Application Note

Simplified RF Testing Guide for CC33xx/CC35xxE

Zach Robbins

ABSTRACT

This guide covers basic RF testing procedures for the following TI devices: CC3300, CC3301, CC3350, CC3351, CC3300MOD, CC3301MOD, CC3350MOD, CC3351MOD, CC3501E and CC3551E. Tests include TX Power, Error Vector Magnitude (EVM), RX Sensitivity and Frequency Accuracy. Following this guide enables users to characterize performance of HW prototypes and even perform regulatory testing on the final product.

Table of Contents

1 Required Items 2
2 Overview of Available Tools 3
3 Getting Started with Radio Tool 3
4 Getting Started with Calibrator Tool 4
5 Wi-Fi Testing 5
5.1 TX Testing Using Radio Tool 5
5.2 TX Testing Using Calibrator Tool 7
5.3 RX Testing Using Radio Tool 8
5.4 RX Testing Using Calibrator Tool 9
6 BLE Testing 10
6.1 TX Power Using Radio Tool 10
6.2 TX Power Using HCI Commands 11
6.3 RX Sensitivity Using Radio Tool 11
6.4 RX Sensitivity Using HCI Commands 12
7 Troubleshooting/FAQs 12
8 Duty Cycle Table 13
9 Summary 13
10 References 13

Trademarks

1 Required Items

The following items are required to perform RF testing:

- CC33xx or CC35xxE. This is the device under test (DUT)
- Computer
- VSA/VSG (such as a LitePoint). TX measurements can be done using a Spectrum Analyzer(SA), but can lead to misinterpreted TX power measurements (see Troubleshooting/FAQ section)
- Latest SDK downloaded. This is where the Calibrator Tool and Radio Tool guides can be found.
  - CC33xx SDK
  - CC35xxE SDK
  - Wi-fi Toolbox (includes Radio Tool)
- Appropriate Debugger (such as the LP-XDS110ET)
- Necessary cabling (See Figure 1-1 and Figure 1-2)

If using Radio Tool: The latest version of Google Chrome is required (other web browsers are supported; however, Chrome is recommended)

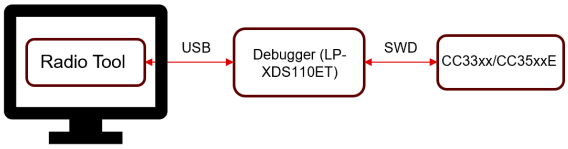

Figure 1-1. Cabling Setup for Radio Tool

If using Calibrator Tool: A Terminal application (such as PuTTY) is required

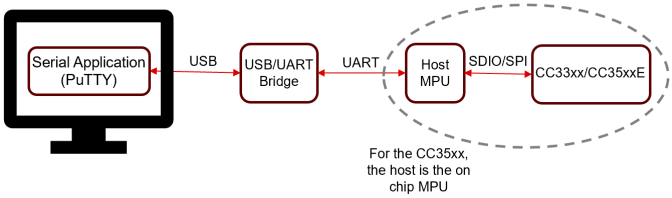

Figure 1-2. Cabling setup for Calibrator Tool

Note

If using the CC33xx with an LP-XDS110ET, it is required to place a jumper between pins 2 and 3 on the Level Shifter Voltage Selector so that the supply comes from the target board. See the below figure from the BP-CC3351 User's Guide

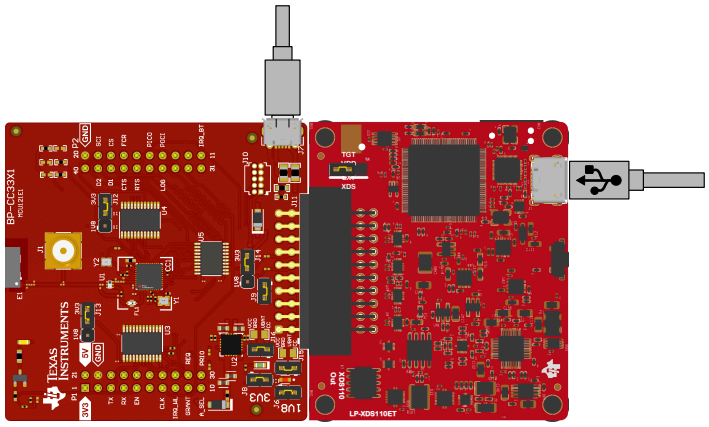

Figure 1-3. Diagram of Jumper Location on LP-XDS110ET

2 Overview of Available Tools

Radio Tool is a GUI that has a dependence on the SWD interface. The TI Evaluation Kits (EVKs) have seamless integration with the LP-XDS110ET debugger, thus Radio Tool is the recommended choice for users testing on EVKs. These include the BP-CC3351 or the LP-EM-CC35x1 paired with a LP-XDS110ET.

Calibrator Tool is a Command Line Interface (CLI) and runs on the host, which means a debugger is no longer required. For the CC33xx the host is the accompanying MPU, for the CC35xxE this is the internal MCU.

3 Getting Started with Radio Tool

Follow these steps if testing with Radio Tool.

1. Open the "simplelink-wifi-toolbox" application and launch Radio Tool. The initial screen appears as shown in Figure 3-1

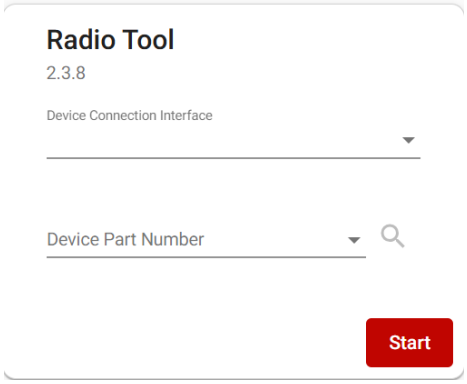

Figure 3-1. Radio Tool Homepage

2. In the first dropdown, select *XDS110*. In the second dropdown, select the serial number matching the device. If the serial number does not appear, click the *refresh* button.

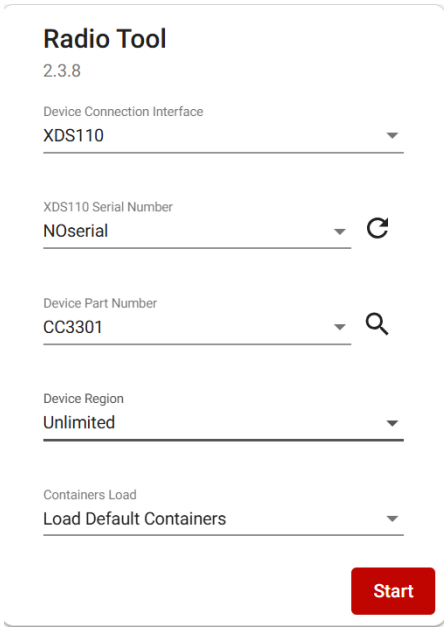

Figure 3-2. Radio Tool XDS110 Connection Page

3. Select the part number corresponding to the board (for example, CC3301).
4. Select appropriate region: For IC testing, this must be Unlimited for full IEEE compliant performance. For Module testing, select other regions to enable power limits imposed to meet Regulatory compliance.
5. Select the desired containers type. TI recommends loading default containers, but the following options are available

- Pre-loaded: If the desired software has already been loaded onto the device in a prior session, select this option
- Default: Select this option to load the official Wi-Fi Toolbox integrated software
- Custom: Select this option if it is desired to load a custom bootloader, firmware, and/or configuration file onto the device. See Radio Tool guide for more information

6. Click *Start.* The user is now ready to perform testing using Radio Tool.

4 Getting Started with Calibrator Tool

Follow these steps if testing with Calibrator Tool. Note: Calibrator Tool runs within the Network Terminal.

1. On the computer, open Device Manager and note the assigned COM port number. For CC33xx, only one option appears. For CC35xxE, note the number next to "Class Application/User UART".
2. Open PuTTY (or another terminal application) and select *Serial* under *Connection Type*.
3. Enter the COM port number under *Serial Line*.
4. Select the baud rate corresponding with the host serial interface. The default value for the TI SDKs is 115200.
5. **(CC35xxE only):** The output should resemble Figure 4-1.

```
================================================================================
Available commands:

help                wlan_ap_role_up     wlan_ap_role_down
wlan_sta_role_up    wlan_sta_role_down  wlan_connect        wlan_set_early_term
wlan_get_early_term wlan_disconnect     wlan_scan           wlan_get_mac
wlan_set_mac        wlan_get_ps         wlan_set_ps         wlan_set_pm
wlan_set_if_ip      wlan_get_if_ip      wlan_set_dhcp       wlan_get_dhcp
test_sleep          wlan_set_LSI        wlan_get_fw_ver     wlan_start
wlan_stop           iperf               iperf_stop          ble_adv_cfg
ble_adv_enable      ble_scan_cfg        ble_scan_enable     ble_connect
ble_disconnect      ble_peers           ble_delete_bonds    ble_get_bd_addr
ble_set_bd_addr     ble_set_tx_pwr      ble_conn_update     ble_set_phy
ble_start           ble_stop            csi_enable          csi_stop
csi_disable         csi_get_results     csi_config          csi_set_mac
calibrator          sntp_config_servers sntp_update         set_date_time
get_date_time       vend_IE_add         vend_IE_remove      set_peer_aging
p2p_role_up         p2p_role_down       p2p_find            p2p_connect
p2p_stop_find       p2p_group_remove    p2p_set_channel     p2p_get_channel
p2p_listen          p2p_cancel          start_ap_wps        wlan_set_con_policy
wlan_get_con_policy wlan_add_profile    wlan_del_profile    wlan_get_profile
wlan_set_dwell_time wlan_profile_connectping                ping_stop
set_cstm_reg_domain get_cstm_reg_domain
================================================================================


user:
```

Figure 4-1. List of Available Network Terminal Commands

6. **(CC33xx only):** Check that the kernel and modules have been configured correctly:

```
zcat /proc/config.gz | grep NL80211_TESTMODE
```

Expected output:

```
CONFIG_NL80211_TESTMODE=y
```

7. **(CC33xx only):** Enter login credentials when prompted, then run the command below to verify that the firmware is loaded correctly:

```
ifconfig wlan0
```

The output should resemble Figure 4-2

```
root@am335x-evm:~# ifconfig wlan0
wlan0     Link encap:Ethernet  HWaddr A4:34:F1:B3:19:54
          UP BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

root@am335x-evm:~#
```

Figure 4-2. Firmware Download Confirmation

5 Wi-Fi Testing

This section covers basic Wi-Fi RF tests. Tests commonly required for IEEE 802.11 standards compliance include: TX Power, EVM, and Frequency Accuracy.

5.1 TX Testing Using Radio Tool

The screen must look like Figure 5-1. If not, or the user has not yet set up Radio Tool, navigate to the Getting Started with Radio Tool section first and follow the steps.

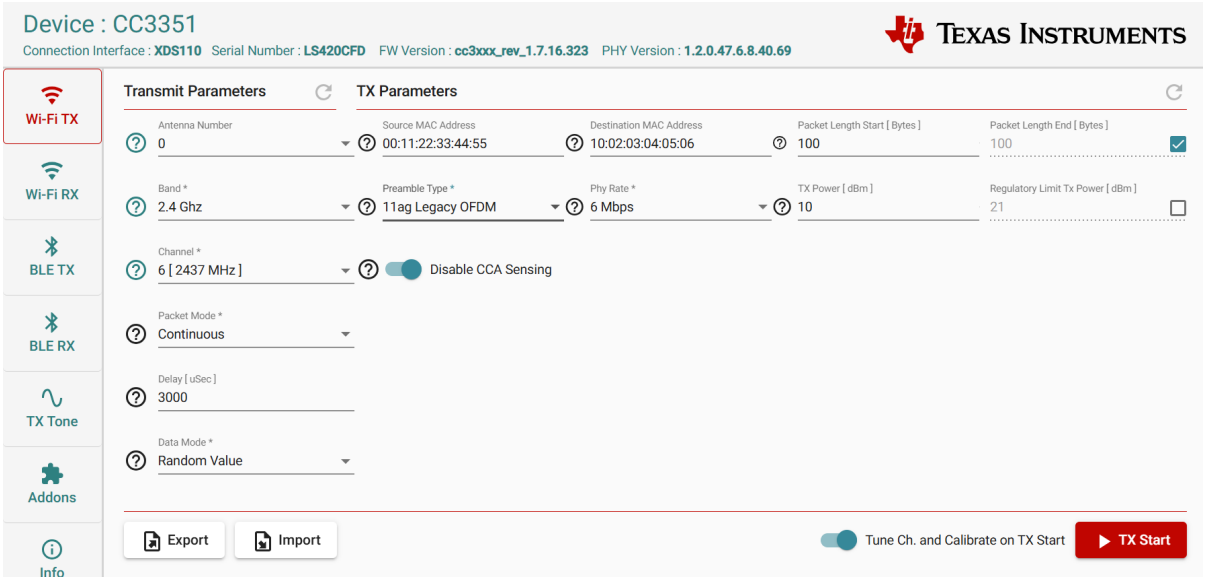

Figure 5-1. Wi-Fi TX Homescreen in Radio Tool

1. In the *Transmit Parameters* column, configure the desired settings. The most relevant parameters are Band and Channel.
2. Under *TX Parameters*, select the desired Preamble Type and PHY Rate, and target test value for TX Power.
3. For optimal performance, set the *Delay* and *Packet Length* parameters so that the duty cycle is approximately 30%. If uncertain on what values to input, see the Duty Cycle Table.
4. Enable the Tune Ch. and Calibrate on TX Start toggle.
5. Before beginning transmission, set the RF Testing instrument to VSA mode at the same frequency configured in Radio Tool. Configure the measurement tables to display TX Power, EVM and Frequency Error. A LitePoint example is shown below.

6.

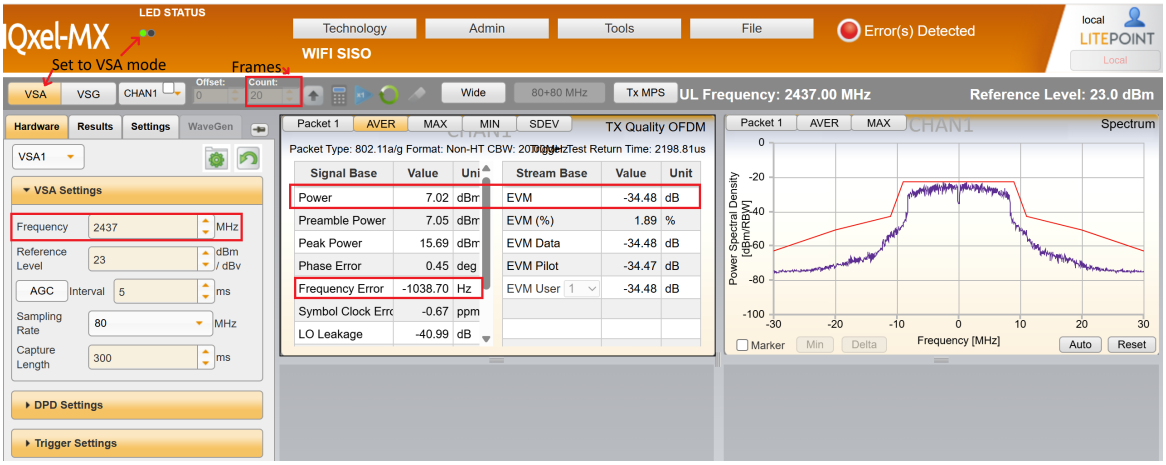

Figure 5-2. Example LitePoint Screen Configuration

7. Click *TX Start* to begin transmitting and run continuous analysis on the VSA. Varying the TX Power, Preamble Type and Phy Rate, should confirm the device meets datasheet TX Power specifications as well as the 802.11 EVM and Frequency Accuracy standards.

Note: Per IEEE 802.11, to properly measure EVM, the test must be performed over at least 20 frames. The average of those frames can then be compared against the IEEE threshold values. The frames must be at least 16 OFDM symbols long.

Note: Account for loss in the setup. As seen in the figures above, there is a 3 dBm discrepancy due to cable loss. If measured TX Power is still below the value set in Radio Tool, see the Troubleshooting/FAQ section.

5.1.1 802.11ax Trigger Based Testing

If desired, Trigger Based (TB) testing can be performed by selecting *11ax TB* under *Preamble Type*. The screen must match Figure 5-3 after doing so.

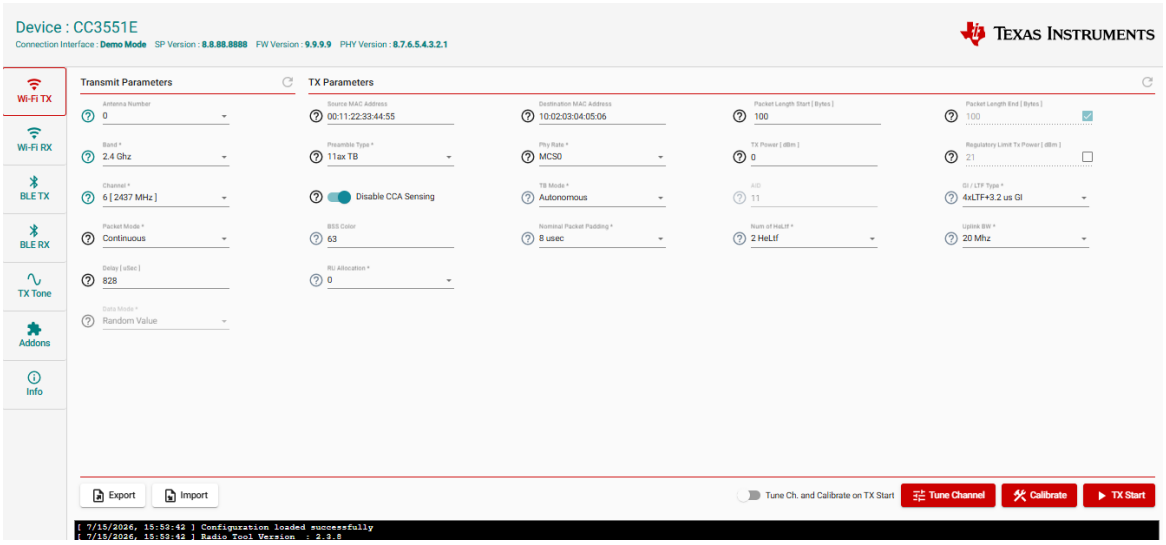

Figure 5-3. Wi-Fi TX 11ax TB Radio Tool Homepage

Radio Tool provides the option to set *Autonomous* or *External Trigger* as the TB mode. It is recommended to use autonomous mode because the configuration for external mode is significantly more complicated. The steps below explain how to use autonomous mode. If using an External Trigger, skip to the External Trigger steps.

1. Select desired *PHY Rate* in Radio Tool and on the VSA.
2. Select desired *GI/LTF type* and *num of HeLtf*. The VSA must be configured to match these settings, otherwise EVM values will appear unusually high.

3. Select desired *RU Allocation* index in Radio Tool and on the VSA.
4. Click *Start* in Radio Tool and run continuous analysis on the VSA.

External Trigger

When using an external trigger, the trigger frame waveform will dictate all parameters that need to be set in both Radio Tool and on the testing instrument.

Note

Setting TX Power in Radio Tool has no effect because TX Power is defined by the trigger frame.

1. Configure the testing instrument so that it is in both VSA and VSG mode.
2. For the VSA, set the GI LTF Type, num LTF, PHY Rate and RU index to match what is defined by the trigger frame.
3. In Radio Tool, set the *PHY rate* and *AID* to match what is defined by the trigger frame. Click *TX Start.*
4. Begin continuous analysis on the VSA.
5. Upload the trigger frame to the VSG and begin transmitting it to the device.

5.2 TX Testing Using Calibrator Tool

If Calibrator tool has not been set up, navigate to the Getting Started with Calibrator Tool section before continuing. Use the below example flows as references for how to perform a TX test. For further information on Calibrator Tool, navigate to the Calibrator Tool guides for the CC33xx and CC35xx located in the respective SDKs.

CC33xx example flow on channel 6, with 11ax SU preamble type, MCS6 rate, TX power 21:

```
calibrator wlan0 plt power_mode on
calibrator wlan0 cc33xx_plt tune_channel 6 0 0
calibrator wlan0 cc33xx_plt set_manual_calib -tx 1
calibrator wlan0 cc33xx_plt set_tx -preamble_type 5 -phy_rate 19 -tx_power 31
calibrator wlan0 cc33xx_plt start_tx
calibrator wlan0 cc33xx_plt stop_tx
```

CC35xx example flow on channel 6, with 11ax SU preamble type, MCS6 rate, TX power 21:

```
wlan_start
calibrator power_mode on
calibrator tune_channel 6 0 0
calibrator set_manual_calib -tx 1
calibrator set_tx -preamble_type 5 -phy_rate 19 -tx_power 31
calibrator start_tx
calibrator stop_tx
```

Note: Figure 5-4 provides assistance when tuning the device. The parameters should be typed in the order they appear.

Parameter	Option	Description
CHAN	1 - 13	2.4 GHz Wi-Fi Channels
	36 - 165	5 GHz Wi-Fi Channels
BAND	0	2.4 GHz Wi-Fi Band
	1	5 GHz Wi-Fi Band
BANDWIDTH	0	Bandwidth Allocation

Figure 5-4. TX Parameters Table

On the VSA, configure the tables so that TX Power, EVM and Frequency Error can be viewed. Varying the TX Power, Preamble Type and Phy Rate must confirm the device meets datasheet TX Power specifications as well as the 802.11 EVM and Frequency Accuracy standards.

5.2.1 802.11ax Trigger Based Testing

If desired, Trigger Based (TB) testing can be performed by setting the *Preamble Type* to 8. The Calibrator Tool provides the option to use *Autonomous* mode or *External Trigger* mode by setting the TB_AUTO parameter. Autonomous mode is the recommended choice, as the configuration for external trigger mode is more complex. If it is desired to use external trigger mode, skip to the External Trigger section. Reference the Calibrator Tool guide for further information on selecting parameters.

1. Select the *PHY Rate* in Calibrator Tool and on the VSA.
2. Select desired *GI/LTF type* and *num of HeLtf*. The VSA must be configured to match these settings, otherwise EVM values will appear unusually high.
3. Select desired *RU Allocation* index in Calibrator Tool and on the VSA.
4. Run *start_tx* in Calibrator Tool and run continuous analysis on the VSA.

External Trigger:

When using an external trigger, the trigger frame waveform will dictate all parameters that need to be set in both Calibrator Tool and on the testing instrument.

Note: Setting TX Power in Calibrator Tool does not change anything because TX Power is defined by the trigger frame.

1. Configure the testing instrument so that it is in both VSA and VSG mode
2. For the VSA, set the GI LTF Type, num LTF, PHY Rate and RU index to match what is defined by the trigger frame
3. In Calibrator Tool, set the *PHY rate* and *AID* to match what is defined by the trigger frame. Run *start_tx*
4. Begin continuous analysis on the VSA
5. Upload the trigger frame to the VSG and begin transmitting it to the device

5.3 RX Testing Using Radio Tool

The screen should have a panel on the left to where the user can click *Wi-Fi RX*. If not, or the user has not yet set up Radio Tool, navigate to the Getting Started with Radio Tool section first and follow the steps. After clicking *Wi-Fi RX*, the screen must look like Figure 5-5.

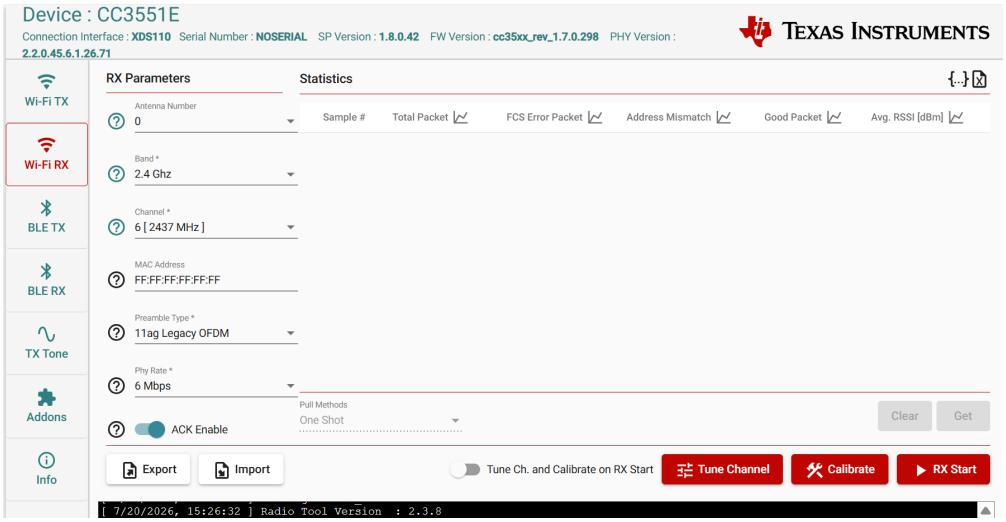

Figure 5-5. Wi-Fi RX Homepage in Radio Tool

1. In the *RX Parameters* column, the default *MAC address* is FF:FF:FF:FF:FF:FF, placing the receiver in broadcast mode. This is appropriate for conductive testing. For over-the-air testing, it can be beneficial to apply MAC filtering by setting the MAC Address to match the source address.
2. Configure the remaining *RX Parameters* as desired.
3. Enable the *Tune Ch. and Calibrate on RX Start* toggle, then click *RX Start* to begin receiving.
4. Three statistics pull methods are available:

- One shot: captures statistics at the moment the *Get* button is clicked.
- Interval: polls at a user-defined interval (in seconds) and posts cumulative stats until stopped.
- Interval and Count: same as *Interval*, but limits the number of polling cycles via the *Number of Samples* parameter.

To test the sensitivity of the device, reference the Receiver Characteristics section in the corresponding datasheet and set the VSG TX power slightly above the listed sensitivity value to account for loss. Import a waveform matching the data rate selected in Radio Tool. If PER is below the applicable threshold (depends on Preamble Type), decrease the VSG power level until the device reaches the threshold.

Note: For best results, this test and any other RX Sensitivity test should be performed in an RF Shielded Enclosure. Additionally, make sure to send a specific number of packets from the VSG as a reference to compare with how many packets the DUT receives.

If experiencing poor performance or no packets are being received, reference the Troubleshooting/FAQ section.

5.4 RX Testing Using Calibrator Tool

This section covers sensitivity testing using Calibrator Tool. If Calibrator Tool has not been set up, please navigate to the Getting Started with Calibrator Tool section before continuing. Use the below example flows as references for how to perform a sensitivity test. For further information on Calibrator Tool, navigate to the Calibrator Tool guides for the CC33xx and CC35xx located in the respective SDKs.

VSG:

- Configure at the same frequency selected in Calibrator Tool
- Import a waveform matching the data rate selected in Calibrator Tool
- Set TX power slightly above the datasheet sensitivity value to account for loss

CC33xx example flow on channel 6, in broadcast mode, with 11ax SU preamble type, MCS7 rate:

```
calibrator wlan0 plt power_mode on
calibrator wlan0 cc33xx_plt tune_channel 6 0 0
calibrator wlan0 cc33xx_plt set_manual_calib -rx 1
calibrator wlan0 cc33xx_plt start_rx -source_mac FF:FF:FF:FF:FF:FF -preamble_type 5 -rate 20
calibrator wlan0 cc33xx_plt get_rx_stats
calibrator wlan0 cc33xx_plt stop_rx
```

CC35xx example flow on channel 6, in broadcast mode, with 11ax SU preamble type, MCS7 rate:

```
wlan_start
calibrator power_mode on
calibrator tune_channel 6 0 0
calibrator set_manual_calib -rx 1
calibrator start_rx -source_mac FF:FF:FF:FF:FF:FF -preamble_type 5 -rate 20
calibrator get_rx_stats
calibrator stop_rx
```

Note: To obtain a fresh set of statistics for each measurement, repeat commands 4-6. Omitting the stop/start cycle causes statistics to accumulate as a running total.

Note: Figure 5-6 provides assistance when tuning the device. The parameters must be typed in the order they appear.

Parameter	Option	Description
CHAN	1 - 13	2.4 GHz Wi-Fi Channels
	36 - 165	5 GHz Wi-Fi Channels
BAND	0	2.4 GHz Wi-Fi Band
	1	5 GHz Wi-Fi Band
BANDWIDTH	0	Bandwidth Allocation

Figure 5-6. RX Parameters Table

Note: For best results, this test and any other RX Sensitivity test must be performed in an RF Shielded Enclosure. Additionally, make sure to send a specific number of packets from the VSG as a reference to compare with how many packets the DUT receives.

If experiencing poor performance or no packets are being received, reference the Troubleshooting/FAQ section.

6 BLE Testing

This section covers all of the basic BLE tests.

6.1 TX Power Using Radio Tool

Select *BLE TX* in the left column. The screen should match Figure 6-1. If not, or if Radio Tool has not yet been set up, navigate to the Getting Started with Radio Tool section first and follow the steps.

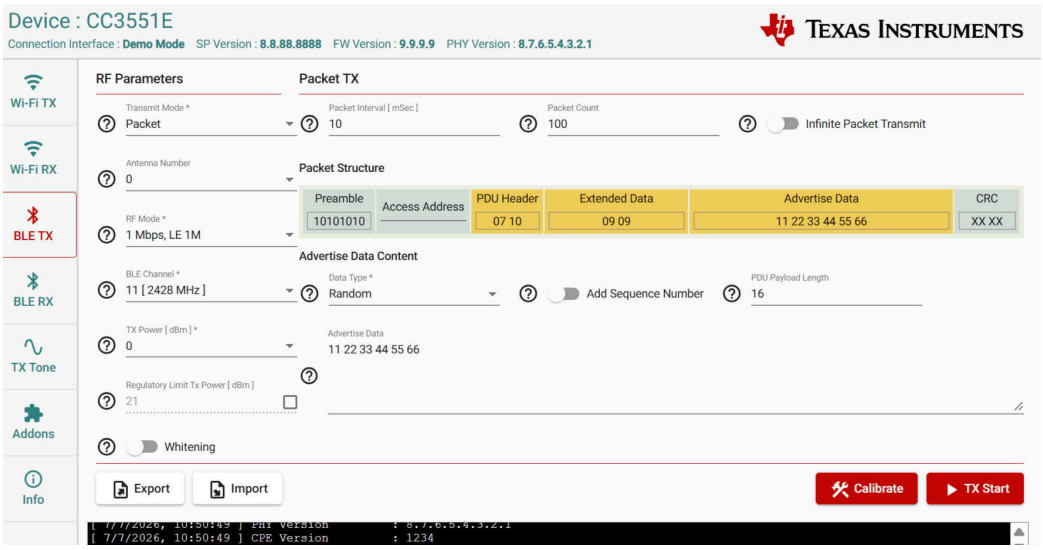

Figure 6-1. BLE TX Homepage in Radio Tool

1. Configure the settings as desired such as BLE Channel, RF Mode, TX Power, and so on.
2. For a smoother testing experience, turn the *Infinite Packet Transmit* toggle on. With this toggle off, the user has to repeatedly click Calibrate and TX Start every time they want to send more packets, which is tedious.
3. Click *Calibrate*. TI recommends doing this before every *TX Start*.
4. Before starting transmission, make sure to configure the VSA properly. If using LitePoint, your screen should resemble Figure 6-2

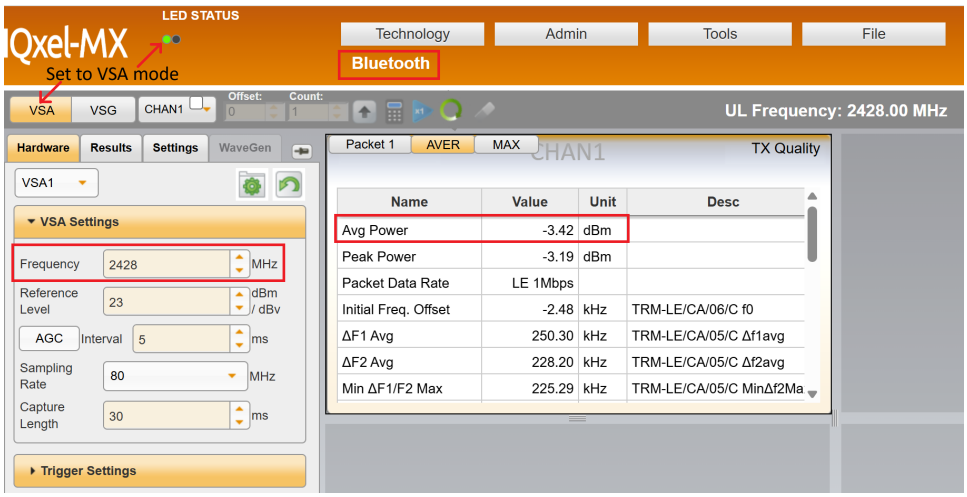

Figure 6-2. Example LitePoint Screen Configuration

5. Run Continuous Analysis on the VSA. In Radio Tool, click *TX Start*.

Note: Always account for loss in the setup. As seen in the images above, there is a 3 dBm discrepancy due to cable loss. If measured TX Power is still below the value set in Radio Tool, refer to the Troubleshooting/FAQ section.

6.2 TX Power Using HCI Commands

If Calibrator tool has not already been set up, please navigate to the Getting Started with Calibrator Tool section before continuing.

To prepare the device for testing, type the following lines:

```
cd /usr/share/cc33xx/
./set_power_mode.sh 0
calibrator wlan0 cc33xx_plt ble_plt
calibrator wlan0 plt power_mode on
calibrator wlan0 cc33xx_plt tune_channel 8 0 3
calibrator wlan0 cc33xx_plt set_manual_calib -tx 1 -rx 1
calibrator wlan0 cc33xx_plt tune_channel 6 0 0
bluetoothctl power on
calibrator wlan0 plt power_mode off
ifconfig wlan0 down
```

Next, configure the parameters as desired and run the test. The commands below show an example flow at TX power 20dBm, on channel 10, with packet length 255, packet pattern PRBS9 and Phy Rate 1Mbps (LE 1M). For more information, reference the *BLE RF Testing Via Linux Driver Guide* found in the CC33xx SDK:

```
hcitool cmd 3F 11 0x6                 #Set TX power
hcitool cmd 08 34 0xB 0xFF 0x00 0x01 #Set CHANNEL, PACKET LENGTH, PACKET PATTERN, PHY RATE. Start TX
hcitool cmd 08 1F                     #Stop TX
```

Configure the VSA so that TX Power can be viewed. After initiating the *Start TX* HCI command, run continuous analysis on the VSA to capture data.

6.3 RX Sensitivity Using Radio Tool

Click *BLE RX* in the left column. Your screen should resemble Figure 6-3. If not, or if Radio Tool has not yet been set up, navigate to the Getting Started with Radio Tool section first and follow the steps.

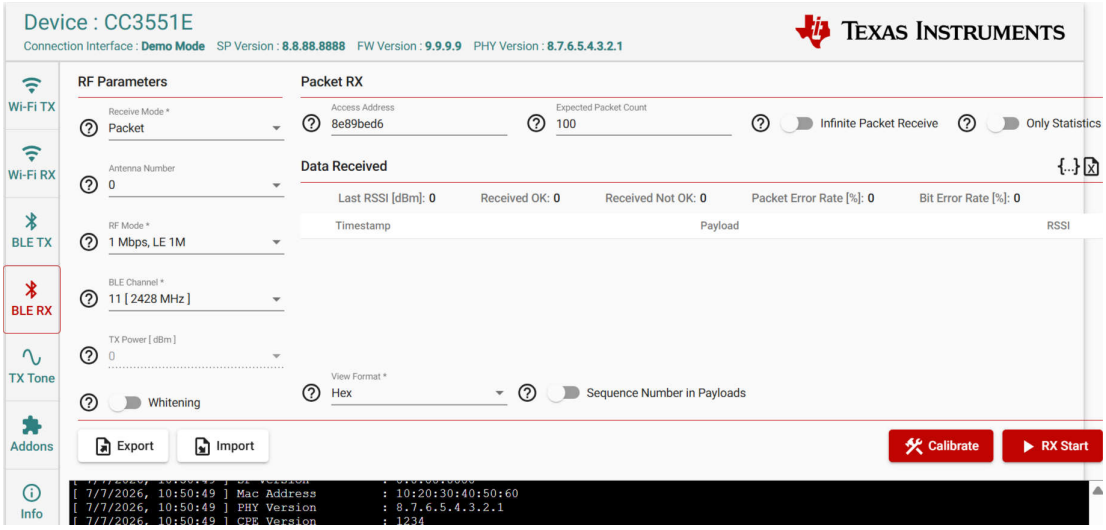

Figure 6-3. BLE RX Homepage in Radio Tool

1. Configure the desired RF parameters, including BLE channel, RF mode and TX power.
2. Set the *Expected Packet Count* to the amount of packets that will be sent from the VSG.
3. Click *Calibrate* before clicking *RX Start*. TI recommends doing this for every test.
4. On the VSG, set the frequency to match the selected frequency in Radio Tool and set the desired power level.
5. Upload a BLE waveform into the VSG and begin transmitting.

Note: For the most accurate results, this test and any other RX Sensitivity test should be conducted in an RF shielded enclosure.

6.4 RX Sensitivity Using HCI Commands

If Calibrator tool has not already been set up, navigate to the Getting Started with Calibrator Tool section before continuing.

To prepare the device for testing, type the following lines:

```
cd /usr/share/cc33xx/
./set_power_mode.sh 0
calibrator wlan0 cc33xx_plt ble_plt
calibrator wlan0 plt power_mode on
calibrator wlan0 cc33xx_plt tune_channel 8 0 3
calibrator wlan0 cc33xx_plt set_manual_calib -tx 1 -rx 1
calibrator wlan0 cc33xx_plt tune_channel 6 0 0
bluetoothctl power on
calibrator wlan0 plt power_mode off
ifconfig wlan0 down
```

Next, configure the parameters as desired and run the test. The below commands show an example flow on channel 10, with PHY Rate 1Mbps (LE 1M), and using Standard Modulation Index. For more information, reference the *BLE RF Testing Via Linux Driver Guide* found in the CC33xx SDK:

```
hcitool cmd 08 33 0xB 0x01 0x00  # Set CHANNEL, PHY RATE, MODULATION INDEX. Start RX
hcitool cmd 08 1F                # Stop RX, show results
```

On the VSG, set the frequency to match the selected frequency in Radio Tool and set the desired power level. Then, upload a BLE waveform into the VSG and begin transmitting.

7 Troubleshooting/FAQs

My device is failing to calibrate when using a TI EVK:

- Ensure that both USB cables are in use. Calibration draws a significant amount of current and can cause the device to brown out if only 1 USB cable is in use
- (RX only) For conductive testing, the device may fail to initialize if the VSG begins transmitting before the device is ready to receive. Start the device in RX mode before sending data from the VSG

I'm seeing lots of error packets when my device is in RX mode: Depending on the testing setup, you may have a capacitor that either runs from the RF connector to the chip, or the antenna to the chip. For conductive testing, if the capacitor faces the antenna rather than the RF connector, packets may be misinterpreted. The same issue can occur in over-the-air testing if the capacitor faces the RF connector.

My VSA is not picking up any data or my device is not receiving any packets: Verify that the test instrument port mode matches the test type: TX tests require the instrument to be in VSA mode; RX tests require it to be in VSG mode. Additionally, verify that the DUT and the testing instrument are on the same channel.

I am performing 802.11ax Trigger Based (TB) testing but my VSA is not reading any data: Trigger based testing involves several more settings, regardless of using Radio Tool or Calibrator Tool, and these must be matched exactly on the VSA. These settings include: GI LTF type, Number of LTF, RU Allocation and PHY rate.

I am seeing a lower TX Power value than expected:

- If using a Spectrum Analyzer (SA), note the width of the testing spectrum. The datasheet specs are calculated based on the full width of the WiFi spectrum (20 MHz) and many SAs do not have that capability so calculations will be needed to extrapolate to WiFi power. Use the following equation to perform this calculation.
  - $P_{\text{corrected}}(\text{dBm}) = P_{\text{measured}}(\text{dBm}) + 10 \times \log_{10}\left(\frac{20\text{MHz}}{\text{SA RBW}}\right)$
- Verify that board trace loss and cable loss have been accounted for in the measurement
- If the board has a capacitor in between the antenna and SMA connector, make sure it is facing the correct direction
- For conductive testing, make sure the RF cable is screwed in completely, in good condition, and free of kinks

- For optimal performance, set the duty cycle to 30%. High duty cycles can lead to degraded TX power
- If using a module, check the Power Limit Array (PLA) configuration. The PLA limits power output based on region, channel and RU index. When using the "unlimited" region, the PLA does not affect power output

8 Duty Cycle Table

Example values for Packet Length and Delay to achieve approximately 30% duty cycle

Table 8-1. Example Values for 30% duty cycle

Preamble Type	PHY Rate	Packet Length (bytes)	Delay (µs)
11b	1 Mbps	100	2875
	2 Mbps	200	2595
	5.5 Mbps	550	2417
	11 Mbps	1100	2366
11a/g OFDM	6 Mbps	650	2170
	9 Mbps	800	1773
	12 Mbps	950	1575
	18 Mbps	1100	1221
	24 Mbps	1250	1044
	36 Mbps	1400	789
	48 Mbps	1550	662
	54 Mbps	1800	680
11n/ax	MCS0	240	810
	MCS1	480	863
	MCS2	710	738
	MCS3	950	732
	MCS4	1450	735
	MCS5	1880	712
	MCS6	2110	710
	MCS7	2350	710

9 Summary

This guide has walked through the full RF testing process for TI CC33xx and CC35xx devices using both the Radio Tool and Calibrator Tool. Following these procedures allows users to verify that their device meets the TX Power, EVM, RX Sensitivity, and Frequency Accuracy specifications listed in the official part datasheets. For any issues encountered during testing, refer to the Troubleshooting/FAQ section.

10 References

Texas Instruments, *BP-CC3351 User's Guide*, user guide

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Last updated 10/2025