RF TEST REPORT

Number 16-049563-01-01

Be based on

FCC CFR 47 Part 15C, section 15.247
ANSI C63.10-2013

For

Applicant	**Woorin Co., Ltd.**
Manufacturer	**Woorin Co., Ltd.**
Model or Type	**Wekey Pocket PN301**
Final HW Version	**N/A**
Final SW Version	**N/A**
Test result	**PASS**

Issue To: **Woorin Co., Ltd.** (Gachon University Sae-Rom Gwan B113) 1342 Seongnam-daero, Sujeong-gu, Seongnam-si, Gyeonggi-do	**Date of Application**	**2016-08-23**
	Date of Report	**2016-09-28**
	Date of Issue	**2016-09-28**

This Test Report consists of 60 pages

The above test certificate is the accredited test results by Korea Laboratory Accreditation Scheme, which signed the ILAC-MRA.

Korea Testing Laboratory

723 Haean-ro, Sangnok-Gu, Ansan-Si, Gyeounggi-Do,15588 KOREA
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Test Report revision History

Revision	Date	Comments
00	2016-09-13	Initial Version
01	2016-09-26	Section 4.9 added
02	2016-09-28	note added in section 4.8.7.2

Signature

This Test Report is issued under the authority as below

Date : 28th September, 2016

Test Engineer : Ban Jong-Gon

Reviewed/Approved by : Song Hoon-Geun

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1. Administrative Information

1.1. Applicant (Client)

Company Name	Woorin Co., Ltd.
Address	1342 Seongnam-daero, Sujeong-gu, Seongnam-si, Gyeonggi-do
Contact Person	
Name	Sung Young. Ryu
E-mail	syryu1110@woorin.kr
Phone	+82-10- 2313 - 3463

1.2. Manufacturer Data (only if different from Appicant)

Company Name	-
Address	-
Contact Person	
Name	-
E-mail	-
Phone	-

1.3. Testing Laboratory Data

The following list shows all places and laboratories involved for test result generation.

Company Name	Korea Testing Laboratory
Address	723 Haean-ro, Sangnok-Gu, Ansan-Si, Gyeounggi-Do, 15588 KOREA
Contact Person	
Name	Ban Jong-gon
E-mail	banjg@ktl.re.kr
Phone	+82-31-500-0133
Fax	+82-31-500-0159

2.EUT Information

2.1. General Description of the EUT

The following section lists all specifications of EUT (Equipment Under Test) involved in test. Additionally, KTL has received sufficient documentation from the client and/or manufacturer to perform the tests

General Information	
FCC ID & Model Number	FCC ID: 2AJK6-PN301, Model Number: Wekey Pocket PN301
Antenna Type	Internal Antenna
Type of Radio transmission	FHSS (GFSK / π/4 DQPSK and 8DPSK)
Frequency Range	2,402 ~ 2,480 MHz
Channel Numbers	79
Antenna Gain	1.25 dBi
Battery options	Li-ion, 3.7 V
Date(s) tested	2016.08.23 ~ 2016.09.23

2.2. Maximum Output Power

Modulation	Conducted Output Power (dBm)
GFSK	3.98
π/4 DQPSK	2.60
8DPSK	2.95

3. SUMMARY OF TEST RESULTS

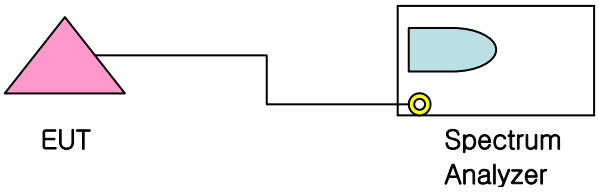
The following table represents the list of measurements required under the FCC CFR47 Part 15.247..

FCC Rules	Test Items	Results	Remarks
15.247(a)(1)(iii)	20dB Bandwidth	Pass	-
15.247(b)(1)	Peak Transmitter Output Power	Pass	-
15.247(d)	Band Edge / Out of band emissions	Pass	-
15.247(a)(1)	Channel Separation	Pass	-
15.247(b)(iii)	Number of channels	Pass	-
15.247(a)(1)(iii)	Time of Occupancy	Pass	-
15.205, 15.209	General Field Strength Limits (Restricted Bands and radiated emissions limits)	Pass	-
15.207	AC Line Conducted Emission	Pass	

4. Measurement & Results

4.1. 20 dB Bandwidth

4.1.1. Test Setup Layout



4.1.2. Test Condition & Limit

The bandwidth at 20 dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the receive antenna while the EUT is operating in transmission mode at the appropriate frequencies. ***The maximum permissible 20 dB bandwidth is 1 MHz, unless more than 15 non-overlapping channels are employed.***

4.1.3. Test result

Channels	Frequency (MHz)	Data Rate (Mbps)	20dB Bandwidth Result (kHz)	Verdict
Low	2402	1.0	945.9	Pass
Middle	2441	1.0	936.8	Pass
High	2480	1.0	941.9	Pass
Low	2402	2.0	1240.0	Pass
Middle	2441	2.0	1258.0	Pass
High	2480	2.0	1315.0	Pass
Low	2402	3.0	1258.0	Pass
Middle	2441	3.0	1257.0	Pass
High	2480	3.0	1256.0	Pass

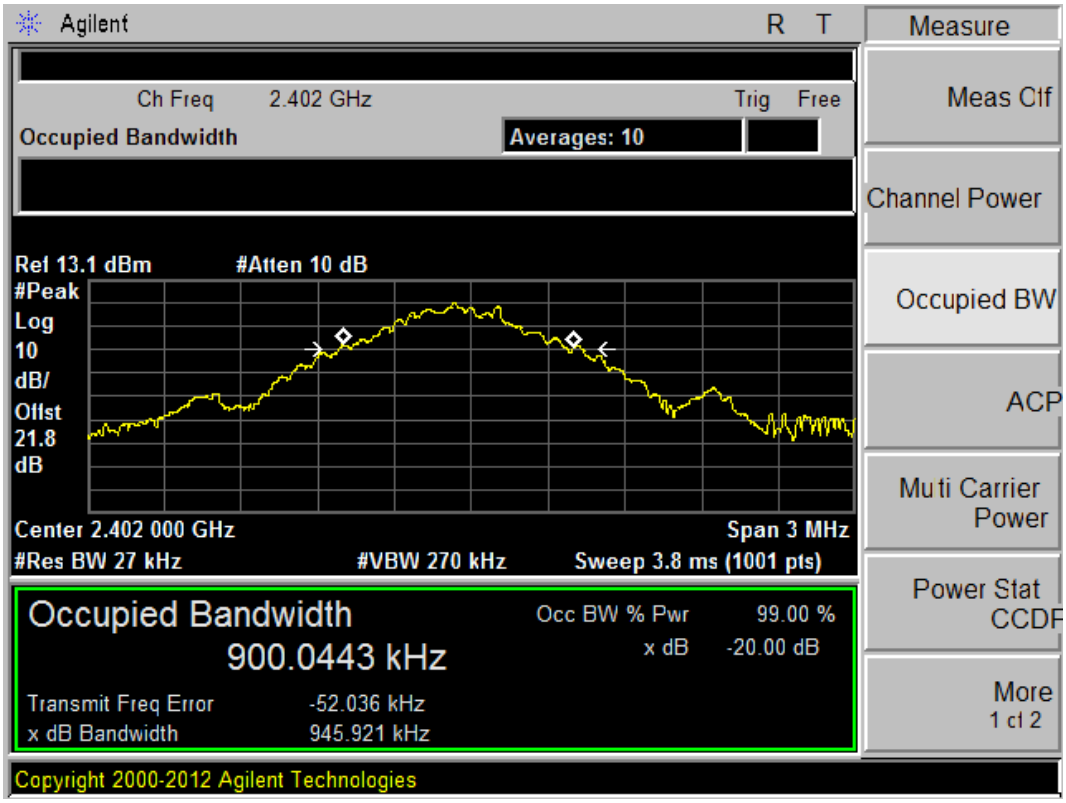


Figure 1. 20 dB Bandwidth Plot (Bluetooth, 1 Mbps – 2402 MHz)

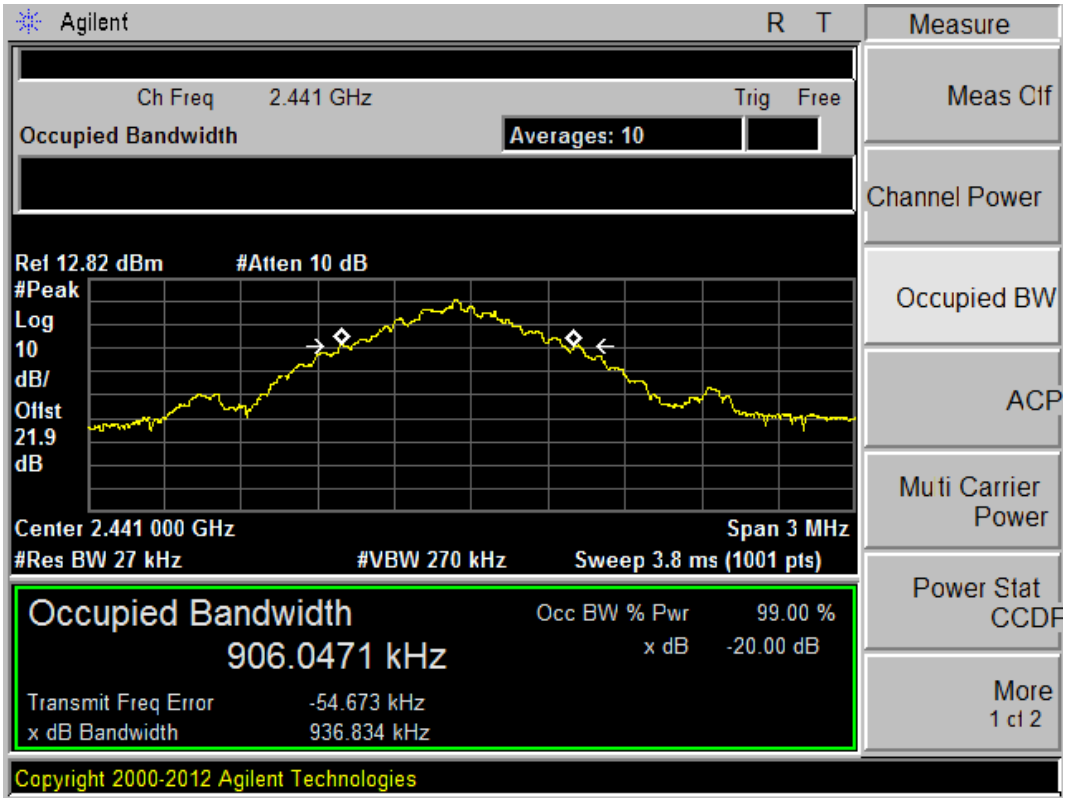


Figure 2. 20 dB Bandwidth Plot (Bluetooth, 1 Mbps - 2441 MHz)

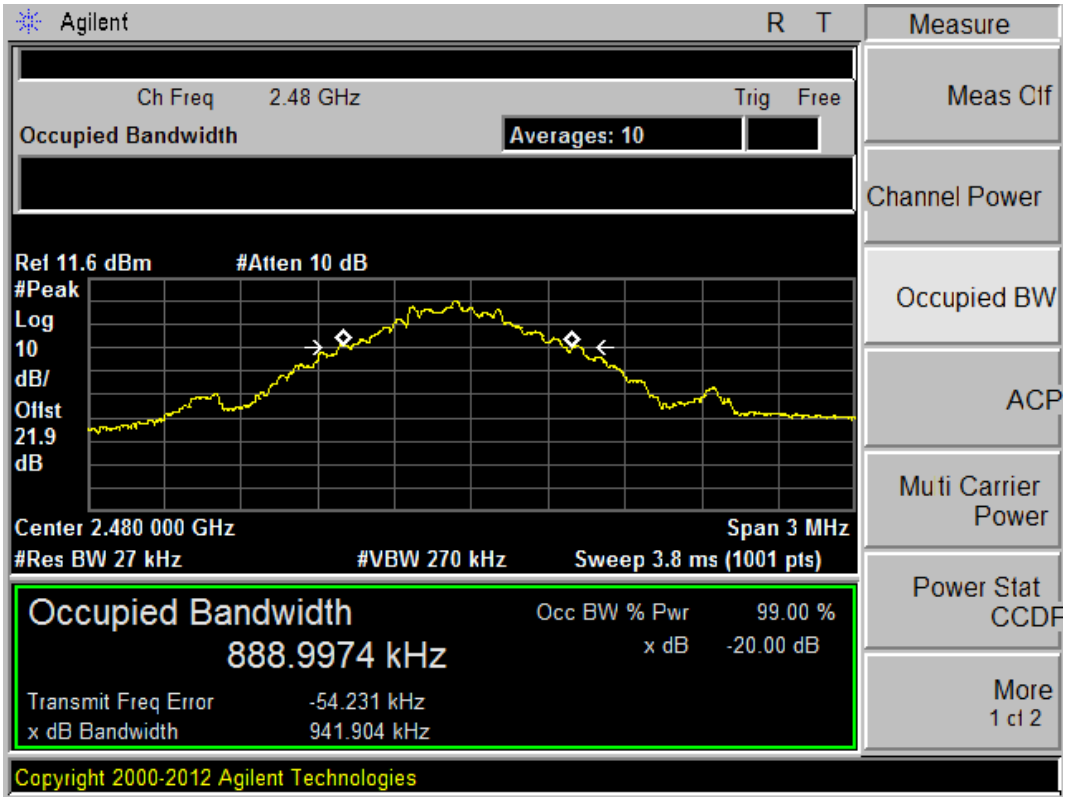


Figure 3. 20 dB Bandwidth Plot (Bluetooth, 1 Mbps - 2480 MHz)

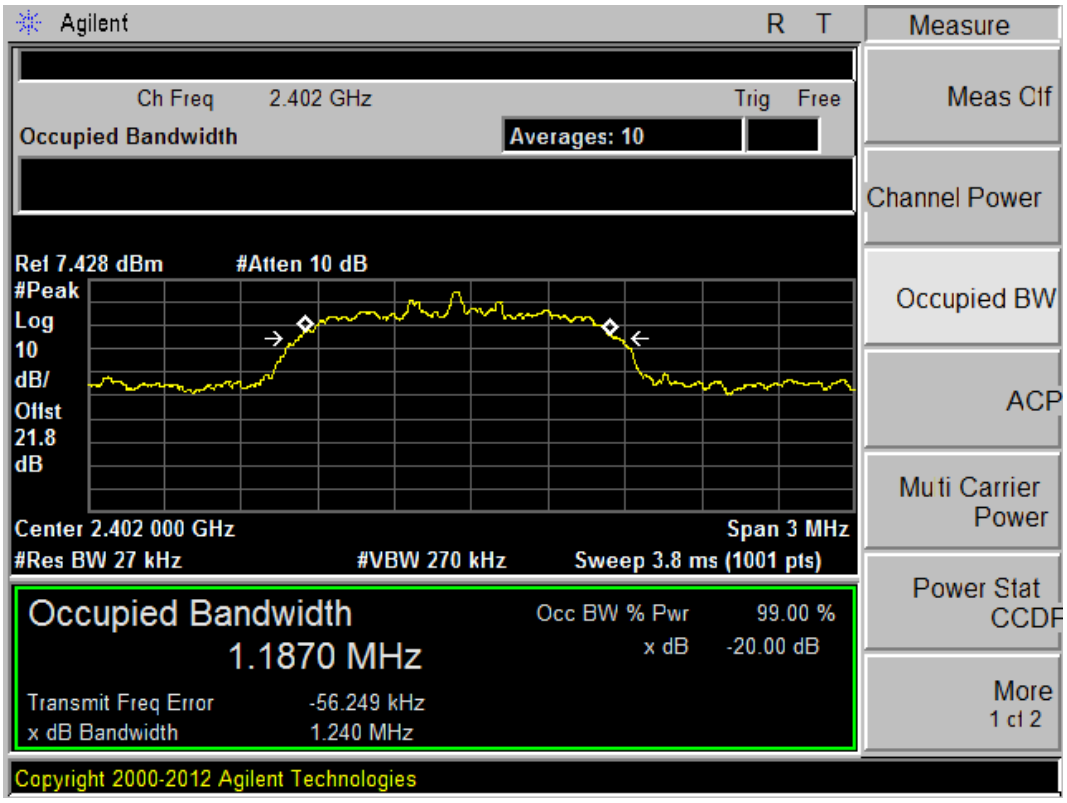


Figure 4. 20 dB Bandwidth Plot (Bluetooth, 2 Mbps - 2402 MHz)

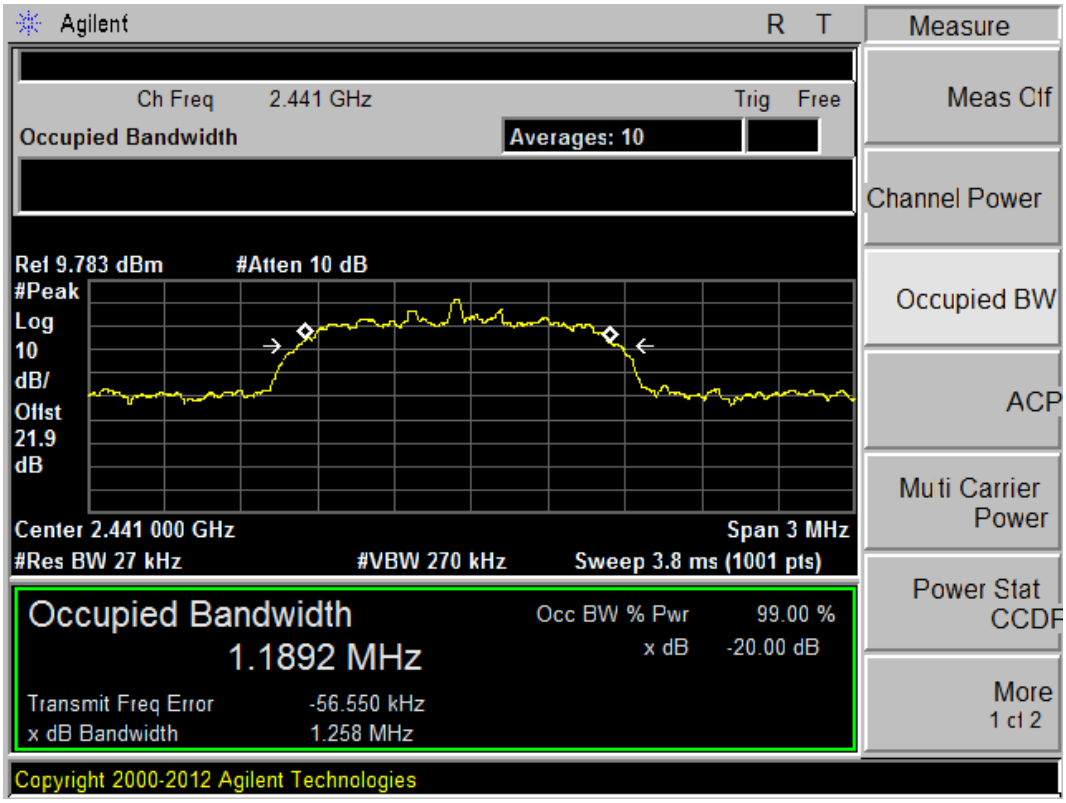


Figure 5. 20 dB Bandwidth Plot (Bluetooth, 2 Mbps - 2441 MHz)

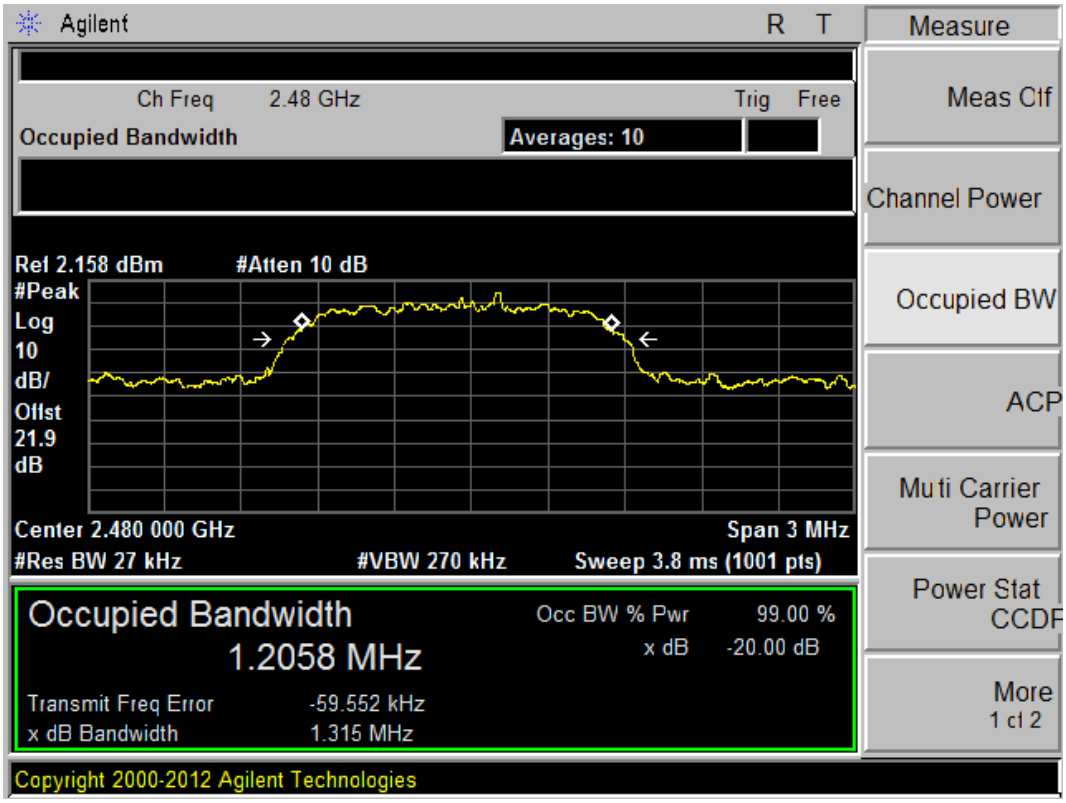


Figure 6. 20 dB Bandwidth Plot (Bluetooth, 2 Mbps - 2480 MHz)

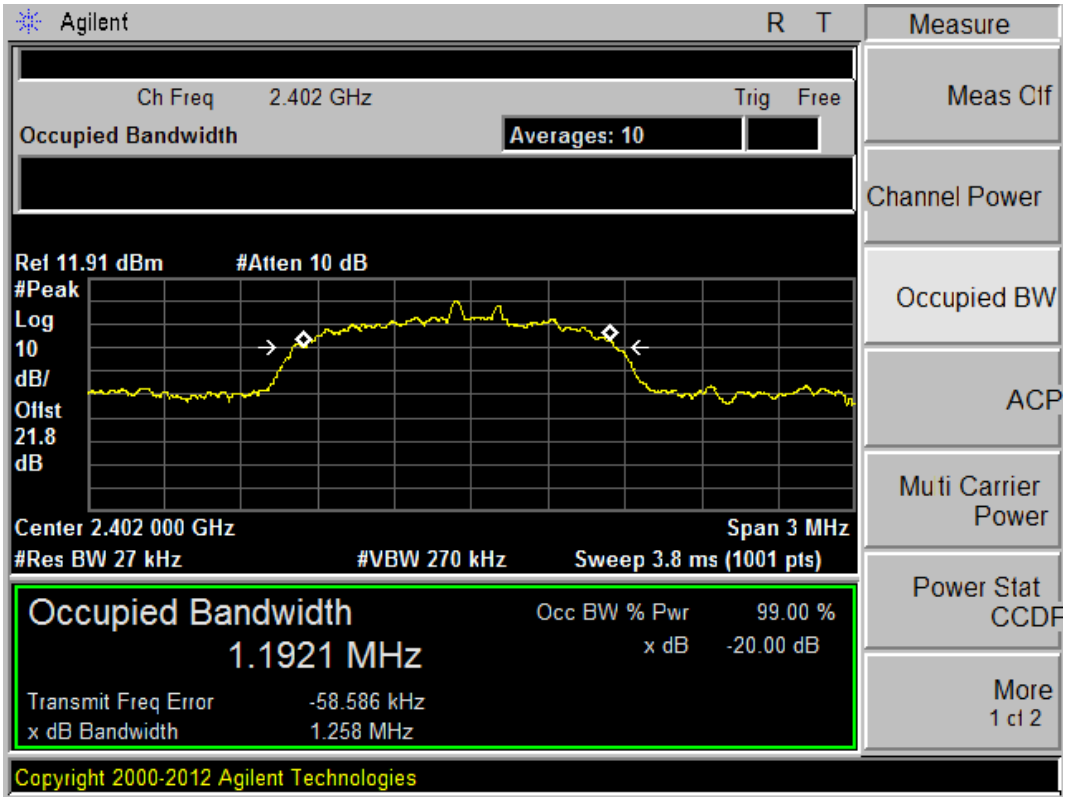


Figure 7. 20 dB Bandwidth Plot (Bluetooth, 3 Mbps - 2402 MHz)

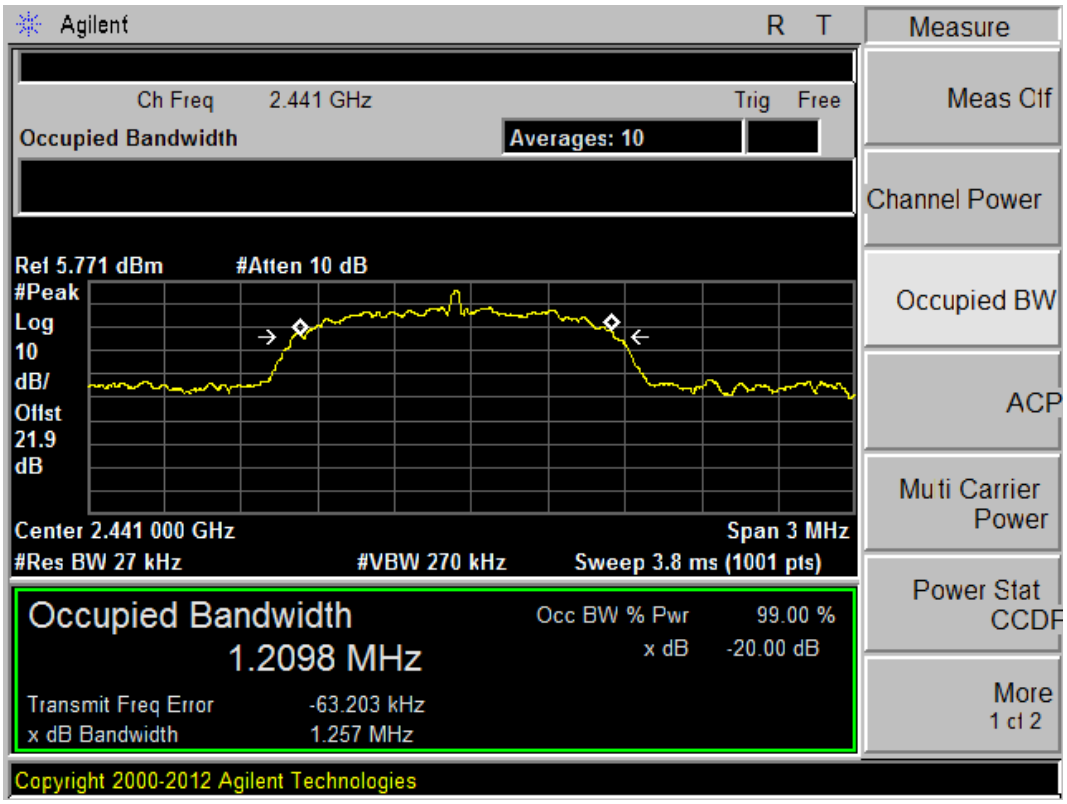


Figure 8. 20 dB Bandwidth Plot (Bluetooth, 3 Mbps - 2441 MHz)

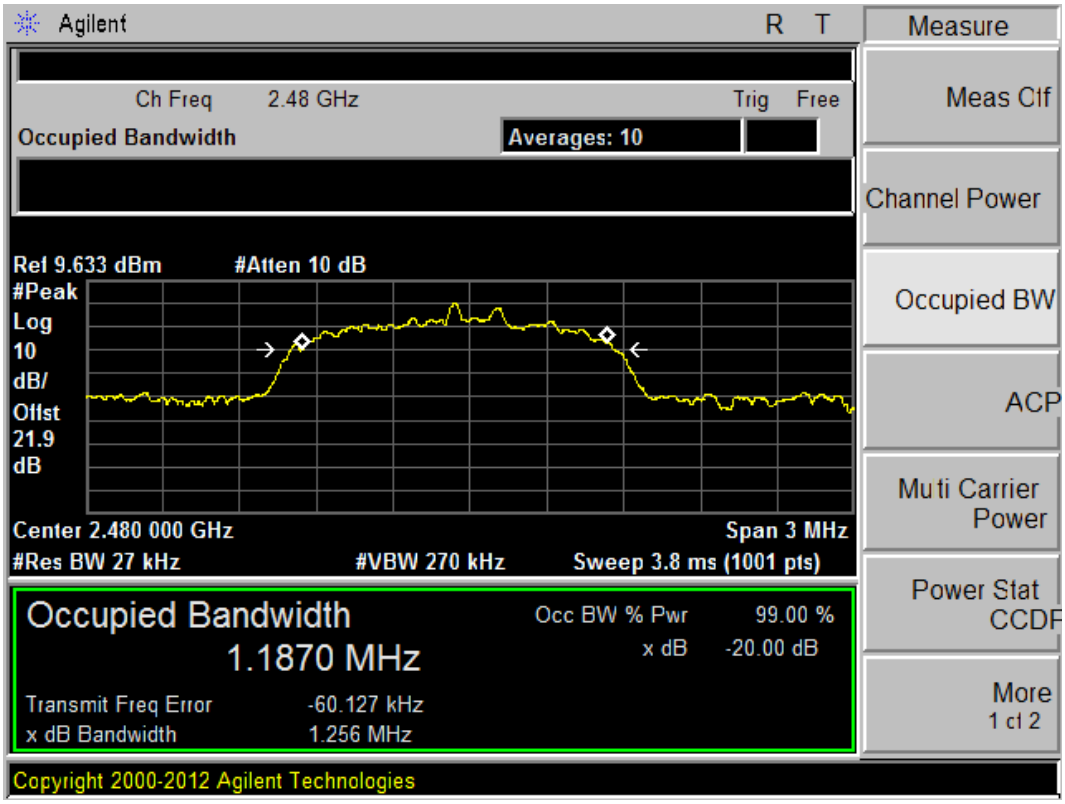
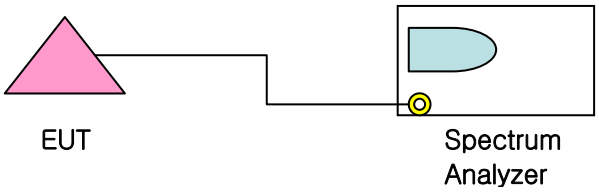


Figure 9. 20 dB Bandwidth Plot (Bluetooth, 3 Mbps - 2480 MHz)

4.2. Peak Transmitter Output Power Measurement

4.2.1. Test Setup Layout



4.2.2. Test Condition & Limit

Measurement is made while the EUT is operating in non-hopping transmission mode. The powers shown below were measured using a spectrum analyzer with a Bluetooth signaling test set used only to maintain a Bluetooth link with the EUT. Peak power measurements are performed in the analyzer's swept spectrum mode using a peak detector with RBW = 3 MHz and VBW > RBW. Average power data is provided to determine the need for Bluetooth SAR testing according to KDB 447498 D01 v05r02. Average power measurements are performed using the analyzer's "burst power" function with RBW = 3 MHz. The burst power function triggers on a single burst set to maximum power and measures the maximum average power over the on-time. The maximum permissible output power is 1 Watt.

This unit was tested with all possible data rates and the highest peak power is reported with the unit transmitting at 1 Mbps.

4.2.3. Test result

Channels	Frequency (MHz)	Data Rate (Mbps)	Peak PWR (dBm / mW)	Average PWR (dBm / mW)	Verdict
Low	2402	1.0	3.98 / 2.50	3.95 / 2.48	Pass
Mid	2441	1.0	3.29 / 2.13	3.23 / 2.10	Pass
High	2480	1.0	1.88 / 1.54	1.83 / 1.53	Pass
Low	2402	2.0	2.60 / 1.82	2.18 / 1.65	Pass
Mid	2441	2.0	1.88 / 1.54	1.49 / 1.41	Pass
High	2480	2.0	0.84 / 1.21	-0.064 / 0.99	Pass
Low	2402	3.0	2.95 / 1.97	2.32 / 1.71	Pass
Mid	2441	3.0	2.32 / 1.70	1.65 / 1.46	Pass
High	2480	3.0	0.77 / 1.20	0.10 / 1.02	Pass

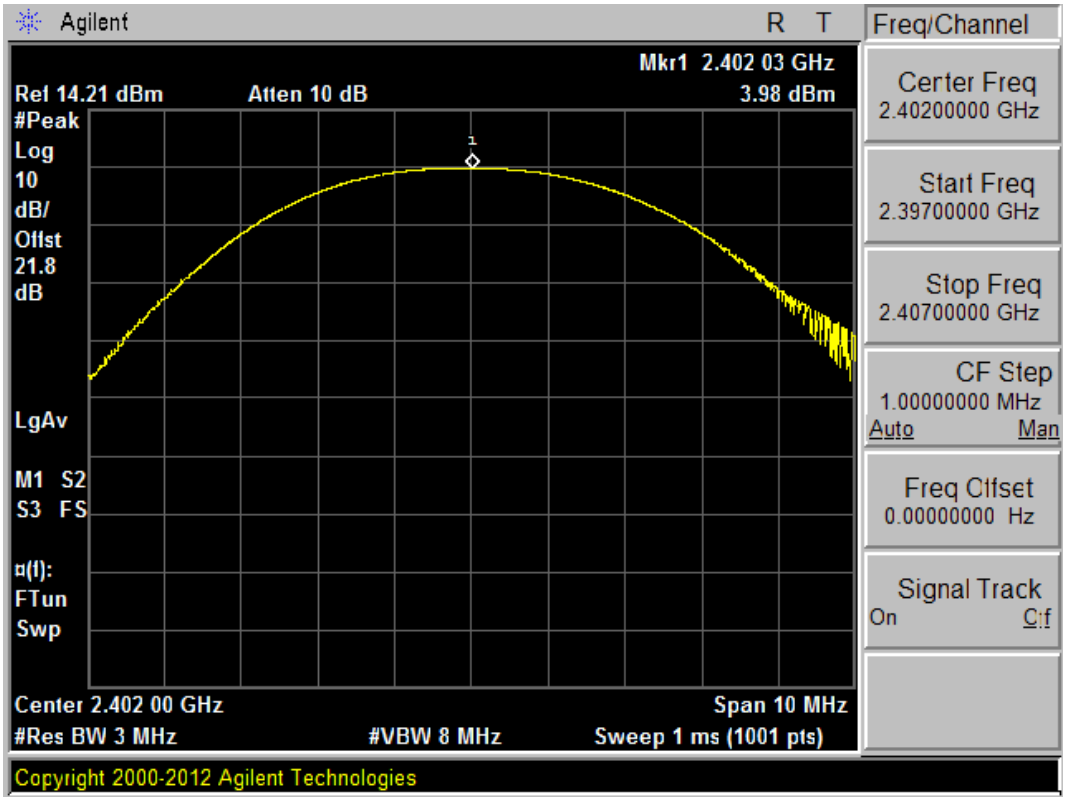


Figure 10. Peak Conducted Power (1 Mbps - 2402 MHz)

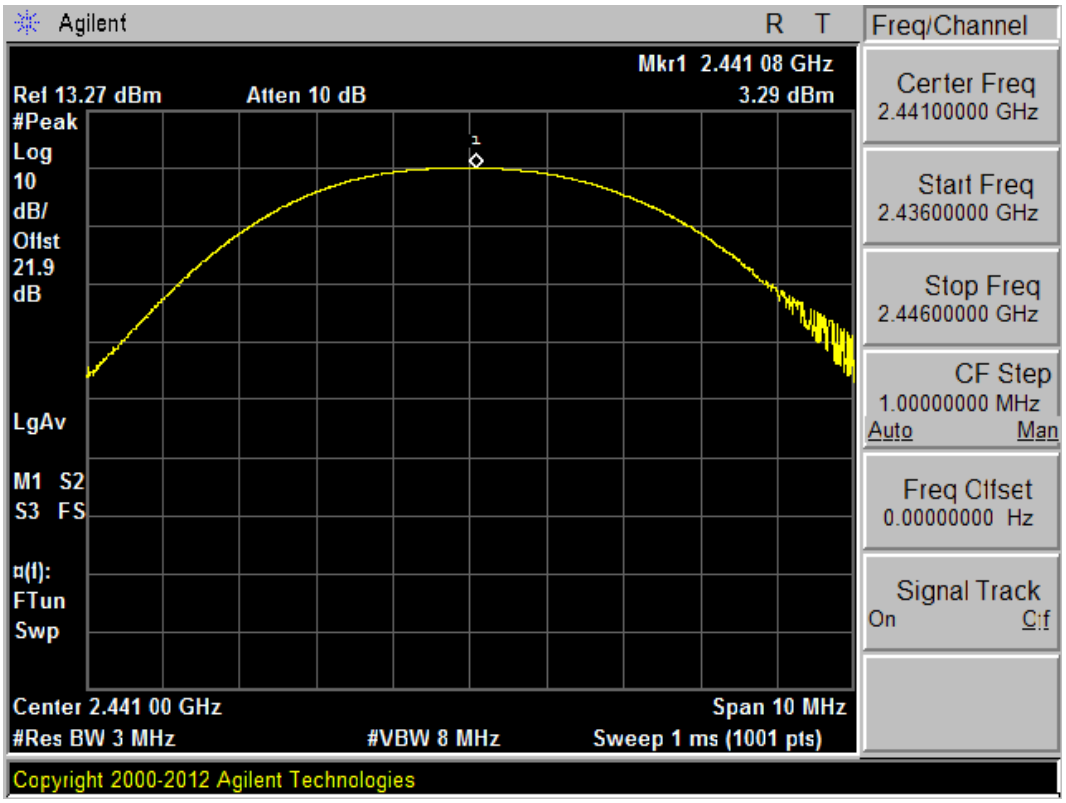


Figure 11. Peak Conducted Power (1 Mbps - 2441 MHz)

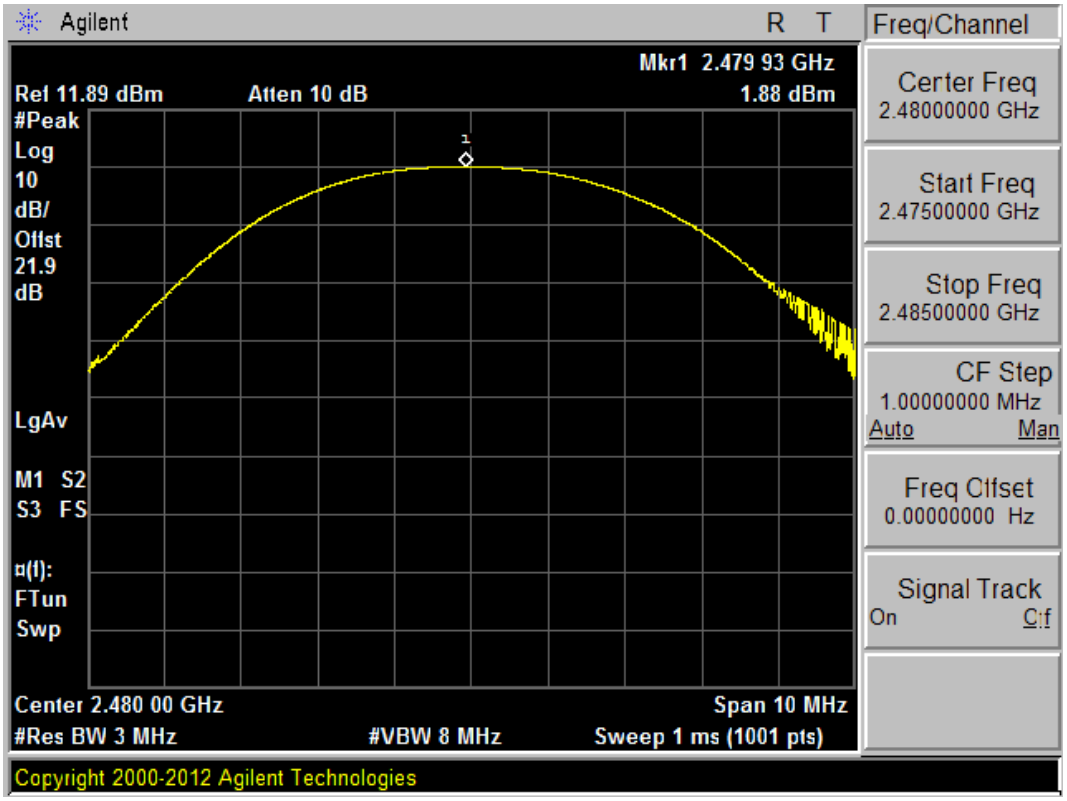


Figure 12. Peak Conducted Power (1 Mbps - 2480 MHz)

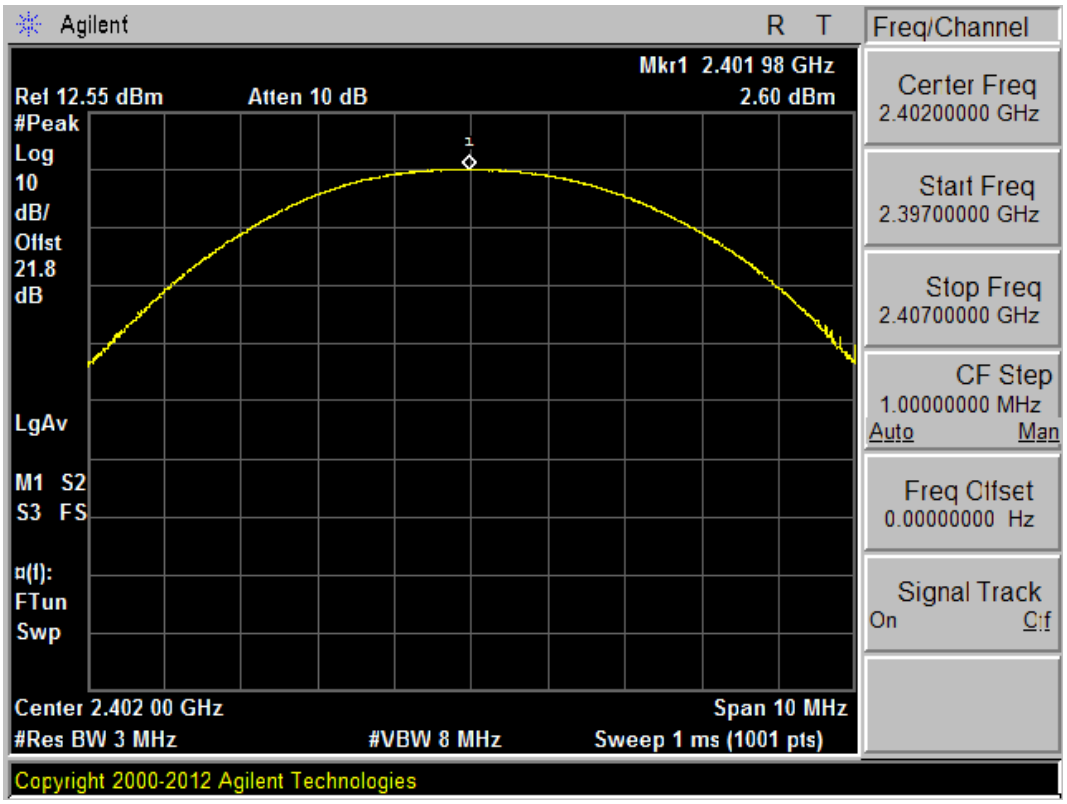


Figure 13. Peak Conducted Power (2 Mbps - 2402 MHz)

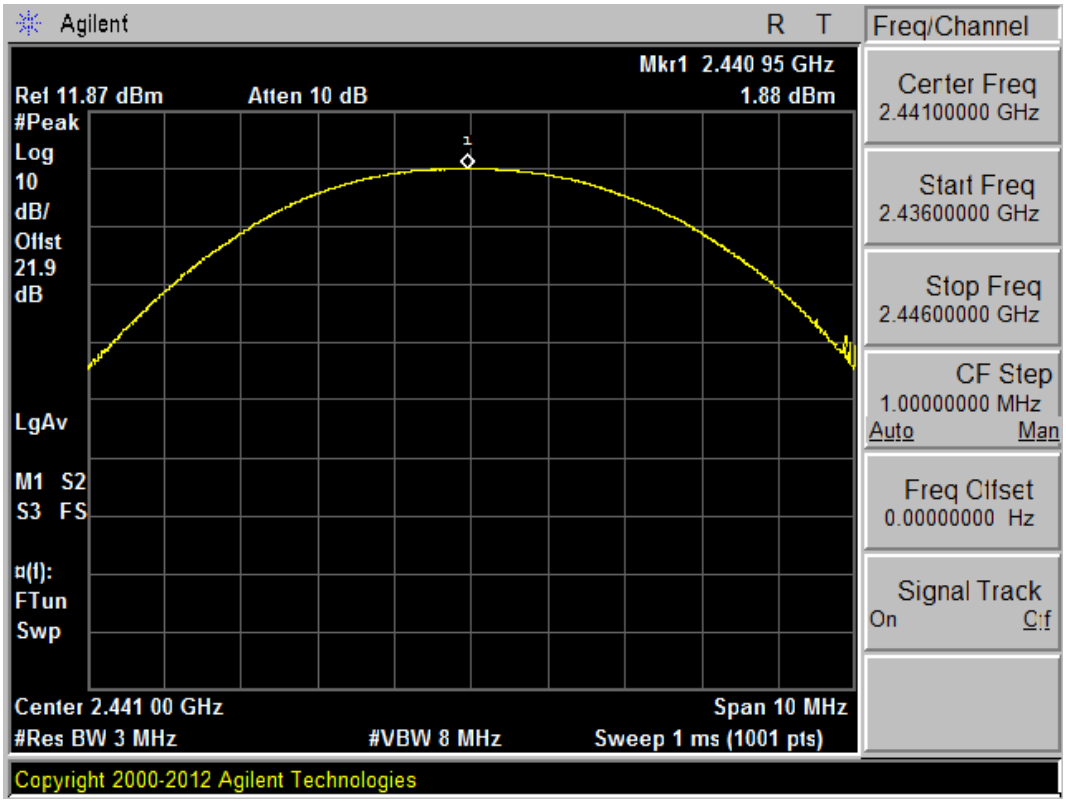


Figure 14. Peak Conducted Power (2 Mbps - 2441 MHz)

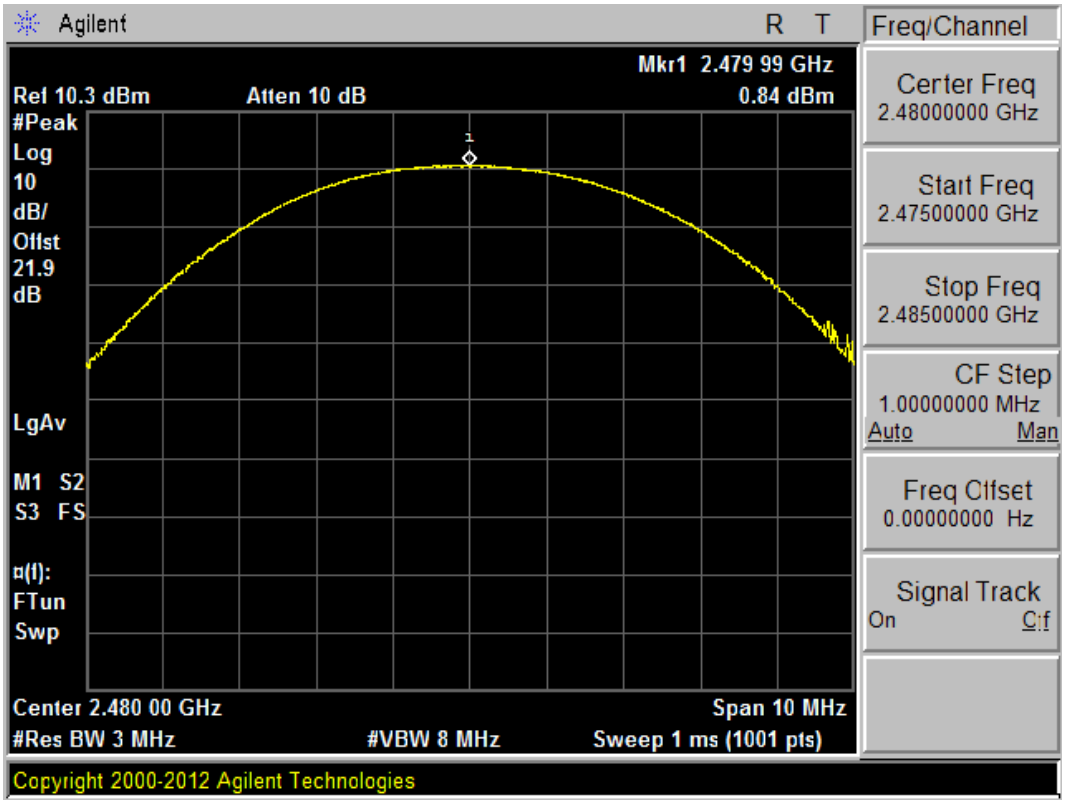


Figure 15. Peak Conducted Power (2 Mbps - 2480 MHz)

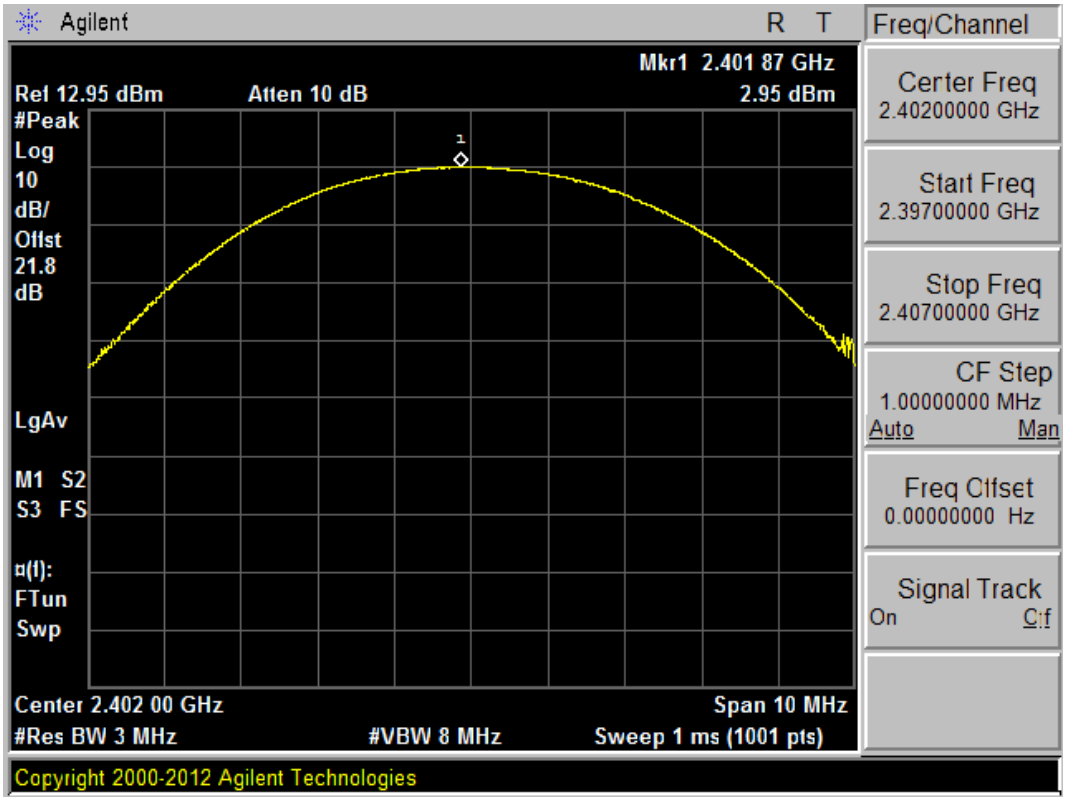


Figure 16. Peak Conducted Power (3 Mbps - 2402 MHz)

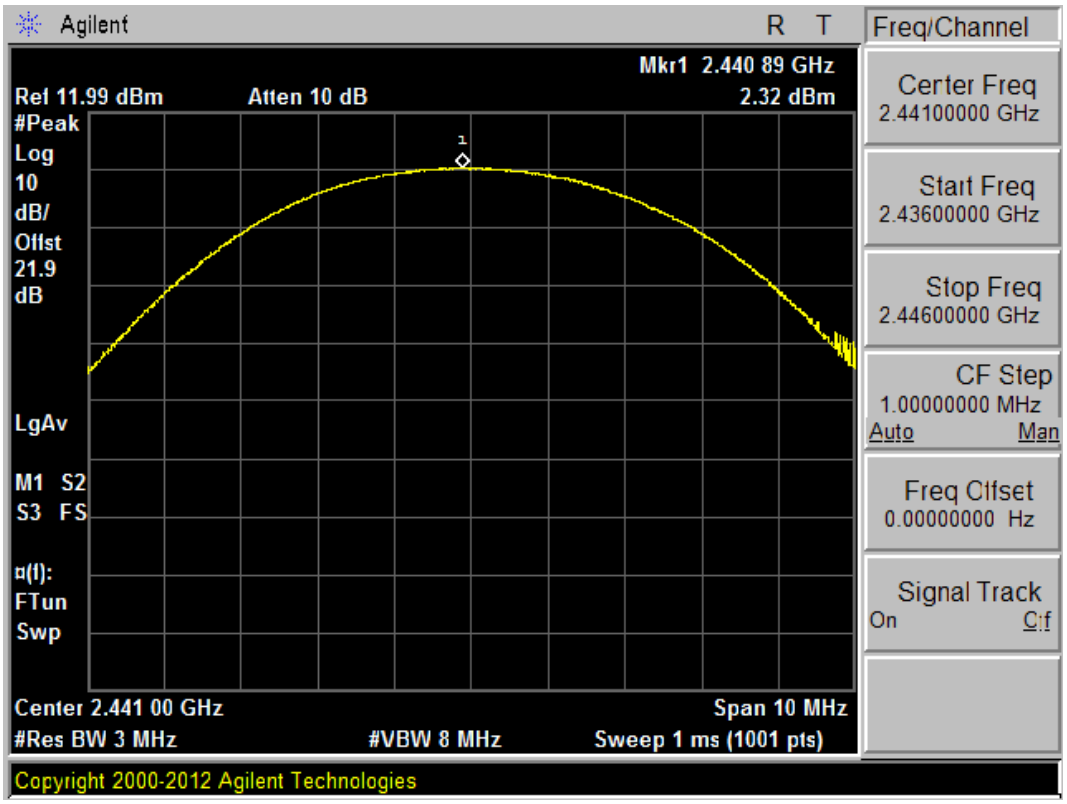


Figure 17. Peak Conducted Power (3 Mbps - 2441 MHz)

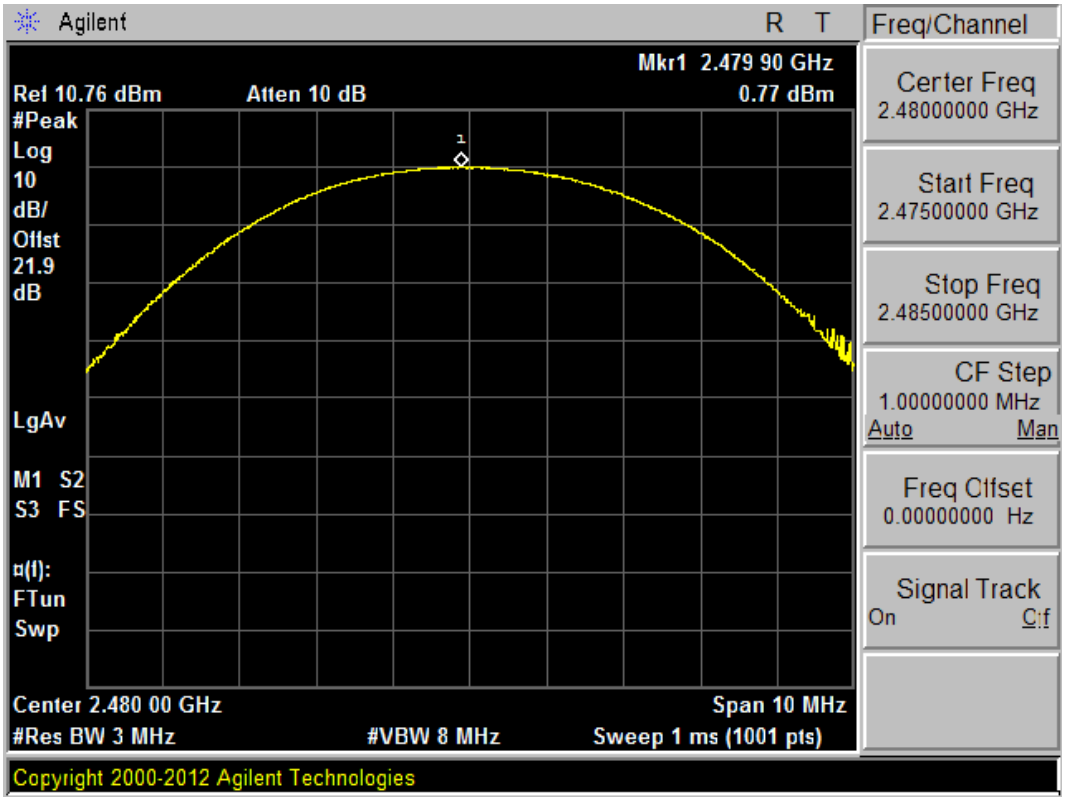


Figure 18. Peak Conducted Power (3 Mbps - 2480 MHz)

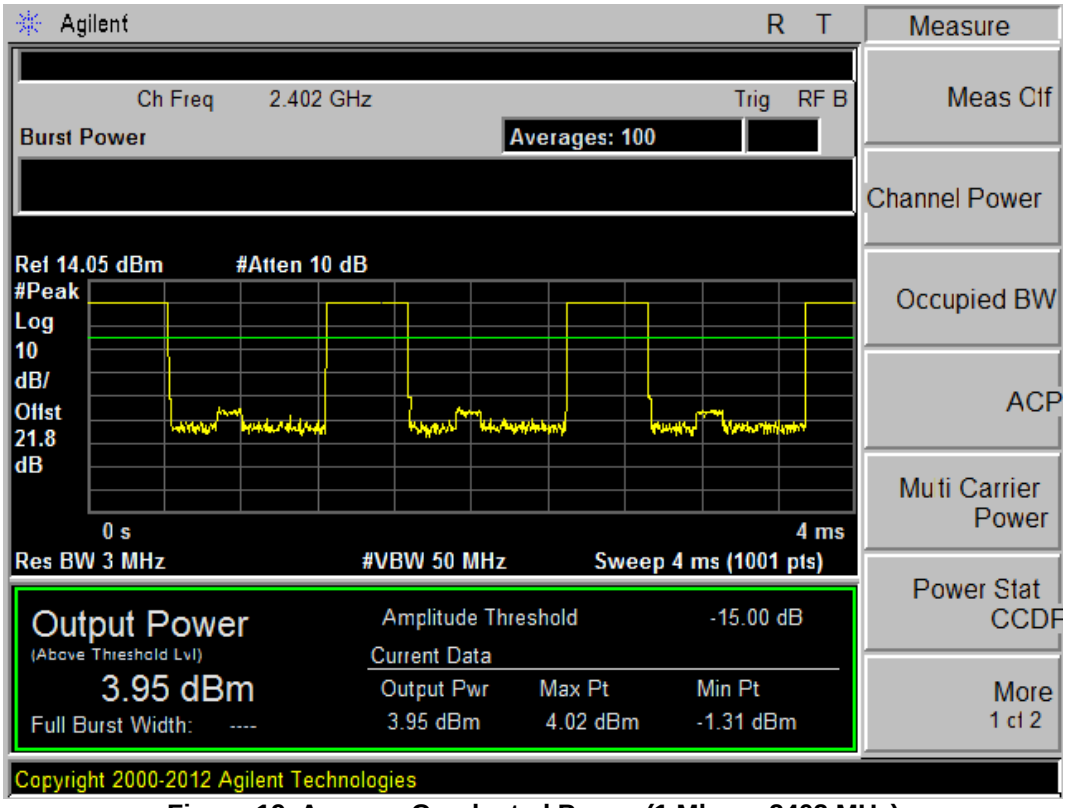


Figure 19. Average Conducted Power (1 Mbps - 2402 MHz)

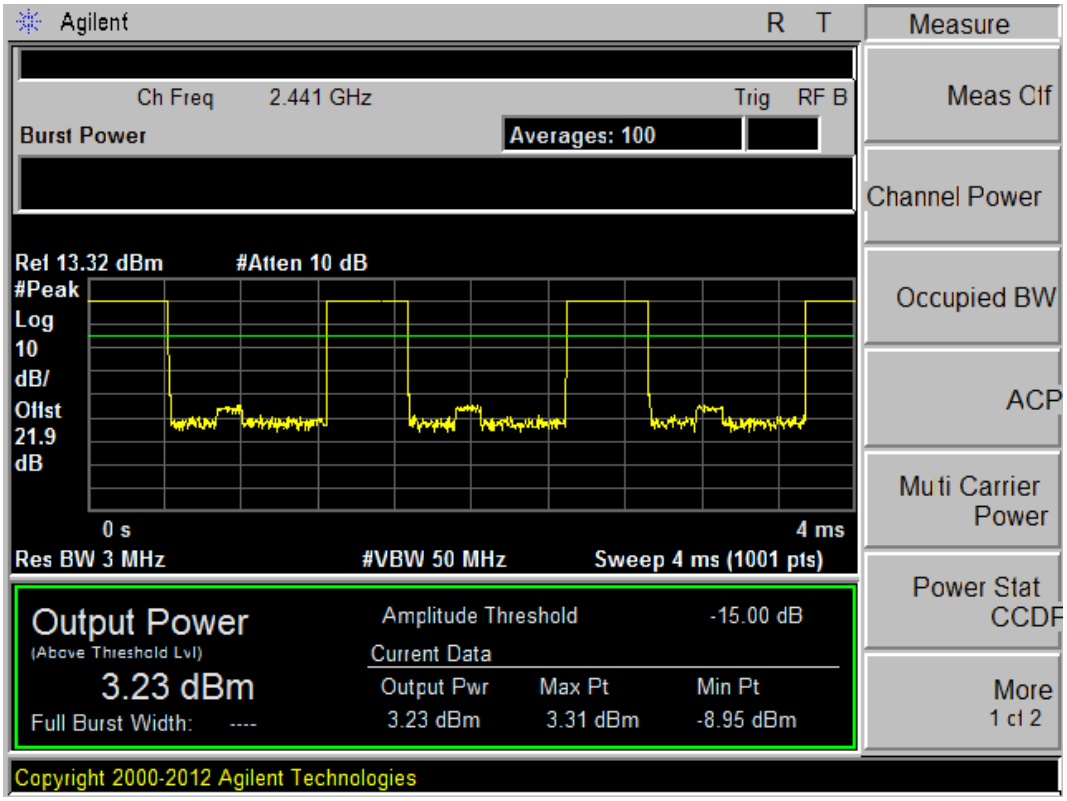


Figure 20. Average Conducted Power (1 Mbps - 2441 MHz)

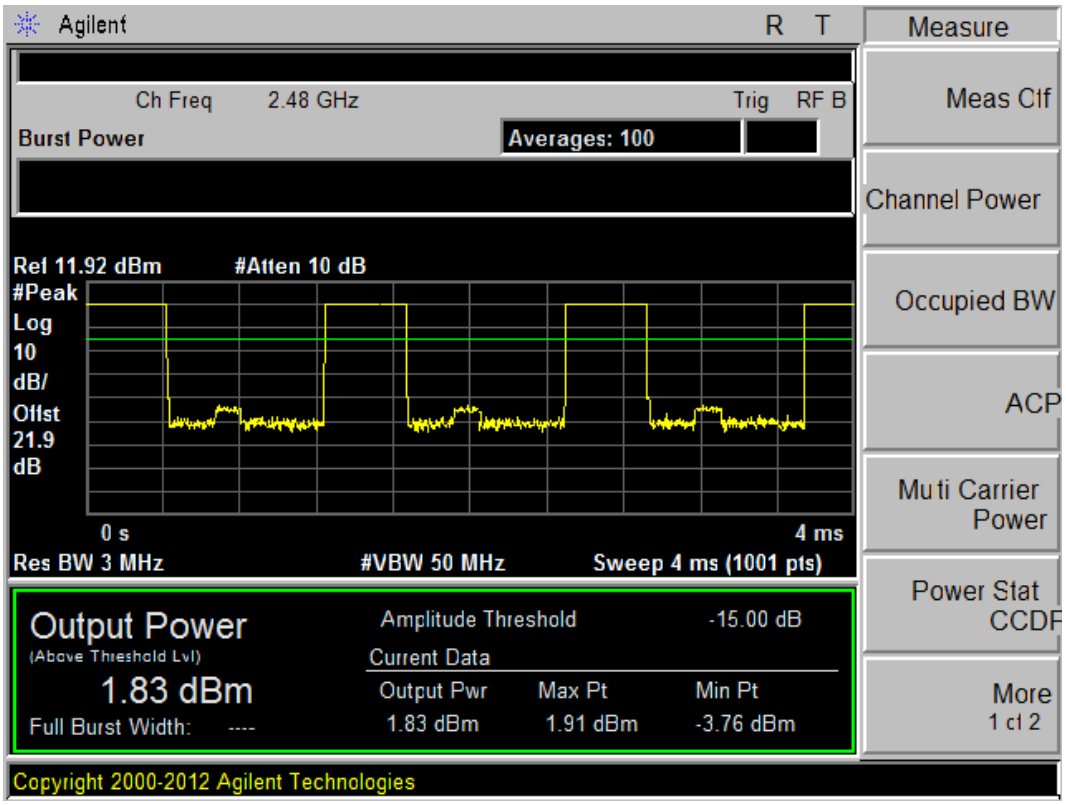


Figure 21. Average Conducted Power (1 Mbps - 2480 MHz)

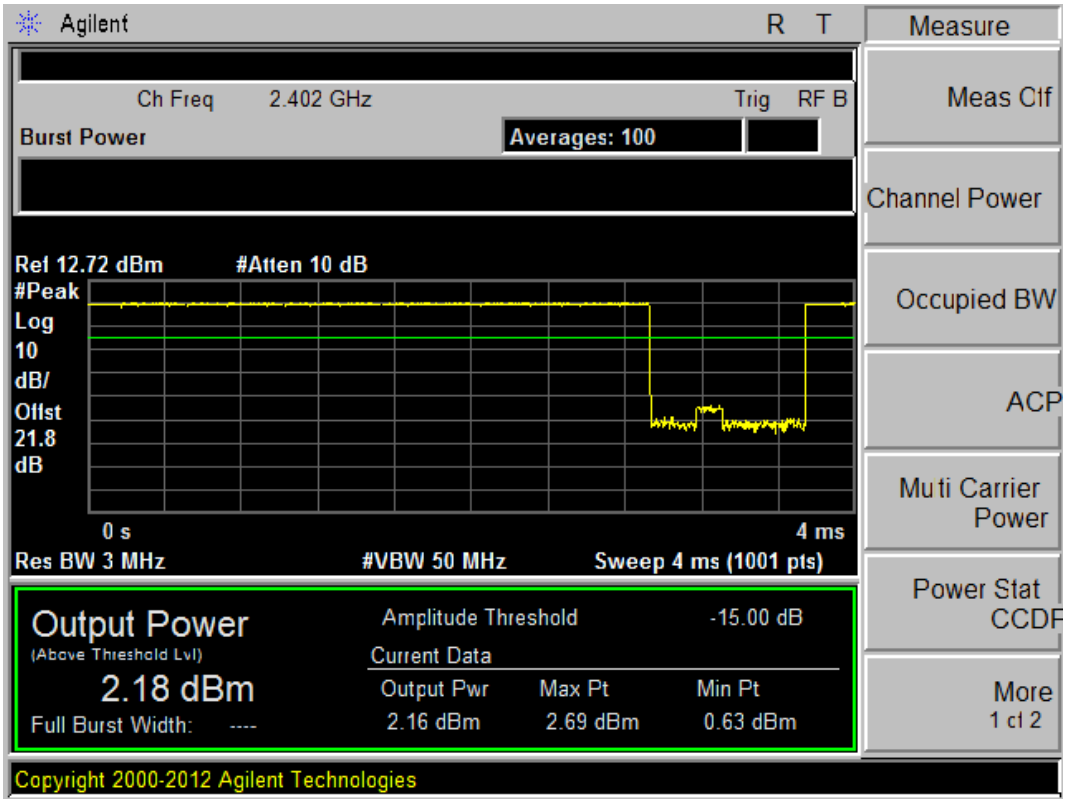


Figure 22. Average Conducted Power (2 Mbps - 2402 MHz)

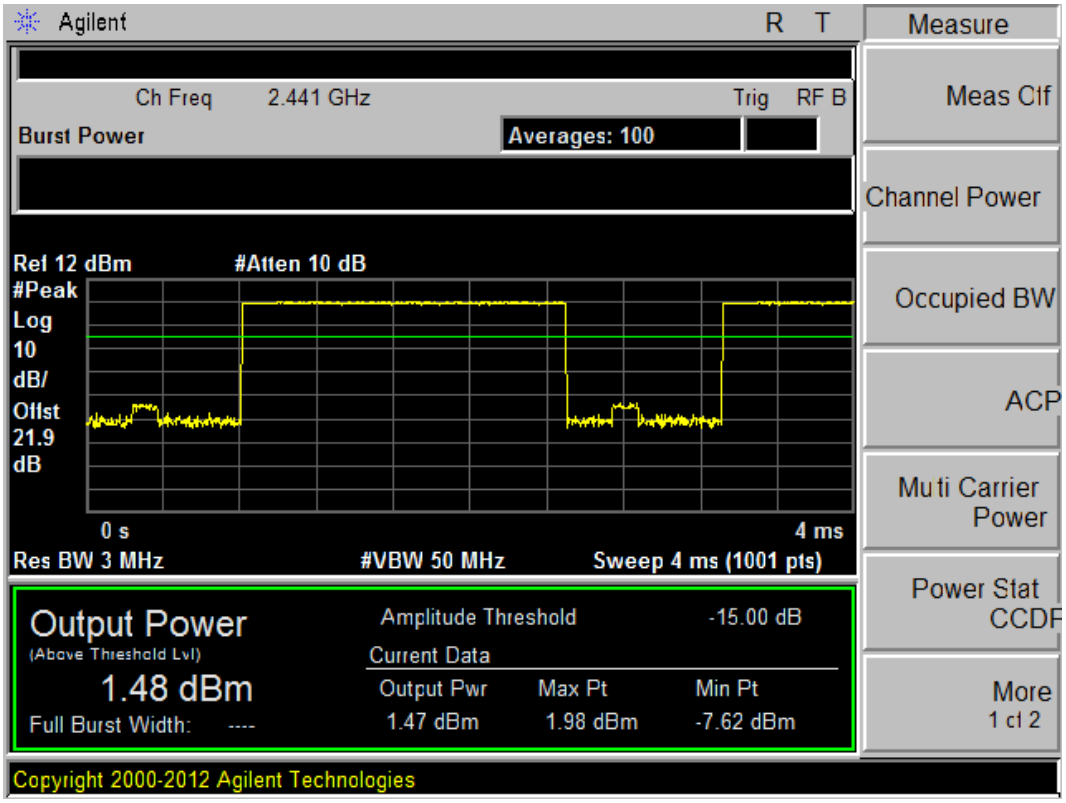


Figure 23. Average Conducted Power (2 Mbps - 2441 MHz)

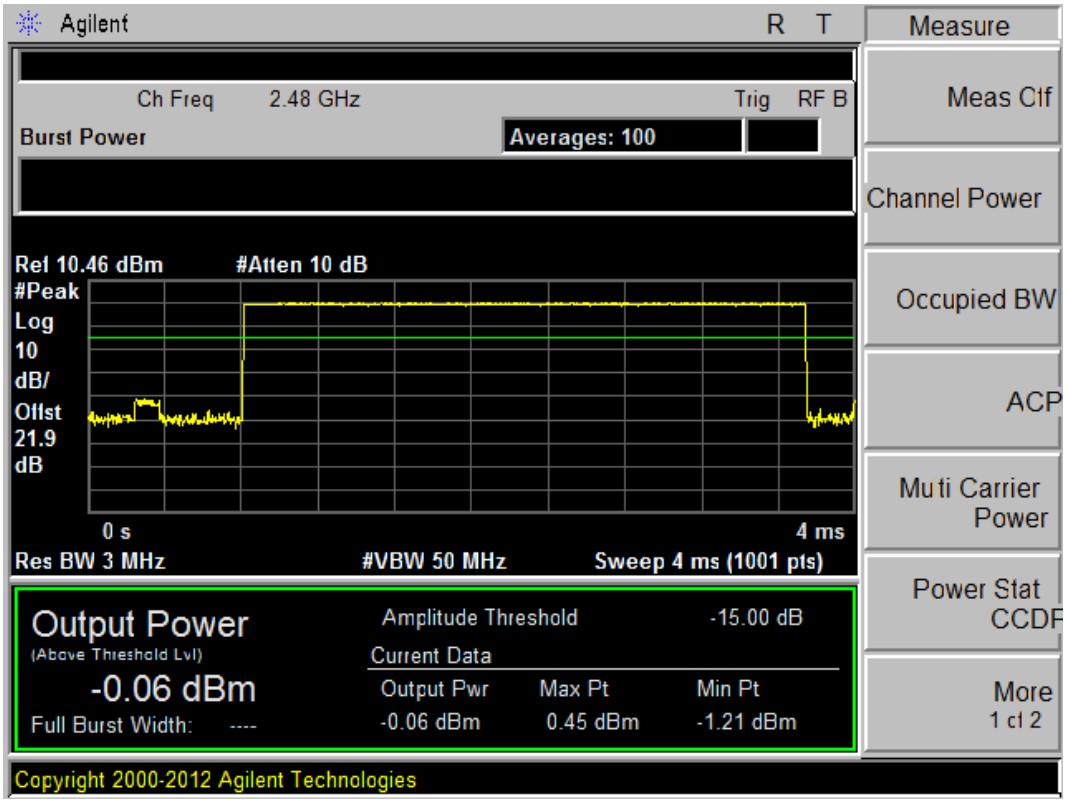


Figure 24. Average Conducted Power (2 Mbps - 2480 MHz)

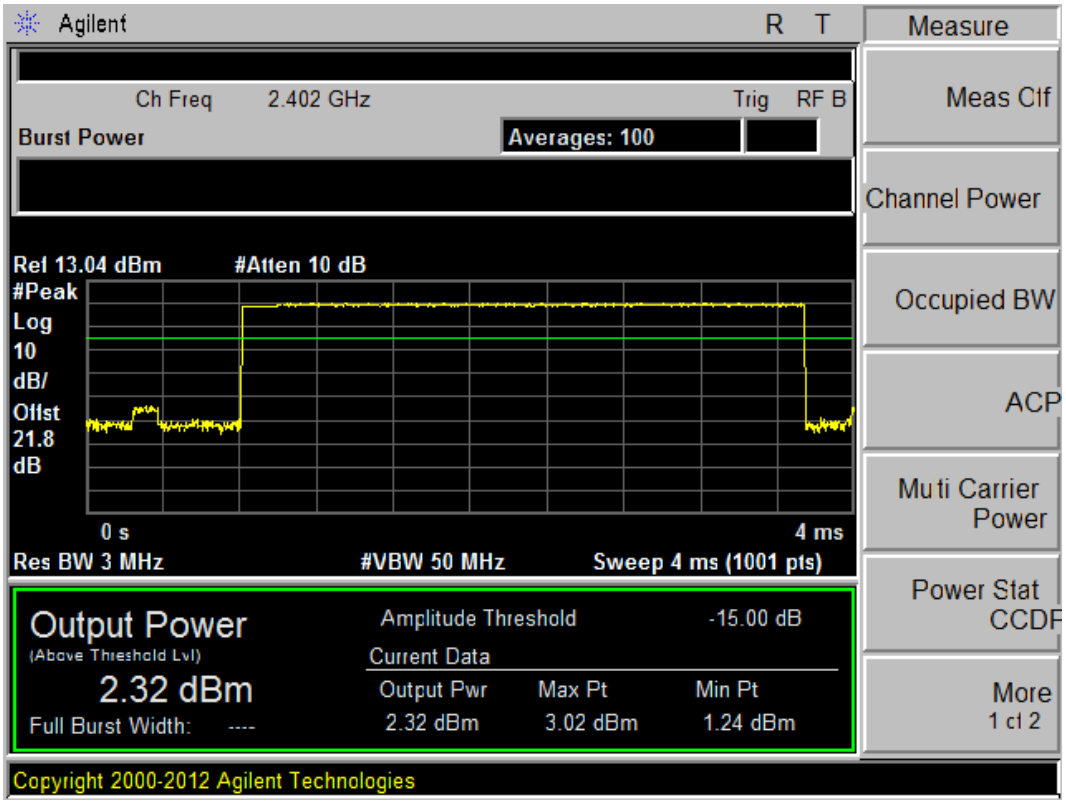


Figure 25. Average Conducted Power (3 Mbps - 2402 MHz)

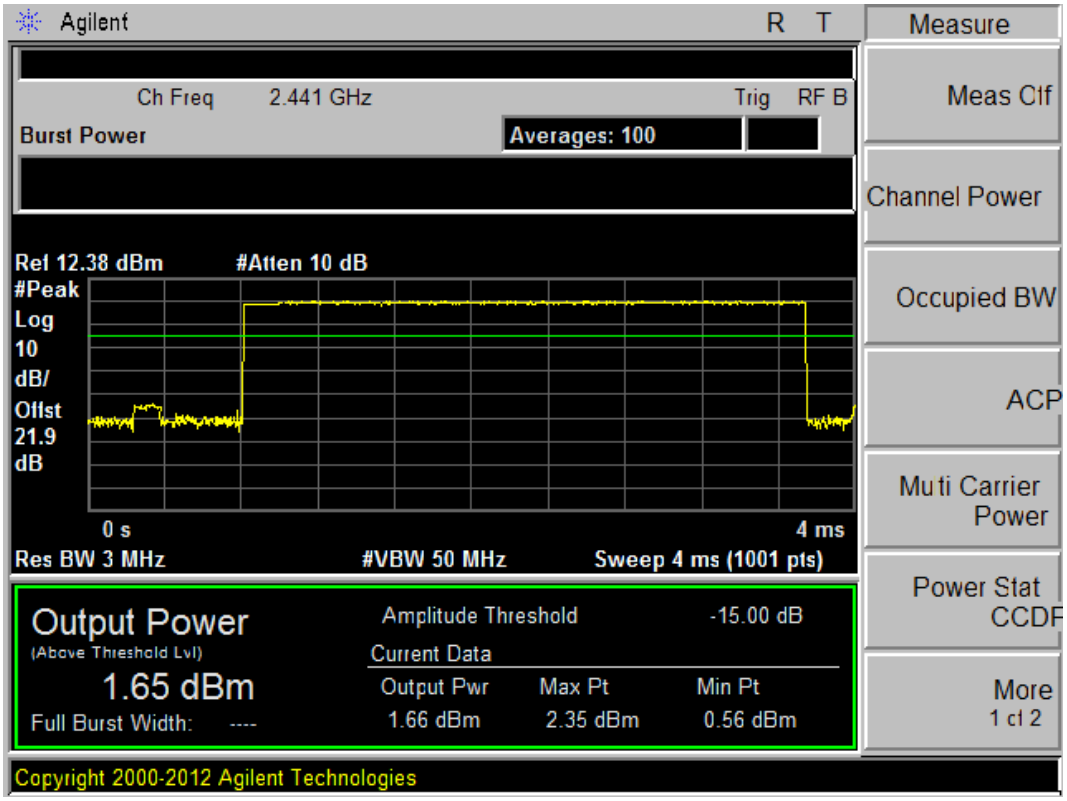


Figure 26. Average Conducted Power (3 Mbps - 2441 MHz)

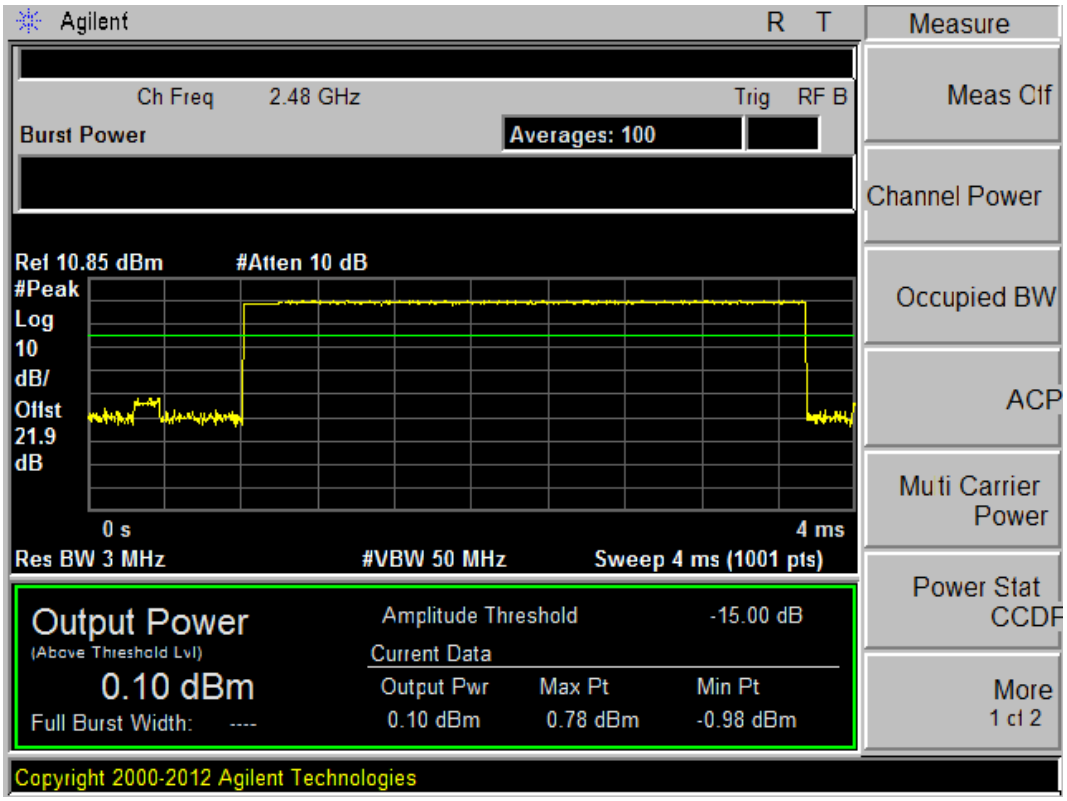
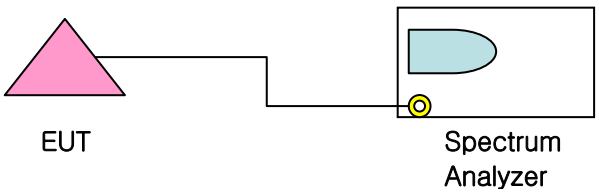


Figure 27. Average Conducted Power (3 Mbps - 2480 MHz)

4.3. Band Edge Emissions

4.3.1. Test Setup Layout



4.3.2. Test Condition & Limit

Measurement is taken at the highest point located outside of the emission bandwidth. The maximum permissible emission level is 20 dBc. Any emission lying outside of the emission bandwidth and in a restricted band is subject to a filed strength limit specified in Section 15.209 of the Title 47 CFR.

Out of band conducted spurious at the band edge were investigated for all data rates and the worst case emissions were found with the EUT transmitting at 1 Mbps. Band edge emissions were also investigate with the EUT transmitting in all data rates. Plots of the worst case emissions are shown below.

4.3.3. Test result

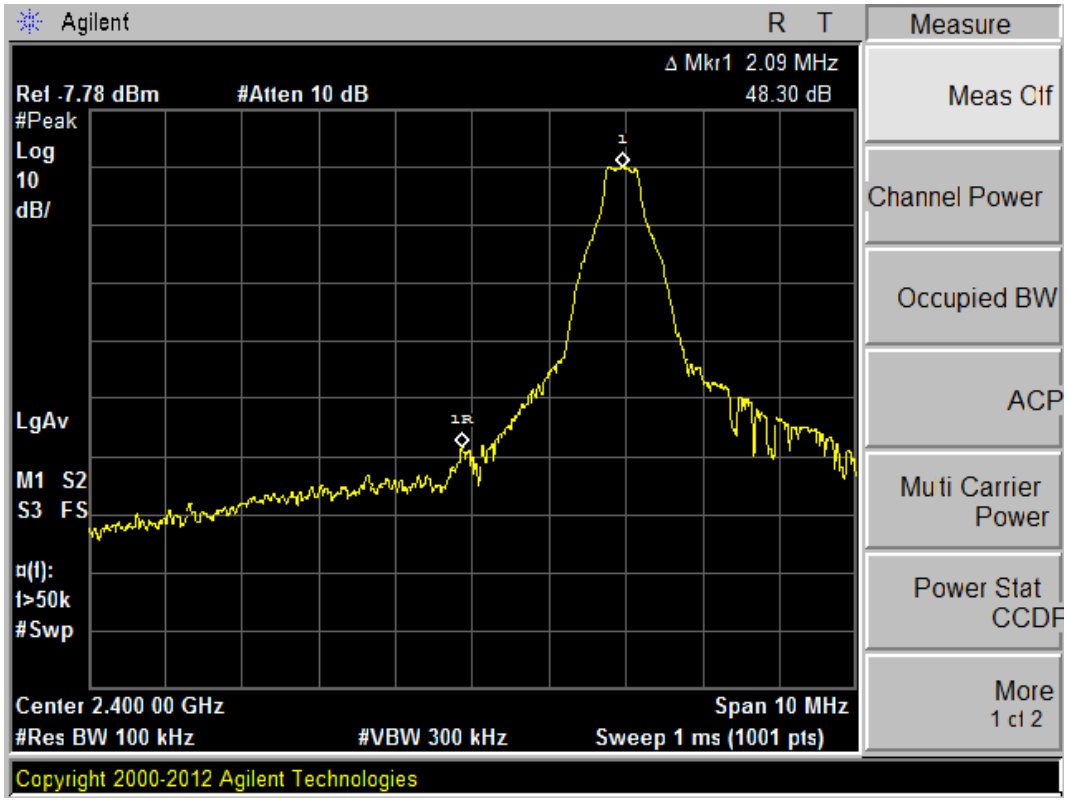


Figure 28. Band Edge Plot (Bluetooth with Hopping disabled, 1 Mbps - 2402 MHz)

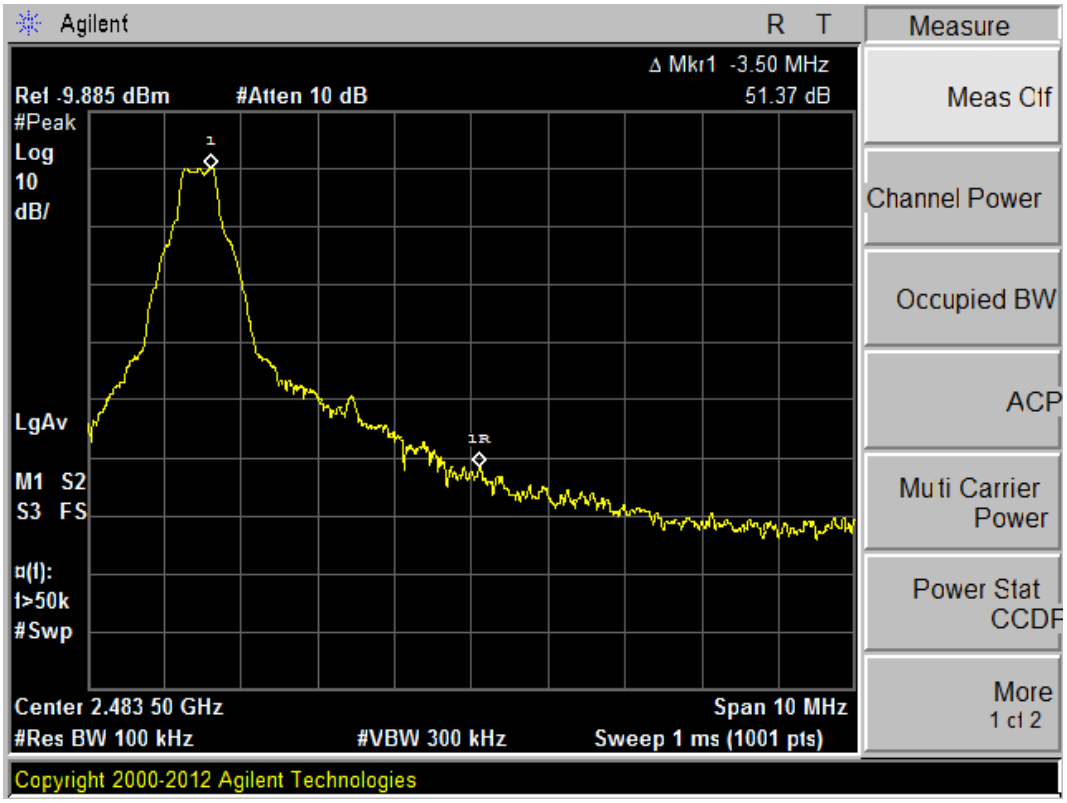


Figure 29. Band Edge Plot (Bluetooth with Hopping disabled, 1 Mbps - 2480 MHz)

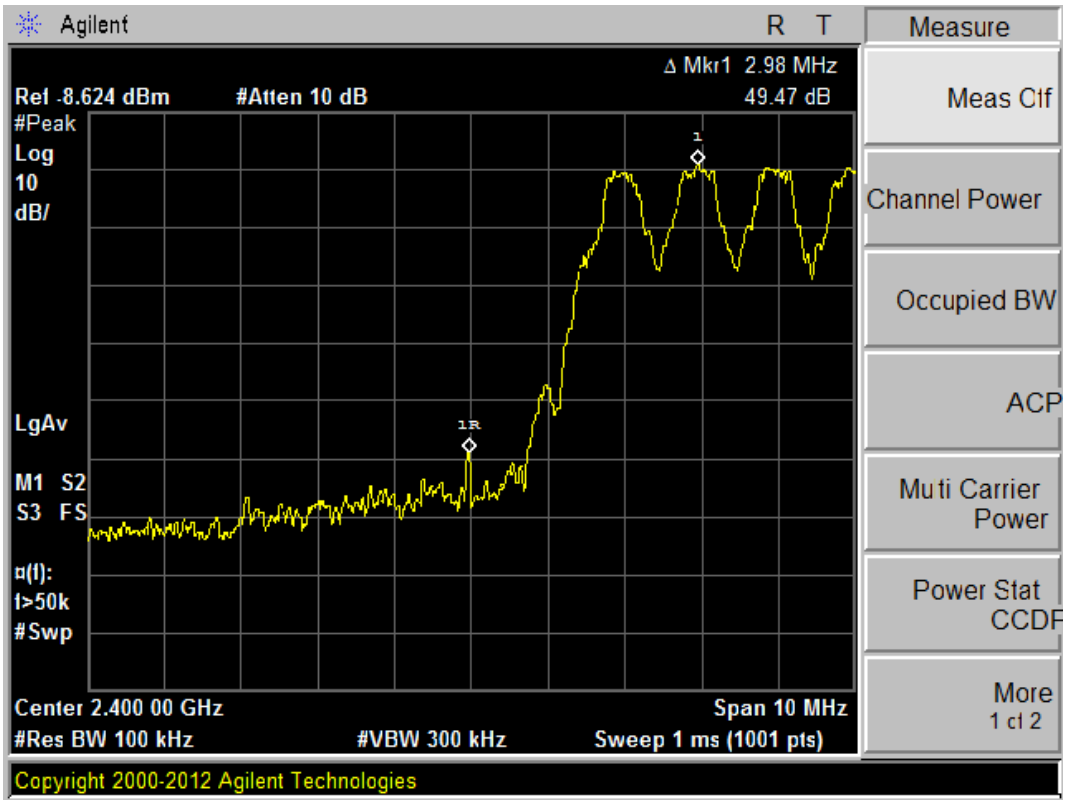


Figure 30. Band Edge Plot (Bluetooth with Hopping enabled, 1 Mbps - 2402 MHz)

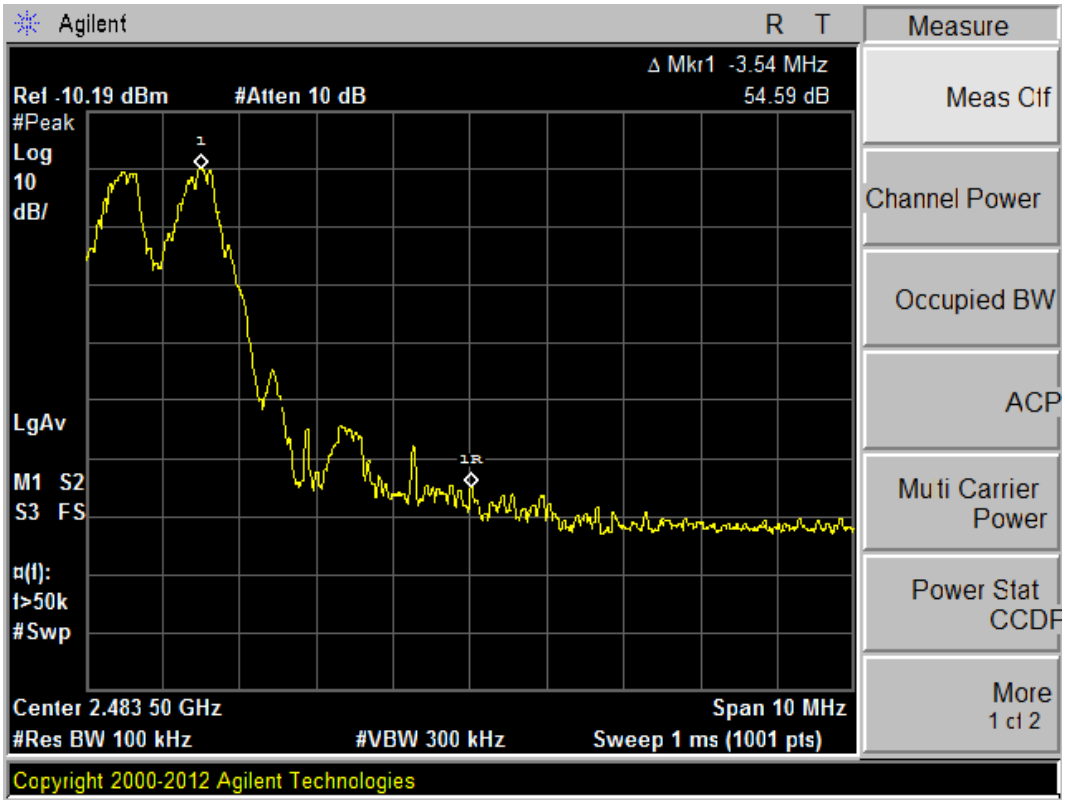
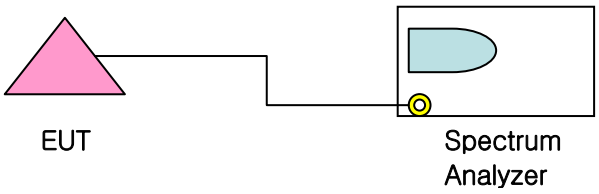


Figure 31. Band Edge Plot (Bluetooth with Hopping enabled, 1 Mbps - 2480 MHz)

4.4. Hopping Channel Separation

4.4.1. Test Setup Layout



4.4.2. Test Condition & Limit

Measurement is made with EUT operating in hopping mode. The minimum permissible channel separation for this system is 2/3 the value of the 20 dB BW.

The EUT complies with the minimum channel separation requirement when it is operating in 1x/EDR mode using 79 channels.

4.4.3. Test result

Frequency (MHz)	Data Rate (Mbps)	20 dB BW (kHz)	Min. Channel Separation (kHz)	Verdict
2402	1.0	945.9	825.0	Pass
2441	1.0	936.8	1005.0	Pass
2480	1.0	941.9	980.0	Pass
2402	2.0	1240.0	995.0	Pass
2441	2.0	1258.0	840.0	Pass
2480	2.0	1315.0	975.0	Pass
2402	3.0	1258.0	990.0	Pass
2441	3.0	1257.0	1000.0	Pass
2480	3.0	1256.0	1005.0	Pass

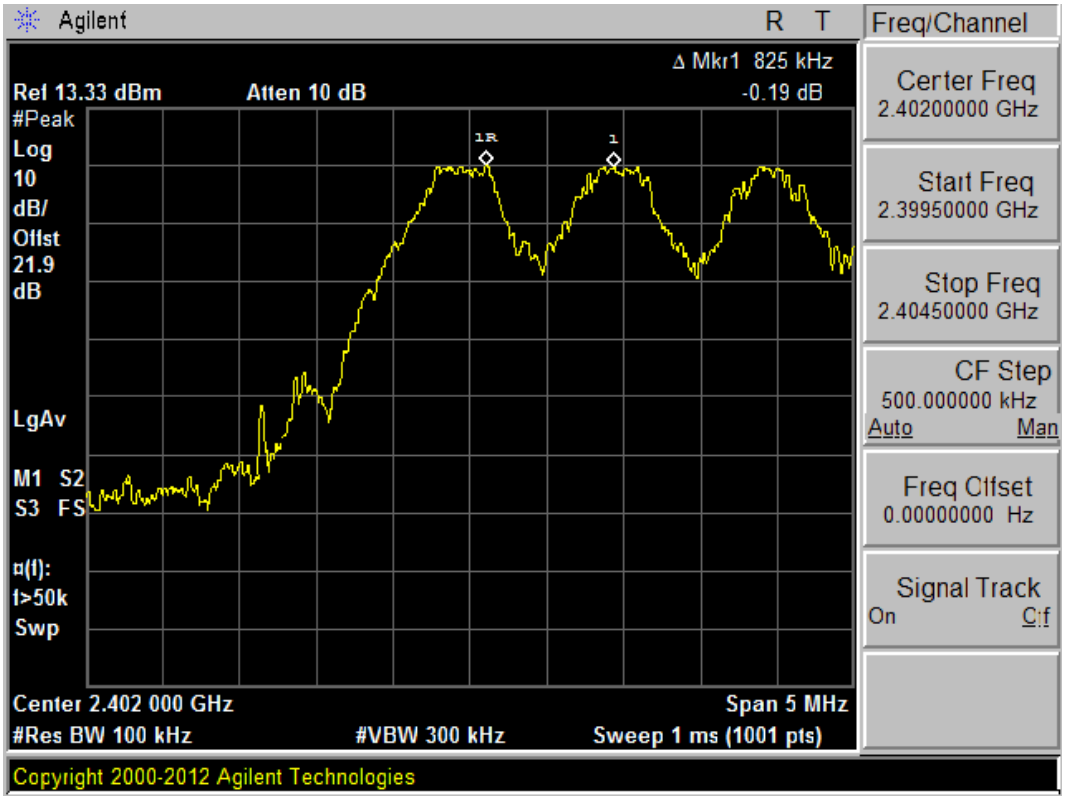


Figure 32. Channel spacing plot (1 Mbps - 2402 MHz)

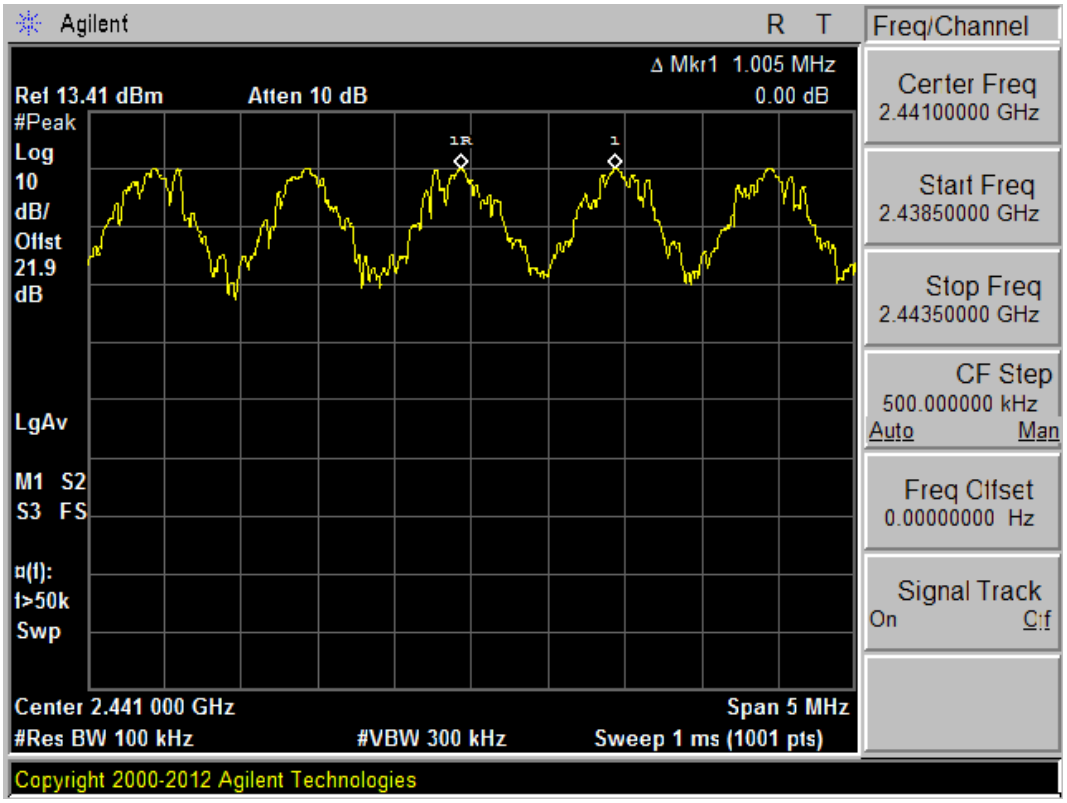


Figure 33. Channel spacing plot (1 Mbps - 2441 MHz)

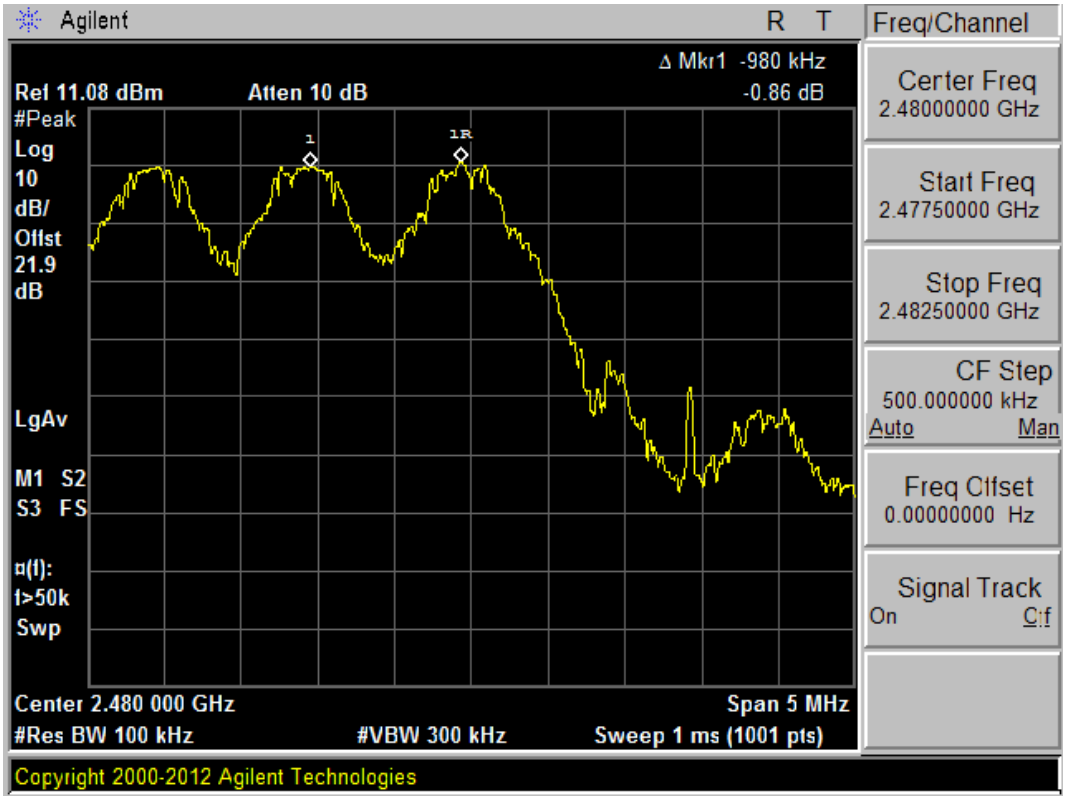


Figure 34. Channel spacing plot (1 Mbps - 2480 MHz)

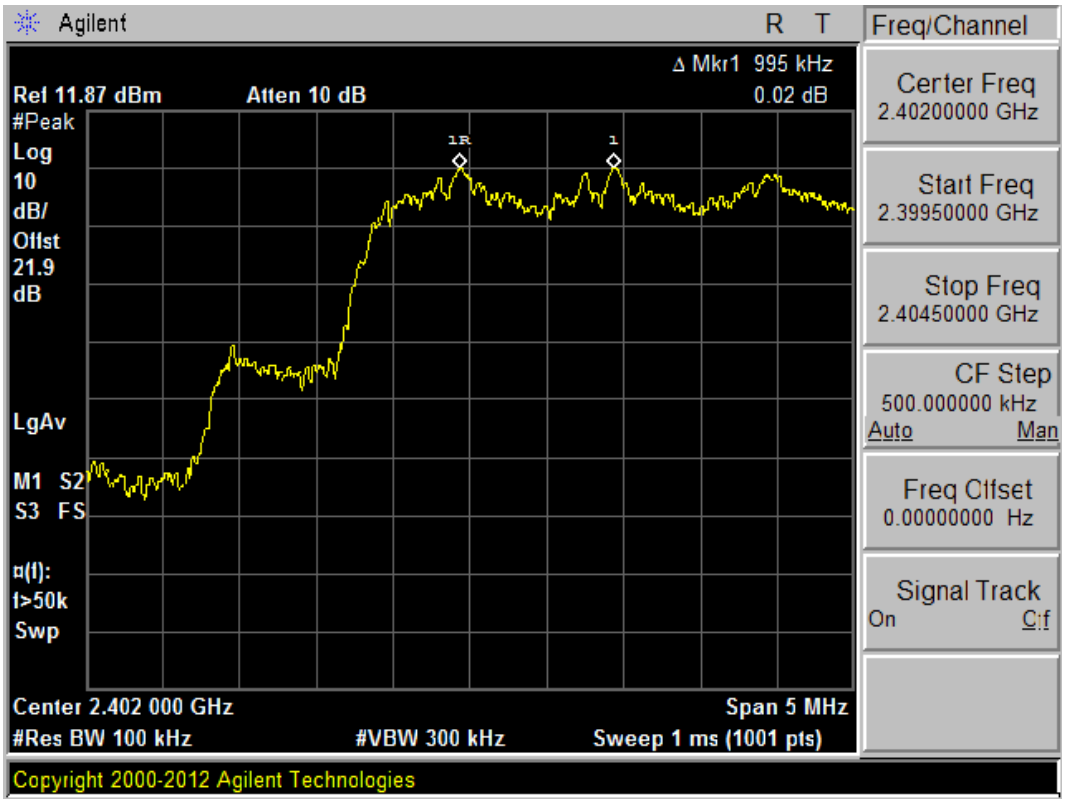


Figure 35. Channel spacing plot (2 Mbps - 2402 MHz)

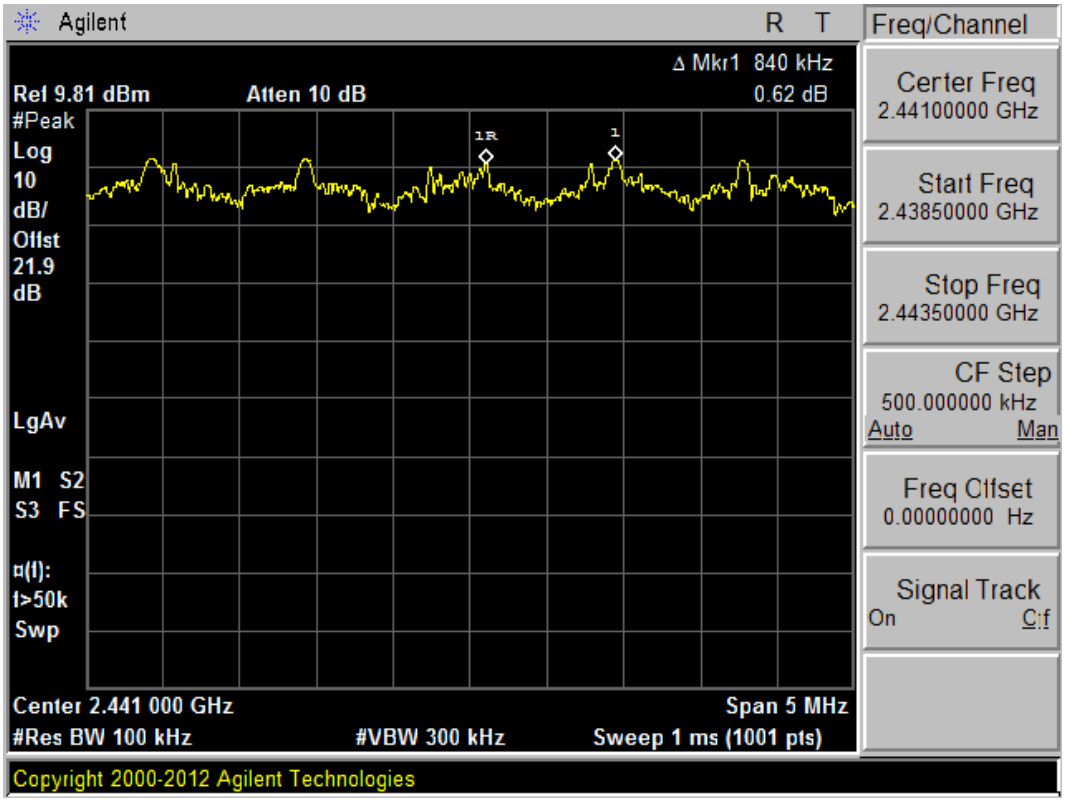


Figure 36. Channel spacing plot (2 Mbps - 2441 MHz)

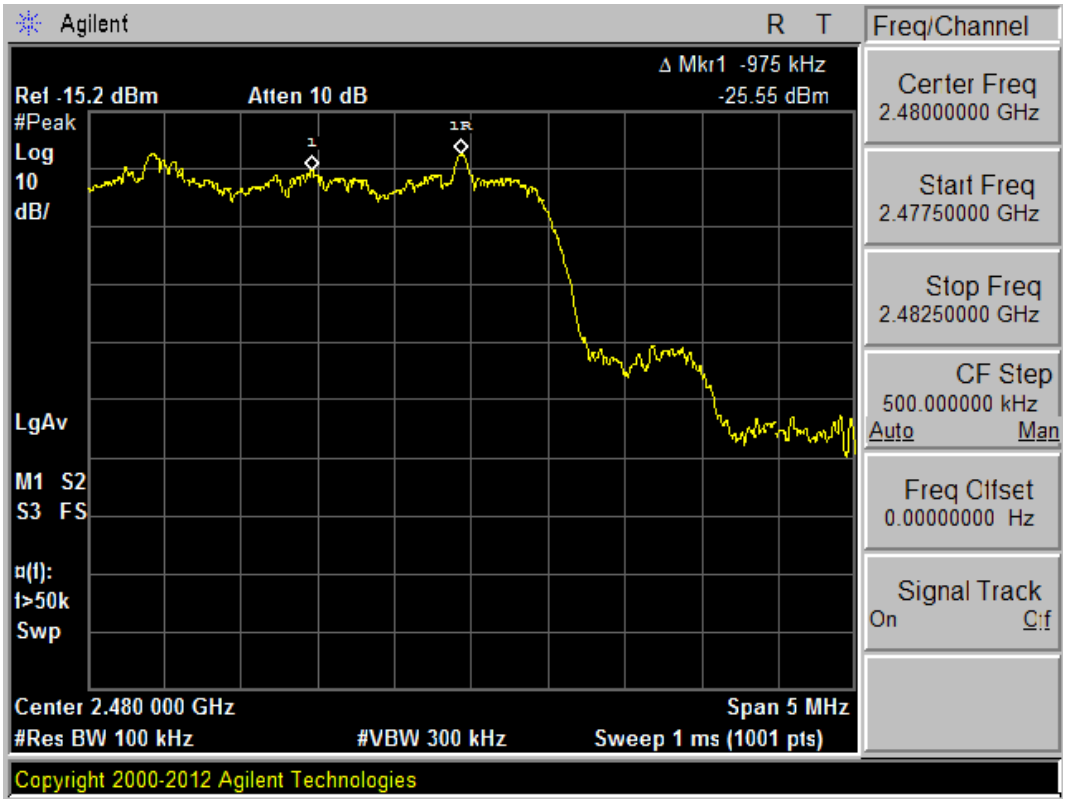


Figure 37. Channel spacing plot (2 Mbps - 2480 MHz)

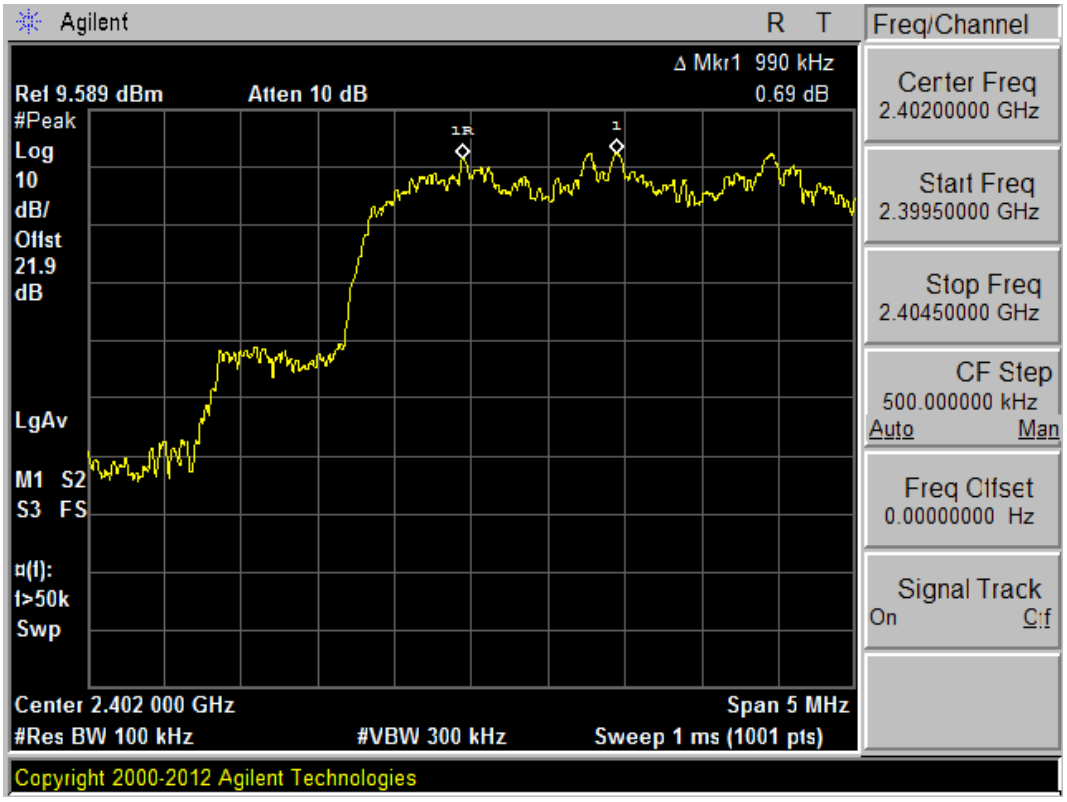


Figure 38. Channel spacing plot (3 Mbps - 2402 MHz)

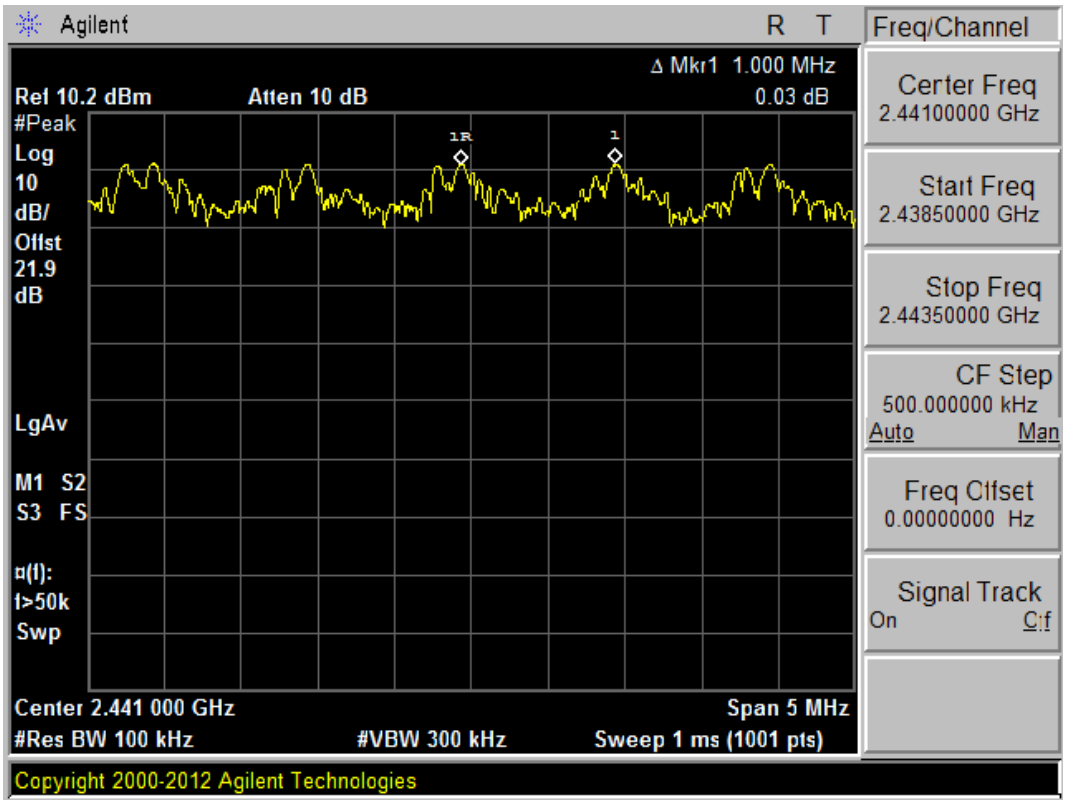


Figure 39. Channel spacing plot (3 Mbps - 2441 MHz)

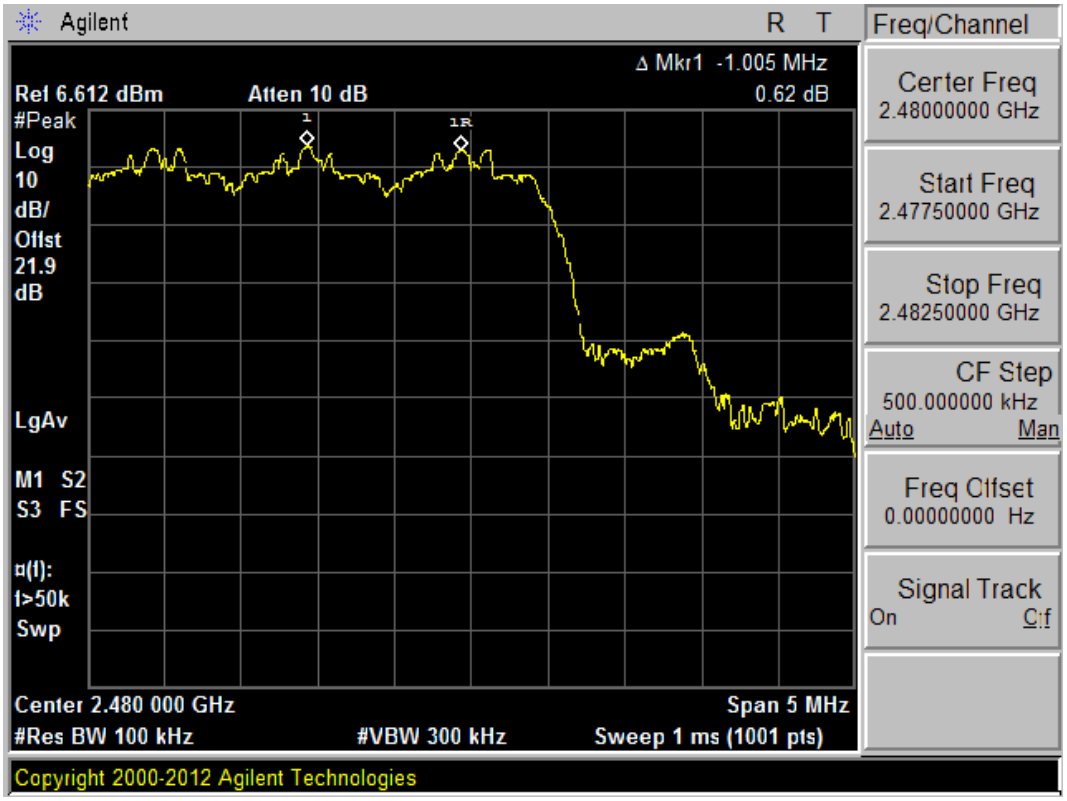
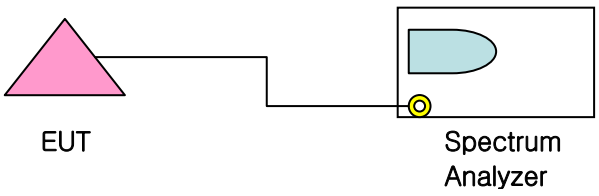


Figure 40. Channel spacing plot (3 Mbps - 2480 MHz)

4.5. Number of Hopping Channels

4.5.1. Test Setup Layout



4.5.2. Test Condition & Limit

Measurement is made while EUT is operating in hopping mode. This frequency hopping system must employ a minimum of 15 hopping channels.

4.5.3. Test result

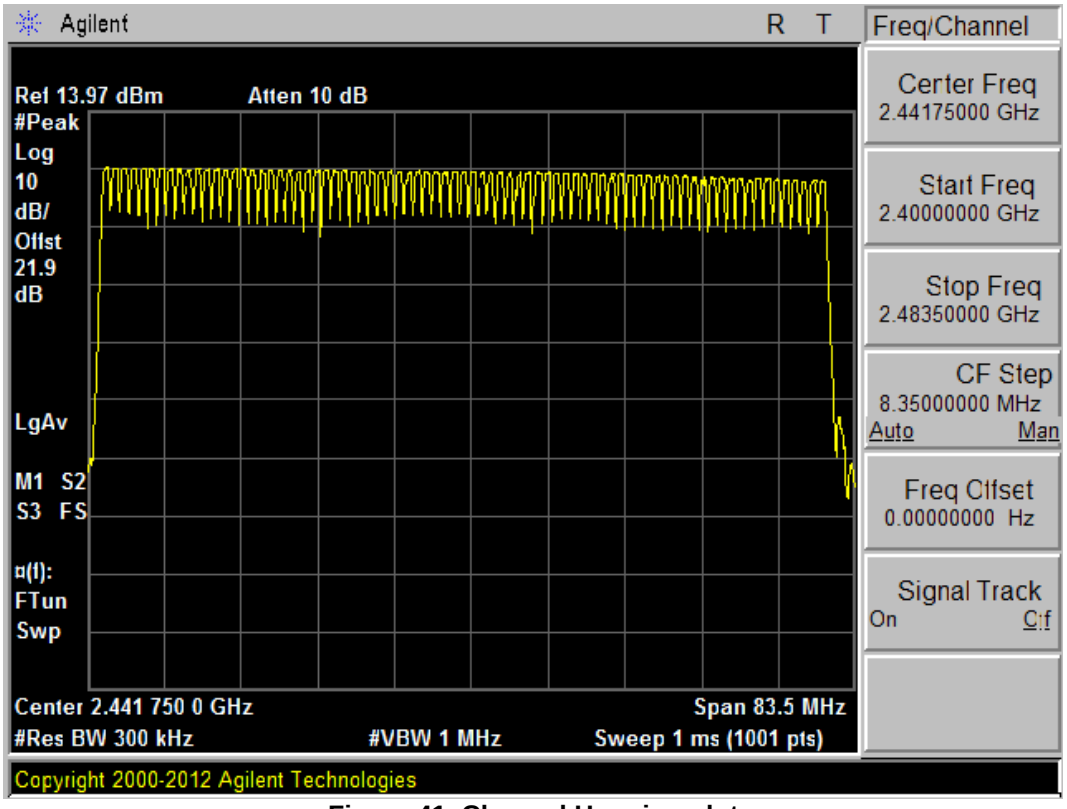
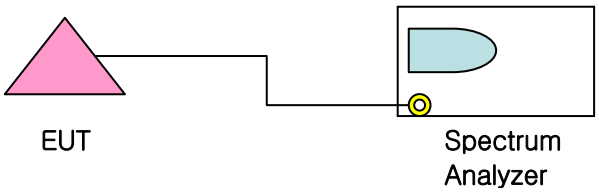


Figure 41. Channel Hopping plot

4.6. Time of Occupancy

4.6.1. Test Setup Layout



4.6.2. Test Condition & Limit

Measurement is made while EUT is operating in hopping mode with the spectrum analyzer set to zero span. The maximum permissible time of occupancy is 400 ms within a period of 400 ms multiplied by the number of hopping channels employed.

4.6.3. Test result

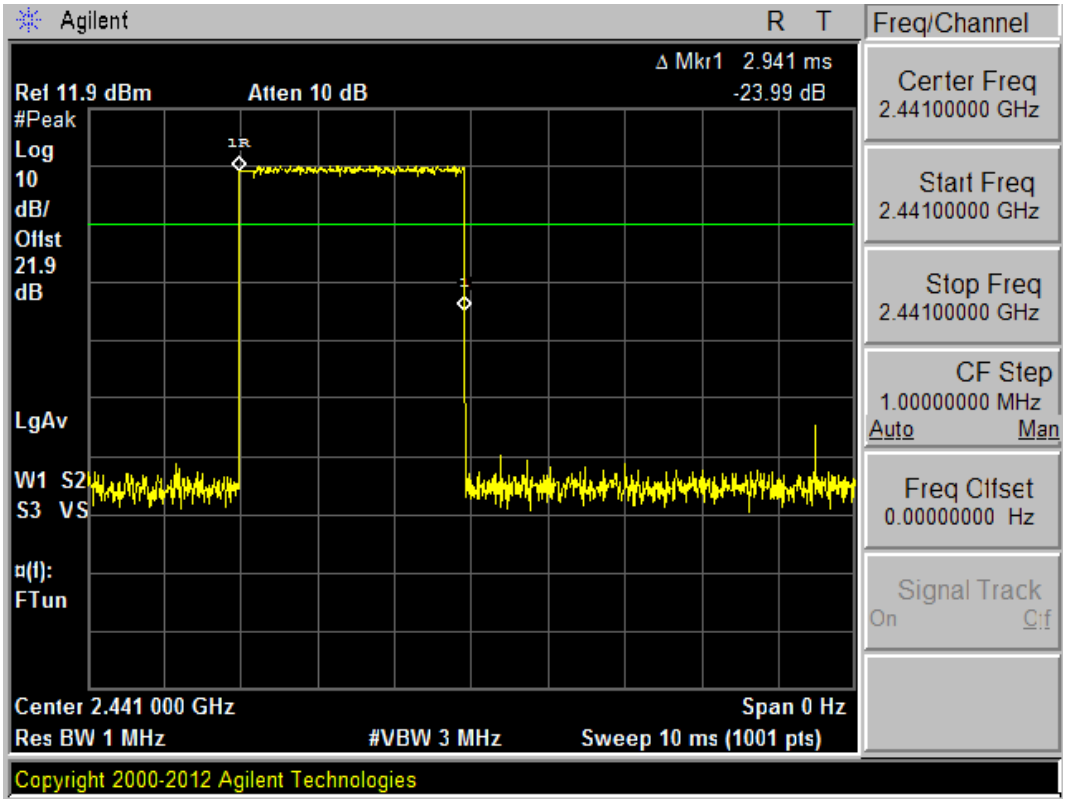


Figure 42. Tme of Occupancy Plot

Bluetooth Time of Occupancy Calculation

Typically, Bluetooth 1x/EDR mode has a channel hopping rate of 1600 hops/s. Since 1x/EDR modes use 5 transmit and 1 receive slot, for a total of 6 slots, the Bluetooth transmitter is actually hopping at a rate of 1600 / 6 = 266.67 (hops/s)/slot

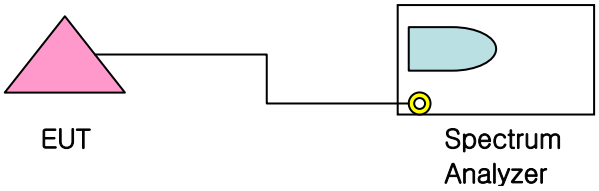
- 400 ms x 79 hopping channels = 31.6 s (Time of Occupancy Limit)
- Worst case BT has 266.67 hops/s (for 1x/EDR modes with DH5 operation)
- 266.67 (hops/s) / 79 channels = 3.38 hops/s (number of hops/s on one channel)
- 3.38 (hops/s)/channel x 31.6 s = 106.67 hops (number of hops over a 31.6 s period)
- 106.67 hops * 2.941 ms/channel = 313.72 ms (worst case dwell time for one channel in 1x/EDR modes)

With AFH, the number of channels is reduced to minimum of 20 channels and the channel hopping rate is reduced by 50 % to 800 hops/s. AFH mode also uses 6 total slots so the Bluetooth transmitter hops at a rate of 800 / 6 = 133.3 (hops/s)/slot

- 400 ms x 20 hopping channels = 8 s (Time of Occupancy Limit)
- Worst case BT has 133.3 (hops/s)/slot (for AFH mode with DH5 operation)
- 133.3 (hops/s) / 20 channels = 6.67 hops/s (number of hops/s on one channel)
- 6.67 (hops/s)/channel x 8 s = 53.34 hops (number of hops over a 8 s period)
- 53.34 hops * 2.941 ms/channel = 156.87 ms (worst case dwell time for one channel in AFH modes)

4.7. Conducted Spurious Emission

4.7.1. Test Setup Layout



4.7.2. Test Condition & Limit

Out of band conducted spurious emissions were investigated for all data rates and the worst case emissions were found with the EUT transmitting at 1 Mbps. Plots of the worst case emissions are shown below.

The display line shown in the following plots denotes the limit at 20 dB below the fundamental emission level measured in a 100 kHz bandwidth. However, since the traces in the following plots are measured with a 1 MHz RBW, the display line may not necessarily appear to be 20 dB below the level of the fundamental in a 1 MHz bandwidth.

4.7.3. Test result

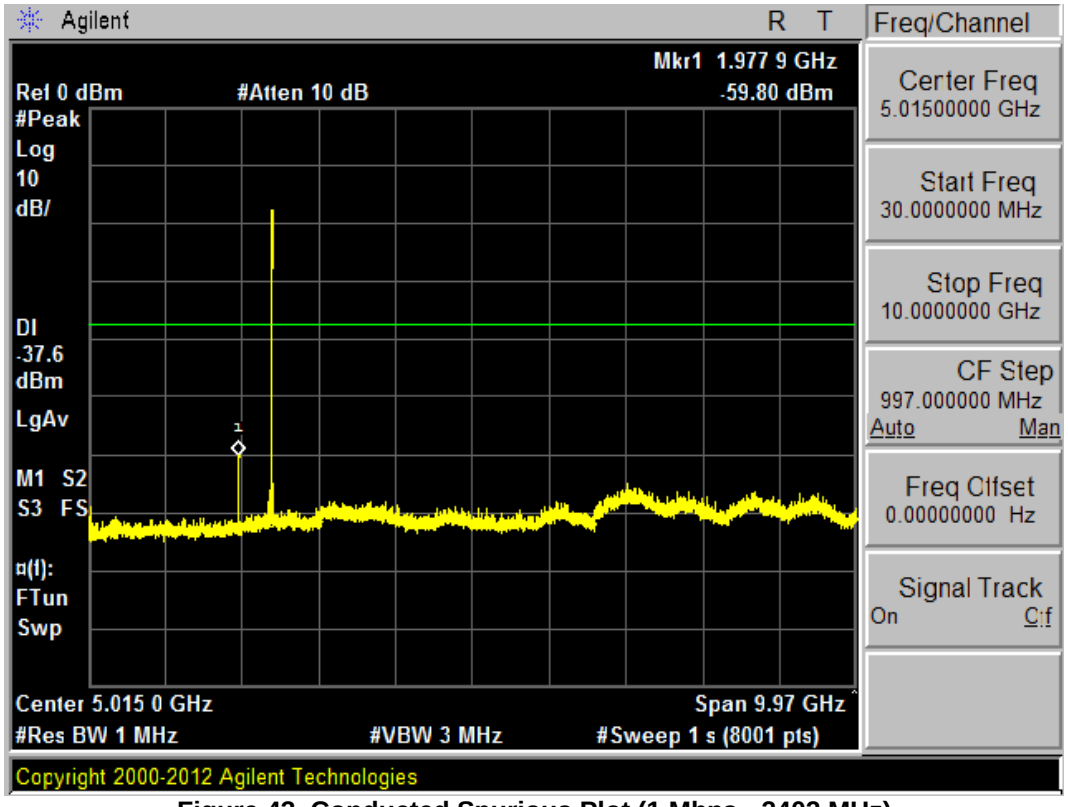


Figure 43. Conducted Spurious Plot (1 Mbps - 2402 MHz)

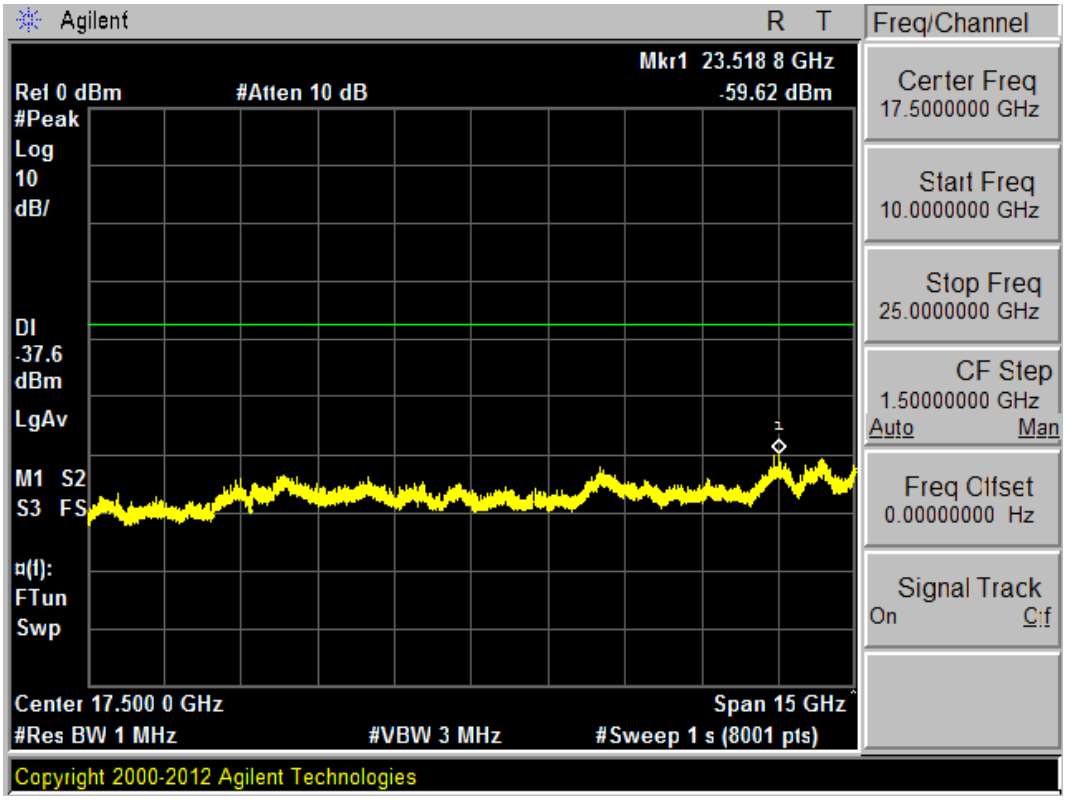


Figure 44. Conducted Spurious Plot (1 Mbps - 2402 MHz)

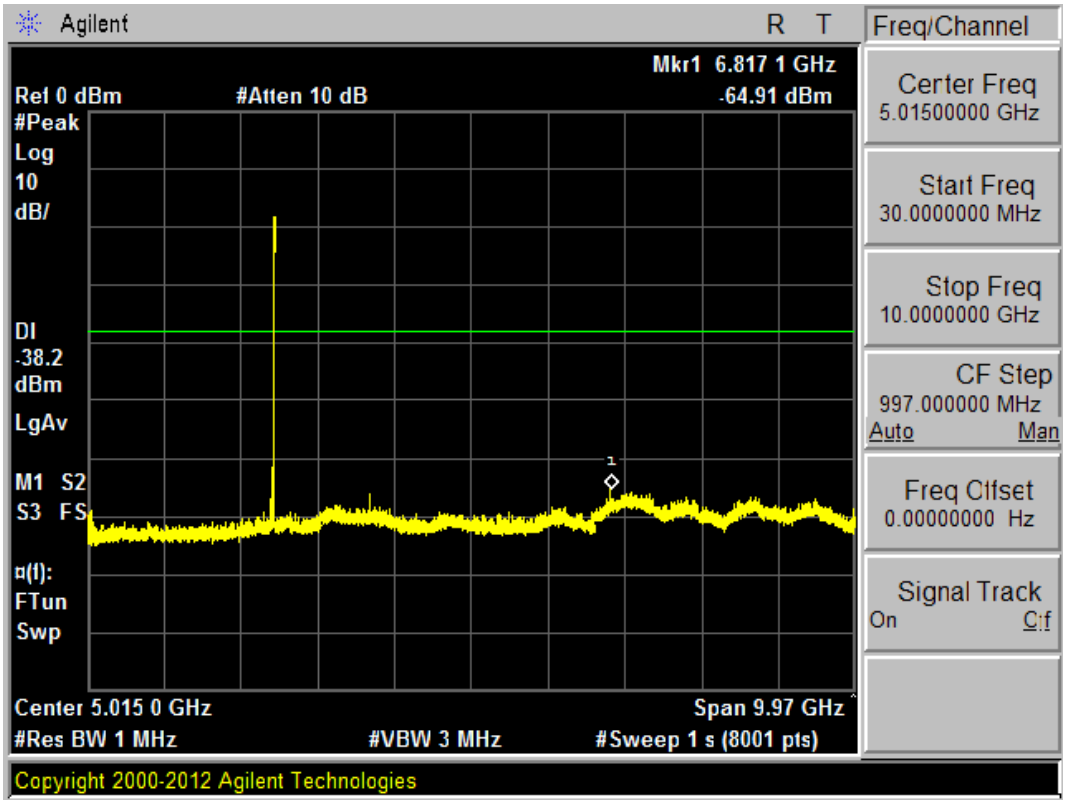


Figure 45. Conducted Spurious Plot (1 Mbps - 2441 MHz)

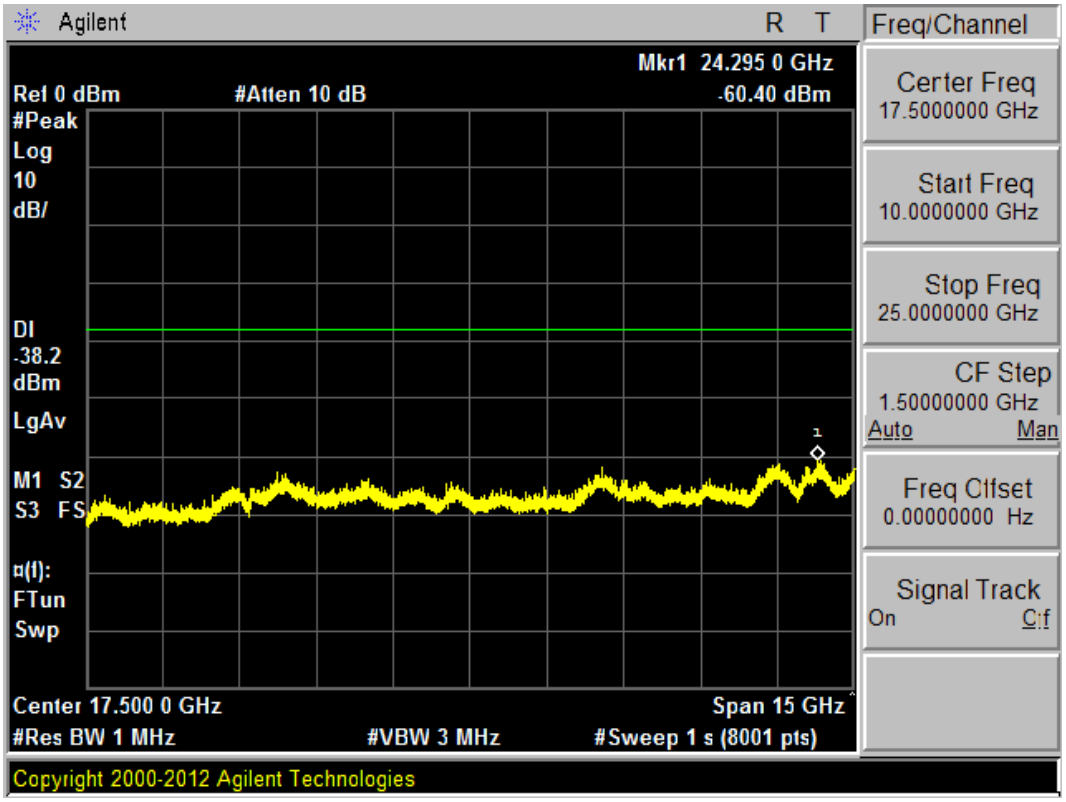


Figure 46. Conducted Spurious Plot (1 Mbps - 2441 MHz)

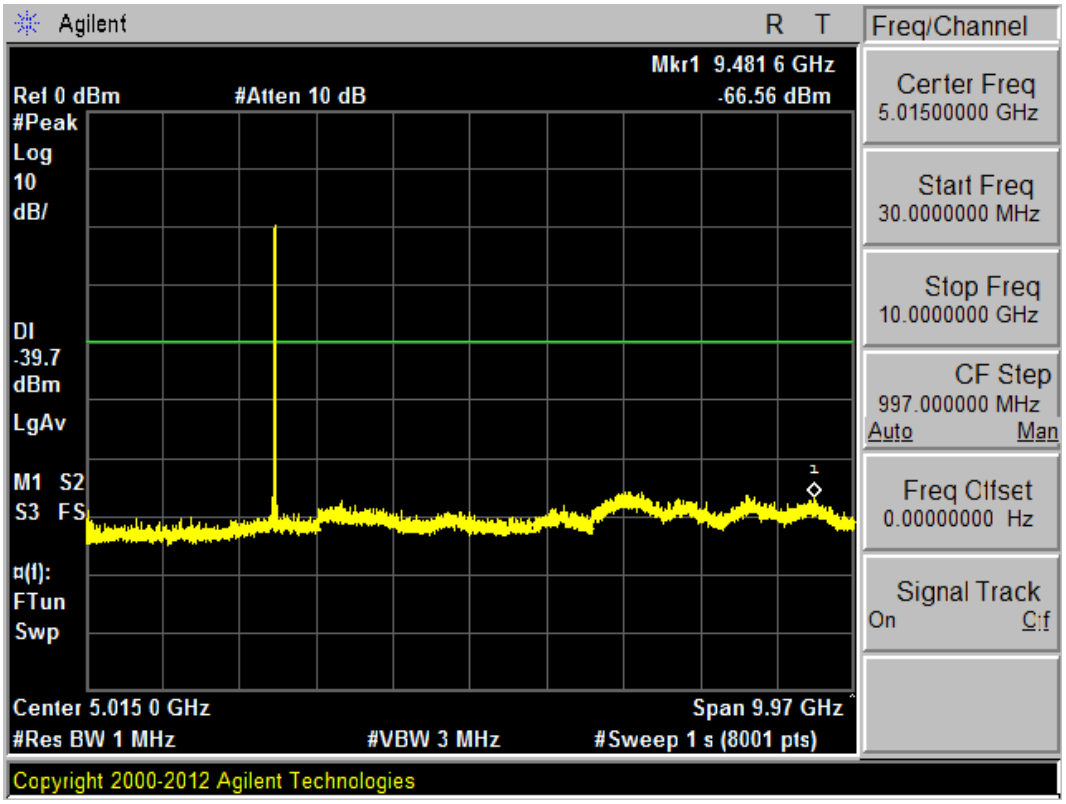


Figure 47. Conducted Spurious Plot (1 Mbps - 2480 MHz)

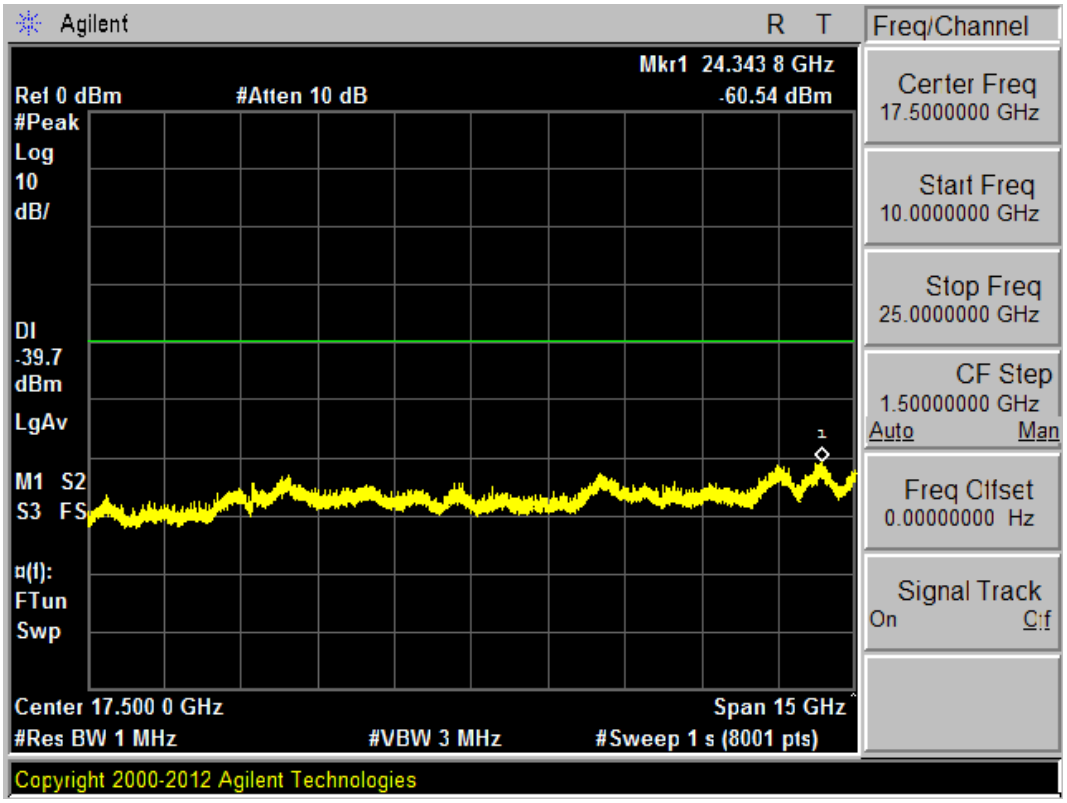


Figure 48. Conducted Spurious Plot (1 Mbps - 2480 MHz)

4.8. Radiated Spurious Emissions

4.8.1. Test Procedure

4.8.1.1 Preliminary Testing for Reference

Preliminary testing was performed in a KTL absorber-lined room to determine the emission characteristics of the EUT. The EUT was placed on the EUT table which is 0.8m in height for receiving antenna (Biconi-Log antenna 30 to 1000 MHz) and 1.5m in height for Horn Antenna : 1 to 40 GHz. These antennas were placed at the distance of 3 meter from the EUT.

An attempt was made to maximize the emission level with the various configurations of the EUT. Emission levels from the EUT with various configurations were examined on a spectrum analyzer connected with a RF amplifier and graphed.
The emission was within the illumination area of the 3 dB beam width of the antenna so that the maximum emission from the EUT is measured.

4.8.1.2 Final Radiated Emission Test at an Absorber-Lined Room

Based on the test results in preliminary test, measurement was made in same test set up and configuration which produced maximum emission level. Receiving antenna was installed at 3-meter distance from the EUT, and was connected to an EMI receiver.

Turntable was rotated through 360 degrees and receiving antenna height was varied from 1 to 4 meters above the ground plane to read maximum emission level. Receiving antenna polarization was changed vertical and horizontal. The worst value was recorded.

If necessary, the radiated emission measurements could be performed at a closer distance than specified distance to ensure higher accuracy and their results were extrapolated to the specified distance using an inverse linear distance extrapolation factor (20 dB/decade) as per Section 15.31(f).

The maximum emission level from the EUT occurred in such configuration as shown in the following photograph.

Tested in x, y, z axis and worst case results are reported

The maximum frequency range measuring with the spectrum from 30 MHz to 40 GHz is investigated with the transmitter

4.8.2. Limits

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	MHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.
[2] Above 38.6

(b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:
Frequency Field Strength Measurement Distance (MHz) (microvolts/meter) (meters)

Frequency (MHz)	Field Strength (microvolts/meter)	Distance (Meters)
30 - 88	100 **	3
88 - 216	150 **	3
216 - 960	200**	3
above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

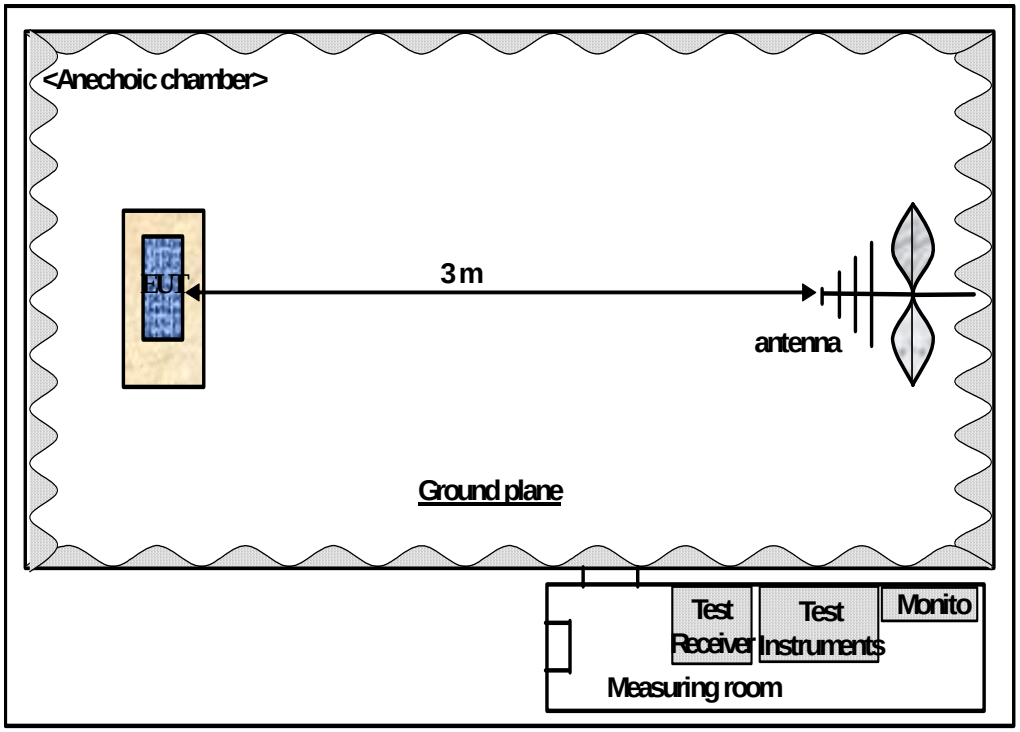
4.8.3. Sample Calculation

The emission level measured in decibels above one microvolt (dBμV) was following sample calculation.

For example ;

	Measured Value at 2390.0 MHz	24.6 dBμV
	Antenna Factor, Cable loss & Preamplifier	28.4 dB
=	Radiated Emission	53 dBμV/m

4.8.4. Measurement Configuration



4.8.5. Restricted Band-edge Test Results (Bluetooth)

Test distance : 3m

Frequency (MHz)	Antenna Pol.	Bandwidth Detector	Reading level (dBuV)	Correction factor(dB)	Level Corrected (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark	Plane X/Y/Z
GFSK - Lower side band-edge [2 310 MHz – 2 390 MHz], Operating frequency : 2402 MHz									
2390.0	V	1000, Peak	24.6	28.4	53.0	74.0	21.0	Peak	X
GFSK - Higher side band-edge [2 483.5 MHz – 2 500 MHz], Operating frequency : 2480 MHz									
2483.9	V	1000,Peak	32.5	28.3	60.8	74.0	13.2	Peak	X
2483.9	V	1000, Peak	19.5	28.3	47.8	54.0	6.2	Average	X

Level Corrected = Reading level + Correction factor (dB/m)
Correction factor = Antenna factor + Cable loss – Pre-amplifier (when using a pre-amplifier)

Note
1. Measurement was done over the Restricted Bands. The EUT was rotated and the antenna was changed to a range of height of from 1 m to 4 m above the ground plane for maximum response.
2. Pre-amplifier was used.+
3. Test results include the rotation of the EUT through three orthogonal axes to determine the maximum emission.
4. If the peak measured values are lower than average limits, average measurements are not performed.
5. RBW/VBW settings for Peak Detection: RBW =1 MHz, VBW= 3 MHz
6. RBW/VBW settings for Average Detection: RBW =1 MHz, VBW= 1 kHz
   [VBW ≥ 1/T (on time) for average measurement, 1/T = 1/0.0029S = 350 Hz, VBW ≥ 350 Hz]

Remark
1. Noise floor of 30 ~ 1000 MHz : <20 dBuV at 3m distance
2. Noise floor of 1000 ~ 5000 MHz : <40 dBuV at 3m distance
3. Noise floor of 5000 ~ 25000 MHz : <50 dBuV at 3m distance

Test distance : 3m

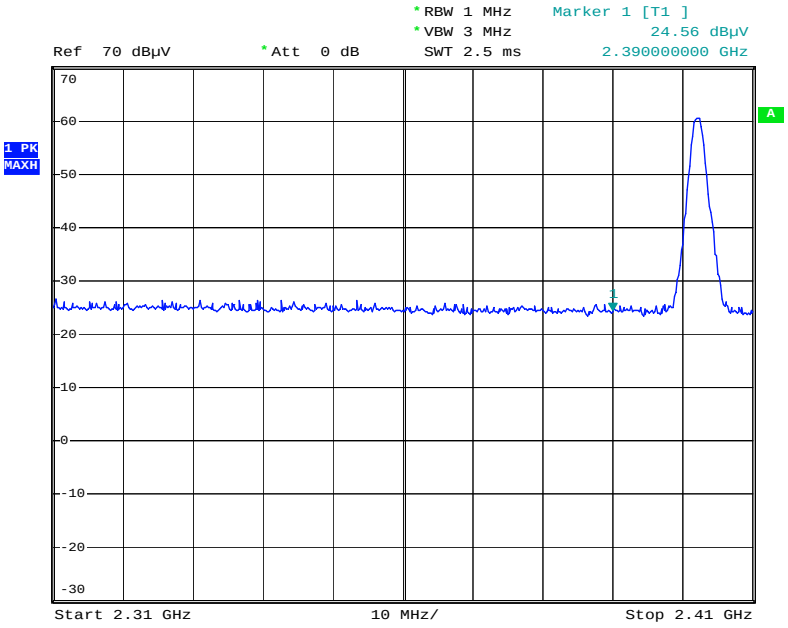
Frequency (MHz)	Antenna Pol.	Bandwidth Detector	Reading level (dBuV)	Correction factor(dB)	Level Corrected (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark	Plane X/Y/Z
π/4 DQPSK - Lower side band-edge [2 310 MHz – 2 390 MHz], Operating frequency : 2402 MHz									
2390.0	V	1000, Peak	25.5	28.4	53.9	74.0	20.1	Peak	X
π/4 DQPSK - Higher side band-edge [2 483.5 MHz – 2 500 MHz], Operating frequency : 2480 MHz									
2483.5	V	1000, Peak	32.4	28.3	60.7	74.0	13.3	Peak	X
2483.5	V	1000, Peak	20.0	28.3	48.3	54.0	5.7	Average	X
8DPSK - Lower side band-edge [2 310 MHz – 2 390 MHz], Operating frequency : 2402 MHz									
2390.0	V	1000, Peak	25.2	28.4	53.6	74.0	20.4	Peak	X
8DPSK - Higher side band-edge [2 483.5 MHz – 2 500 MHz], Operating frequency : 2480 MHz									
2483.5	V	1000, Peak	32.5	28.3	60.8	74.0	13.2	Peak	X
2483.5	V	1000, Peak	20.4	28.3	48.7	54.0	5.3	Average	X

Level Corrected = Reading level + Correction factor (dB/m)
Correction factor = Antenna factor + Cable loss – Pre-amplifier (when using a pre-amplifier)

Note
1. Measurement was done over the Restricted Bands. The EUT was rotated and the antenna was changed to a range of height of from 1 m to 4 m above the ground plane for maximum response.
2. Pre-amplifier was used.
3. Test results include the rotation of the EUT through three orthogonal axes to determine the maximum emission.
4. If the peak measured values are lower than average limits, average measurements are not performed.
5. RBW/VBW settings for Peak Detection: RBW =1 MHz, VBW= 3 MHz
6. RBW/VBW settings for Average Detection: RBW =1 MHz, VBW= 1 kHz
   [VBW ≥ 1/T (on time) for average measurement, 1/T = 1/0.0029S = 350 Hz, VBW ≥ 350 Hz]

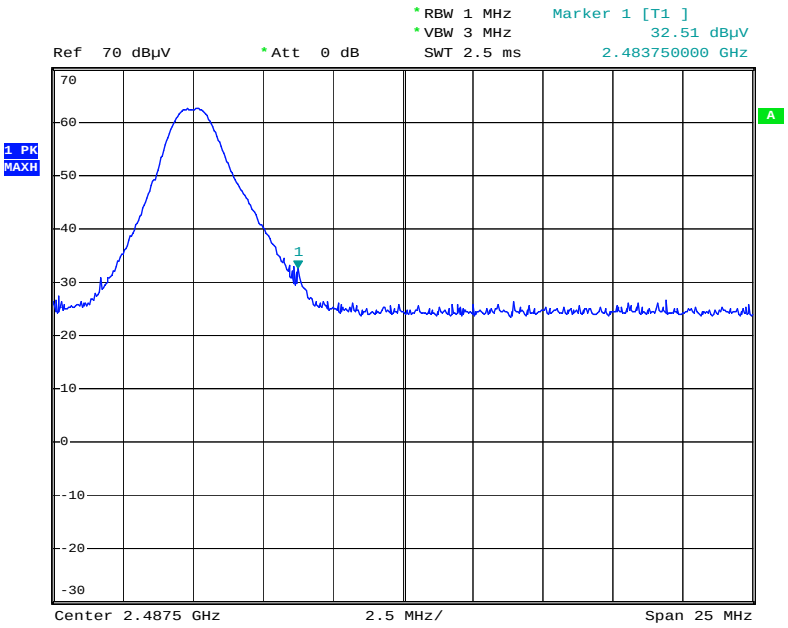
Remark
1. Noise floor of 30 ~ 1000 MHz : <20 dBuV at 3m distance
2. Noise floor of 1000 ~ 5000 MHz : <40 dBuV at 3m distance
3. Noise floor of 5000 ~ 25000 MHz : <50 dBuV at 3m distance

4.8.6. Restricted Band-edge Measurement Plots



Date: 8.SEP.2016 10:04:56

Figure 499. GFSK Low channel band-edge plot Peak



Date: 8.SEP.2016 10:10:44

Figure 50. GFSK High channel Band-edge plot Peak

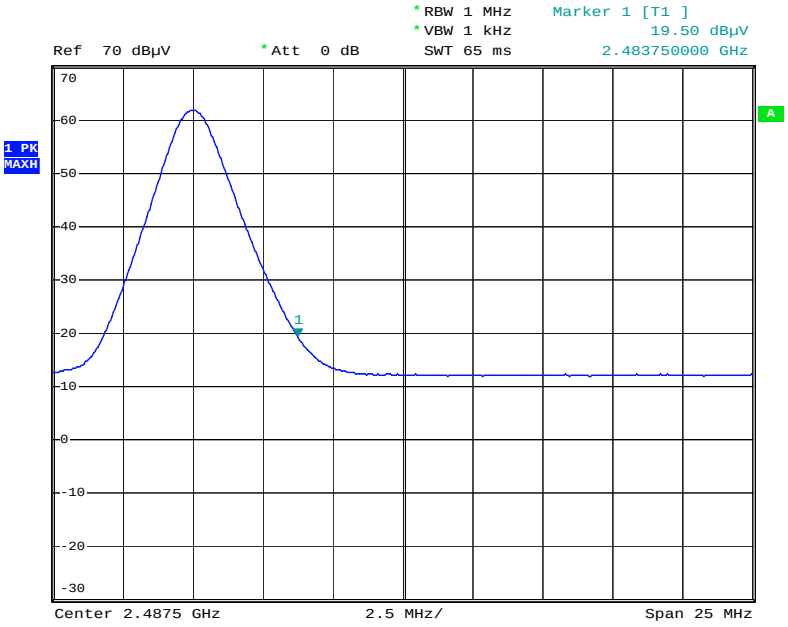


Figure 51. GFSK High channel Band-edge plot Avg

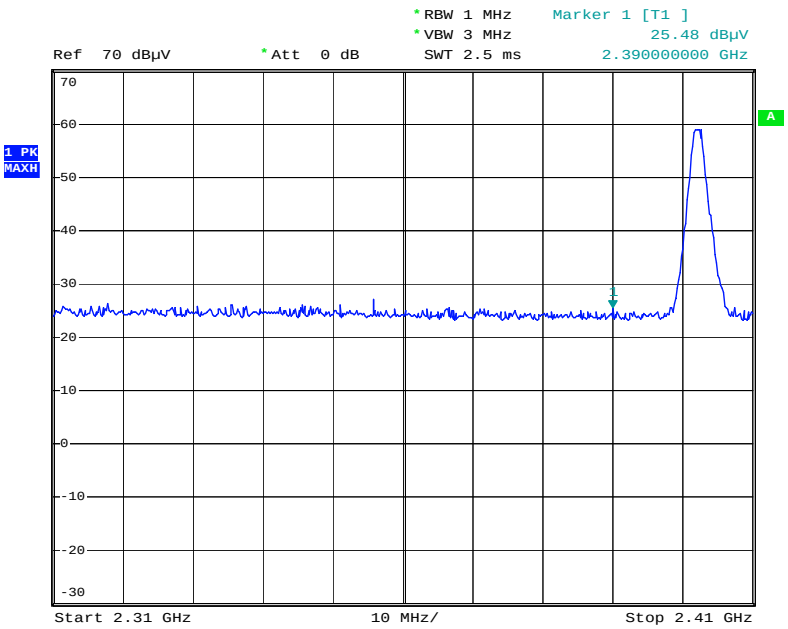
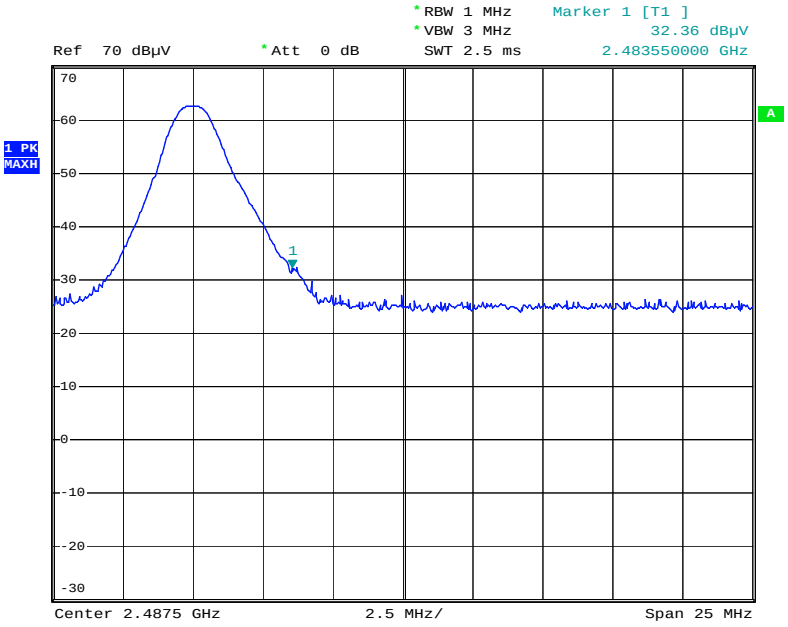
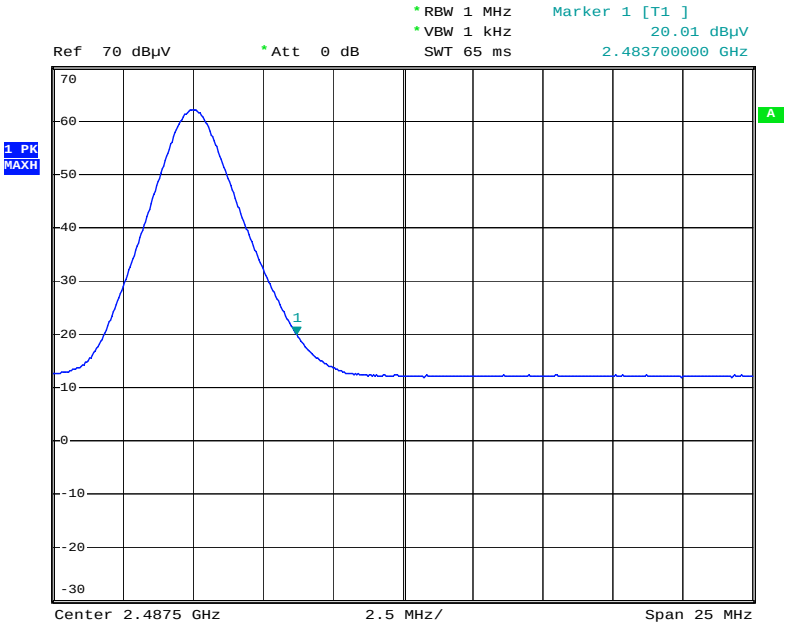


Figure 52. π/4 DQPSK Low channel band-edge plot Peak



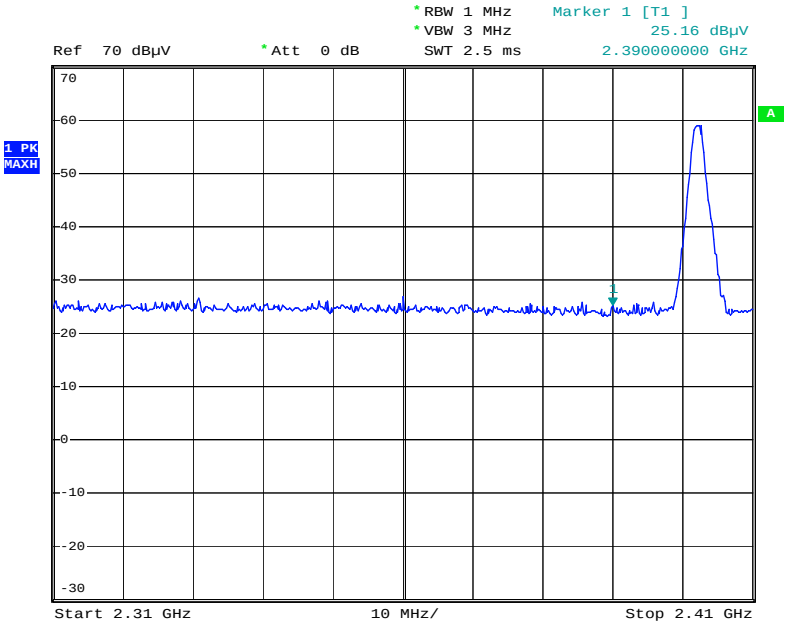
Date: 8.SEP.2016 10:20:15

Figure 53. π/4 DQPSK High channel band-edge plot Peak



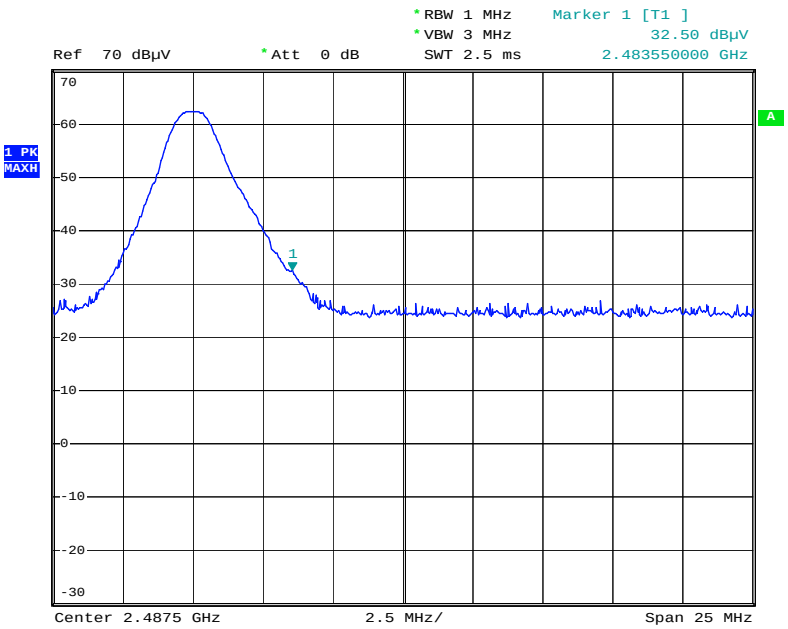
Date: 8.SEP.2016 10:22:15

Figure 54. π/4 DQPSK High channel band-edge plot Avg



Date: 8.SEP.2016 10:30:47

Figure 55. 8DPSK Low channel band-edge plot Peak



Date: 8.SEP.2016 10:24:20

Figure 56. 8DPSK High channel band-edge plot Peak

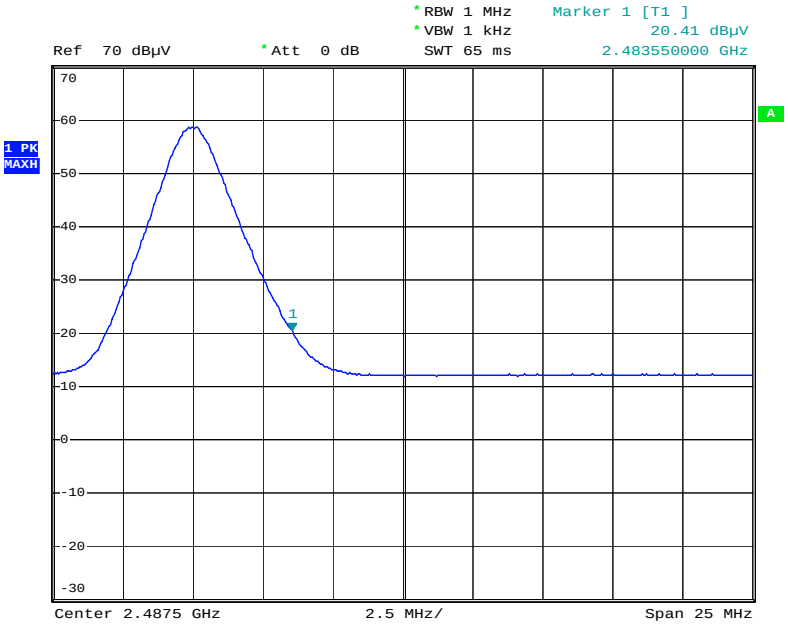


Figure 57. 8DPSK High channel band-edge plot Avg

4.8.7. Spurious Emission Test Results (Bluetooth)

4.8.7.1 Spurious Radiated Emission (Worst case configuration, 30 MHz ~ 1 GHz)

Test mode: GFSK, π/4 DQPSK, 8DPSK

Frequency (MHz)	Antenna Pol.	Bandwidth	Reading level [Quasi-Peak]	Correction factor(dB)	Level Corrected (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Plane X/Y/Z
-								
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

Level Corrected = Reading level + Correction factor (dB/m)
Correction factor = Antenna factor + Cable loss – Pre-amplifier (when using a pre-amplifier)

Note 1. Measurement was done over the frequency range from 30 MHz to 1 GHz. The EUT was rotated and the antenna was changed to a range of height of from 1 m to 4 m above the ground plane for maximum response.
2. Testing is include the rotation of the EUT through three orthogonal axes to determine the maximum emission.
3. Any emission values 20dB lower than the limit are not recorded.
4. RBW/VBW settings for Quasi-Peak Detection: RBW/VBW=120 kHz

Remark 1. Noise floor of 30 ~ 1000 MHz : <20 dBuV at 3m distance
2. Noise floor of 1000 ~ 5000 MHz : <40 dBuV at 3m distance
3. Noise floor of 5000 ~ 25000 MHz : <45 dBuV at 3m distance

4.8.7.2 Spurious Radiated Emission (1 GHz ~ 25 GHz)

BT mode : GFSK

Frequency (MHz)	Antenna Pol.	Bandwidth Detector	Reading level (dBuV)	Correction factor(dB)	Level Corrected (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark	Plane X/Y/Z
Lowest channel Ch. 0									
4804.0	V	1000, Peak	21.9	34.9	56.8	74.0	17.2	Peak	X
4804.0	V	1000, Peak	14.5	34.9	49.4	54.0	4.6	Average	X
7206.0	V	1000, Peak	31.8	30.4	62.2	74.0	11.8	Peak	X
7206.0	V	1000, Peak	20.1	30.4	50.5	54.0	3.5	Average	X
9608.0	H	1000, Peak	30.8	26.7	57.5	74.0	16.5	Peak	Y
9608.0	H	1000, Peak	19.7	26.7	46.4	54.0	7.6	Average	Y
Middle channel Ch. 39									
4882.0	V	1000, Peak	14.9	35.1	50.0	74.0	24.0	Peak	X
7323.0	H	1000, Peak	33.6	29.9	63.5	74.0	10.5	Peak	X
7323.0	H	1000, Peak	21.6	29.9	51.5	54.0	2.5	Average	X
Highest channel Ch. 79									
4960.0	H	1000, Peak	18.8	34.8	53.6	74.0	20.4	Peak	X
7440.0	H	1000, Peak	26.0	29.5	55.5	74.0	18.5	Peak	X
7440.0	H	1000, Peak	17.3	29.5	46.8	54.0	7.2	Average	X

Level Corrected = Reading level + Correction factor (dB/m)
(Measured value unit dBm is converted to dBuV)
Correction factor = Antenna factor + Cable loss – Pre-amplifier (when using a pre-amplifier)

Note
1. Measurement was done over the frequency range from 1GHz to 10th harmonic. The EUT was rotated and the antenna was changed to a range of height of from 1 m to 4 m above the ground plane for maximum response.
2. Pre-amplifier was used in the range between 1 GHz ~ 25 GHz.
3. Test results include the rotation of the EUT through three orthogonal axes to determine the maximum emission.
4. If the peak measured values are lower than average limits, average measurements are not performed.
5. Any emission values 20dB lower than the limit are not recorded.
6. RBW/VBW settings for Peak Detection: RBW =1 MHz, VBW= 3 MHz
7. RBW/VBW settings for Average Detection: RBW =1 MHz, VBW= 1 kHz
[VBW ≥ 1/T (on time) for average measurement, 1/T = 1/0.0029S = 350 Hz, VBW≥ 350 Hz]
8. Emission was scanned up to 25 GHz; range between 18 GHz ~ 25 GHz, no emissions were detected above the noise floor which was at least 20 dB below the specification limit.

Remark
1. Noise floor of 30 ~ 1000 MHz : <20 dBuV at 3m distance
2. Noise floor of 1000 ~ 5000 MHz : <40 dBuV at 3m distance
3. Noise floor of 5000 ~ 25000 MHz : <50 dBuV at 3m distance

BT mode : π/4 DQPSK, 8DPSK

Frequency (MHz)	Antenna Pol.	Bandwidth Detector	Reading level (dBuV)	Correction factor(dB)	Level Corrected (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark	Plane X/Y/Z
8DPSK									
Lowest channel Ch. 0									
4804.0	V	1000, Peak	18.9	34.9	53.8	74.0	20.2	Peak	X
7206.0	V	1000, Peak	33.1	30.4	63.5	74.0	10.5	Peak	X
7206.0	V	1000, Peak	17.1	30.4	47.5	54.0	6.5	Average	X
Middle channel Ch. 39									
4882.0	V	1000, Peak	20.2	35.1	55.3	74.0	18.7	Peak	X
4882.0	V	1000, Peak	0.9	35.1	36.0	54.0	18.0	Average	X
7323.0	V	1000, Peak	29.6	29.9	59.5	74.0	14.5	Peak	X
7323.0	V	1000, Peak	16.8	29.9	46.7	54.0	7.3	Average	X
Highest channel Ch. 79									
4960.0	H	1000, Peak	19.1	34.8	53.9	74.0	20.1	Peak	X
7440.0	H	1000, Peak	29.4	29.5	58.9	74.0	15.1	Peak	X
7440.0	H	1000, Peak	18.0	29.5	47.5	54.0	6.5	Average	X
π/4 DQPSK									
Emission levels were measured under 20 dB lower than the limit									

Level Corrected = Reading level + Correction factor (dB/m)
(Measured value unit dBm is converted to dBuV)
Correction factor = Antenna factor + Cable loss – Pre-amplifier (when using a pre-amplifier)

Note
1. Measurement was done over the frequency range from 1GHz to 10th harmonic. The EUT was rotated and the antenna was changed to a range of height of from 1 m to 4 m above the ground plane for maximum response.
2. Pre-amplifier was used in the range between 1 GHz ~ 25 GHz.
3. Test results include the rotation of the EUT through three orthogonal axes to determine the maximum emission.
4. If the peak measured values are lower than average limits, average measurements are not performed.
5. Any emission values 20dB lower than the limit are not recorded.
6. RBW/VBW settings for Peak Detection: RBW =1 MHz, VBW= 3 MHz
7. RBW/VBW settings for Average Detection: RBW =1 MHz, VBW= 1 kHz
[VBW ≥ 1/T (on time) for average measurement, 1/T = 1/0.0029S = 350 Hz, VBW ≥ 350 Hz]
8. Emission was scanned up to 25 GHz; range between 18 GHz ~ 25 GHz, no emissions were detected above the noise floor which was at least 20 dB below the specification limit.

Remark
1. Noise floor of 30 ~ 1000 MHz : <20 dBuV at 3m distance
2. Noise floor of 1000 ~ 5000 MHz : <40 dBuV at 3m distance
3. Noise floor of 5000 ~ 25000 MHz : <50 dBuV at 3m distance

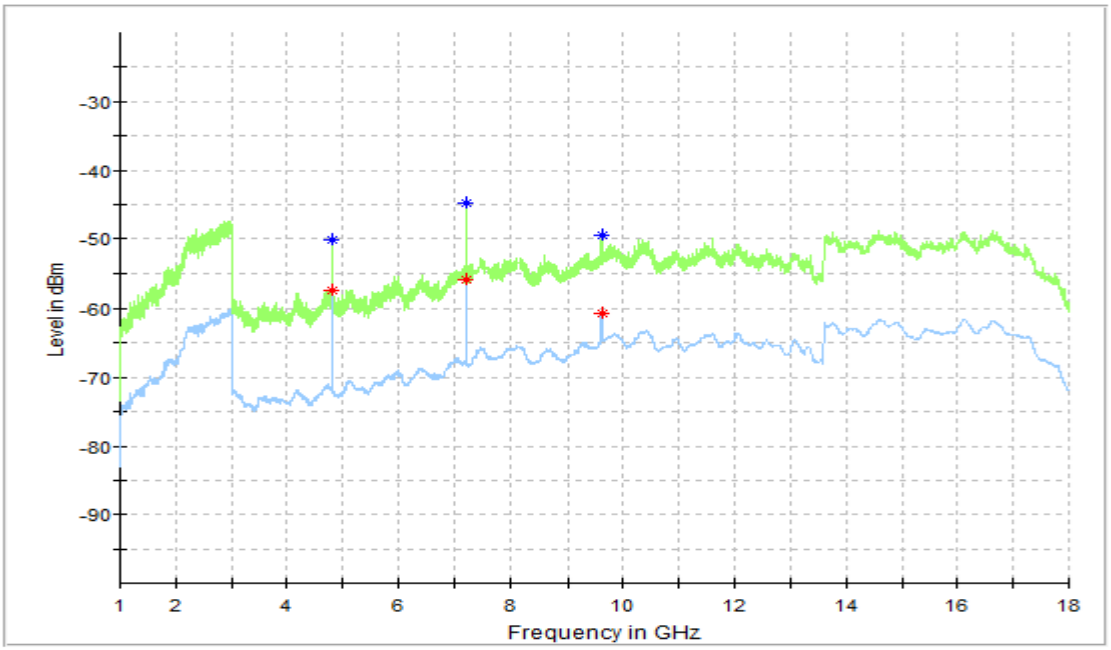


Figure 58. GFSK Low channel Spurious Radiated Emission Plot

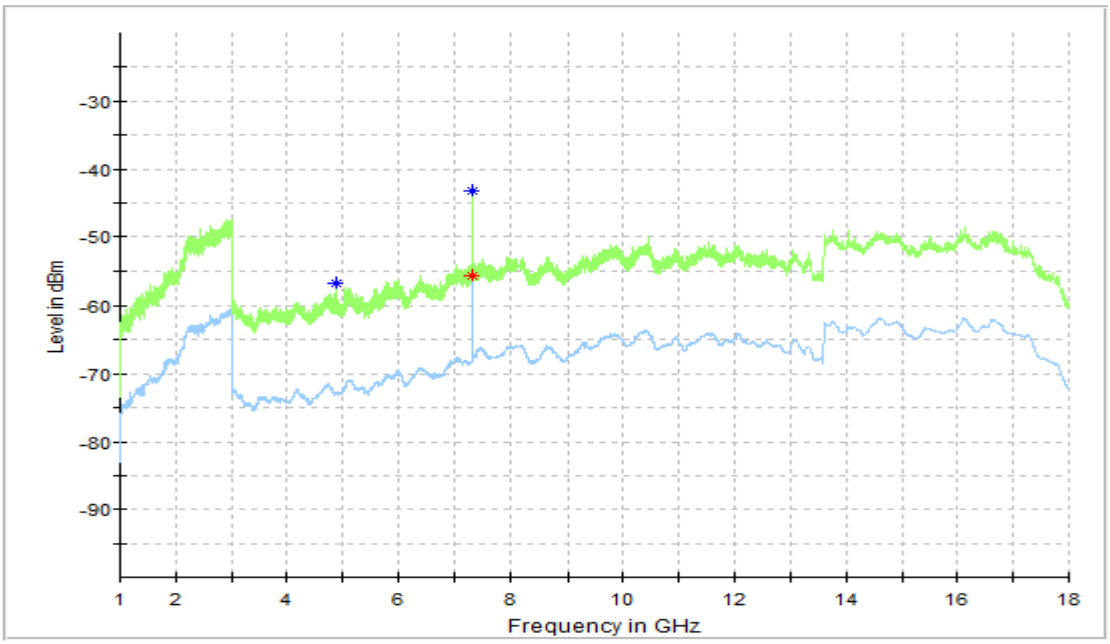


Figure 59. GFSK Mid channel Spurious Radiated Emission Plot

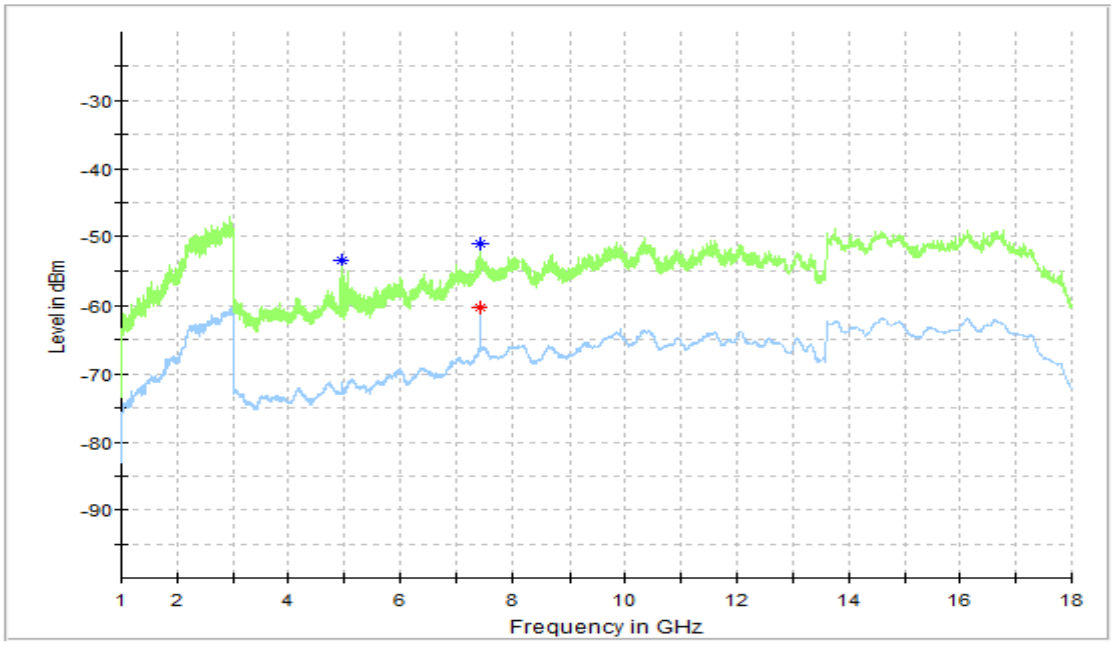


Figure 60. GFSK High channel Spurious Radiated Emission Plot

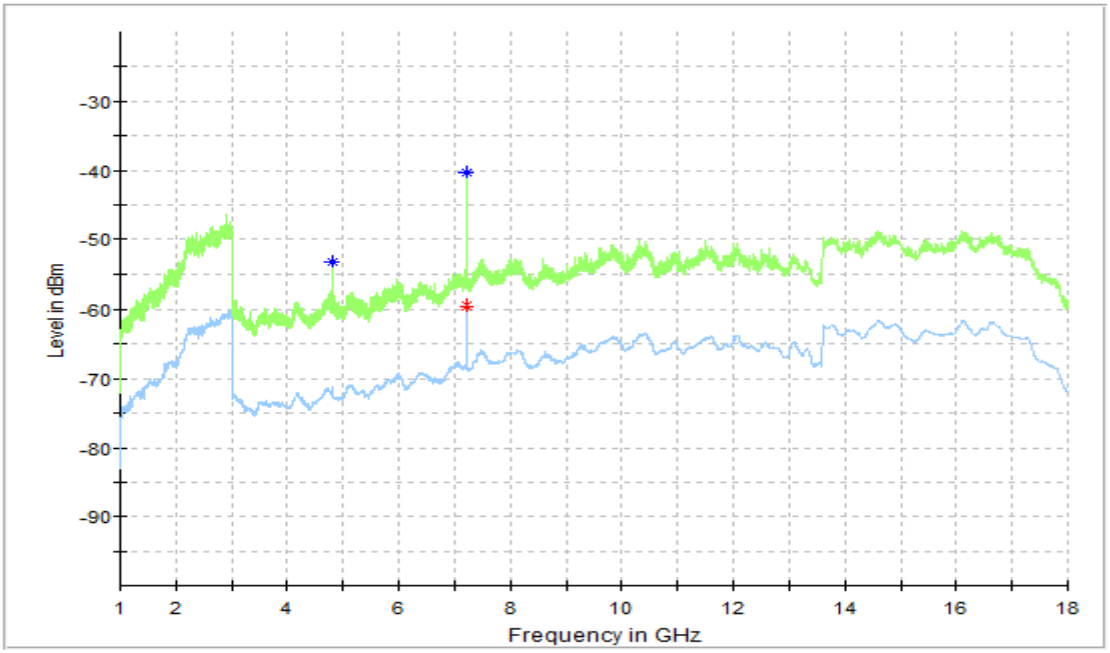


Figure 61. 8DPSK Low channel Spurious Radiated Emission Plot

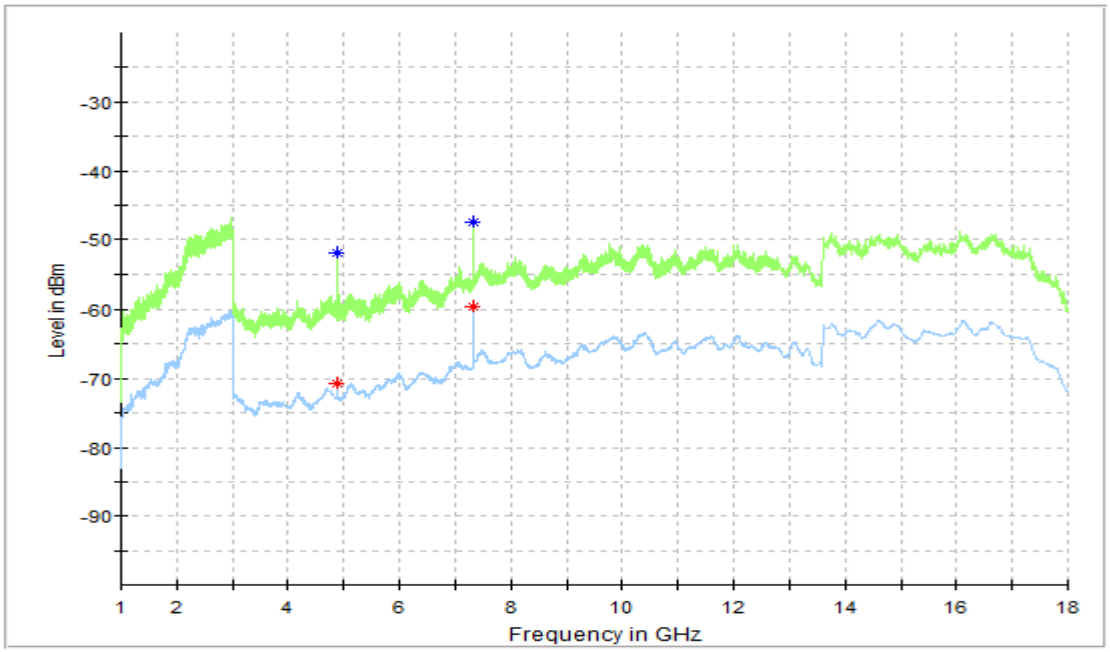


Figure 62. 8DPSK Mid channel Spurious Radiated Emission Plot

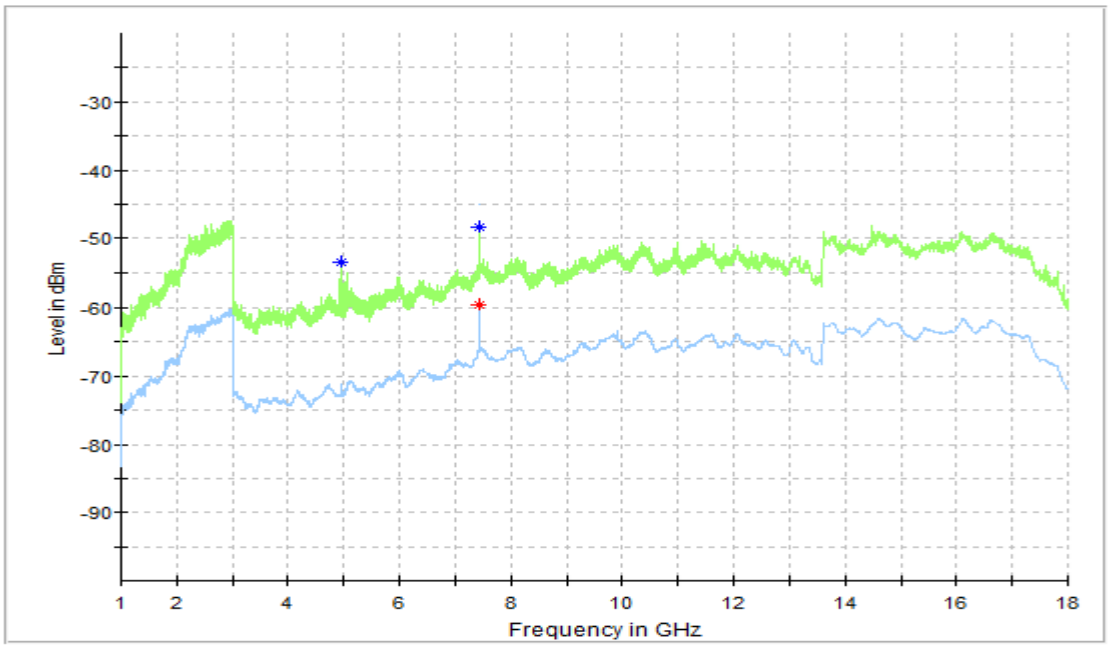


Figure 63. 8DPSK High channel Spurious Radiated Emission Plot

4.9. AC Conducted Emissions

4.9.1. Test Procedure

Conducted emission measurements on the EUT were performed by "AC Power Line Conducted Emissions Testing" procedure as per ANSI C63.10. The EUT was set up on a wooden table 0.8 meters height, 1.0 by 1.5 meters in size, placed in the shielded enclosed with a side of wall of which constituted a vertical conducting surface of 2.2 m x 3.1 m in size to maintain 40 cm from the rear of EUT

LISN(Line Impedance Stabilization Network, ROHDE & SCHWARZ, ENV216, 50 ohm / 50 μH) was installed and electrically boned to the conducting ground plane. The EUT was connected to the LISN using a typical power adapter.
One of two 50 ohm output terminals of the LISN was connected to the EMI Receiver the other was terminated in 50 ohms. Measurements were again performed after interchanging such a connection oppositely.
The frequency range from 150 kHz to 30 MHz was examined and the remarkable frequencies were measured with Quasi-peak and Average values using the EMI receiver instrument (ROHDE & SCHWARZ, Detector Function ; CISPR Quasi-Peak & Average). The 6 dB bandwidth of the Receiver was set to 9 kHz

The position of connecting cables of the EUT was changed to find the worst case configuration during measurements. The maximum emission level from the EUT occurred in such configuration as shown in the following photograph.

4.9.2. Limits

Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency (MHz)	Conducted Limits (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 *	56 to 46 *
0.5-5	56	46
5-30	60	50

- Decreases with the logarithm of the frequency.

4.9.3. Sample calculation

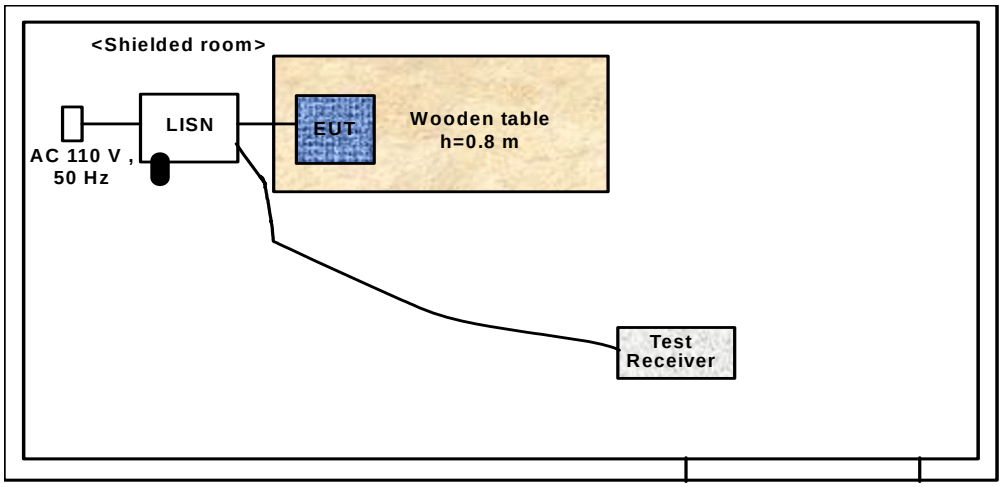
The emission level measured in decibels above one microvolt (dBμV) was converted into microvolt (μV) as shown in following sample calculation.

For example :

Measured Value at	0.1635 MHz	31.5 dBμV @ Q-Peak mode
+ Correct factor *		10.0 dB
= Conducted Emission		41.5 dBμV

* Correct factor is adding RF cable loss and Attenuation

4.9.4. Photograph for the test configuration



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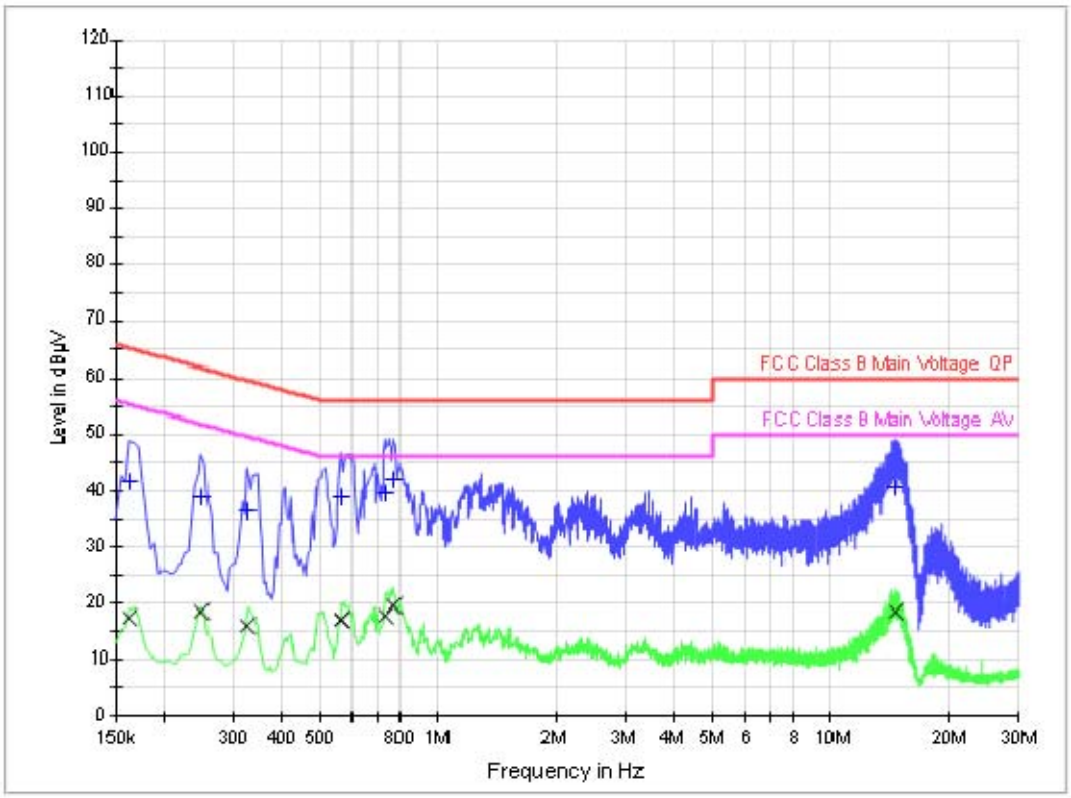
4.9.5.Test Results

<L1>



Final Result 1

Frequency (MHz)	QuasiPeak (dB µ V)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.163500	41.5	1000.0	9.000	L1	10.0	23.8	65.3
0.249000	38.9	1000.0	9.000	L1	10.1	22.9	61.8
0.325500	36.2	1000.0	9.000	L1	10.1	23.4	59.6
0.568500	38.8	1000.0	9.000	L1	10.1	17.2	56.0
0.730500	39.7	1000.0	9.000	L1	10.1	16.3	56.0
0.766500	41.9	1000.0	9.000	L1	10.1	14.1	56.0
14.523000	40.5	1000.0	9.000	L1	10.4	19.5	60.0

Final Result 2

Frequency (MHz)	CAverage (dB µ V)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.163500	17.5	1000.0	9.000	L1	10.0	37.7	55.3
0.249000	18.7	1000.0	9.000	L1	10.1	33.1	51.8
0.325500	16.1	1000.0	9.000	L1	10.1	33.5	49.6
0.568500	17.0	1000.0	9.000	L1	10.1	29.0	46.0
0.730500	17.9	1000.0	9.000	L1	10.1	28.1	46.0
0.766500	19.6	1000.0	9.000	L1	10.1	26.4	46.0
14.523000	18.7	1000.0	9.000	L1	10.4	31.3	50.0

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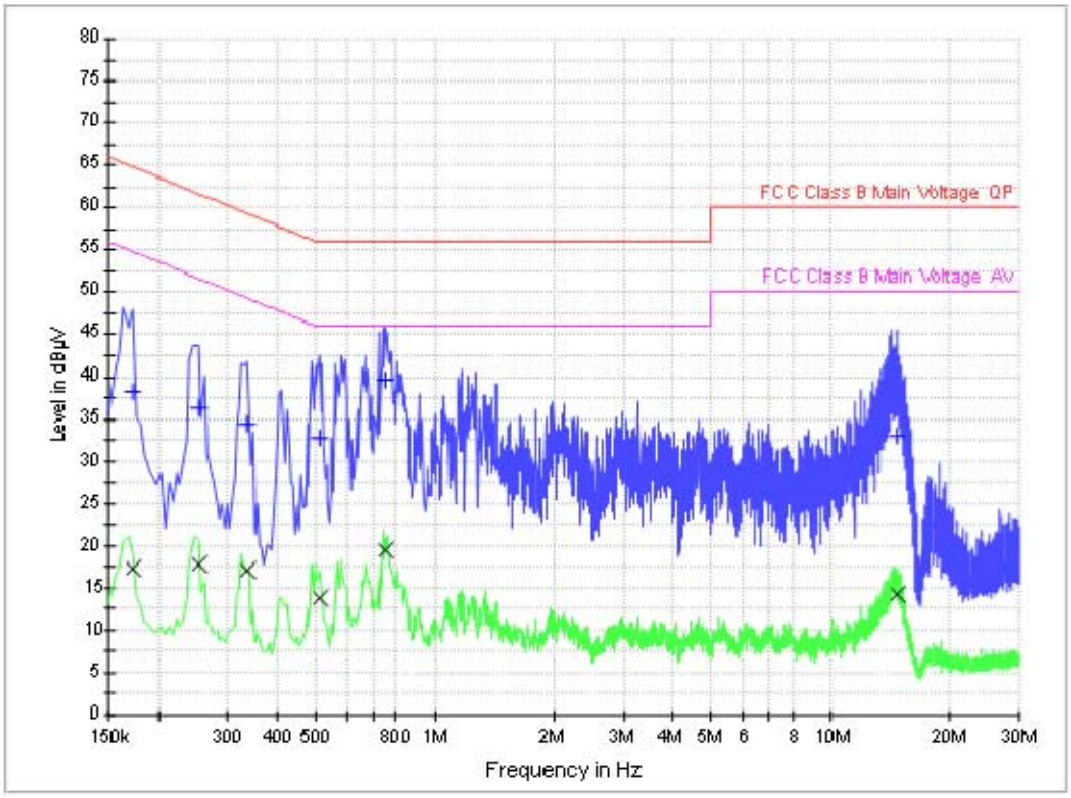

Final Result 1

Frequency (MHz)	QuasiPeak (dB µ V)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.172500	38.3	1000.0	9.000	N	9.7	26.6	64.8
0.253500	36.3	1000.0	9.000	N	9.7	25.3	61.6
0.334500	34.5	1000.0	9.000	N	9.7	24.8	59.3
0.510000	32.7	1000.0	9.000	N	9.8	23.3	56.0
0.753000	39.7	1000.0	9.000	N	9.8	16.3	56.0
14.676000	33.1	1000.0	9.000	N	10.2	26.9	60.0

Final Result 2

Frequency (MHz)	CAverage (dB µ V)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.172500	17.3	1000.0	9.000	N	9.7	37.5	54.8
0.253500	17.8	1000.0	9.000	N	9.7	33.8	51.6
0.334500	17.0	1000.0	9.000	N	9.7	32.3	49.3
0.510000	13.7	1000.0	9.000	N	9.8	32.3	46.0
0.753000	19.5	1000.0	9.000	N	9.8	26.5	46.0
14.676000	14.2	1000.0	9.000	N	10.2	35.8	50.0

5. TEST EQUIPMENTS

No.	Equipment	Manufacturer	Model	S/N	Calibration Due date
1	Spectrum Analyzer	Agilent	E4407B	US41443316	02/05/2017
2	Synthesized Sweeper	HP	83620A	3250A01653	01/12/2017
3	Digital RF Signal Generator	Agilent	E4438C	US41460859	01/19/2017
4	Signal Generator	R&S	SMBV100A	259341	01/11/2017
5	PSA Series Spectrum Analyzer	Agilent	E4448A	US44300484	01/08/2017
6	DC Power Supply	Agilent	E3645A	MY55466008	03/21/2017
7	DC Power Supply	Agilent	E3645A	MY54086747	01/07/2017
8	AC Power Supply	Agilent	6811B	MY41000446	01/07/2017
9	Oscilloscope	Tektronix	TDS2014	C050079	01/15/2017
10	Directional Coupler	Agilent	87300C	MY44300126	01/19/2017
11	Directional Coupler	Agilent	773D	MY28390213	01/20/2017
12	VHF Attenuator	HP	355D	2522A45959	01/05/2017
13	Coaxial Attenuator	Weinschel	56-20	N8527	01/20/2017
14	Coaxial Attenuator	Agilent	8491B	50109	01/20/2017
15	Power Divider	HP	11636A	09084	02/04/2017
16	Power Spliter	HP	11667A	21063	01/20/2017
17	Temp/Humidity Chamber	ESPEC	SH-641	92007483	01/21/2017
18	Function/Arbitrary Waveform Generator	Agilent	33250A	MY40015646	01/29/2017
19	EMI Receiver	R&S	ESIB26	100280	05/20/2017
20	Pre-Amplifier	Agilent	8449B	3008A02080	01/20/2017
21	Pre-Amplifier	SONA INSTRUMENT	310	284609	01/27/2017
22	Biconi-Log Antenna	Schwarzbeck	VULB9168	397	03/06/2017
23	Double Ridged Horn Antenna	Schwarzbeck	BBHA9120D	653	06/09/2017
24	Double Ridged Horn Antenna	ETS-Lindgren	3116	2662	08/26/2018
25	Spectrum Analyzer	R&S	FSP30	100229	01/07/2017
26	TWO-LINE V-NETWORK (LISN)	R&S	ENV216	100095	02/16/2017