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TEST REPORT

Report Number	210100083SEL-TEL1
Applicant Name / Address	Kenzen Inc 35640 Fremont Blvd # 358, Fremont, California 94536, United States
Test Sample Description	
- Product name	Kenzen Patch
- Model and/or Brand name	KP01
- FCC ID	2AYWX-KP01
- IC	
- Manufacturer Name	Aprotech CO., LTD.
- Manufacturer Address	52 Deokcheon-ro, Manan-gu, Anyang-si Gyeonggi-do 14087, Republic of Korea
- Variant model Name.....	N/A
Date of receipt of sample(s)	01 Feb. 2021
Date of Test	24 Feb. 2021 - 05 Mar. 2021
Test standard(s)	CFR 47 Part15 Subpart C, RSS-247 Issue 2 CFR 47 Part 2.1091, RSS-102 issue 5
Test Results & uncertainty	See Summary
Issue date	26 April. 2021

Note 1. The results shown in this test report refer only to the sample(s) tested.

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Tested by

Name : Criss.Lee
RF Engineer

Approved by

Name : Bran.Ko
RF Technical Manager

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SECTION 1 CONTENTS

SECTION NAMES	PAGE
1. Contents	2
2. General Description	3
3. Summary	7
4. Test Result	8
5. Revision History	60

SECTION 2 GENERAL DESCRIPTION

1. Laboratory Information

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2. Applicant Information

Name	Kenzen Inc
Address	35640 Fremont Blvd # 358, Fremont, California 94536, United States
Contact Person	Elena Hui
Phone No.	+1-415-413-0080

3. Description of EUT

Product name	Kenzen Patch
Model name	KP01
Serial No.	-
Manufacturer	Aprotech CO., LTD.
Country of Manufacture	Republic of Korea
Rated Voltage	DC 3.70 V
Approved RF Module	-
Approved Module FCC ID	-
Frequency Range	2 402 MHz ~ 2 480 MHz (BT LE)
Modulation Technique	GFSK (1 Mbps / 2 Mbps)
Number of Channel	40 CH
Antenna Type	Integral Antenna
Antenna Gain	2.23 dBi
Transmit Power	1.32 dBm (Peak)
H/W Version	KEM DVT-03
S/W Version	v.2.25
RF Power Setting Parameter	TX Power: 3 dBm

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4. Test Instrument

Control No.	Equipment	Manufacturer	Model	Serial No.	Cal. Due.
EMC001	EMI Test Receiver	Rohde & Schwarz	ESU40	100478	2022/1/4
EMC002	EMI Test Receiver	Rohde & Schwarz	ESU26	100590	2022/1/4
EMC003	Open Switch and Control Platform	Rohde & Schwarz	OSP130	101467	N/A
EMC007	Two-Line V-Network	Rohde & Schwarz	ENV216	101982	2021/10/5
EMC009	Loop Antenna	Rohde & Schwarz	HFH2-Z2	100465	2023/1/5
EMC025	Biconilog (Type7)	ETS-Lindgren	3142E	00203547	2021/12/6
EMC029	DRG Horn (Medium)	ETS-Lindgren	3117	00203763	2021/7/2
EMC031	Standard Gain Horn	ETS-Lindgren	3160-09	LM9860	2021/5/12
EMC074	AMP	Rohde & Schwarz	SCU-01D	1904843	2021/6/22
EMC077	AMP	Rohde & Schwarz	SCU-18D	1952128	2021/6/22
EMC079	AMP	Rohde & Schwarz	SCU-26D	1879069	2021/6/22
EMC122	Programmable controller	PACIFIC smartsource	UPC12	N/A	2021/6/24
RF003	VECTOR SIGNAL GENERATOR	Rohde & Schwarz	SMBV100A	261569	2021/6/22
RF004	SIGNAL GENERATOR	Rohde & Schwarz	SMB100A	178493	2021/6/30
RF005	SPECTRUM ANALYZER	Rohde & Schwarz	FSW43	103893	2021/6/23
RF009	FIXED COAXIAL ATTENUATOR	WEINSCHEL	56-10	71087	2021/6/24
RF018	Notch Rf filter	Micro-Tronics	BRM50702-02	G043	2021/6/23
RF022	System DC Power Supply	KEYSIGHT	N5747A	US16D4132P	2021/6/22
41	Softwarer	Rohde & Schwarz	EMC32	Ver10.30.00	N/A

5. Support Equipment

Description	Manufacturer	Model	Serial No.
Note-PC	Samsung Electronics Co., Ltd.	NT500R5Q	0HV991BH500176W
Tablet PC	Apple Inc.	A1474	-
AC Adaptor	Kenzen Inc	JZB310-050100UU	-
USB Cable	Kenzen Inc	-	-

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6. Channel List

Channel No.	Frequency(MHz)	Channel No.	Frequency(MHz)
0	2 402	20	2 442
1	2 404	21	2 444
2	2 406	22	2 446
3	2 408	23	2 448
4	2 410	24	2 450
5	2 412	25	2 452
6	2 414	26	2 454
7	2 416	27	2 456
8	2 418	28	2 458
9	2 420	29	2 460
10	2 422	30	2 462
11	2 424	31	2 464
12	2 426	32	2 466
13	2 428	33	2 468
14	2 430	34	2 470
15	2 432	35	2 472
16	2 434	36	2 474
17	2 436	37	2 476
18	2 438	38	2 478
19	2 440	39	2 480

7. Test Condition

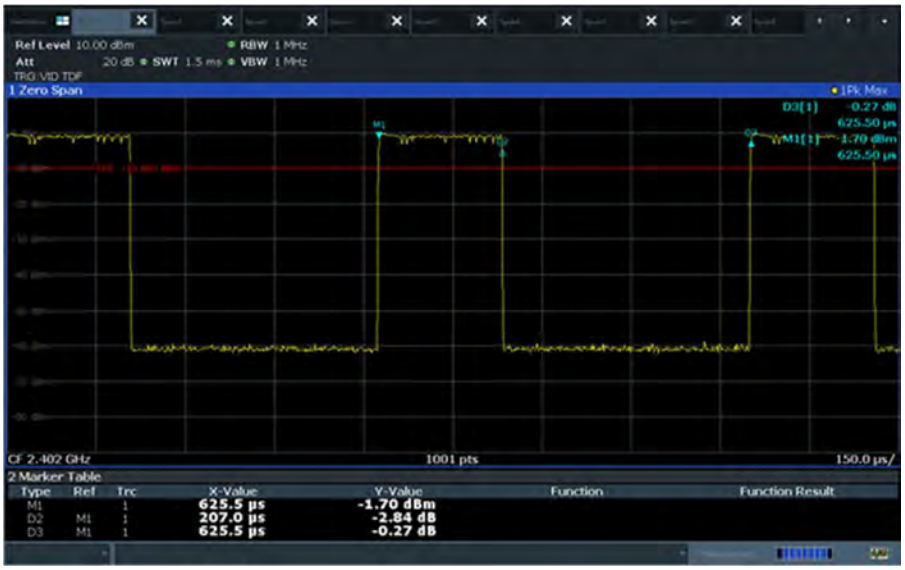
Mode	Test Frequency(MHz)		
	Lowest	Middle	Highest
GFSK_1 Mbps	2 402	2 440	2 480
GFSK_2 Mbps	2 402	2 440	2 480

8. Duty Cycle Correction Factor

Test Mode – GFSK 1 Mbps – Lowest Channel -2 402 MHz

Note 1) Period : 0.625 5 ms, On time : 0.393 ms (Packet Transmission)
Note 2) DCCF = 10log(1/x) = 10log(1/0.628) = 2.018 dB, x = 0.393/0.625 5 = 0.628
Note 3) D = 62.8 % (duty cycle < 98 %)

Test Mode – GFSK 2 Mbps – Lowest Channel -2 402 MHz



Note 1) Period : 0.625 5 ms, On time : 0.207 ms (Packet Transmission)
Note 2) DCCF = 10log(1/x) = 10log(1/0.331) = 4.803 dB, x = 0.207/0.625 5 = 0.331
Note 3) D = 33.1 % (duty cycle < 98 %)

SECTION 3 SUMMARY

1. Summary of test results

Requirements	FCC Rule	IC Rule	Compliance
Antenna Requirement	15.203 15.247(b)(4)	-	Complied
Maximum Output Power	15.247(b)(4)	RSS-247 5.4(d)	Complied
Power Spectral Density	15.247(e)	RSS-247 5.2(b)	Complied
6 dB Channel Bandwidth	15.247(a)(2)	RSS-247 5.2(a)	Complied
Occupied Bandwidth	-	RSS-GEN 6.6	Complied
Radiated Spurious Emissions & Restricted Band, Conducted Spurious Emissions & Band Edge	15.247(d) 15.205(a) 15.209(a)	RSS-247 5.5, RSS-GEN 8.9, 8.10	Complied
Conducted Emissions	15.207(a)	RSS-GEN, 8.8	Complied
Test method: According to ANSI C63.10-2013, KDB 558074 D01 DTS Meas. Guidance v04			

2. Measurement Uncertainty

Parameters	Uncertainty (k = 2)	
Maximum Peak Conducted Output Power	1.66 dB	
Power Spectral Density	1.32 dB	
Channel Bandwidth	2.02 kHz	
Spurious Emissions (Conducted)	1.32 dB	
Spurious Emissions (Radiated)	9 kHz to 30 MHz	4.5 dB
	30 MHz to 1 GHz	4.6 dB
	1 GHz to 6 GHz	5.6 dB
	6 GHz to 18 GHz	5.8 dB
	18 GHz to 26.5 GHz	4.5 dB

SECTION 4 TEST RESULT

1. Antenna Requirement

1.1 Rule

According to §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

1.2 Test Results – Complied

The antenna(Chip antenna) of this product is **permanently attached** and there are no provisions for connection to an external antenna. Directional peak gain of the antenna is 2.23 dBi.

2. Maximum Peak Output Power

2.1 Rule

According to §15.247(b)(3), For systems using digital modulation in the 902-928 MHz, 2 400-2 483.5 MHz, and 5 725-5 850 MHz bands: 1 Watt.
As an alternative to a peak power measurement, compliance with the 1 Watt limit can be based on a measurement of the maximum conducted output power.
Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

According to §15.247(b)(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

2.2 Measurement Procedure

According to ANSI C63.10-2013 & KDB 558074 D01 DTS Meas. Guidance v04, 9.1.3 PKPM1 Peak power meter method.

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

2.3 Test Results - Complied

Test Mode	Test Frequency	Peak Output Power (dBm)				Limit (dBm)
GFSK_1 Mbps	2 402 MHz	P	=	0.18	dBm	30
	2 440 MHz	P	=	0.74	dBm	
	2 480 MHz	P	=	1.32	dBm	
GFSK_2 Mbps	2 402 MHz	P	=	0.20	dBm	30
	2 440 MHz	P	=	0.75	dBm	
	2 480 MHz	P	=	1.27	dBm	

Note :

1. Peak Output Power = Reading (dBm) + Cable loss (dB) + Attenuator (dB)
2. Peak Output Power was tested by Power meter & sensor (VBW = 50 MHz)

3. Power Spectral Density

3.1 Rule

According to §15.247(e), 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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

3.2 Measurement Procedure

According to ANSI C63.10-2013 & KDB 558074 D01 DTS Meas. Guidance v04, 10.2 Method PKPSD.

This procedure shall be used if maximum peak conducted output power was used to demonstrate compliance, and is optional if the maximum conducted (average) output power was used to demonstrate compliance.

a) Set Spectrum Analyzer centre frequency to DTS channel centre frequency.
b) Set the span to 1.5 x DTS bandwidth.
c) Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d) Set the VBW ≥ 3 x RBW.
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum amplitude level within the RBW.
j) If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

3.3 Test Results – Complied

Test Mode	Test Frequency	Power Spectral Density (dBm/3 kHz)				Limit (dBm/3 kHz)
GFSK_1 Mbps	2 402 MHz	P.S.D.	=	-15.90	dBm/3 kHz	8
	2 440 MHz	P.S.D.	=	-14.92	dBm/3 kHz	
	2 480 MHz	P.S.D.	=	-13.74	dBm/3 kHz	
GFSK_2 Mbps	2 402 MHz	P.S.D.	=	-18.41	dBm/3 kHz	8
	2 440 MHz	P.S.D.	=	-17.41	dBm/3 kHz	
	2 480 MHz	P.S.D.	=	-16.31	dBm/3 kHz	

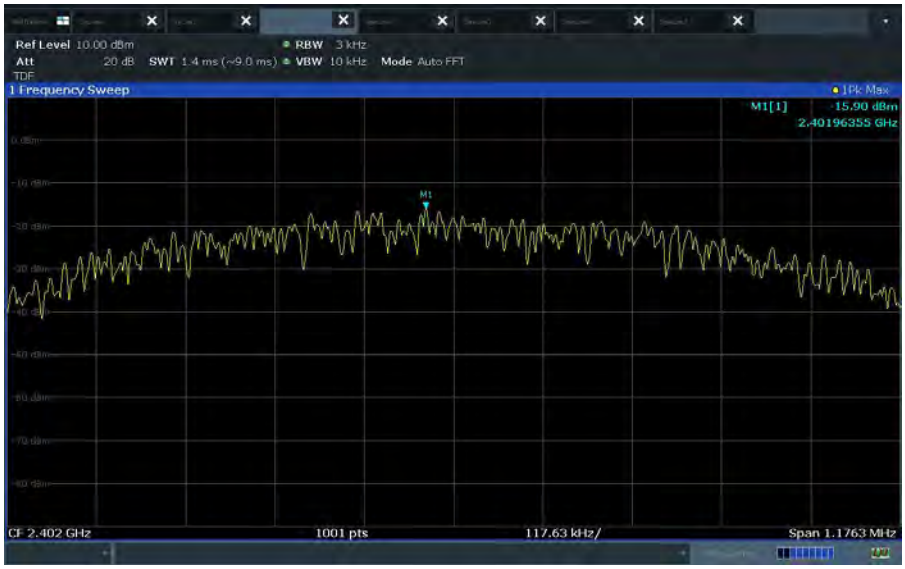
Note :

1. Power Spectral Density(dBm/3 kHz)= Reading (dBm/3 kHz) + Cable loss (dB) + Attenuator (dB)

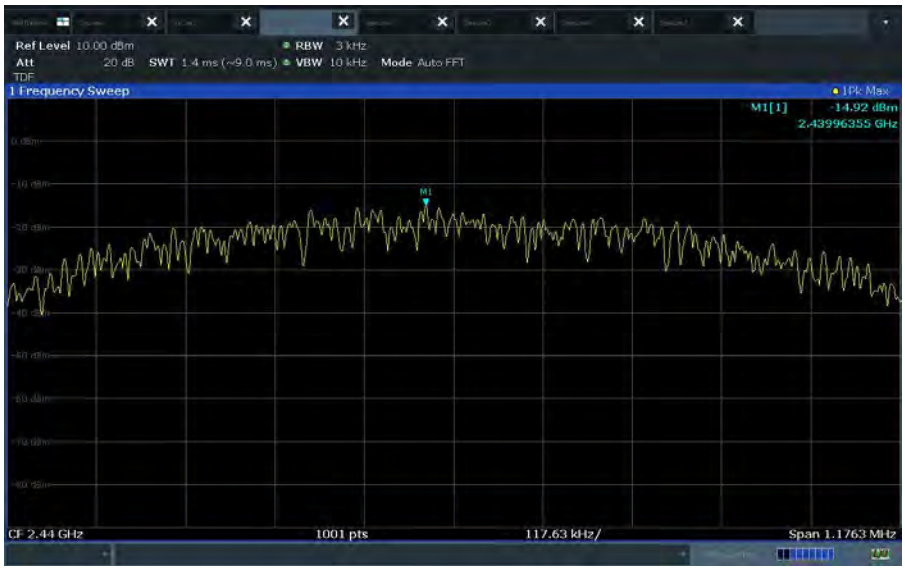
Photographs of Test Results

Test Mode – GFSK 1 Mbps

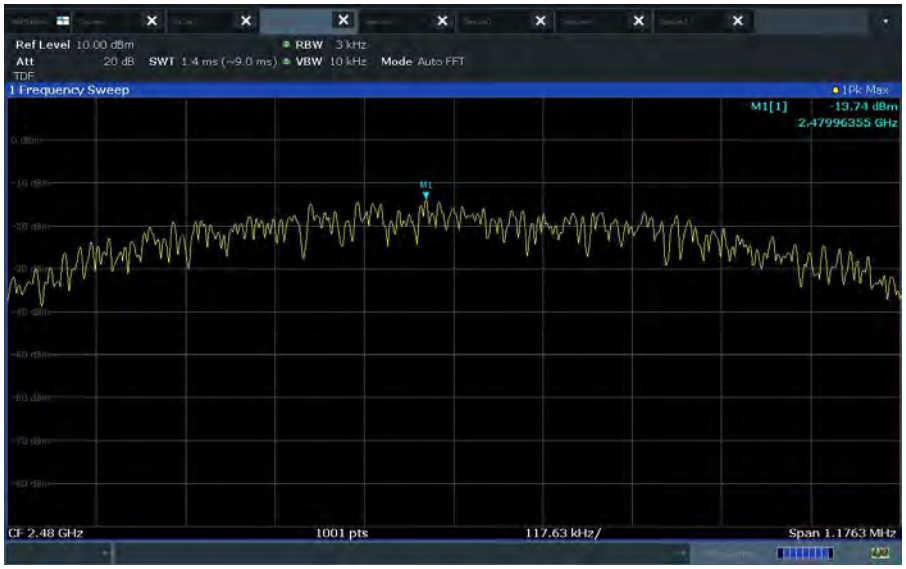
Lowest – 2 402 MHz



Middle – 2 440 MHz

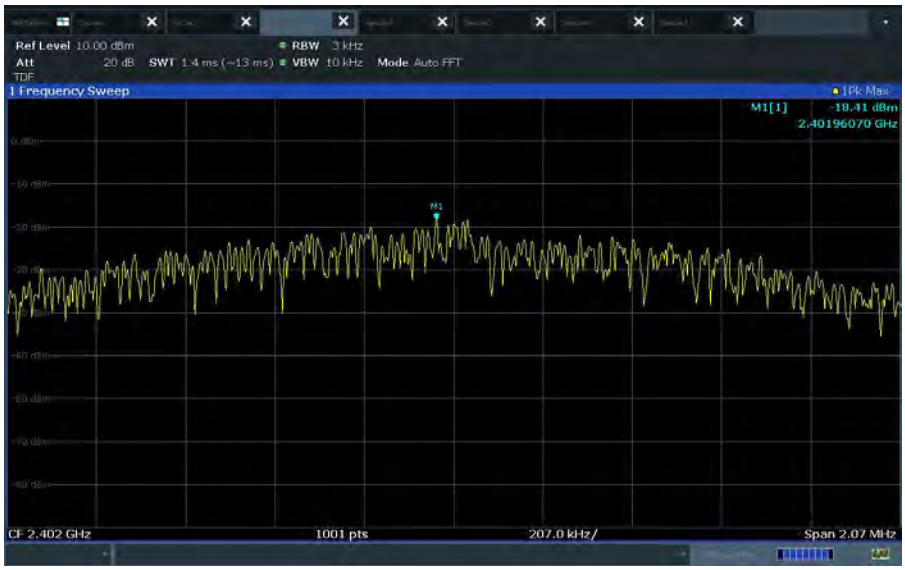


Highest – 2 480 MHz

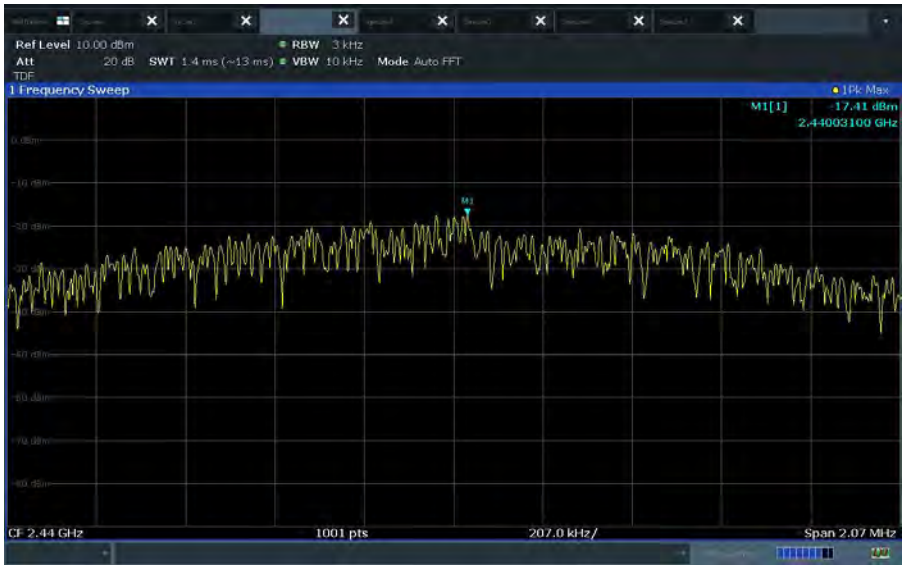


Test Mode – GFSK 2 Mbps

Lowest – 2 402 MHz



Middle – 2 440 MHz



Highest – 2 480 MHz

4 6 dB Bandwidth (DTS Channel Bandwidth) & Occupied Bandwidth

4.1 Rule

- 6 dB Bandwidth
According to §15.247(a)(2) Systems using digital modulation techniques may operate in the 902–928 MHz, 2 400–2 483.5 MHz, and 5 725–5 850 MHz bands.
The minimum 6 dB bandwidth shall be at least 500 kHz.

- Occupied Bandwidth
The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3x the resolution bandwidth.
When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

4.2 Measurement Procedure

- 6 dB Bandwidth
According to ANSI C63.10-2013 & KDB 558074 D01 DTS Meas. Guidance v04, 8.2 Option 2.

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 x RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

- Occupied Bandwidth
According to RSS-GEN 6.6 Occupied Bandwidth

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3x RBW.

4.3 Test Results - Complied

Test Mode	Frequency (MHz)	6 dB Bandwidth (MHz)	Occupied Bandwidth (MHz)	Limit (kHz)
GFSK_1 Mbps	2 402	0.78	1.05	500
	2 440	0.78	1.06	
	2 480	0.78	1.06	
GFSK_2 Mbps	2 402	1.38	2.04	500
	2 440	1.38	2.05	
	2 480	1.38	2.05	

Photographs of Test Results (6 dB Bandwidth)

Test Mode – GFSK 1 Mbps

Lowest – 2 402 MHz

Middle – 2 440 MHz

Highest – 2 480 MHz

Test Mode – GFSK 2 Mbps

Lowest – 2 402 MHz

Middle – 2 440 MHz

Highest – 2 480 MHz

Photographs of Test Results (Occupied Bandwidth)

Test Mode – GFSK 1 Mbps

Lowest – 2 402 MHz

Middle – 2 440 MHz

Highest – 2 480 MHz

Test Mode – GFSK 2 Mbps

Lowest – 2 402 MHz

Middle – 2 440 MHz

Highest – 2 480 MHz

5. Radiated Spurious Emissions & Restricted Band, Conducted Spurious Emissions & Band Edge

5.1 Rule

According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated 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, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.
Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, 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)).

According to §15.209(a), 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 (kHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009 - 0.490	2 400/F(kHz)	20log (2 400/F(kHz))	300
0.490 - 1.705	24 000/F(kHz)	20log (24 000/F(kHz))	30
1.705 - 30	30	30	30
30 - 88	100**	100**	3
88 - 216	150**	150**	3
216 - 960	200**	200**	3
Above 960	500	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., §15.231 and 15.241.

According to §15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.009 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505	16.694 75 - 16.695 25	608 - 614	5.35 - 5.46
2.173 5 - 2.190 5	16.804 25 - 16.804 75	960 – 1 240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1 300 – 1 427	8.025 - 8.5
4.177 25 - 4.177 75	37.5 - 38.25	1 435 – 1 626.5	9.0 - 9.2
4.207 25 - 4.207 75	73 - 74.6	1 645.5 – 1 646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1 660 – 1 710	10.6 - 12.7
6.267 75 - 6.268 25	108 - 121.94	1 718.8 – 1 722.2	13.25 - 13.4
6.311 75 - 6.312 25	123 - 138	2 200 – 2 300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2 310 – 2 390	15.35 - 16.2
8.362 - 8.366	156.524 75 - 156.525 25	2 483.5 – 2 500	17.7 - 21.4
8.376 25 - 8.386 75	156.7 - 156.9	2 690 – 2 900	22.01 - 23.12
8.414 25 - 8.414 75	162.012 5 - 167.17	3 260 – 3 267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3 332 – 3 339	31.2 - 31.8
12.519 75 - 12.520 25	240 - 285	3 345.8 – 3 358	36.43 - 36.5
12.576 75 - 12.577 25	322 - 335.4	3 600 – 4 400	Above 38.6
13.36 - 13.41			

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1 000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements

5.2 Measurement Procedure

According to ANSI C63.10-2013, 11.11 Emissions in non-restricted frequency band, and 11.12 Emissions in restricted frequency bands

5.2.1. Test Procedures for emission below 30 MHz

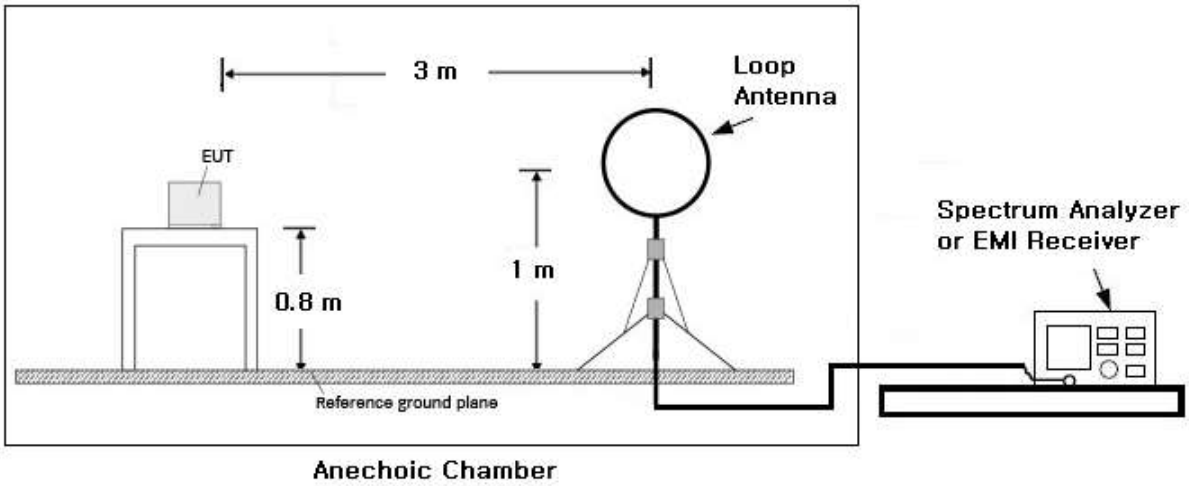
1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
2. Then antenna is a loop antenna is fixed at one meter above the ground to determine the maximum value of the field strength. Both parallel and perpendicular of the antenna are set to make the measurement.
3. For each suspected emission, the EUT was arranged to its worst case and then the table was turned from 0 degrees to 360 degrees to find the maximum reading.
4. The test-receiver system was set to quasi peak detect function and Specified Bandwidth with Maximum Hold Mode.

5.2.2. Test Procedures for emission below 1 000 MHz & above 1 000 MHz

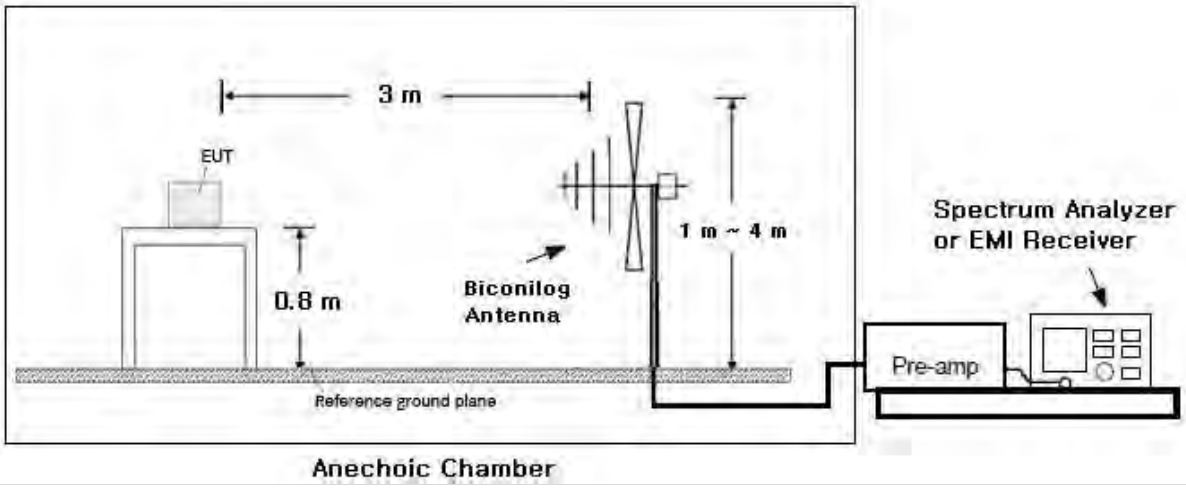
1. The EUT was placed on the top of a rotating table 0.8 meters above the ground at anechoic chamber test site (below 1 GHz) and 1.5 meters above the ground at anechoic chamber test site (above 1 GHz).
   The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
3. The antenna is a bi-log antenna, a horn antenna and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength (Keeping antenna aimed at EUT). Both horizontal and vertical polarizations of the antenna are set to make the measurement.
4. The test-receiver system was set to quasi peak detect function (below 1 GHz), peak detect function and average detect function (above 1 GHz).

5.2.3. Test Setup

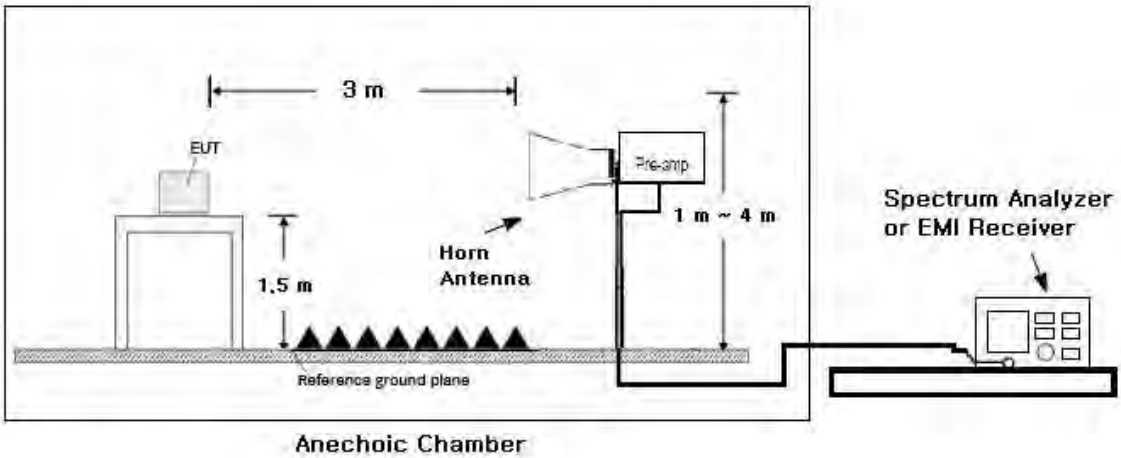
1. 9 kHz to 30 MHz Emissions



2. 30 MHz to 1 000 MHz Emissions



3. Above 1 000 MHz Emissions



NOTE;

All data rates and modes were investigated for radiated spurious emissions. Only the radiated emissions of the configuration that produced the worst case emissions are reported in this section.

1. Unwanted Emissions into Non-Restricted Frequency Bands

- The Reference Level Measurement refer to section 11.2
Set Analyzer centre frequency to DTS channel centre frequency, SPAN ≥ 1.5 times the DTS bandwidth, the RBW = 100 kHz and VBW ≥ 3 × RBW, Detector = Peak, Sweep time = Auto couple, Trace = Max hold.

- Unwanted Emissions Level Measurement refer to section 11.3
Set the centre frequency and span to encompass frequency range to be measured, the RBW = 100 kHz and VBW ≥ 3 × RBW, Detector = Peak, Sweep time = Auto couple, Trace = Max hold.

2. Unwanted Emissions into Restricted Frequency Bands

- Peak Power measurement procedure refer to section 12.2.4
Set RBW = as specified in Table 1, VBW ≥ 3 x RBW, Detector = Peak, Sweep time = auto, Trace = Max hold.

Table 1- RBW as a function of frequency

Frequency	RBW
9 – 150 kHz	200 – 300 Hz
0.15 – 30 MHz	9 – 10 kHz
30 – 1 000 MHz	100 – 120 kHz
> 1 000 MHz	1 MHz

-Average Power measurements procedure refer to section 12.2.5.2
The EUT shall be configured to operate at the maximum achievable duty cycle.
Measure the duty cycle, x, of the transmitter output signal as described in section 6.0.
Set RBW = 1 MHz, VBW ≥ 3 x RBW, Detector = RMS, if span / (# of points in sweep) ≤ (RBW/2).
Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied then the detector mode shall be set to peak.

Averaging type = power (i.e., RMS).
As an alternative the detector and averaging type may be set for linear voltage averaging.
Some instruments require linear display mode in order to use linear voltage averaging. Log or dB averaging shall not be used. Sweep time = auto, Perform a trace average of at least 100 traces.

A correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle. The correction factor is computed as follows:

1) If power averaging (RMS) mode was used in step f), then the applicable correction factor is 10 log (1/x), where x is the duty cycle.
3) If a specific emission is demonstrated to be continuous (≥ 98 percent duty cycle) rather than turning on and off with the transmit cycle, then no duty cycle correction is required for that emission.

the EUT is manipulated through three orthogonal planes (X, Y, Z). Worst orthogonal plan of EUT is **X – axis** during radiation test.

5.3 Test results – Complied

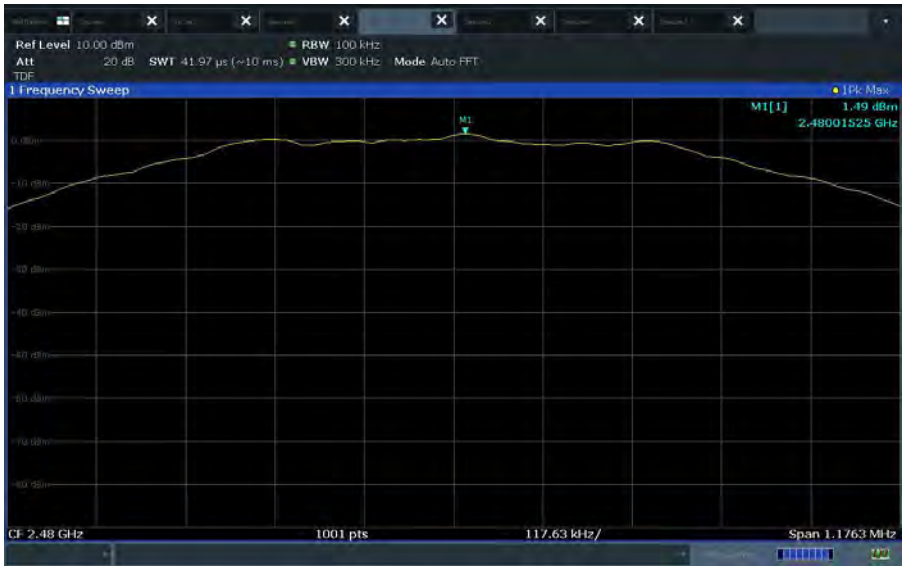
Photographs of Test Result (Conducted Measurements)

Test Mode – GFSK 1 Mbps

Reference Level– 2 402 MHz

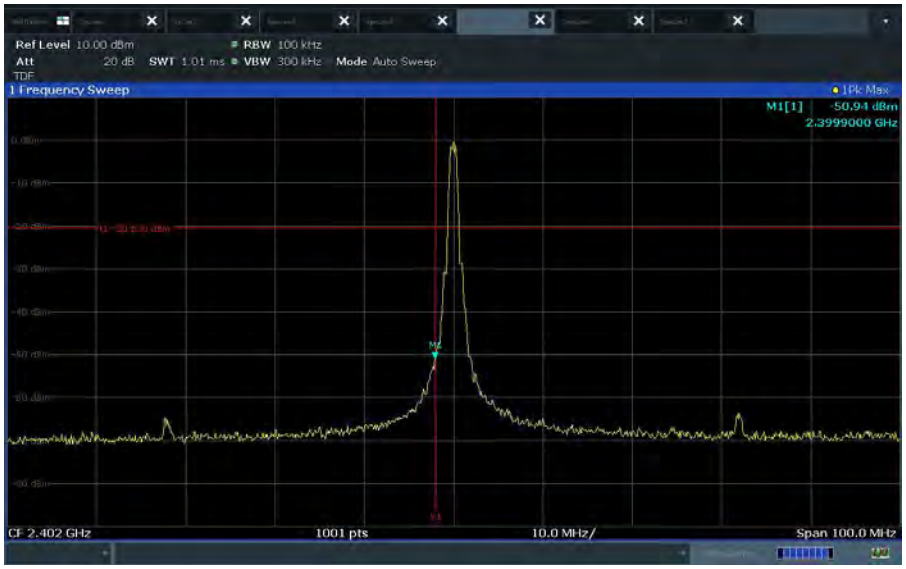
Reference Level– 2 440 MHz

Reference Level– 2 480 MHz

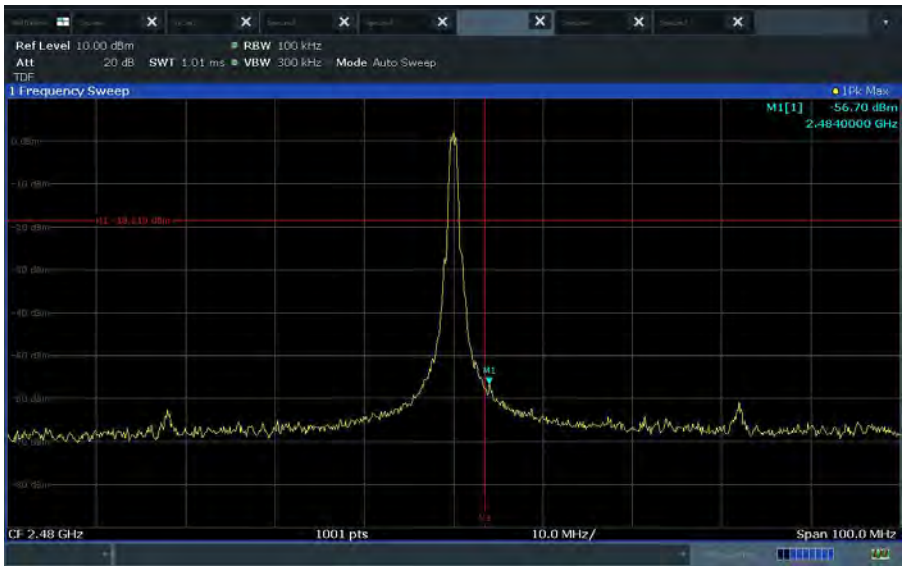


Band Edge

Lowest – 2 402 MHz

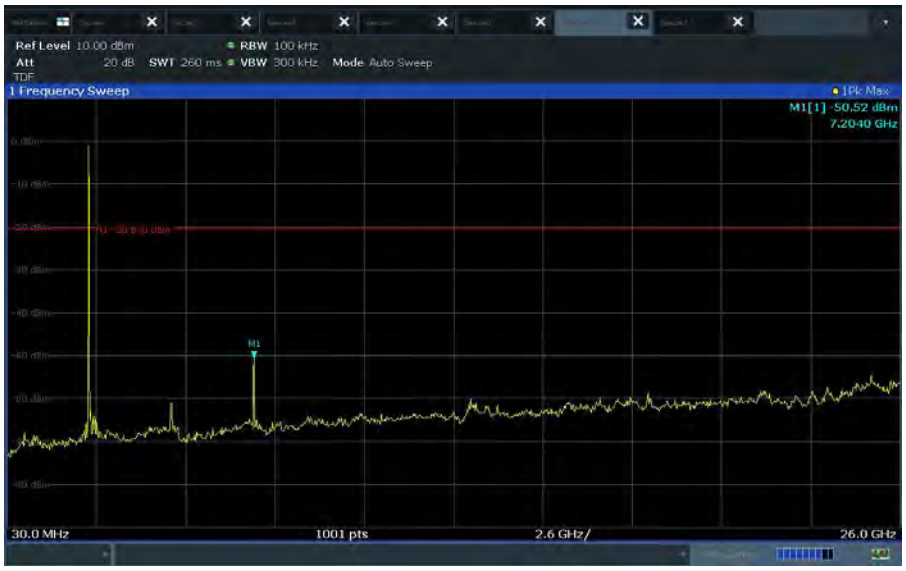


Highest – 2 480 MHz

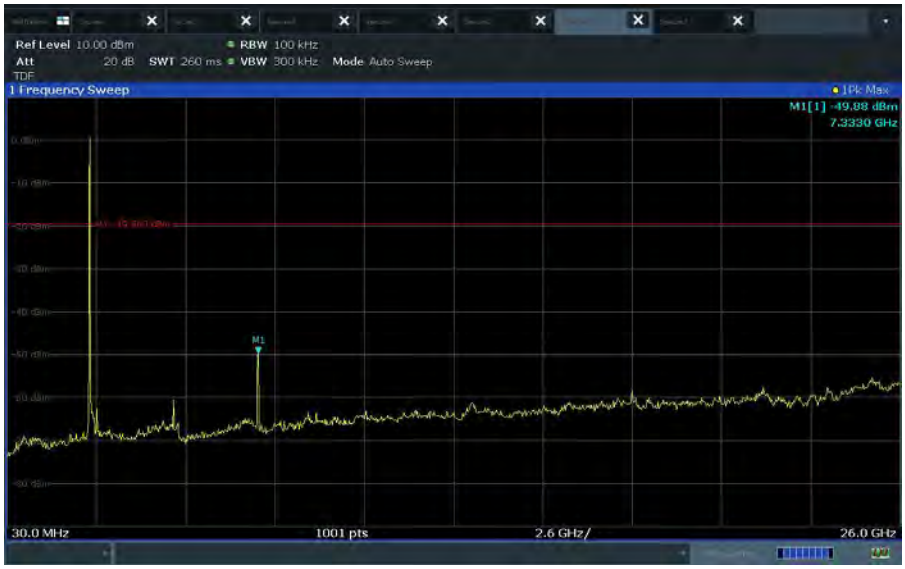


Spurious

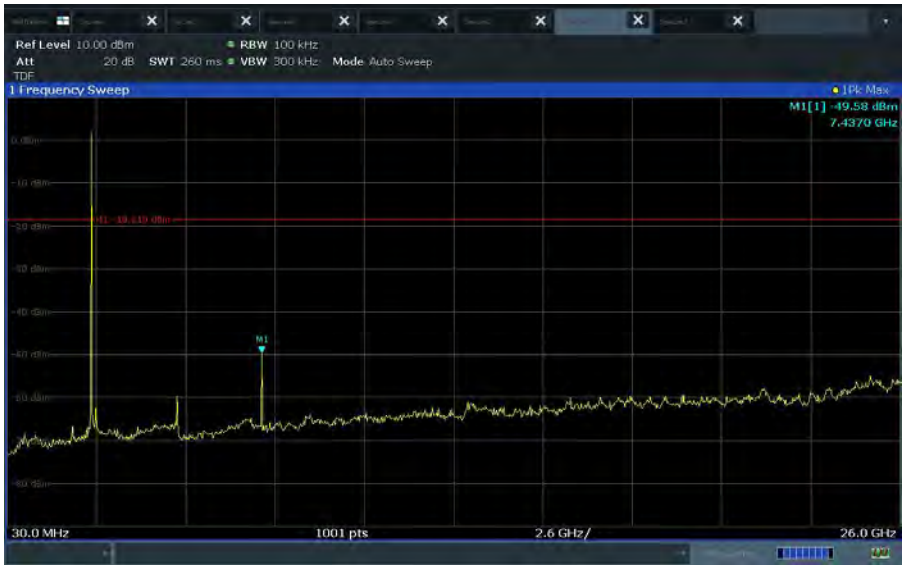
Lowest – 2 402 MHz



Middle – 2 440 MHz

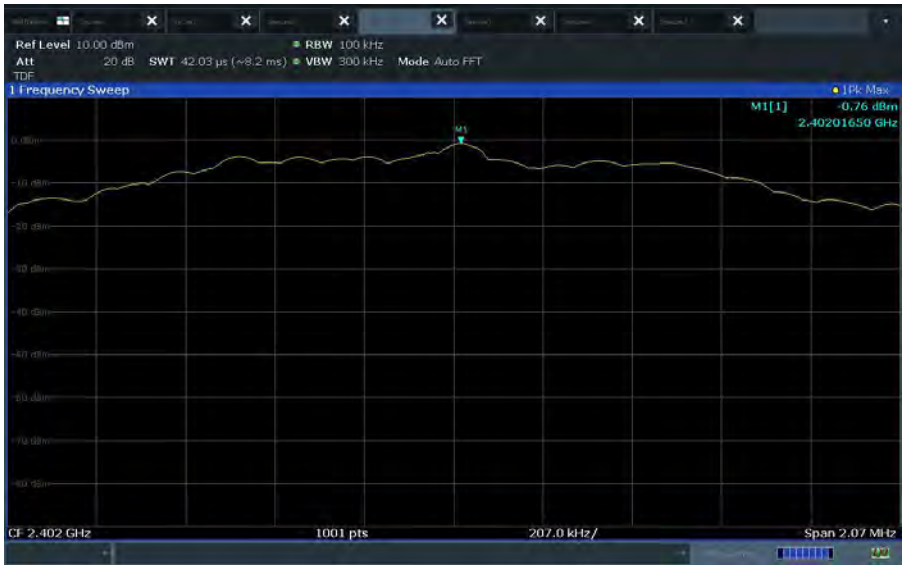


Highest – 2 480 MHz

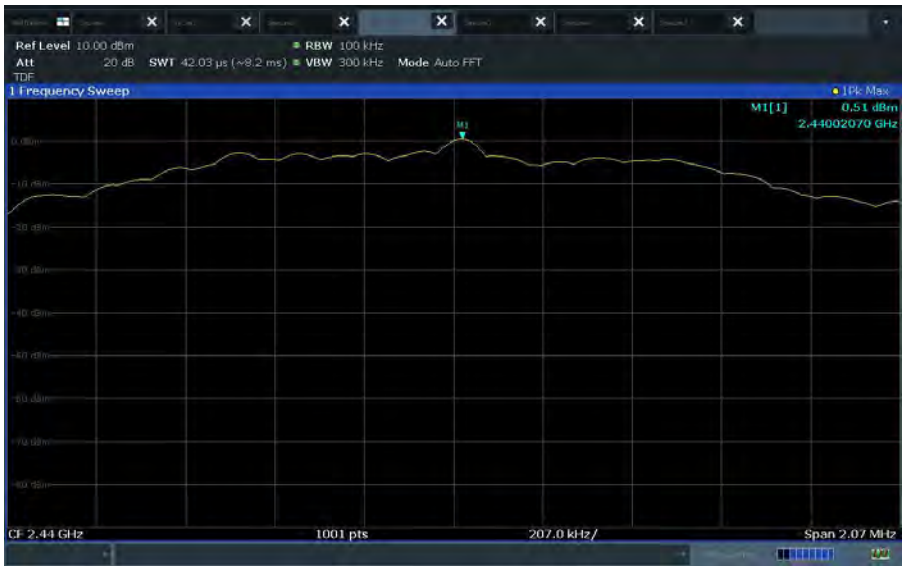


Test Mode – GFSK 2 Mbps

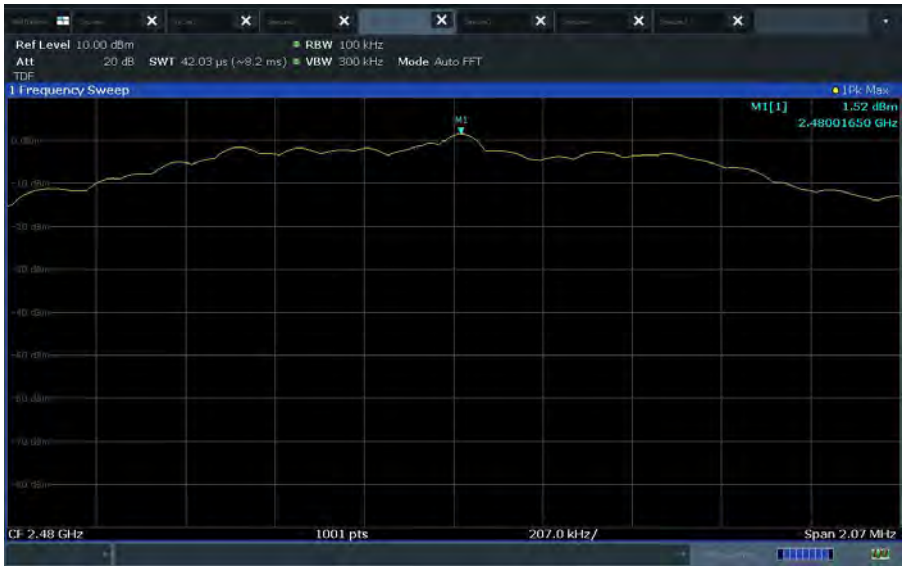
Reference Level– 2 402 MHz



Reference Level– 2 440 MHz

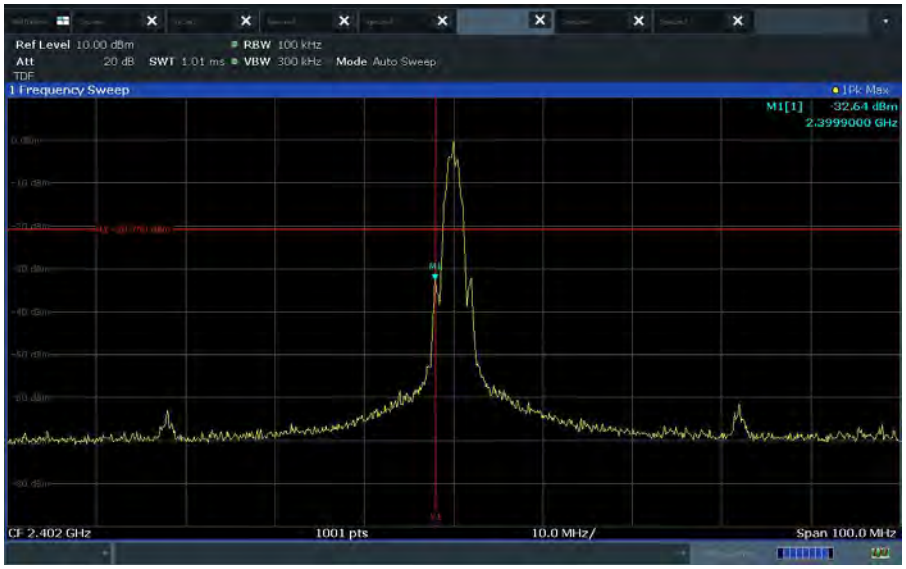


Reference Level– 2 480 MHz

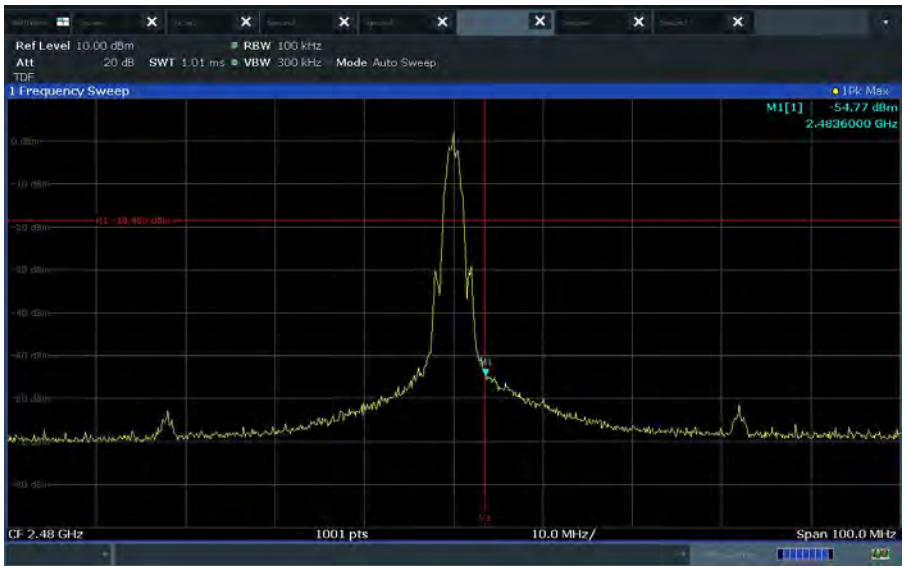


Band Edge

Lowest – 2 402 MHz

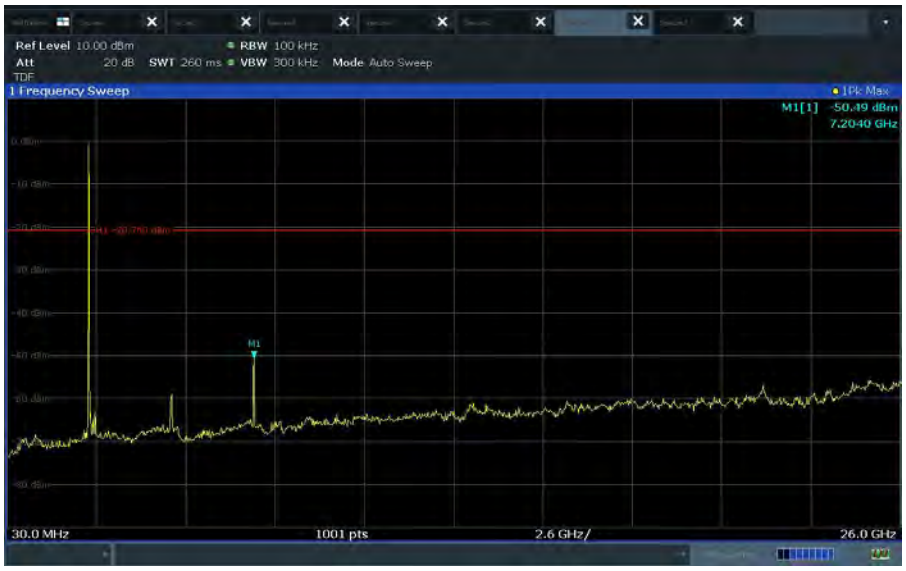


Highest – 2 480 MHz

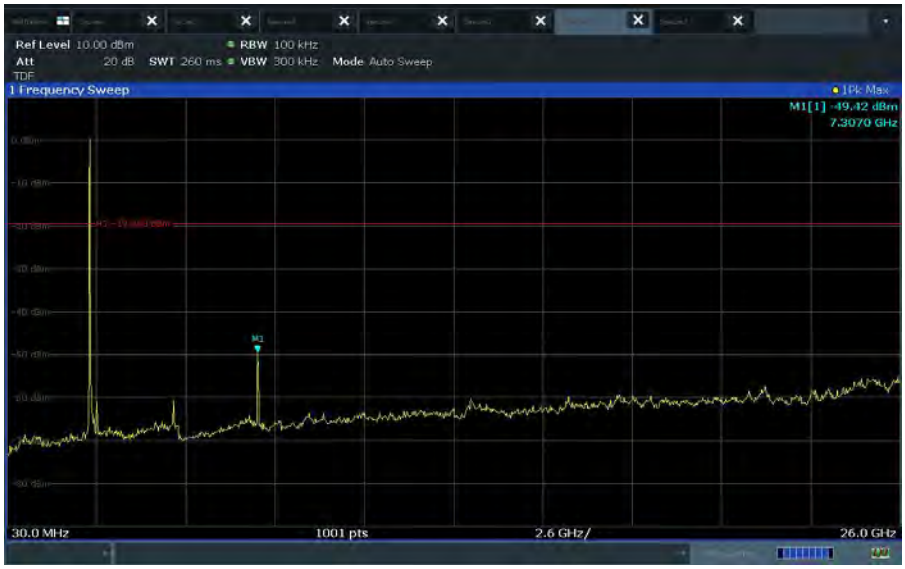


Spurious

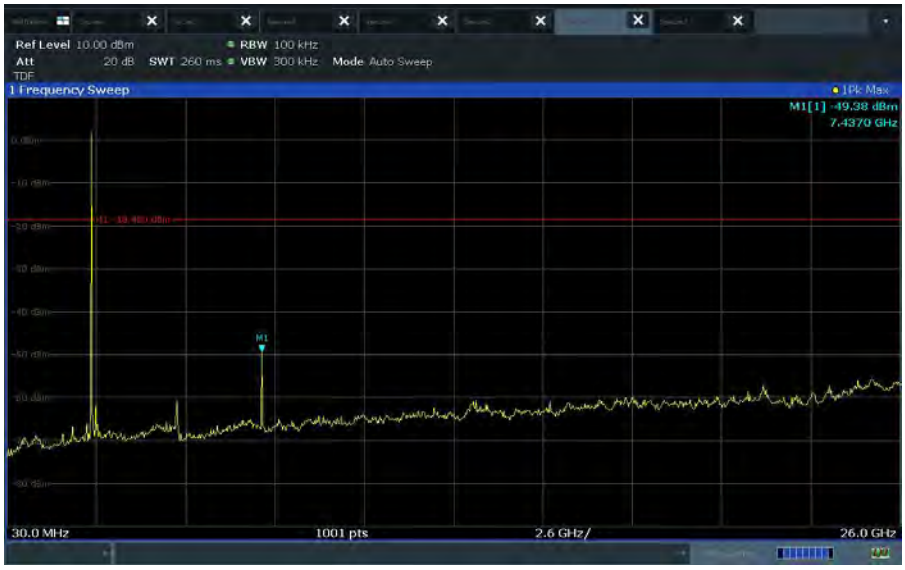
Lowest – 2 402 MHz



Middle – 2 440 MHz



Highest – 2 480 MHz



Photographs of Test Result (Radiated Measurement)

Note :

The radiated measurement was performed continuous transmission of the EUT (Duty cycle $D = 100\ \%$).

9 kHz ~ 30 MHz

Test Mode – GFSK 1 Mbps – highest Channel - 2 480 MHz (Worst Case)

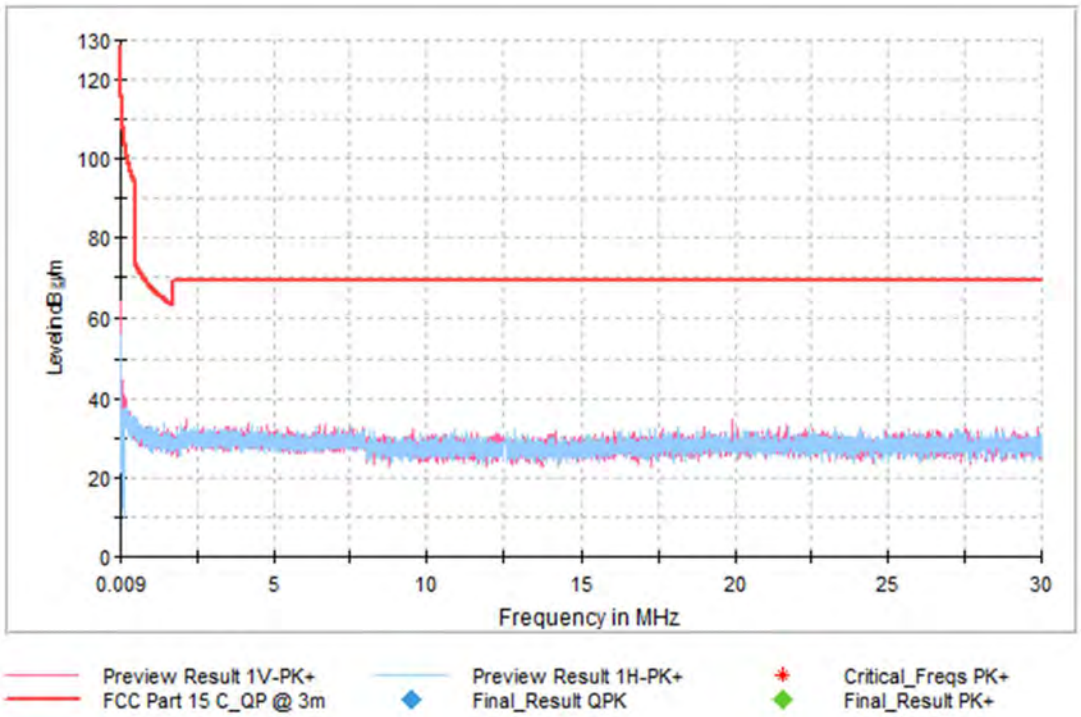
Frequency [MHz]	QuasiPeak [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Pol.	Azimuth [deg]	Corr. [dB/m]
No spurious emissions were detected within 20 dB of the limit.							

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. QuasiPeak[dB(µV)/m] = Reading value[dB(µV)] + Corr.[dB/m]
3. According to § 15.31(f)(2), an extrapolation factor of 40 dB/decade is applied because measured distance of radiated emission is 3 m.

Test Data

- 9 kHz ~ 30 MHz



30 MHz ~ 1 GHz

Test Mode – GFSK 1 Mbps – highest Channel - 2 480 MHz (Worst Case)

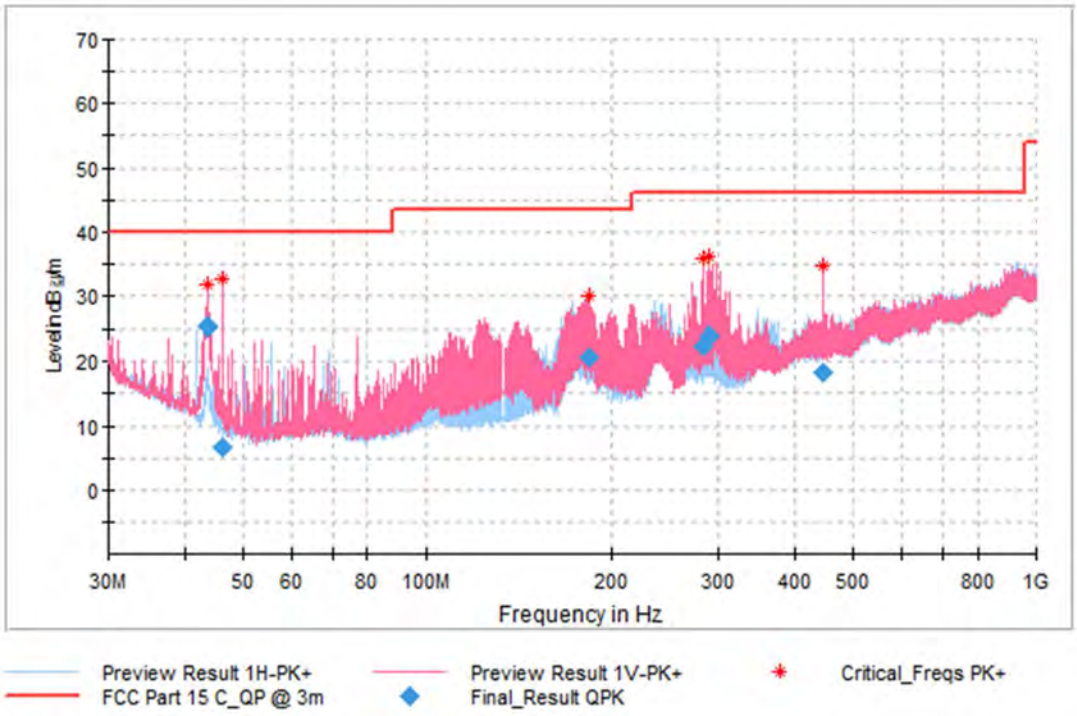
Frequency [MHz]	QuasiPeak [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
43.72	25.47	40.00	14.53	120.0	100.0	V	84.0	-14.06
46.19	6.57	40.00	33.43	120.0	100.0	V	218.0	-15.24
183.49	20.56	43.50	22.94	120.0	100.0	V	73.0	-11.07
283.20	22.49	46.00	23.51	120.0	200.0	V	150.0	-8.7
288.66	24.01	46.00	21.99	120.0	200.0	V	161.0	-8.6
447.06	18.25	46.00	27.75	120.0	200.0	V	50.0	-2.43

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. QuasiPeak[dB(µV)/m] = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 30 MHz ~ 1 GHz



1 GHz ~ 18 GHz

Test Mode – GFSK 1 Mbps – Lowest Channel - 2 402 MHz

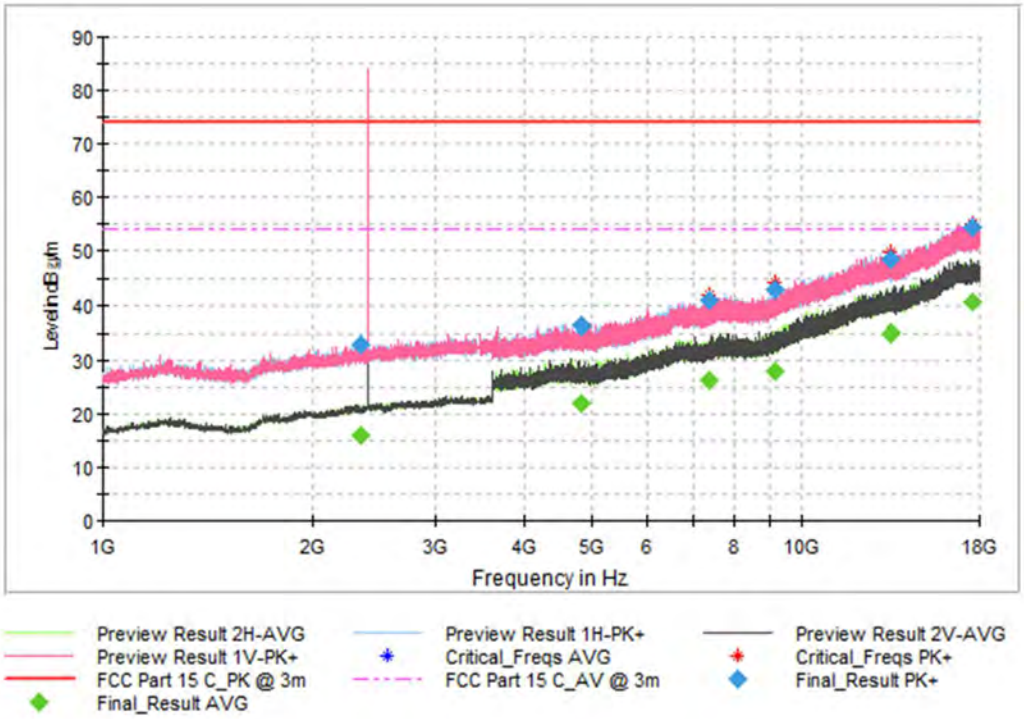
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
#2 349.01	32.83	---	74.00	41.17	1000.0	100.0	V	0.0	0.93
#2 349.01	---	15.89	54.00	38.11	1000.0	100.0	V	0.0	0.93
#4 814.65	---	22.01	54.00	31.99	1000.0	100.0	H	71.0	4.56
#4 814.65	36.31	---	74.00	37.69	1000.0	100.0	H	71.0	4.56
#7 385.97	40.89	---	74.00	33.11	1000.0	400.0	H	111.0	9.35
#7 385.97	---	26.30	54.00	27.70	1000.0	400.0	H	111.0	9.35
#9 176.88	42.84	---	74.00	31.16	1000.0	400.0	V	68.0	11.26
#9 176.88	---	27.99	54.00	26.01	1000.0	400.0	V	68.0	11.26
13 437.97	48.57	---	74.00	25.43	1000.0	100.0	V	167.0	18.24
13 437.97	---	34.88	54.00	19.12	1000.0	100.0	V	167.0	18.24
17 554.02	---	40.41	54.00	13.59	1000.0	100.0	H	0.0	23.42
17 554.02	54.52	---	74.00	19.48	1000.0	100.0	H	0.0	23.42

Note :

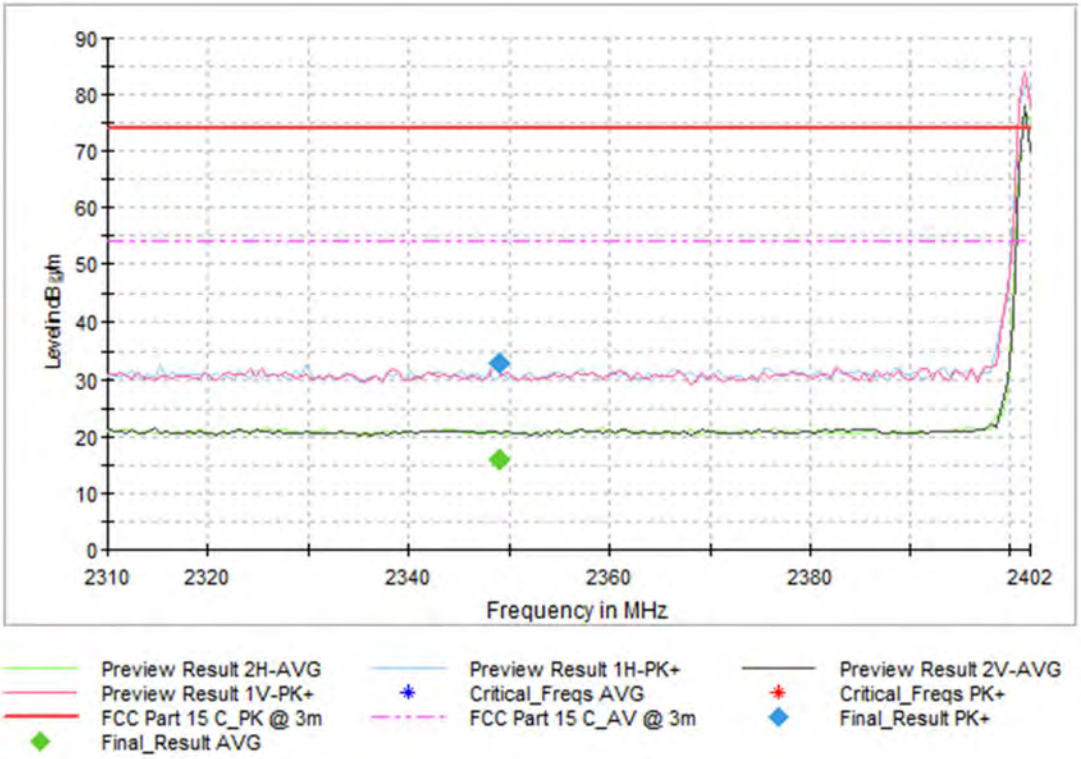
1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 1 GHz ~ 18 GHz



- Restricted Band



Test Mode – GFSK 1 Mbps – Middle Channel - 2 440 MHz

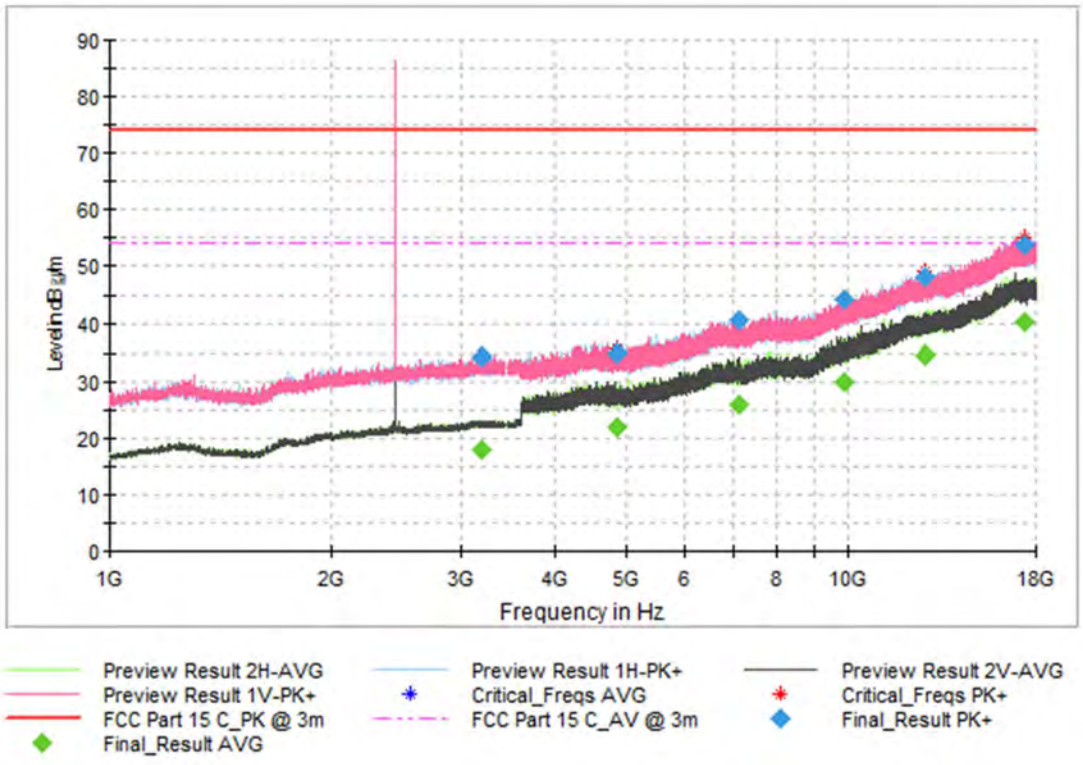
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
3 207.000	34.05	---	74.00	39.95	1000.0	200.0	V	12.0	2.43
3 207.000	---	17.96	54.00	36.04	1000.0	200.0	V	12.0	2.43
#4 862.260	34.91	---	74.00	39.09	1000.0	400.0	V	110.0	4.65
#4 862.260	---	22.08	54.00	31.92	1000.0	400.0	V	110.0	4.65
7 094.410	40.42	---	74.00	33.58	1000.0	200.0	V	0.0	8.94
7 094.410	---	25.93	54.00	28.07	1000.0	200.0	V	0.0	8.94
9 894.330	---	29.75	54.00	24.25	1000.0	100.0	H	4.0	13.06
9 894.330	44.27	---	74.00	29.73	1000.0	100.0	H	4.0	13.06
12 719.940	---	34.41	54.00	19.59	1000.0	200.0	V	175.0	17.56
12 719.940	48.13	---	74.00	25.87	1000.0	200.0	V	175.0	17.56
17 328.070	53.95	---	74.00	20.05	1000.0	200.0	V	259.0	23.17
17 328.070	---	40.21	54.00	13.79	1000.0	200.0	V	259.0	23.17

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 1 GHz ~ 18 GHz



Test Mode – GFSK 1 Mbps – Highest Channel - 2 480 MHz

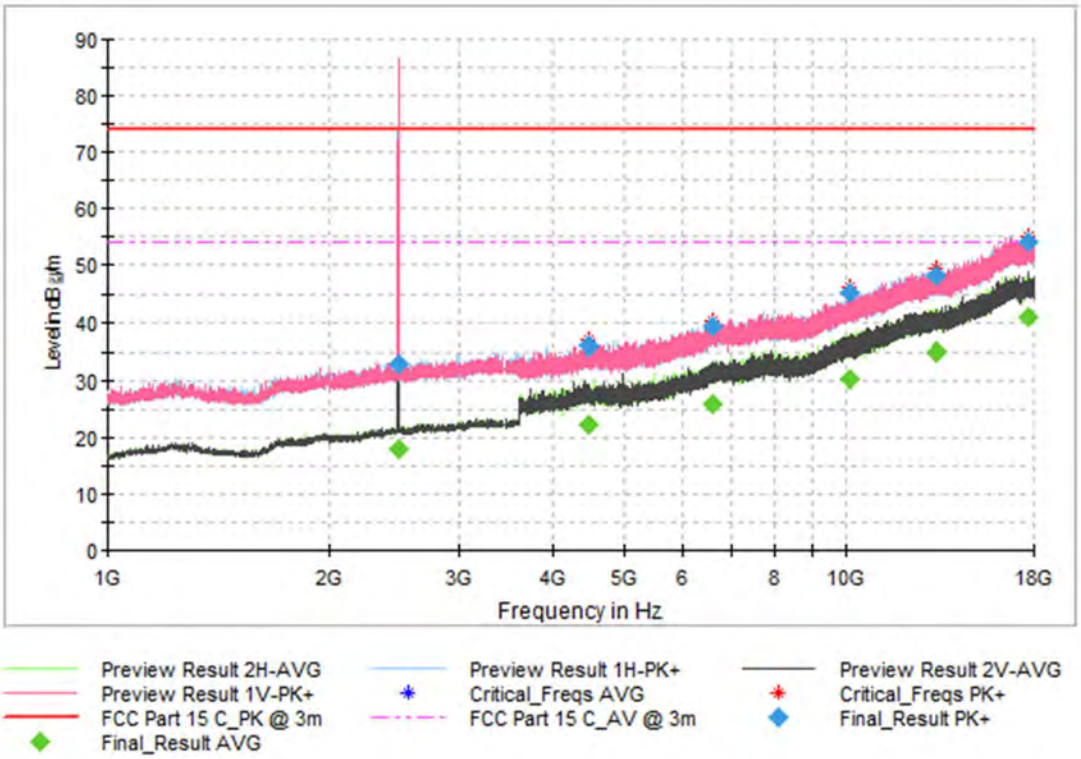
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
#2 486.050	---	17.78	54.00	36.22	1000.0	100.0	V	82.0	1.08
#2 486.050	32.82	---	74.00	41.18	1000.0	100.0	V	82.0	1.08
4 479.220	---	22.36	54.00	31.64	1000.0	200.0	V	0.0	4.75
4 479.220	35.76	---	74.00	38.24	1000.0	200.0	V	0.0	4.75
6 589.110	39.04	---	74.00	34.96	1000.0	200.0	H	56.0	8.98
6 589.110	---	25.94	54.00	28.06	1000.0	200.0	H	56.0	8.98
10 111.100	45.07	---	74.00	28.93	1000.0	200.0	H	5.0	13.54
10 111.100	---	30.21	54.00	23.79	1000.0	200.0	H	5.0	13.54
#13 251.400	---	34.72	54.00	19.28	1000.0	200.0	H	314.0	18.1
#13 251.400	48.26	---	74.00	25.74	1000.0	200.0	H	314.0	18.1
#17 735.980	---	40.71	54.00	13.29	1000.0	300.0	V	35.0	23.76
#17 735.980	54.20	---	74.00	19.80	1000.0	300.0	V	35.0	23.76

Note :

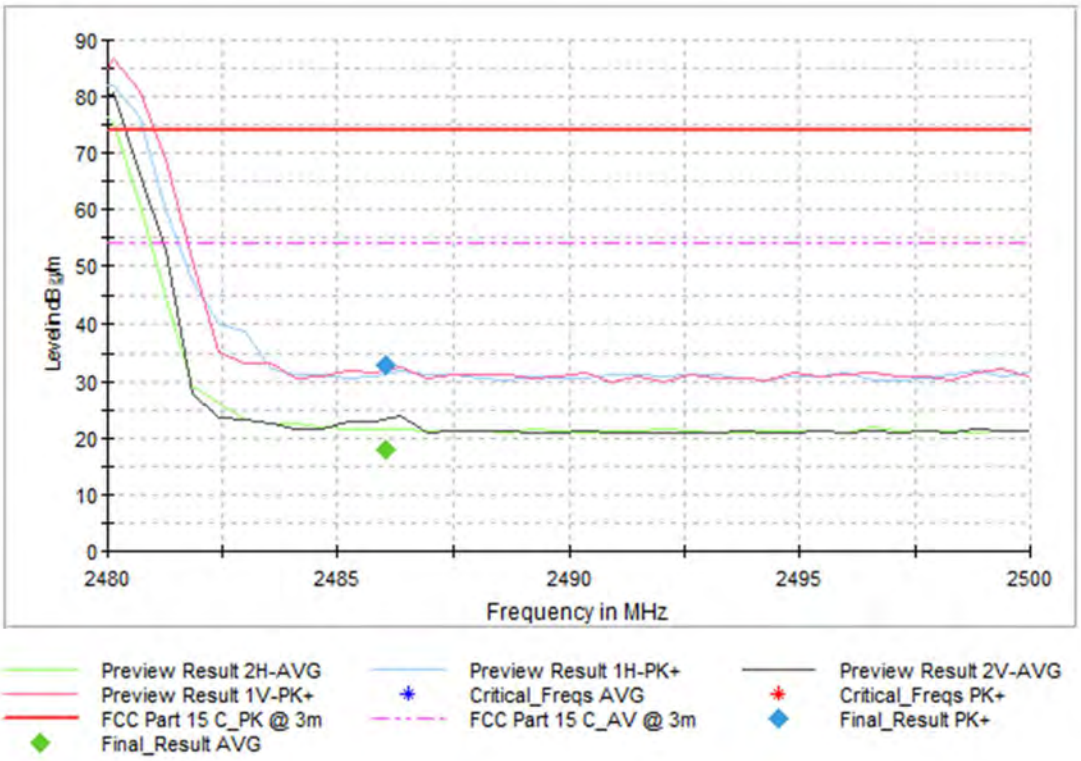
1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 1 GHz ~ 18 GHz



- Restricted Band



Test Mode – GFSK 2 Mbps – Lowest Channel - 2 402 MHz

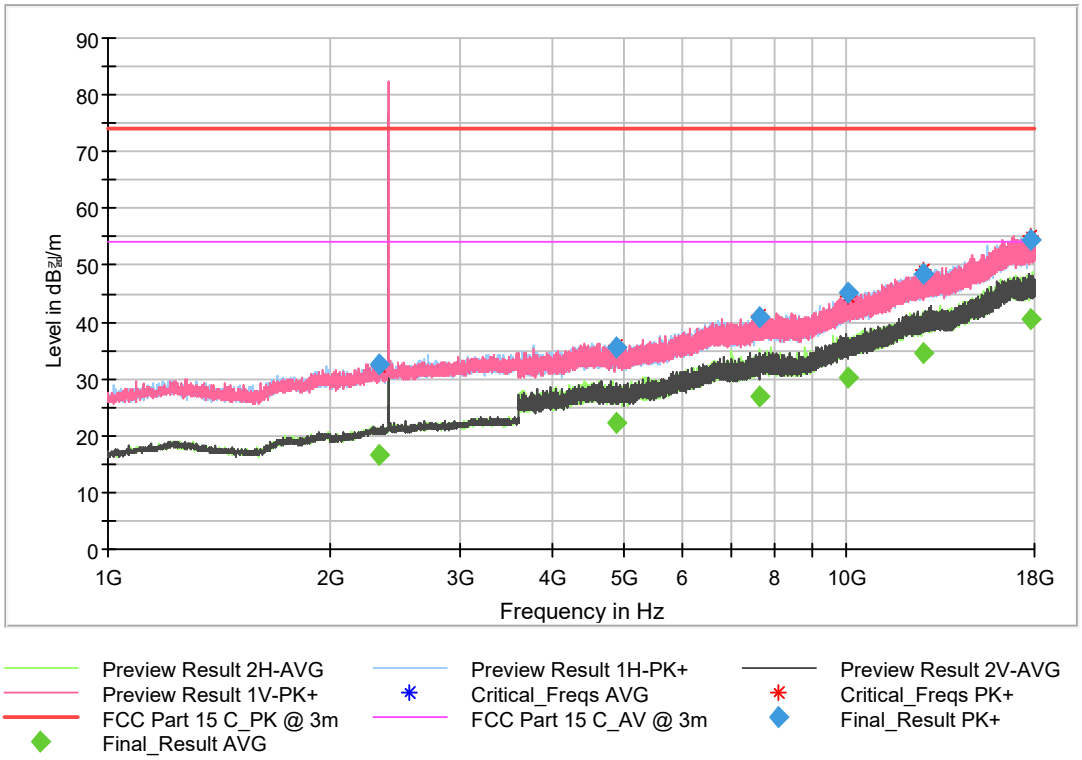
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
#2 486.05	---	17.78	54.00	36.22	1000.0	100.0	V	82.0	1.08
#2 486.05	32.82	---	74.00	41.18	1000.0	100.0	V	82.0	1.08
4 479.22	---	22.36	54.00	31.64	1000.0	200.0	V	0.0	4.75
4 479.22	35.76	---	74.00	38.24	1000.0	200.0	V	0.0	4.75
6 589.11	39.04	---	74.00	34.96	1000.0	200.0	H	56.0	8.98
6 589.11	---	25.94	54.00	28.06	1000.0	200.0	H	56.0	8.98
10 111.10	45.07	---	74.00	28.93	1000.0	200.0	H	5.0	13.54
10 111.10	---	30.21	54.00	23.79	1000.0	200.0	H	5.0	13.54
#13 251.40	---	34.72	54.00	19.28	1000.0	200.0	H	314.0	18.1
#13 251.40	48.26	---	74.00	25.74	1000.0	200.0	H	314.0	18.1
#17 735.98	---	40.71	54.00	13.29	1000.0	300.0	V	35.0	23.76
#17 735.98	54.20	---	74.00	19.80	1000.0	300.0	V	35.0	23.76

Note :

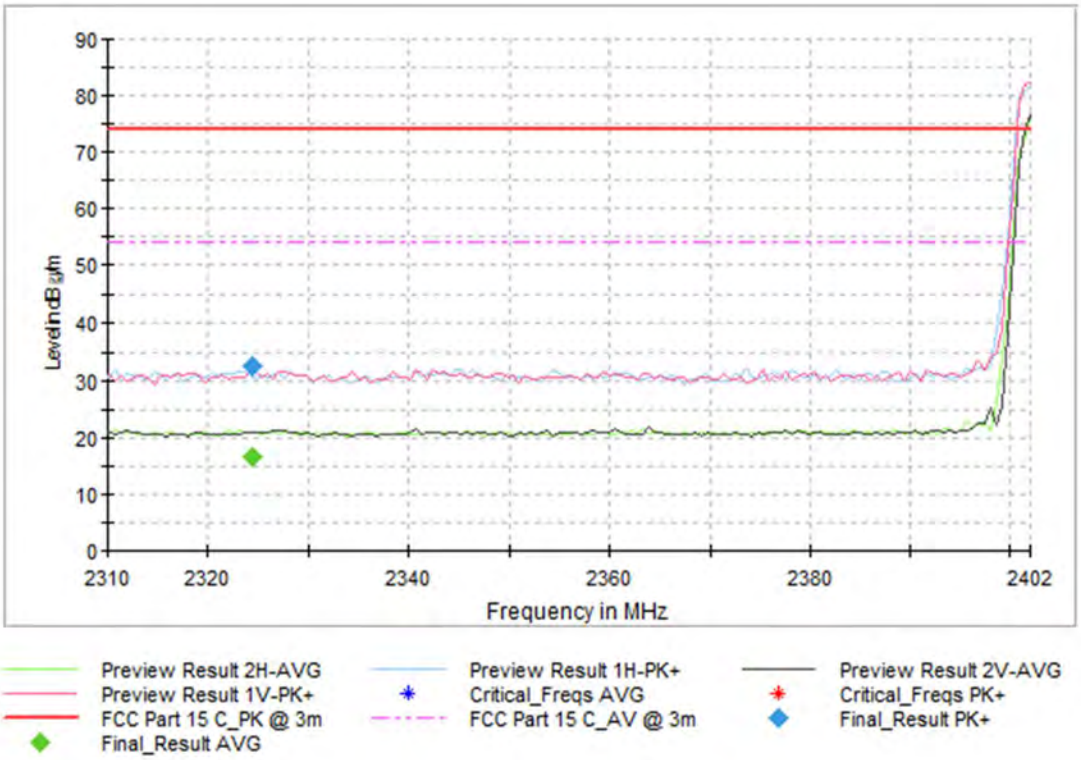
1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 1 GHz ~ 18 GHz



- Restricted Band



Test Mode – GFSK 2 Mbps – Middle Channel - 2 440 MHz

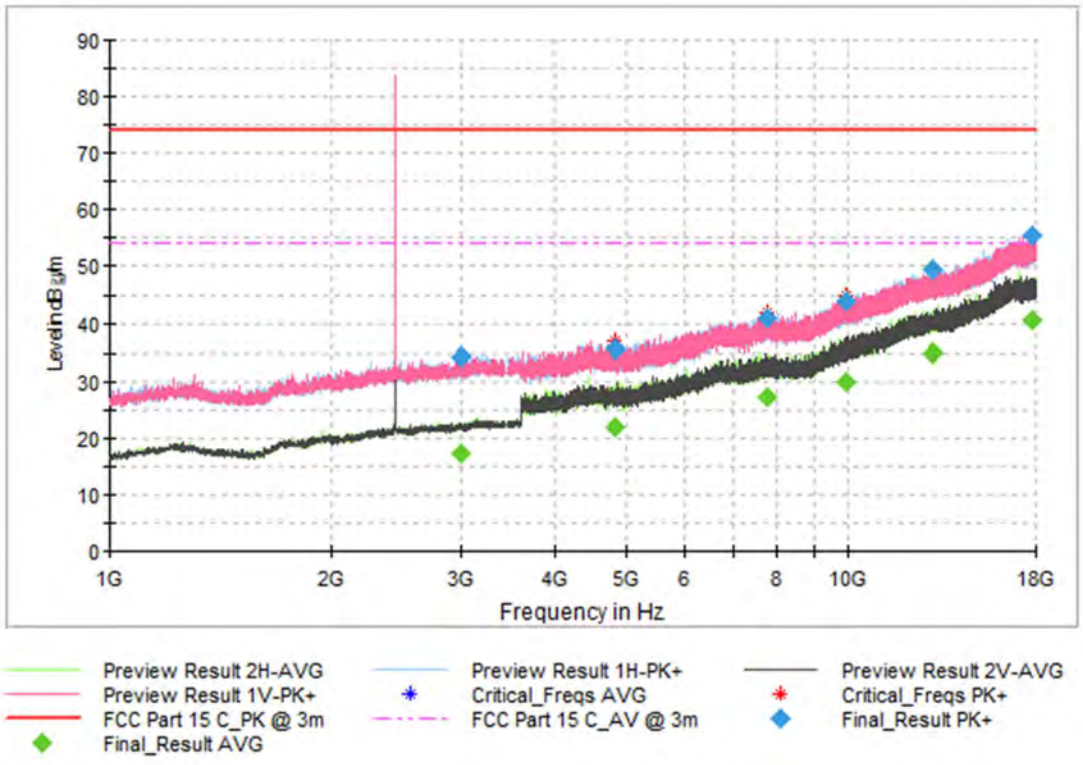
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
2 997.960	---	17.37	54.00	36.63	1000.0	300.0	V	10.0	1.95
2 997.960	34.21	---	74.00	39.79	1000.0	300.0	V	10.0	1.95
#4 824.690	---	22.00	54.00	32.00	1000.0	100.0	H	169.0	4.58
#4 824.690	35.69	---	74.00	38.31	1000.0	100.0	H	169.0	4.58
7 756.580	40.89	---	74.00	33.11	1000.0	100.0	H	139.0	10.27
7 756.580	---	27.09	54.00	26.91	1000.0	100.0	H	139.0	10.27
9 959.190	---	29.97	54.00	24.03	1000.0	300.0	V	0.0	13.3
9 959.190	43.93	---	74.00	30.07	1000.0	300.0	V	0.0	13.3
13 038.070	49.49	---	74.00	24.51	1000.0	100.0	H	359.0	17.9
13 038.070	---	34.75	54.00	19.25	1000.0	100.0	H	359.0	17.9
#17 794.950	---	40.62	54.00	13.38	1000.0	300.0	H	353.0	23.75
#17 794.950	55.31	---	74.00	18.69	1000.0	300.0	H	353.0	23.75

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 1 GHz ~ 18 GHz



Test Mode – GFSK 2 Mbps – Highest Channel - 2 480 MHz

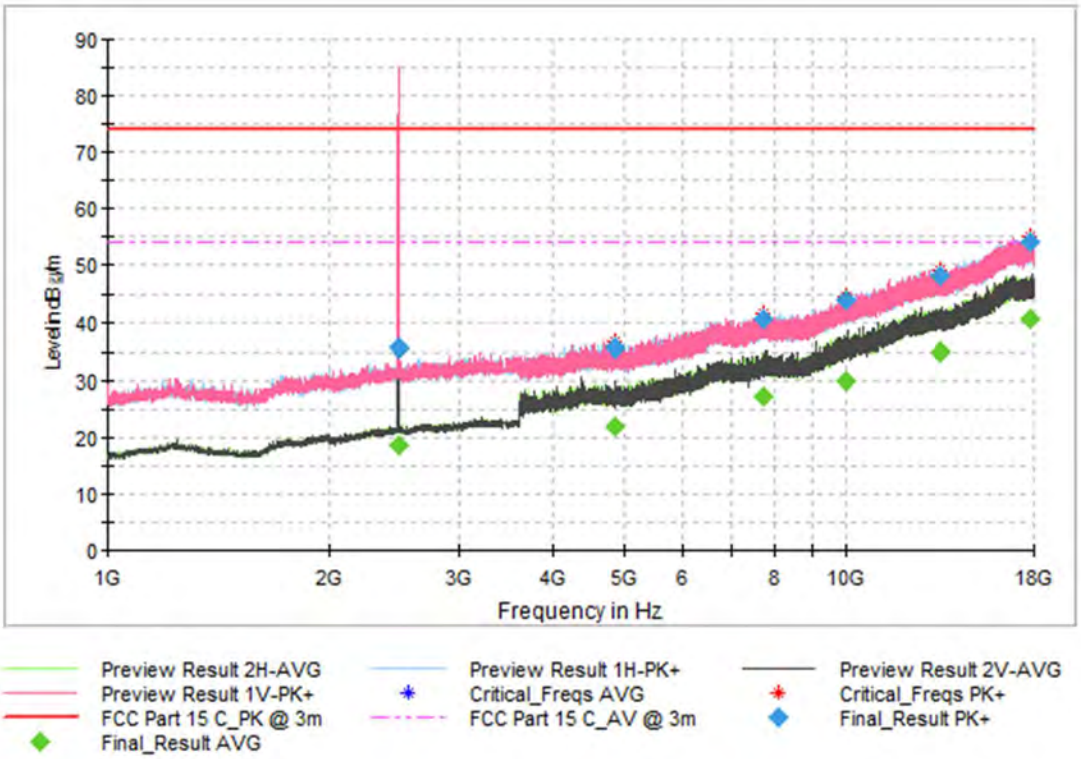
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
#2 484.190	35.69	---	74.00	38.31	1000.0	100.0	V	41.0	1.08
#2 484.190	---	18.52	54.00	35.48	1000.0	100.0	V	41.0	1.08
#4 848.940	---	21.96	54.00	32.04	1000.0	200.0	H	0.0	4.63
#4 848.940	35.62	---	74.00	38.38	1000.0	200.0	H	0.0	4.63
#7 710.640	40.67	---	74.00	33.33	1000.0	100.0	V	354.0	10.17
#7 710.640	---	27.12	54.00	26.88	1000.0	100.0	V	354.0	10.17
9 987.190	43.84	---	74.00	30.16	1000.0	100.0	H	0.0	13.4
9 987.190	---	30.01	54.00	23.99	1000.0	100.0	H	0.0	13.4
13 422.930	---	34.87	54.00	19.13	1000.0	200.0	H	108.0	18.25
13 422.930	48.28	---	74.00	25.72	1000.0	200.0	H	108.0	18.25
#17 837.660	54.22	---	74.00	19.78	1000.0	100.0	H	137.0	23.76
#17 837.660	---	40.63	54.00	13.37	1000.0	100.0	H	137.0	23.76

Note :

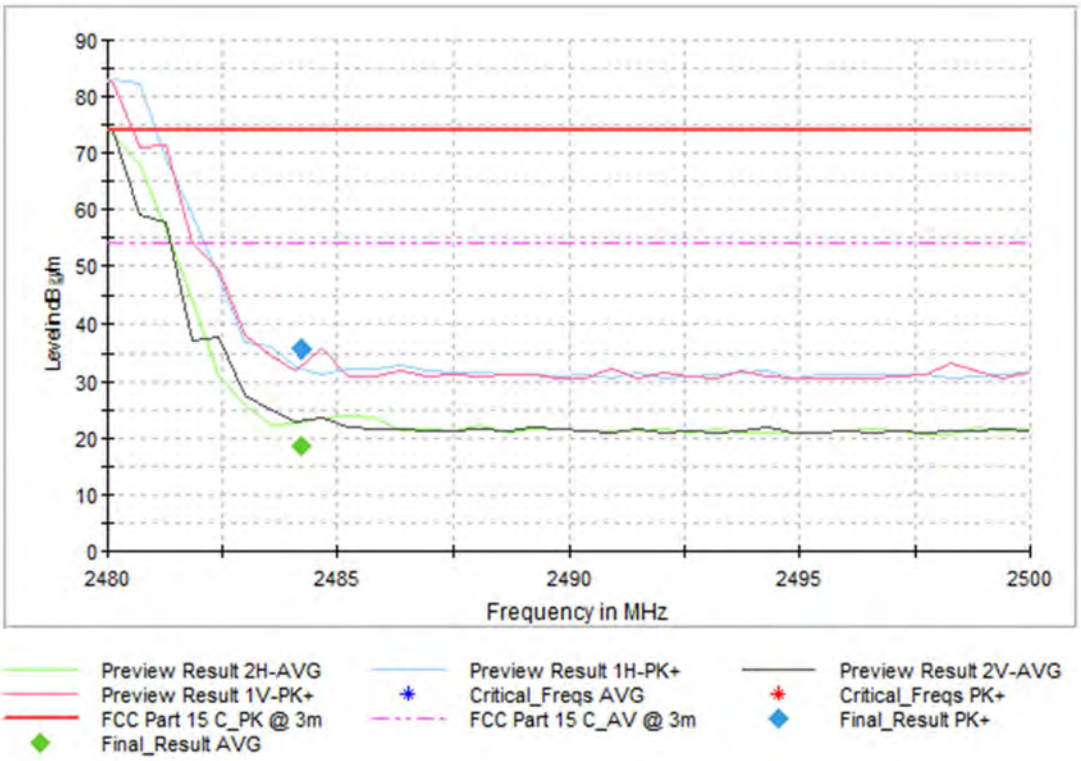
1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 1 GHz ~ 18 GHz



- Restricted Band



18 GHz ~ 26.5 GHz

Test Mode – GFSK 1 Mbps – Lowest Channel - 2 402 MHz

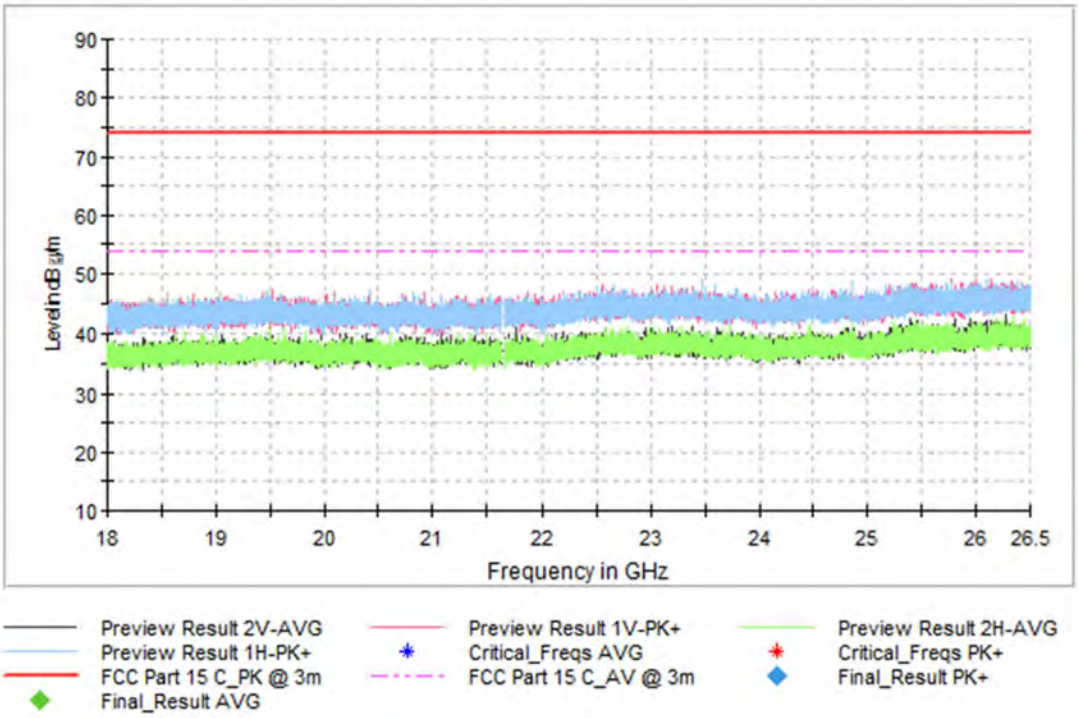
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
No spurious emissions were detected within 20 dB of the limit.									

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 18 GHz ~ 26.5 GHz



Test Mode – GFSK 1 Mbps – Middle Channel - 2 440 MHz

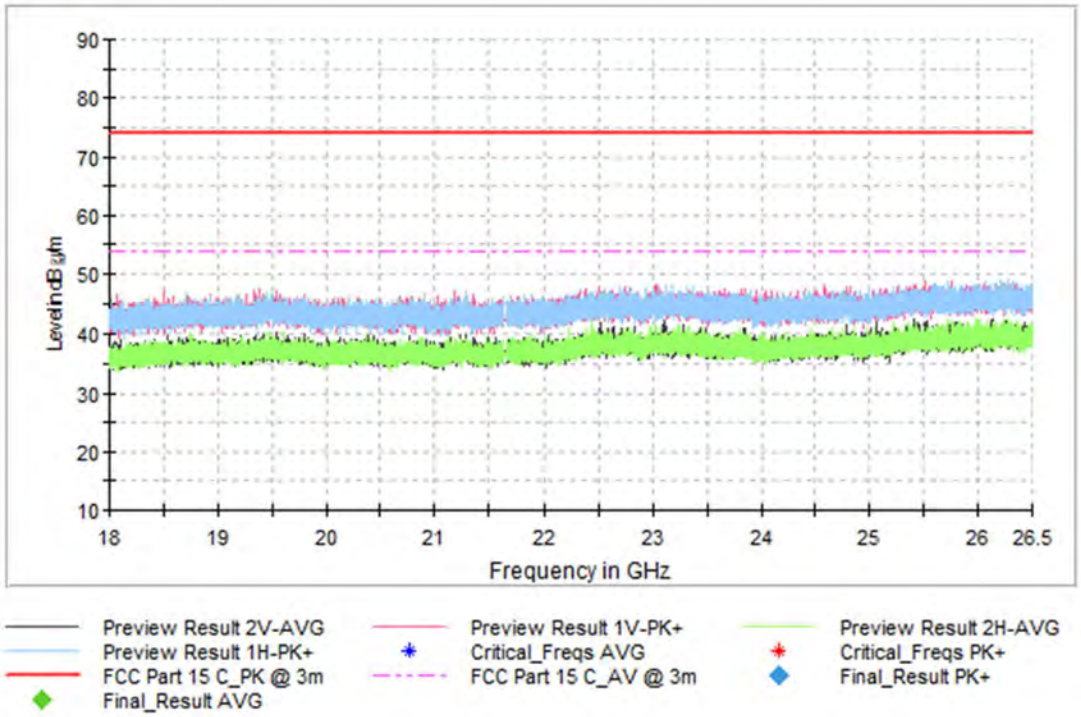
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
No spurious emissions were detected within 20 dB of the limit.									

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 18 GHz ~ 26.5 GHz



Test Mode – GFSK 1 Mbps – Highest Channel - 2 480 MHz

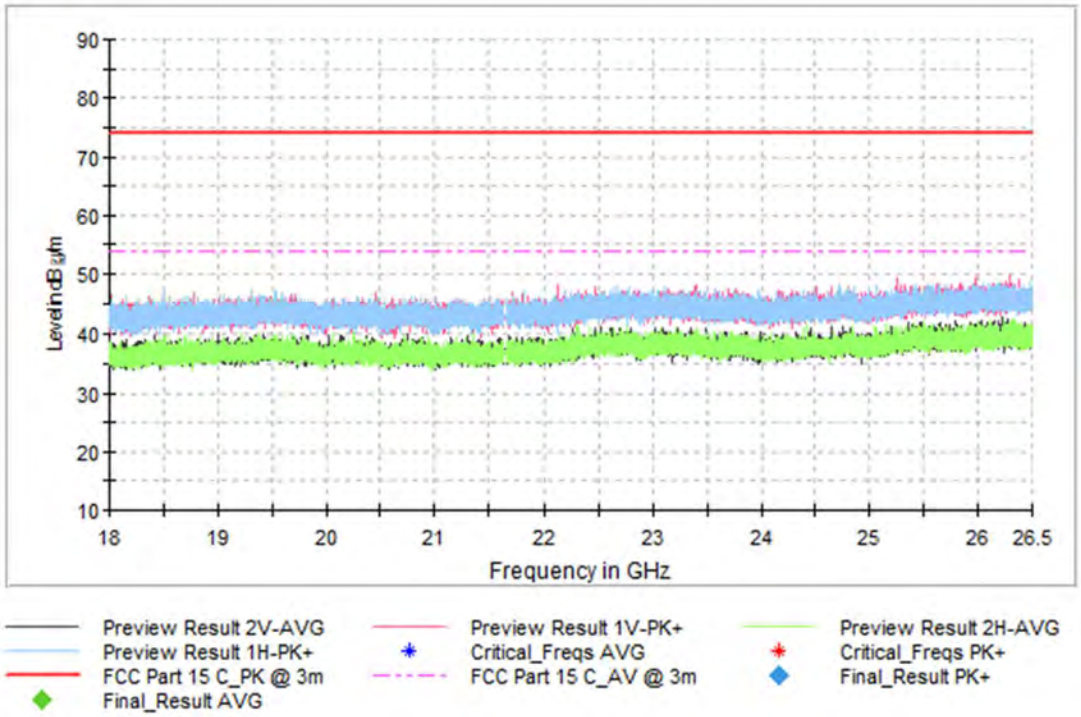
Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
No spurious emissions were detected within 20 dB of the limit.									

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 18 GHz ~ 26.5 GHz



Test Mode – GFSK 2 Mbps – Lowest Channel - 2 402 MHz

Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
No spurious emissions were detected within 20 dB of the limit.									

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 18 GHz ~ 26.5 GHz

Test Mode – GFSK 2 Mbps – Middle Channel - 2 440 MHz

Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
No spurious emissions were detected within 20 dB of the limit.									

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 18 GHz ~ 26.5 GHz

Test Mode – GFSK 2 Mbps – Highest Channel - 2 480 MHz

Frequency [MHz]	MaxPeak [dB(µV)/m]	Average [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Bandwidth [kHz]	Height [cm]	Pol.	Azimuth [deg]	Corr. [dB/m]
No spurious emissions were detected within 20 dB of the limit.									

Note :

1. According to § 15.31(o), Emission levels are not reported much lower than the limits by over 20 dB.
2. "#" means the restricted band.
3. Maxpeak & Average = Reading value[dB(µV)] + Corr.[dB/m]

Test Data

- 18 GHz ~ 26.5 GHz

6. Conducted Emissions

6.1 Rule

According to §15.207(a), 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 Ω 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 range (MHz)	Limits dB(µV)			
	Quasi-peak		Average	
	Class A	Class B	Class A	Class B
0.15 to 0.50	79	66 to 56	66	56 to 46
0.50 to 5	73	56	60	46
5 to 30		60		50

Note 1 The lower limit shall apply at the transition frequencies.
Note 2 The limit decreases linearly with the logarithm of the frequency in the range (0.15 ~ 0.5) MHz.
Note 3 Result (dBµV) = Reading (dBµV) + Corr. (Insertion Loss (dB) + Cable Loss (dB))
Result: Final value, Reading: Receiver reading value, Corr.: Correction Factor
Margin = Limit – Result

6.2 Measurement Procedure

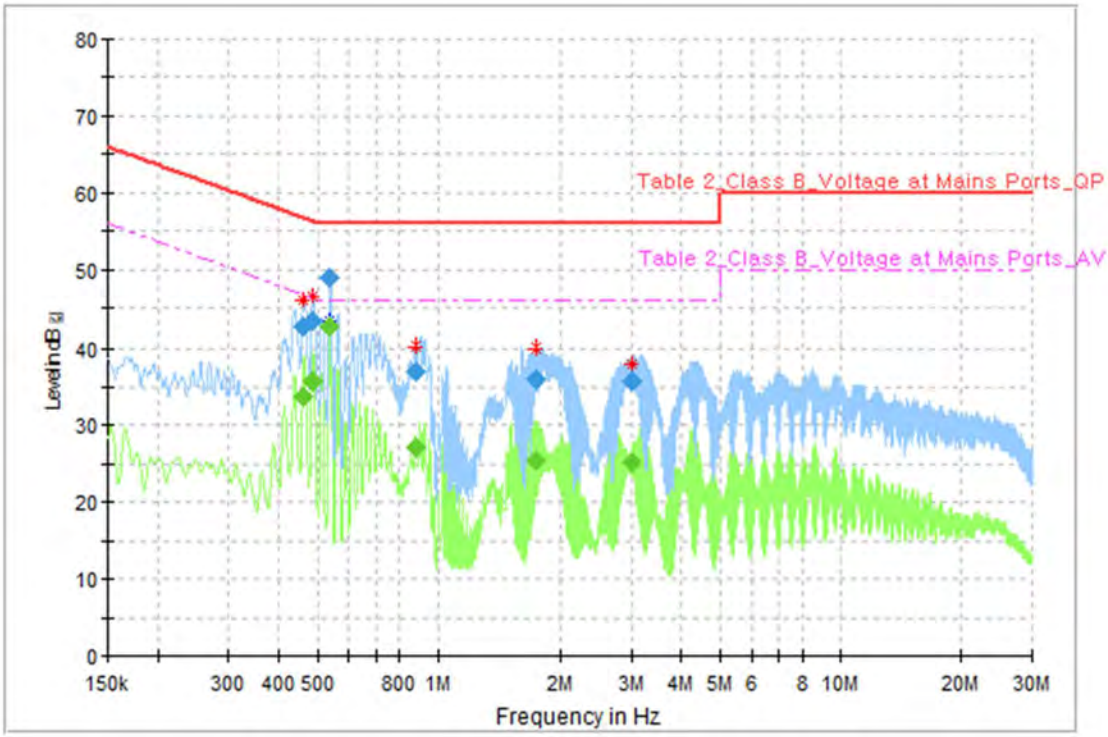
All data rates and modes were investigated for this test. The full data for the worst case data rate are reported in this section.

AC line conducted emissions from the EUT were measured according to the dictates of ANSI C63.10-2013

1. The test procedure is performed in a 6.5 m × 3.6 m × 3.6 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. The excess power cable between the EUT and the LISN was bundled. All connecting cables of EUT were moved to find the maximum emission.

6.3 Test result – Complied

- Neutral / Live



Frequency [MHz]	QuasiPeak [dB(µV)/m]	CAverage [dB(µV)/m]	Limit [dB(µV/m)]	Margin [dB]	Corr. [dB/m]
0.459445	---	33.82	46.70	12.88	10.0
0.459445	42.58	---	56.70	14.13	10.0
0.485315	---	35.74	46.25	10.51	10.0
0.485315	43.42	---	56.25	12.83	10.0
0.538050	---	42.61	46.00	3.39	10.0
0.538050	48.98	---	56.00	7.02	10.0
0.879335	---	27.13	46.00	18.87	9.9
0.879335	37.06	---	56.00	18.94	9.9
1.742995	---	25.52	46.00	20.48	10.0
1.742995	36.03	---	56.00	19.97	10.0
3.006645	---	25.20	46.00	20.80	10.0
3.006645	35.61	---	56.00	20.39	10.0

SECTION 5 REVISION HISTORY

REVISION HISTORY			
Revision	Report No.	Issue Date	Description
0	210100083SEL-TEL1	26 Apr. 2021	Initial

- End -