

FCC 15.247 (b) Maximum output power and antenna gain

Limits

For systems using digital modulation in the 2400-2483.5 MHz band: 1 watt (30 dBm).

Results

The maximum peak conducted output power level in the fundamental emission was measured using the method according to point 11.9.1.1 "RBW $\geq$ DTS bandwidth" of ANSI C.63.10-2013.

The EIRP power (dBm) is calculated by adding the declared maximum antenna gain to the measured conducted power.

Maximum Declared Antenna Gain: 2 dBi

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Freq (MHz)	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
2402.00000	-0.045	1.955
2440.00000	0.369	2.369
2480.00000	-0.439	1.561

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Freq (MHz)	Maximum Conducted Power (dBm)	Maximum EIRP Power (dBm)
2402.00000	-0.198	1.802
2440.00000	0.161	2.161
2480.00000	-0.572	1.428

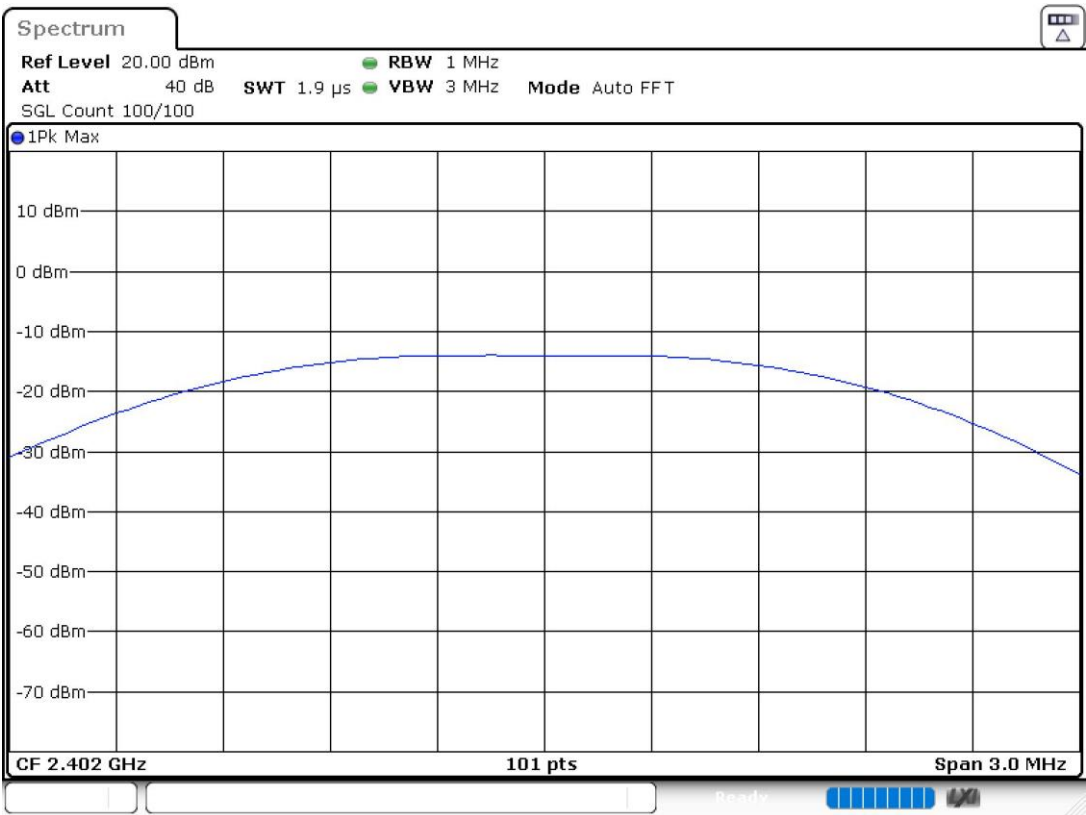
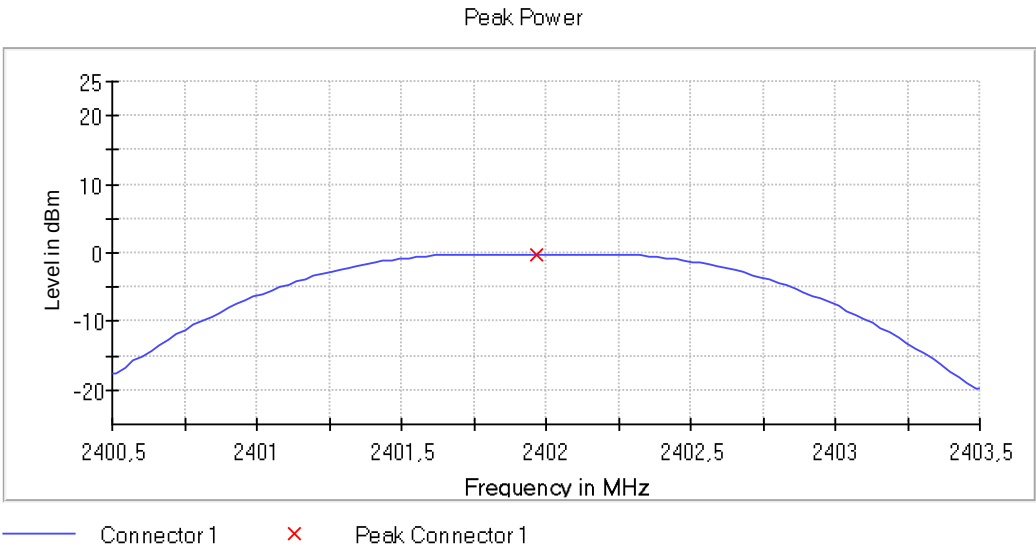
Verdict

Pass

Attachments

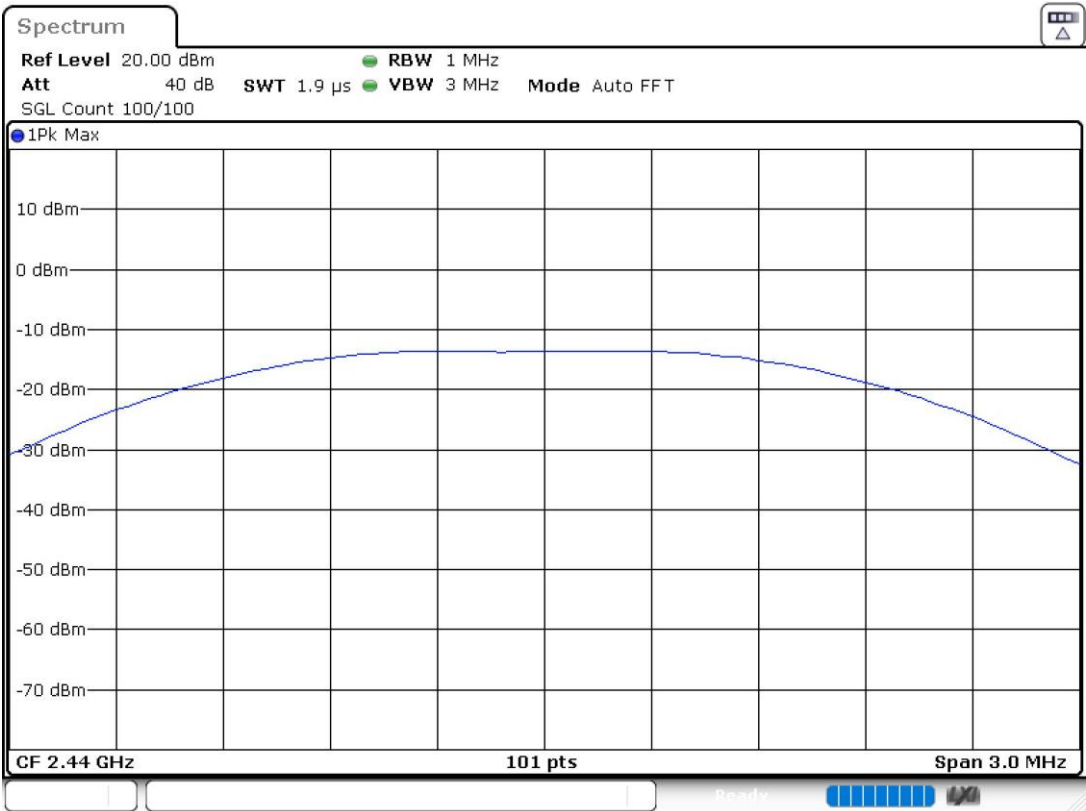
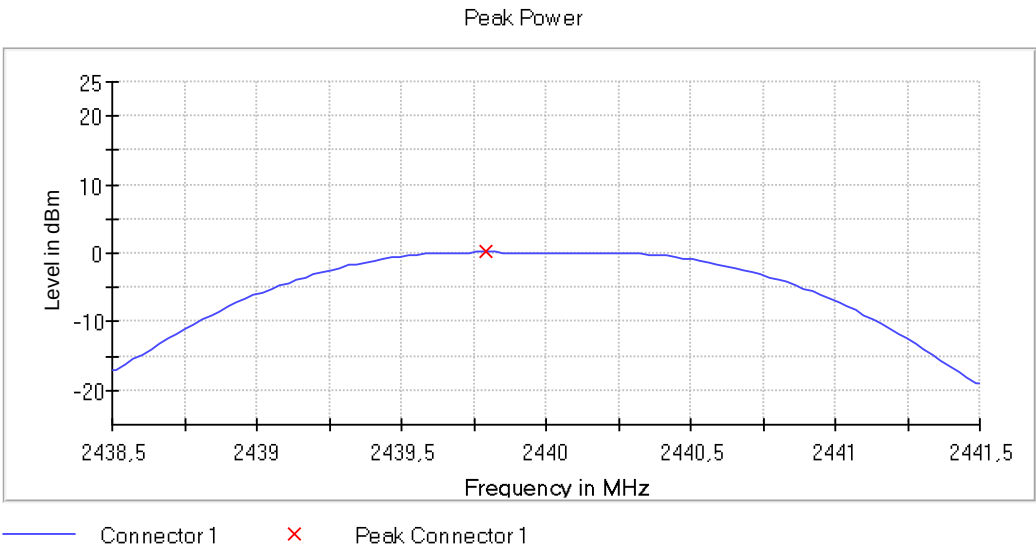
Operation Band MHz = [2400, 2483.5], Frequency MHz = 2412.00000, Equipment Type = Digital
Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s)

Images:



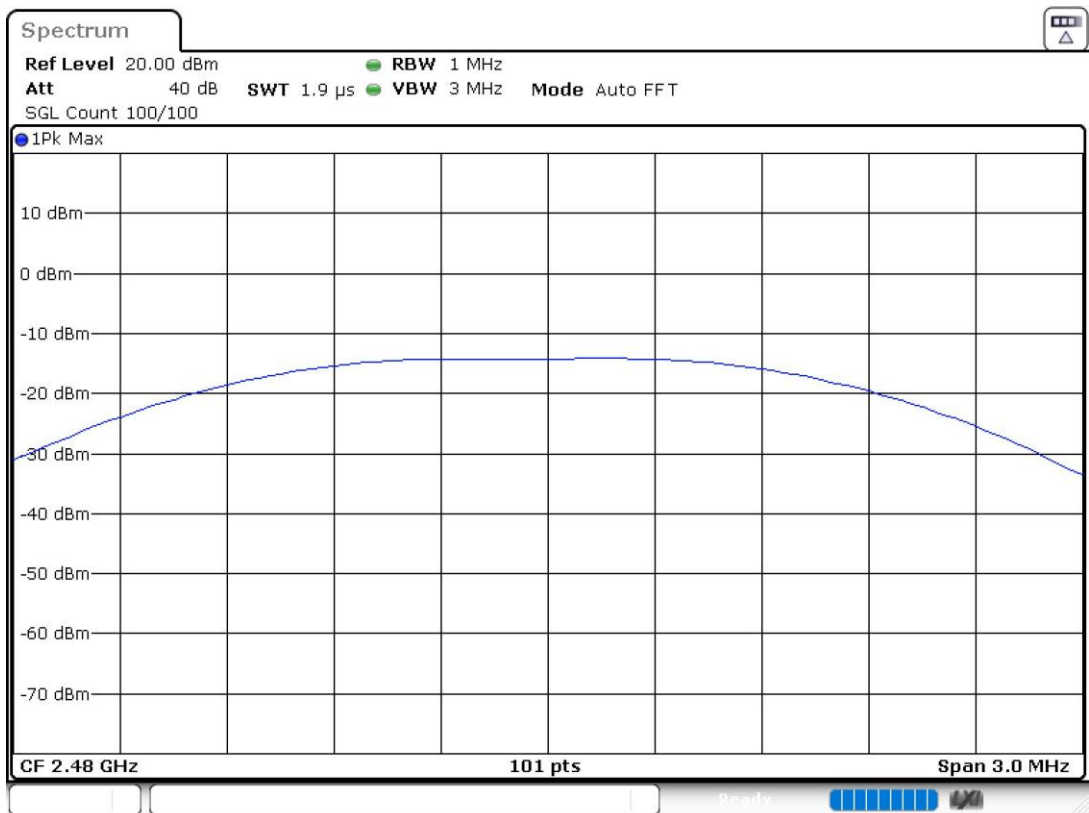
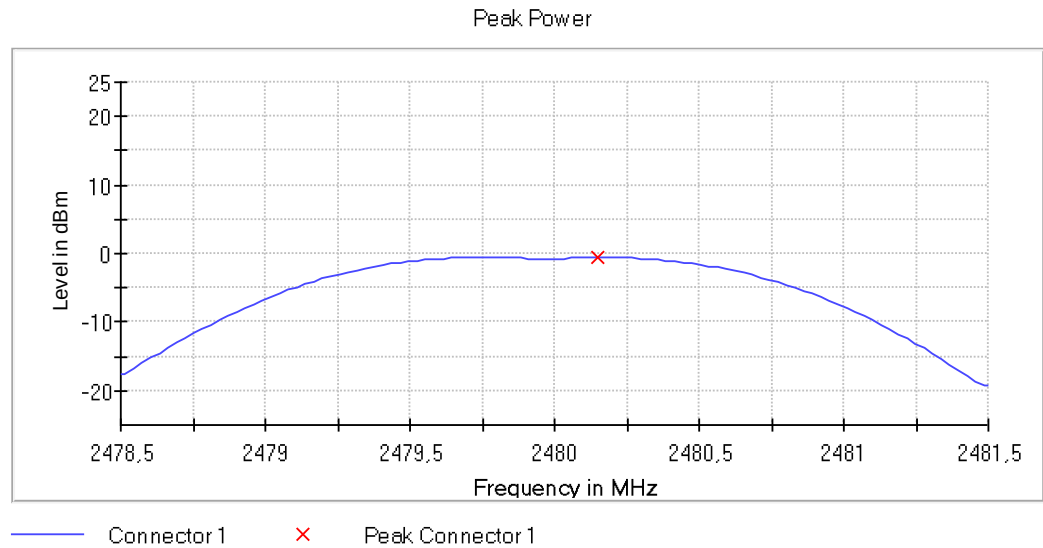
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Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s)

Images:



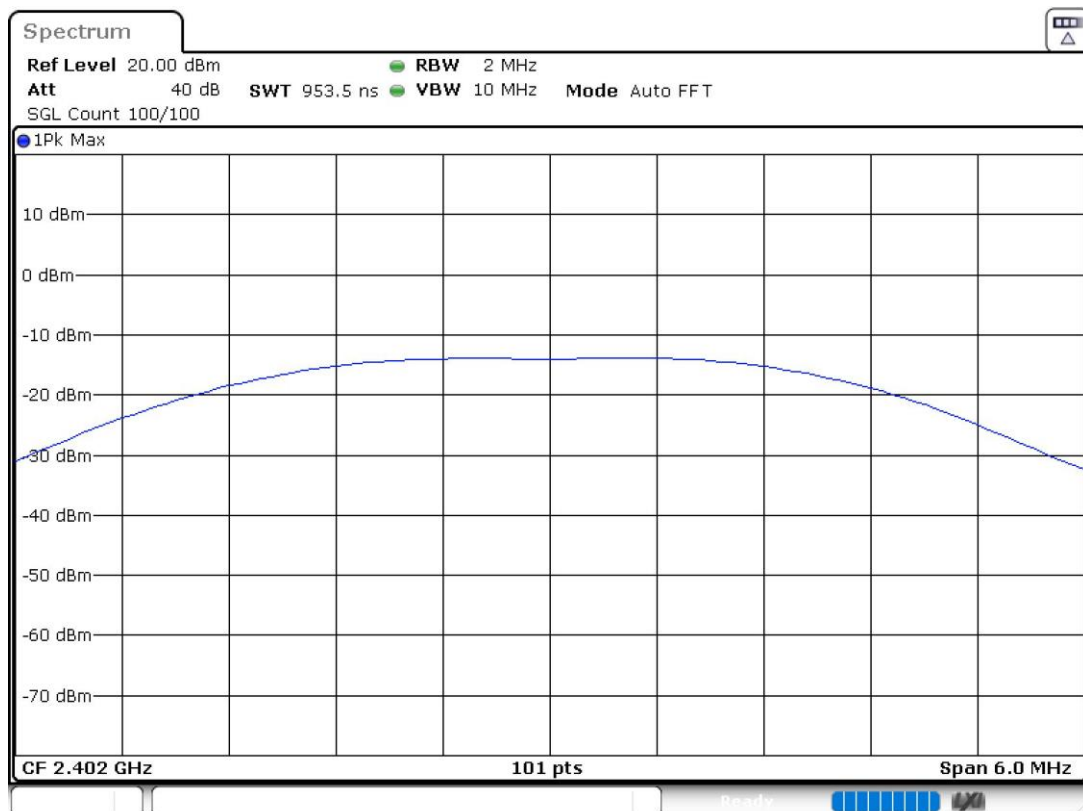
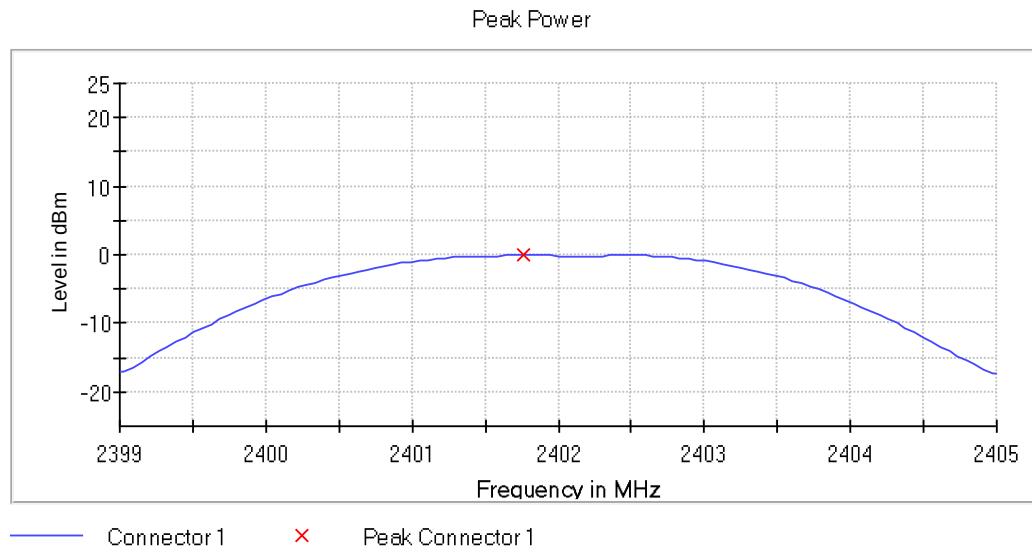
Operation Band MHz = [2400, 2483.5], Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s)

Images:



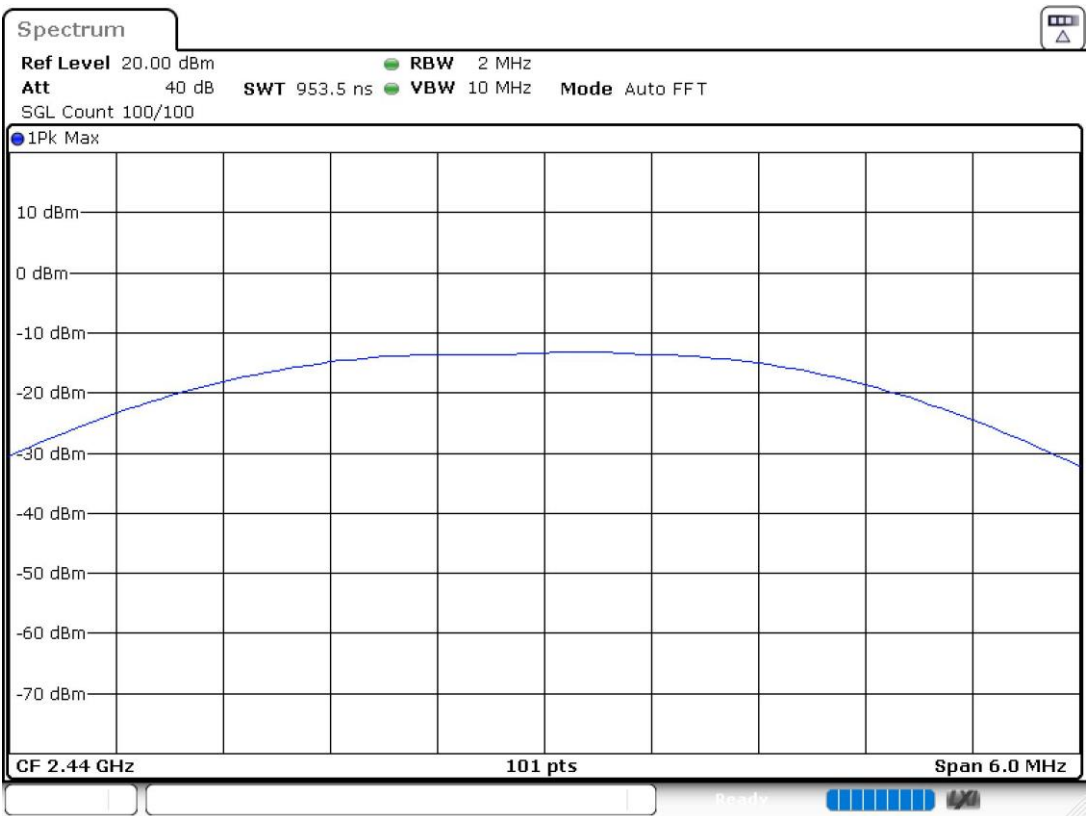
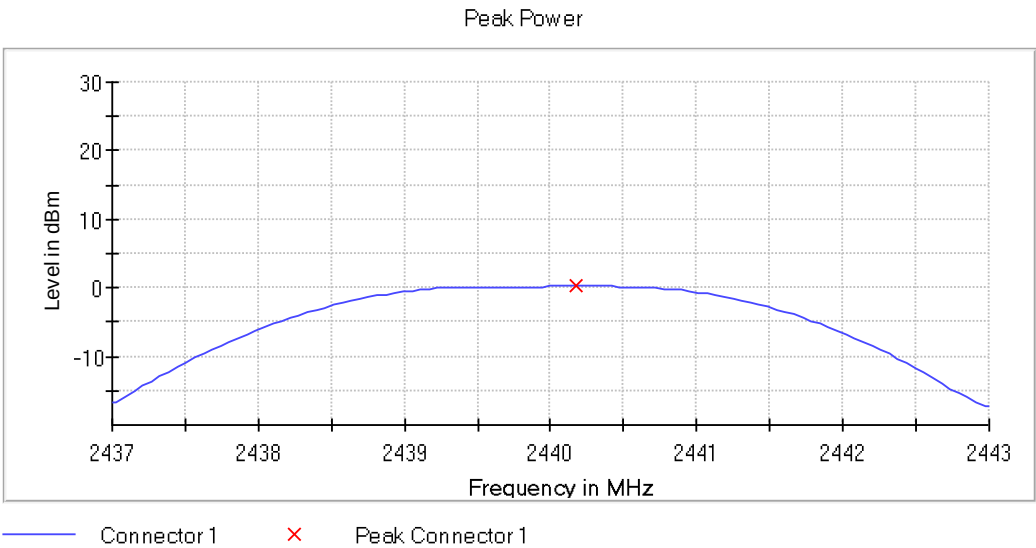
Operation Band MHz = [2400, 2483.5], Frequency MHz = 2412.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s)

Images:



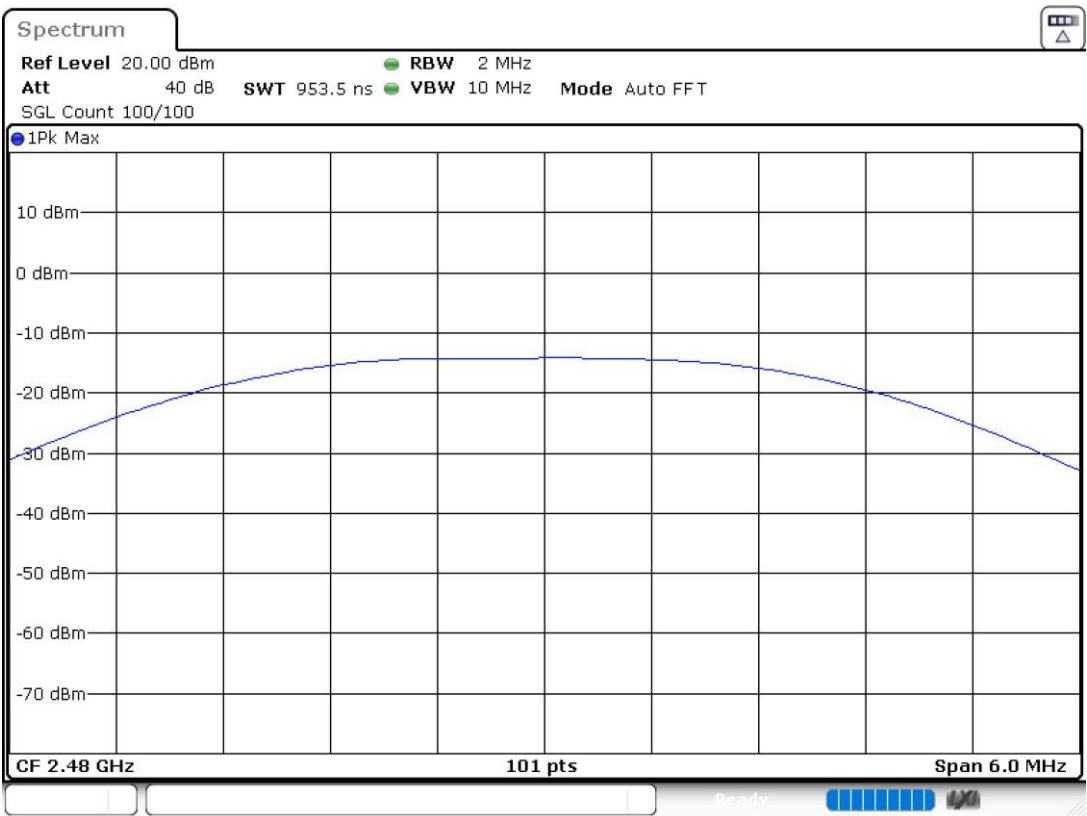
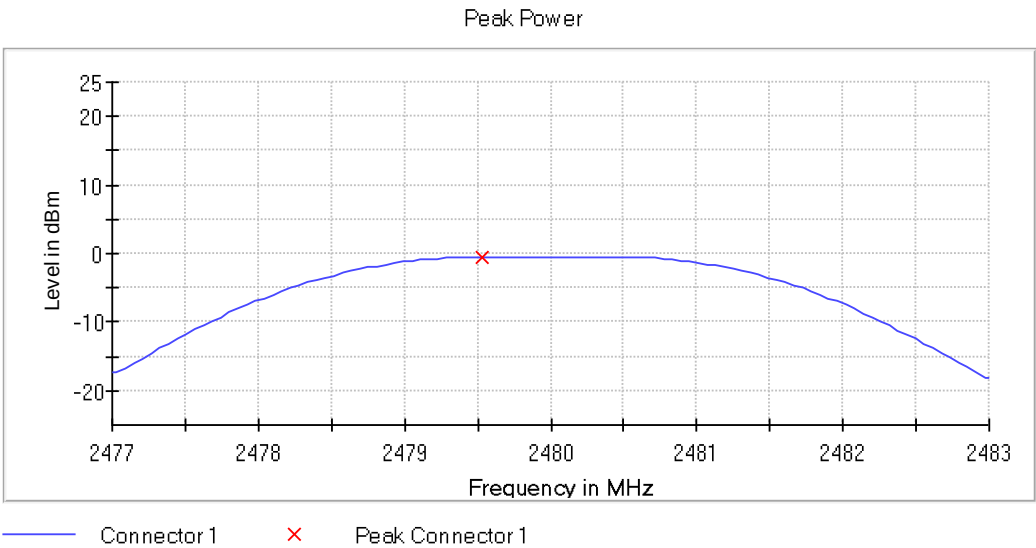
Operation Band MHz = [2400, 2483.5], Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s)

Images:



Operation Band MHz = [2400, 2483.5], Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s)

Images:



FCC 15.247 (d) Band-edge emissions compliance (Transmitter)

Limits

In any 100 kHz bandwidths outside the frequency band in which the intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Operation Band: [2400, 2483.5]

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Results

Radiated measurements were used to show compliance with the limits in the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Results

Radiated measurements were used to show compliance with the limits in the restricted bands 2.31-2.39 GHz and 2.4835-2.5 GHz.

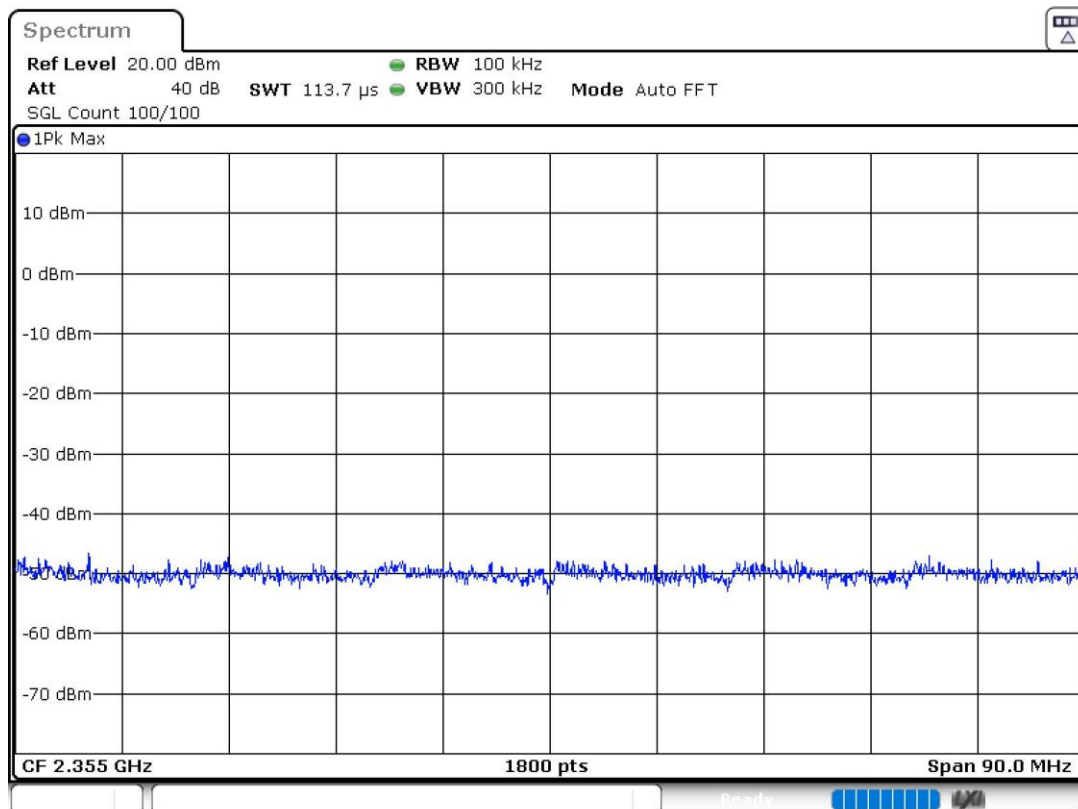
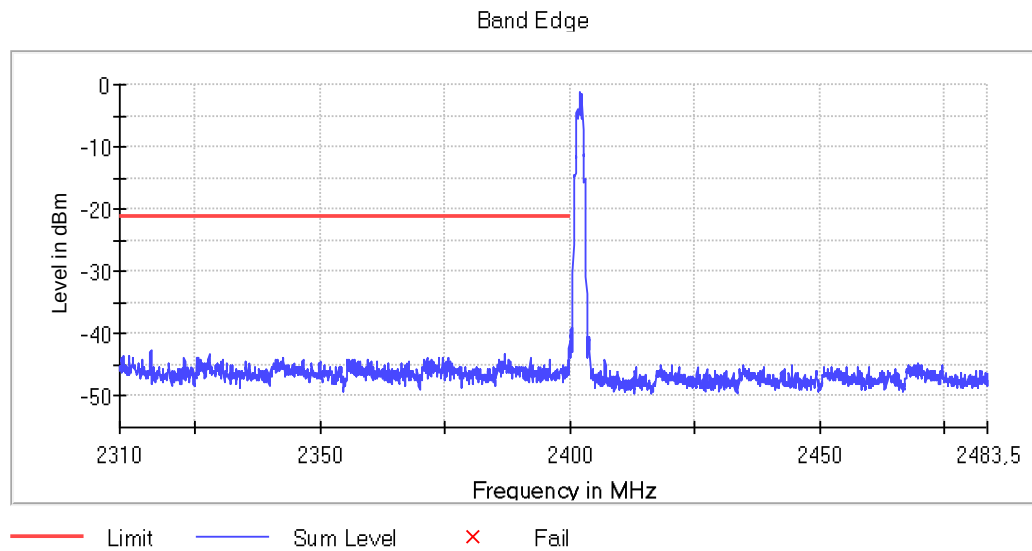
Verdict

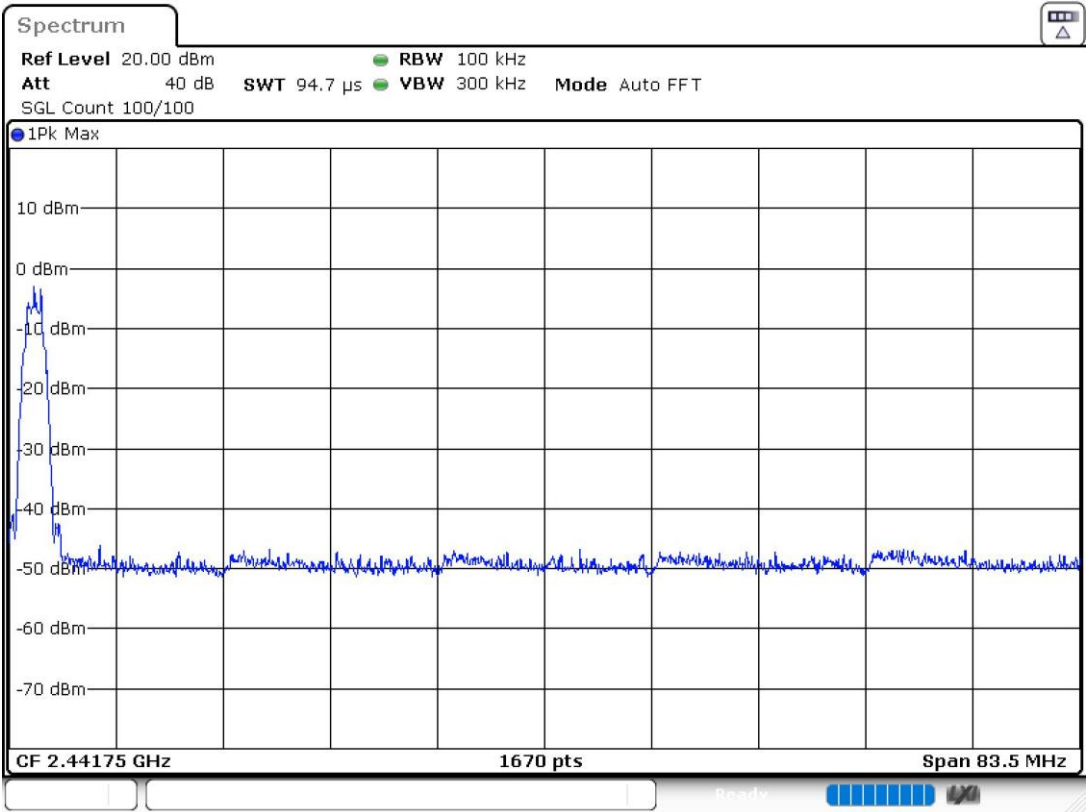
Pass

Attachments

Operation Band MHz = [2400, 2483.5], Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Measurement Point = 1

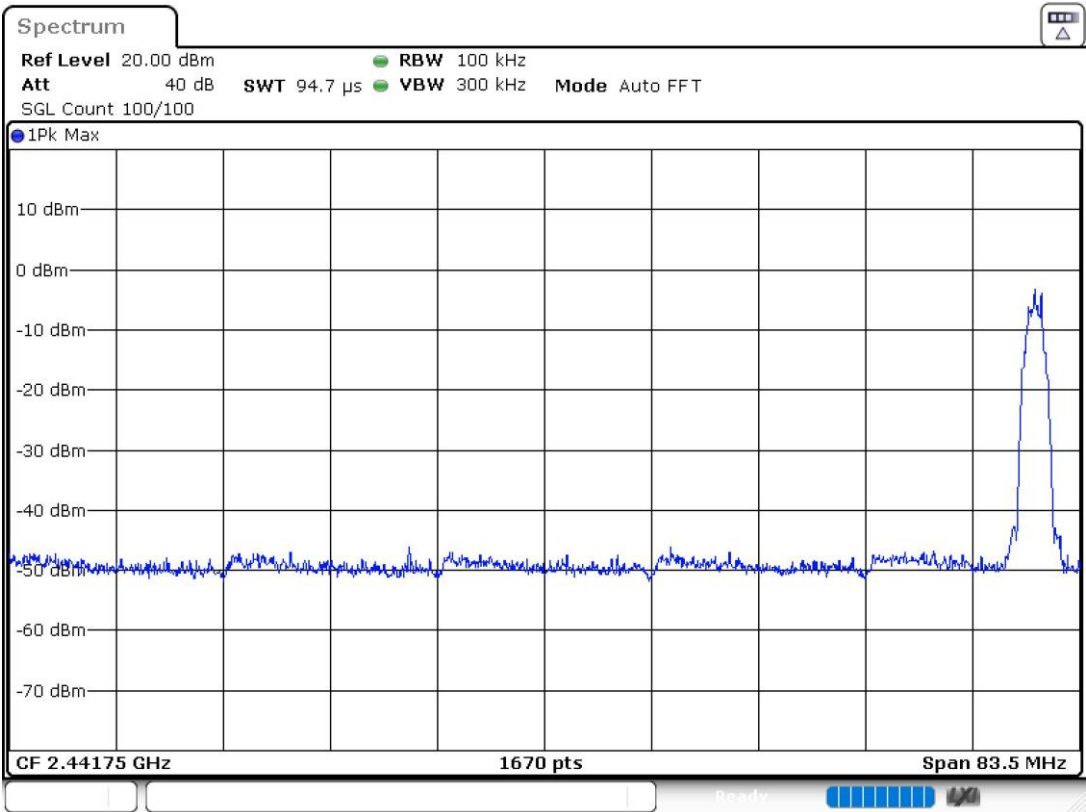
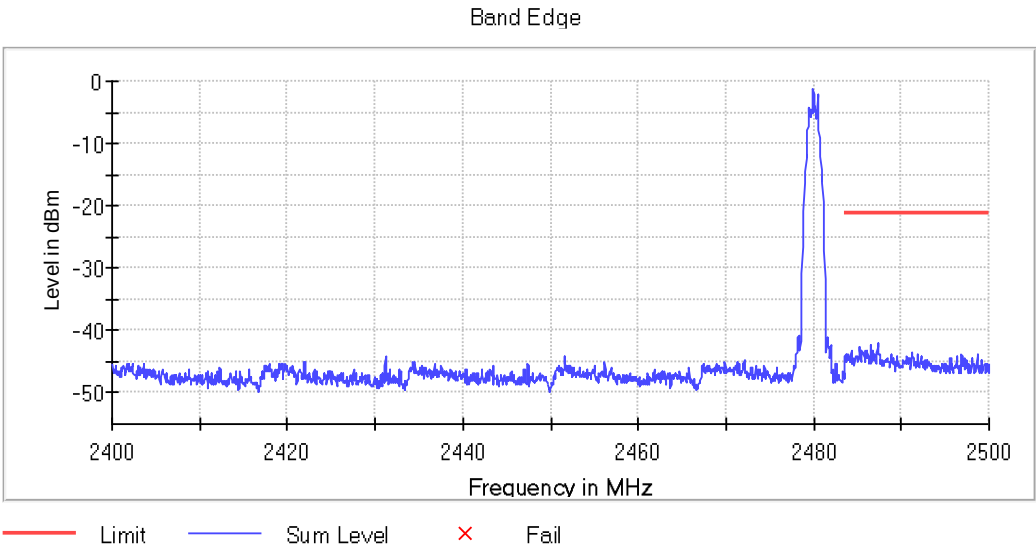
Images:

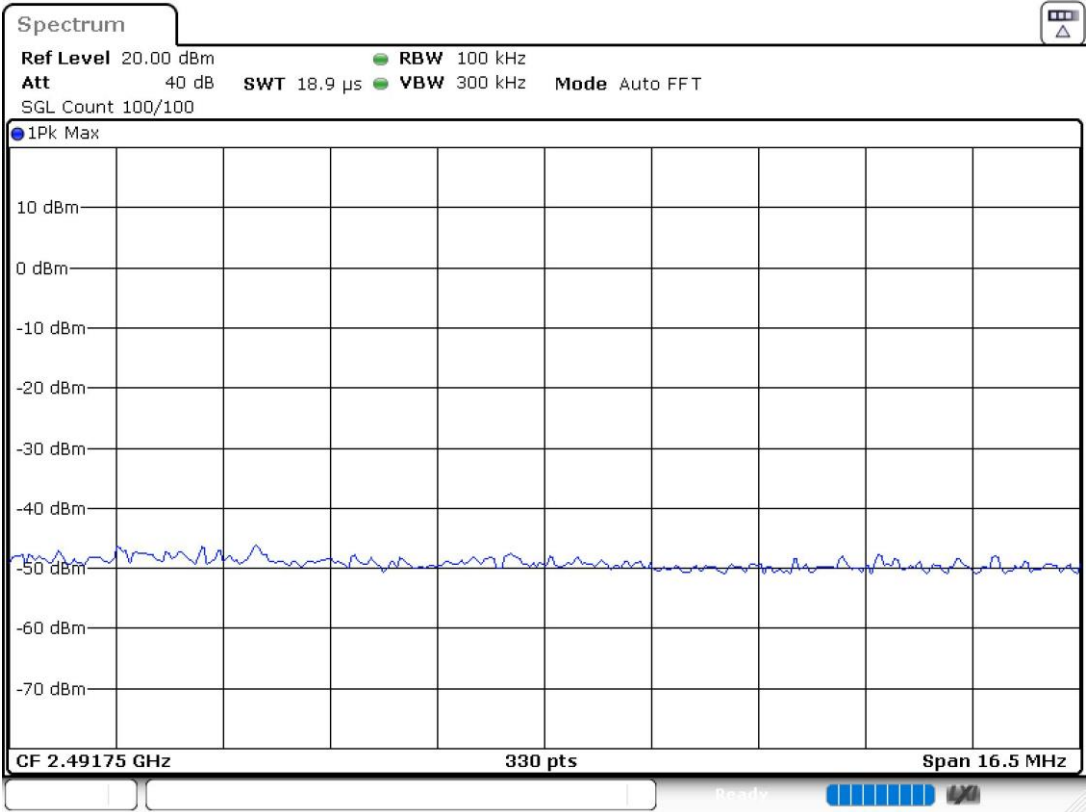




Operation Band MHz = [2400, 2483.5], Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Measurement Point = 1

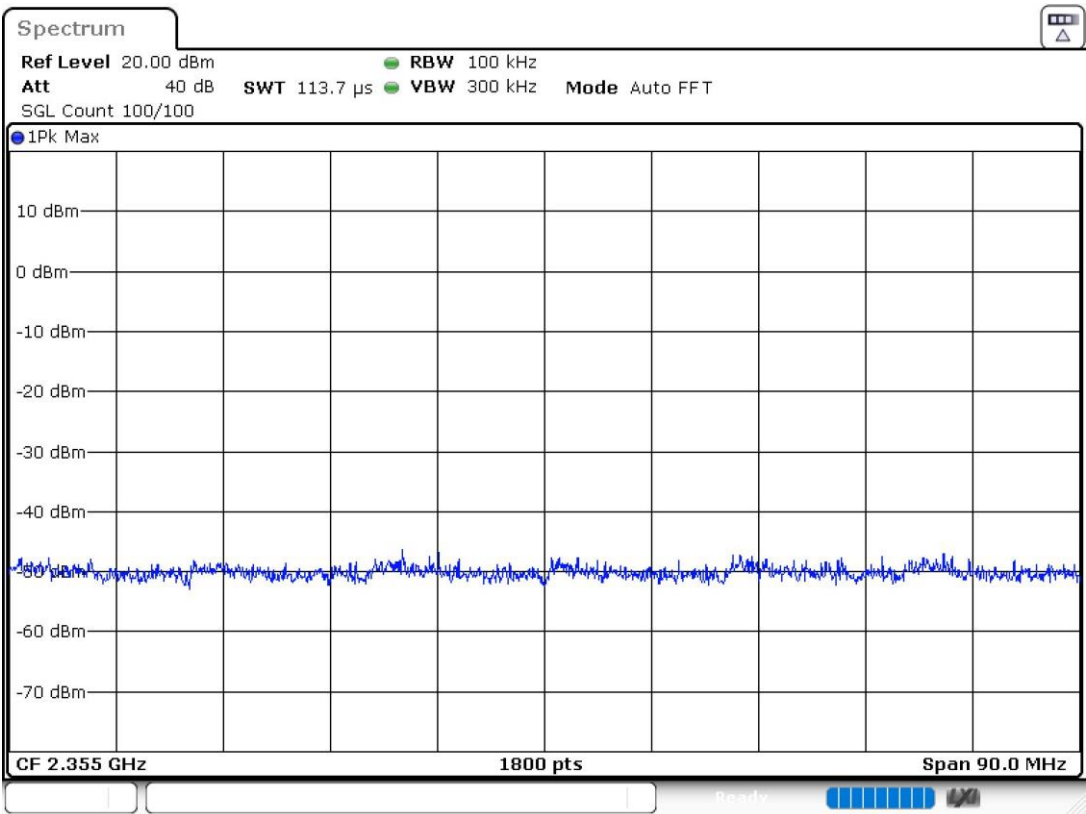
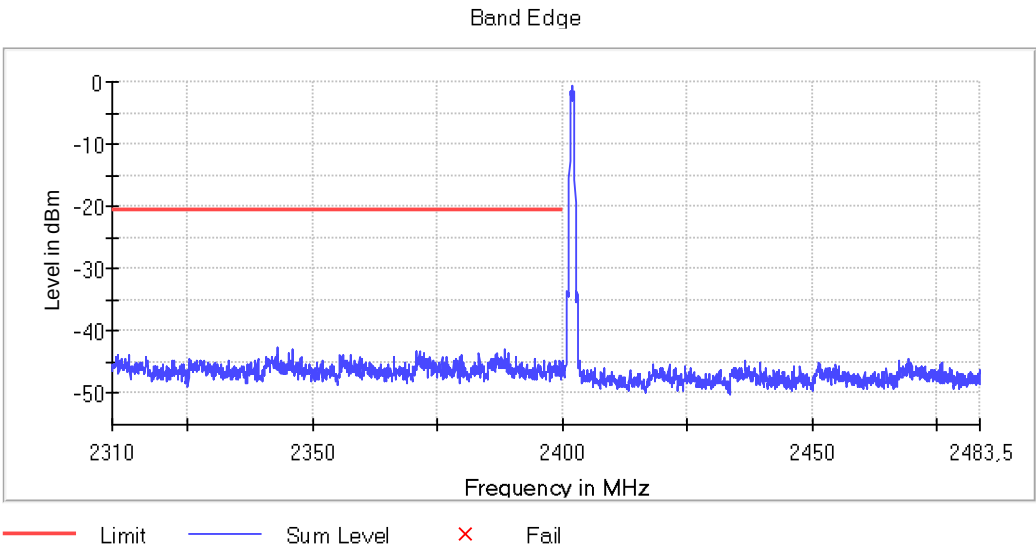
Images:

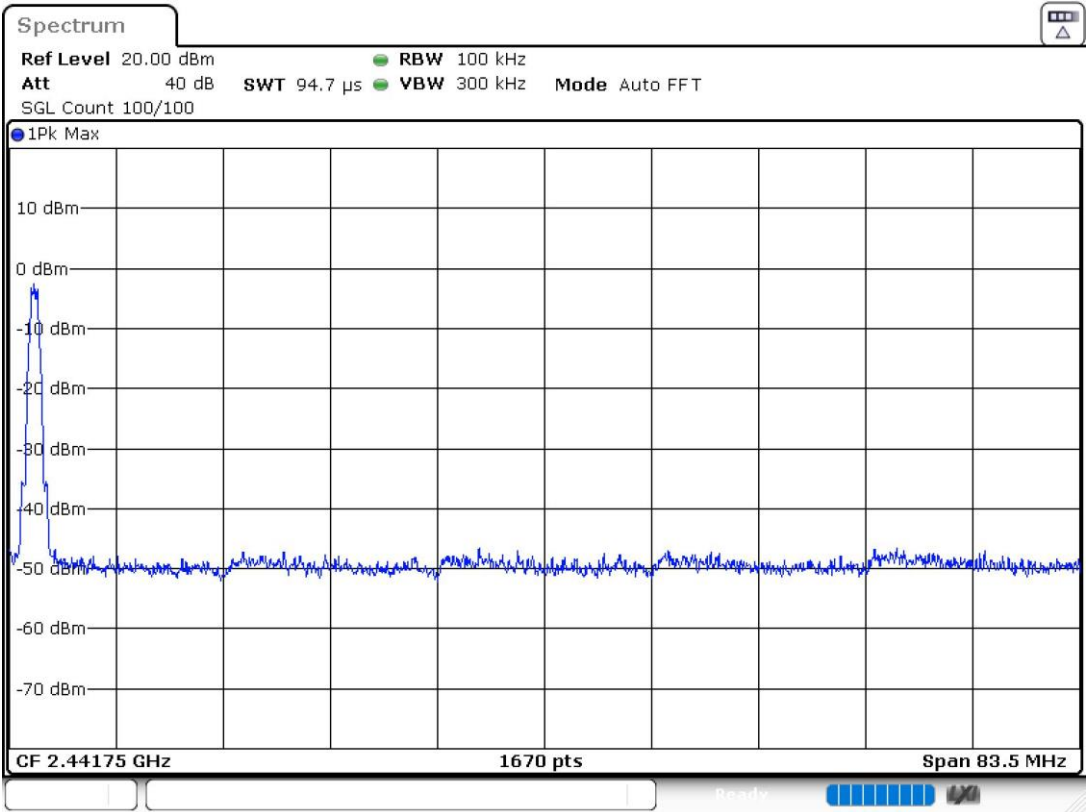




Operation Band MHz = [2400, 2483.5], Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Measurement Point = 1

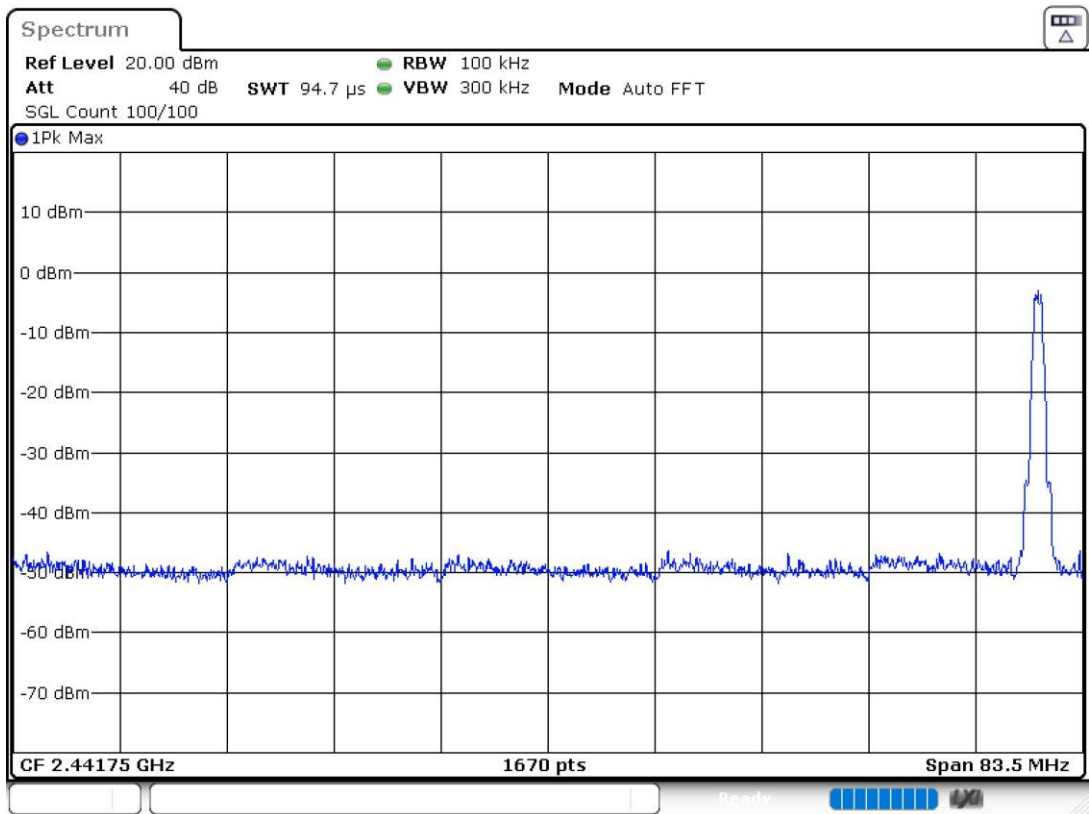
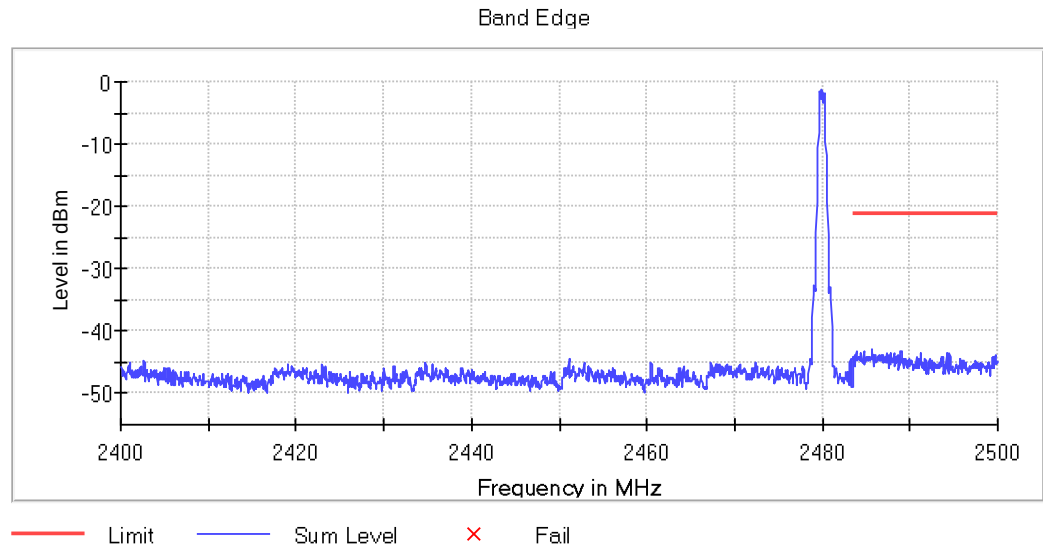
Images:

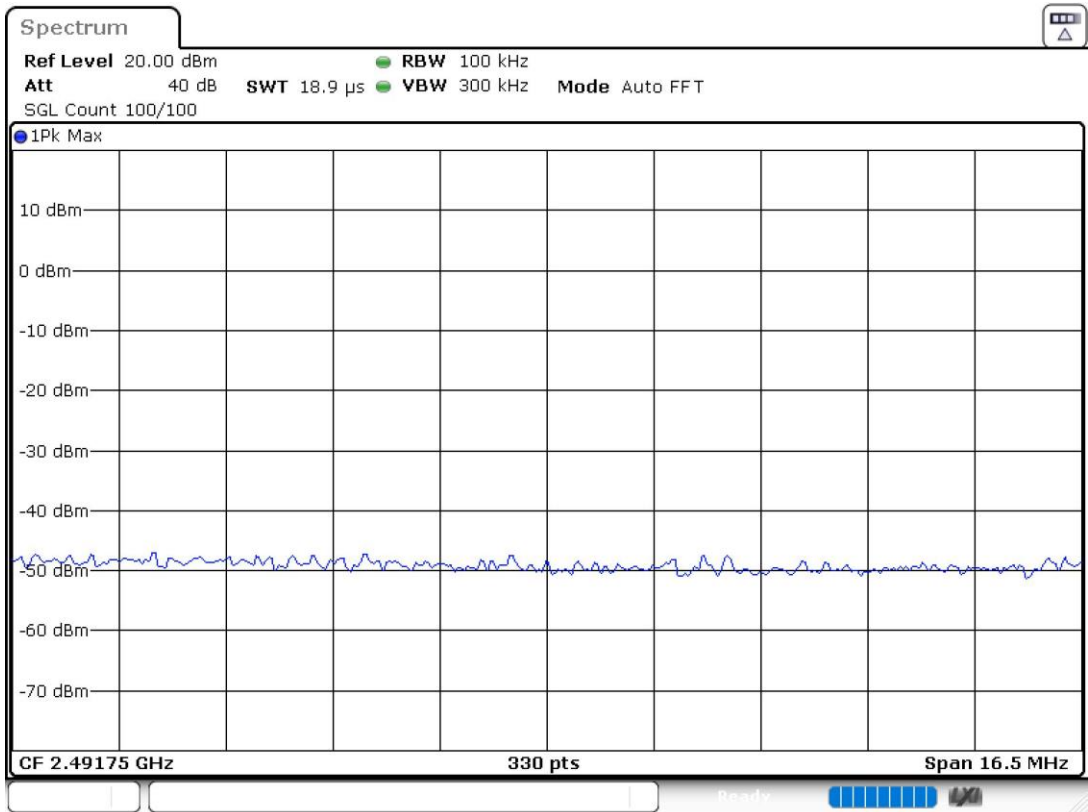




Operation Band MHz = [2400, 2483.5], Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Measurement Point = 1

Images:





FCC 15.247 (d) Emission limitations radiated (Transmitter)

Limits

Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)):

Frequency Range (MHz)	Field strength ($\mu\text{V/m}$)	Field strength ($\text{dB}\mu\text{V/m}$)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

Frequency range 30 MHz – 1 GHz:

The spurious frequencies detected do not depend on either the modulation or the operating channel.

Spurious frequencies detected at less than 20 dB below the limit:

Freq Rng (GHz)	Unwanted Freq (MHz)	Unwanted Lvl ($\text{dB}\mu\text{V/m}$)	Pol	Detector
[0.03, 1]	874.9913	43.90	V	QP

Frequency range 1 GHz – 26 GHz:

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Spurious frequencies detected at less than 20 dB below the limit:

Freq (MHz)	Freq Rng (GHz)	Unwanted Freq (GHz)	Unwanted Lvl (dBμV/m)	Pol	Detector
2402.0000	[3, 17]	4.2333	46.30	V	Peak
		4.9064	45.87	V	Peak
		4.9543	47.14	V	Peak
2440.0000		4.2333	46.04	V	Peak
		5.0118	44.84	V	Peak
		5.0598	46.49	V	Peak
2480.0000		4.2333	44.29	V	Peak
		5.0763	46.81	V	Peak
		5.3836	50.36	V	Peak

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Spurious frequencies detected at less than 20 dB below the limit:

Freq (MHz)	Freq Rng (GHz)	Unwanted Freq (GHz)	Unwanted Lvl (dBμV/m)	Pol	Detector
2402.0000	[3, 17]	4.2334	45.05	V	Peak
		4.9158	43.15	H	Peak
		4.9636	44.15	H	Peak
2440.0000		5.0118	47.33	V	Peak
		5.0598	48.42	V	Peak
		5.1076	45.89	V	Peak
2480.0000		5.0310	46.83	V	Peak
		5.1078	49.81	V	Peak
		5.4238	45.03	H	Peak

Verdict

Pass

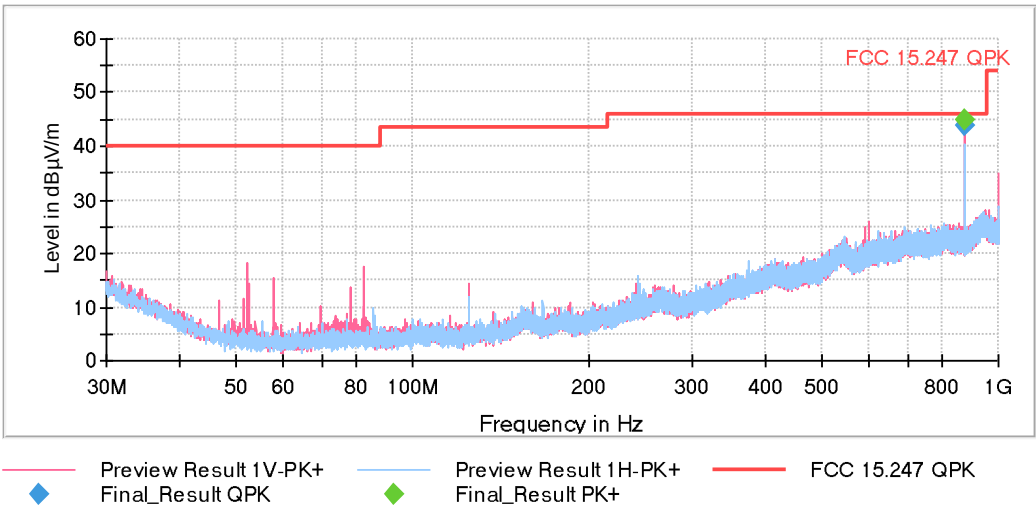
Attachments

The setting for each range of frequency is indicated in the following tables:

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW 44] 30 MHz - 1 GHz	30,312 kHz	PK+	100 kHz	1 s	0 dB
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW 44] 1 GHz - 3 GHz	30,769 kHz	PK+ ; AVG	1 MHz	1 s	0 dB
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESW 44] 3 GHz - 17 GHz	140 kHz	PK+ ; AVG	1 MHz	1 s	30 dB
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [FSV 40] 17 GHz - 26 GHz	300 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

Equipment Type = Digital Transmission System (DTS), Frequency Range GHz = [0.03, 1], Number of Transmission Chains = 1, Measurement Point = 1

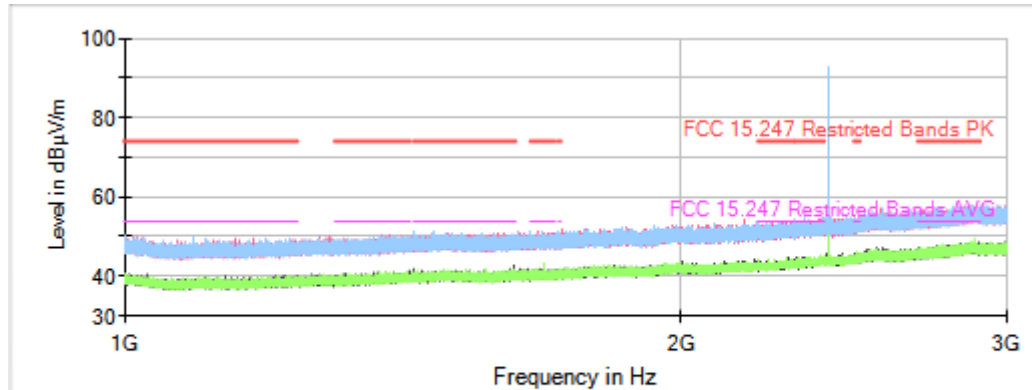
Images:



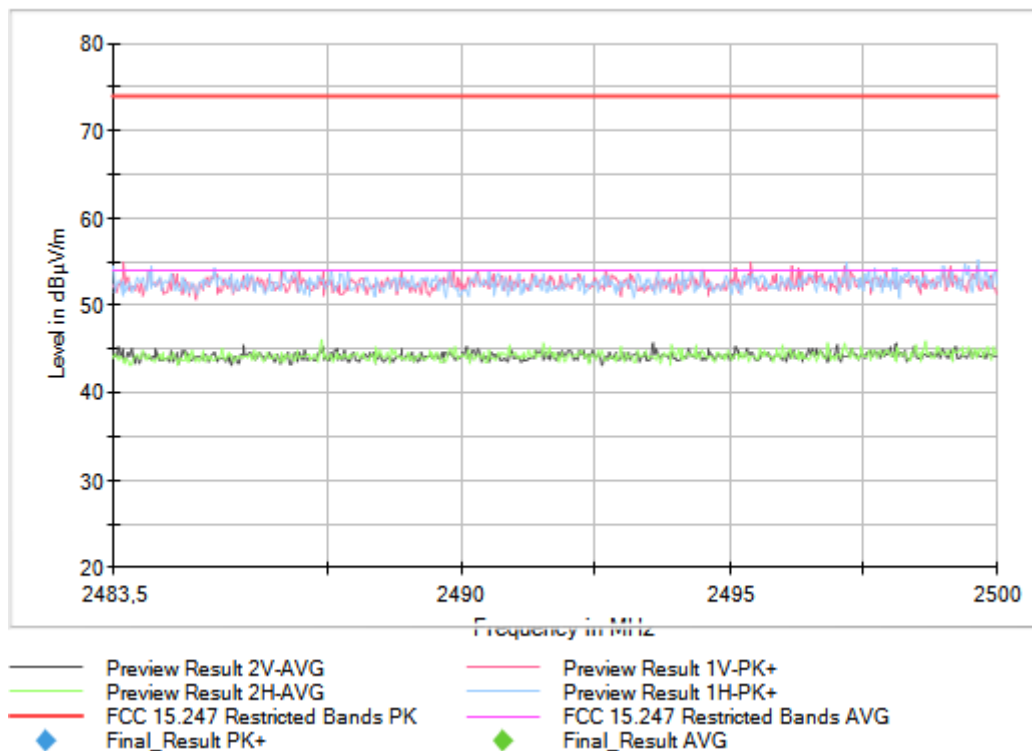
This plot is valid for all channel and all modulations

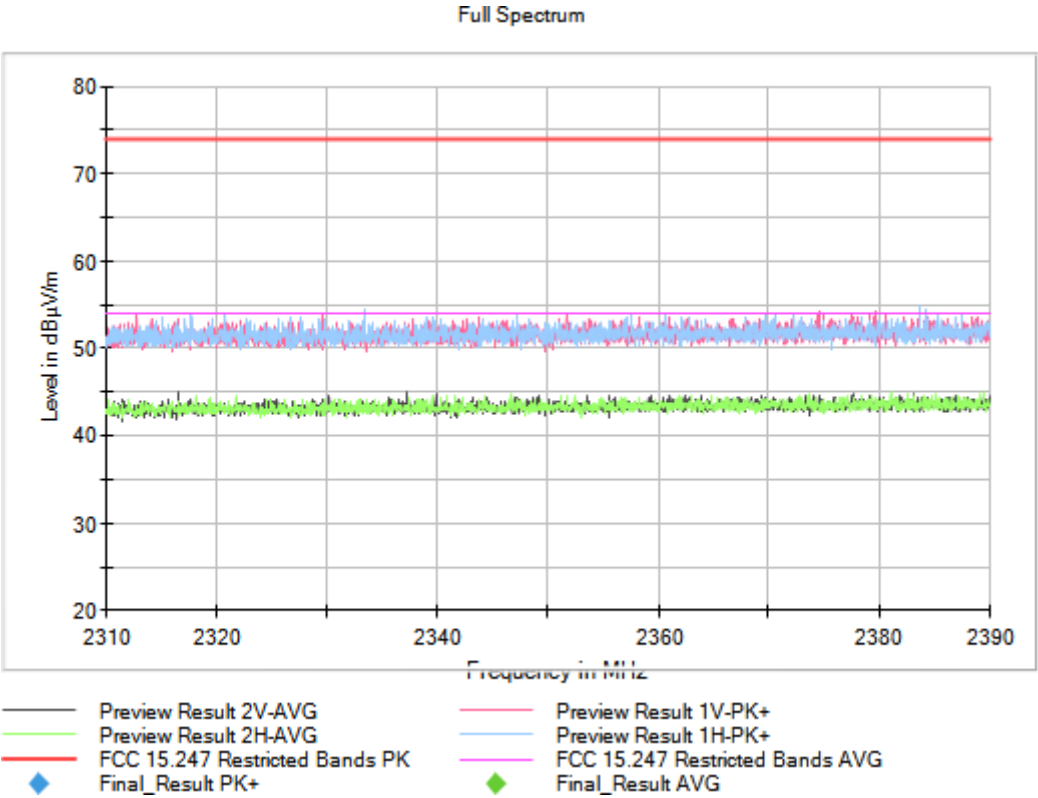
Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range GHz = [1, 3], Number of Transmission Chains = 1, Measurement Point = 1

Images:



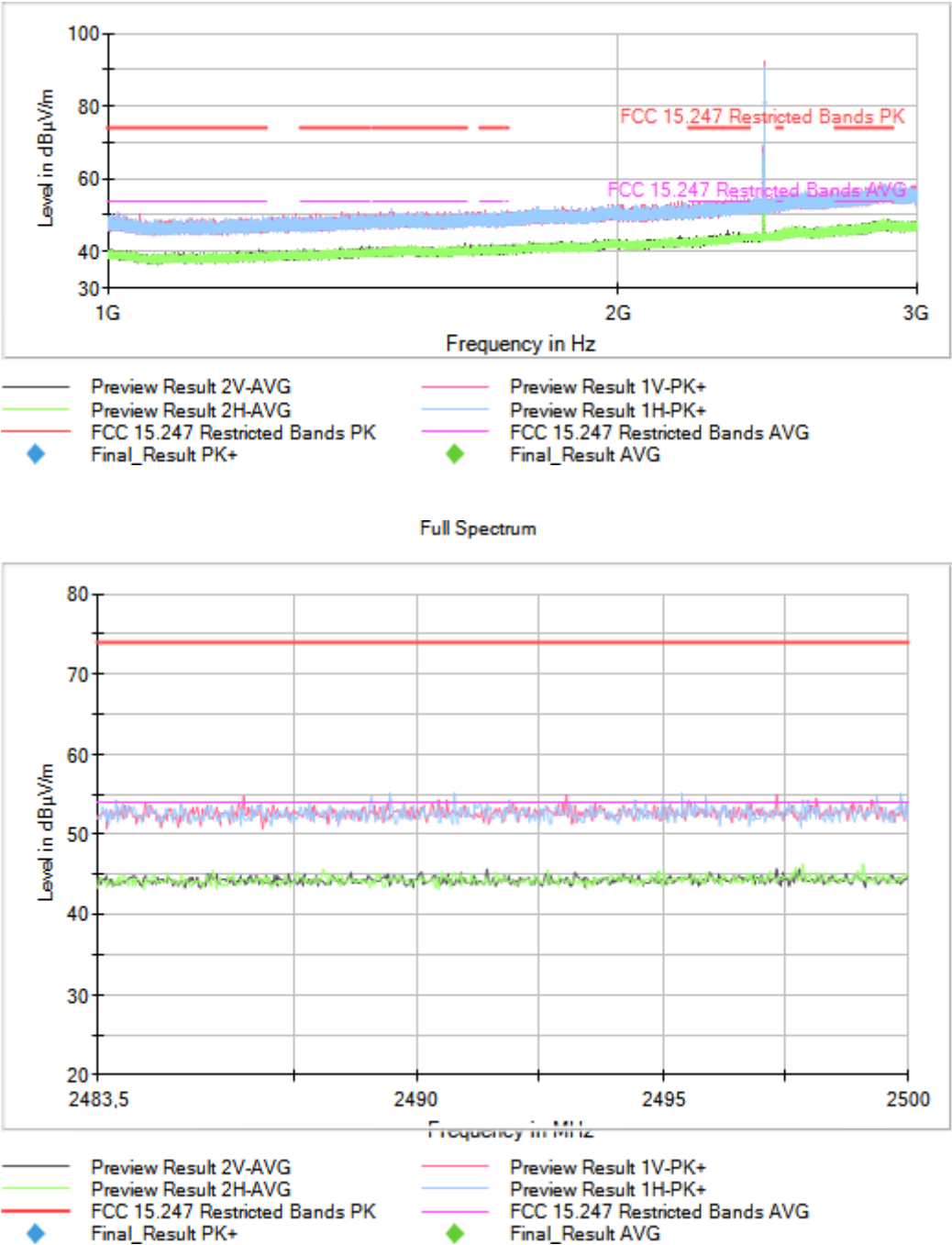
Full Spectrum

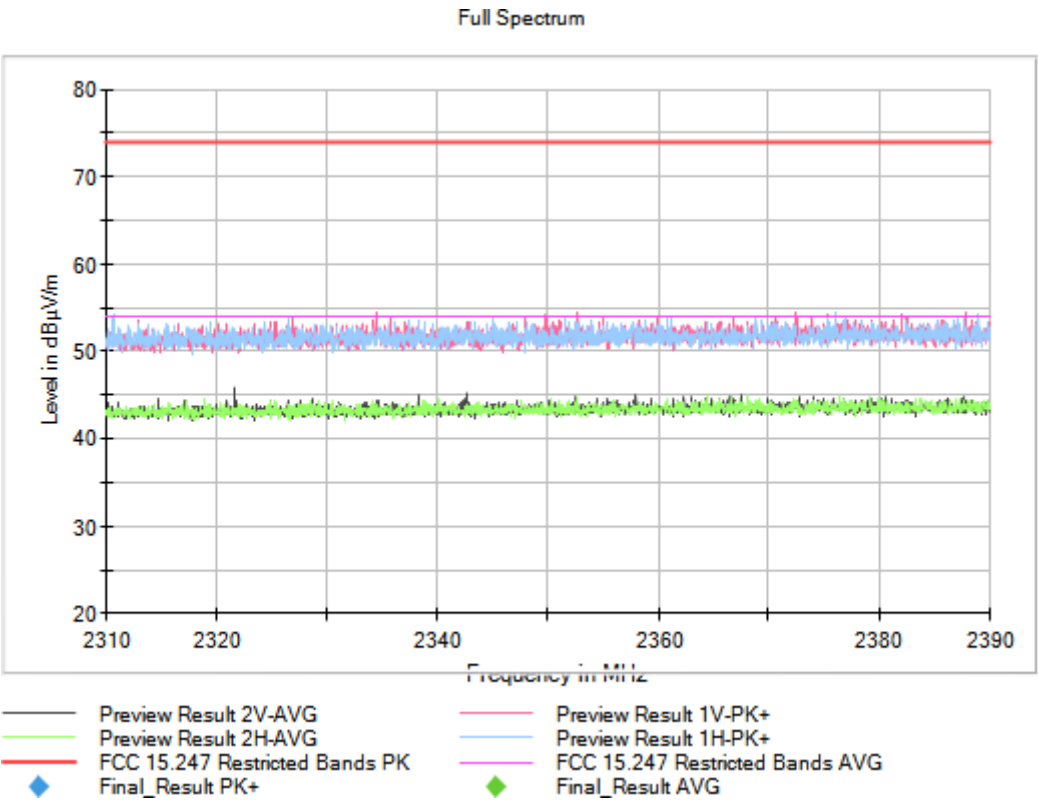




Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range GHz = [1, 3], Number of Transmission Chains = 1, Measurement Point = 1

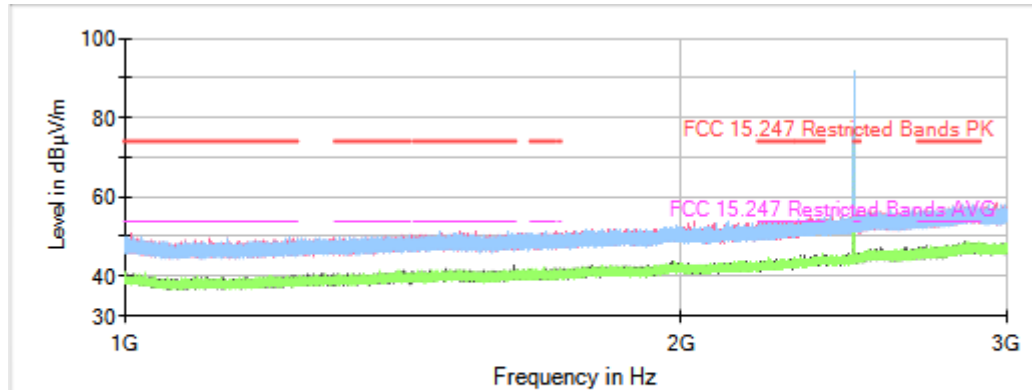
Images:





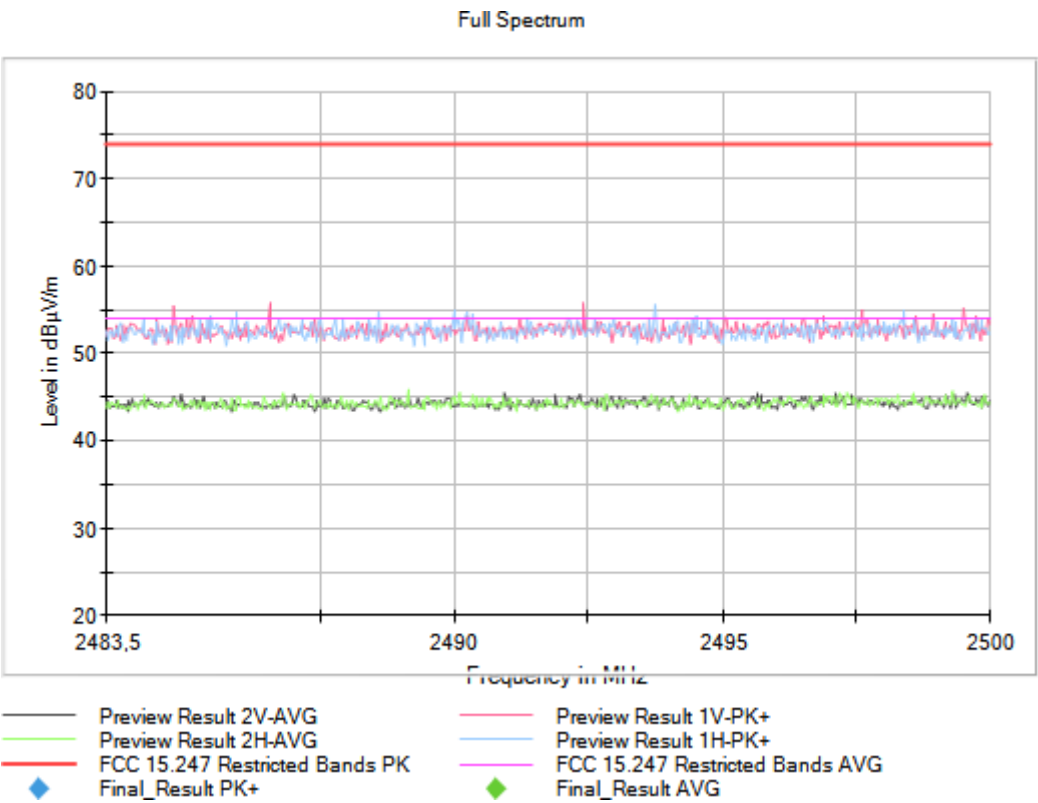
Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range GHz = [1, 3], Number of Transmission Chains = 1, Measurement Point = 1

Images:



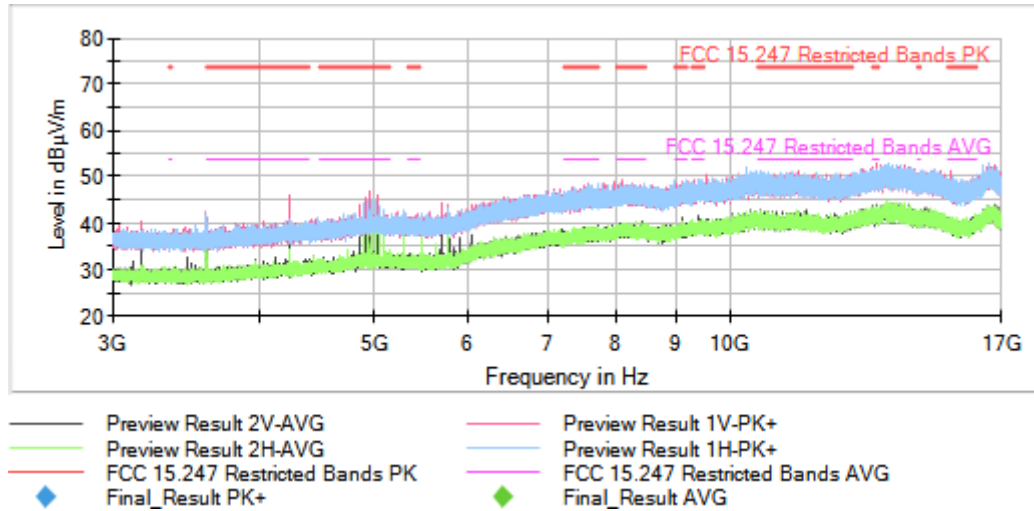
Full Spectrum





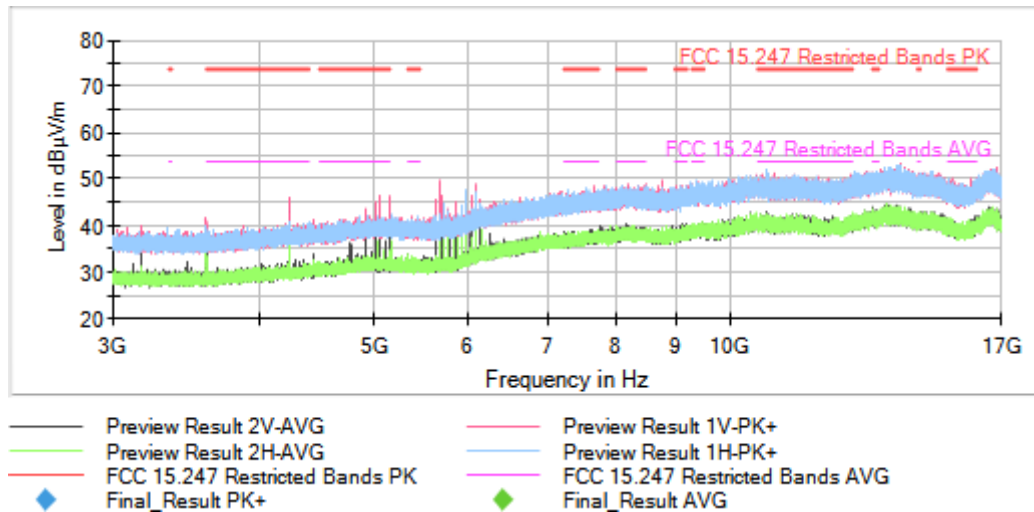
Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range GHz = [3, 17], Number of Transmission Chains = 1, Measurement Point = 1

Images:



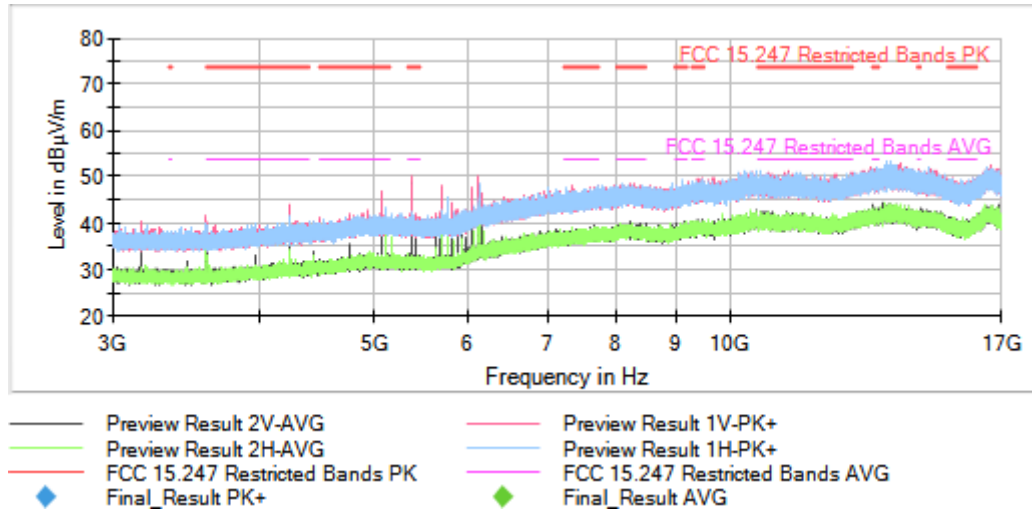
Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range GHz = [3, 17], Number of Transmission Chains = 1, Measurement Point = 1

Images:



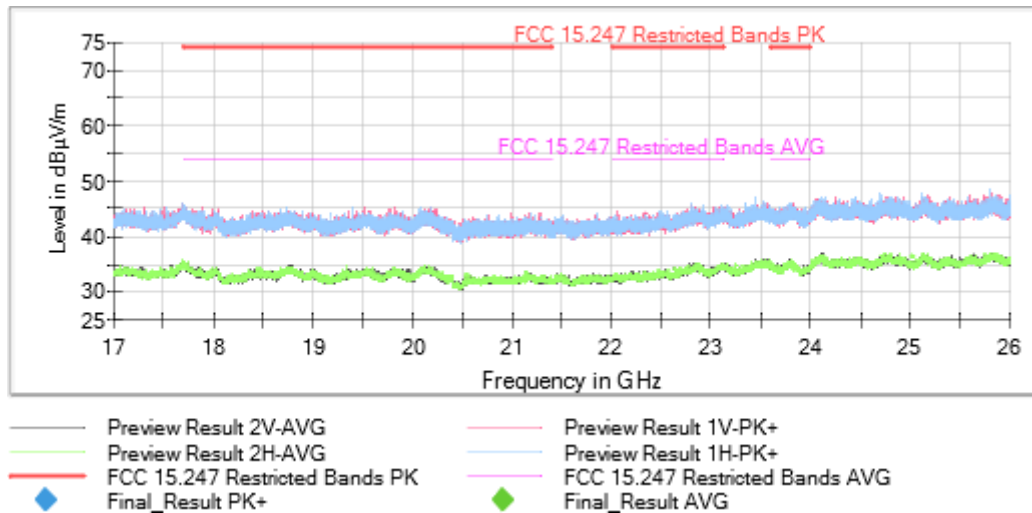
Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Frequency Range GHz = [3, 17], Number of Transmission Chains = 1, Measurement Point = 1

Images:



Equipment Type = Digital Transmission System (DTS), Frequency Range GHz = [17, 26], Number of Transmission Chains = 1, Measurement Point = 1

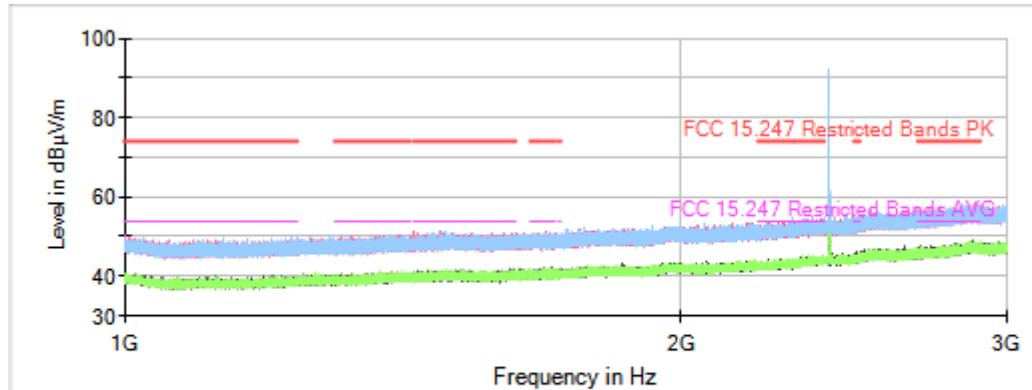
Images:



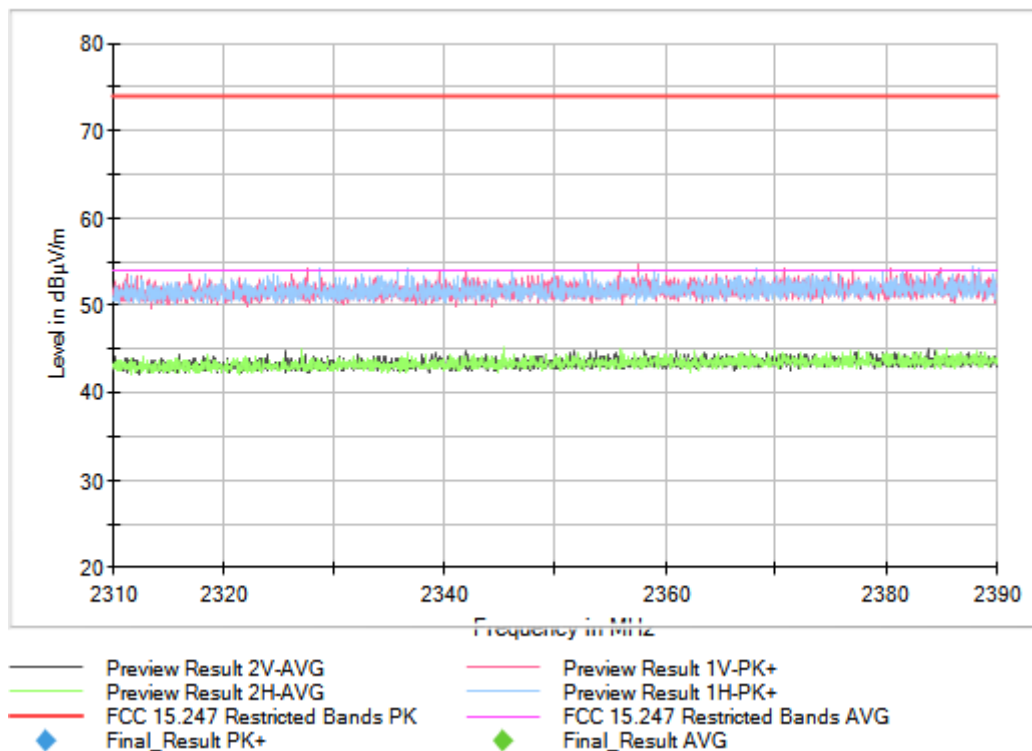
This plot is valid for all channel and all modulations

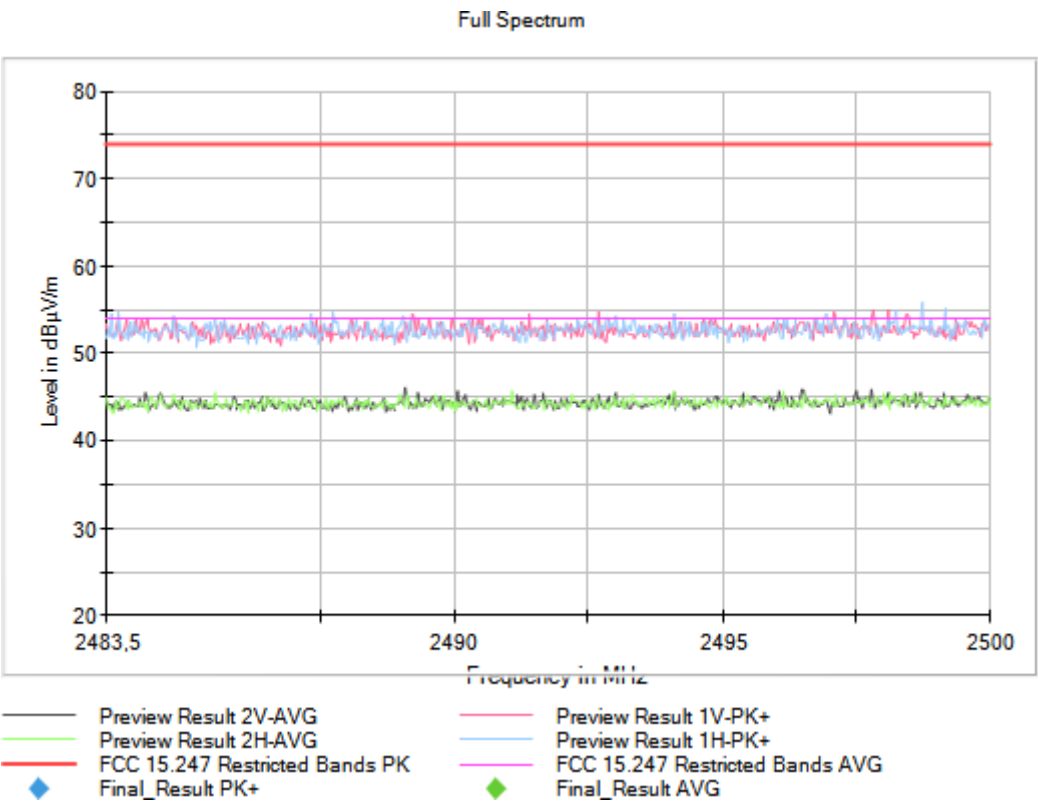
Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range GHz = [1, 3], Number of Transmission Chains = 1, Measurement Point = 1

Images:



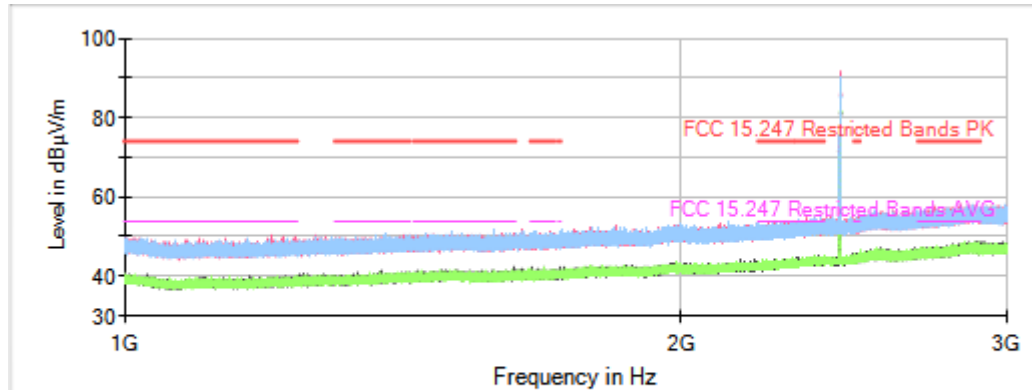
Full Spectrum



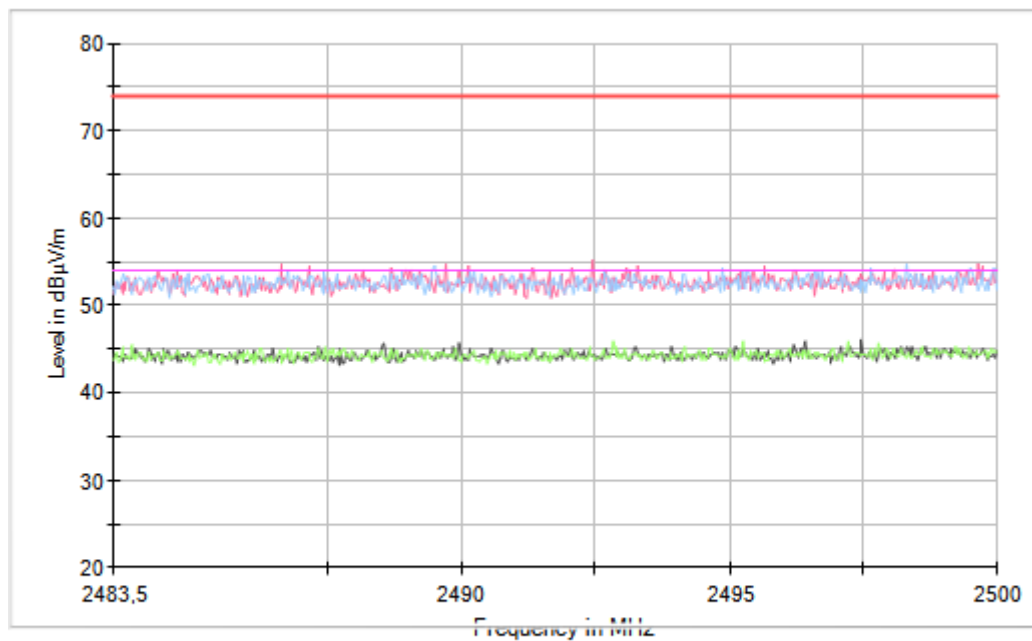


Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range GHz = [1, 3], Number of Transmission Chains = 1, Measurement Point = 1

Images:



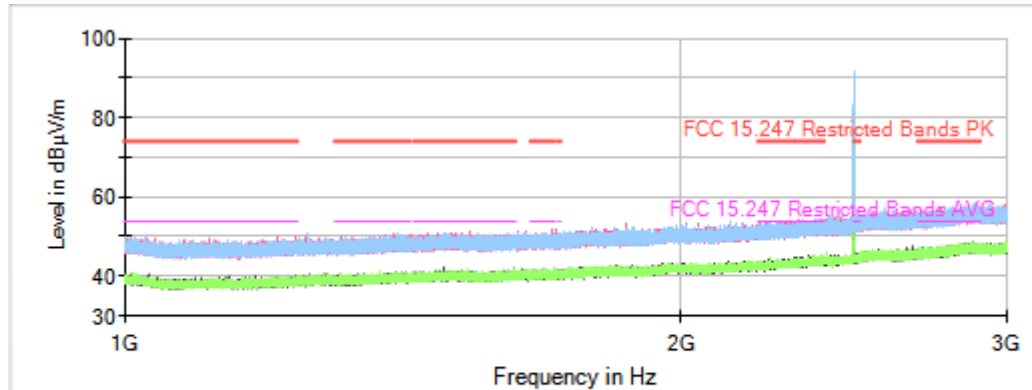
Full Spectrum



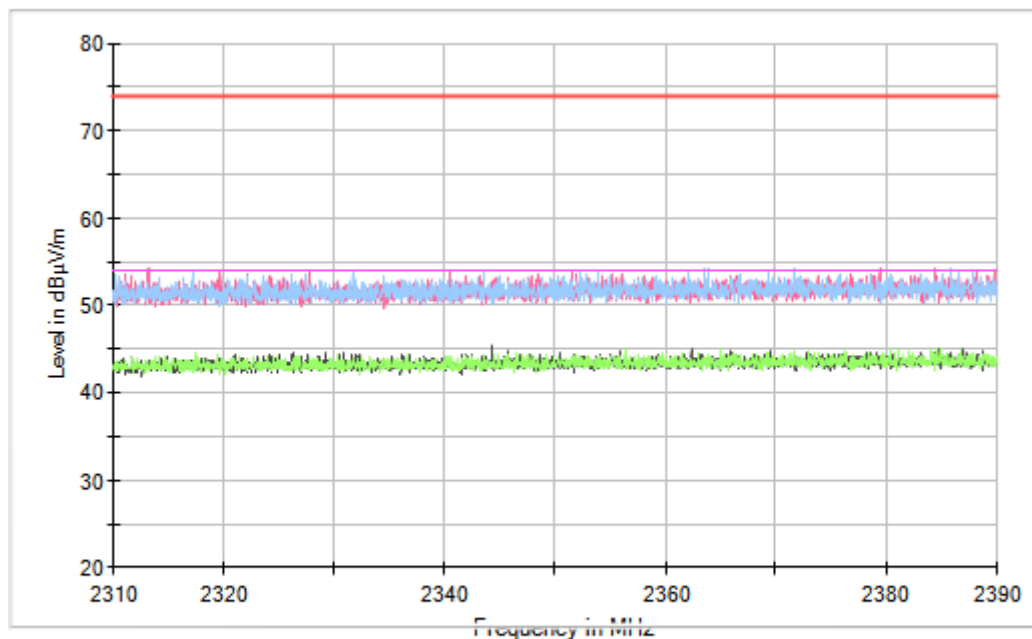


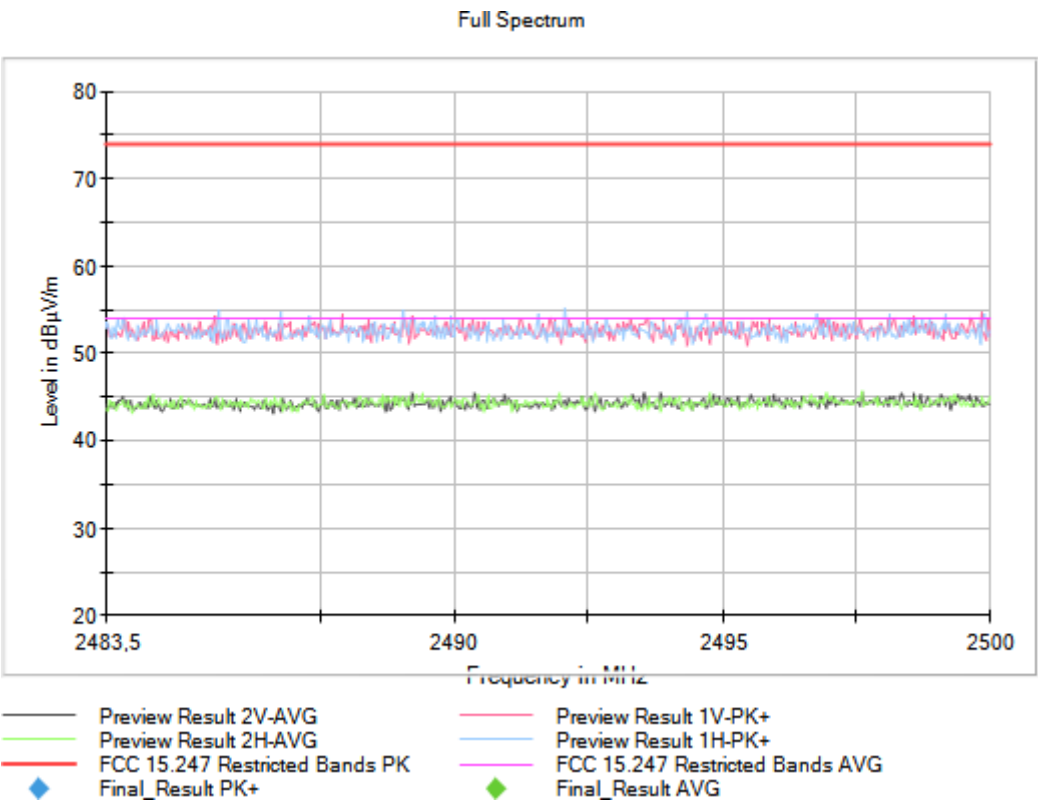
Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range GHz = [1, 3], Number of Transmission Chains = 1, Measurement Point = 1

Images:



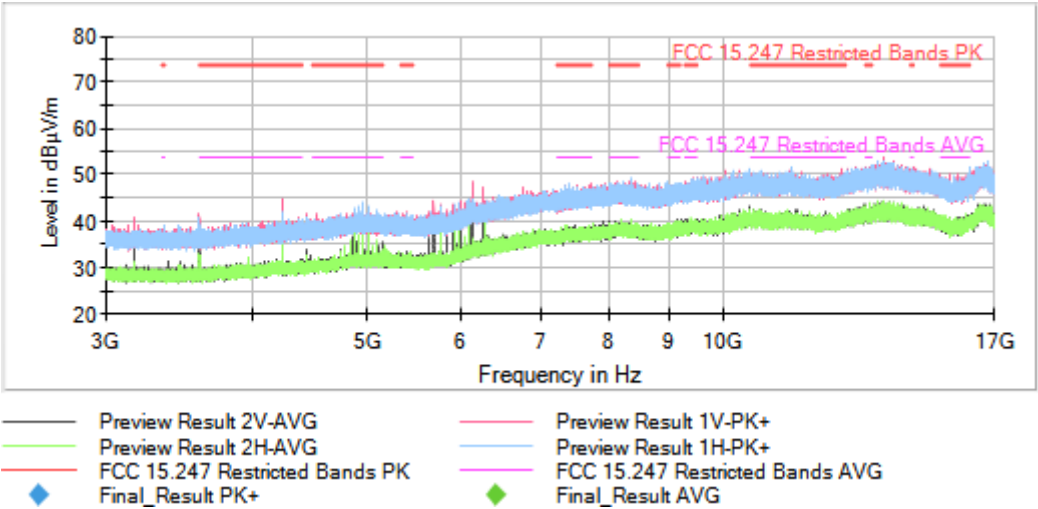
Full Spectrum





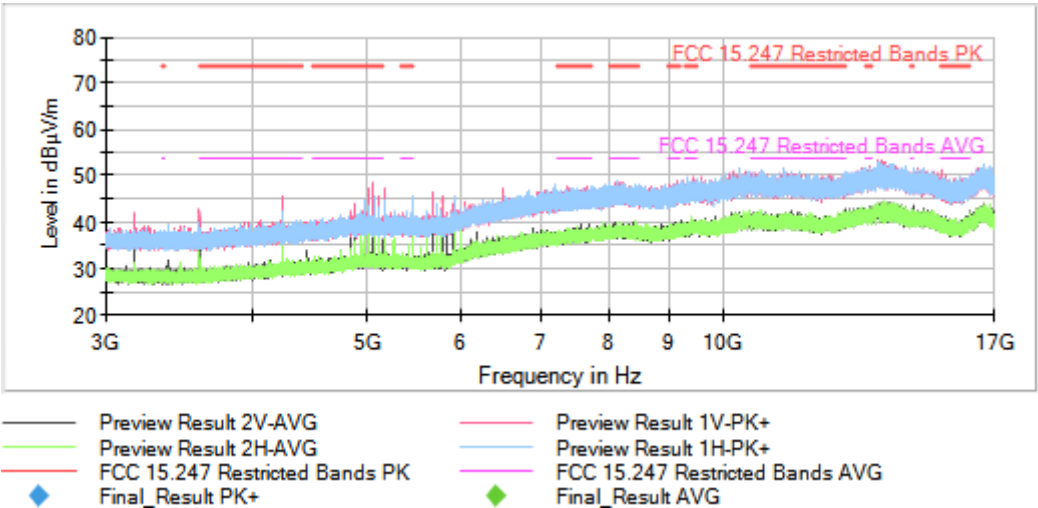
Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range GHz = [3, 17], Number of Transmission Chains = 1, Measurement Point = 1

Images:



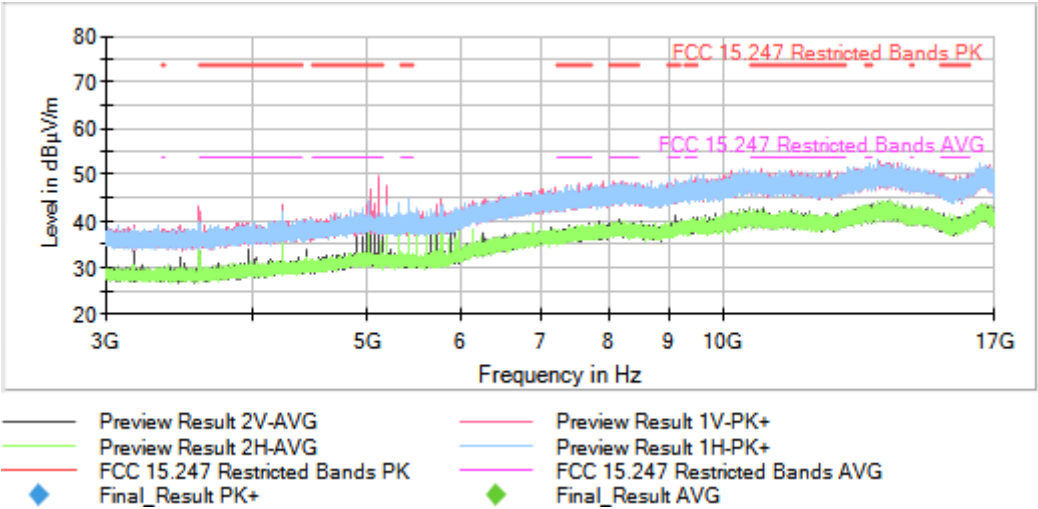
Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range GHz = [3, 17], Number of Transmission Chains = 1, Measurement Point = 1

Images:



Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Frequency Range GHz = [3, 17], Number of Transmission Chains = 1, Measurement Point = 1

Images:



Appendix D: Test results. Bluetooth Low Energy 5.1 (2M, 1M). Chipset 2

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<i>Occupied Channel Bandwidth 99%</i>	281
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TEST CONDITIONS

(*): Data provided by the client.

POWER SUPPLY (*):

Vnominal:	12Vdc
Type of Power Supply:	Battery

ANTENNA (*):

Type of Antenna:	External antenna
Maximum Declared Antenna Gain:	2dBi

TEST FREQUENCIES (*):

Low Channel:	2402 MHz
Middle Channel:	2440 MHz
High Channel:	2480 MHz

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and it is connected to the TS8997 using a low loss RF cable. The reading of the spectrum analyser is corrected taking into account the cable loss.



RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz and 1 GHz-17 GHz Double ridge horn antenna) is situated at a distance of 3 m and at a distance of 1.5 m for the frequency range 17 GHz-26 GHz (17 GHz-40 GHz horn antenna).

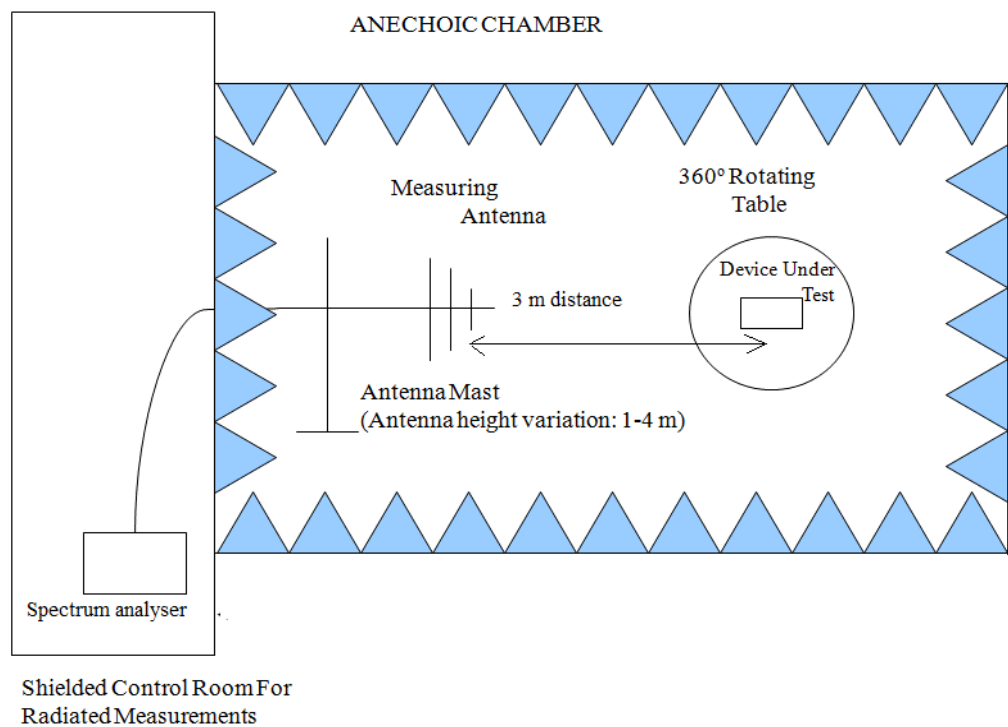
For radiated emissions in the range 17 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission.

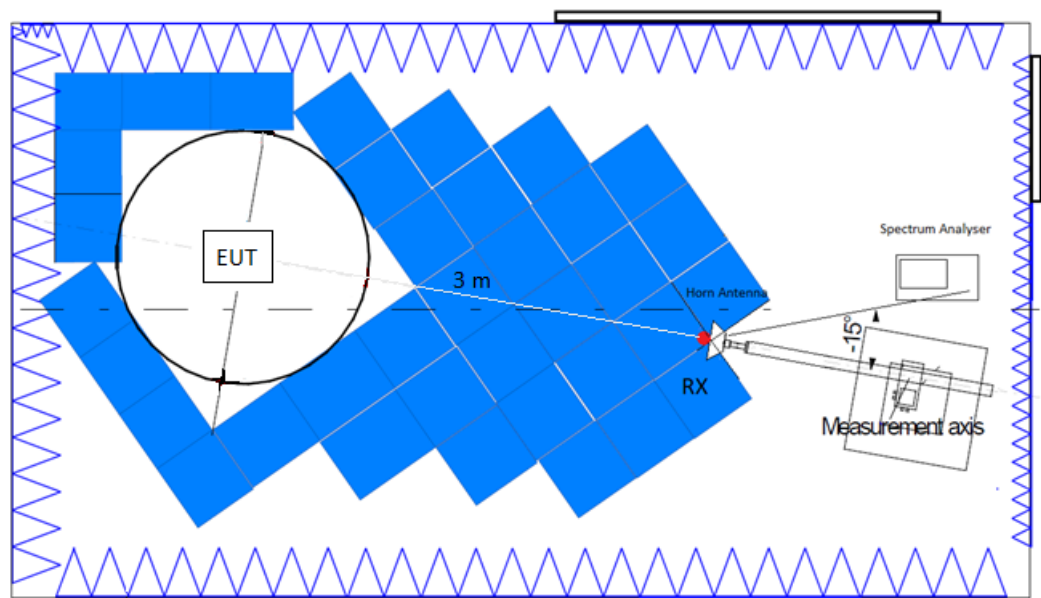
Measurements were made in both horizontal and vertical planes of polarization.

A resolution bandwidth/video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

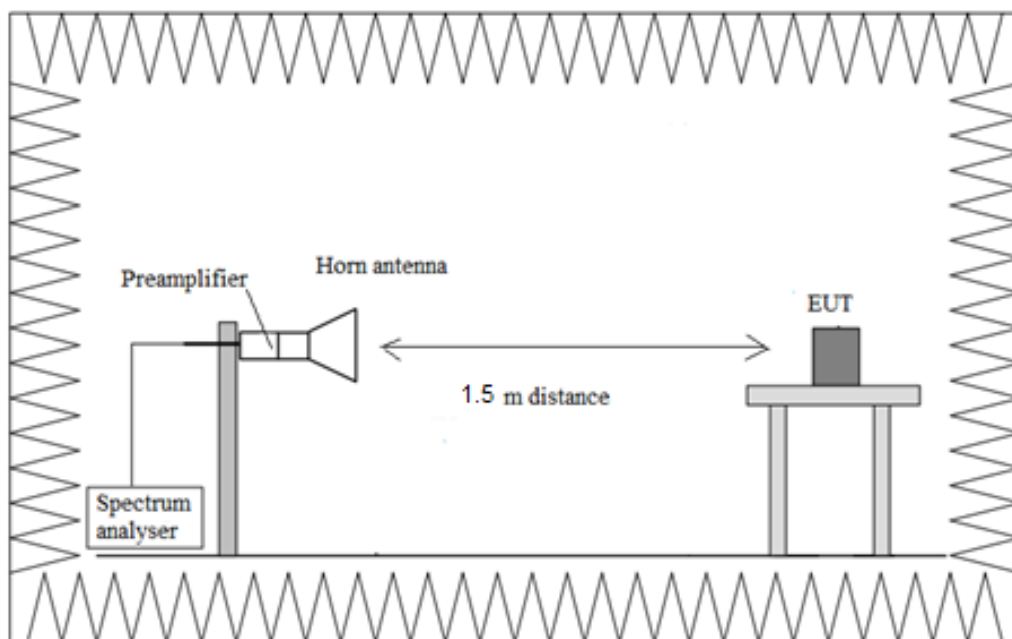
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup $f > 17$ GHz:



TEST CASES DETAILS

Occupied Channel Bandwidth 99%

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Results

Freq (MHz)	Occ Ch BW (MHz)
2402.00000	1.020
2440.00000	1.020
2480.00000	1.020

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Results

Freq (MHz)	Occ Ch BW (MHz)
2402.00000	1.990
2440.00000	1.980
2480.00000	1.990

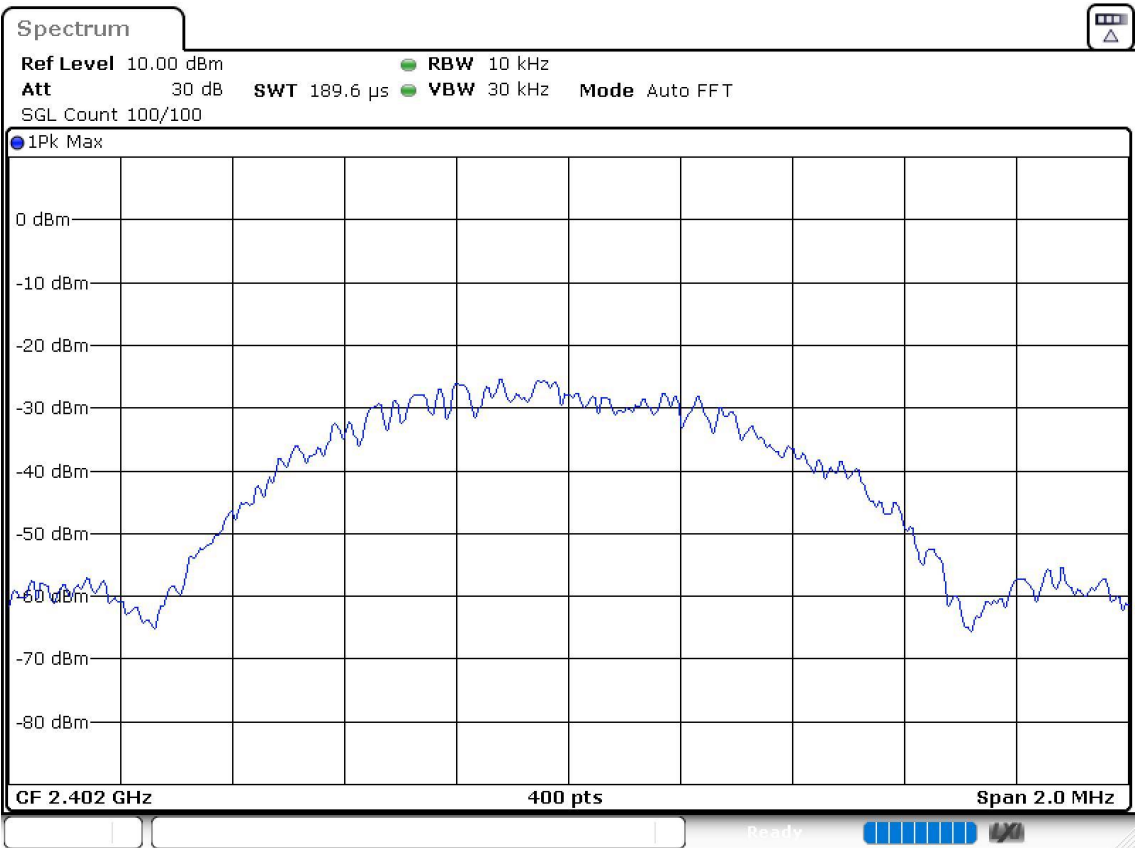
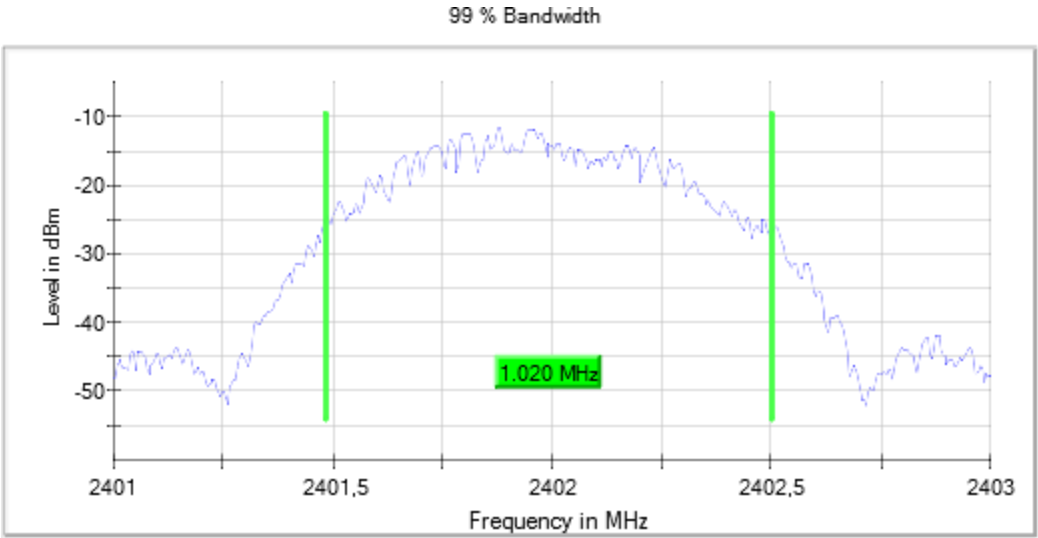
Verdict

Pass

Attachments

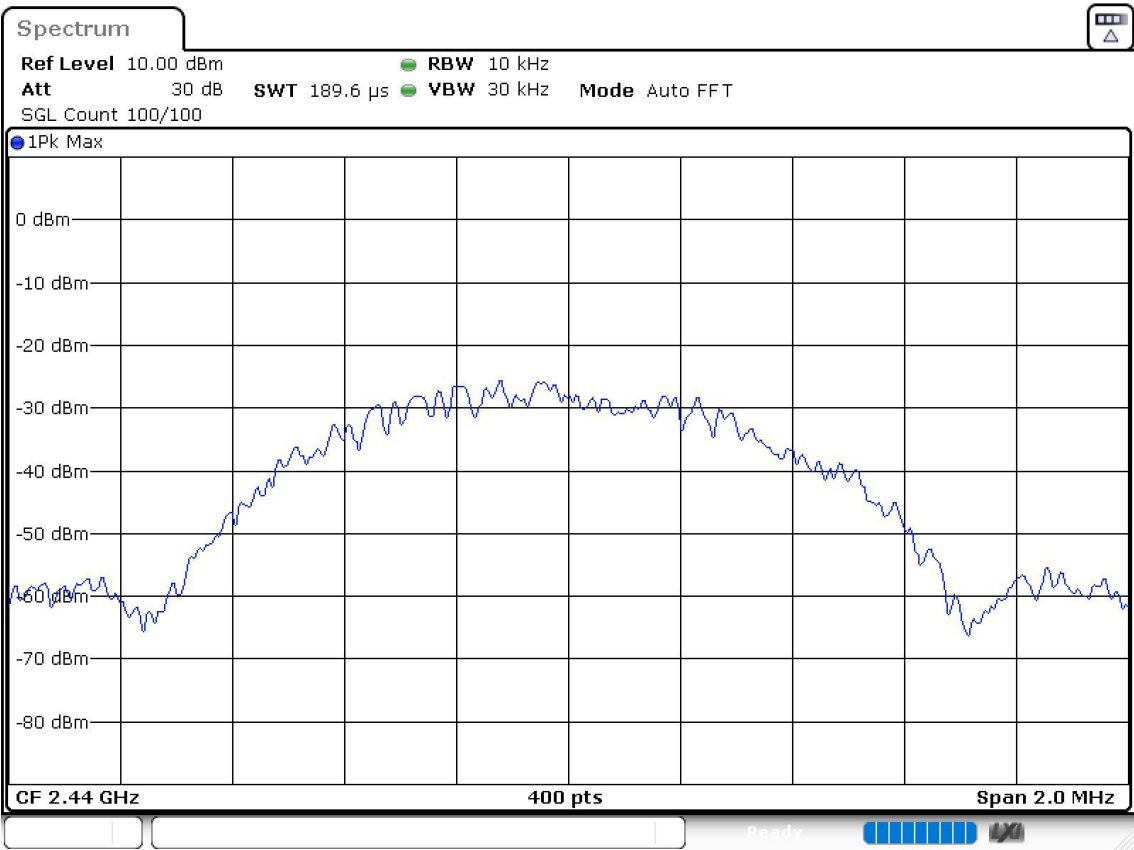
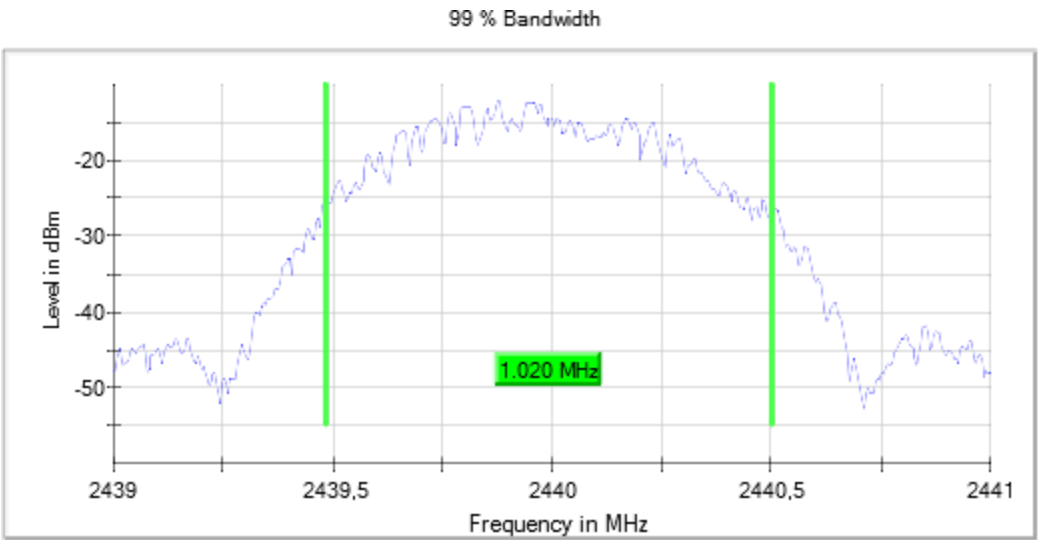
Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 1, Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



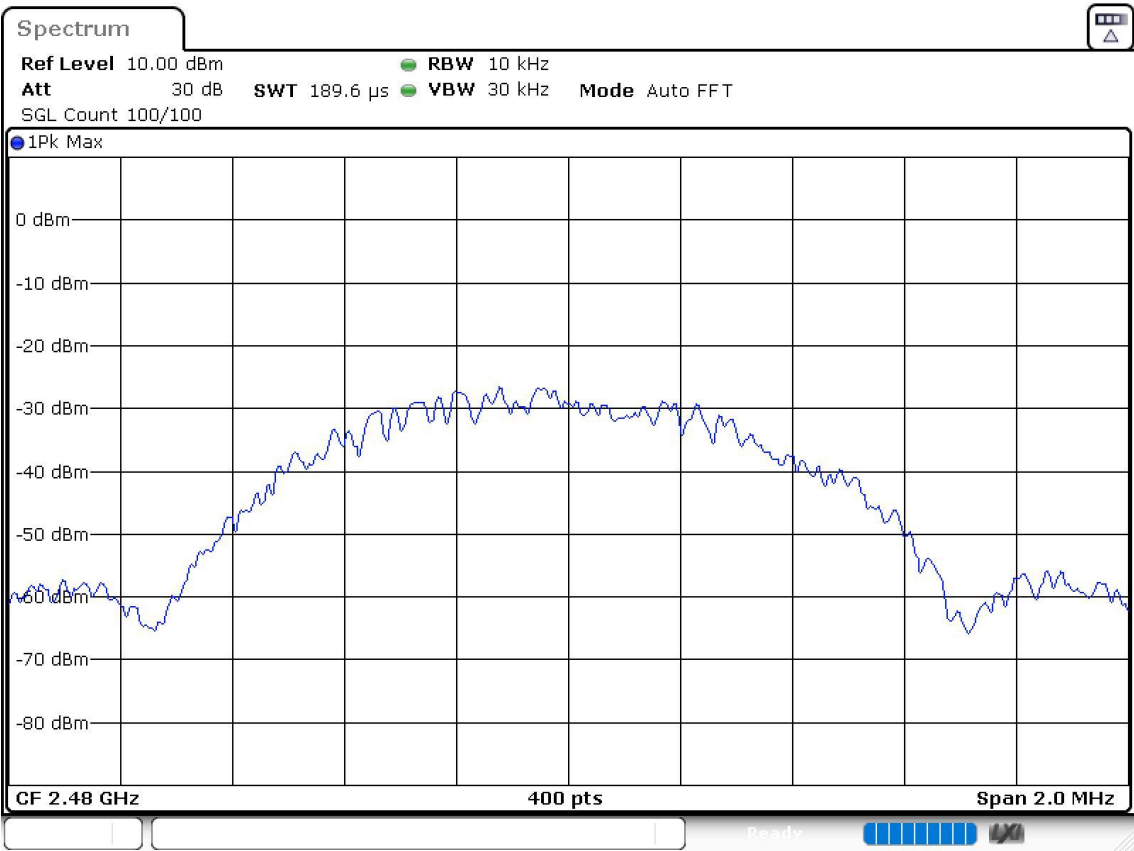
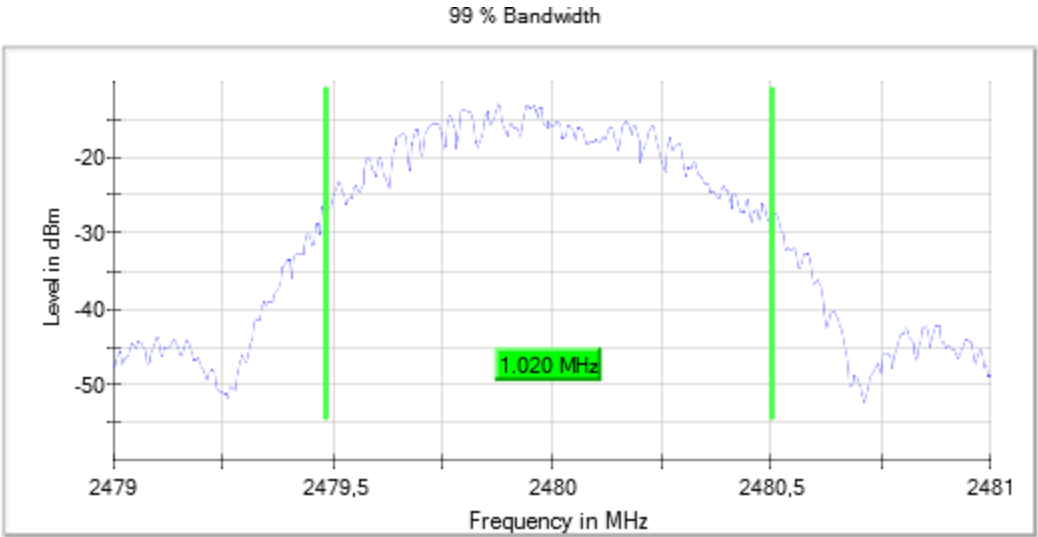
Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 1,
Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



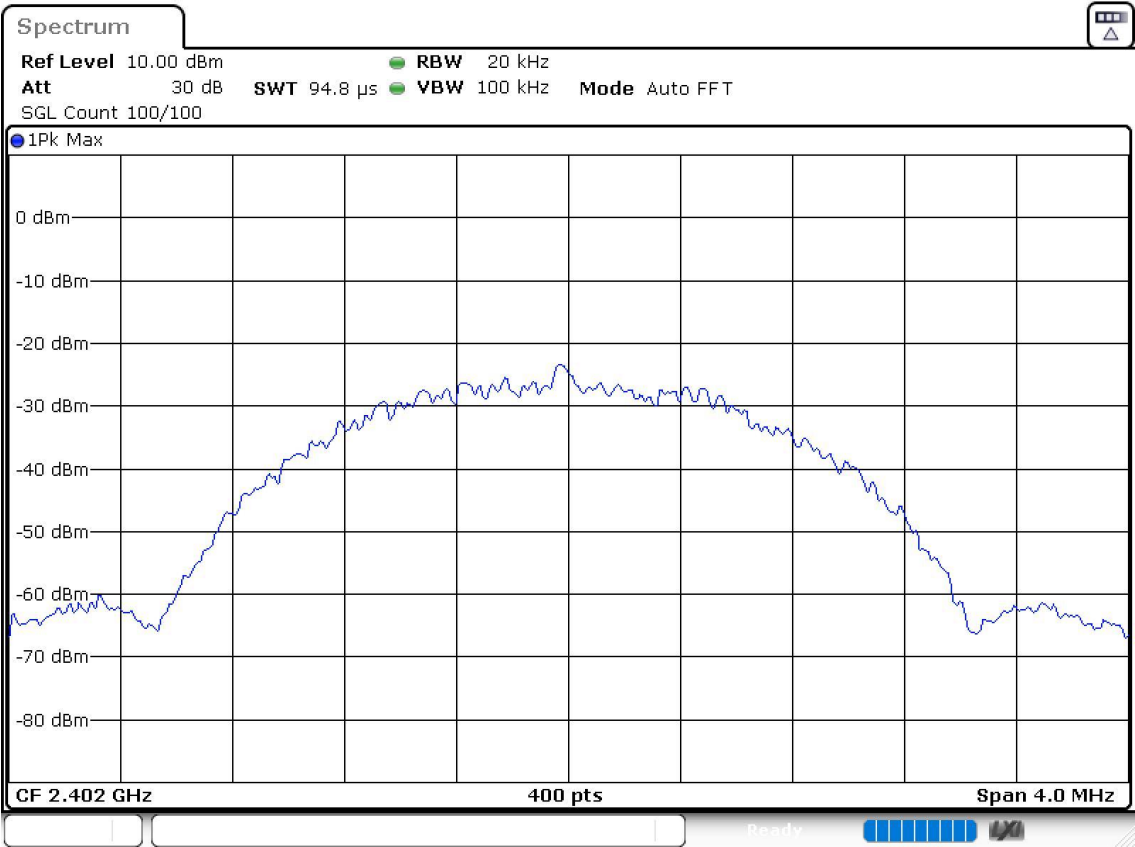
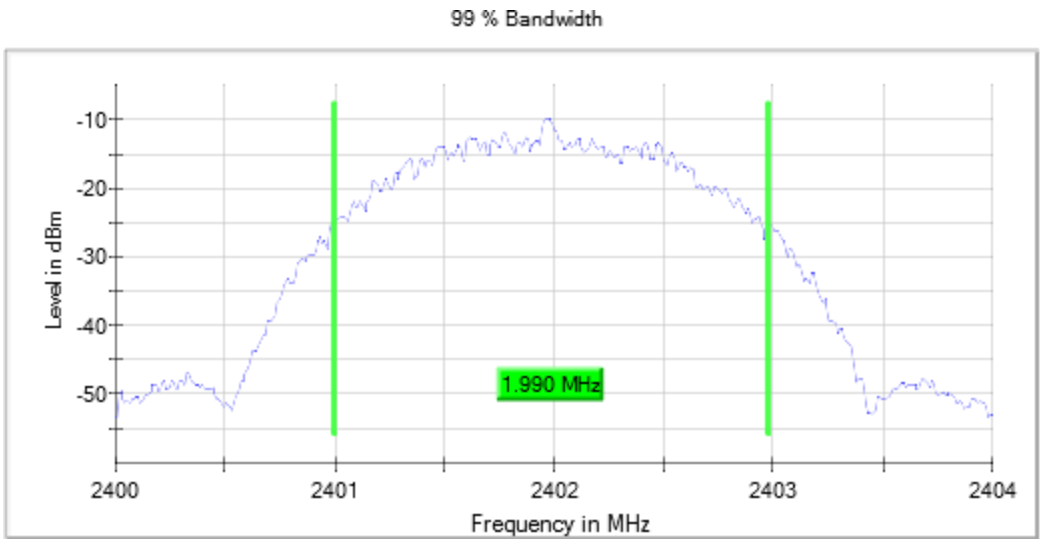
Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 1,
Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



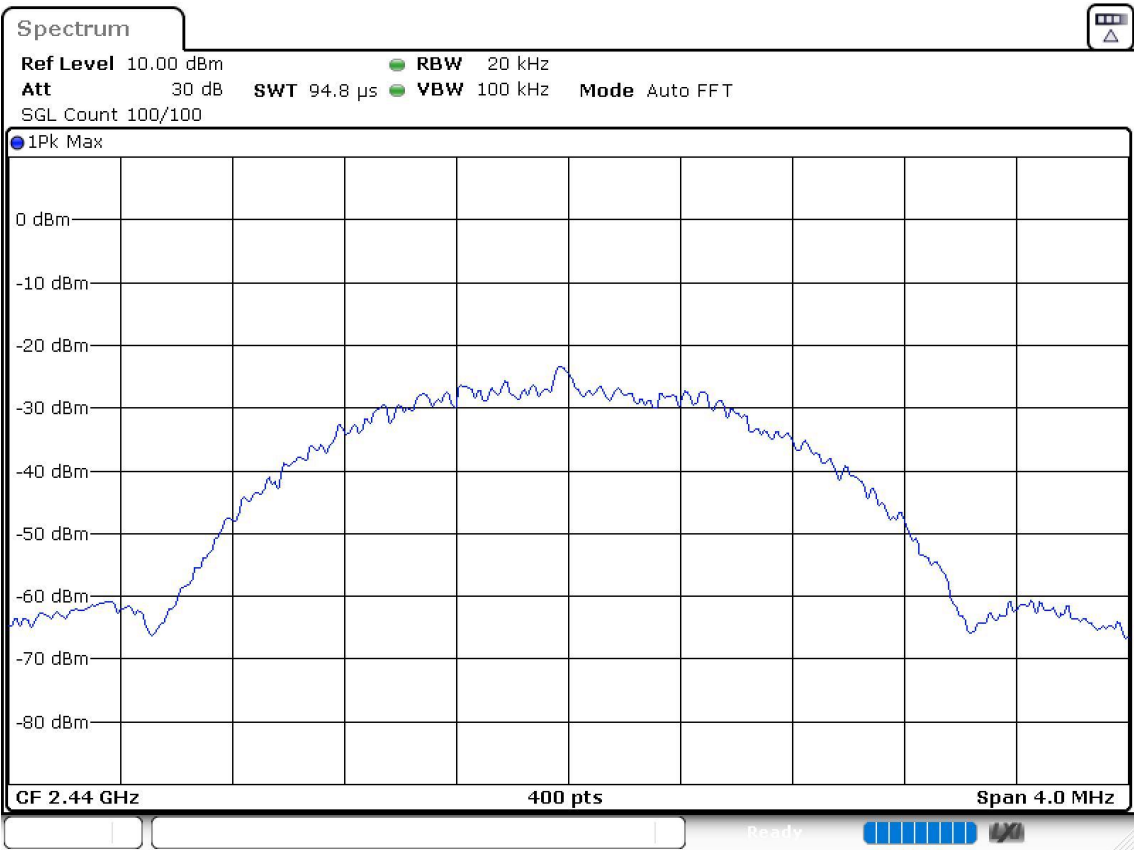
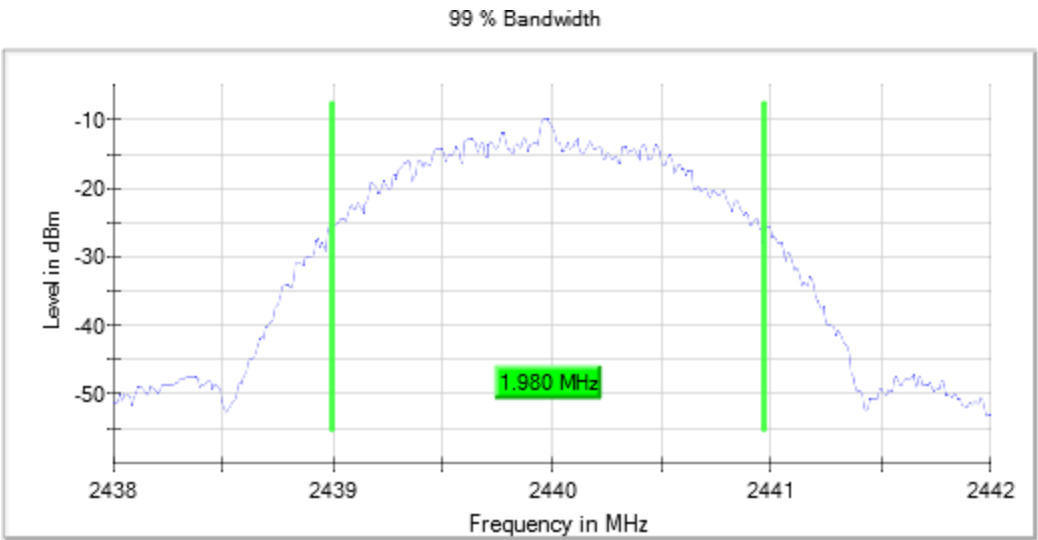
Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 2,
Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



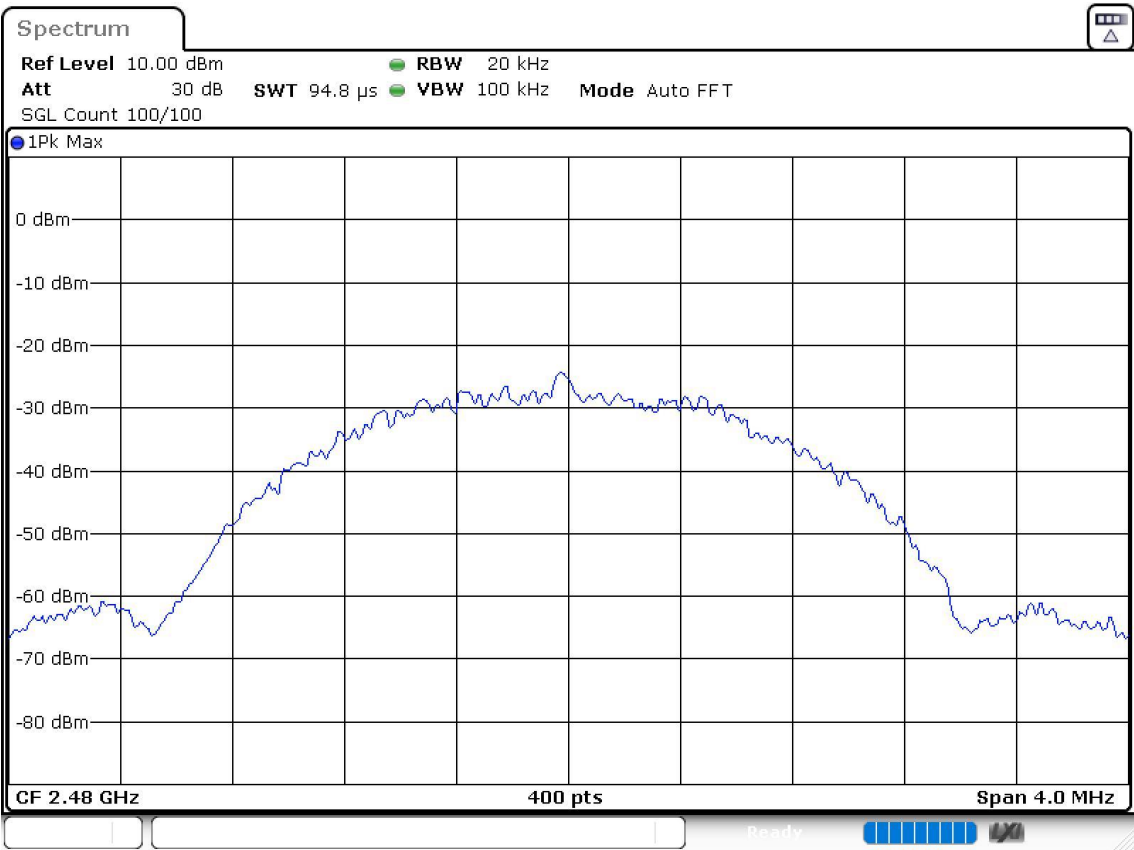
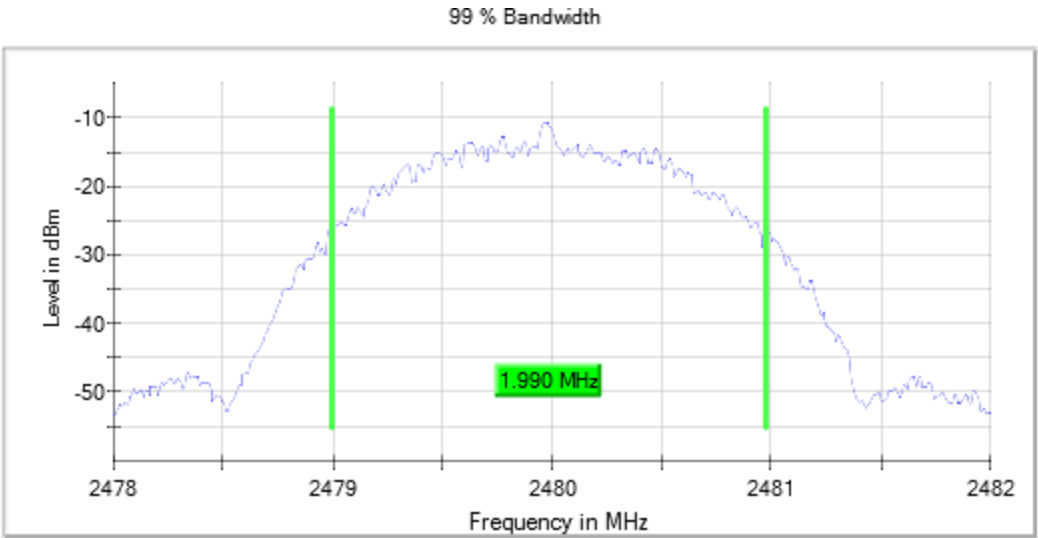
Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 2, Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 2, Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



FCC 15.247 (a) (2) 6 dB Bandwidth

Limits

The minimum 6 dB bandwidth shall be at least 500 kHz.

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Results

Freq (MHz)	6 dB Bandwidth (MHz)
2402.00000	0.7129
2440.00000	0.7129
2480.00000	0.7129

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Results

Freq (MHz)	6 dB Bandwidth (MHz)
2402.00000	1.1881
2440.00000	1.1881
2480.00000	1.1881

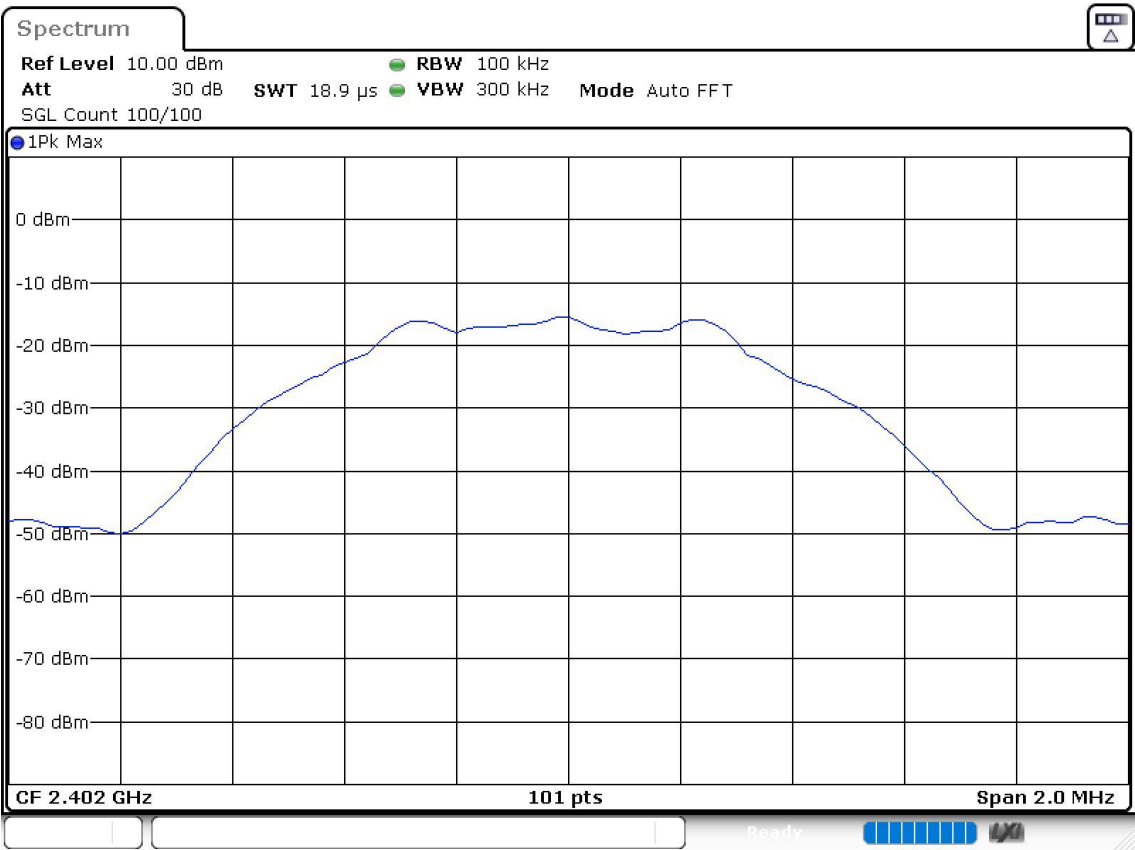
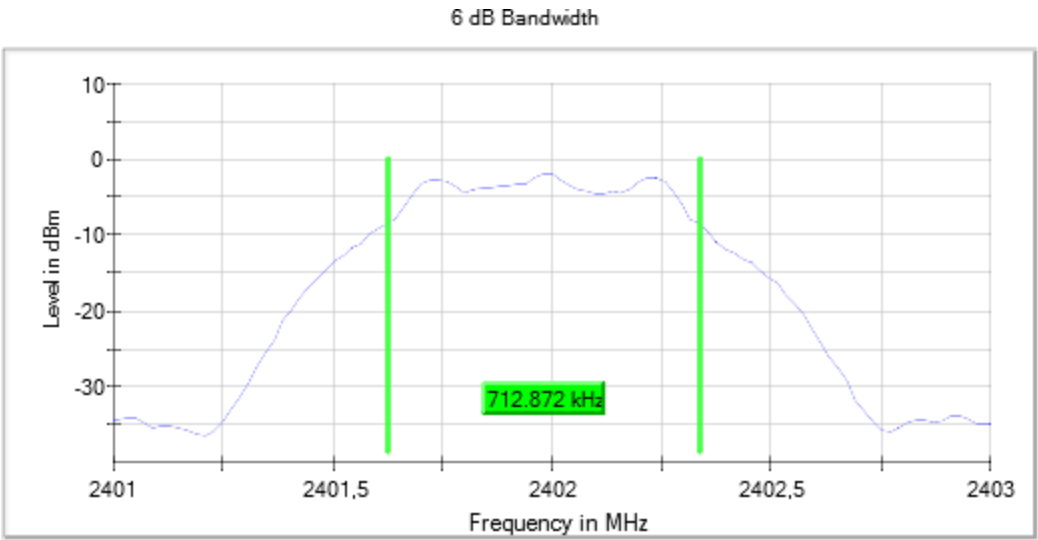
Verdict

Pass

Attachments

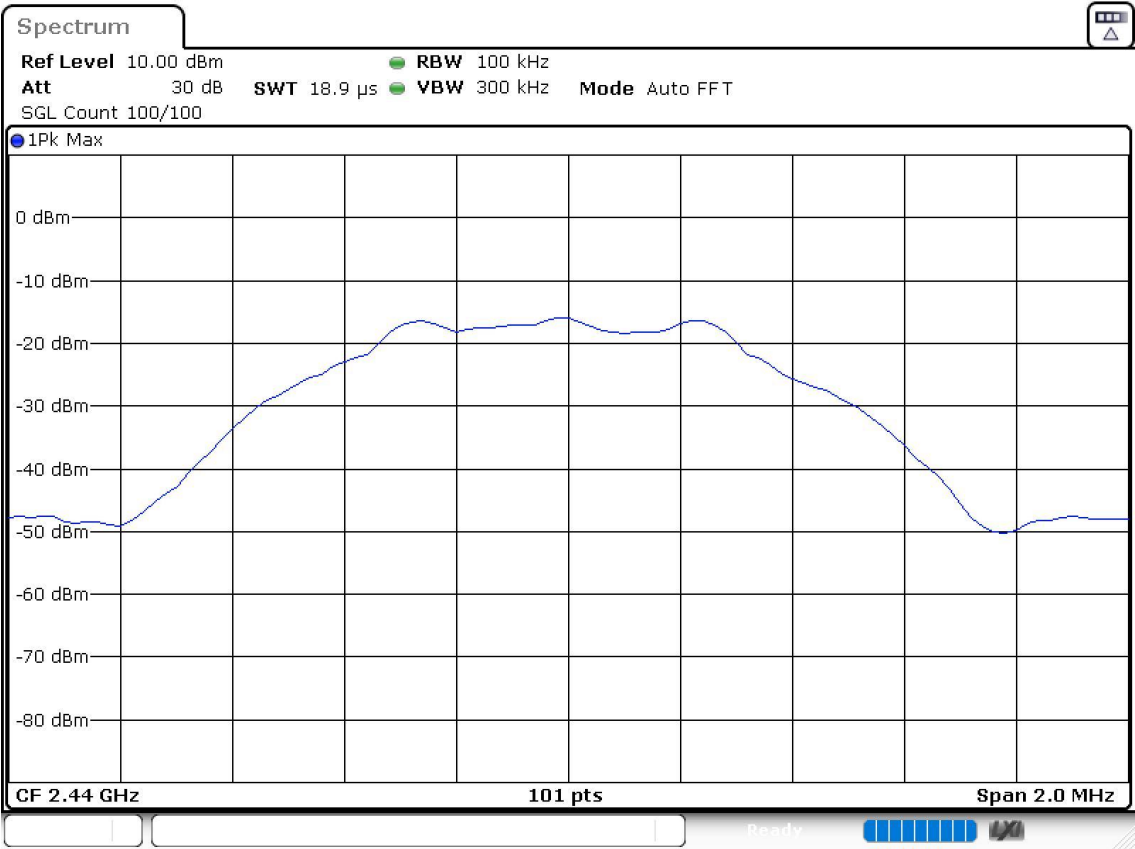
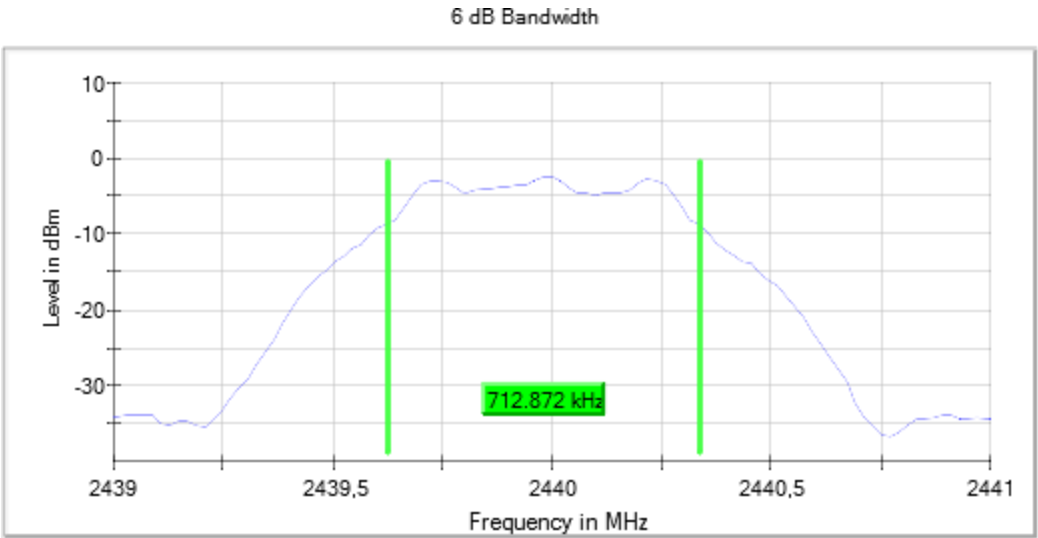
Frequency MHz = 2402.00000, Bandwidth MHz = 1, Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



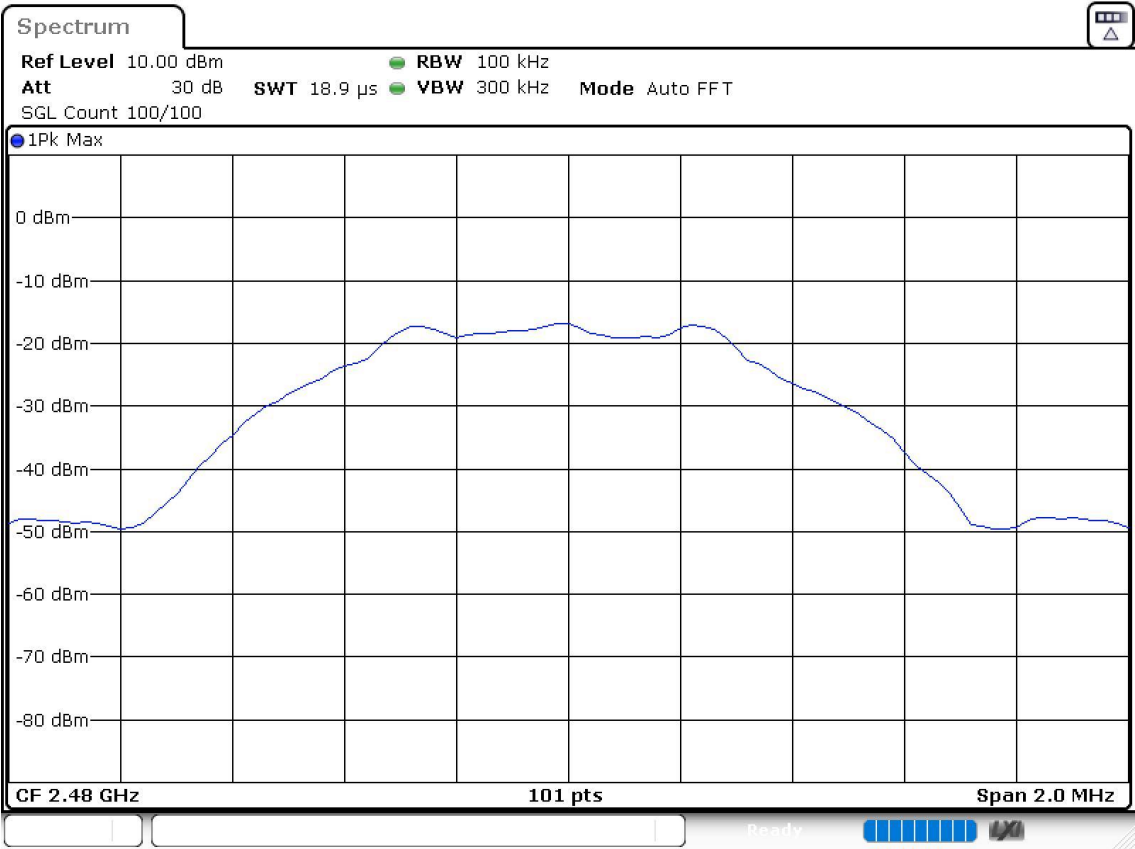
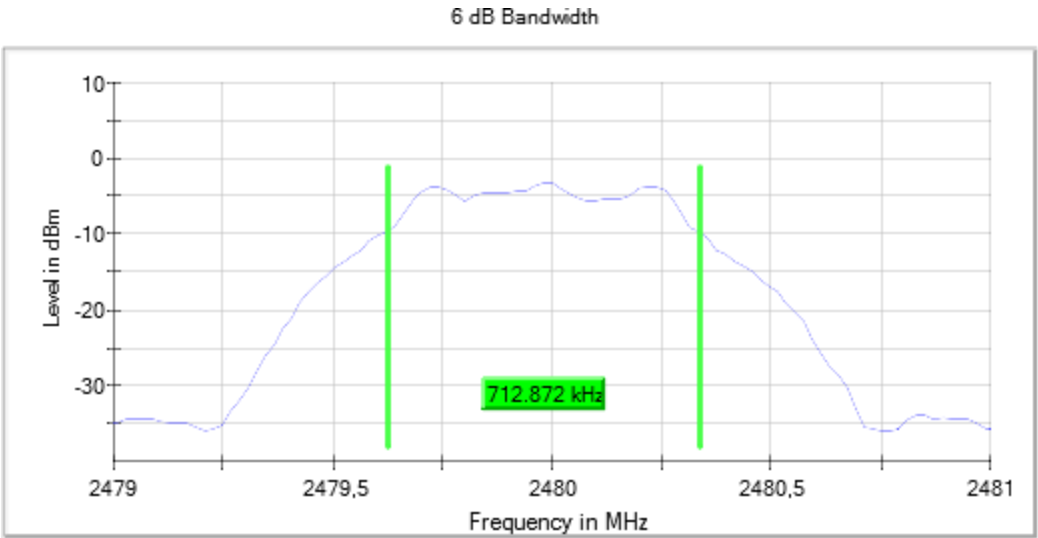
Frequency MHz = 2440.00000, Bandwidth MHz = 1, Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



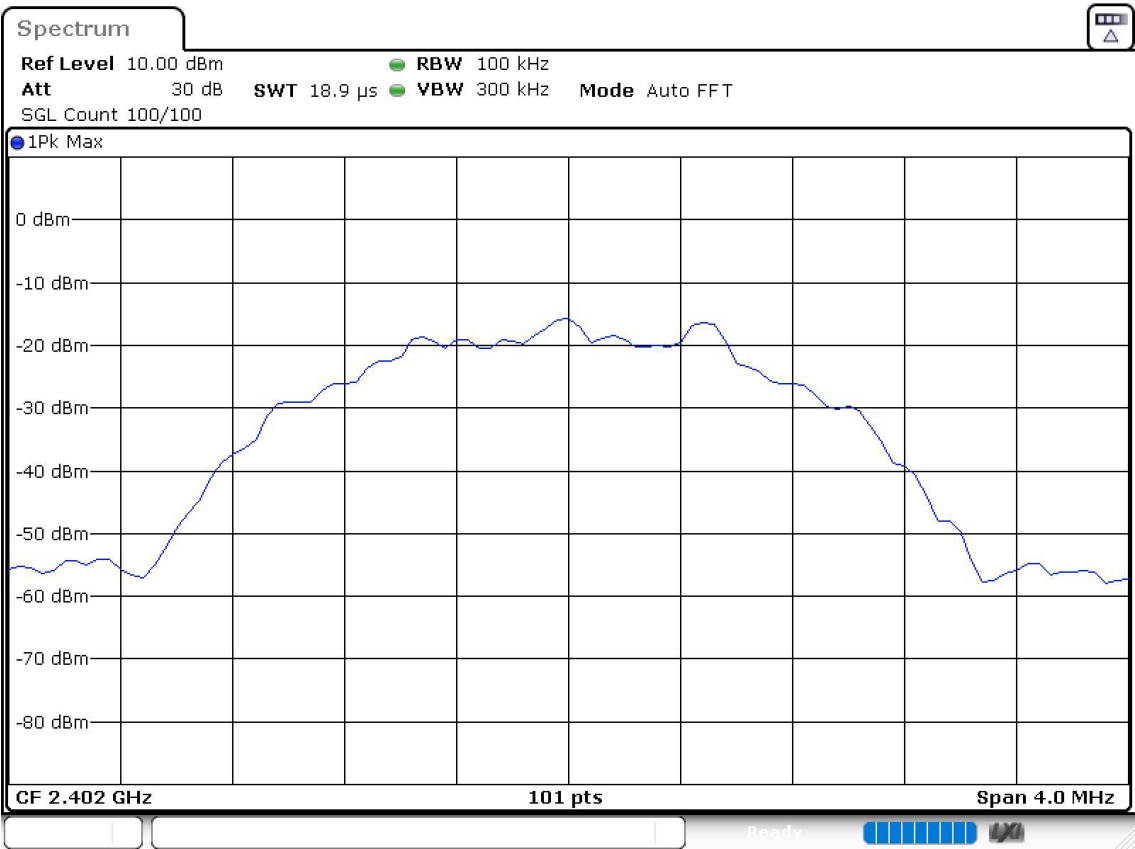
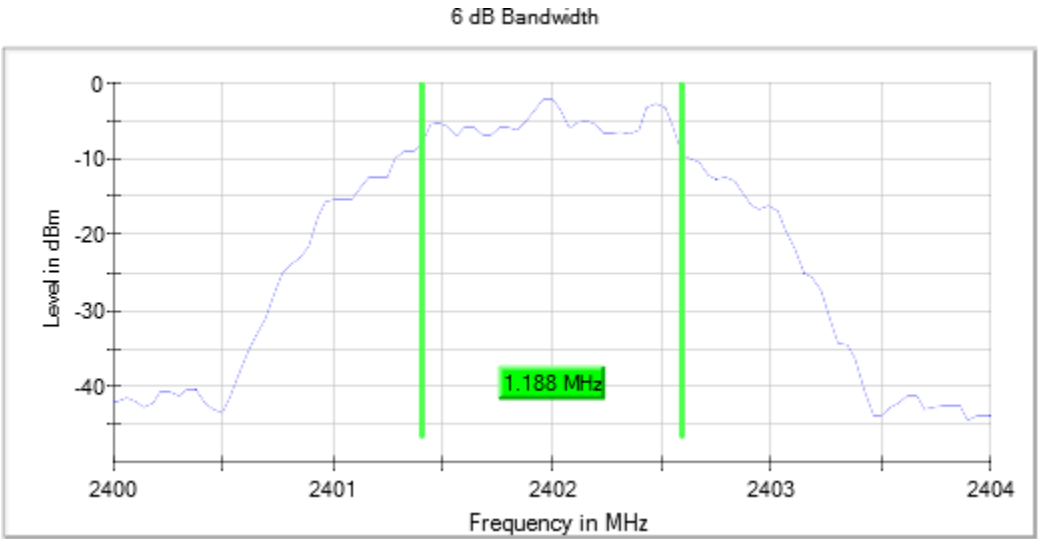
Frequency MHz = 2480.00000, Bandwidth MHz = 1, Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



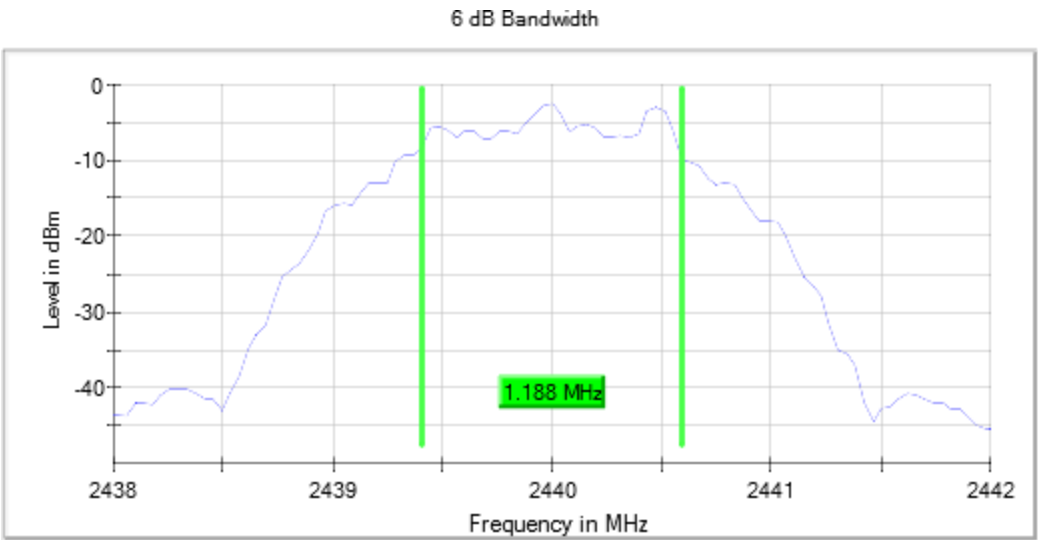
Frequency MHz = 2402.00000, Bandwidth MHz = 2, Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



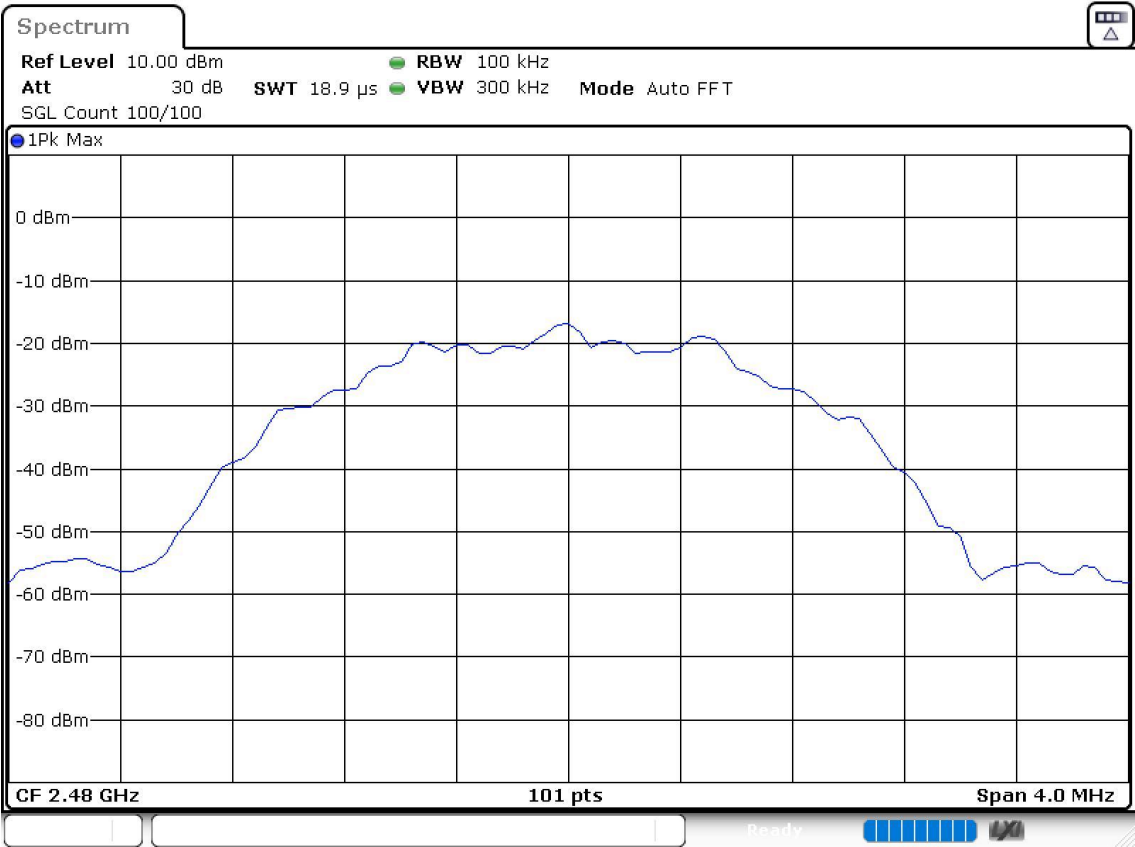
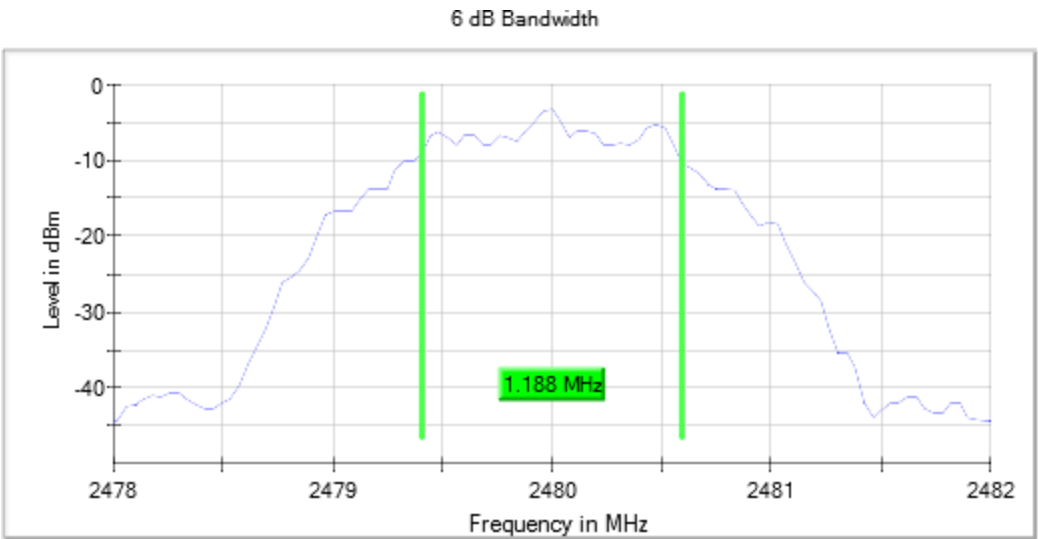
Frequency MHz = 2440.00000, Bandwidth MHz = 2, Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



Frequency MHz = 2480.00000, Bandwidth MHz = 2, Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



FCC 15.247 (e) Power spectral density

Limits

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Modulation: BTLE 5.1 (GFSK 1 Mbit/s)

Results

Freq (MHz)	PSD (dBm)
2402.00000	-11.754
2440.00000	-11.945
2480.00000	-12.845

Modulation: BTLE 5.1 (GFSK 2 Mbit/s)

Results

Freq (MHz)	PSD (dBm)
2402.00000	-14.449
2440.00000	-14.595
2480.00000	-15.529

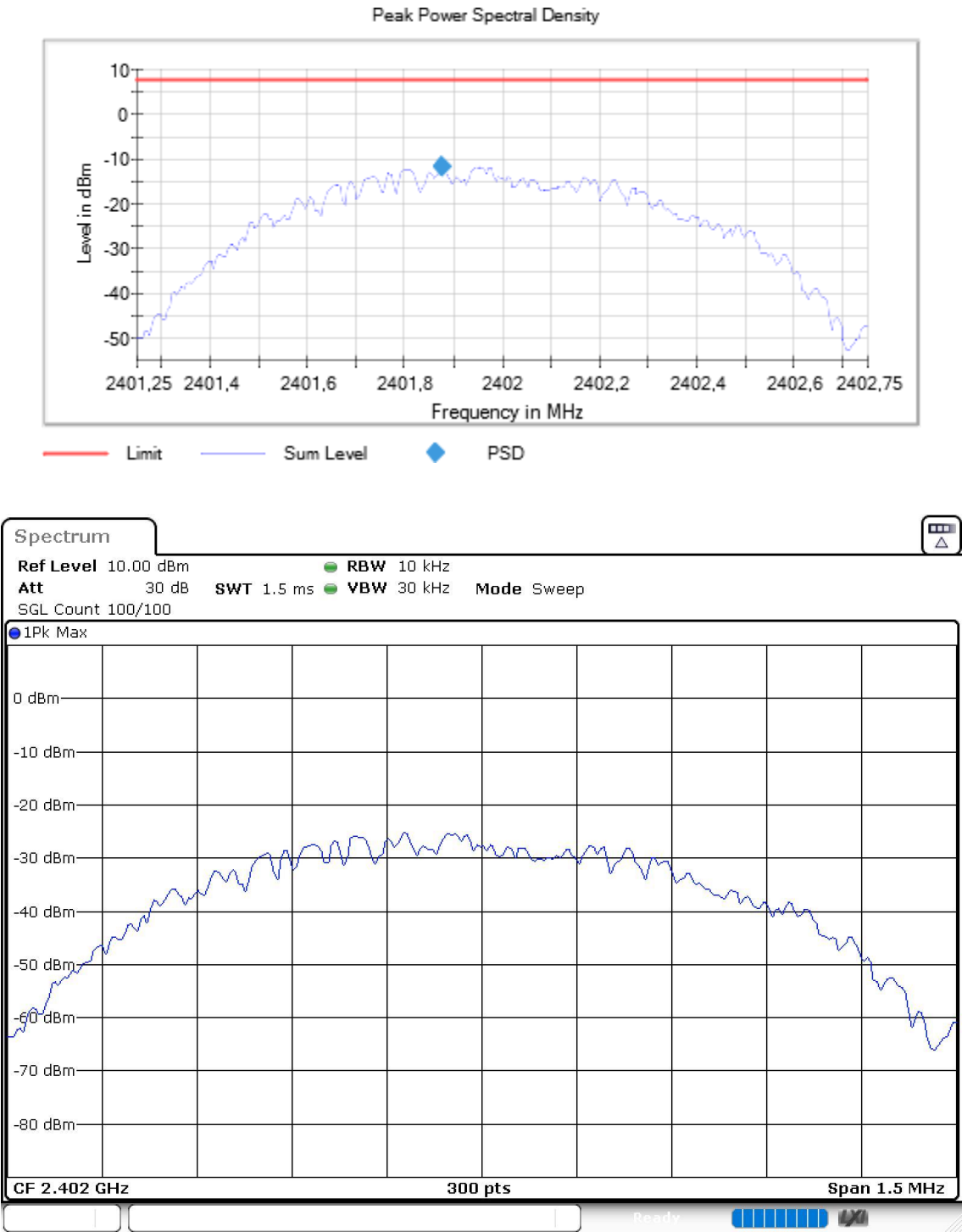
Verdict

Pass

Attachments

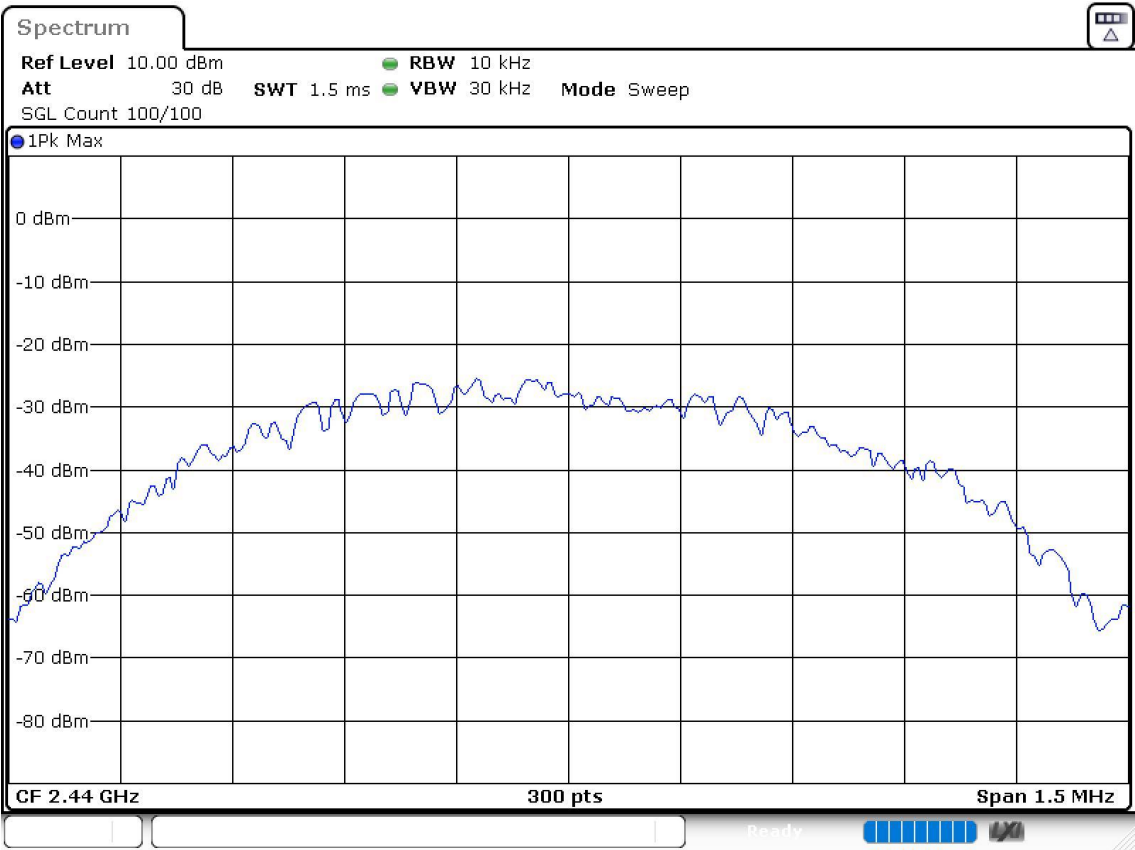
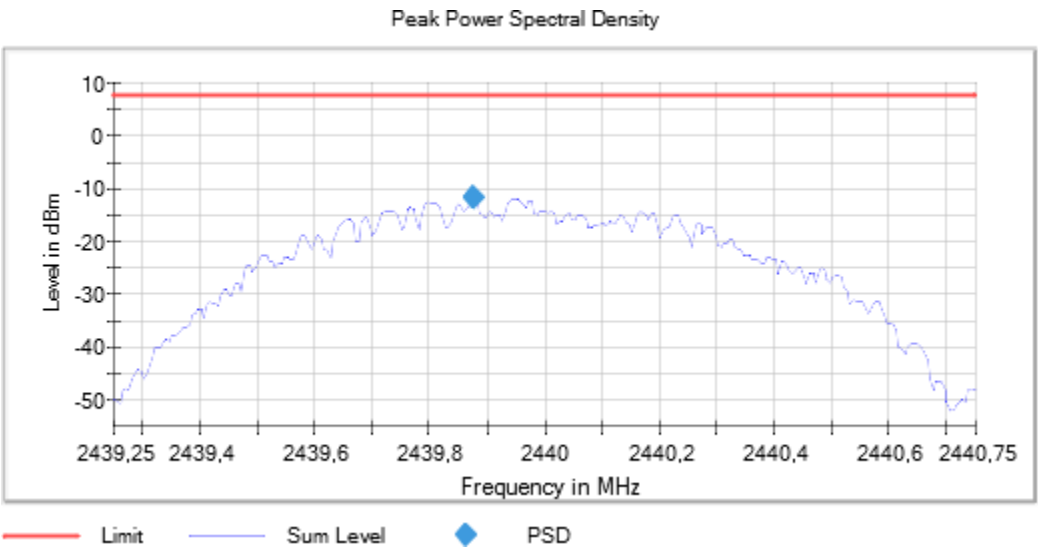
Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 1, Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



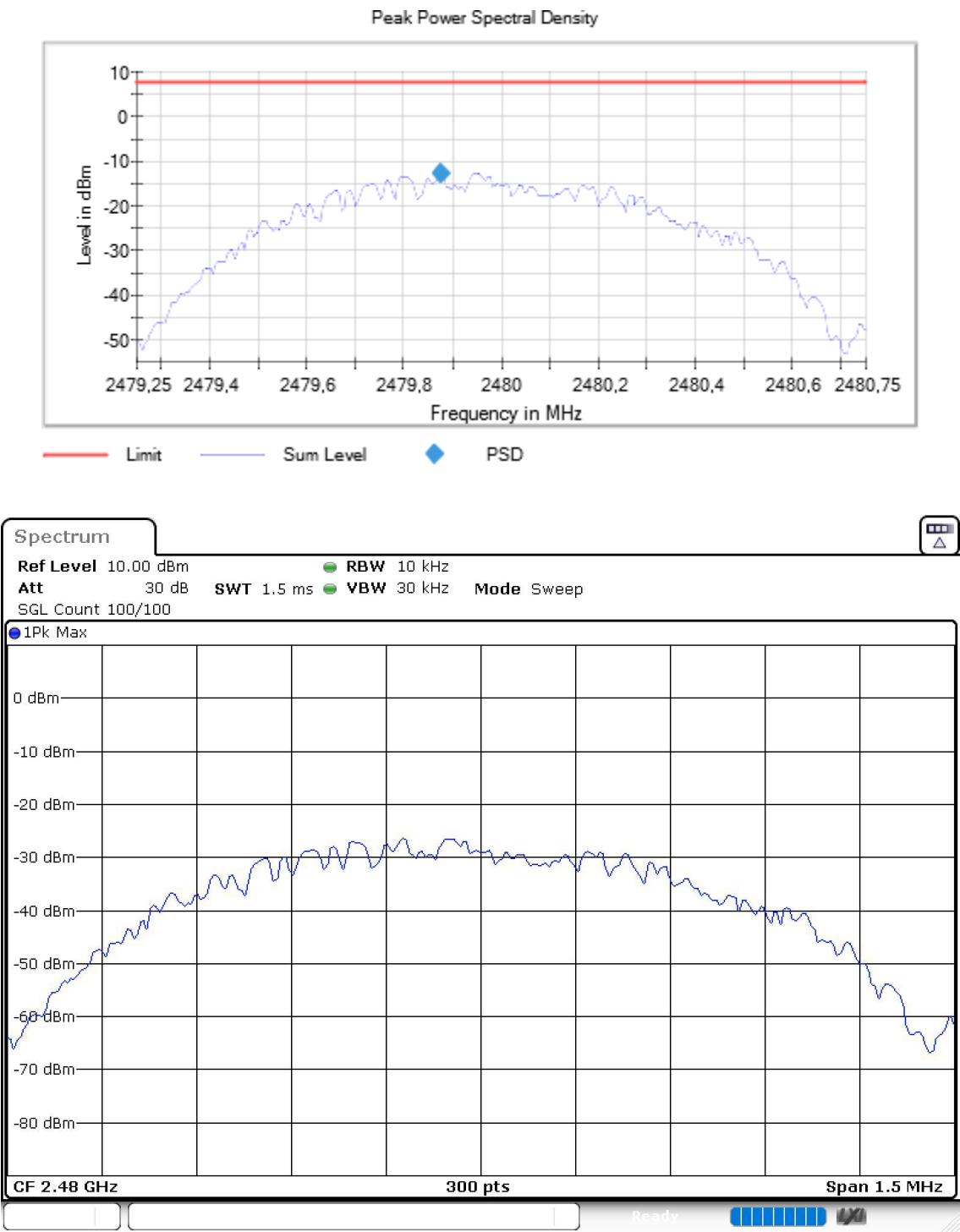
Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 1, Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



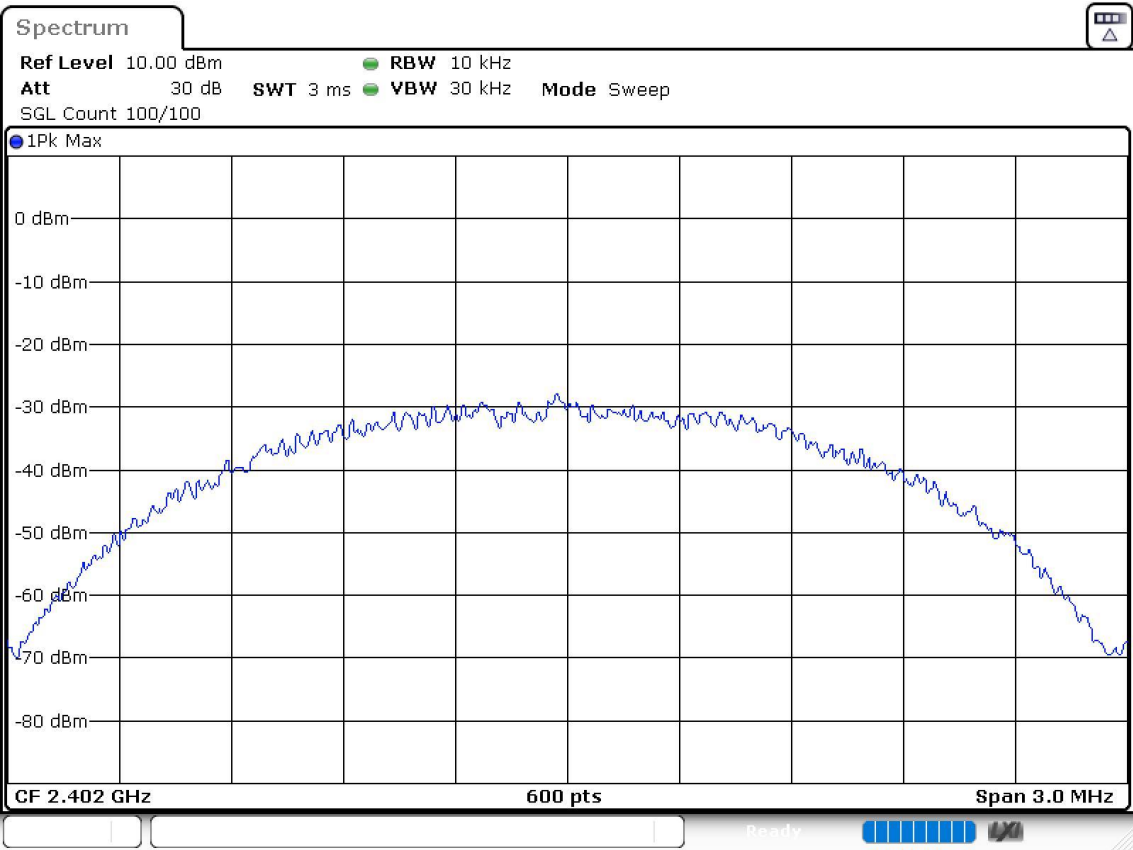
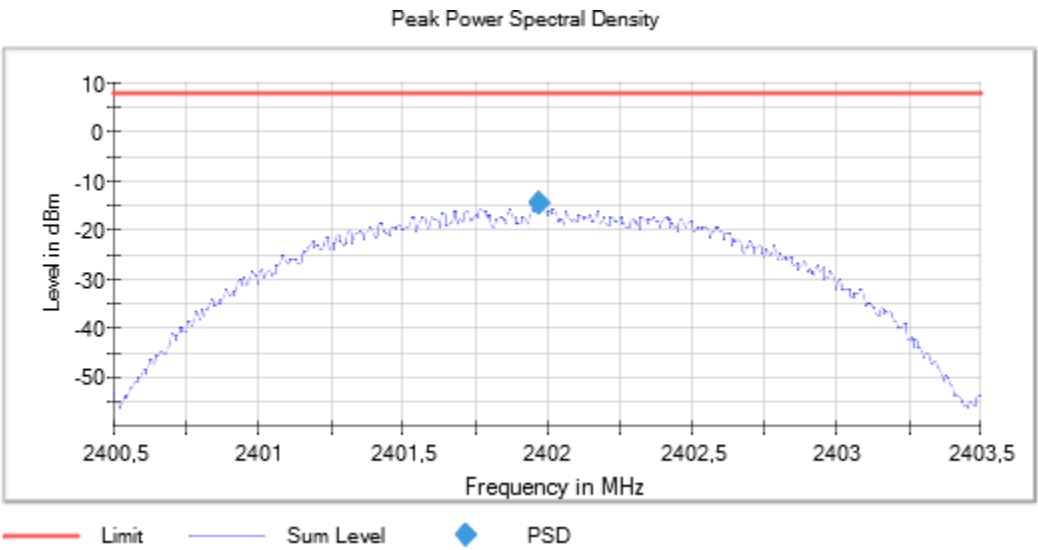
Frequency MHz = 2480.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 1,
Modulation = BTLE 5.1 (GFSK 1 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



Frequency MHz = 2402.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 2,
Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:



Frequency MHz = 2440.00000, Equipment Type = Digital Transmission System (DTS), Bandwidth MHz = 2,
Modulation = BTLE 5.1 (GFSK 2 Mbit/s), Number of Transmission Chains = 1, Active Port = 1

Images:

