Certification Guide

Sterling-LWB/LWB5

Version 2.2

Revision History

Version	Date	Notes	Contributors	Approver
1.0	3/20/2018	Initial release		Greg Gates
1.1	19 June 2018	Minor fixes to test commands and labeling	Mike Richter	Greg Gates
1.2	19 Oct 2020	Changed the following Bluetooth Classic command: *BTC connectionless RX test for Bluetooth packets* *hcitool cmd 3f 52 FC 0e ee ff c0 88 00 00 f4 01 00 04 01 0f 53 0* to: *hcitool cmd 3f 52 ee ff c0 88 00 00 f4 01 00 04 01 0f 53 01*	Alexander Mohr	Mike Richter
2.0	8 May 2024	Ezurio rebranding	Sue White	Dave Drogowski
2.1	13 May 2024	Removed 40MHz examples in Commands to Perform Testing (40MHz channels not supported in 2.4 GHz)	Alexander Mohr	Andy Ross
2.2	20 March 2025	Update installation, country code information	D Ramsier	

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1 Preface/Requirements

This document provides guidance in using the Infineon WL_Tool Linux-based commands and BlueZ HCI Tool commands for Linux-based host platforms and SOM manufacturers. Prior knowledge of the Linux operating system running on the host platform or SOM system is required. In-depth knowledge of configuring Wi-Fi under the Linux O/S and Wi-Fi in general is also required.

Prior experience with the Sterling-LWB Linux Integration Guide is also a requirement before using this document. Please see the online Software Integration Guide at https://lairdcp.github.io/guides/linux_docs/1.0/lwb-sona-ifx/sig_lwb_sona_ifx_series_radio_linux_intro.html

2 Installation and Setup

Regulatory testing requires special manufacturing firmware as well as the wlan client utility from Infineon ('wl tool'). Ezurio provides these files in a self-extracting archive that must be installed on the target Device Under Test.

Please contact Ezurio (https://www.ezurio.com/resources/support) for the regulatory testing package needed for your host platform architecture.

2.1 Installation

To install the regulatory tools copy the self-extracting regulatory tools package to the target device and invoke it with the parameter 'install'

```
# ./regCypress-arm-eabihf-x.x.x.x.sh install
Installing wl to /usr/bin/wl
Installing wl_legacy to /usr/bin/wl_legacy
Installing brcmfmac4339-sdio-mfg_v6.37.39.141.bin to /lib/firmware/brcm/brcmfmac4339-sdio-mfg_v6.37.39.141.bin
Installing brcmfmac43430-sdio-mfg_v7.45.98.132.bin to /lib/firmware/brcm/brcmfmac43430-sdio-
mfg_v7.45.98.132.bin
```

The brcmfmac Wi-Fi client driver looks for specific file names when loading firmware. Symbolic links are used to point to the correct firmware to load. The firmware symbolic link will already exist and point to regular production firmware. The firmware link must be manually changed to point to the manufacturing firmware so that manufacturing firmware is loaded for regulatory testing.

See the following table for the proper link names:

Table 1 Firmware Link Names

	Soft Link	Target File – Normal Mode	Target File – Mfg Mode
LWB	brcmfmac43430-sdio.bin	brcmfmac43430-sdio-prod_<version>.bin	brcmfmac43430-sdio-prod_<version>.bin
LWB5	brcmfmac4339-sdio.bin	brcmfmac4339-sdio-prod_<version>.bin	brcmfmac4339-sdio-mfg_<version>.bin

The host platform must be rebooted after the firmware is installed and links changed so that the manufacturing firmware is loaded.

Note: Manufacturing firmware should only reside in the Linux host filesystem during certification testing.

2.2 Application Interference

User space daemons that interact with the Wi-Fi driver must be disabled so they do not interfere with regulatory testing. Failure to do this will cause unexpected and random failures. These daemons are platform specific but could include the following:

- NetworkManager
- wpa_supplicant
- hostapd
- sdcsupp
- systemd-networkd
- iwd

3 In-Country Testing Commands

The LWB and LWB5 firmware/CLM blob contain the channel and rate specific power limits needed for compliance in each supported country. These limits assume the use of a compliant antenna. Changes in recommended module integration or antenna selection may require custom power tables. It is essential to configure the correct country code when doing regulatory compliance testing.

The CLM blob file in the LWB firmware release contains all of the supported LWB country codes and related power limits. See the regulatory release notes for the list of supported countries. The desired country can be selected with the wl country command using just the two letter country code. See the Software Integration Guide for more details on configuring the country for production use.

The country and power information for the LWB5 is embedded in the LWB5 firmware. The firmware contains many countries and many revisions for some of the countries. It is essential that the correct country and revision are selected when performing regulatory testing with the LWB5.

The following table shows the valid countries and associated country/revision for use with the LWB5. No other country or country configuration is valid for use with the LWB5:

Table 2 LWB5 Country List

Country	CC/Rev
United States	US/911
Canada	CA/938
EU	EU/116
JP	JP/101
KR	KR/301

3.1 WL Command Overview

Below are the most used WL commands. Use the -help option to learn more about the available command options and variables.

wl ver	Get wl and driver version information
wl mpc	Set minimum power consumption mode
wl down	Reset and mark adapter down (disabled)
wl up	Reinitialize and mark adapter up (operational)

wl band — Sets the operating band. Choose one of

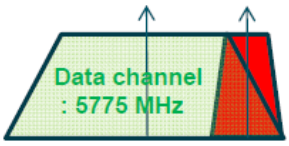
Auto	Auto-switch between available bands (default)
a	Force use of 802.11a band
b	Force use of 802.11b band

wl chanspec — Get/set the channel using a chanspec

20 MHz	[2 g|5 g] <channel>[/20]
40 MHz	[2 g|5 g] <channel>/40 [u,l]
80 MHz	[5 g] <channel>/80

Optional band 2 g or 5 g, default to 2 g if channel ≤ 14

ex> wl chanspec 161/80



Selective Channels

Band	2G			5G			
BW	HT20	HT40		HT20	HT40		VHT80
	1 (0x1001)	5u (0x1903)	1l (0x1803)	34 (0xd022)	40u (0xd926)	36l (0xd826)	36/80 (0xe02a)
	2 (0x1002)	6u (0x1904)	2l (0x1804)	36 (0xd024)	48u (0xd92e)	44l (0xd82e)	52/80 (0xe03a)
	3 (0x1003)	7u (0x1905)	3l (0x1805)	38 (0xd026)	56u (0xd936)	52l (0xd836)	100/80 (0xe06a)
	4 (0x1004)	8u (0x1906)	4l (0x1806)	40 (0xd028)	64u (0xd93e)	60l (0xd83e)	116/80 (0xe07a)
	5 (0x1005)	9u (0x1907)	5l (0x1807)	42 (0xd02a)	104u (0xd966)	100l (0xd866)	132/80 (0xe08a)
	6 (0x1006)	10u (0x1908)	6l (0x1808)	44 (0xd02c)	112u (0xd96e)	108l (0xd86e)	149/80 (0xe09b)
	7 (0x1007)	11u (0x1909)	7l (0x1809)	46 (0xd02e)	120u (0xd976)	116l (0xd876)	40/80 (0xe12a)
	8 (0x1008)	12u (0x190a)	8l (0x180a)	48 (0xd030)	128u (0xd97e)	124l (0xd87e)	56/80 (0xe13a)
	9 (0x1009)	13u (0x190b)	9l (0x180b)	52 (0xd034)	136u (0xd986)	132l (0xd886)	104/80 (0xe16a)
	10 (0x100a)			56 (0xd038)	144u (0xd98e)	140l (0xd88e)	120/80 (0xe17a)
	11 (0x100b)			60 (0xd03c)	153u (0xd997)	149l (0xd897)	136/80 (0xe18a)
	12 (0x100c)			64 (0xd040)	161u (0xd99f)	157l (0xd89f)	153/80 (0xe19b)
	13 (0x100d)			100 (0xd064)			44/80 (0xe22a)
	14 (0x100e)			104 (0xd068)			60/80 (0xe23a)
Channel				108 (0xd06c)			108/80 (0xe26a)
				112 (0xd070)			124/80 (0xe27a)
				116 (0xd074)			140/80 (0xe28a)
				120 (0xd078)			157/80 (0xe29b)
				124 (0xd07c)			48/80 (0xe32a)
				128 (0xd080)			64/80 (0xe33a)
				132 (0xd084)			112/80 (0xe36a)
				136 (0xd088)			128/80 (0xe37a)
				140 (0xd08c)			144/80 (0xe38a)
				144 (0xd090)			161/80 (0xe39b)
				149 (0xd095)			
				153 (0xd099)			
				157 (0xd09d)			
				161 (0xd0a1)			
				165 (0xd0a5)			

Figure 1: Selective channels

wl chanspecs	This returns a list of all available chanspecs for the current device. The list can be filtered down to just chanspecs for a specific band and bandwidth. Also, the list can be generated for a different country setting
wl 2g_rate	Set/Get the rate override for unicast data frames in the 2GHz band. If no arguments given, the command will display the current rate override for the 2GHz band, or "auto" if no override. The output format depends on the rate.

r R, --rate=R	Legacy rate (CCK, DSSS, OFDM)
h M, --ht=M	HT MCS index [0-23]
v M[[xS], --vht=M[xS]	VHT MCS index M [0-9], and optionally Nss S[1-8]
s S, --ss=S	VHT Nss [1-8], number of spatial streams, default 1
stbc	Use STBC expansion, otherwise no STBC
l, --ldpc	Use LDPC encoding, otherwise no LDPC
g, --sgi	SGI, Short Guard Interval, otherwise standard GI
b, --bandwidth	Transmit bandwidth MHz; 20, 40, 80

wl 5g_rate	Other than band, everything is compatible with 2g_rate

wl scansuppress	Suppress all scans for testing

0	Allow scans
1	Suppress scans

wl country	Select Country code for use
wl phy_forcecal	Force the PHY calibration to run immediately.
wl phy_watchdog	PHY watchdog can hit periodically to run some calibration tests. This is known to create trouble when we intend to run pkteng for several minutes. Hence it is recommended to disable watchdog before running test. (wl phy_watchdog 0)
wl pkteng_start	PKT Engine is a feature in driver+ucode.

TX Start

Usage	wl pkteng_start [addr] [tx/txwithack][(async)lsync][ipg][len][nframes][src]
Addr	tx txwithack – The destination address
Tx	Transmit packets
Txwithack	Transmit packets and wait for ACK
Sync	Synchronous mode
Ipg	Inter packet gap – Used only for Tx, ignored if RIFS is enabled
Len	Specifies the length of packet to be sent from DUT, used only for Tx
Nframes	Specifies the number of packets to be transmitted from DUT; zero indicates continuous transmission, used only for Tx

Rx Start

Usage	wl pkteng_start [addr][rx/rxwithack][(async)lsync][rxframes][rxtimeout]
Addr	Rx – DUT accepts frames with this destination address Rxwithack – DUT accepts frames with this destination address and sends ACK to this address
Rx	Receive packets and don't transmit ACK
Rxwithack	Receive packets and transmit ACK
Rxframes	Number of receive frames (sync mode only)
Rxwithout	Maximum timeout in msec (sync mode only)

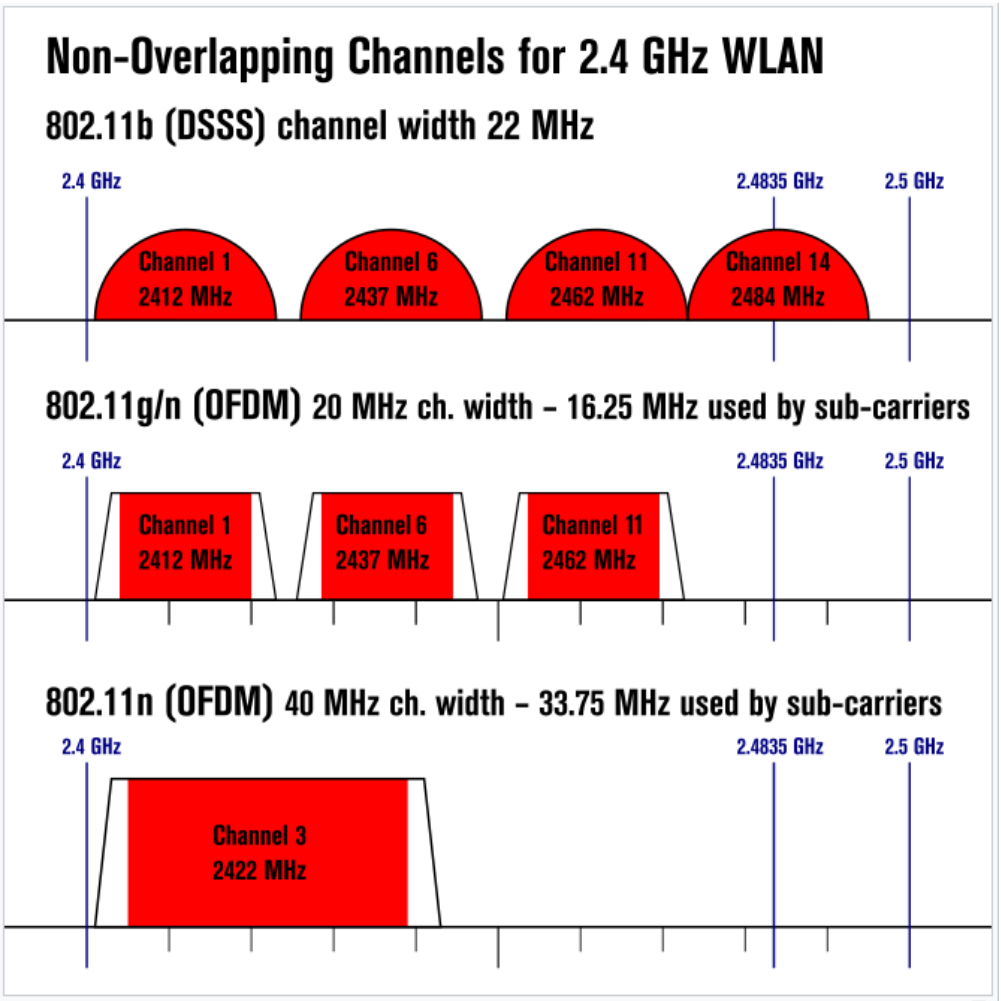
Usage Examples

- Transmit 1000 data frames of 200 bytes with 30 micro-seconds IFS
  wl pkteng_start 10:20:30:40:50:60 tx 30 200 1000
- Receive frames without ACK
  wl pkteng_start 10:20:30:40:50:60 rx

Limitation – Packet engine must be used when not associated

wl pkteng_stop	Used to stop the Tx/Rx mode Usage – wl pkteng_stop *tx/rx*

3.2 Graphical Overview of Available Channels and Frequencies to be Tested



Graphical representation of Wireless LAN channels in 2.4 GHz band. Note "channel 3" in the 40 MHz diagram above is often labelled with the 20MHz channel numbers "1+5" or "1" with "+ Upper" or "5" with "+ Lower" in router interfaces.

Figure 2: Non-overlapping channels for 2.4 GHz WLAN (Source: https://en.wikipedia.org/wiki/List_of_WLAN_channels)

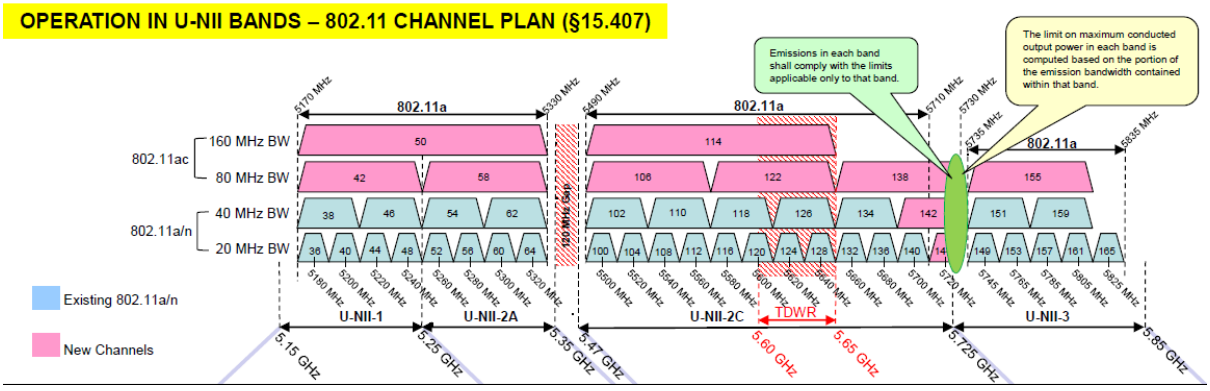


Figure 3: Operation in U-NII bands
(Full image is available from the FCC website: https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?switch=P&id=27155)

3.3 Commands to Perform Testing

The following is an example of a set of commands to put the Sterling-LWB into test mode for band B (2.4 GHz) MCS7 20 MHz channel 2412 MHz:

```
./wl ver
./wl down
./wl mpc 0
./wl phy_watchdog 0
./wl country US
./wl band b
./wl chanspec 1    Note: (1 = 0x1001, chanspec can be set from 1–14 here following HT20 table)
./wl 2g_rate -h 7 -b 20
./wl up
./wl phy_forcecal 1
./wl phy_activecal
./wl txpwr1 -1
./wl scansuppress 1
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0
```

Note: Use the 2G/HT20 data only in the Selective Channel table image above for the Sterling-LWB. The Sterling-LWB does not support 40MHz channels.

Note: While switching between tests, always issue the following command before changing variables.

```
./wl  pkteng_stop tx
```

The following are examples for TX testing legacy 802.11 b, g, and n:

802.11b

```
./wl ver
./wl down
./wl mpc 0
./wl phy_watchdog 0
./wl country US
./wl band b
./wl chanspec 1     Note: (0x1001, can be any HT20 channel 1 – 13)
./wl 2g_rate -r 1     Note: (where r can be 1, 2, 5.5 or 11)
./wl up
./wl phy_forcecal 1
./wl phy_activecal
./wl txpwr1 -1
./wl scansuppress 1
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0
```

802.11g

```
./wl ver
./wl down
./wl mpc 0
./wl phy_watchdog 0
./wl country US
./wl band b
./wl chanspec 1     Note: (0x1001)
./wl 2g_rate -r 6     Note: (where r can be 6, 9, 12, 18, 24, 36, 48, 54)
./wl up
./wl phy_forcecal 1
./wl phy_activecal
./wl txpwr1 -1
./wl scansuppress 1
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0
```

802.11n

./wl ver
./wl down
./wl mpc 0
./wl phy_watchdog 0
./wl country US
./wl band b
./wl chanspec 1 Note: (0x1001)
./wl 2g_rate -h 0 -b 20 Note: (where h can be 0, 1, 2, 3, 4, 5, 6 or 7)
./wl up
./wl phy_forcecal 1
./wl phy_activecal
./wl txpwr1 -1
./wl scansuppress 1
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

To select desired channels for the Sterling-LWB5, use any of the channels desired from the Selective Channel table (Figure 1).

Note: When changing test frequencies between 2.4 GHz and 5 GHz, the *wl*band command must be manipulated as defined below. Failure to change this yields errors from the WL command. Below is a summary of how these must work together.

wl band b = 2.4GHz = wl 2g_rate
wl band a = 5 GHz = wl 5g_rate

While switching between tests, always issue the following command before changing variables.

./wl pkteng_stop tx

The following are additional examples of WL command options to use for certain band A (5GHz) chanspecs. Review the 5g_rate -v that is required to test MCS8 and MCS9 on the LWB5:

MCS8 20 MHz

./wl pkteng_stop tx
./wl chanspec 36/20
./wl 5g_rate -v 8 -s 1 -b 20
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

MCS8 40 MHz (mcs9)

./wl pkteng_stop tx
./wl chanspec 36l
./wl 5g_rate -v 8 -s 1 -b 40
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

MCS8 80 MHz (mcs9)

./wl pkteng_stop tx
./wl chanspec 40/80
./wl 5g_rate -v 8 -s 1 -b 80
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

Additional 5 GHz 80 MHz Channels

./wl chanspec 40/80
Chanspec set to 0xe12a
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 56/80
Chanspec set to 0xe13a
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 104/80
Chanspec set to 0xe16a
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 120/80
Chanspec set to 0xe17a
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 136/80
Chanspec set to 0xe18a
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 153/80
Chanspec set to 0xe19b
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

Additional Channels 5 GHz 40 MHz Bandwidth

./wl chanspec 44l
Chanspec set to 0xd82e
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 52l
Chanspec set to 0xd836
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 60l
Chanspec set to 0xd83e
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 100l
Chanspec set to 0xd866
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 108l
Chanspec set to 0xd86e
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 116l
Chanspec set to 0xd876
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 124l
Chanspec set to 0xd87e
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 132l
Chanspec set to 0xd886
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 140l
Chanspec set to 0xd88e
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 149l
Chanspec set to 0xd897
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

./wl chanspec 157l
Chanspec set to 0xd89f
./wl pkteng_start 00:11:22:33:44:55 tx 100 1024 0

4 Bluetooth

Below are the necessary commands to perform Bluetooth testing. The hcitool is used here, so the host Linux platform must have the hcitool executable available and support for it from the stack. There are two sets of commands, one with hexadecimal op-codes and one without. Please use the one that is compatible with your host platform operating system.

Note: The Sterling-LWB and LWB5 require a firmware patch for Bluetooth. This patch file must be loaded for the radio to produce proper results.

4.1 Bluetooth Classic

BTC TX Packet channel 0 (2402 MHz) power table index 0 payload 339

hcitool cmd 0x3F 0x051 0xee 0xff 0xc0 0x88 0x00 0x00 0x01 0x00 0x04 0x01 0x0F 0x53 0x01 0x09 0x00 0x00
hcitool cmd 3F 051 ee ff c0 88 00 00 01 00 04 01 0F 53 01 09 00 00

BTC TX Packet channel 0 (2402 MHz) power table index 0 payload 339 (Hopping)

hcitool cmd 0x3F 0x051 0xee 0xff 0xc0 0x88 0x00 0x00 0x00 0x00 0x04 0x01 0x0F 0x53 0x01 0x09 0x00 0x00
hcitool cmd 3F 051 ee ff c0 88 00 00 00 00 04 01 0F 53 01 09 00 00

EDR3 TX Packet channel 0 (2402 MHz) power table index 0 payload 1021

hcitool cmd 0x3F 0x051 0xee 0xff 0xc0 0x88 0x00 0x00 0x01 0x00 0x04 0x00 0x0F 0xfd 0x03 0x09 0x00 0x00
hcitool cmd 3F 051 ee ff c0 88 00 00 01 00 04 00 0F FD 03 09 00 00

EDR3 TX Packet channel 0 (2402 MHz) power table index 0 payload 1021 (Hopping)

hcitool cmd 0x3F 0x051 0xee 0xff 0xc0 0x88 0x00 0x00 0x00 0x00 0x04 0x00 0x0F 0xfd 0x03 0x09 0x00 0x00
hcitool cmd 3F 051 ee ff c0 88 00 00 00 00 04 00 0F FD 03 09 00 00

BTC HCI Reset

hcitool cmd 0x03 0x003
hcitool cmd 03 003

BTC connectionless RX test for Bluetooth packets

hcitool cmd 3f 52 ee ff c0 88 00 00 f4 01 00 04 01 0f 53 01

BTC & EDR RX Receive (Requires the radio to be in DUT – Device Under Test mode)

hcitool cmd 03 05 02 00 03 (Set Event Filter)
hcitool cmd 03 1a 03 (Write Scan Enable)
hcitool cmd 06 03 (Enable Device Under Test Mode)
Use Bluetooth test instrument to control module in DUT and measure BER performance
(Example: R&S CBT Bluetooth Tester)

4.2 Bluetooth Low Energy

BLE TX Packet 2402 MHz

hcitool cmd 0x08 0x01e 0x00 0x25 0x00
hcitool cmd 08 01e 00 25 00

BLE TX Packet 2440 MHz

hcitool cmd 0x08 0x01e 0x13 0x25 0x00
hcitool cmd 08 01e 13 25 00

BLE TX Packet 2480 MHz

hcitool cmd 0x08 0x01e 0x27 0x25 0x00
hcitool cmd 08 01e 27 25 00

BLE TX End

hcitool cmd 0x08 0x01f
hcitool cmd 08 01f

BLE RX

hcitool cmd 0x08 0x01d 0x00 (Start Receiving)
hcitool cmd 08 01d 00
Start transmit packets (Lightpoint or other BLE packet generator)
Hcitool cmd 0x08 0x01f (Stop receiving)
01 1f 20 00 xx yy – (Output, determine the number of successful packets from yy xx)

4.3 Frequency Analyzer Suggestions

Using a frequency analyzer to review output signals and power levels is common practice in performing tests with BT and Wi-Fi radios. Figure 4 is a screen snapshot of a frequency analyzer while measuring a BLE signal. This is displayed to present a correct waveform being measured by the frequency analyzer.

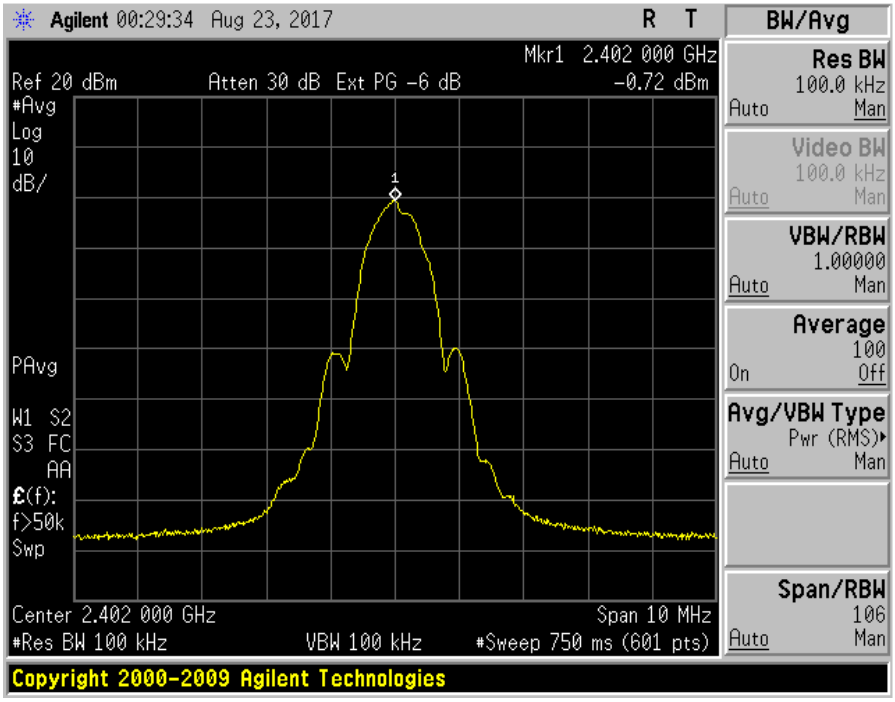


Figure 4: Frequency analyzer

We suggest that you adjust the MAX HOLD and SWEEP functions to achieve proper measured power output. Power output is averaged on these instruments but increasing sweep and locking onto a waveform with correct max hold settings provides proper power output.

Observed output power is also a function of resolution bandwidth. Higher resolution bandwidth loses graphical side-bands but increases power output representation.

Notice that this waveform has side-bands displayed because of a lower resolution bandwidth on the frequency analyzer.

5 Additional Information

Please contact your local sales representative or our support team for further assistance:

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