Qualcomm Technologies, Inc.

QCC74x Design Verification Test

Report

80-WL740-71 Rev. AC

February 12, 2025

Contents

1 Wi-Fi DVT

1.1 Basic information

This document describes the hardware RF design test data for QCC74x.

Test samples information

- Sample Size: 2
- Tx/Rx Chains: 1 Tx, 1 Rx
- Supported Modes: Single band 2.4 GHz, 802.11b/g/n/ax
- Sample Type: TT

Bench Software

QCC740.OR.1.0

DVT Specifics

- DVT Level: CS
- Temperature/Voltages:

Condition	Value
Temperature	+25°C
Voltage	Nominal

The test results captured here are based on early sample evaluation of the system-level performance of the [platform] using conducted tests. Results are in relation to the limited number of samples, the uniqueness of the test implementation (test instruments, fixtures, software, etc.), the uncertainty of the test station upon which the tests are conducted, and the software level used in the tests.

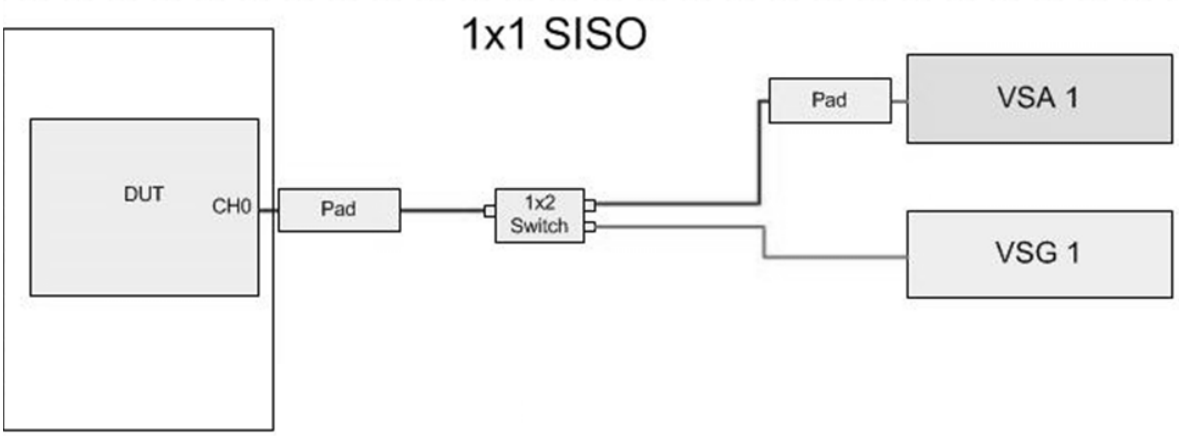
1.2 List of acronyms

Table 1-1 Acronyms and descriptions

Acronym	Description
DUT	Device under test
EVM	Error vector magnitude
ISS	Input signal strength
KPI	Key performance indicators
LAN	Local area network

Acronym	Description
MAD	Median absolute deviation
MIMO	Multiple Input Multiple Output
MTP	Modem test platform
Nrx	Number of Receive antennas
Nss	Number of Spatial streams
Ntx	Number of Transmit antennas
PER	Packet error rate
PSR	Packet success rate
Rx	Receiver
Tx	Transmitter
VSA	Vector signal analyzer
VSG	Vector signal generator
VST	Vector signal transceiver
WAN	Wide area network (also WWAN, wireless WAN)
WLAN	Wireless LAN

1.3 Test setup



DVT test setup for Wi-Fi testing

1.4 Wi-Fi test items

As part of DVT, the following tests have been conducted as per IEEE 802.11 ax/b/g/n specification requirements.

- Transmitter Tests
  - Tx Power Accuracy
  - Tx EVM
  - Tx Spectral Mask
  - Tx Center Frequency Tolerance
- Receiver Tests
  - Rx Sensitivity
  - Rx Dynamic Range

1.5 Tx power accuracy

1.5.1 Purpose of test

This test measures the Target power vs. Measured output power for each Tx antenna.

1.5.2 Test methodology

With the DUT placed inside a shielded enclosure, each chain's antenna port is connected through a set of 50 ohm coaxial cables to each input port of VSA. The DUT is configured to transmit

continuously at its calibrated transmit power levels for given data rates on all available Tx Chains simultaneously. The output power for each chain is measured.

1.5.3 Specifications

Calibration target power levels account for EVM compliance, spectral mask compliance, transmit packet error rate compliance, and power consumption compliance.

1.6 Tx EVM

1.6.1 Purpose of test

This test measures transmitter modulated signal quality per the 802.11 a/b/g/n error vector magnitude specifications of the IEEE.

1.6.2 Test methodology

With the DUT placed inside a shielded enclosure, the DUT's main antenna port is connected through a set of 50 ohm coaxial cables and splitters to a Vector Signal Analyzer. The DUT is configured to transmit at targeted power level on all available Tx Chains. The test is performed across a set of defined channels and rates. EVM Measurements are either with Header only and/or Full Packet Channel Estimation. Output Power and EVM is recorded for each chain following IEEE measurement guideline of at least 16 symbols.

1.6.3 Specifications

- 802.11a/g: IEEE Std 802.11-2012; Section 18.3.9.8; Table 18-13
- 802.11n: IEEE Std 802.11-2012; Section 20.3.20.7.4; Table 20-22
- 802.11ax: IEEE P802.11ax/D1.0 Nov 2016; Table 28-45

Table 1-2 802.11a/g maximum EVM Limits specification

Data Rate (Mbps)	Relative Constellation Error (dB)
6	-5
9	-8
12	-10
18	-13
24	-16
36	-19
48	-22
54	-25

Table 1-3 802.11n maximum EVM limits specification

MCS Index	Modulation	Coding Rate	Relative Constellation Error (dB)
MCS 0	BPSK	1/2	-5

MCS Index	Modulation	Coding Rate	Relative Constellation Error (dB)
MCS 1	QPSK	1/2	-10
MCS 2	QPSK	3/4	-13
MCS 3	16-QAM	1/2	-16
MCS 4	16-QAM	3/4	-19
MCS 5	64-QAM	2/3	-22
MCS 6	64-QAM	3/4	-25
MCS 7	64-QAM	5/6	-27

Table 1-4 802.11ax maximum EVM limits specification

MCS Index	Modulation	Coding Rate	Relative Constellation Error (dB)
MCS 0	BPSK	1/2	-5
MCS 1	QPSK	1/2	-10
MCS 2	QPSK	3/4	-13
MCS 3	16-QAM	1/2	-16
MCS 4	16-QAM	3/4	-19
MCS 5	64-QAM	2/3	-22
MCS 6	64-QAM	3/4	-25
MCS 7	64-QAM	5/6	-27
MCS8	256-QAM	3/4	-30
MCS9	256-QAM	5/6	-32

1.7 Tx spectral mask

1.7.1 Purpose of test

This test measures the maximum conducted transmit power at which the transmit spectrum meets the IEEE mask requirements.

1.7.2 Test methodology

With the DUT placed inside a shielded enclosure, the DUT's antenna ports are connected through a set of 50 ohm coaxial cables and splitters to an NI VSA. The DUT is configured to transmit at a given data rate. The transmitter output power is increased until the appropriate IEEE mask specifications are exactly met, at which point the output power is recorded. The test is performed across a set of pre-defined channels and rates.

1.7.3 Specifications

- 802.11b: IEEE Std 802.11-2012; Section 16.4.7.5; Figure 16-11
- 802.11a/g: IEEE Std 802.11-2012; Section 18.3.9.3; Figure 18-13
- 802.11n: IEEE Std 802.11-2012; Section 20.3.20.1; Figure 20-17 to 20
- 802.11ax: IEEE P802.11ax/D1.0-Nov 2016; Section 28.3.18.1

Table 1-5 IEEE spectral mask specification

Mode	Frequency Offset (MHz)	IEEE Specification (dBr)
802.11b	± 11	0
	± 22	-30
	>22	-50
802.11a/g	± 9	0
	± 11	-20
	± 20	-28
	± 30	-40
802.11n HT20 (2.4 GHz)	± 9	0
	± 11	-20
	± 20	-28
	± 30	-45
802.11n HT40 (2.4 GHz)	± 19	0
	± 21	-20
	± 40	-28
	± 60	-45
802.11ax HE20 (2.4 GHz)	± 9.75	0
	± 10.25	-20
	± 20	-28
	± 30	-40
802.11ax HE40 (2.4 GHz)	± 19.5	0
	± 20.5	-20
	± 40	-28
	± 60	-40

1.8 Tx frequency tolerance

1.8.1 Purpose of test

This test measures the reference oscillator frequency drift.

1.8.2 Test methodology

With the DUT placed inside a shielded enclosure, the DUT's main antenna port is connected through a 50-Ohm coaxial cable to an NI VSA and is configured to transmit a continuous wave carrier, and the carrier frequency is measured. PPM is calculated using the equation below.

$$PPM = \frac{f_{measured} - f_{carrier}}{f_{carrier}} \times 10^6$$

1.8.3 Specifications

- 802.11n: IEEE Std 802.11-2012; Section 20.3.20.4

Table 1-6 IEEE center frequency tolerance specification

Frequency Band (GHz)	Frequency Tolerance Limit (PPM)
2.4	+/- 25

1.9 Rx sensitivity

1.9.1 Purpose of test

This test measures the minimum RF input signal level at which the receiver Packet Error Rate (PER) is less than 10%. Equivalently, this test measures the minimum RF input level at which the receiver Packet Success Rate (PSR) is greater than 90%.

1.9.2 Test methodology

With the DUT placed inside a shielded enclosure, the antenna ports are connected through a set of 50 ohm coaxial cables to the output ports of NI VSG. The output signal of VSG is reduced until the DUT's received packet error rate is 10% at which point the input signal level (dBm) to DUT including cable losses and if any applied attenuation is recorded. The procedure is repeated for pre-specified frequencies and rates. Test is conducted on each individual chain alone and all available chains receiving at once.

1.9.3 Specifications

- 802.11b: IEEE Std 802.11-2012; Section 16.4.8.2, 17.4.8.2
- 802.11a/g: IEEE Std 802.11-2012; Section 18.3.10.2; Table 18-14
- 802.11n: IEEE Std 802.11-2012; Section 20.3.21.1; Table 20-23
- 802.11ax: IEEE P802.11ax/D1.0 Nov-2016 Section 28.3.17.2; Table 28-41

Table 1-7 802.11b minimum sensitivity specification

Data Rate (Mbps)	Minimum Sensitivity (dBm)
2L	-80
2S	-80
11L	-76
11S	-76

Table 1-8 802.11a/g minimum sensitivity specification

Data Rate (Mbps)	Minimum Sensitivity (dBm)
6	-82
9	-81

Data Rate (Mbps)	Minimum Sensitivity (dBm)
12	-79
18	-77
24	-74
36	-70
48	-66
54	-65

Table 1-9 802.11n minimum sensitivity specification

MCS Index	Modulation	Coding Rate	Minimum Sensitivity (dBm)	
			20 MHz BW	40 MHz BW
MCS 0	BPSK	1/2	-82	-79
MCS 1	QPSK	1/2	-79	-76
MCS 2	QPSK	3/4	-77	-74
MCS 3	16-QAM	1/2	-74	-71
MCS 4	16-QAM	3/4	-70	-67
MCS 5	64-QAM	2/3	-66	-63
MCS 6	64-QAM	3/4	-65	-62
MCS 7	64-QAM	5/6	-64	-61

Table 1-10 802.11ax minimum sensitivity specification

MCS Index	Modulation	Coding Rate	Minimum Sensitivity (dBm)	
			20 MHz BW	40 MHz BW
MCS 0	BPSK	1/2	-82	-79
MCS 1	QPSK	1/2	-79	-76
MCS 2	QPSK	3/4	-77	-74
MCS 3	16-QAM	1/2	-74	-71
MCS 4	16-QAM	3/4	-70	-67
MCS 5	64-QAM	2/3	-66	-63
MCS 6	64-QAM	3/4	-65	-62
MCS 7	64-QAM	5/6	-64	-61
MCS 8	256-QAM	3/4	-59	-56
MCS 9	256-QAM	5/6	-57	-54

1.10 Rx dynamic range (waterfall)

1.10.1 Purpose of test

This test measures the receiver's conducted packet success rate percentage as the input signal level is swept through the receiver's entire dynamic range. The test effectively measures the receiver's minimum detectable input signal level, the maximum detectable input signal level, and the AGC performance across the input signal amplitude range.

1.10.2 Test methodology

The test methodology is identical to that employed in the receiver sensitivity test. However, instead of searching specifically for the input signal level at which the DUT's received PER meets 10%, the test sweeps the input signal level to the DUT in 2 dB steps across the entire receiver dynamic range, and records receiver PER vs. input power. The test is performed across a set of pre-defined channels and data rates. Test is conducted on each individual chain alone and all available chains receiving at once.

1.10.3 Specifications

- 802.11b: IEEE Std 802.11-2012; Section 16.4.8.3, 17.4.8.3
- 802.11a/g: IEEE Std 802.11-2012; Section 18.3.10.5
- 802.11n: IEEE Std 802.11-2012; Section 20.3.21.4
- 802.11ax: IEEE P802.11ax/D1.0 Nov-2016; Section 28.3.17.5

Table 1-10 IEEE receiver maximum input specification

Mode	Receiver Maximum Input Level (dBm)
802.11b (2 Mbps)	-4
802.11b (11 Mbps)	-10
802.11g	-20
802.11n 2.4 GHz	-20
802.11ax 2.4 GHz	-20

1.11 DVT test coverage

This section provides information on the DVT coverage.

Table 1-11 List of center frequencies tested in standard DVT

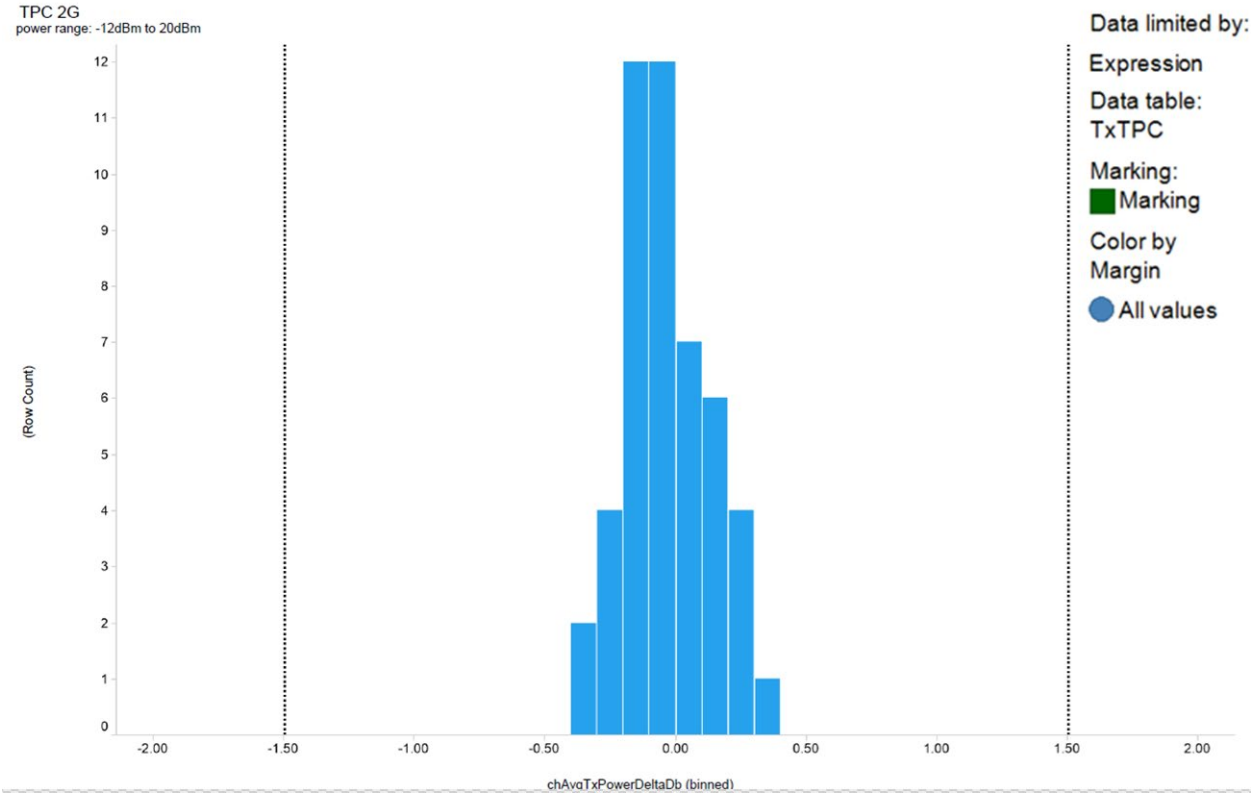
Band	Frequencies (MHz)
2.4 GHz BW20	2412, 2437, 2462, 2472
2.4 GHz BW40	2422, 2437, 2452, 2462

1.12 Summary result

Unless otherwise stated, the summary results are for each DUT and each channel tested.

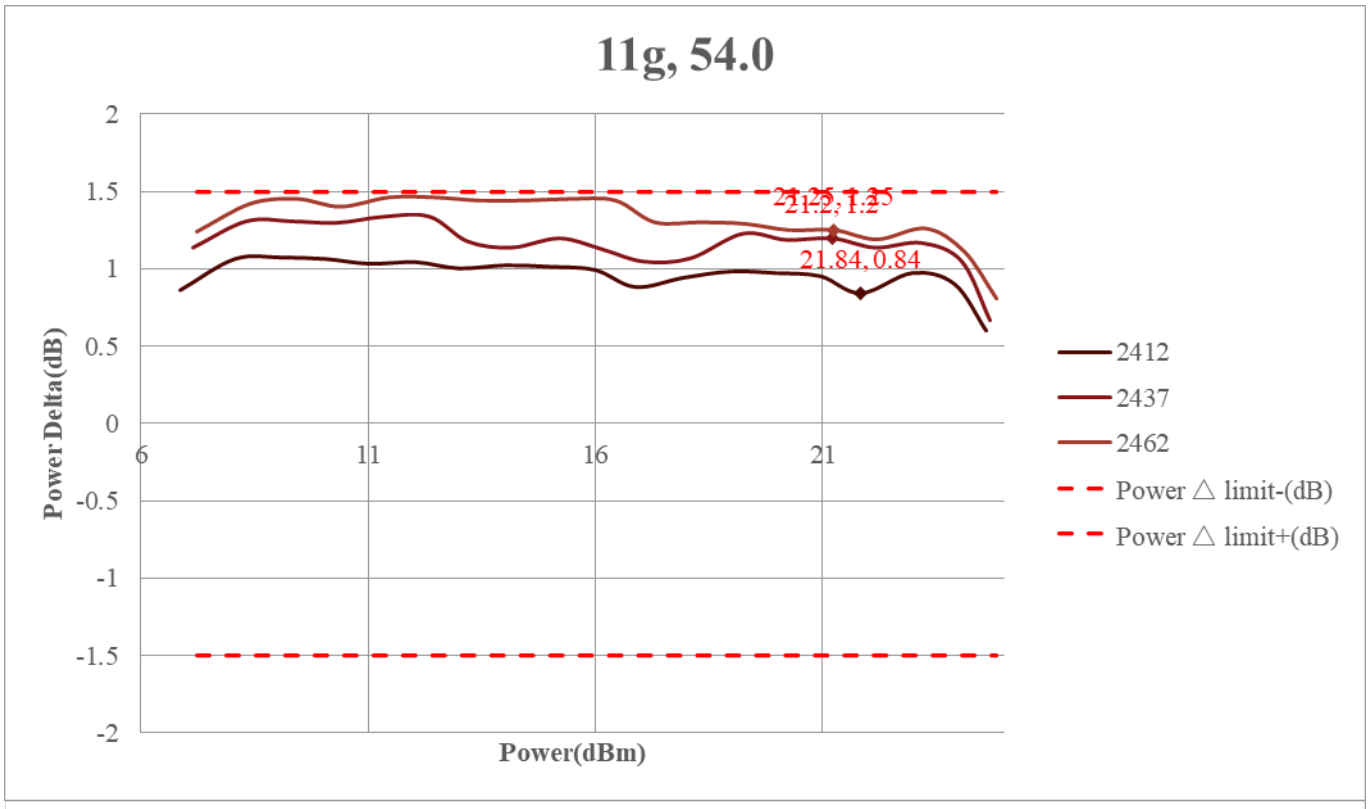
1.12.1 Tx power accuracy summary

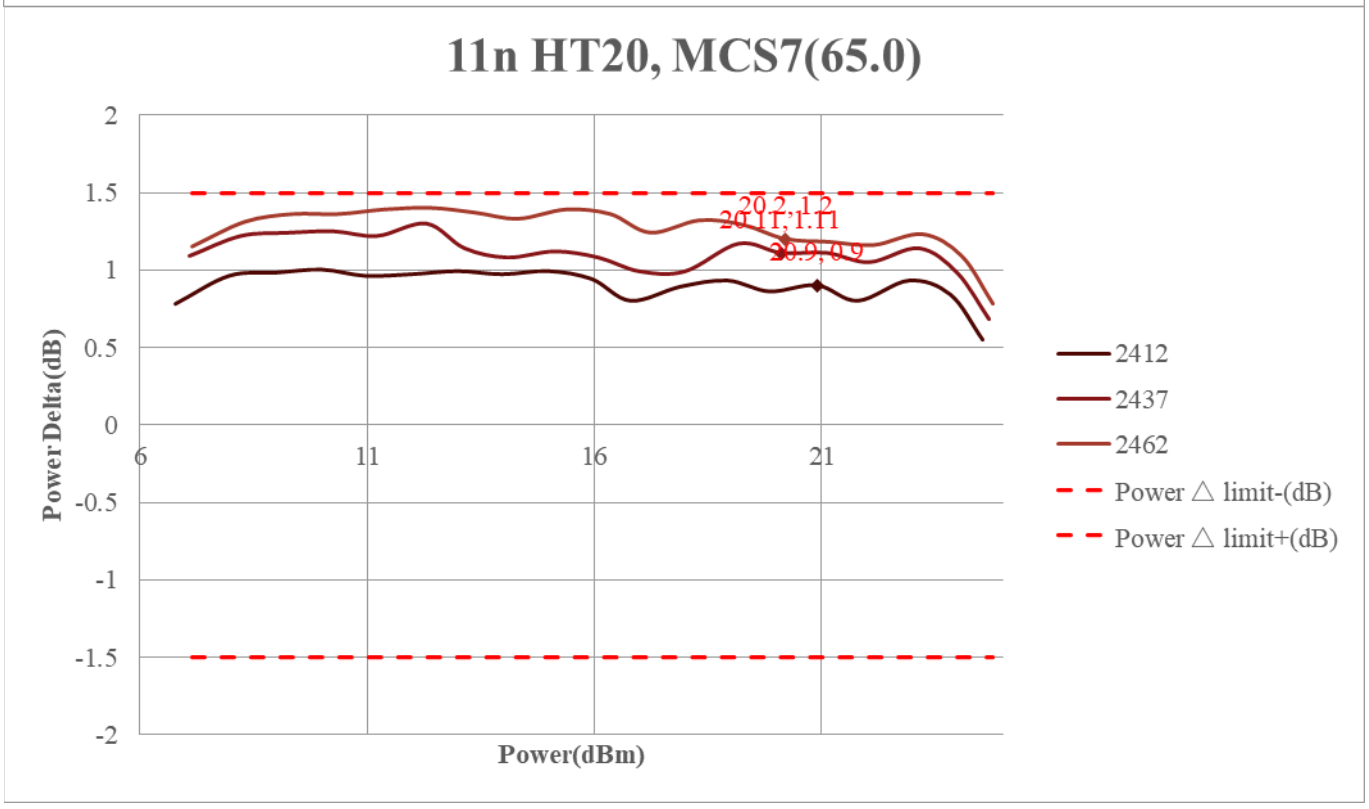
Tx power accuracy histogram 2 GHz

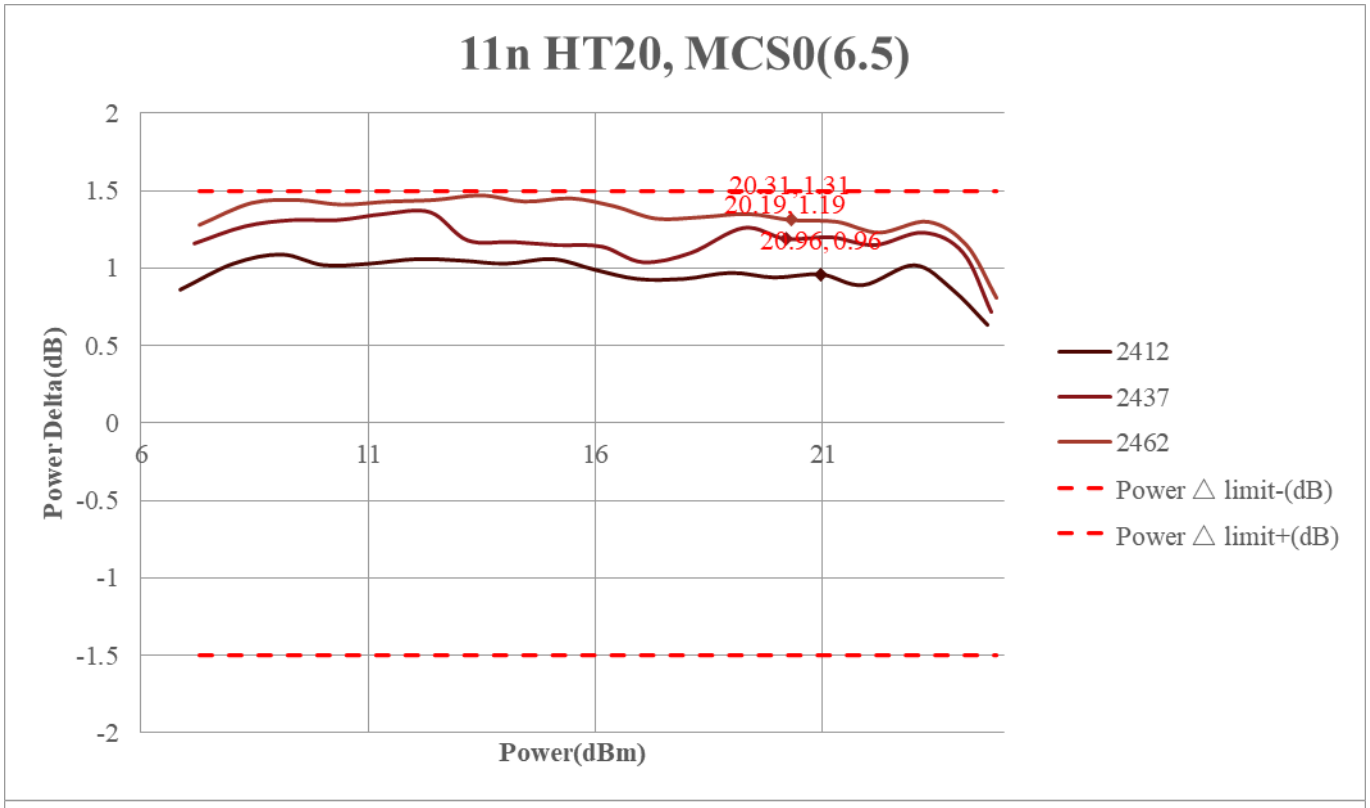


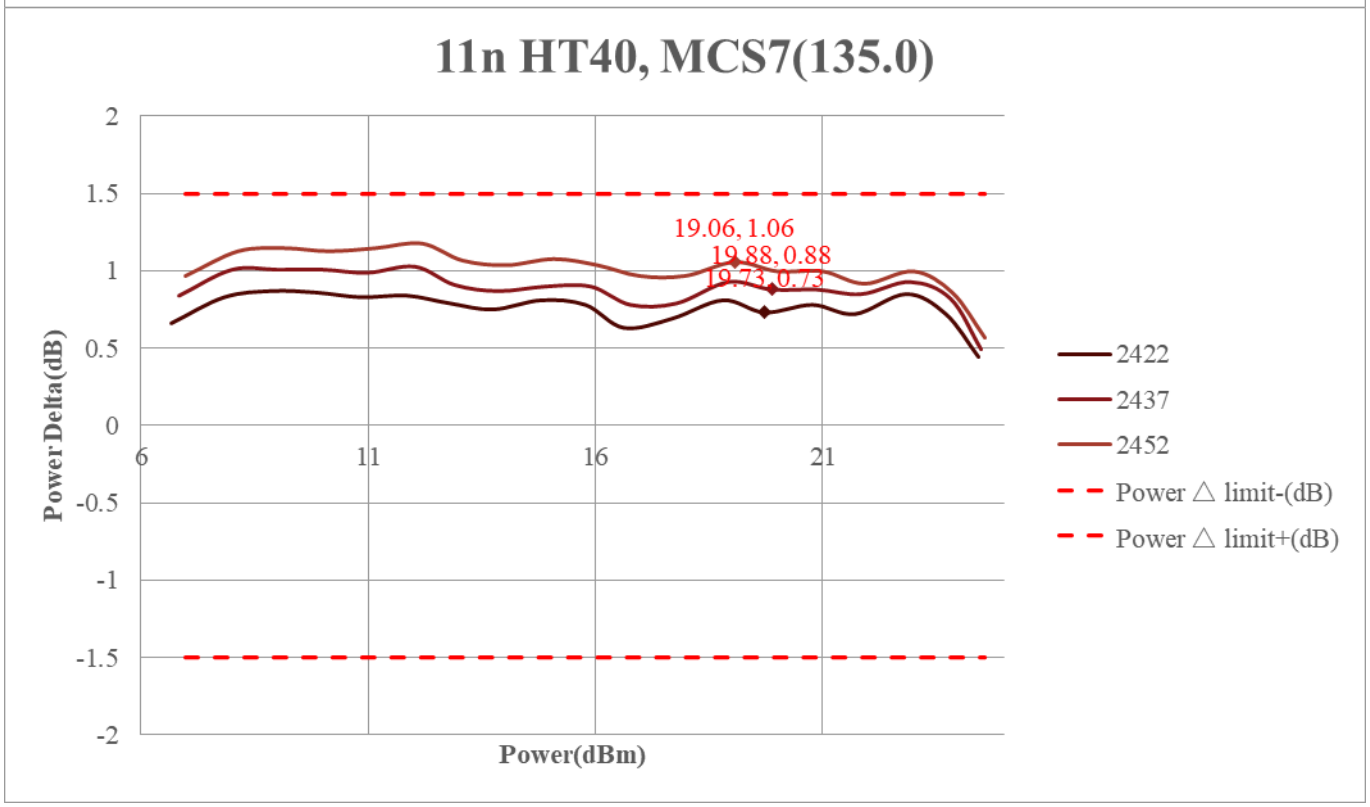
Histogram of 2 GHz transmit power accuracy for all test conditions and boards at T = 25°C

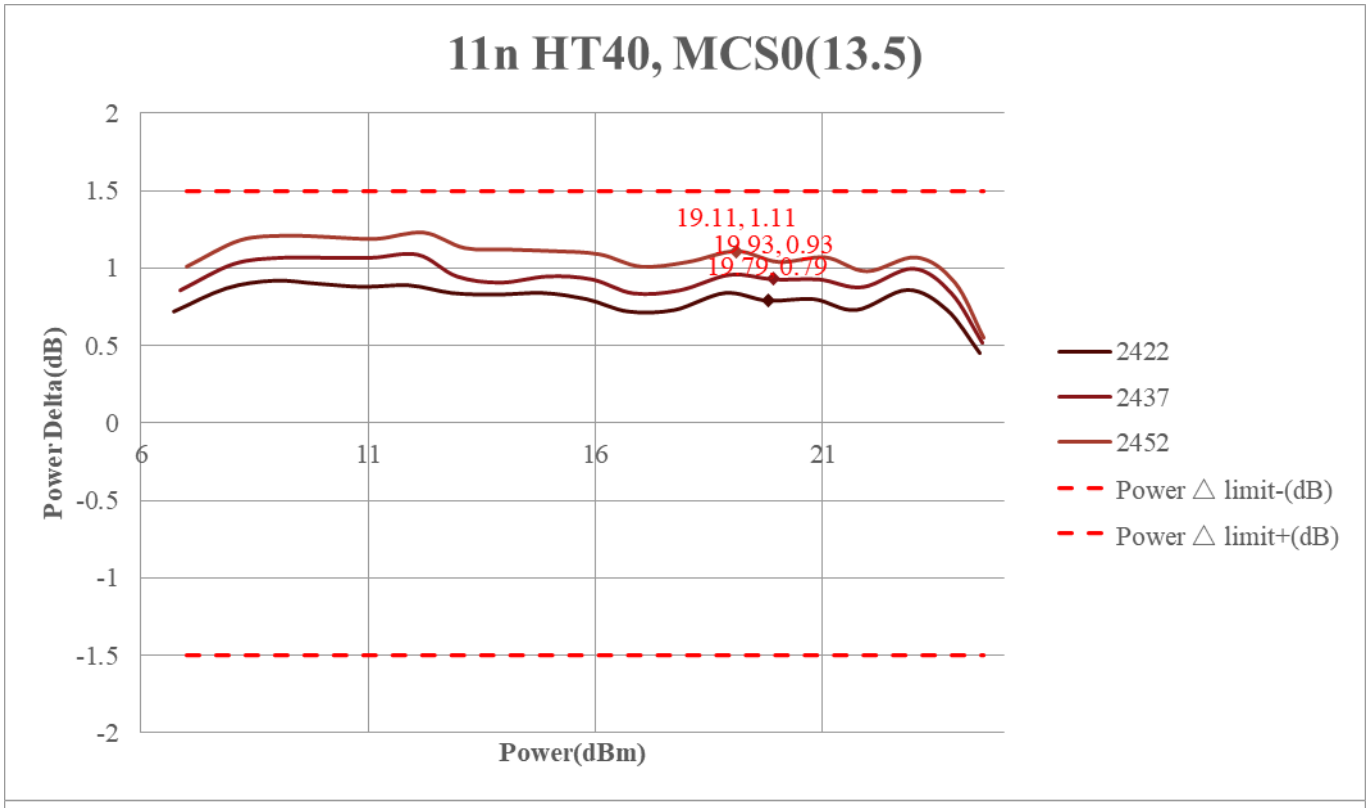
1.12.2 Tx power accuracy

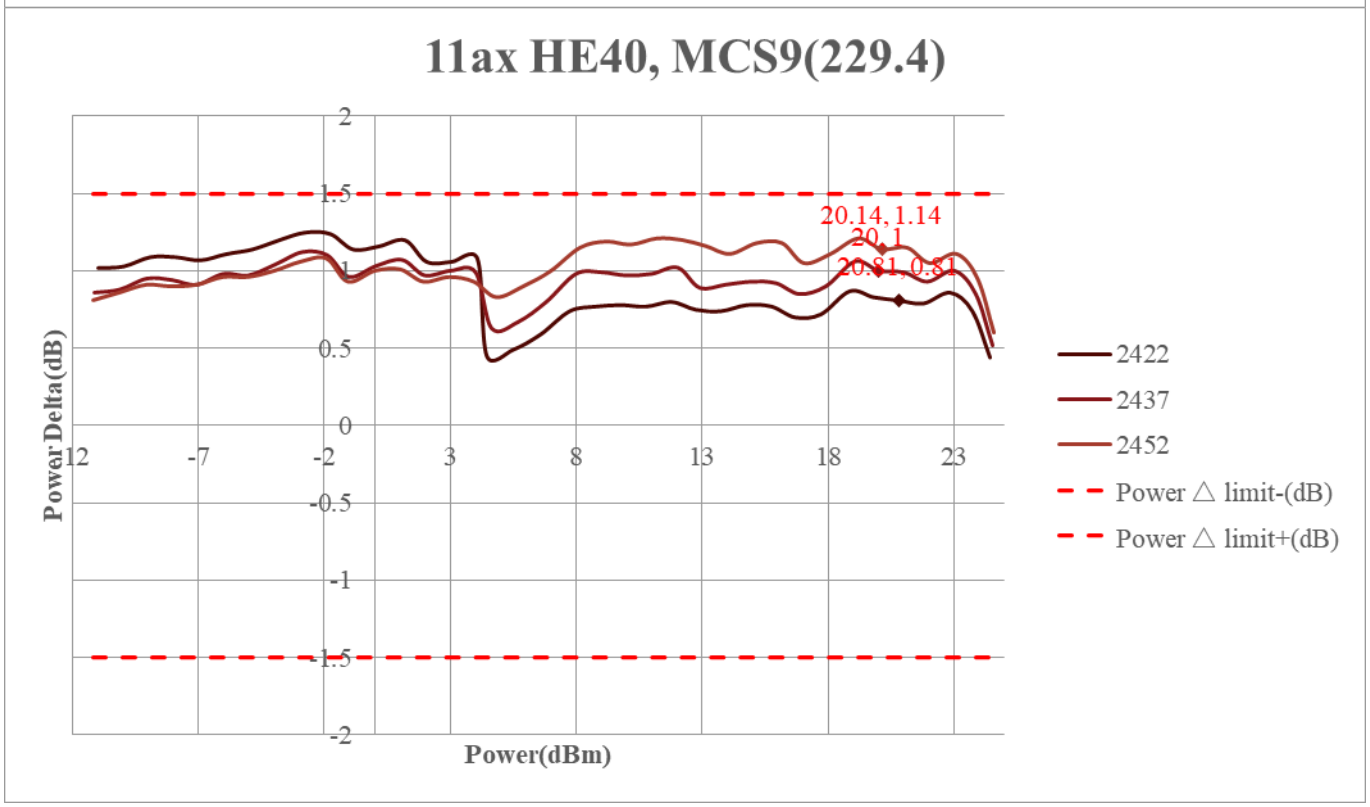


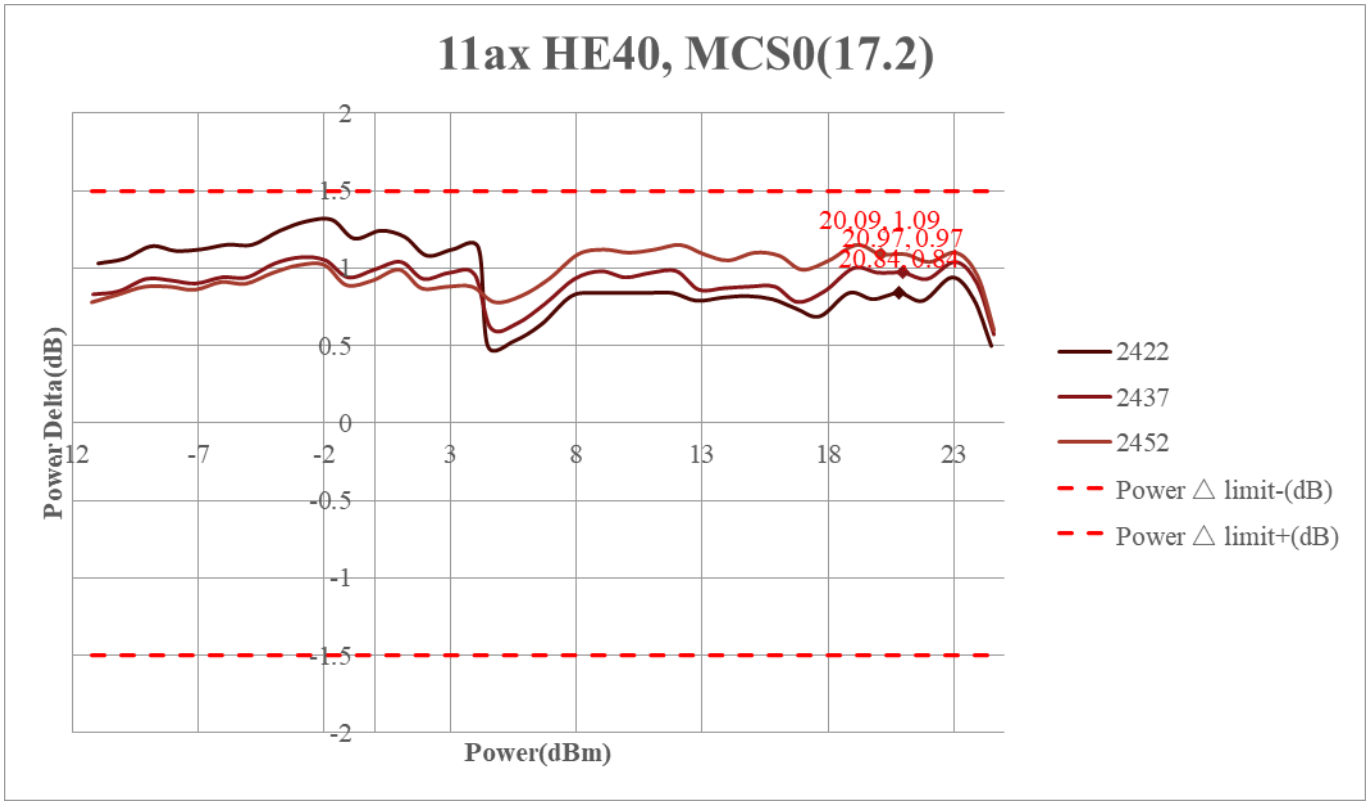



11n HT20, MCS0(6.5)
20.31, 1.31
20.19, 1.19
20.96, 0.96
Power Delta(dB)
Power(dBm)
2412
2437
2462
Power △ limit-(dB)
Power △ limit+(dB)


11n HT40, MCS7(135.0)
19.06, 1.06
19.88, 0.88
19.73, 0.73
Power Delta(dB)
Power(dBm)
2422
2437
2452
Power △ limit-(dB)
Power △ limit+(dB)


11n HT40, MCS0(13.5)
19.11, 1.11
19.93, 0.93
19.79, 0.79
Power Delta(dB)
Power(dBm)
2422
2437
2452
Power △ limit-(dB)
Power △ limit+(dB)


11ax HE40, MCS9(229.4)
20.14, 1.14
20.1
20.81, 0.81
Power Delta(dB)
Power(dBm)
2422
2437
2452
Power △ limit-(dB)
Power △ limit+(dB)



Observations:

All tests meet transmit power accuracy of +/- x dB.

Table 1-12 Tx target power 2 GHz

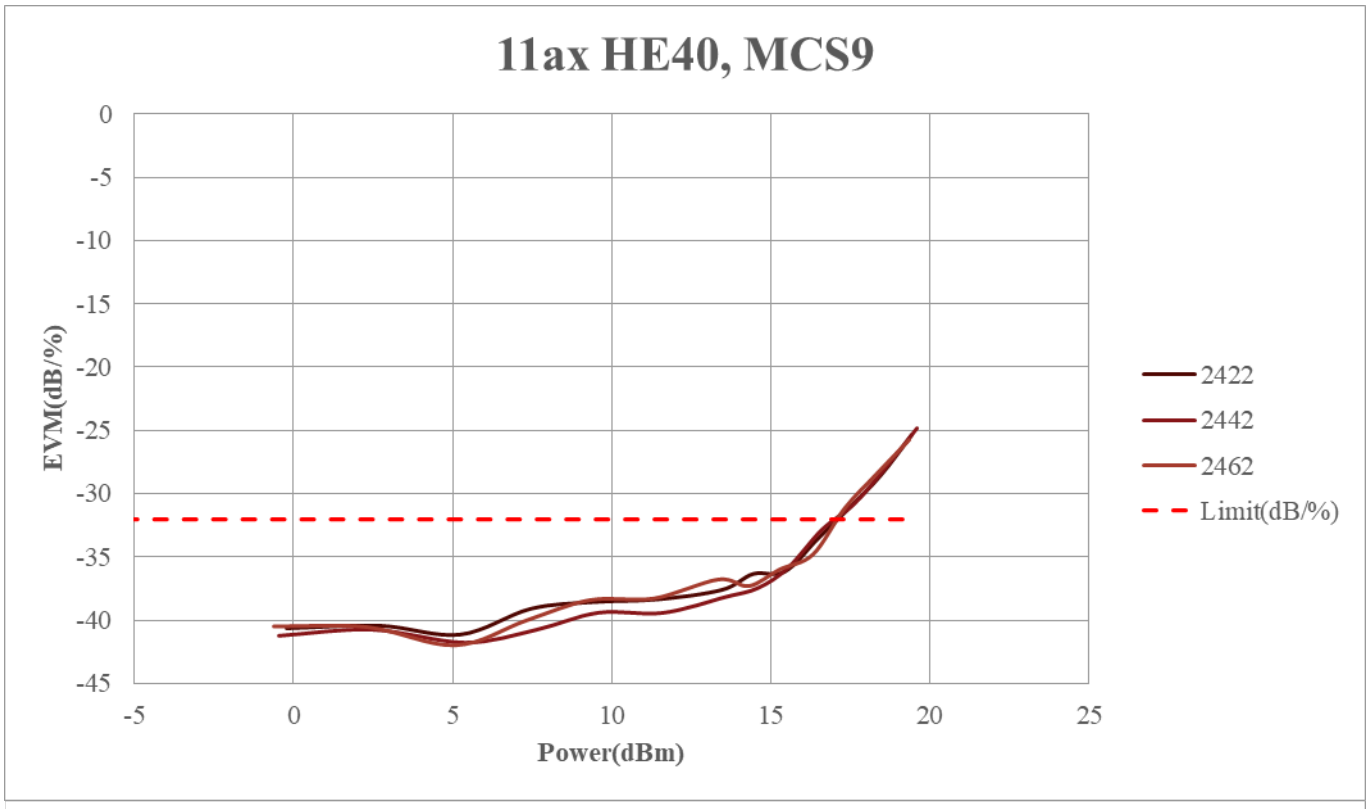
RateName	Nss	Ntx	PowerLevel	Median (txPowerAvg)
11B_1Mbps	-	1	22.00	21.9
11B_11Mbps	-	1	22.00	21.9
11G_6Mbps	-	1	22.00	21.8
11G_54Mbps	-	1	20.00	19.8
11N_HT20_MCS0	1	1	22.00	21.8
11N_HT20_MCS7	1	1	20.00	19.8
11N_HT40_MCS0	1	1	22.00	21.7
11N_HT40_MCS7	1	1	20.00	19.7
11ax_HE20_MCS0	1	1	20.00	19.5
11ax_HE20_MCS9	1	1	18.00	17.4
11ax_HE40_MCS0	1	1	20.00	19.4
11ax_HE40_MCS9	1	1	17.00	16.4

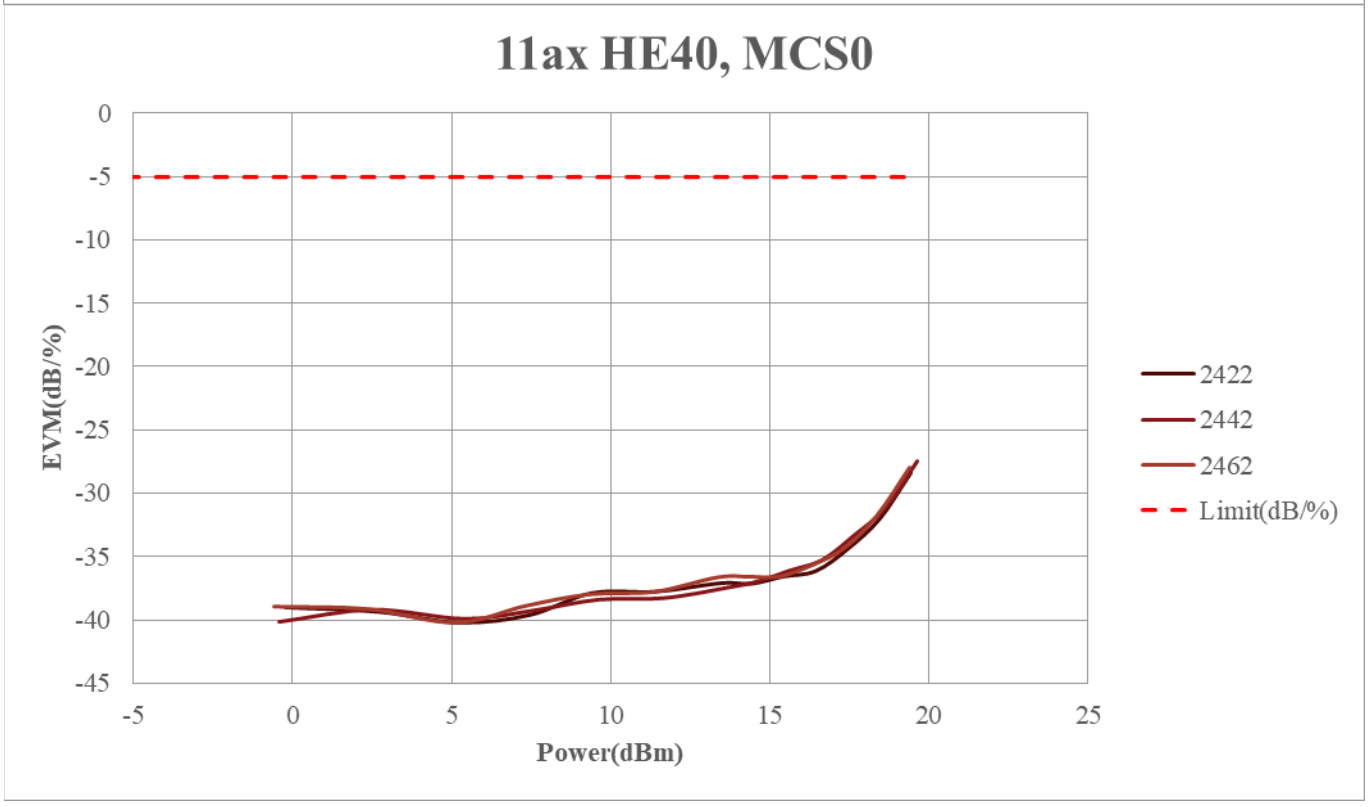
1.12.3 Tx EVM summary

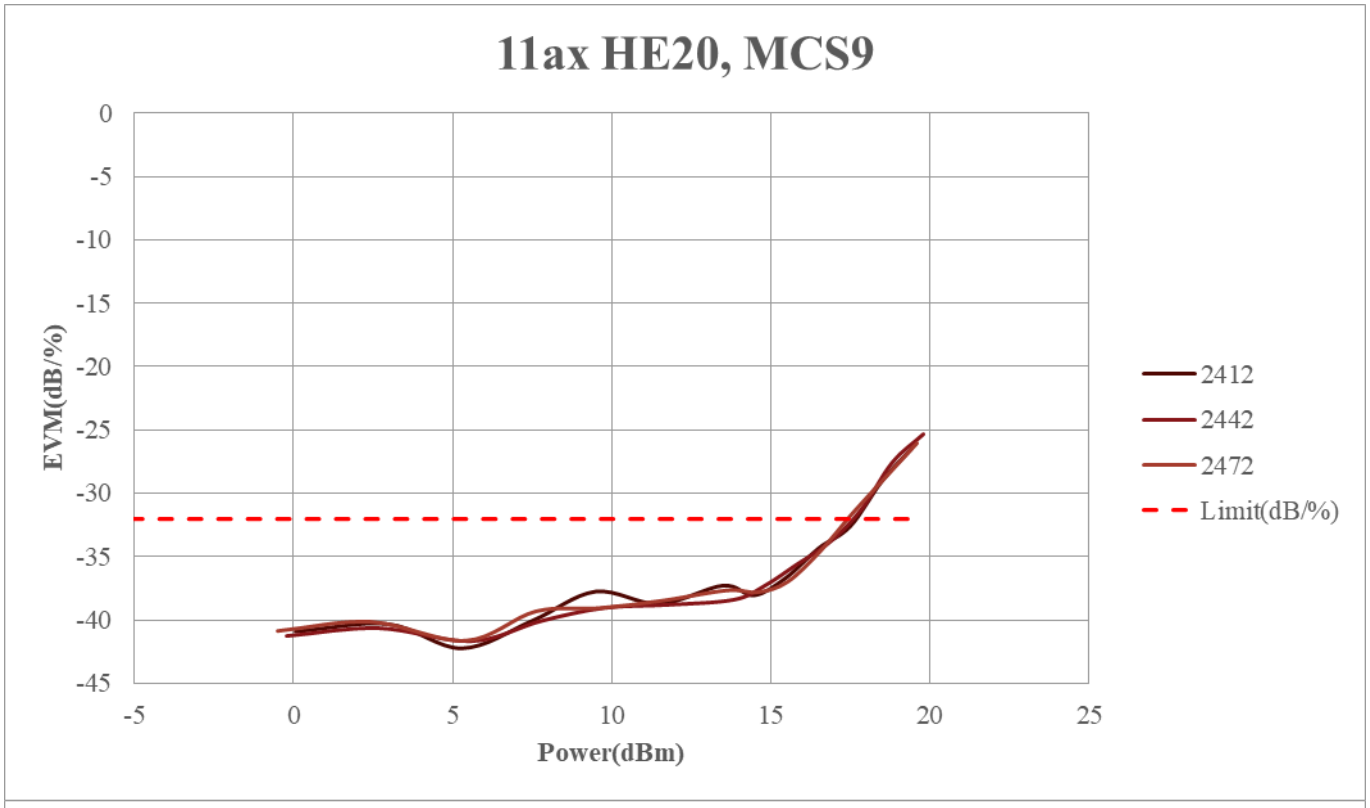
Table 1-13 Tx EVM summary 2.4 GHz

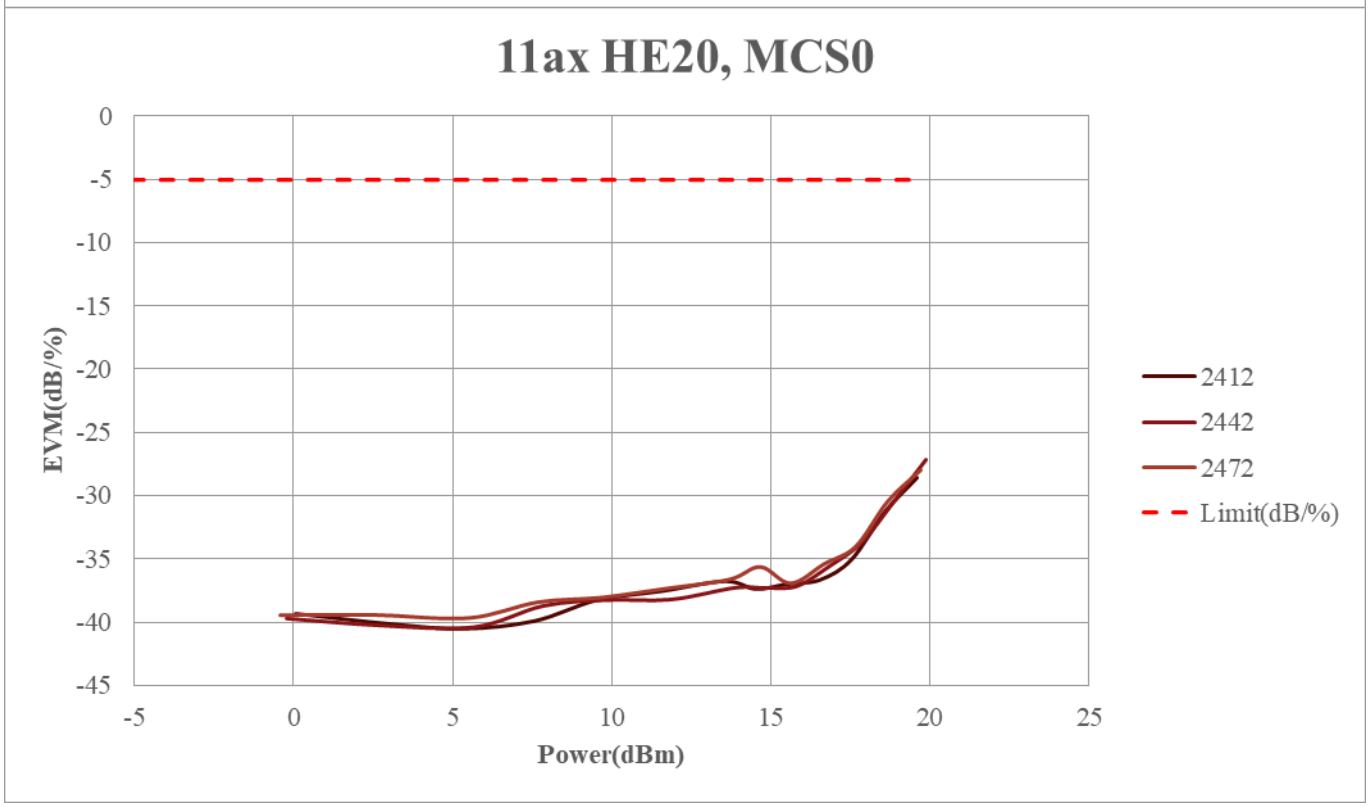
RateName	Nss	Ntx	PowerLevel	chEstimationMethod	Median (evm)
11G_54Mbps	-	1	16	preambleOnly	-35.7
11N_HT20_MCS7	1	1	15	preambleOnly	-35.2
11N_HT40_MCS7	1	1	12	preambleOnly	-35.1
11ax_HE20_MCS9	1	1	16	preambleOnly	-36.7
11ax_HE40_MCS9	1	1	16	preambleOnly	-36.1

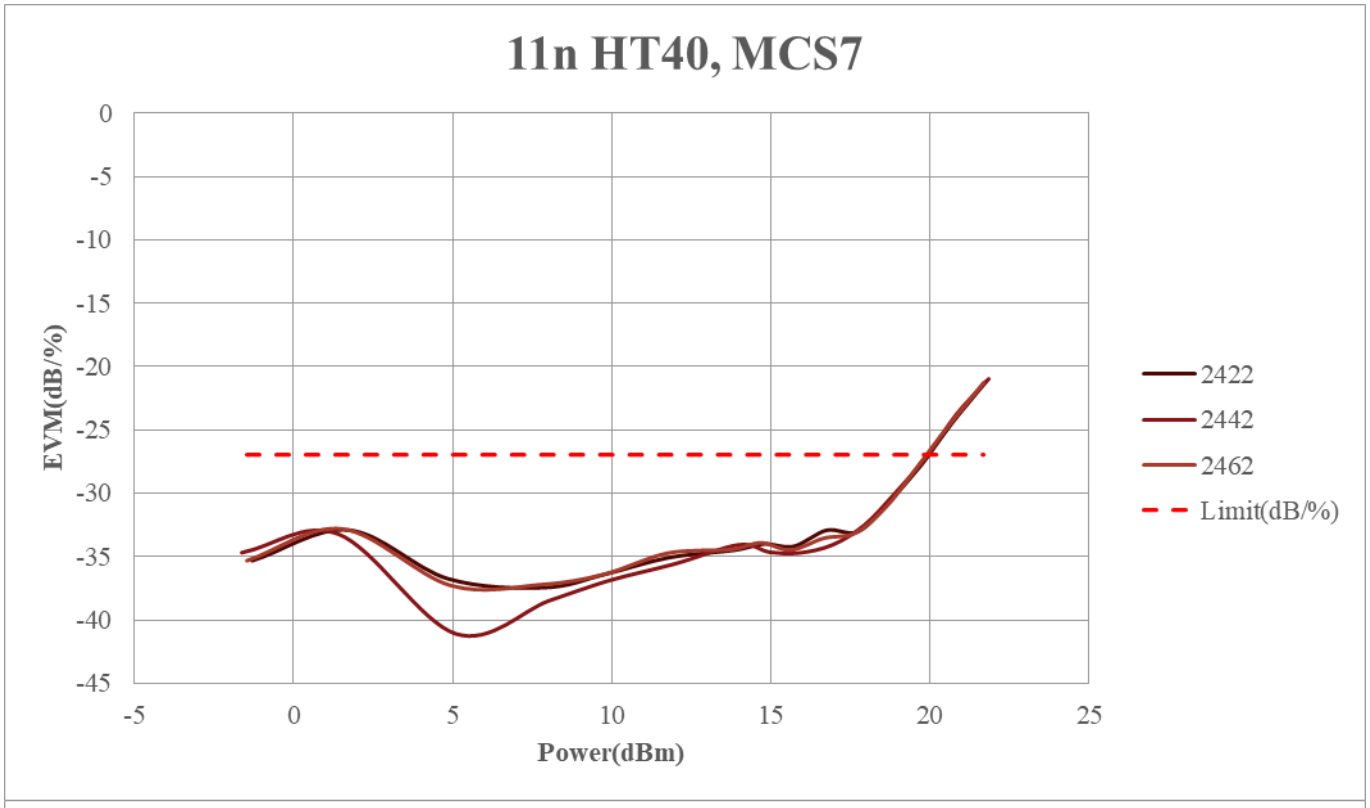
1.12.4 Tx power vs. EVM

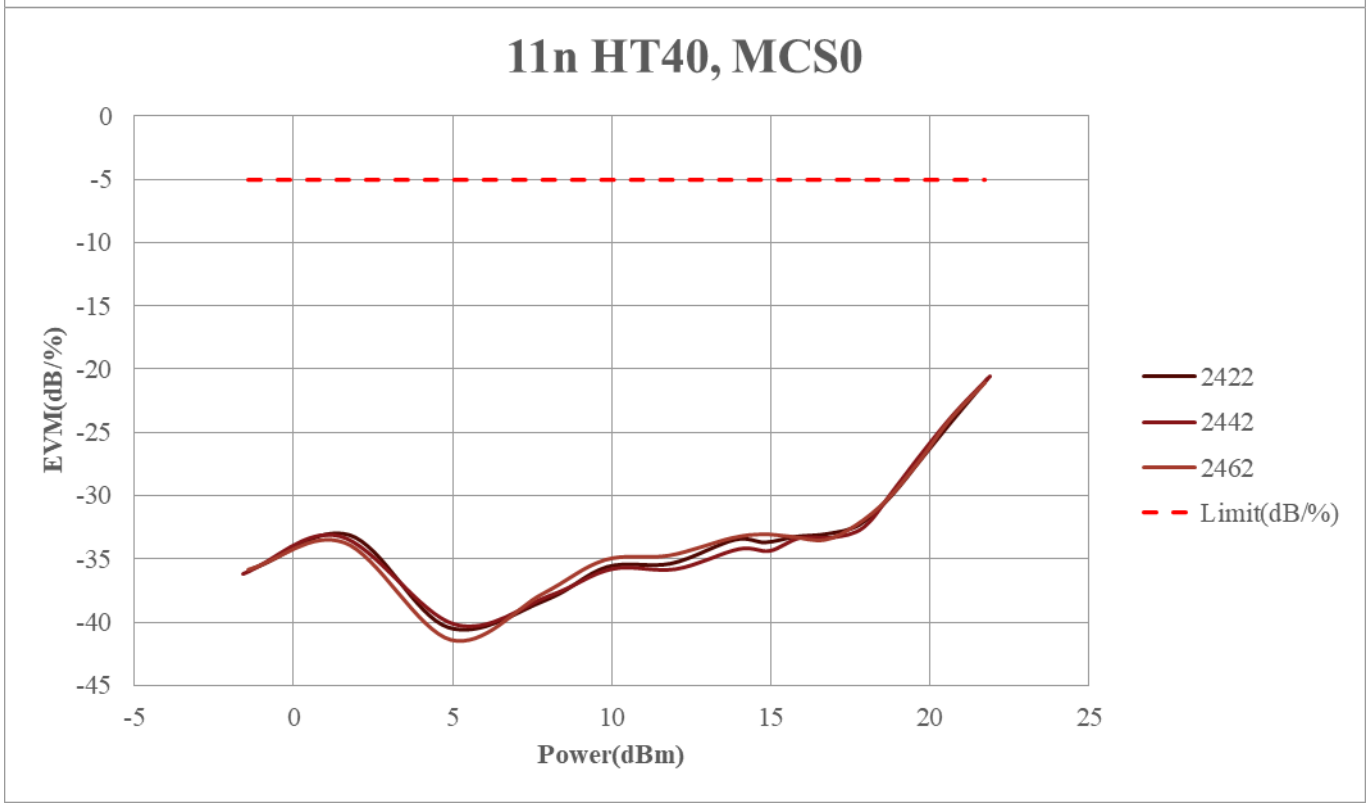


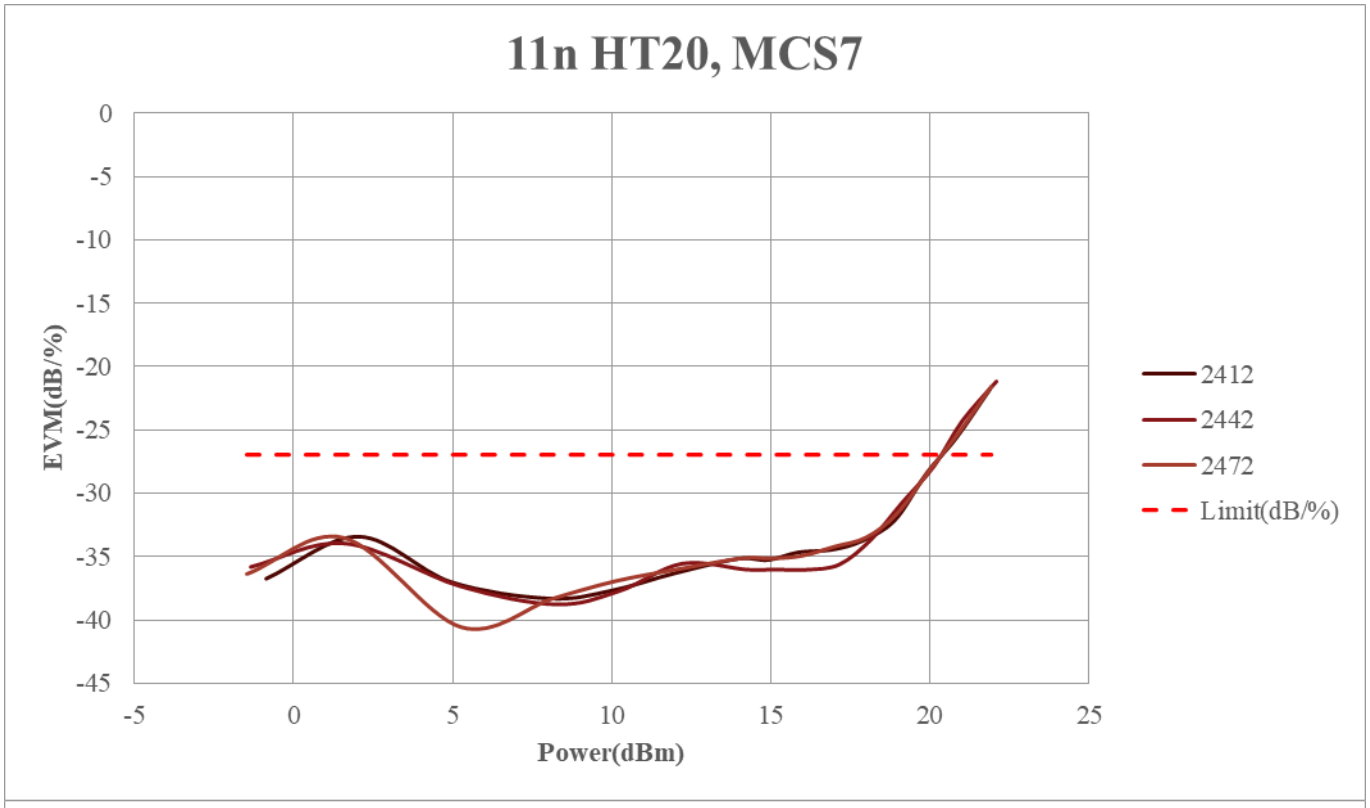


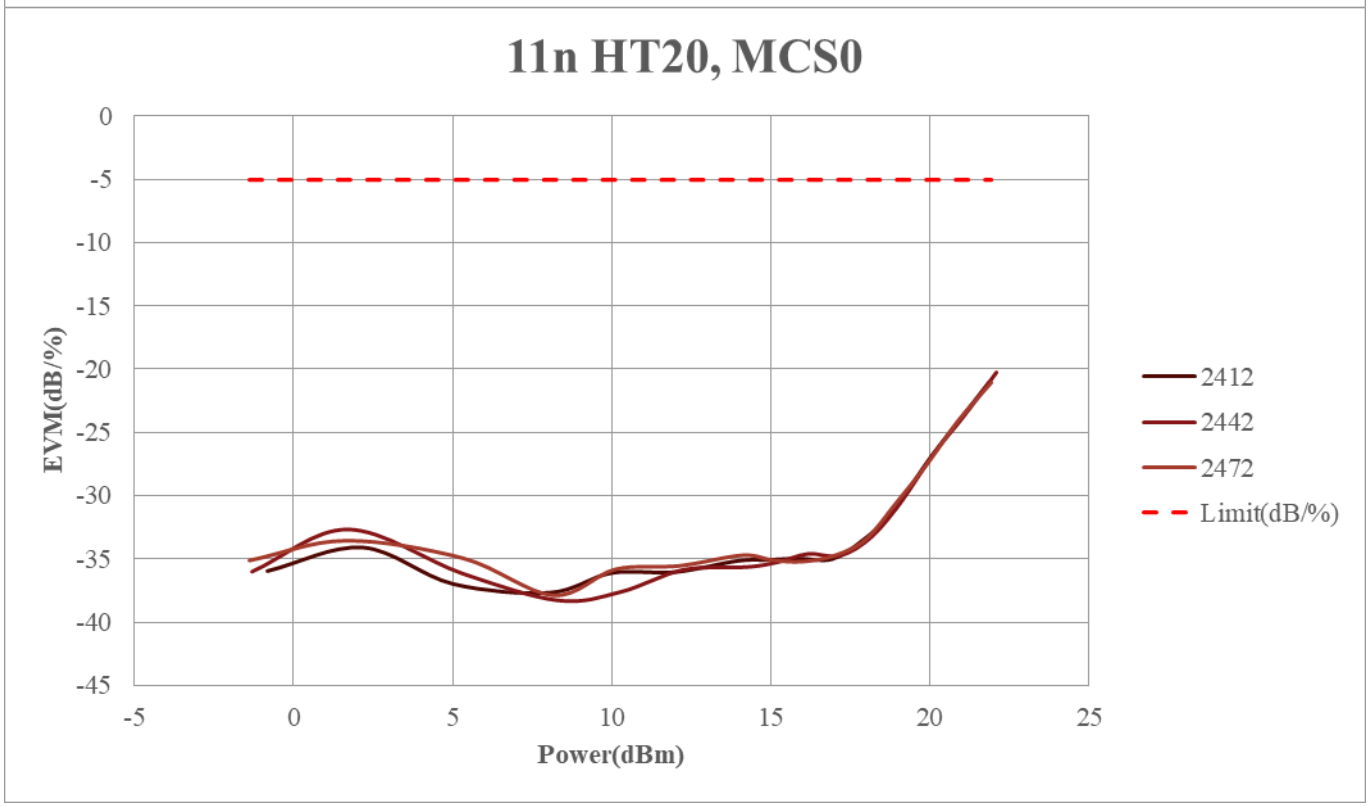

11ax HE20, MCS9
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472
Limit(dB/%)

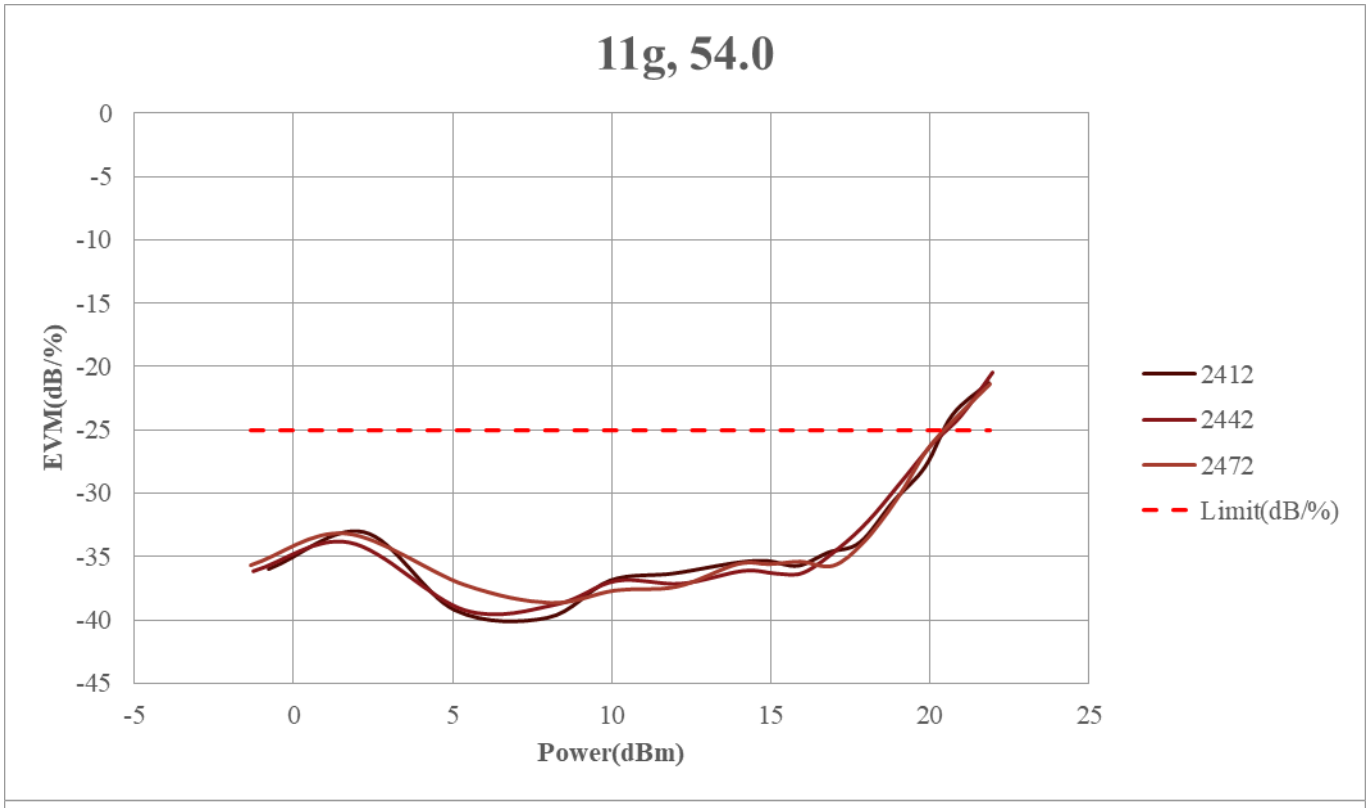

11ax HE20, MCS0
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472
Limit(dB/%)

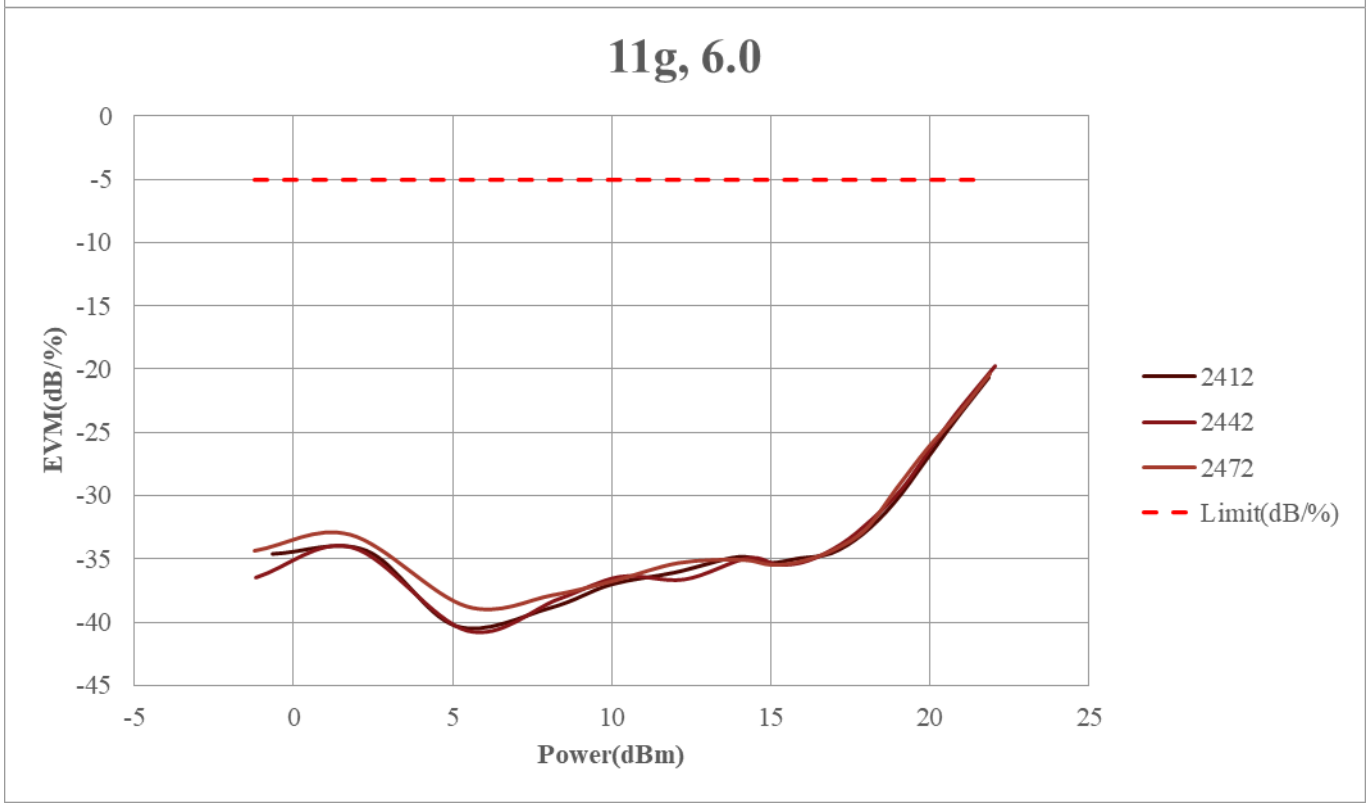

11n HT40, MCS7
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2422
2442
2462
Limit(dB/%)

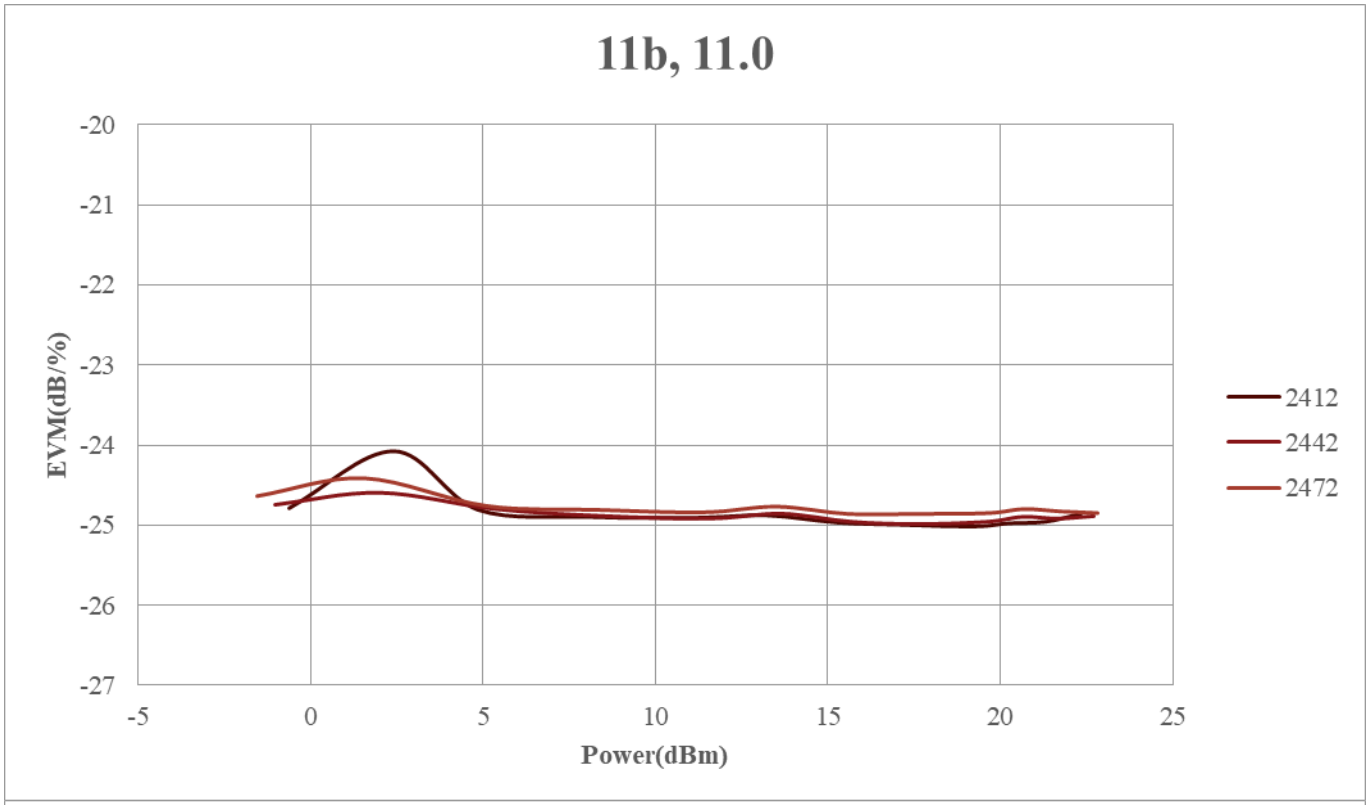

11n HT40, MCS0
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2422
2442
2462
Limit(dB/%)

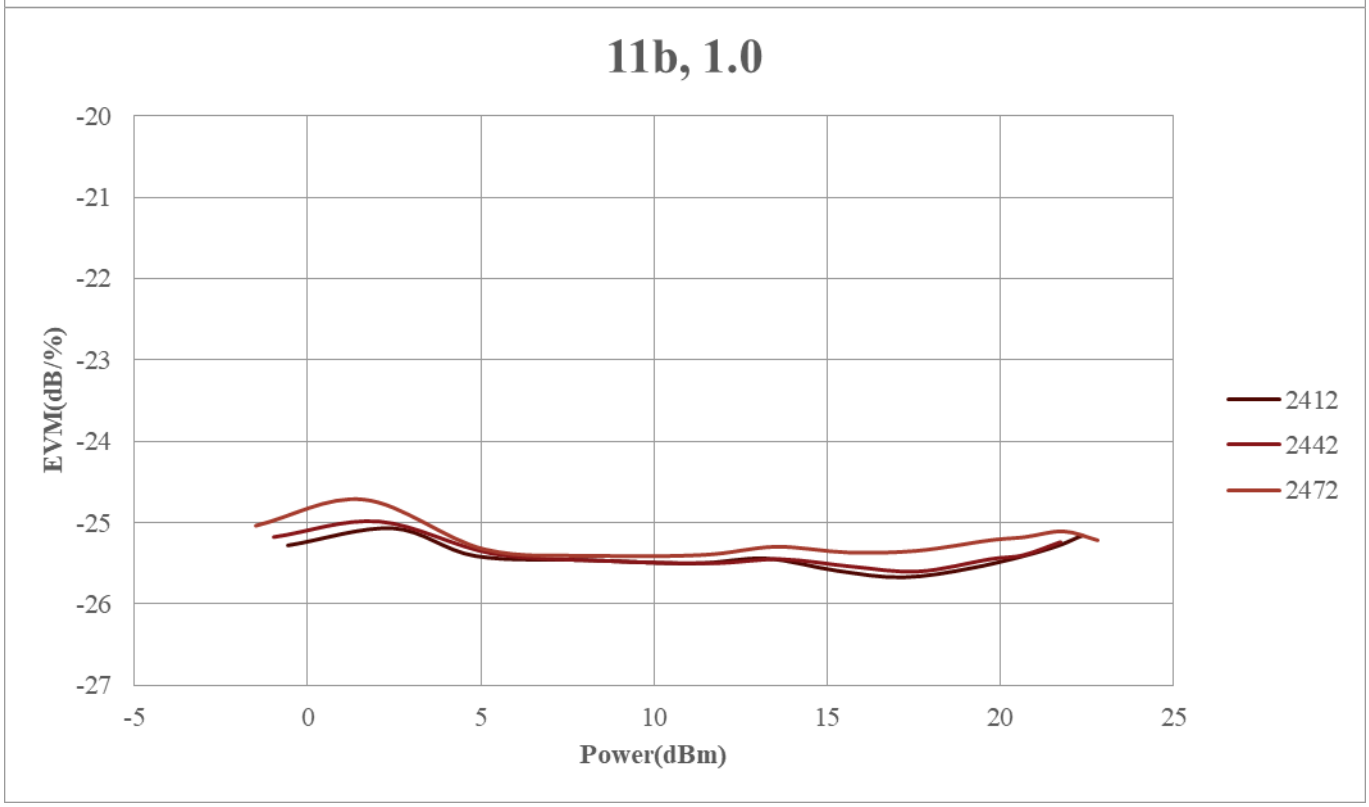

11n HT20, MCS7
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472
Limit(dB/%)


11n HT20, MCS0
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472
Limit(dB/%)


11g, 54.0
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472
Limit(dB/%)


11g, 6.0
EVM(dB/%)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472
Limit(dB/%)


11b, 11.0
EVM(dB/%)
-20
-21
-22
-23
-24
-25
-26
-27
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472


11b, 1.0
EVM(dB/%)
-20
-21
-22
-23
-24
-25
-26
-27
-5
0
5
10
15
20
25
Power(dBm)
2412
2442
2472

1.12.5 Tx spectral mask summary

Table 1-14 Tx mask summary 2.4 GHz

Modulation	Rate	Channel	Power level (dBm)	Mask Margin (dB)
11b	1Mbps	2412	21	8.8
		2442	21	8.5
		2472	21	6.8
	11Mbps	2412	21	10.4
		2442	21	9.1
		2472	21	6.9
11g	6Mbps	2412	20	7.2
		2442	20	5.8
		2472	20	6.1
	54Mbps	2412	18	9.4
		2442	18	9.7
		2472	18	9.7
11n	MCS0_20M	2412	19	4.7
		2442	19	4.2
		2472	19	4.1
	MCS0_40M	2422	18	11.6
		2442	18	10.4
		2462	18	11.1
11ax	MCS0_20M	2412	19	4.9
		2442	19	4.9
		2472	19	5.2
	MCS0_40M	2422	18	8.5
		2442	18	8.2
		2462	18	8.5

1.12.6 Tx frequency tolerance

Table 1-15 Tx frequency tolerance summary

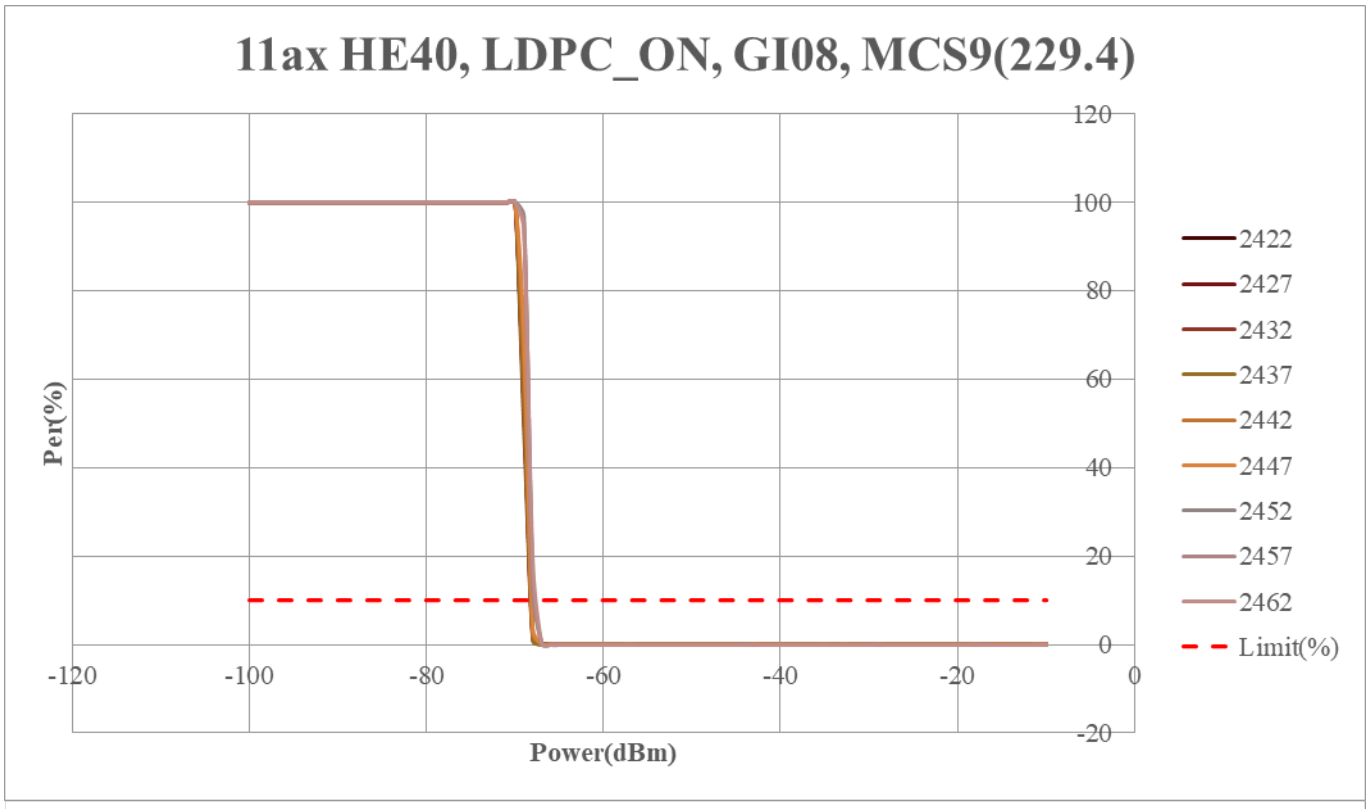
UUT_ID	2.4 GHz	
	Min (freqErr)	Max (freqErr)
D0365_CRYSTAL	-10	10
D0386_CRYSTAL	-10	10

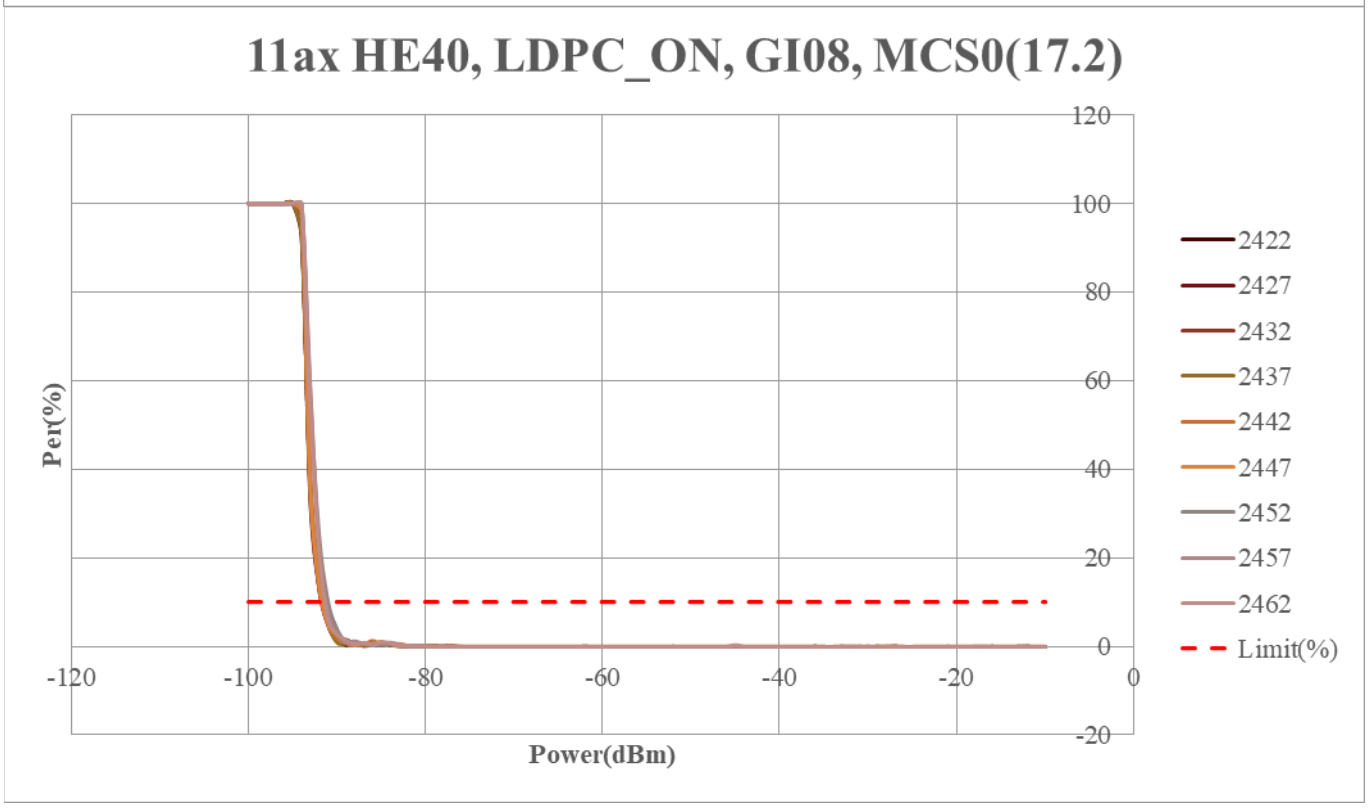
1.12.7 Rx sensitivity summary

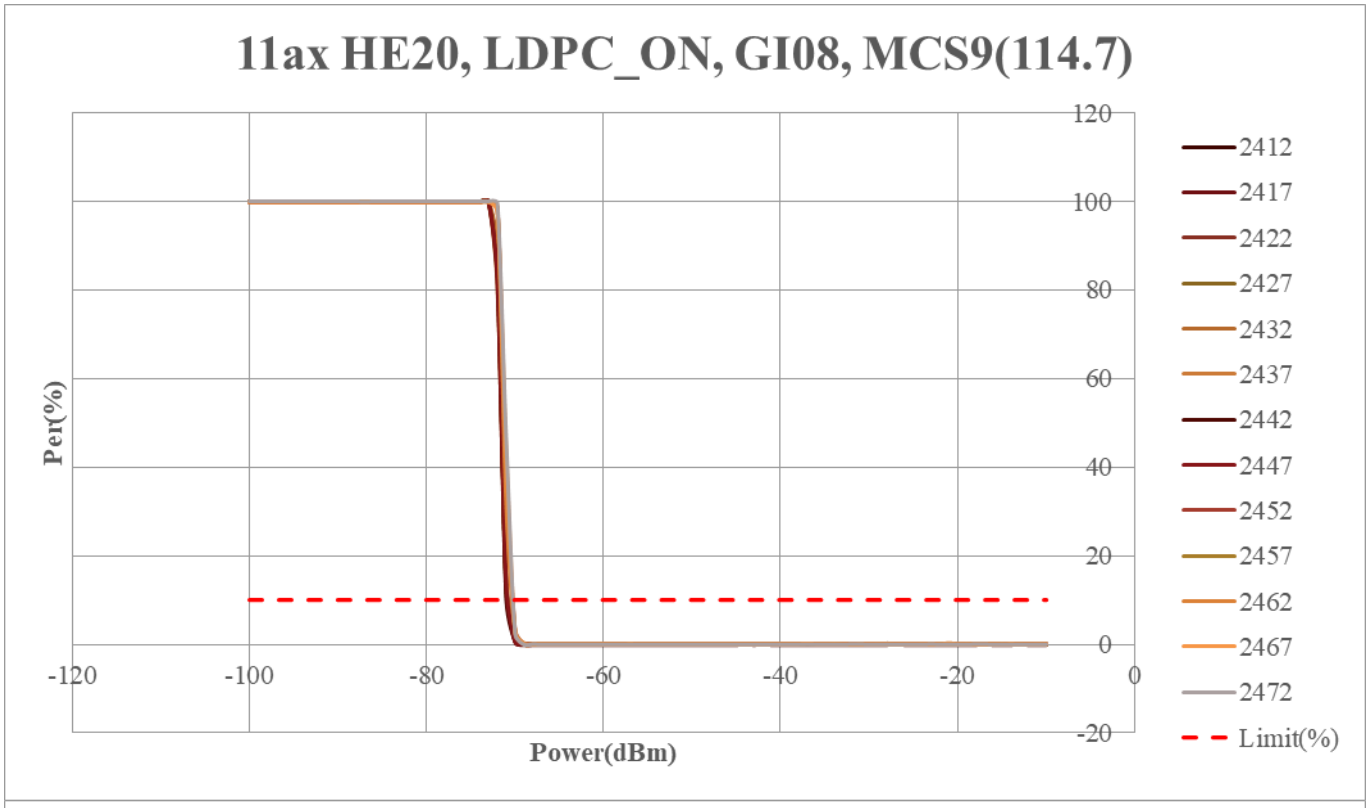
Table 1-16 Rx sensitivity per rate 2 GHz

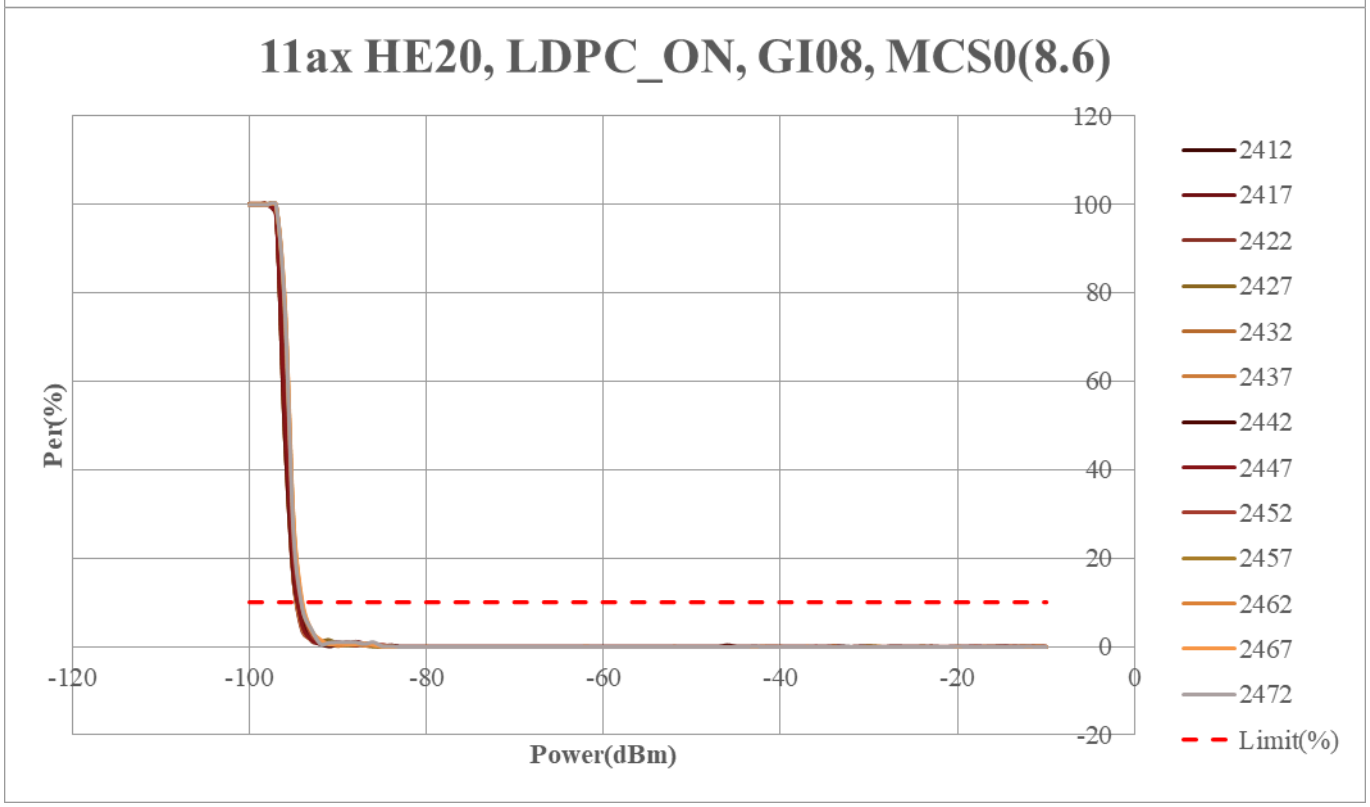
RateName	Nss	Nrx	Median (PerPower)
11B_LONG_1_MBPS	-	1	-99.5
11B_LONG_11_MBPS	-	1	-90.5
11A_6_MBPS	-	1	-93
11A_54_MBPS	-	1	-78
11N_HT20_MCS0	1	1	-89
11N_HT20_MCS7	1	1	-72
11N_HT40_MCS0	1	1	-89.0
11N_HT40_MCS7	1	1	-74
11ax_HE20_MCS0	1	1	-93
11ax_HE20_MCS9	1	1	-70
11ax_HE40_MCS9	1	1	-89.5
11ax_HE40_MCS9	1	1	-67.5

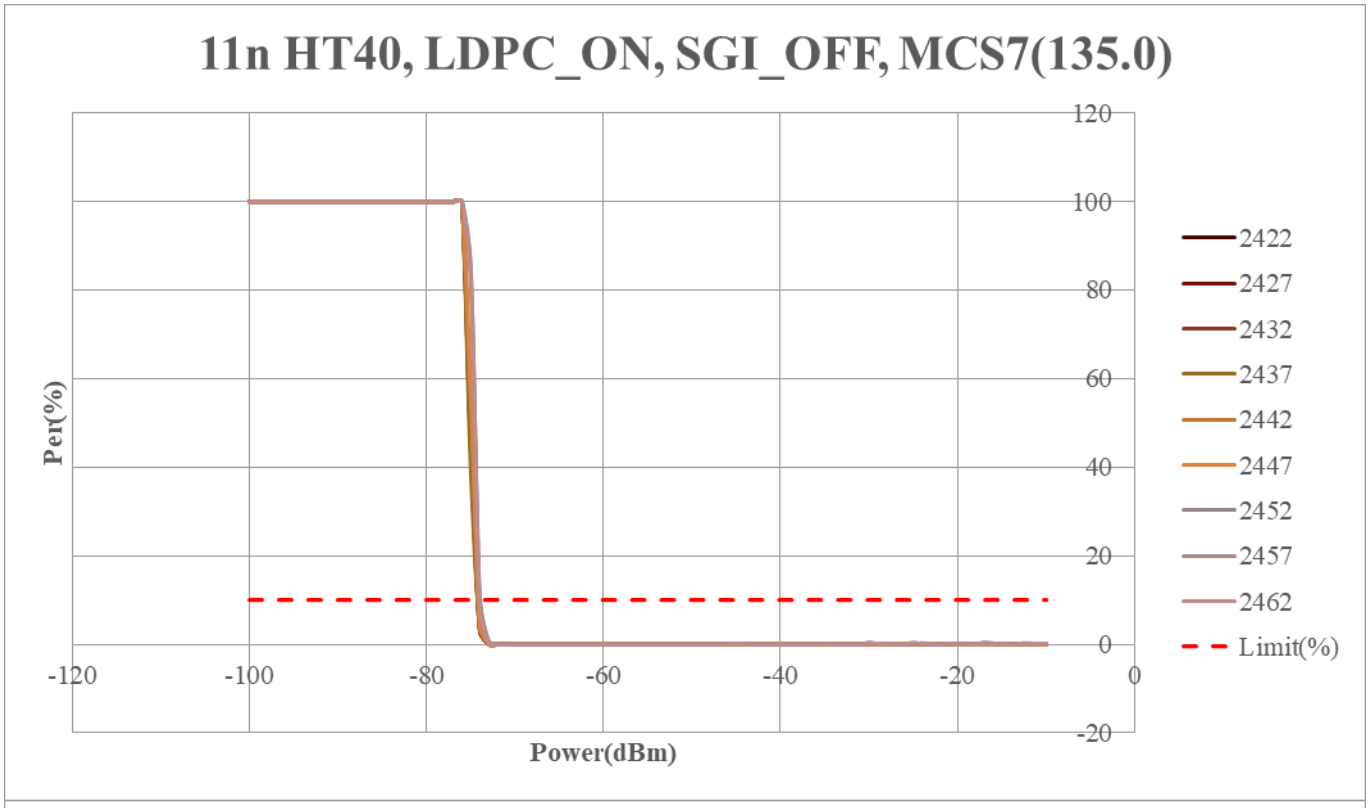
1.12.8 Waterfall plots

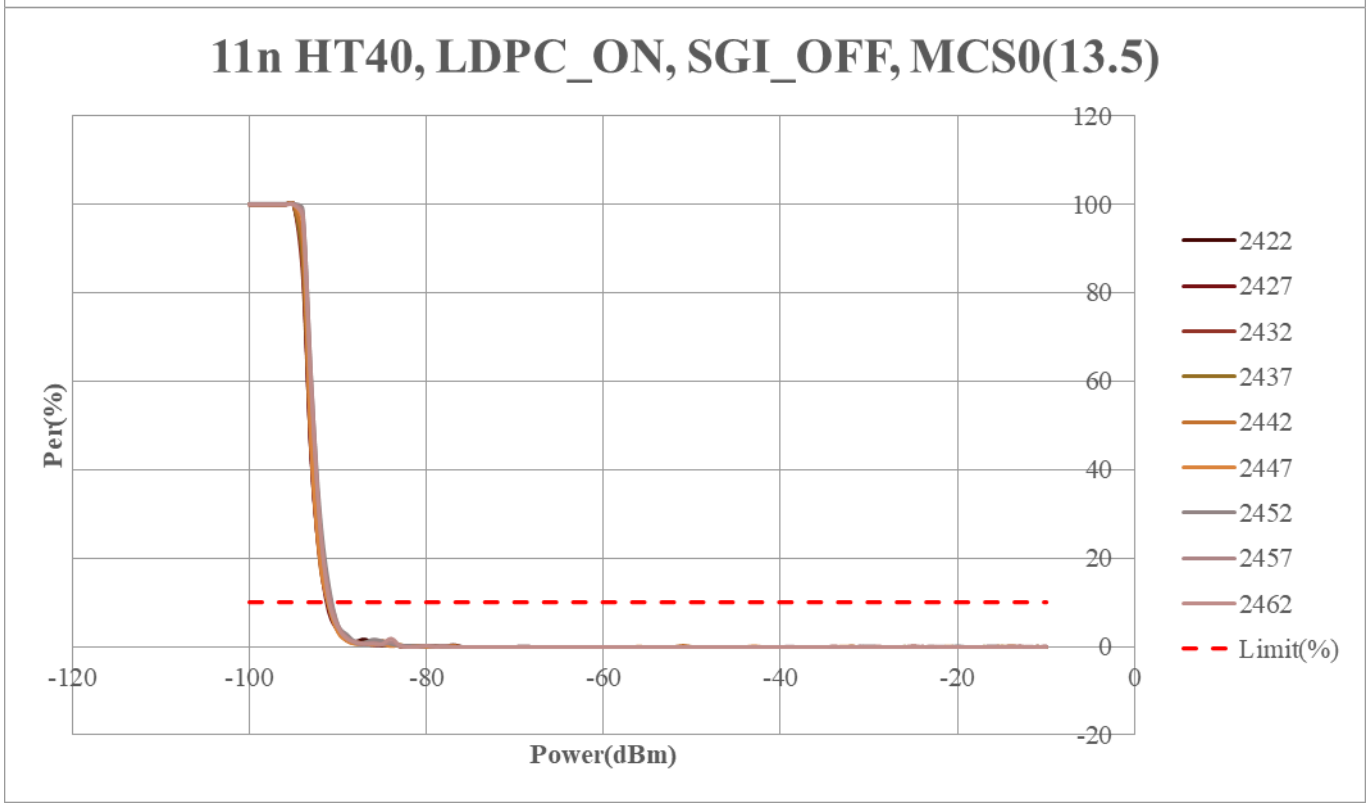


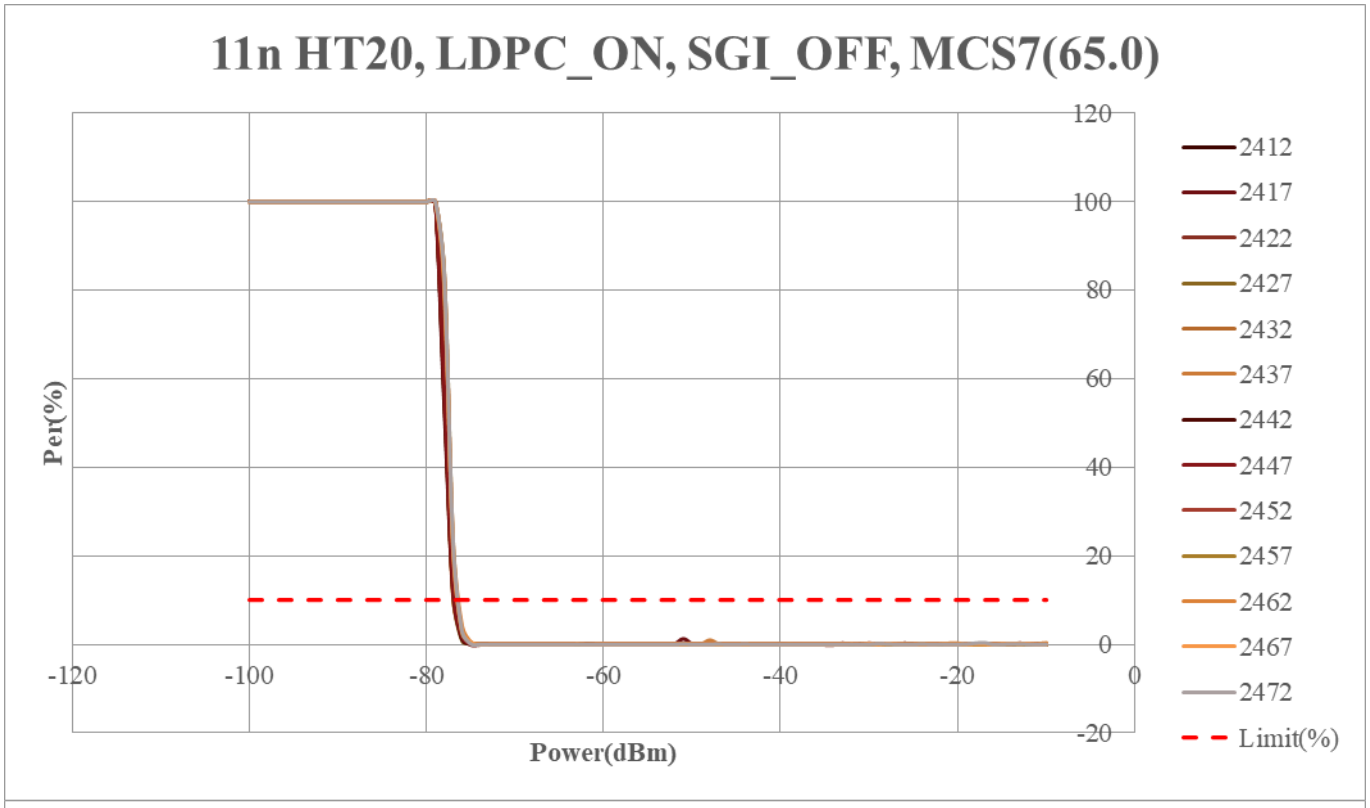


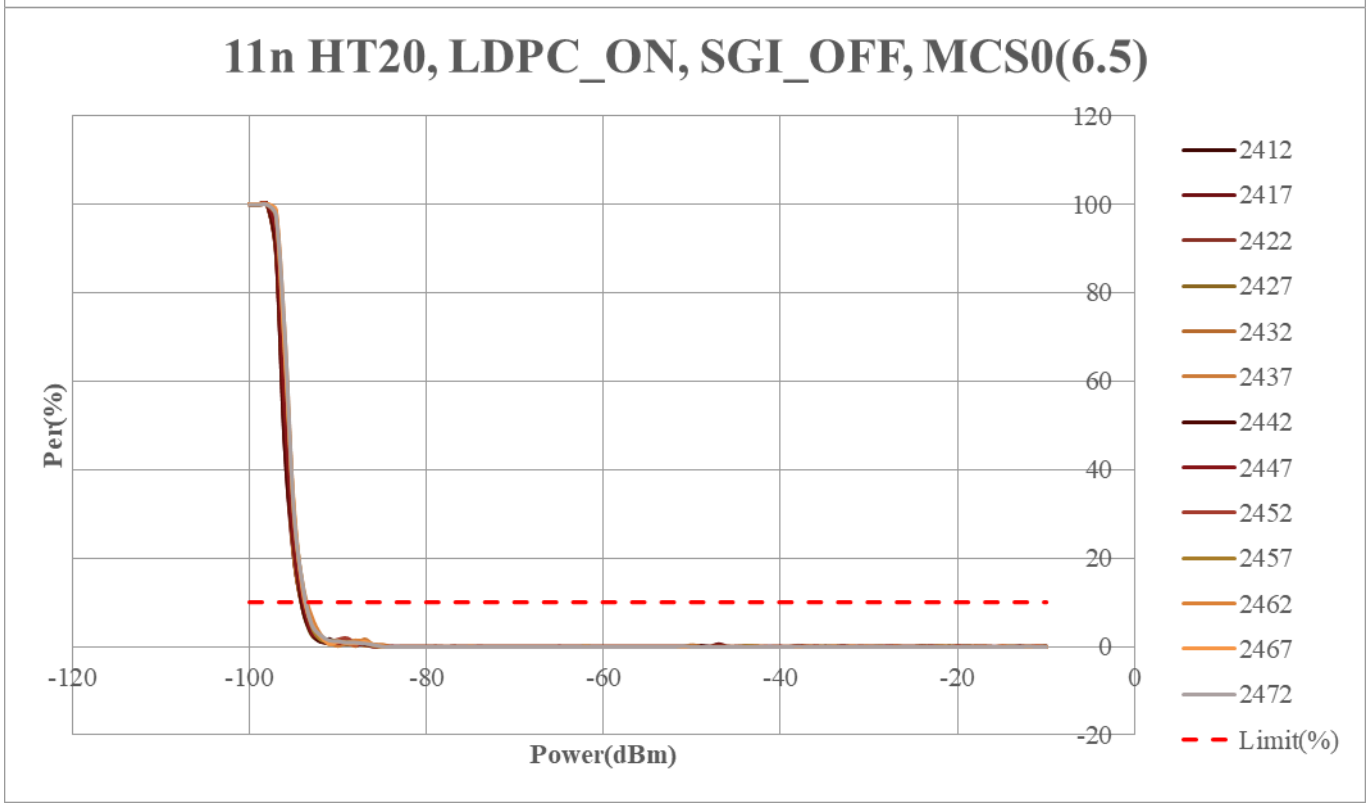

11ax HE20, LDPC_ON, GI08, MCS9(114.7)
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
Limit(%)

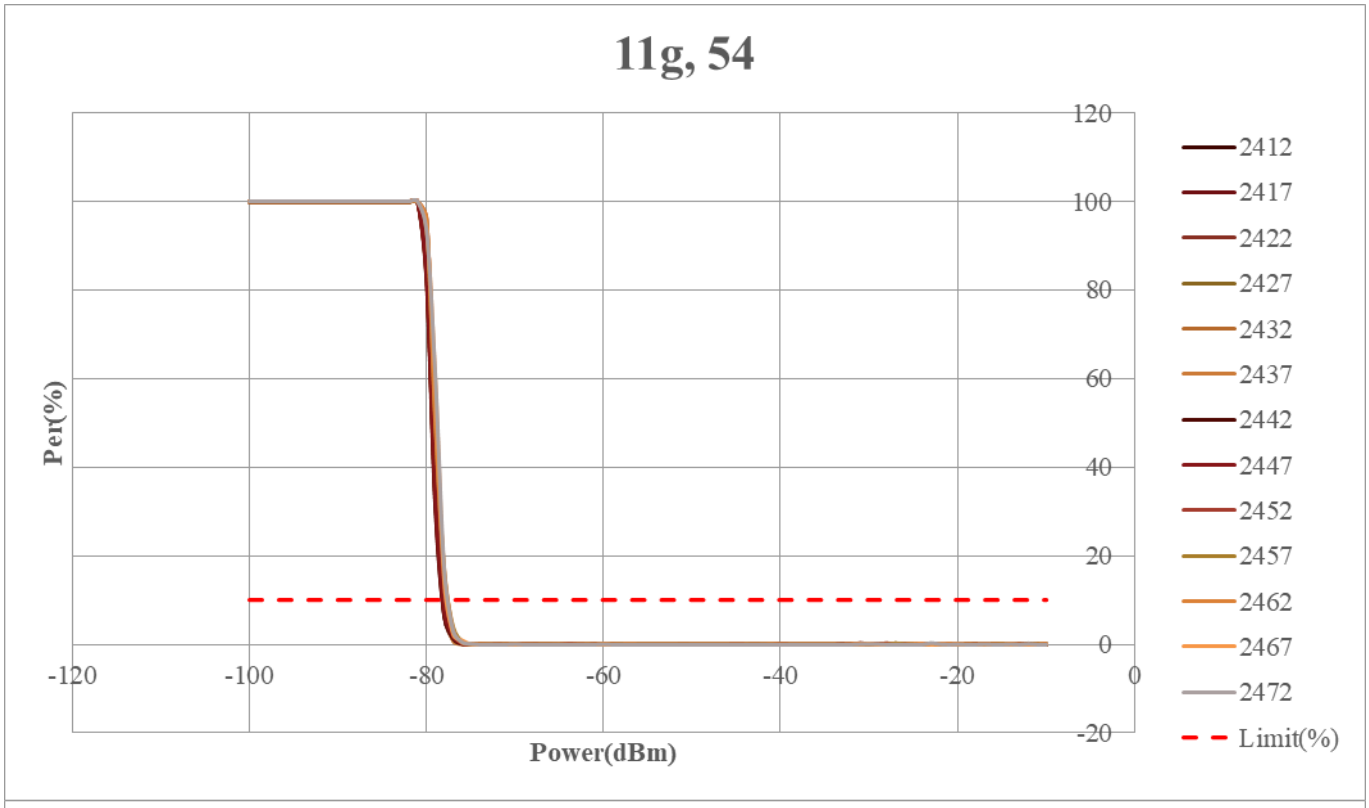

11ax HE20, LDPC_ON, GI08, MCS0(8.6)
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
Limit(%)

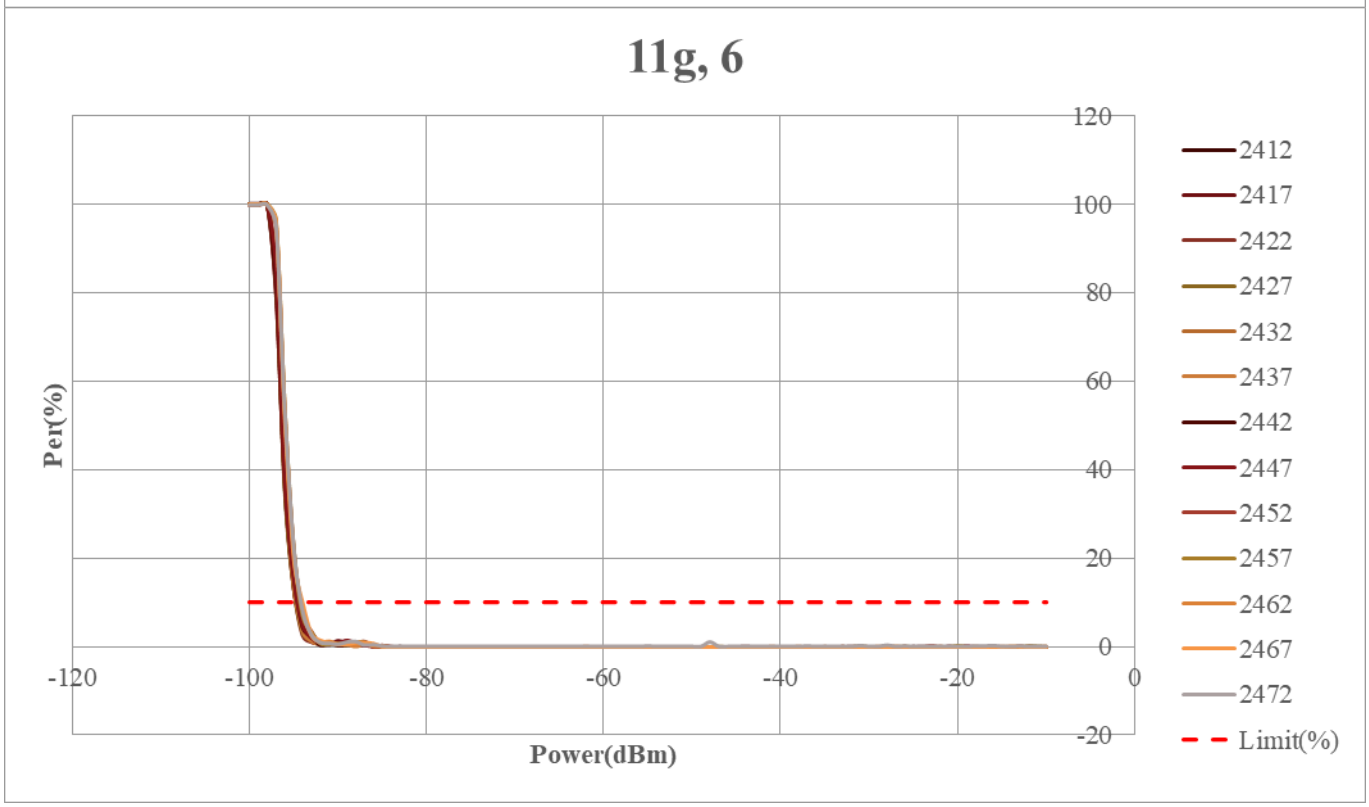

11n HT40, LDPC_ON, SGI_OFF, MCS7(135.0)
Per(%)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
Power(dBm)
2422
2427
2432
2437
2442
2447
2452
2457
2462
Limit(%)

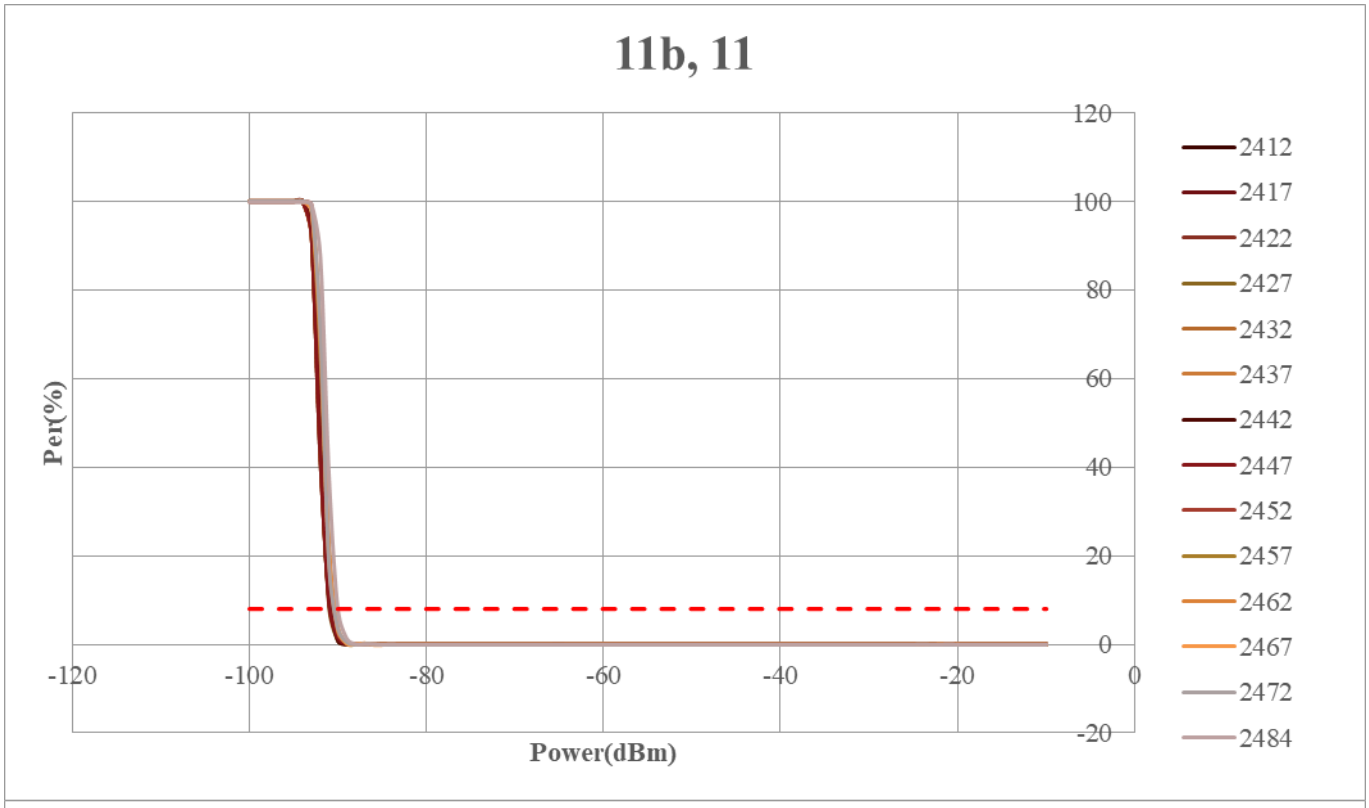

11n HT40, LDPC_ON, SGI_OFF, MCS0(13.5)
Per(%)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
Power(dBm)
2422
2427
2432
2437
2442
2447
2452
2457
2462
Limit(%)

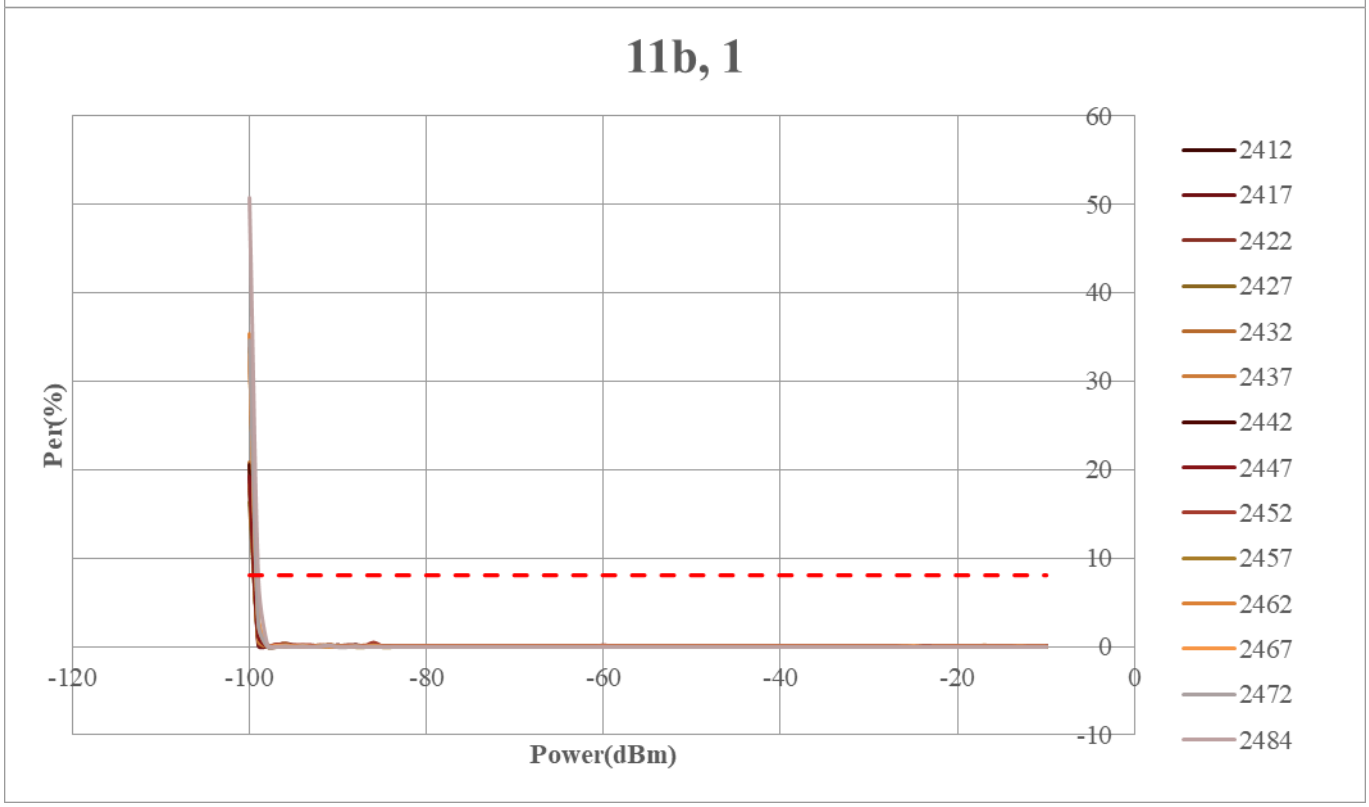

11n HT20, LDPC_ON, SGI_OFF, MCS7(65.0)
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
Limit(%)


11n HT20, LDPC_ON, SGI_OFF, MCS0(6.5)
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
Limit(%)


11g, 54
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
Limit(%)


11g, 6
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
Limit(%)


11b, 11
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
2484


11b, 1
Per(%)
Power(dBm)
60
50
40
30
20
10
0
-10
-120
-100
-80
-60
-40
-20
0
2412
2417
2422
2427
2432
2437
2442
2447
2452
2457
2462
2467
2472
2484

2 Bluetooth and Bluetooth Low Energy DVT

This chapter describes the hardware Bluetooth and Bluetooth Low Energy (BLE) DVT - RF design test data for QCC74x.

Test Conditions

- Sample Size: 3
- Tx/Rx Chains: 1 Tx, 1 Rx
- Test Frequencies: 2402 – 2480 MHz
- Sample Type: TT

Bench Software

QCC740.OR.1.0

DVT Specifics

- DVT Level: CS

2.1 References and specifications

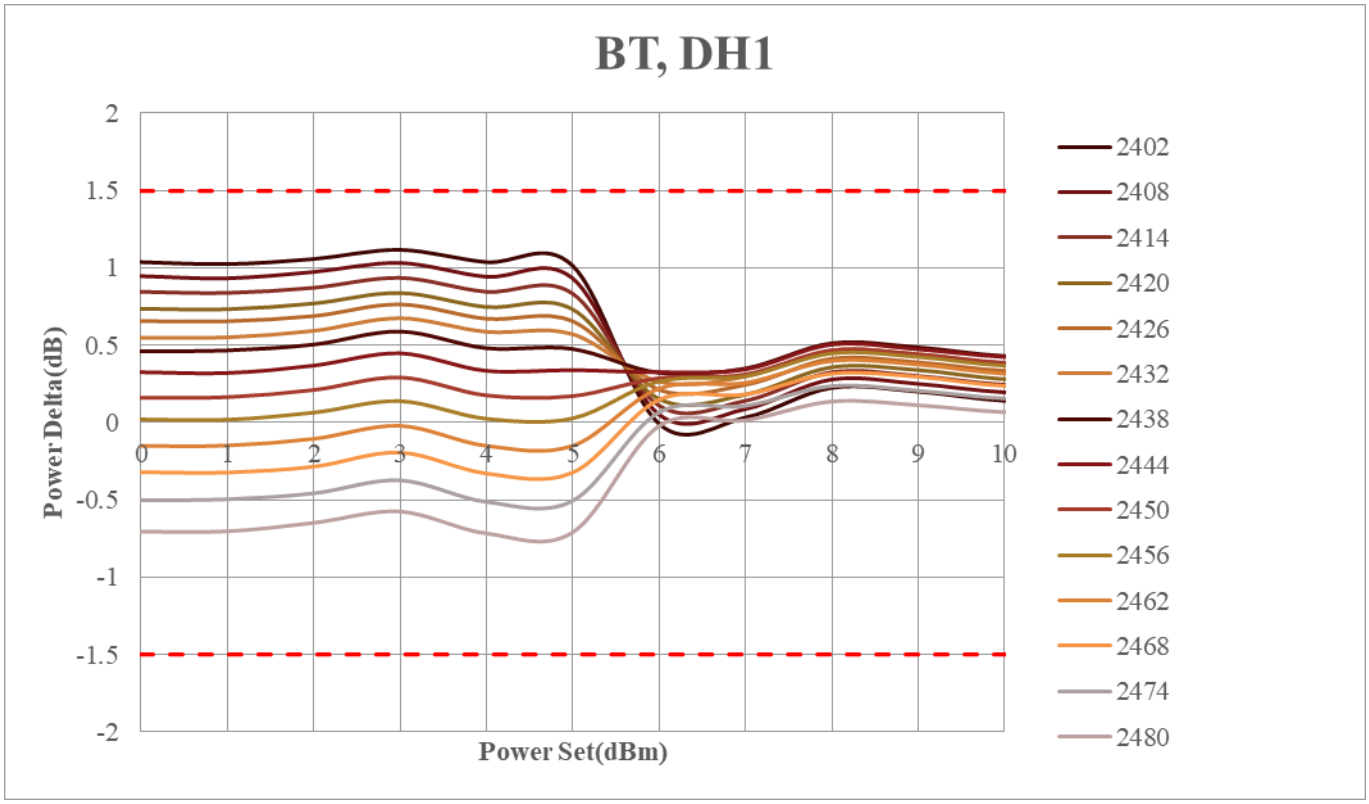
The documents below are references and specifications utilized for BT and BLE testing.

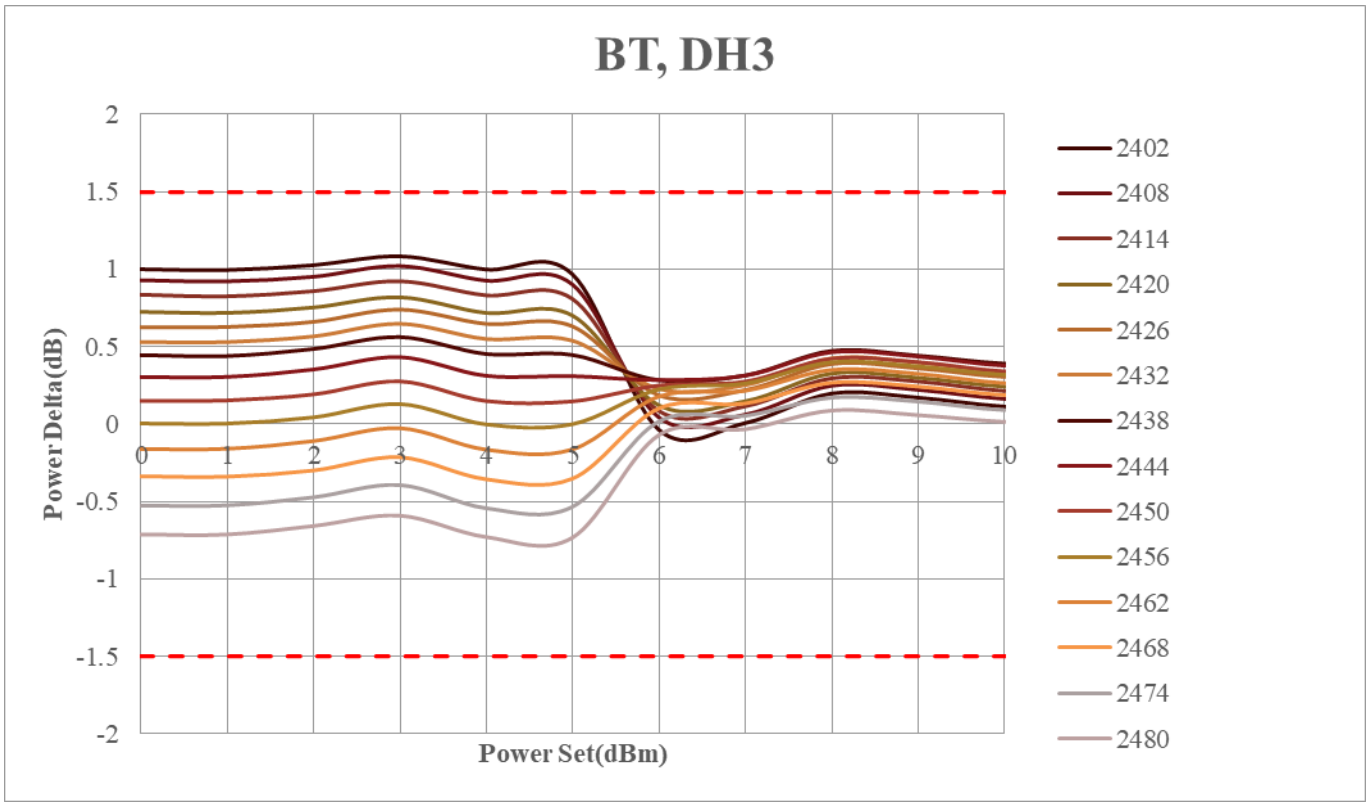
- Bluetooth Test Strategy and Terminology Overview
- Bluetooth Specification, v4.0 or later, Vol. 6, Part A; Physical Layer Specification
- ICS Proforma for Bluetooth Low Energy RF PHY, v1.0 or later
- Bluetooth Specification v4.0 or later, Vol. 6, Part F; Direct Test Mode
- IXIT Perform or Bluetooth Low Energy Conformance Test Specifications, v4.2 or later
- Bluetooth Core Specification Addendum 5, Volume 6, Part A; Physical Layer Specification
- Bluetooth Specification v5.0 or later, Vol. 6, Part A; Physical Layer Specification

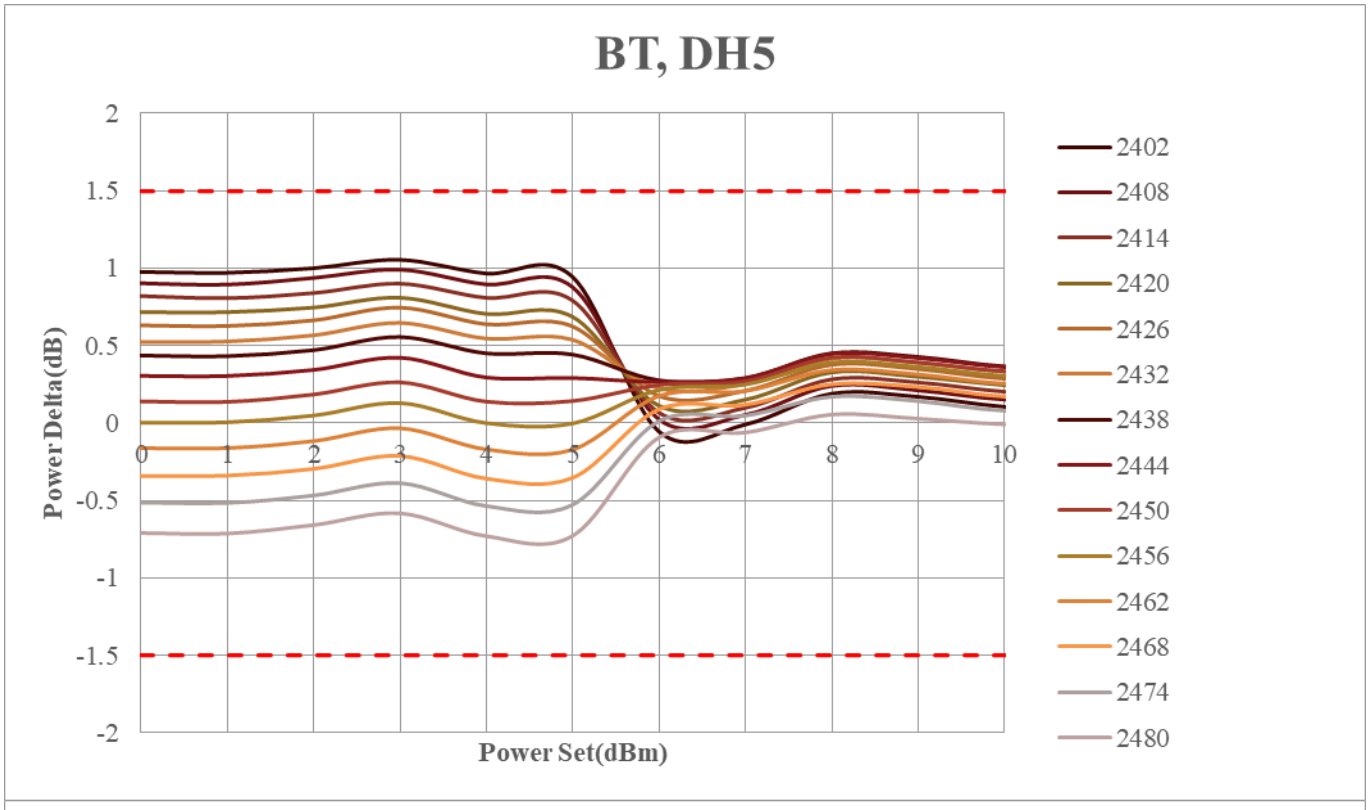
Mode	Test item	Requirements	Channels		
			2402	2441	2480
Output Power	Tx Output Power DH5	10	10.51	10.78	10.35
	Tx Output Power 2DH5	8	8.44	8.72	8.28
	Tx Output Power 3DH5	8	8.44	8.72	8.28
Modulation Characteristics	BR 1Mbps, Δf1avg	160 KHz	159.66 kHz	160.01 kHz	159.20 kHz
	BR 1Mbps, Δf2max > 115KH	100%	136.20 kHz	136.90 kHz	136.20 kHz
	BR 1Mbps, Δf2avg/Δf1avg	> 0.85	0.88	0.88	0.89
	EDR 2Mbps, RMS DEVM	< 2.5	1.5	1.5	1.5
	EDR 2Mbps, Peak DEVM	< 6.0	3.4	3.6	3.9
	EDR 2Mbps, 99% DEVM	< 4.0	2.7	2.6	2.7
	EDR 3Mbps, RMS DEVM	< 2.5	1.4	1.3	1.4
	EDR 3Mbps, Peak DEVM	< 6.0	3.3	3	3.3
	EDR 3Mbps, 99% DEVM	< 4.0	2.5	2.4	2.5
In-Band Emission	EDR 2Mbps, F = F0± 2MHz	-39	-38.32	-38.50	-38.35
	EDR 2Mbps, F = F0± 3MH	-43	-43.96	-43.34	-43.93
	EDR 3Mbps, F = F0± 2MH	-38	-37.60	-37.52	-37.95
	EDR 3Mbps, F = F0± 3MH	-43	-43.01	-42.65	-42.87
Adjacent Channel Power	BR 1Mbps, F = F0± 2MH	-48	-50.87	-50.54	-51.12
	BR 1Mbps, F = F0± 3MH	-48	-52.65	-52.35	-52.88

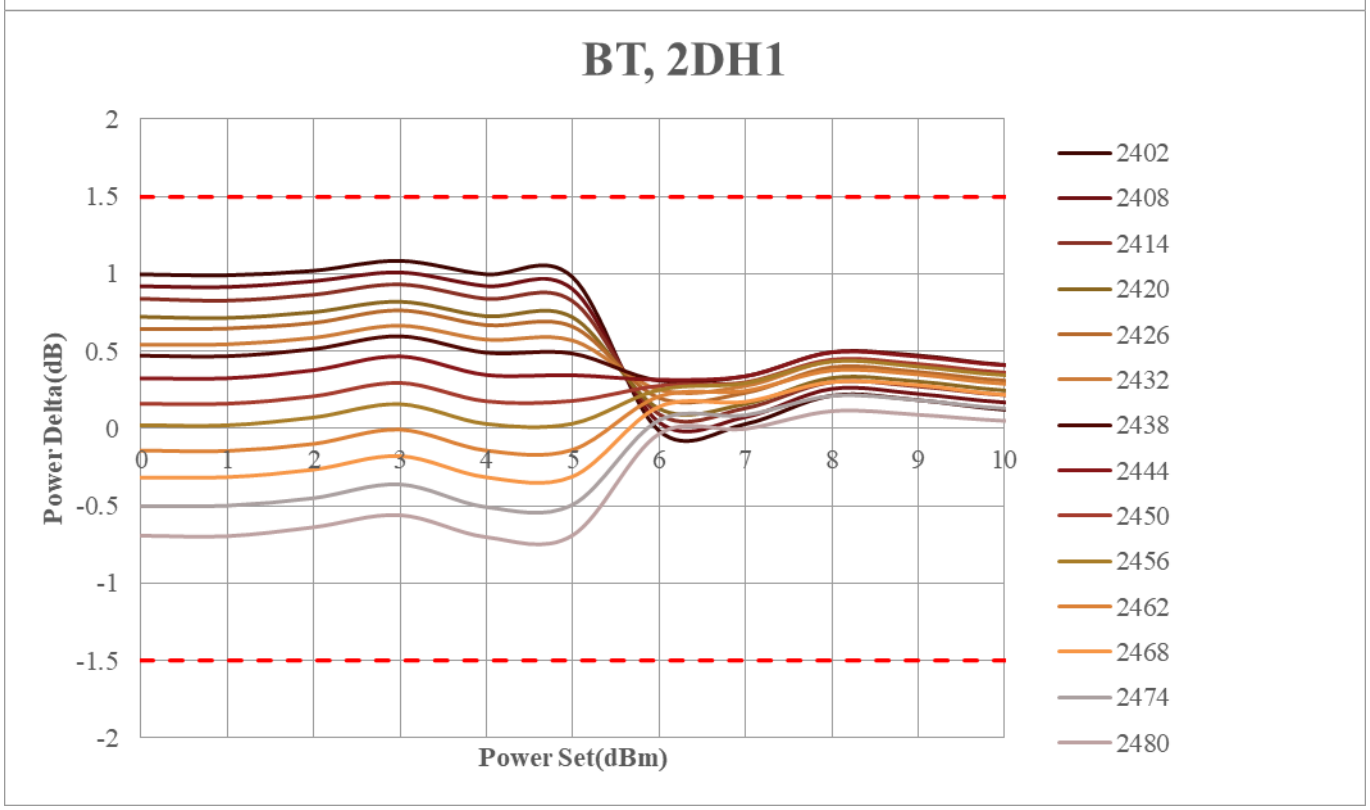
Mode	Test item	Requirements	Channels		
			2402	2441	2480
Output Power	Tx Output Power BLE	20	20.47	20.81	20.4
In-Band Emission	1Mbps, F = F0± 2 MHz	-48	-39.28	-39.25	-39.42
	1Mbps, F = F0± 3 MHz	-50	-41.08	-41.60	-41.69
	2Mbps, F = F0± 4 MHz	-51	-41.84	-42.27	-42.19
	2Mbps, F = F0± 5MH	-53	-42.70	-43.36	-43.37
	2Mbps, F = F0± 6 MHz	< -50	-42.90	-43.46	-43.53
Modulation Characteristics	1Mbps, Δf1avg	251 KHz	250.56 kHz	250.36 kHz	252.05 kHz
	1Mbps, Δf2max > 185KH	100%	214.50 kHz	211.90 kHz	212.20 kHz
	1Mbps, Δf2avg/Δf1avg	0.89	0.89	0.87	0.86
	2Mbps, Δf1avg	502 KHz	501.28 kHz	501.33 kHz	502.23 kHz
	2Mbps, Δf2max > 370KH	100%	433.60 kHz	433.60 kHz	442.20 kHz
	2Mbps, Δf2avg/Δf1avg	0.89	0.87	0.88	0.89
	S8 (125 Kbps), Δf1avg	251	251.06 kHz	251.35 kHz	251.62 kHz
	S8 (125 Kbps), Δf1max > 185KH	100%	246.74 kHz	246.02 kHz	245.30 kHz

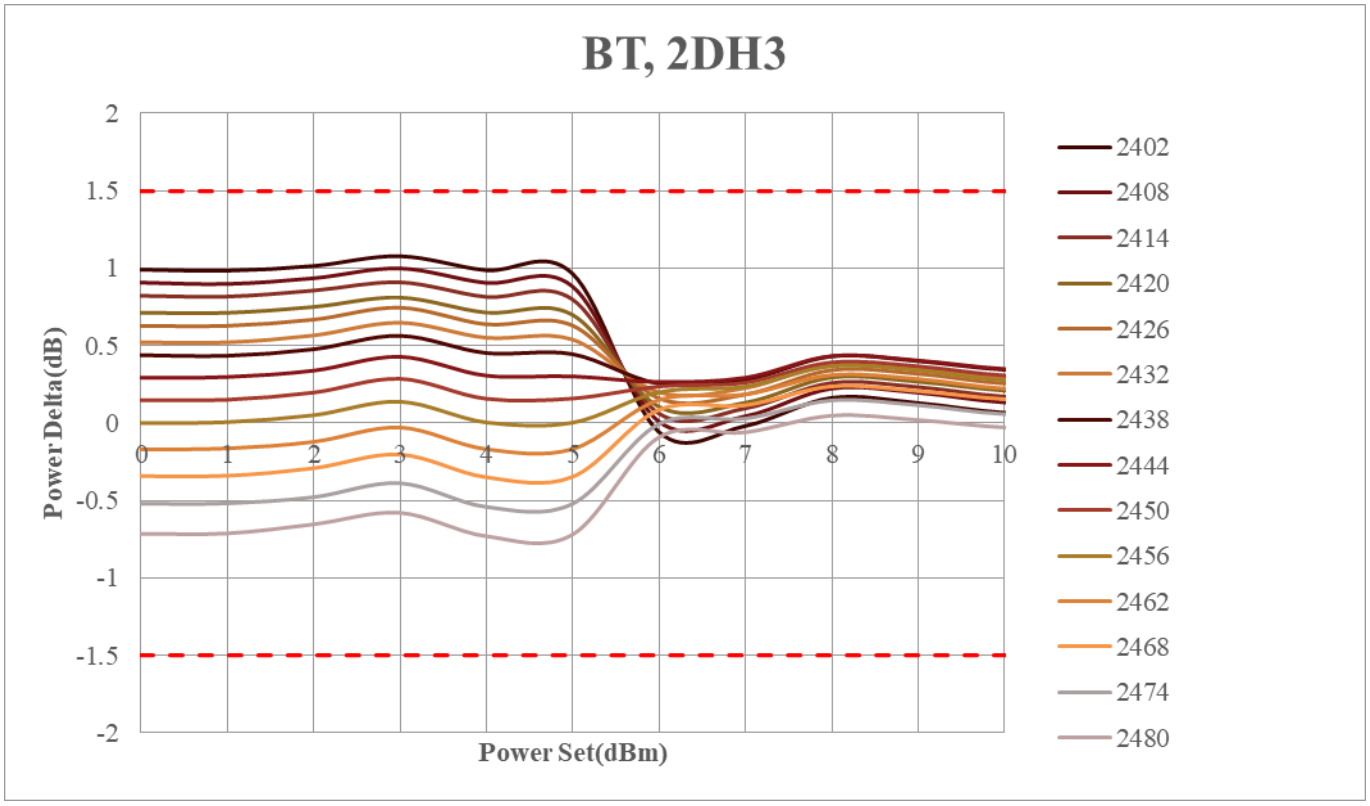
2.1.1 Tx power accuracy

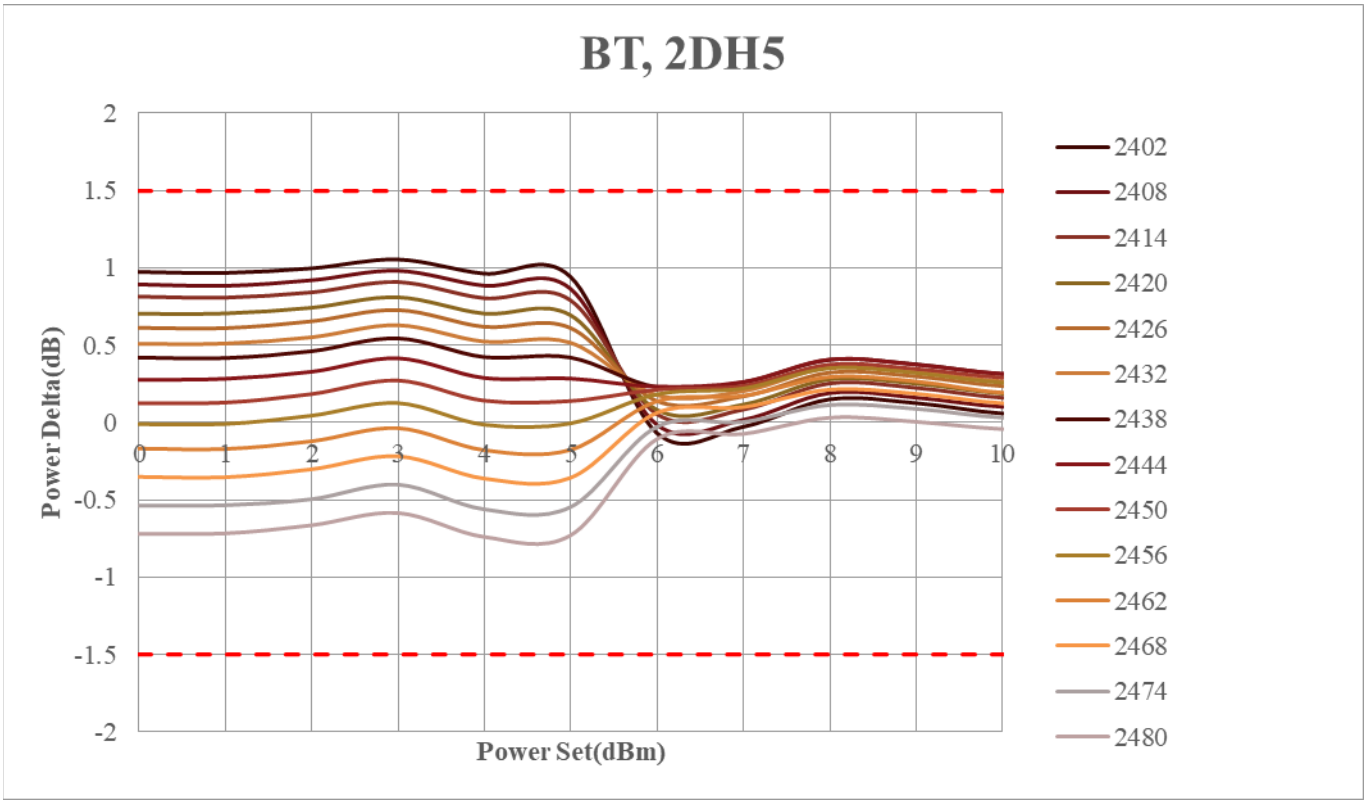


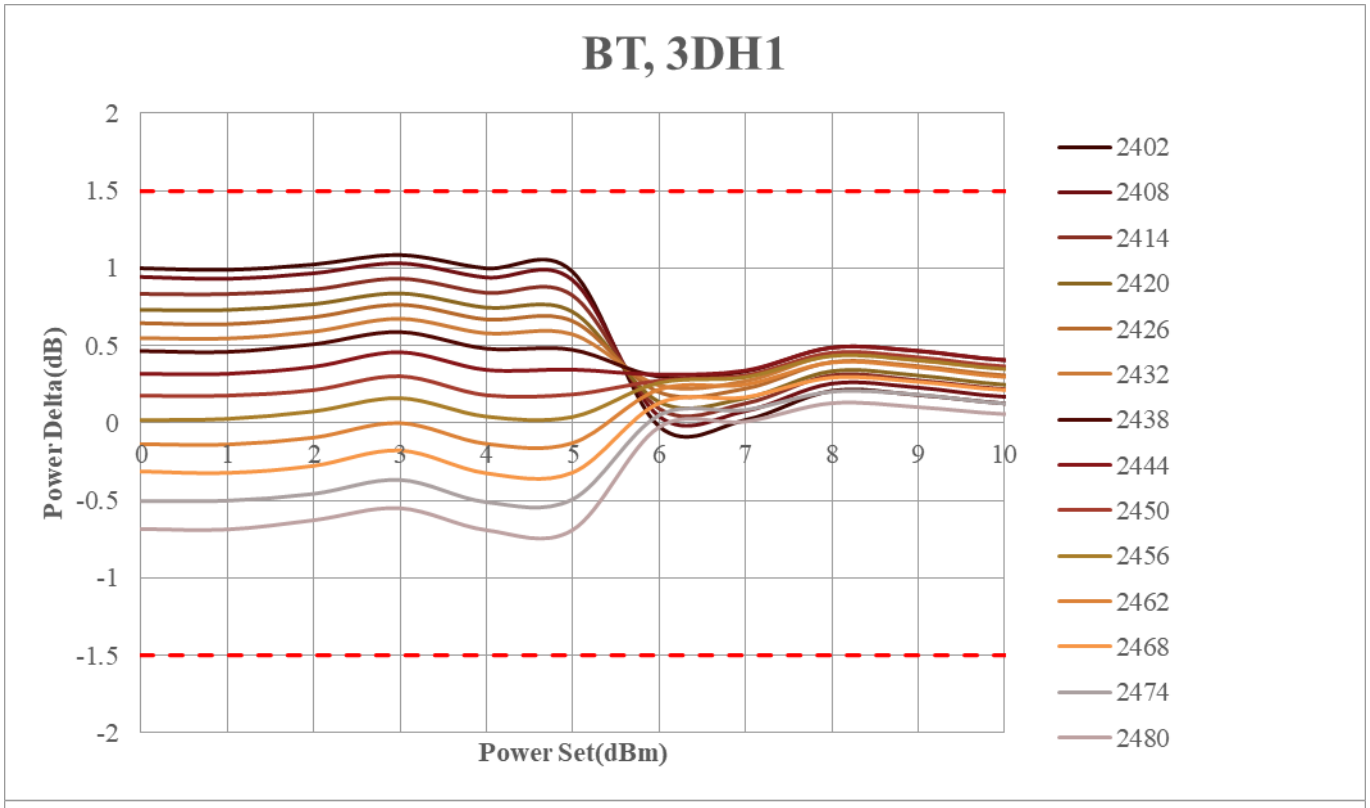


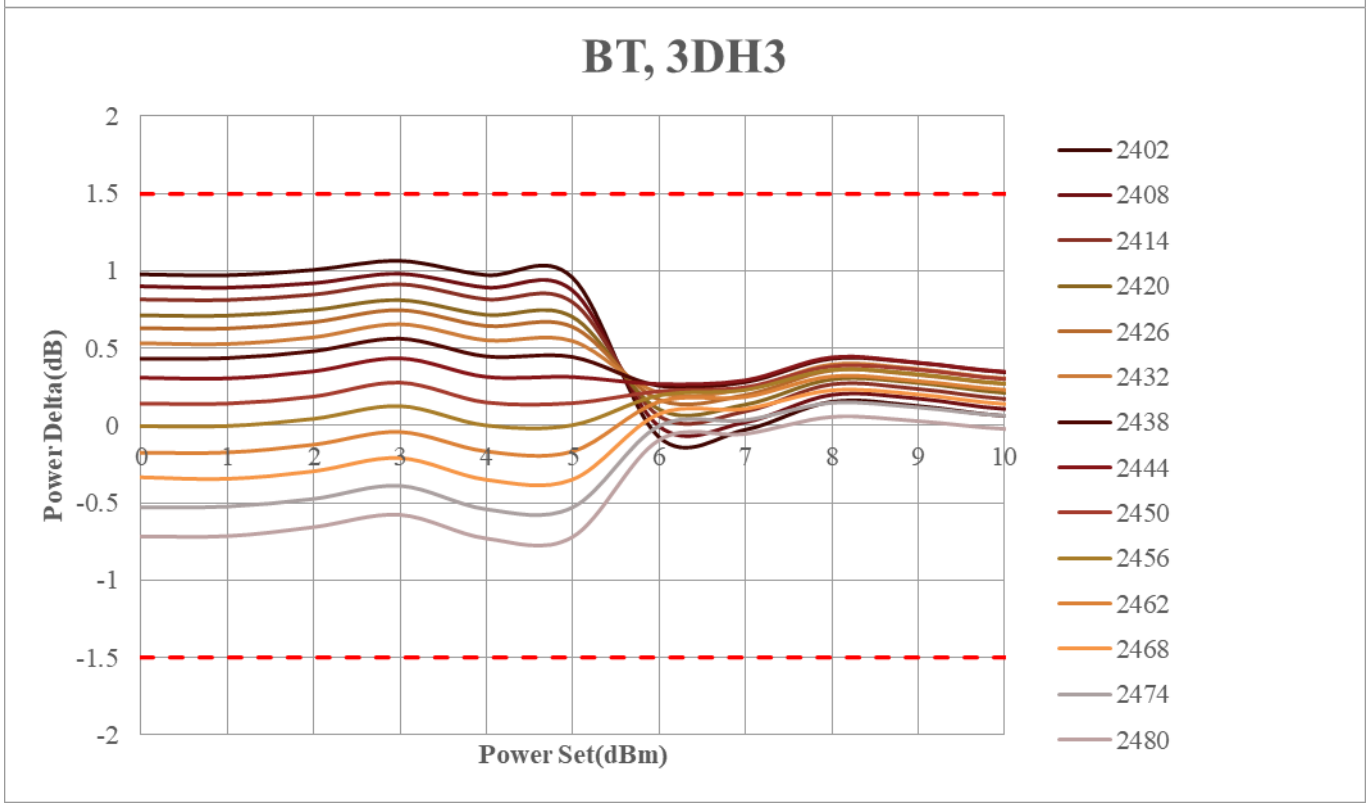

BT, DH5
Power Delta(dB)
Power Set(dBm)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
1
2
3
4
5
6
7
8
9
10
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480

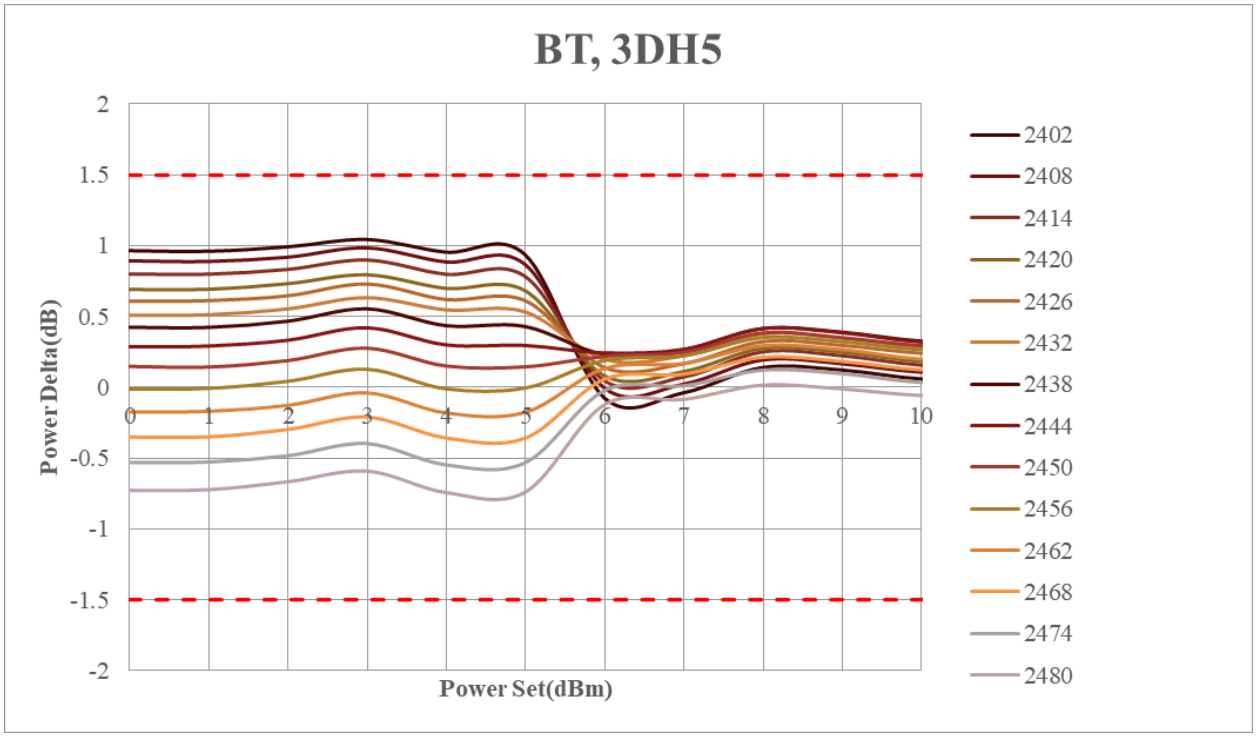

BT, 2DH1
Power Delta(dB)
Power Set(dBm)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
1
2
3
4
5
6
7
8
9
10
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480


BT, 2DH3
Power Delta(dB)
Power Set(dBm)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
1
2
3
4
5
6
7
8
9
10
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480


BT, 2DH5
Power Delta(dB)
Power Set(dBm)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
1
2
3
4
5
6
7
8
9
10
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480

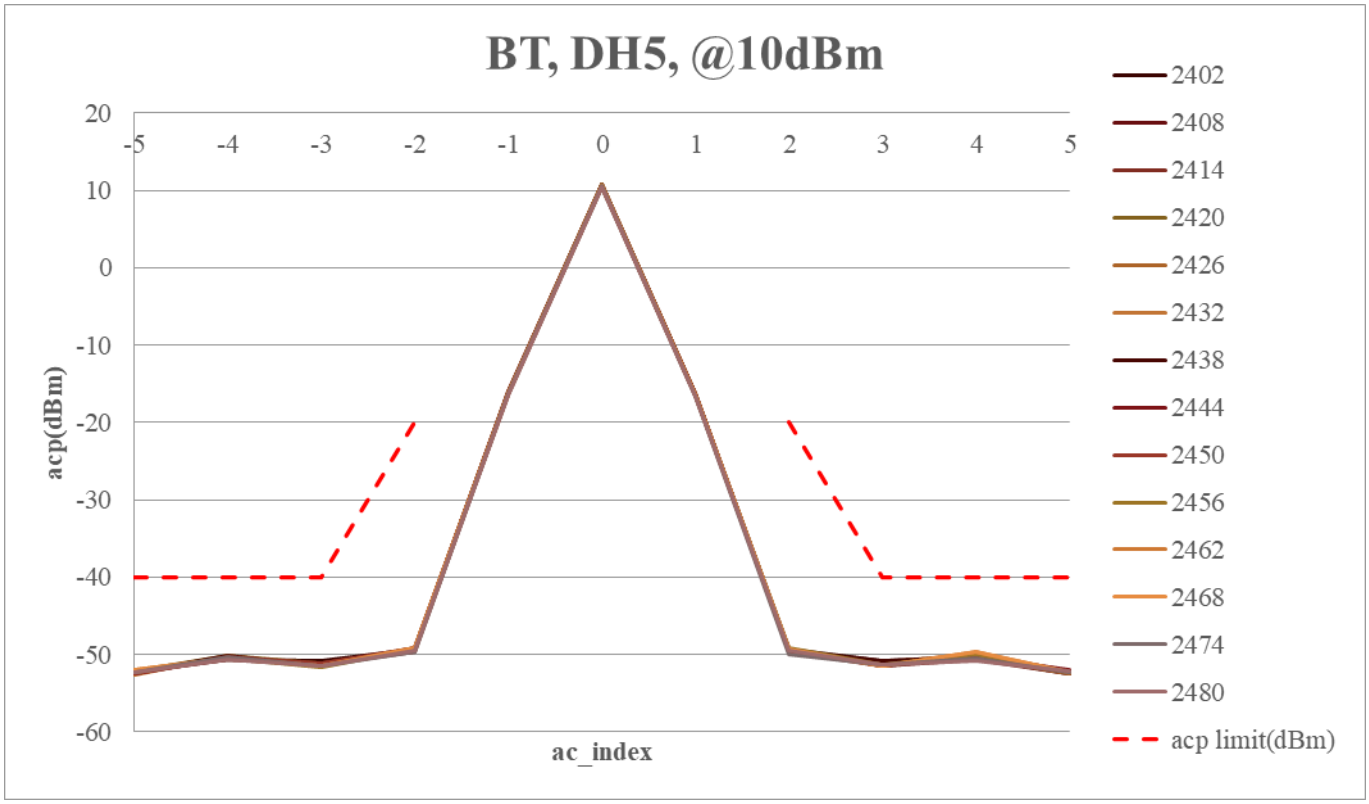

BT, 3DH1
Power Delta(dB)
Power Set(dBm)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
1
2
3
4
5
6
7
8
9
10
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480


BT, 3DH3
Power Delta(dB)
Power Set(dBm)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
1
2
3
4
5
6
7
8
9
10
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480

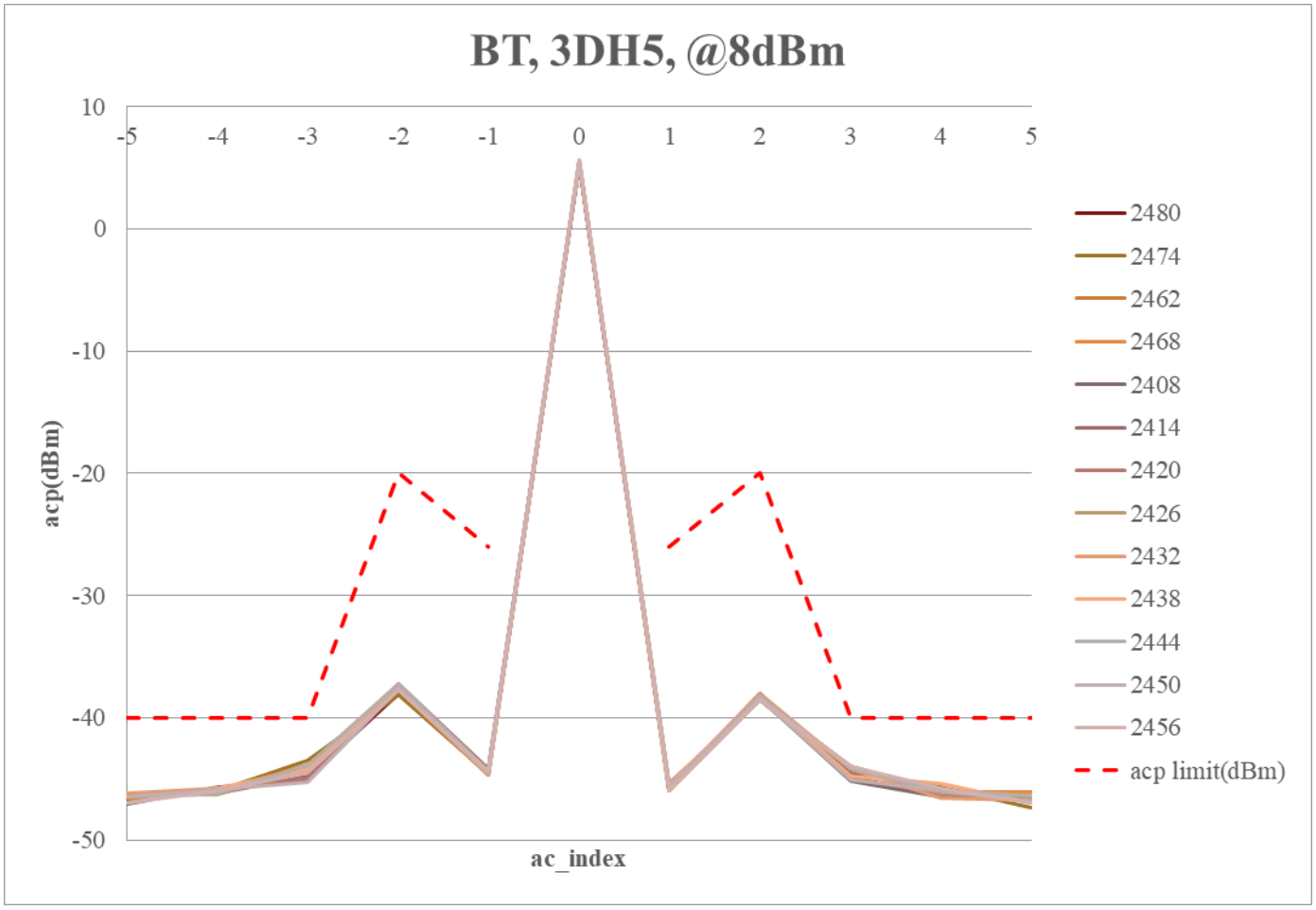


2.1.2 Adjacent channel transmit power vs. channels packet type

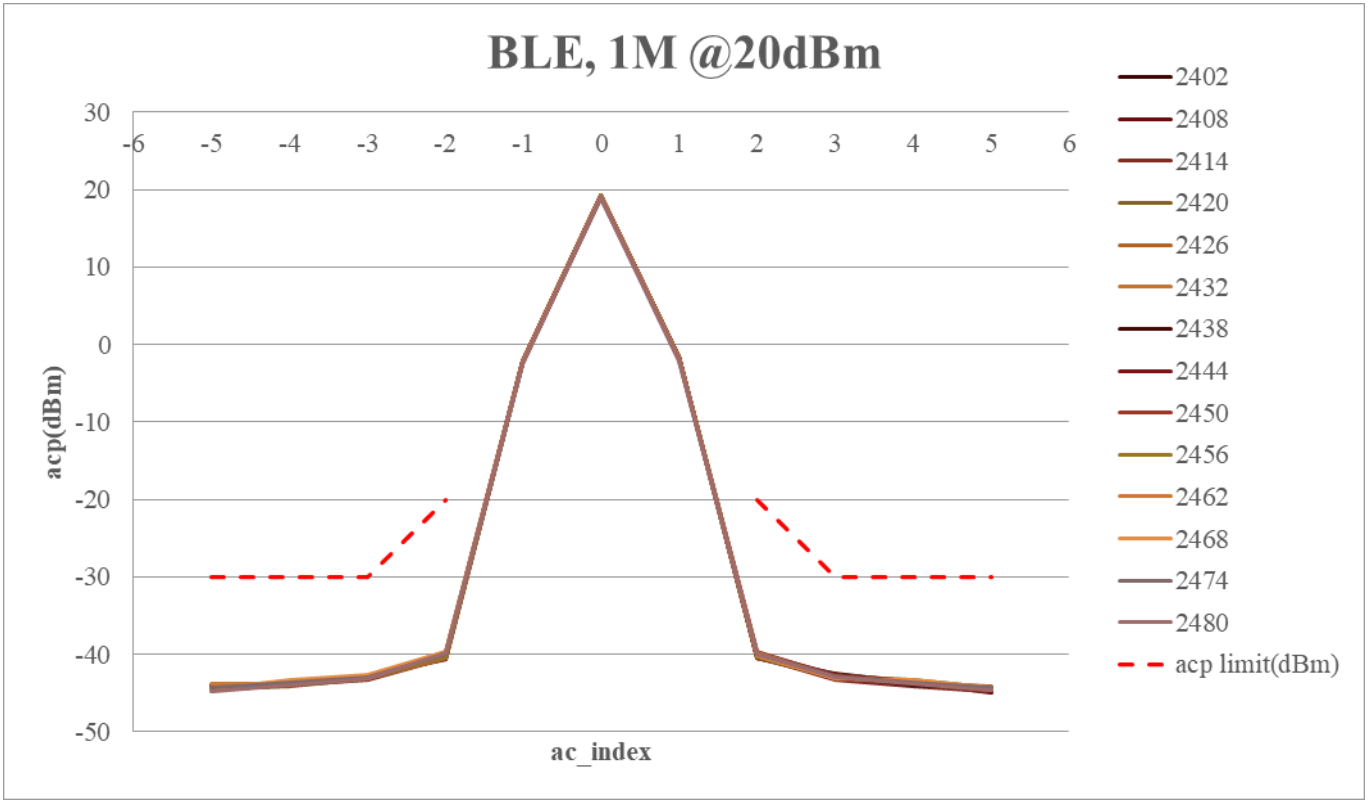
PL10: Adjacent Channel Transmit Power vs. Channels Packet Type = DH5



PL8: Adjacent Channel Transmit Power vs. Channels Packet Type = 3DH5

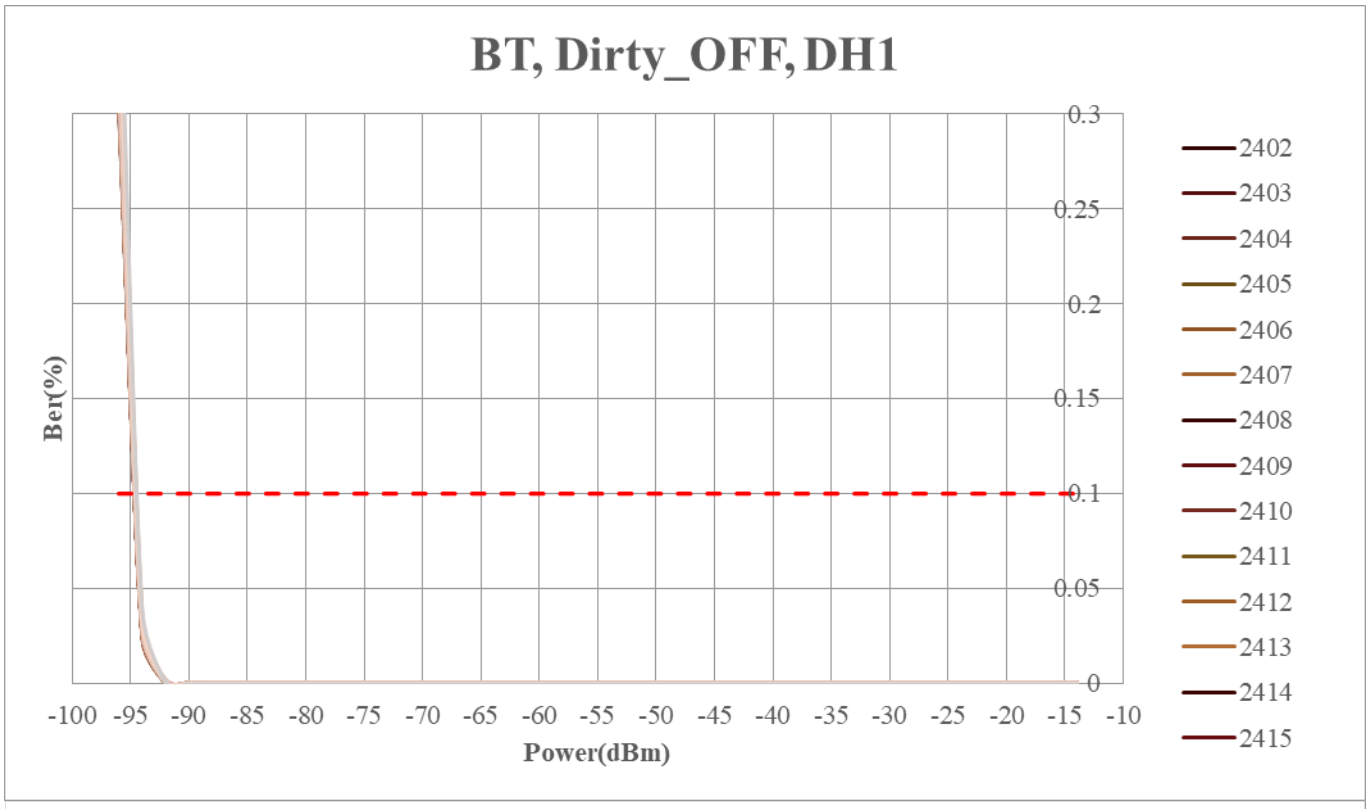


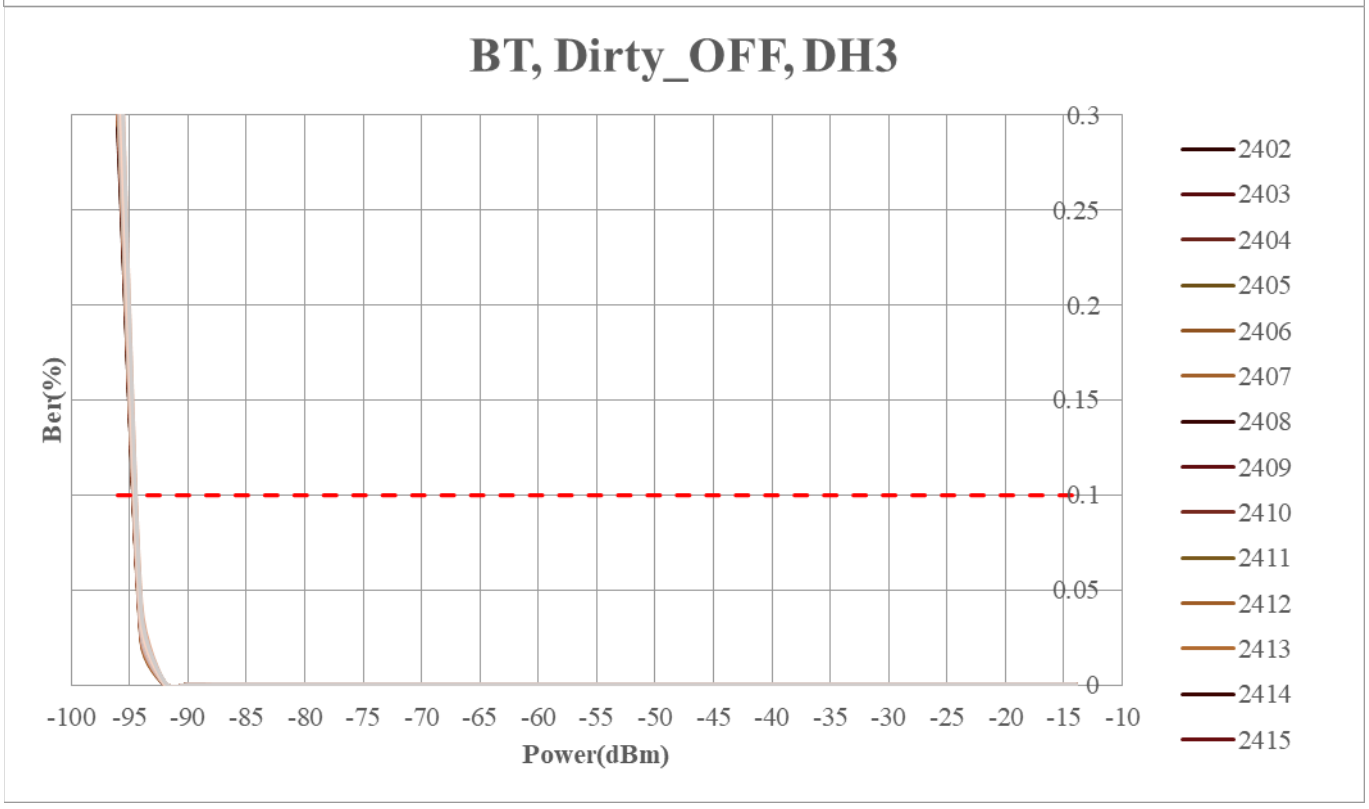
PL20: Adjacent Channel Transmit Power vs. Channels Packet Type = BLE 1M

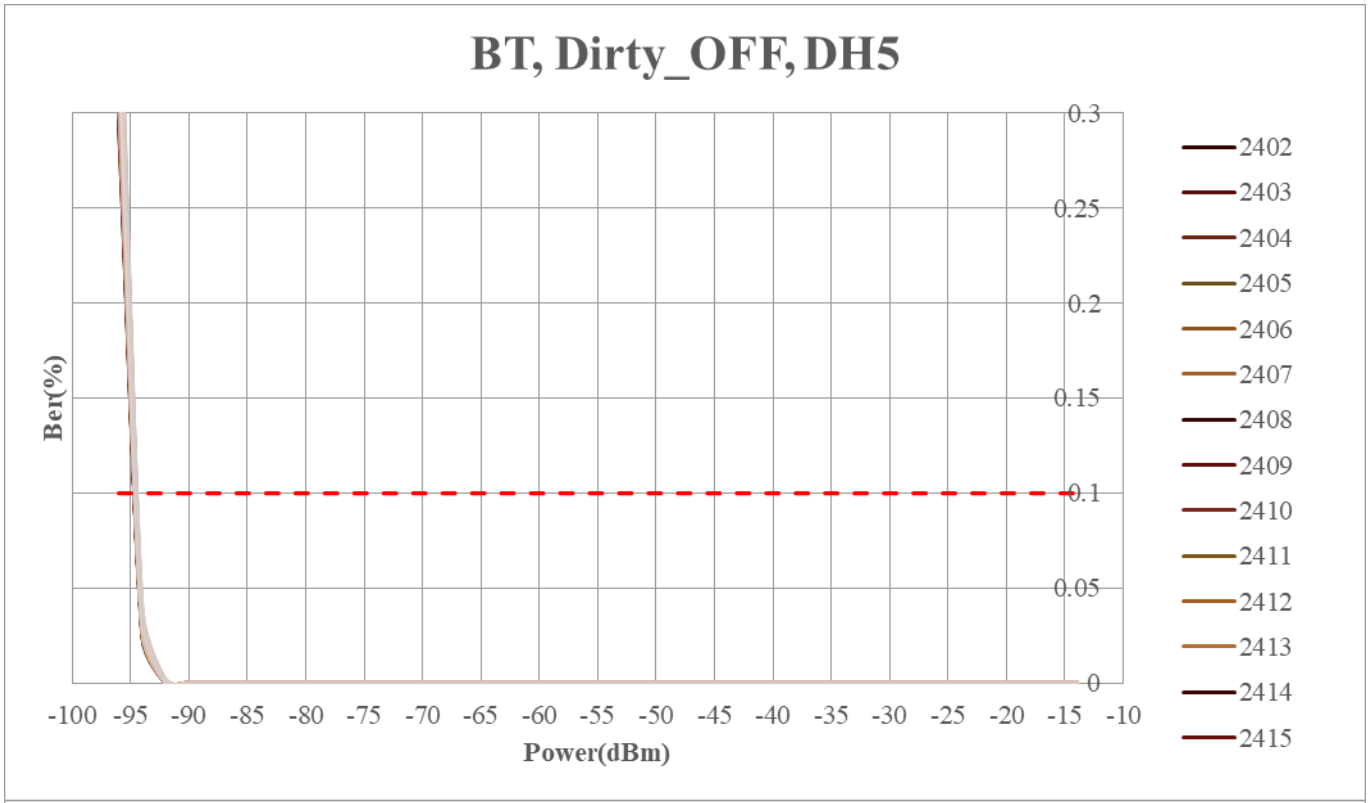


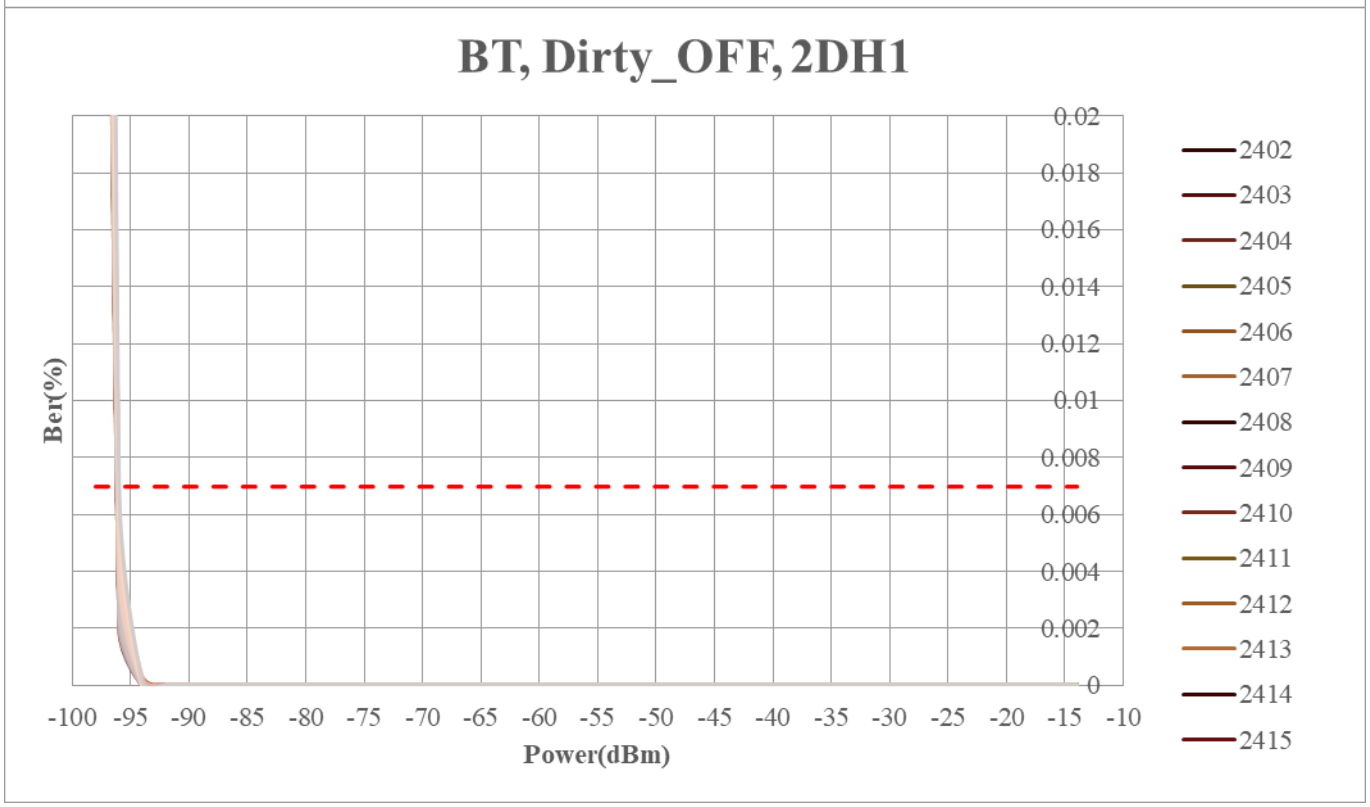
Mode	Test item	Note	Requirements	Channels		
				2402	2441	2480
Receiver Sensitivity	BR 1Mbps Multi-slot	0.1% BER, Dirty Transmitter off	-94	-95	-95	-95
	EDR 2Mbps Multi-slot	0.01% BER, Dirty Transmitter off	-96	-98	-98	-98
	EDR 3Mbps Multi-slot	0.01% BER, Dirty Transmitter off	-90	-92.5	-92.5	-92.5
	LE 1M	Packet Length 37 bytes, Dirty Transmitter off	-99	-99.5	-99.5	-99.5
	LE 2M	Packet Length 37 bytes, Dirty Transmitter off	-97	-96.5	-96.5	-96.5
	S=2(500 Kbps)	Packet Length 37 bytes, Dirty Transmitter off	-102	-103	-103	-103
	S=8(125 Kbps)	Packet Length 37 bytes, Dirty Transmitter off	-105	-106	-105.5	-106

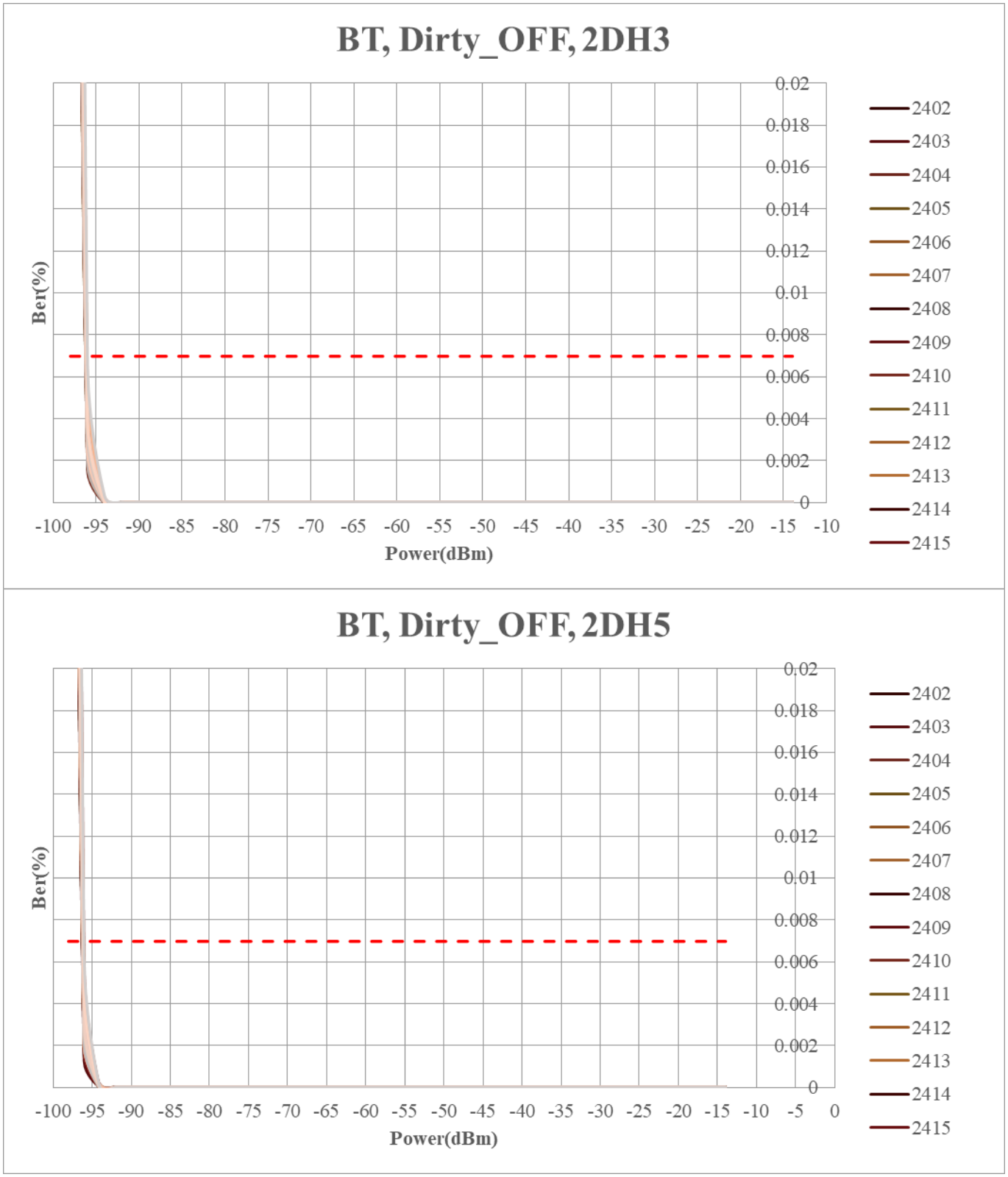
2.1.3 Waterfall plots for BT data rates

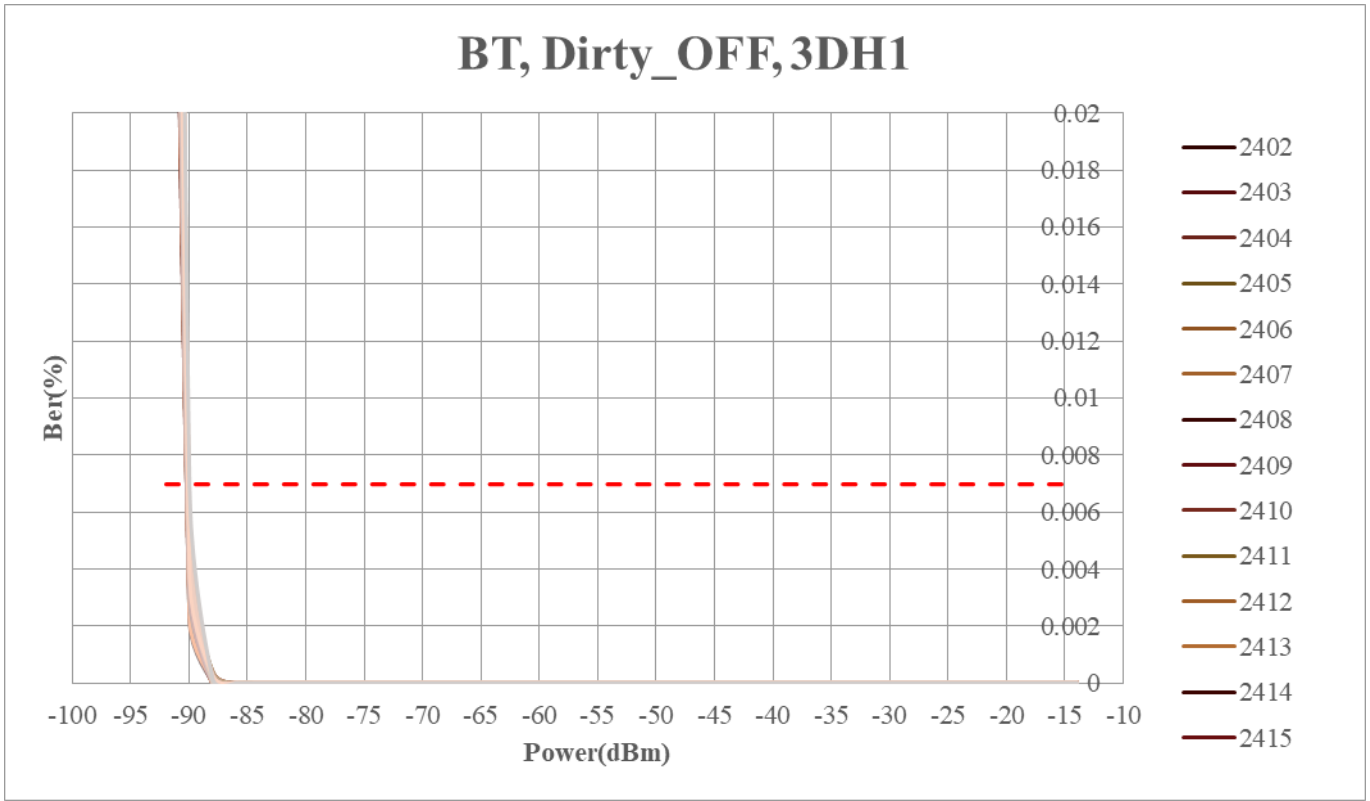


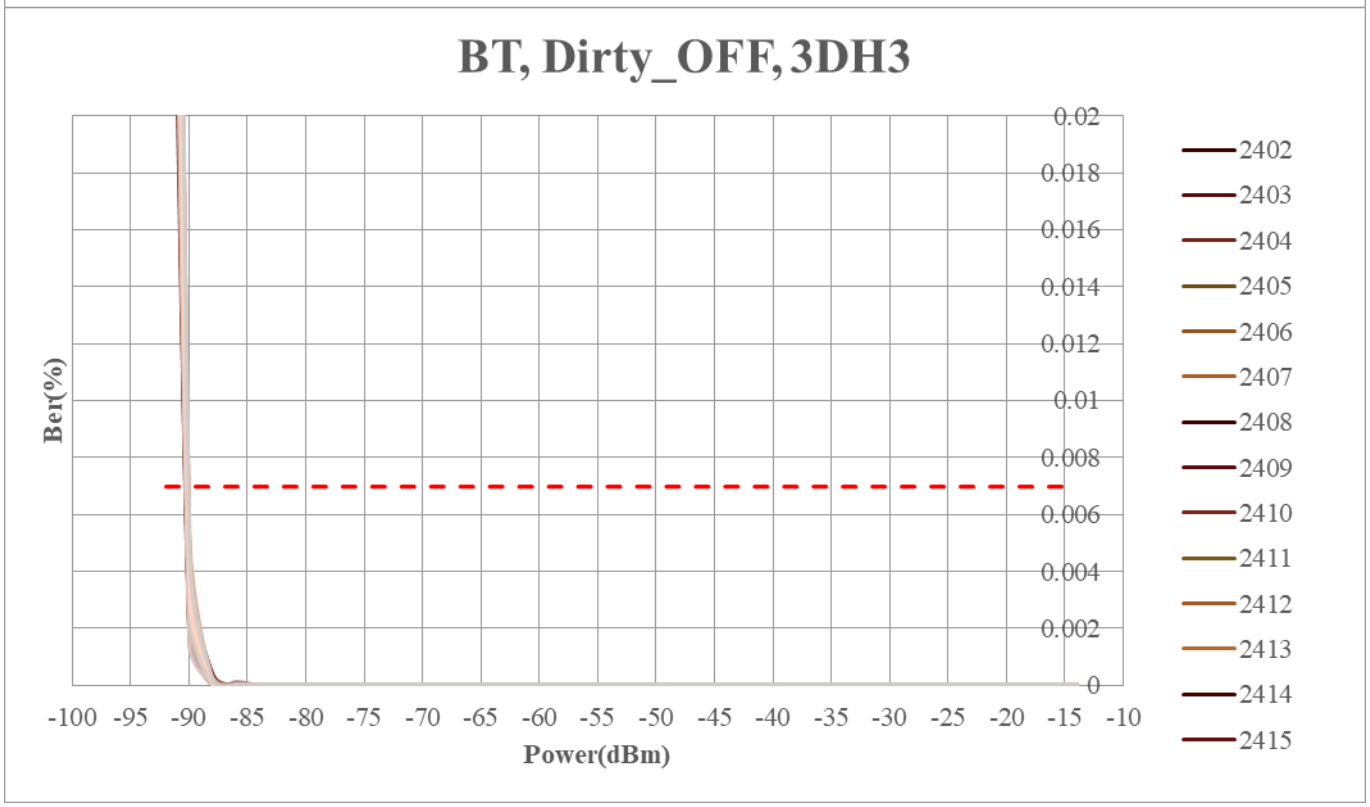


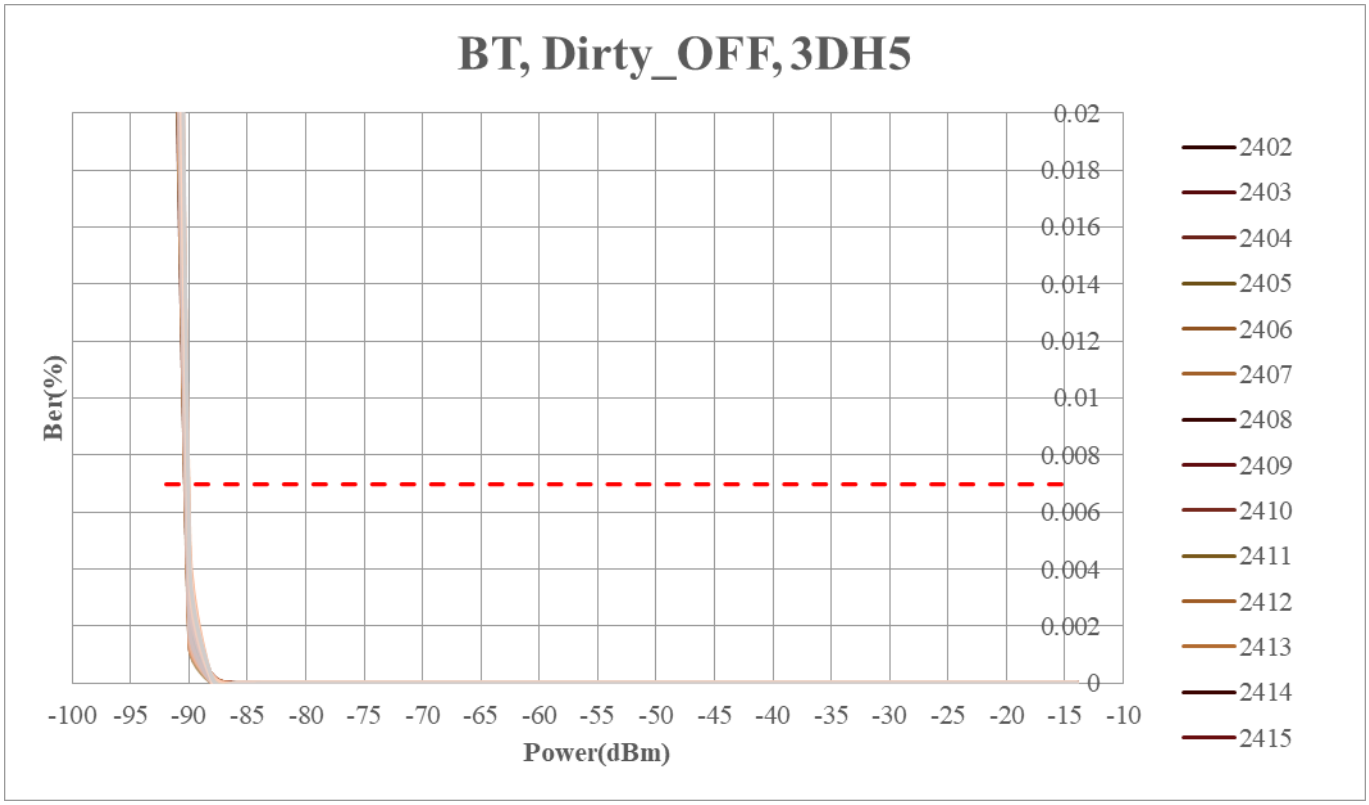

BT, Dirty_OFF, DH5
Ber(%)
0.3
0.25
0.2
0.15
0.1
0.05
0
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10
Power(dBm)
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415


BT, Dirty_OFF, 2DH1
Ber(%)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10
Power(dBm)
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415

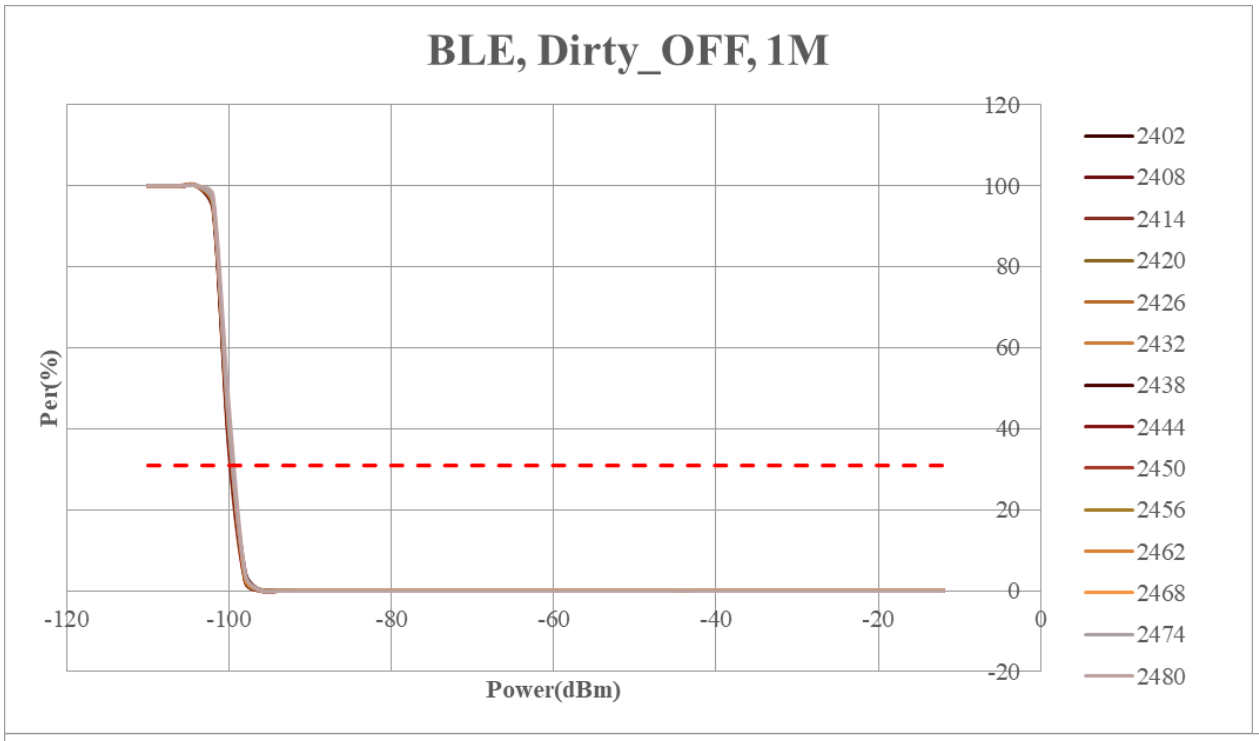

BT, Dirty_OFF, 2DH3
Ber(%)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10
Power(dBm)
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415
BT, Dirty_OFF, 2DH5
Ber(%)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0
Power(dBm)
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415

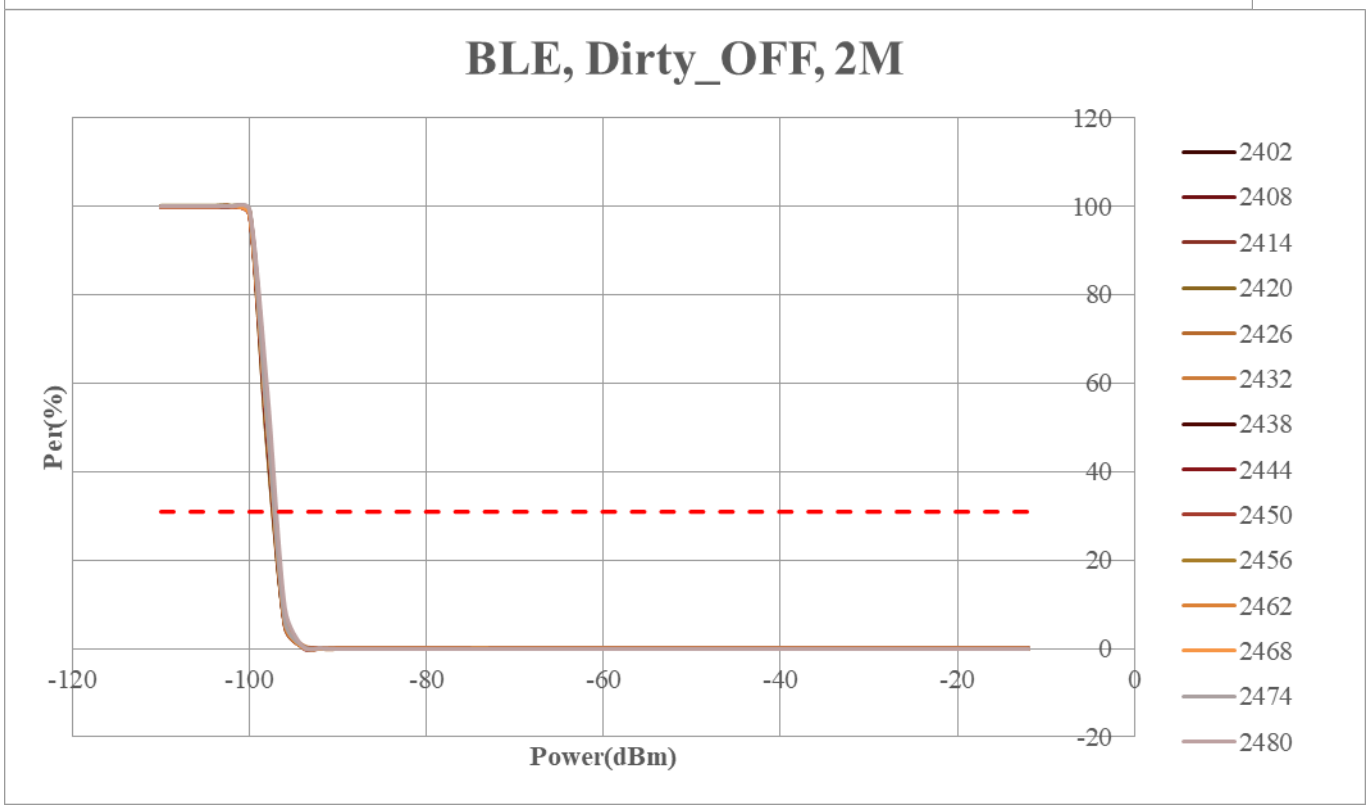

BT, Dirty_OFF, 3DH1
Ber(%)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10
Power(dBm)
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415

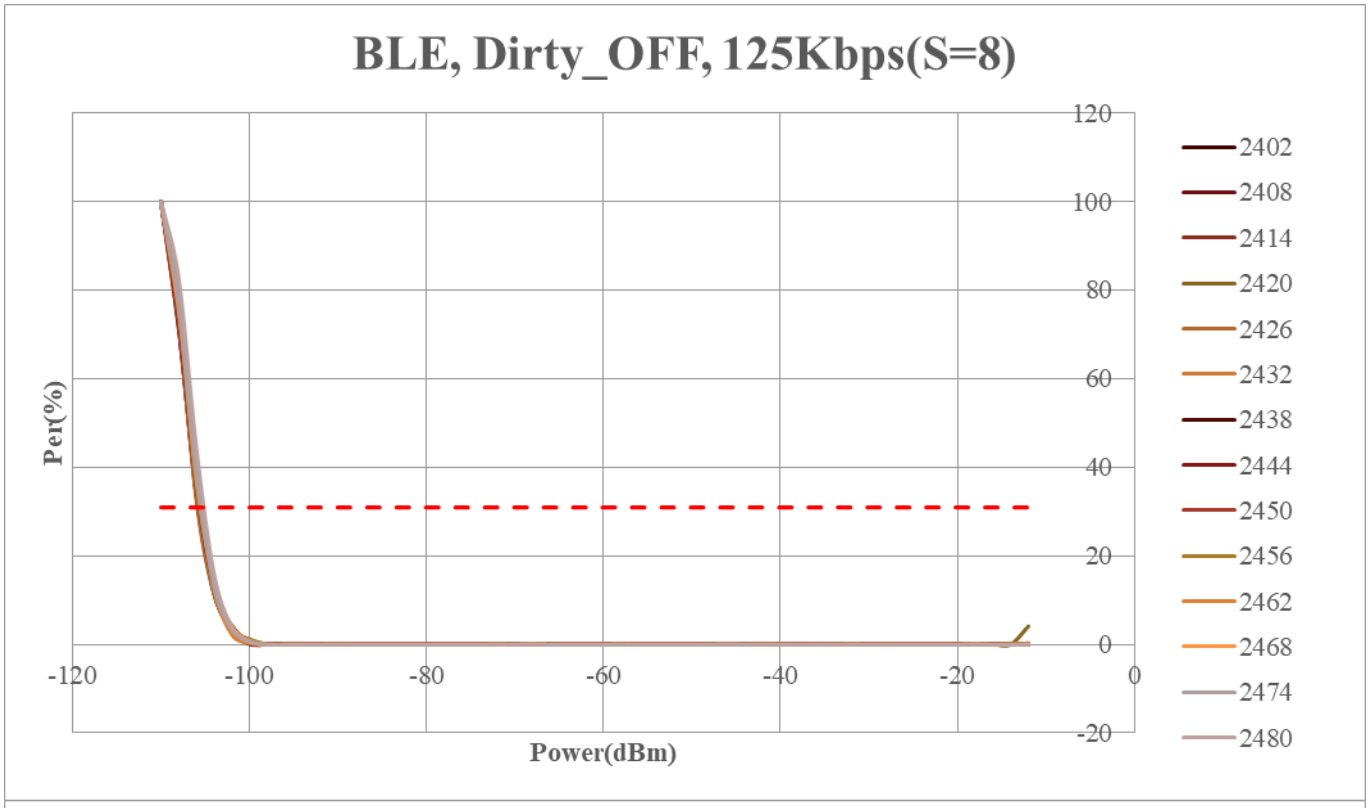

BT, Dirty_OFF, 3DH3
Ber(%)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10
Power(dBm)
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415

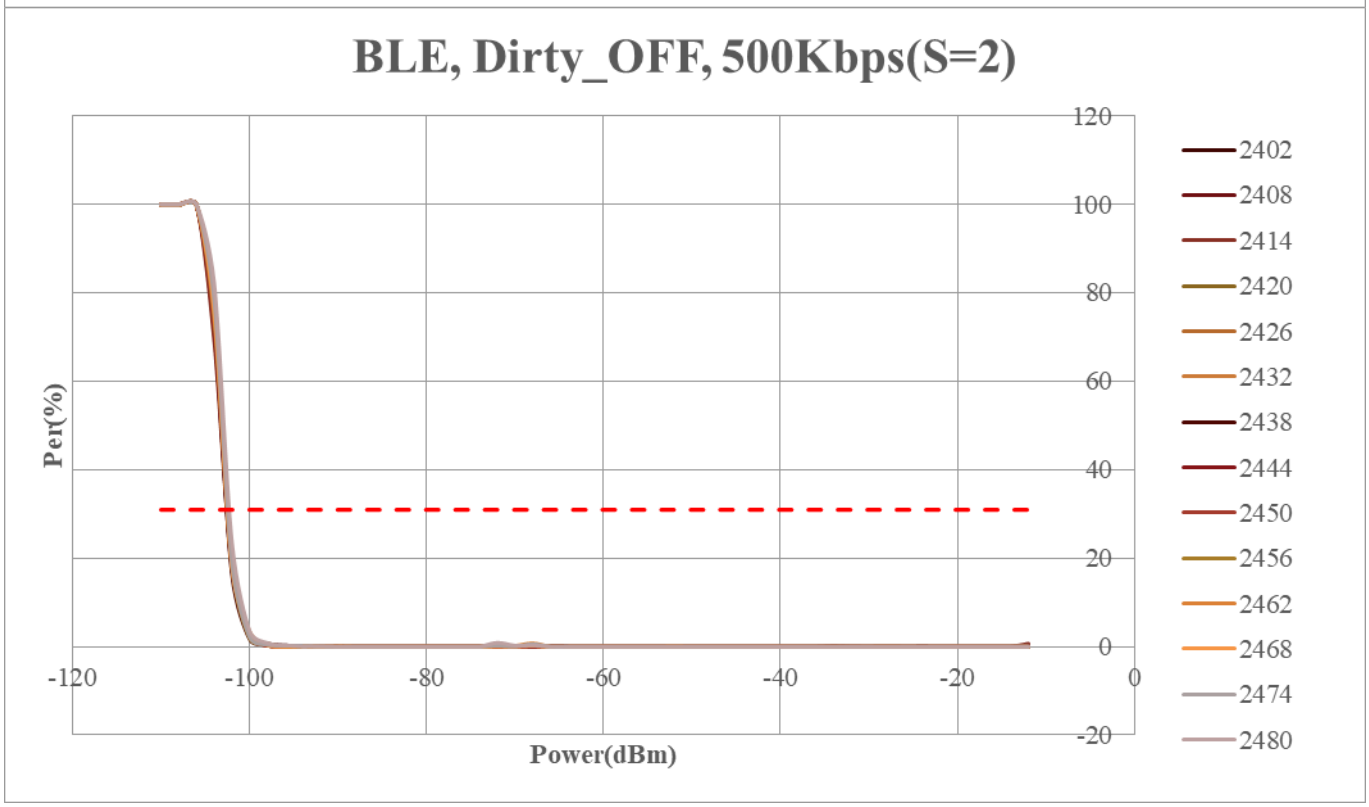

BT, Dirty_OFF, 3DH5
Ber(%)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-100 -95 -90 -85 -80 -75 -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10
Power(dBm)
2402
2403
2404
2405
2406
2407
2408
2409
2410
2411
2412
2413
2414
2415

2.1.4 Waterfall plots for BLE data rates






BLE, Dirty_OFF, 125Kbps(S=8)
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480


BLE, Dirty_OFF, 500Kbps(S=2)
Per(%)
Power(dBm)
120
100
80
60
40
20
0
-20
-120
-100
-80
-60
-40
-20
0
2402
2408
2414
2420
2426
2432
2438
2444
2450
2456
2462
2468
2474
2480

3 802.15.4 DVT

This chapter describes the hardware 802.15.4 DVT RF design test data for QCC74x.

Test conditions

- Sample Size: 3
- Tx/Rx Chains: 1 Tx, 1 Rx
- Test Frequencies: 2400 – 2483.5 MHz
- Sample Type: TT

Bench Software

QCC740.OR.1.0

DVT Specifics

- DVT Level: CS

3.1 References and specifications

The documents below are references and specifications utilized for 802.15.4 testing.

- 802.15.4-2011 IEEE Standard
- 802.15.4-2012 IEEE Standard Amendment

3.1.1 General requirements and definitions

The PHY defined in this document is:

O-QPSK PHY: direct sequence spread spectrum (DSSS) PHY employing offset quadrature phase- shift keying (O-QPSK) modulation, operating in the 2450 MHz band

3.1.1.1 Operating frequency range

A compliant device shall operate in the frequency band using the modulation and spreading formats summarized below.

PHY (MHz)	Frequency band (MHz)	Spreading parameters		Data parameters		
		Chip rate (kchip/s)	Modulation	Bit rate (kb/s)	Symbol rate (ksymbol/s)	Symbols
2450 DSSS	2400–2483.5	2000	O-QPSK	250	62.5	16-ary orthogonal

3.1.1.2 Channel assignments

Channel assignments are defined through a combination of channel numbers and channel pages.

3.1.1.3 Channel numbering for 2450 MHz bands

For channel page zero, 16 channels are available in the 2450 MHz band. The center frequency of these channels is defined as follows:

$F_c = 2405 + 5\ (k - 11)$ in megahertz, for $k = 11, 12, \ldots, 26$ where

k is the channel number.

For channel pages one and two, 11 channels numbered zero to ten are available across the two frequency bands to support the O-QPSK PHYs.

3.2 Radio specifications

3.2.1 RF power measurement

Unless otherwise stated, all RF power measurements, either transmit or receive, shall be made at the appropriate transceiver to antenna connector. The measurements shall be made with equipment that is either matched to the impedance of the antenna connector or corrected for any mismatch. For devices without an antenna connector, the measurements shall be interpreted as effective isotropic radiated power (EIRP) (that is, a 0 dBi gain antenna), and any radiated measurements shall be corrected to compensate for the antenna gain in the implementation.

3.2.2 Receiver sensitivity definitions

The conditions for measuring receiver sensitivity are defined below:

Term	Definition of term	Conditions
Packet error rate (PER)	Average fraction of transmitted packets that are not correctly received.	Average measured over random PSDU data.
Receiver sensitivity	Lowest input power for which the PER conditions are met.	PSDU length = 20 octets. – PER < 1%. Power measured at antenna terminals. Interference is not present.

3.2.3 RF power measurements

Unless otherwise stated, all RF power measurements, either transmit or receive, shall be made at the appropriate transceiver to antenna connector. The measurements shall be made with equipment that is either matched to the impedance of the antenna connector or corrected for any mismatch. For devices without an antenna connector, the measurements shall be interpreted as effective isotropic radiated power (EIRP) (that is, a 0 dBi gain antenna), and any radiated measurements shall be corrected to compensate for the antenna gain in the implementation.

3.2.4 Transmit power spectral density (PSD) mask

When operating in the 2450 MHz band, the transmitted spectral products shall be less than the limits specified below. For both relative and absolute limits, average spectral power shall be measured using a 100 kHz resolution bandwidth. For the relative limit, the reference level shall be the highest average spectral power measured within ±1 MHz of the carrier frequency.

Table 3-1 2450 MHz band O-QPSK transmit PSD limits

Frequency	Relative limit	Absolute limit
$\|f - f_c\| > 3.5$ MHz	–20 dB	–30 dBm

3.2.5 Symbol rate

The O-QPSK PHY symbol rate shall be 62.5 ksymbol/s when operating in the 2450 MHz band with an accuracy of ±40 ppm.

3.2.6 Receiver sensitivity

A compliant device shall be capable of achieving a receiver sensitivity of –84 dBm or better.

3.2.7 Receiver interference rejection

The minimum receiver interference rejection levels are given below. The adjacent channel is one on either side of the desired channel that is closest in frequency to the desired channel, and the alternate channel is one more removed from the adjacent channel. For example, when channel 5 is the desired channel, channel 4 and channel 6 are the adjacent channels, and channel 3 and channel 7 are the alternate channel.

Table 3-2 Minimum receiver interference rejection requirements

Adjacent channel rejection	Alternate channel rejection
25 dB	35 dB

The adjacent channel rejection shall be measured as follows: the desired signal shall be a compliant O-QPSK PHY signal, of pseudo-random data. The desired signal is input to the receiver at a level 3 dB greater than the maximum allowed receiver sensitivity.

In either the adjacent or the alternate channel, a compliant O-QPSK PHY signal, is input at the level specified relative to the desired signal. The test shall be performed for only one interfering signal at a time. The receiver shall meet the error rate criteria defined under these conditions.

3.2.8 Error vector magnitude (EVM)

The O-QPSK PHY shall have EVM values of less than 5% when measured for 1000 chips

3.2.9 Transmit center frequency tolerance

The O-QPSK PHY transmit center frequency tolerance shall be ±40 ppm maximum.

3.2.10 Transmit power

The O-QPSK PHY shall be capable of transmitting at a power level of +20dBm, the output power range shall be from +0dBm to +20dBm.

3.2.11 Receiver maximum input level of desired signal

The O-QPSK PHY shall have a receiver maximum input level greater than or equal to –9 dBm.

3.3 Summary result

802.15.4 KPI

Test item	Target	Channels		
		2405	2440	2480
Transmitter				
Output Power	+20 dBm	19.3	19.7	19.8
Variation over Channels	+/- 1 dB	0.7	0.3	0.2
Variation over Temperature	+/- 1.5 dB	-	-	-
EVM	< 13%	12.3	12.3	12.1
Center Frequency Tolerance	+/- 100 kHz	-23.2	-24.9	-16.9
Spectral PSD Mask (Margin)	< 30 dB	19.3	19.7	19.8
Spurious Emission (2^{nd} & 3^{rd} Harmonics)	41 dBc	-54 / -57		
Receiver				
Sensitivity	-102 dBm	-105	-104	-104

802.15.4 executive summary

Test item	Target	Channels		
		2405	2440	2480
Transmit Output Power	+20 dBm w/Discrete PA	Pass	Pass	Pass
Transmit Output Power (Variation over Channels)	+/- 1 dB	Pass	Pass	Pass
Transmit Output Power (Variation over Temperature)	+/- 1.5 dB	Pass	Pass	Pass
Transmit Output Power (Variation at Max Power)	+/- 3.5 dB	Pass	Pass	Pass
Transmit EVM	<13%	Pass	Pass	Pass
Center Frequency Tolerance	+/- 100 kHz	Pass	Pass	Pass
Spectral PSD Mask (Margin)	<30 dB	Pass	Pass	Pass
Receiver Sensitivity	-102 dBm	Pass	Pass	Pass

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