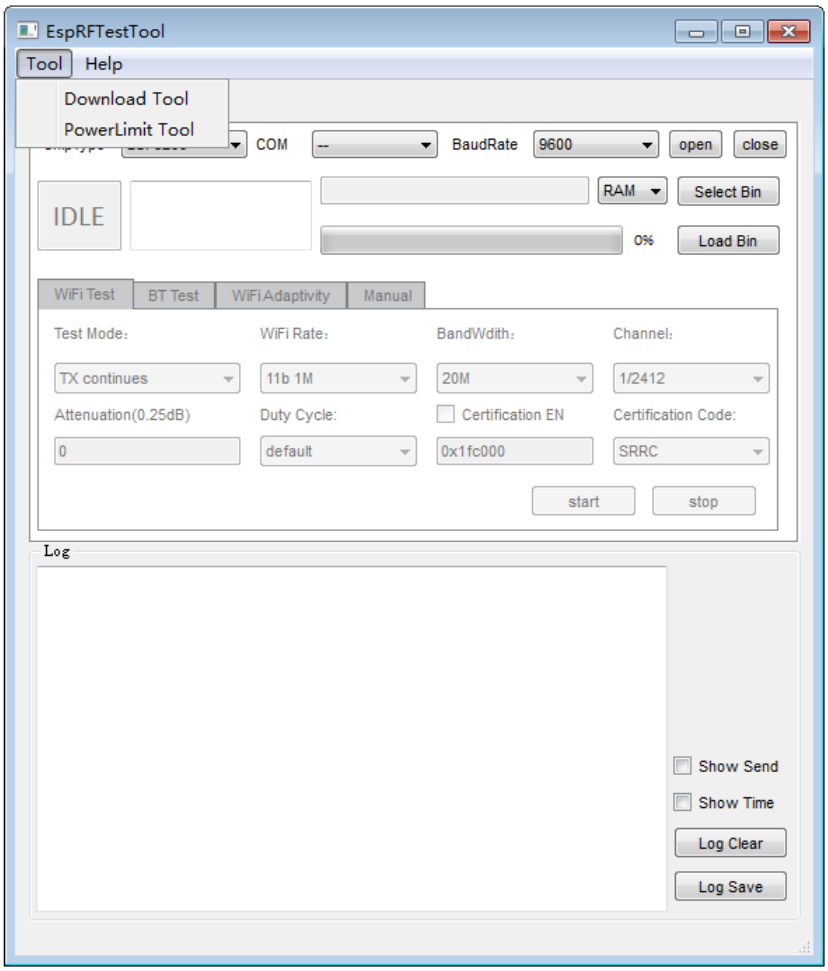

Figure 1-1. EspRFTestTool Main Interface

PowerLimitTool can generate a Phy Init Bin required for a single or multiple certifications by different countries or regions, such as SRRC, CE, and FCC, as shown in Figure 1-2.

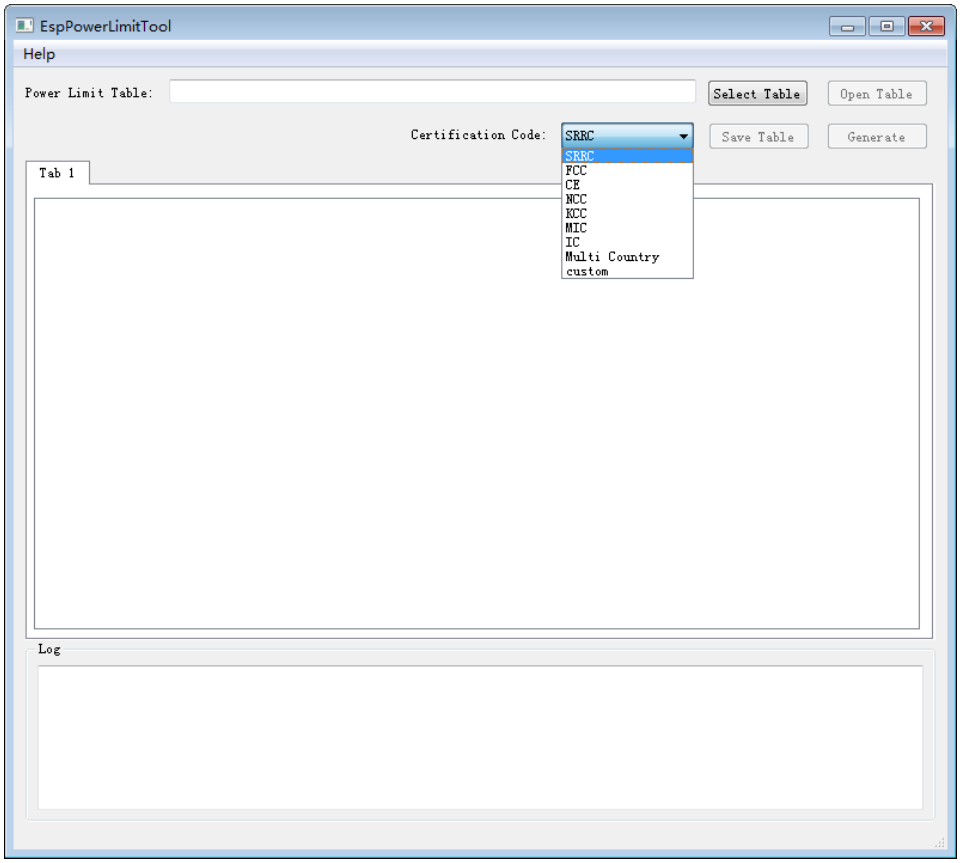

Figure 1-2. PowerLimitTool Main Interface

1.2. Power Table Configuration

To import power tables, click **Select Table**. Then in the appeared window, double-click on the TX_Power_setting.xlsx file, as shown in Figure 1-3.

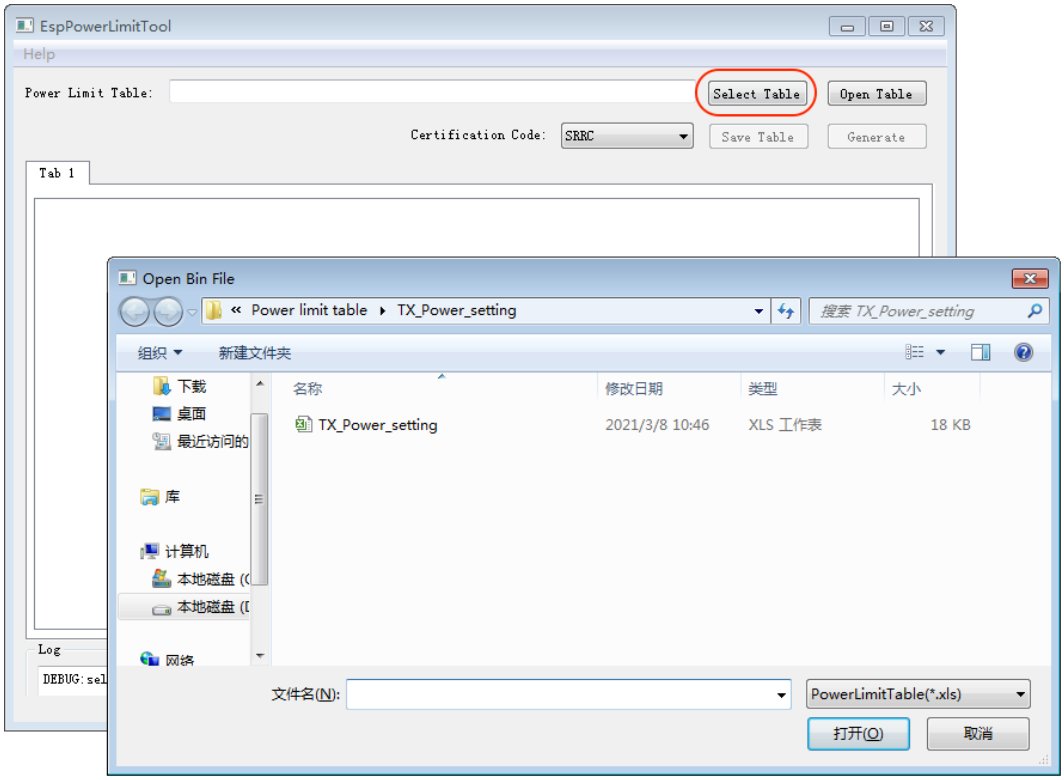

Figure 1-3. Importing TX_Power_Setting

In the main interface, click **Open Table**. The channel power tables for Actual_Result as well as seven certifications of different countries/regions are displayed in different tabs, as shown in Figure 1-4.

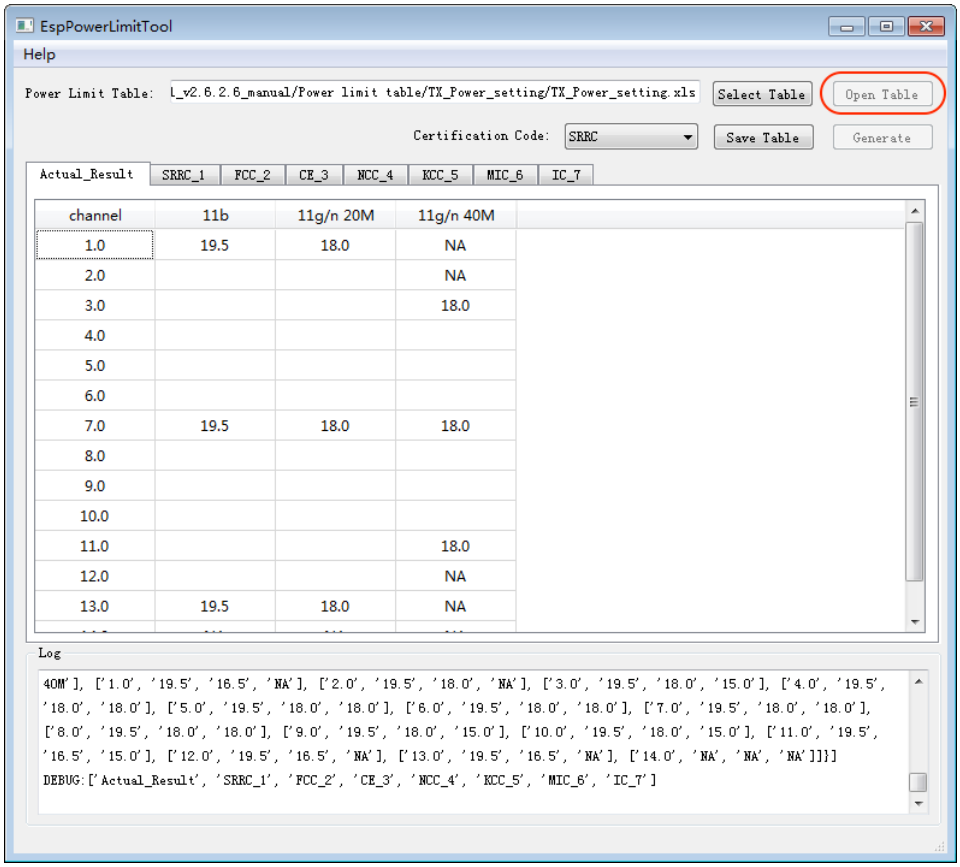

Figure 1-4. TX_Power_Setting Table

1.2.1. Power Table Description

Actual_Result: the actual test results of products, indicating the product performance. Please refer to Appendix A for more information.

SRRC_1: the certification of mainland China, focusing on the limits on power, such as PSD.

FCC_2: the US certification, focusing on the limits on harmonics and restricted bands emissions.

CE_3: the EU certification, focusing on the limits on PSD, RE, and receiver spurious emissions.

NCC_4: the certification of Taiwan, focusing on the limits on RE and receiver spurious emissions.

NCC_4: the certification of Korea, focusing on the limits on receiver spurious emissions.

MIC_6: the certification of Japan, focusing on limits on spurious emissions and PSD within certain frequency bands.

IC_7: the certification of Canada, focusing on the limits on harmonics and restricted bands emissions.

1.2.2. Fill in Power Values

Actual_Result:

It is recommended to test the average power at the lowest data rate for all channels under the 11b, g, n20, and n40 modes. Then, fill in the power table. If power values between channels are too close, you can only test three channels, the high, medium, and low channel, at the corresponding rate. The average values of the three channels will be used to calculate the power of other channels.

Certification Power Tables:

Certifications tests will test out the maximum power values of three channels (high, medium, and low channels) in each mode that can meet the requirement of certifications. You should record the corresponding attenuation values. The actual power values that you should fill in the certification power table equal Actual_Result minus the attenuation value of the corresponding channel.

Note:

- Certification tests only test three channels, but all the specified channels in certification power tables need a power value. So, the power of the high and low channel are calculated according to their own attenuation values, while the power of other channels are all calculated according to the attenuation value of the medium channel in the certification report.
- Certification tests are generally conducted in the Tx Continue mode, while actual power (Actual_Result) tests of modules are done in the Tx Packet mode.
- The attenuation value in the certification report is expressed in the unit of 1/4 dB and needs converting to the unit of dB before the calculation of power values. For example, an attenuation of 4 represents 1dB.

1.3. Generate Phy Init Bin File

After filling out the certification power values, click **Save Table** to save the power configuration, and select the corresponding certification in the **Certification Code** drop-down list, as shown in Figure 1-5. Then, click **Generate** to generate the corresponding Phy Init Bin file in the specified folder, as Figure 1-6 shows.

The Phy Init bin file contains the power values of all channels that meet the certification requirements. It can be used for RF testing and practical applications, as detailed in the next chapter.

Note:

The drop-down list of Certification Code includes options for a single certification, Multiple Country and Custom. Selecting a single certification will generate a single Phy Init Bin file for this certification, which contains a total of 128 bytes except parity and control bits; Selecting Multiple Country will generate Combined Phy Init Bin files, including a Default bin file and seven others for SRRC, FCC, CE, NCC, KCC, MIC, and IC. The combined files contain 8 x 128 bytes; Selecting Custom will generate a single or multiple certification bin files depending on your choice.

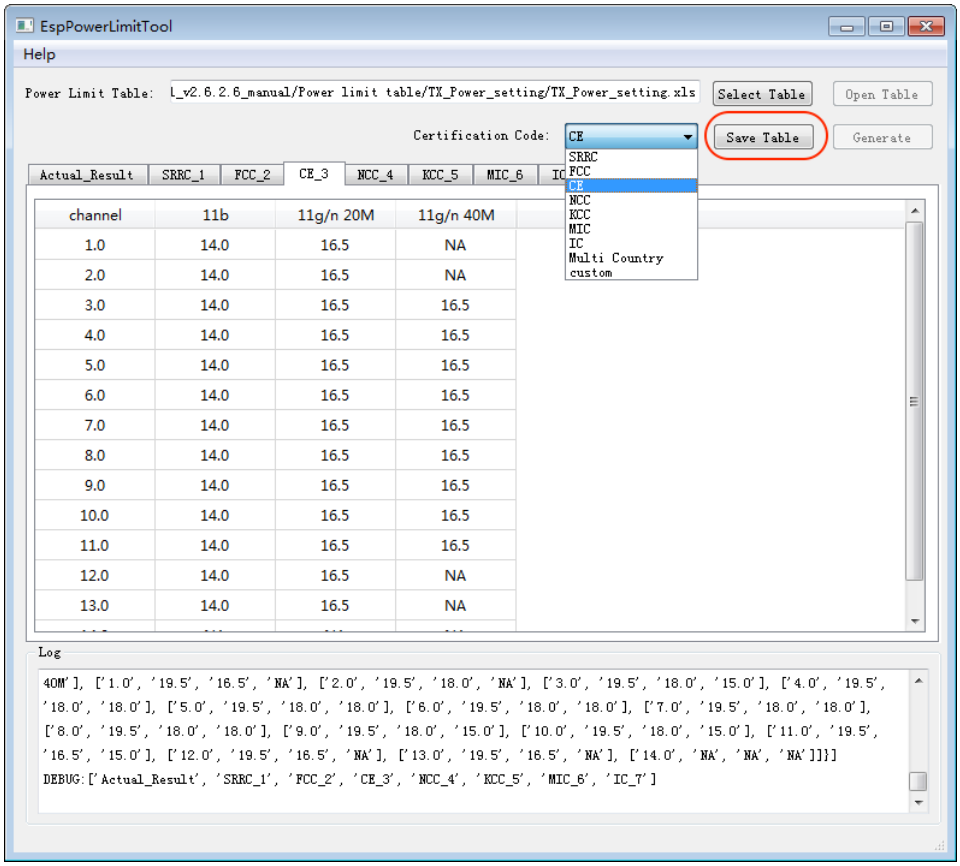

Figure 1-5. Selecting Certifications

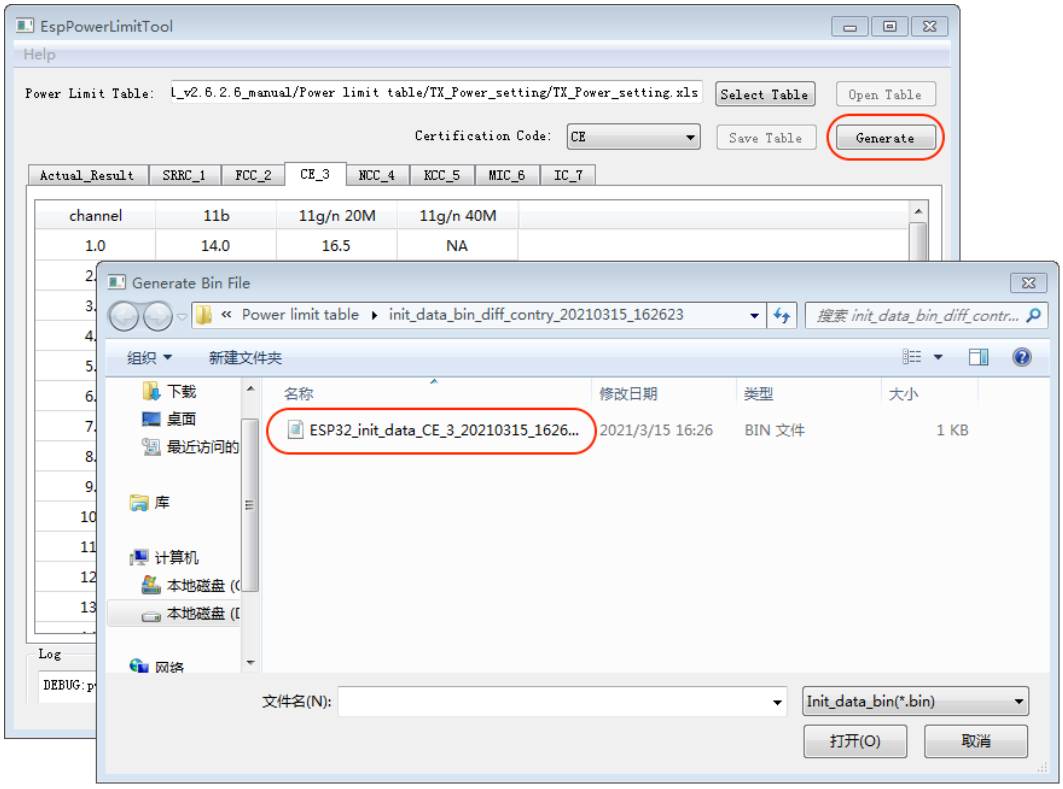

Figure 1-6. Generating Phy Init Bin Files for Certifications

1.4. Example

1.4.1. A Single Certification: CE

1.4.1.1. Fill in Actual_Result

Test the actual average output power of a module in the Tx Packet mode. For more information on RF non-signaling tests, please refer to 2.2.

In this example, only three channels (high, medium, low) are tested because power values between channels are quite close.

- Tested under the 11b mode at the data rate of 1 Mbps, the power values for the low, medium and high channels are 19.5 dBm, 19.2 dBm, and 19 dBm respectively;
- Tested under the 11g/11n-20M modes at 6 Mbps and MCS0 respectively, the largest three power values of these channels are 17.5 dBm, 17.3 dBm, and 17dBm respectively;
- Tested under the 11n-40M mode at MSC0, the power values of the three channels are 17.2 dBm, 17 dBm, and 16.8 dBm, as shown in Figure 1-7.

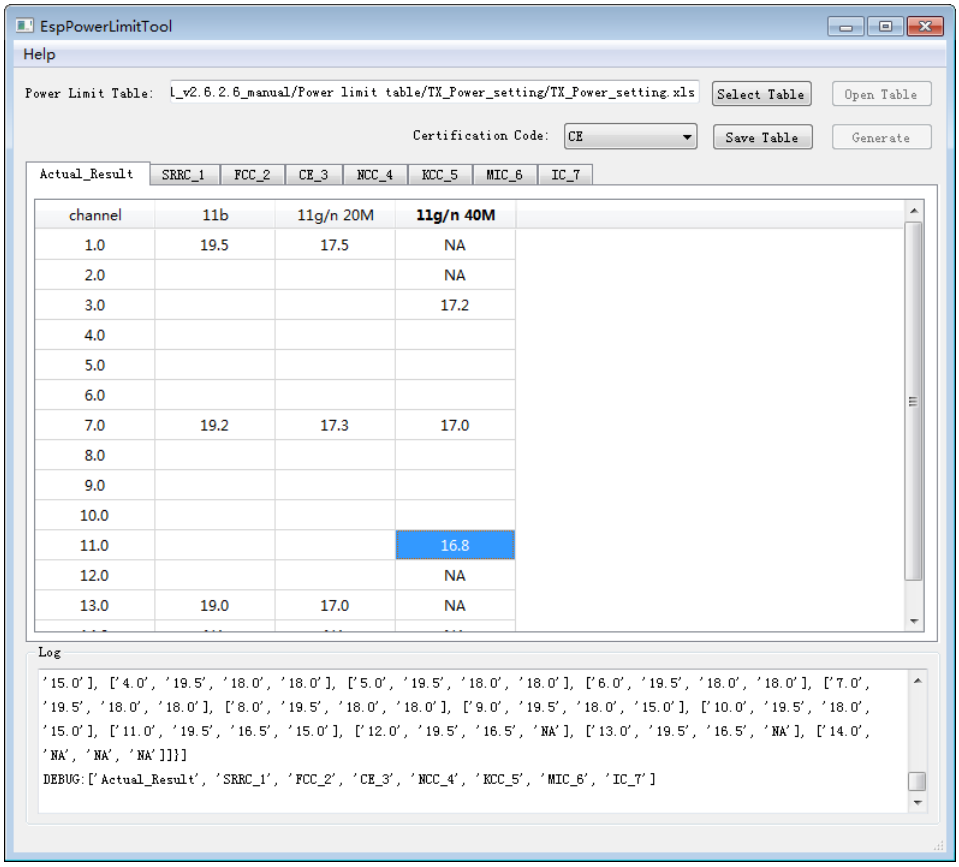

Figure 1-7. Filling in Power Tables

1.4.1.2. Calculate Attenuation Values

According to the certification test report or laboratory validation, record the maximum power of the module that can meet the CE certification requirements and corresponding attenuation values somewhere such as the **Attenuation** column in the table below. Then convert it to the actual value in dB and record in the **Attenuation*0.25 (dB)** column. In general, only three channels (high, medium, low) are used for certification tests, so the high and low channels will use the actual tested attenuation values, and the rest channels will use that of the medium channel.

In this example, the channel power attenuation values that meet the certification requirements are as follows:

In 11b mode, the highest power occurs at the data rate of 1 Mbps. In 11g mode, 6 Mbps. In 11n-20M, MCS0. In 11n-40M, MCS0. For 11g and 11n-20M modes, the higher power values are adopted as the power of channels.

Table 1-1. Actual_Result and CE Certification Power Values

Mode	Data Rate	Channel	Attenuation	Attenuation *0.25 (dB)	Actual_Result (dBm)	Power Table (dBm)
802.11b	1 Mbps	2412	12	3	19.5	16.5
		2437	12	3	19.2	16.2
		2472	10	2.5	19	16.5
802.11b	11 Mbps	2412	10	2.5		
		2437	10	2.5		
		2472	10	2.5		
802.11g	6 Mbps	2412	8	2	17.5	15.5
		2437	8	2	17.3	15.3
		2472	6	1.5		
802.11g	54 Mbps	2412	0	0		
		2437	0	0		
		2472	0	0		
802.11n-HT20	MCS0	2412	8	2		
		2437	6	1.5		
		2472	8	2	17	15
802.11n-HT20	MCS7	2412	0	0		
		2437	0	0		
		2472	0	0		
802.11n-HT40	MCS0	2422	16	4	17.2	13.2
		2437	16	4	17	13
		2462	16	4	16.8	12.8
802.11n-HT40	MCS7	2422	0	0		
		2437	0	0		

Mode	Data Rate	Channel	Attenuation	Attenuation *0.25 (dB)	Actual_Result (dBm)	Power Table (dBm)
		2462	0	0		

1.4.1.3. Fill in the CE Power Table

The power values to be filled in the CE Power Table = Actual_Result - Attenuation

- For the CE certification, the power values in 11b mode are 16.5 dBm (low channel), 16.2 dBm (medium channel), and 16.5 dBm (high channel).
- The power values in 11g/n20 modes are 15.5 dBm, 15.3 dBm, and 15 dBm, calculated based on the higher attenuation value of 6 Mbps and MCS0.
- The power values in 11n40M mode are 13.2 dBm, 13 dBm, and 12.8 dBm.

Fill in the Power Table in the CE tab. Fill all the channels (except the first and last) with the power values of the medium channel, as shown in Figure 1-8.

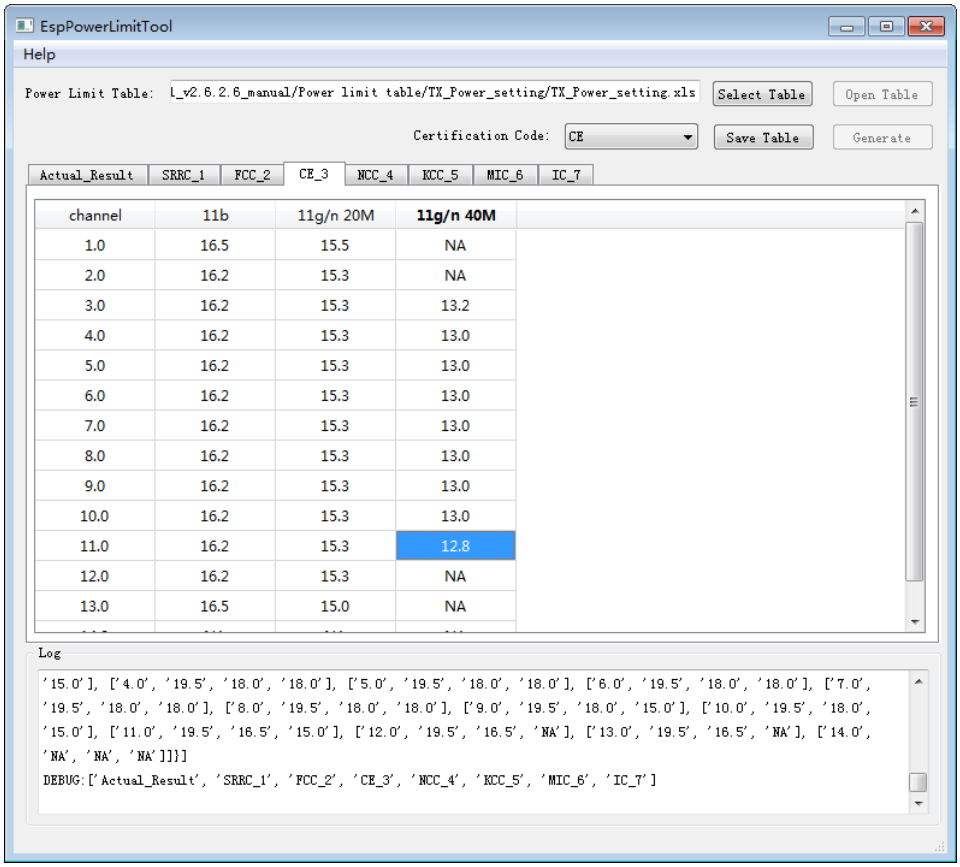

Figure 1-8. Filling in Power Values for CE Certification

1.4.1.4. Generate CE Phy Init Bin

Select **CE** from the Certification drop-down list, and click **Save Table** to save all changes, as shown in Figure 1-9.

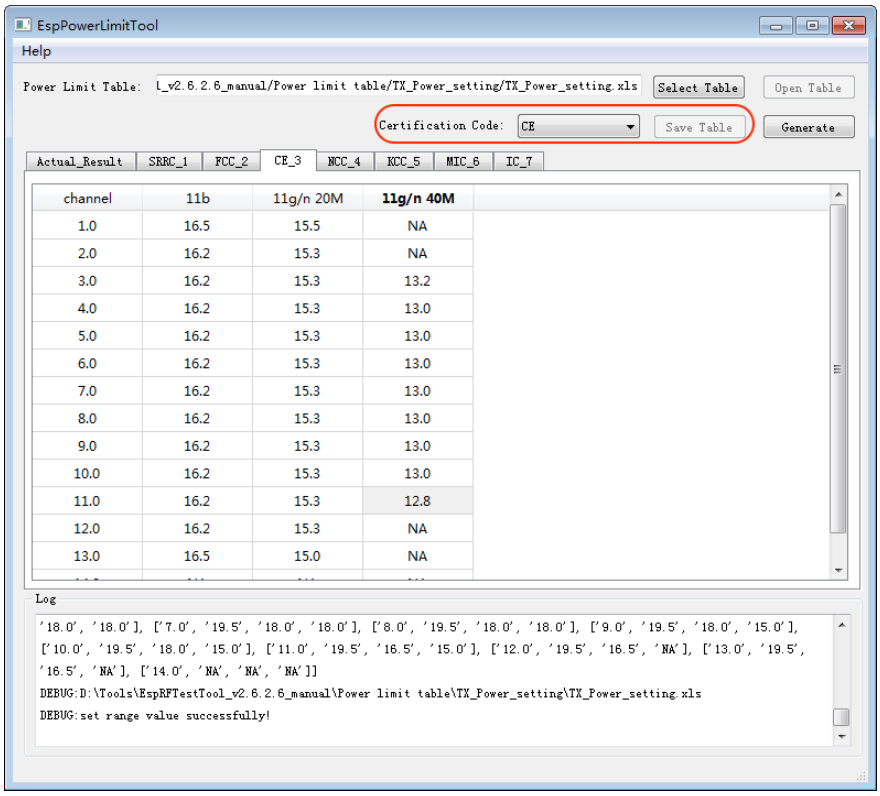

Figure 1-9. Selecting CE Certification and Saving Table

Click **Generate** to generate an CE phy init bin file with CRC checks, as shown in Figure 1-10.

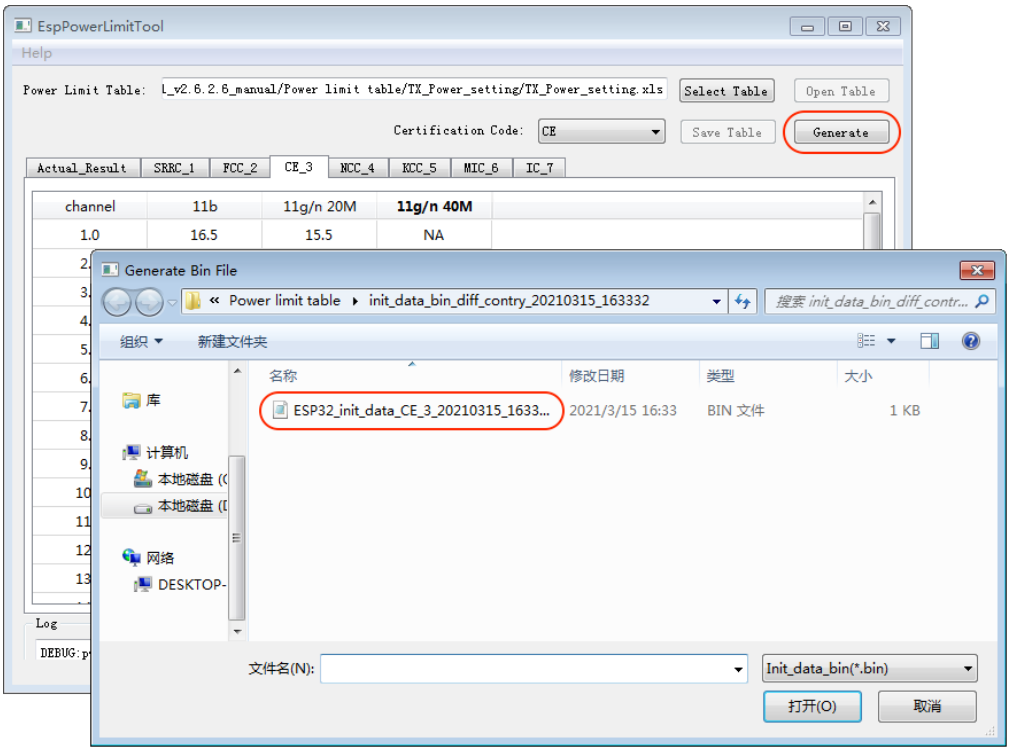

Figure 1-10. Generating CE Phy Init Bin File

1.4.2. Multiple Certifications

The power testing processes for Actual_Result and each certification are similar to those of the single certification of CE. After the tests, calculate the power values and fill in the power table. Select **Multi Country** from the **Certification Code** drop-down list, and click **Save Table** to save all changes, as shown in Figure 1-11.

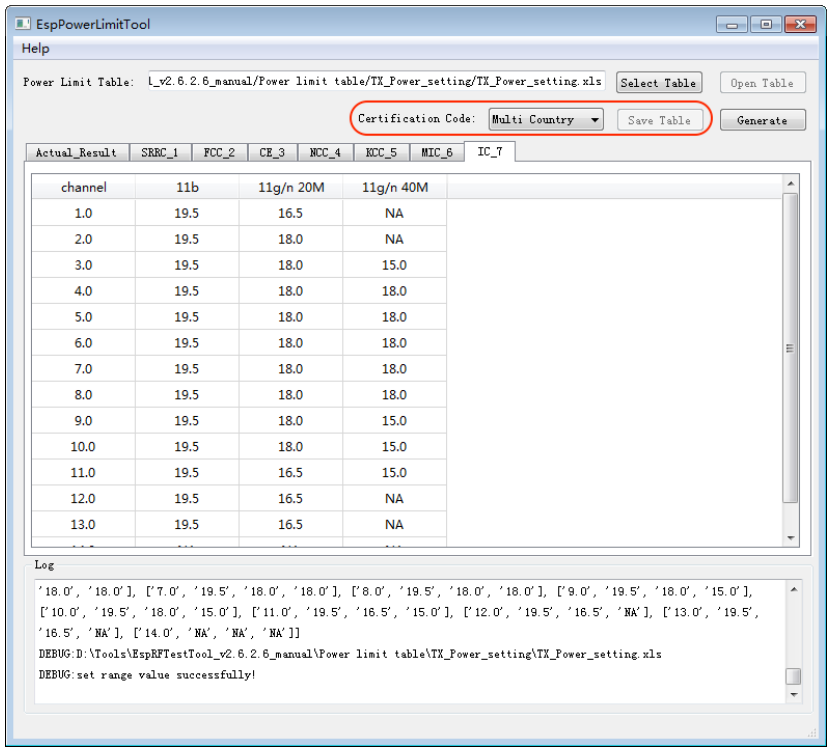

Figure 1-11. Selecting Multiple Country and Saving Table

Click **Generate** to generate Combined files, as shown in Figure 1-12.

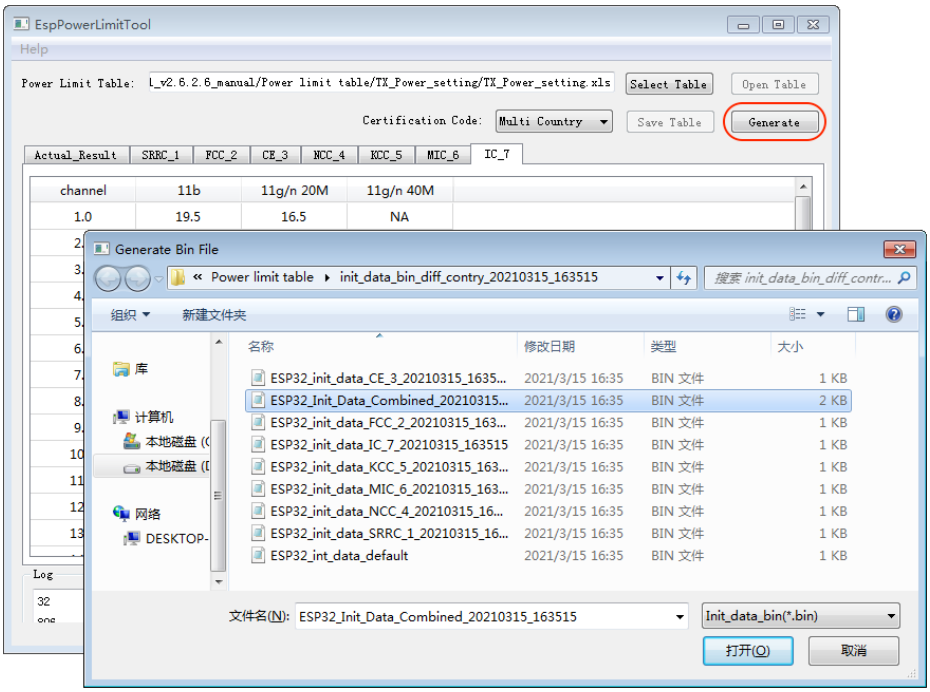

Figure 1-12. Generating Combined Phy Init Bin File

2. Download and RF Test

2.1. Download the Phy Init Bin

Select **DownloadTool** from the **Tool** drop-down list to enter the DownloadTool interface, as shown in Figure 2-1. and 2-2.

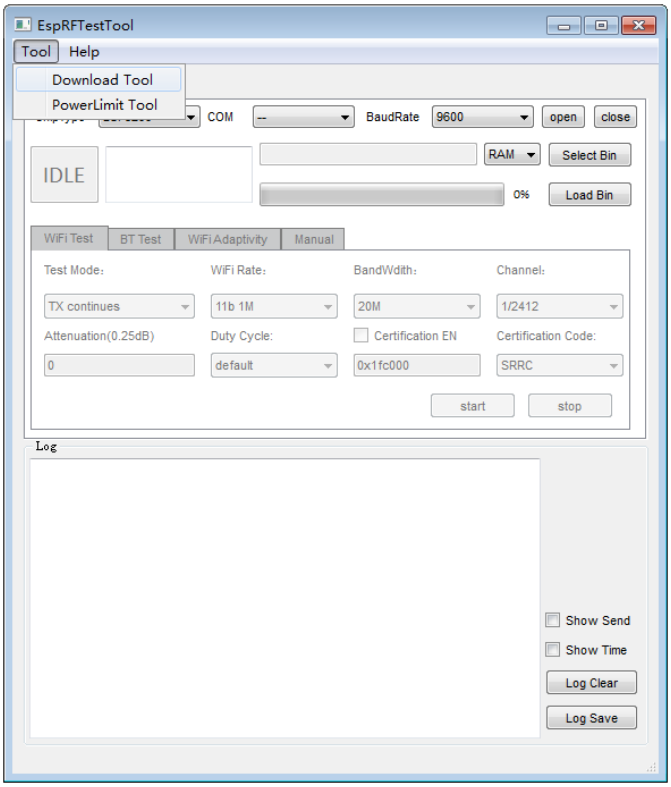

Figure 2-1. ESPRFTestTool Main Interface

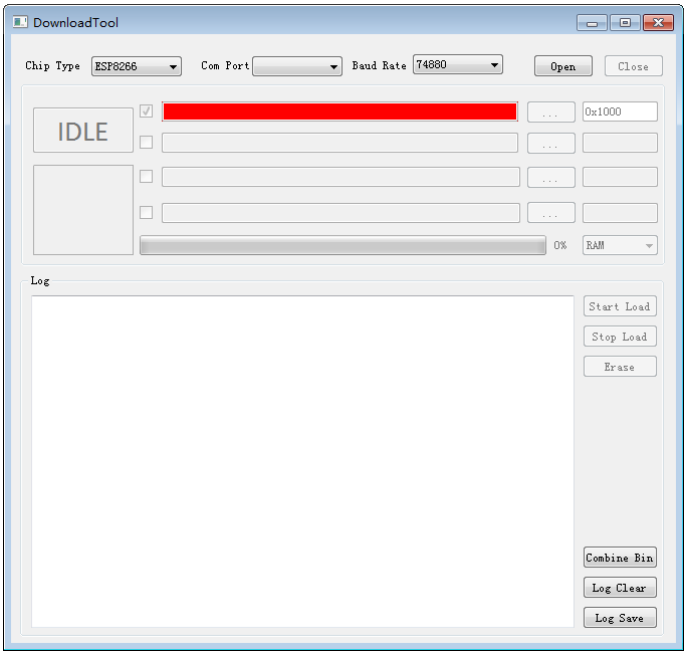

Figure 2-2. DownloadTool Main Interface

Downloading Steps, as shown in Figure 2-3:

- Select the corresponding **ChipType**, **Com**, **BaudRate**, and click **Open** to open the serial port.
- Pull Boot low to let the module enter the downloading mode.
- Select where to download the bin: **Flash**.
- Select the Phy Init bin and enter the address: 0x1fc000.
- Select the RF test firmware and set the corresponding address: 0x1000.
- Click **Start Load** to start downloading. SUCC will appear if the downloading was successful.
- Click **Close** to close the serial port and exit DownloadTool.

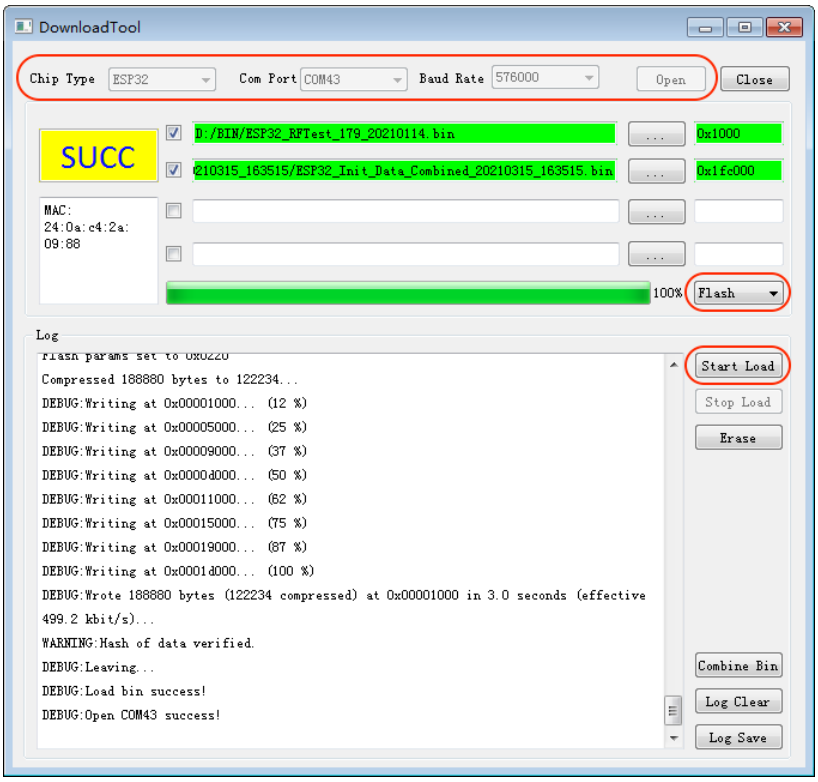

Figure 2-3. Downloading Phy Init Bin File

Note:

- The boot pin is GPIO0 for ESP32 and ESP32-S2, and GPIO9 for ESP32-C3.
- The DownloadTool is flashed into RAM by default. If you want to specify a downloading address, select Flash instead of RAM.
- The downloading address of Phy Init Bin can be changed. If changed, you need keep it consistent in the subsequent RF testing.
- It is recommended to download the Phy Init Bins of Multiple Country to 0x1fc000, the same address as a single certification.

2.2. RF Test with Phy Init Bin

The RF test can test out the output power with a Wi-Fi tester and check whether Phy Init is working.

Testing steps, as shown in Figure 2-4:

- In the **Manual Test** tab, select the corresponding **Chip Type**, **Com**, **BaudRate**, and click **Open** to open the serial port.
- Open the **WiFi Test** tab, and select **Test Mode**, **Rate**、**BandWidth** and **Channel**.
- Set **Attenuation** to 0, and **Duty Cycle** to 10%;
- With **Certification EN** unchecked, i.e., Phy init not enabled, the tool tests the initial performance of modules.
- With **Certification EN** checked, i.e., Phy init enabled, the tool tests the performance for certification.
- The address should be where the Phy Init Bin is actually downloaded. If you downloaded it to another address instead of 0x1fc000, keep it consistent here.
- For Multiple Country certifications, select one of them from the drop-down list of **Certification Code**.

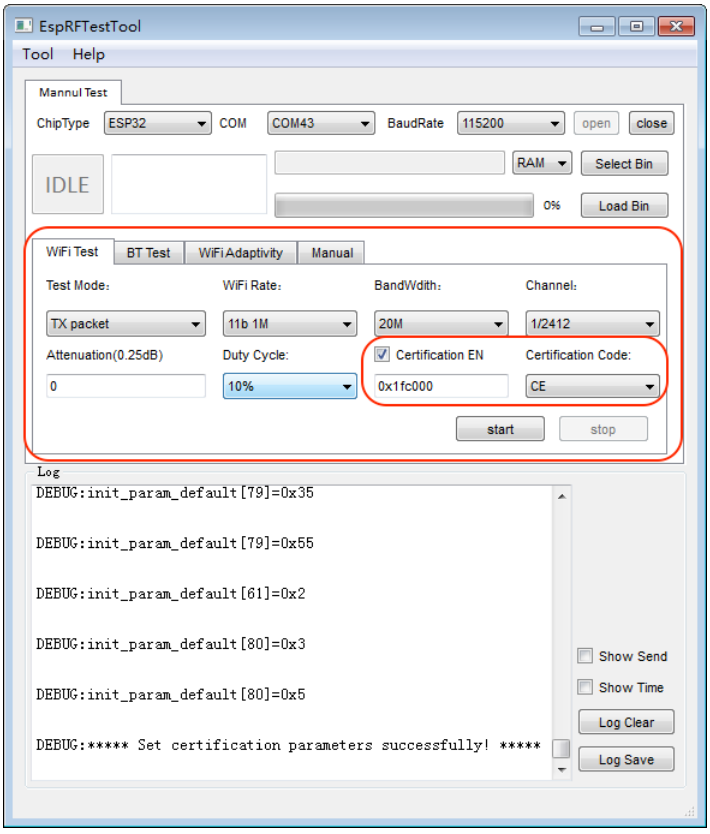

Figure 2-4. RF Test Configuration

Note:

Phy Init Bin files are applicable to product application firmware.

Appendix A. Typical Average Output Power of ESP32 Series

See the table below for the typical average output power of ESP32 series

Table A-1. ESP32 Series Target TX Power

Rates	ESP32 (dBm)	ESP32-S2 (dBm)	ESP32-C3 (dBm)
11b 1 Mbps	19.5	19.5	20.5
11b 11 Mbps	19.5	19.5	20.5
11g 6 Mbps	18	18	20
11g 54 Mbps	14	15	18
11n-20 MCS0	18	18	19
11n-20 MCS7	13	13.5	17.5
11n-40 MCS0	18	18	18.5
11n-40 MCS7	13	13.5	17

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