

FCC & ISCED CERTIFICATION TEST REPORT

Project Number : EA1912C-014
Test Report Number : TR-W1912-002
Type of Equipment : BLE Module
Model Name : CRM-24B
FCC ID : CCECRM-24B
ISED Canada ID : 22254-CRM24B
Multiple Model Name : N/A
Applicant : COMMAX Co., Ltd.
Address : 494 Dunchon-Daero, Jungwon-Gu, Seongnam-si, Gyeonggi-do,
South Korea
Manufacturer : COMMAX Co., Ltd.
Address : 494 Dunchon-Daero, Jungwon-Gu, Seongnam-si, Gyeonggi-do,
South Korea
Regulation : FCC Part 15 Subpart C Section 15.247, ISCED RSS-247 Issue2
Total page of Report : 52 Pages
Date of Receipt : 2019-11-12
Date of Issue : 2019-12-05
Test Result : PASS

This test report only contains the result of a single test of the sample supplied for the examination.
It is not a generally valid assessment of the features of the respective products of the mass-production.

Prepared by	Song, In-young / Senior Engineer		2019-12-05
		Signature	Date
Reviewed by	Choi, Yeong-min / Technical Manager		2019-12-05
		Signature	Date

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Release Control Record

Issue Report No.	Issued Date	Details/Revisions
TR-W1912-002	2019-12-05	Initial Release
-	-	-

1. TEST SUMMARY

1.1 Regulations and results

The sample submitted for evaluation (Hereafter referred to as the EUT) has been tested in accordance with the following regulations or standards.

FCC Reference Section	ISED Reference Section	Description	Result			
			P	F	N.T.	Note
15.247(a)(2)	RSS-247 5.2 a)	6 dB Bandwidth Occupied Bandwidth	P			
15.247(b)(3)	RSS-247 5.4 d)	Maximum peak output power	P			
15.247(d)	RSS-247 5.5	Band Edge Conducted spurious emission	P			
15.247(e)	RSS-247 5.2 b)	Power spectral density	P			
15.205(a) 15.209(a)	RSS 247 5.5 RSS-GEN 8.9	Radiated spurious emissions	P			
15.207(a)	RSS GEN 8.8	AC power line conducted emissions	P			
Remark: P means Passed F means Failed N.T. means Not Tested						

1.2 Test Methodology

The tests mentioned in clause 1.1 in this test report were performed according to FCC CFR 47 Part 2, CFR 47 Part 15 and ANSI C63.10-2013, and RSS-Gen Issue 4.

KDB 558074 D01DTS Meas. Guidance v05r02: Measurement Procedure PK is used for power measurement.

1.3 Additions, deviations, exclusions from standards

No additions, deviations or exclusions have been made from standard.

1.4 Purpose of the test

The test was performed to determine whether the equipment under test fulfills the requirements of the regulation stated in FCC Part 15 Subpart C Section 15.247, RGG-Gen and RSS-247.

1.5 Test Facility

The measurement facilities are located at 135-60 Gyeongchung-daero, Gonjam-eup, Gwangju-si, Gyeonggi-do 12813, Korea. Our test facilities are accredited as a Conformity Assessment Body (CAB) by the FCC and ISED Canada, designated by the RRA (National Radio Research Agency), and accredited by KOLAS (Korea Laboratory Accreditation Scheme) in Korea and approved by TUV Rheinland, TUV SÜD and Korean Register of Shipping according to the requirement of ISO/IEC 17025.

Laboratory Qualification	Registration No.	Mark
FCC	KR0160	
ISED Canada	12721A	
RRA	KR0160	
TUV Rheinland	UA 50314109-0002	
TUV SÜD	CARAT 094465 0004 Rev.00	
Korean Agency for Technology and Standards	KT733	
KOREAN REGISTER OF SHIPPING	PCT40841-TL001	

Remark. This report is not related to KOLAS accreditation and relevant regulation.

2. EUT (Equipment Under Test) INFORMATION

2.1 General Description

The COMMAX Co., Ltd., Model CRM-24B (referred to as the EUT in this report) is a BLE Module. The EUT is a device for transferring Bluetooth low energy signal to a Bluetooth low energy Device through wireless communication. The product specification described herein was obtained from product data sheet or user's manual.

Operating Frequency	2 402 MHz ~ 2 480 MHz
Kind of Class	DTS – Digital Transmission System
Max. RF Output Power	0.76 dBm
Modulation Types	GFSK
Number of Channels	40 CH
Channel Bandwidth	2 MHz
Generated or used Freq. in EUT	32.768 kHz, 16 MHz
Type of Antenna	☒ Integrated Type ☐ Dedicated Type
Antenna Gain	3.90 dBi
Operating Temperature	- 40 °C ~ + 85 °C
Normal Test Voltage	DC 3.3 V
Electrical Rating	DC 3.3 V
Test SW Version	Tera Term Version 4.91
RF power setting in TEST SW	04
Software Version	191114
Hardware Version	2.01

2.2 Additional Model

None

2.3 Available channel number and frequency

Operating Mode: Bluetooth LE, 2 MHz Channel Spacing					
Channel	Frequency(MHz)	Channel	Frequency(MHz)	Channel	Frequency(MHz)
0	2 402	14	2 430	28	2 458
1	2 404	15	2 432	29	2 460
2	2 406	16	2 434	30	2 462
3	2 408	17	2 436	31	2 464
4	2 410	18	2 438	32	2 466
5	2 412	19	2 440	33	2 468
6	2 414	20	2 442	34	2 470
7	2 416	21	2 444	35	2 472
8	2 418	22	2 446	36	2 474
9	2 420	23	2 448	37	2 476
10	2 422	24	2 450	38	2 478
11	2 424	25	2 452	39	2 480
12	2 426	26	2 454		
13	2 428	27	2 456		

3. TEST CONDITION

3.1 Equipment Used During Test

The following peripheral devices and/or interface cables were connected during the measurement:

Description	Model No.	Serial No.	Manufacturer.
BLE Module (EUT)	CRM-24B	N/A	COMMAX Co., Ltd.
Notebook PC	E5470	ZU10190-15008	DELL
Adapter for Notebook PC	LA65NM130	N/A	DELL

3.2 Mode of operation during the test

Software used to control the EUT for staying in continuous transmitting mode is programmed.

The used modulation type for the testing is GFSK.

3.3 Preliminary Testing for Worst case configuration

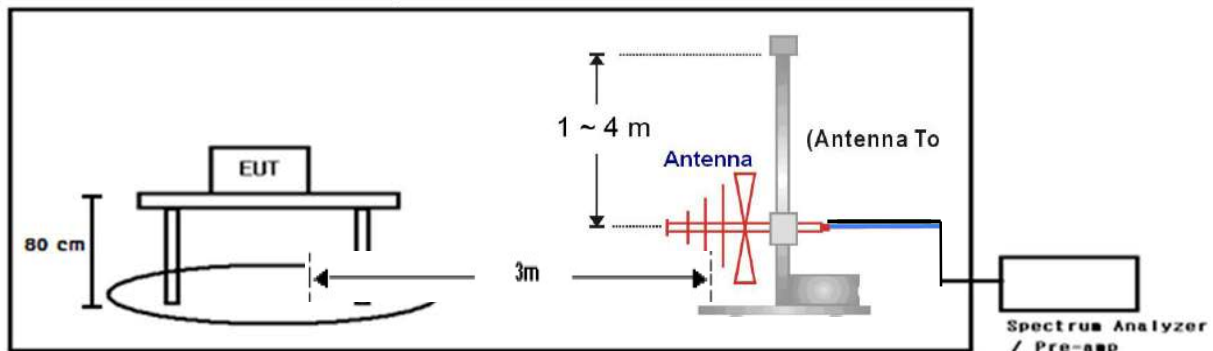
For finding worst case configuration and operating mode, preliminary testing was performed and radiated emission and conducted emission tests were performed with the EUT set to transmit and receive at the channel with the highest output power as worst case scenario. All spurious emission tests were performed in X, Y and Z axis direction. And the worst Z-axis (9 kHz ~ 30 MHz), Y-axis (30 MHz ~ 1 GHz, Above 1 GHz) test condition was recorded in this test report.

Based on preliminary testing following operating modes were selected for the final test as listed below.

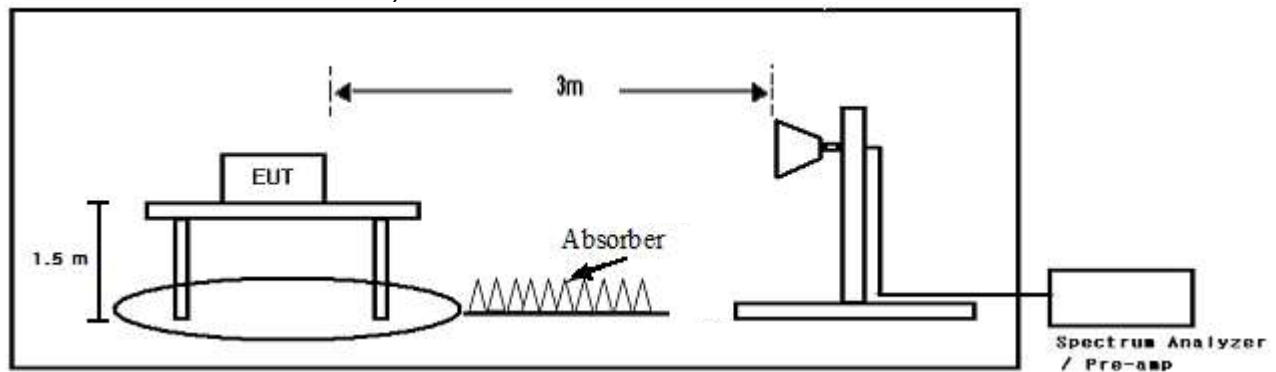
3.3.1 Test Channel and Frequency

Operating Mode	Test Channel	Frequency
Bluetooth Low Energy	Low Channel	2 402 MHz
	Middle Channel	2 440 MHz
	High Channel	2 480 MHz

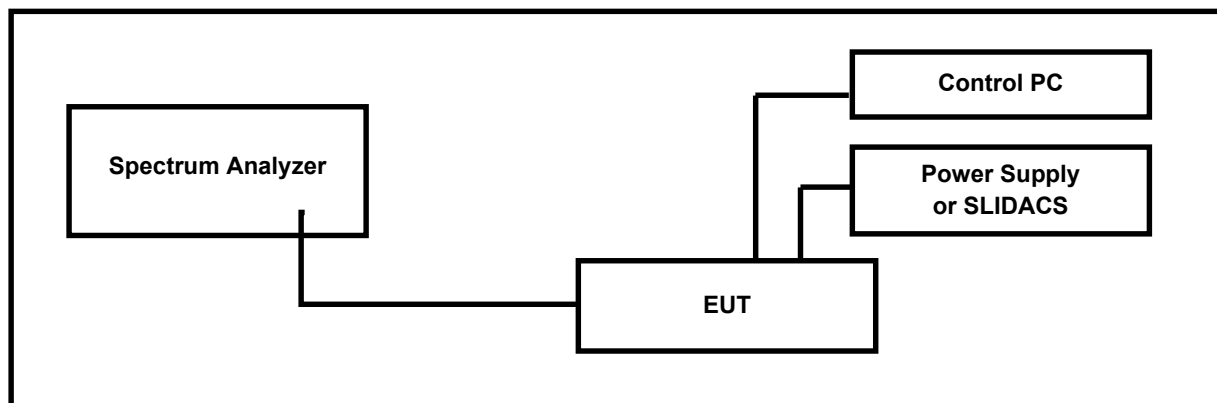
3.4 Test Setup Drawing (Radiated Test below 1 GHz)



(Radiated Test above 1 GHz)



(Conducted Test)



3.5 EUT Modifications

- No EMC Relevant Modifications were performed by this test laboratory.

4. ANTENNA REQUIREMENT

According to FCC CFR 47 Part 15 section 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 provision of this section.

4.1 Antenna Description

Frequency Band (GHz)	Antenna Type	Max Peak Gain (dBi)	Connector Type
2.4	PCB Pattern Antenna	3.90	-

4.2 Conclusion

The antenna connector type of the EUT is PCB Pattern Antenna, so the EUT met the requirement.

5. TEST RESULT

5.1 6 dB Bandwidth

5.1.1 Limit

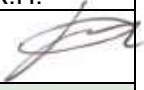
The minimum 6 dB bandwidth shall be at least 500 kHz acc to Section 15.247 (a) (2), and RSS-247 5.2 (a).

5.1.2 Method of Measurement

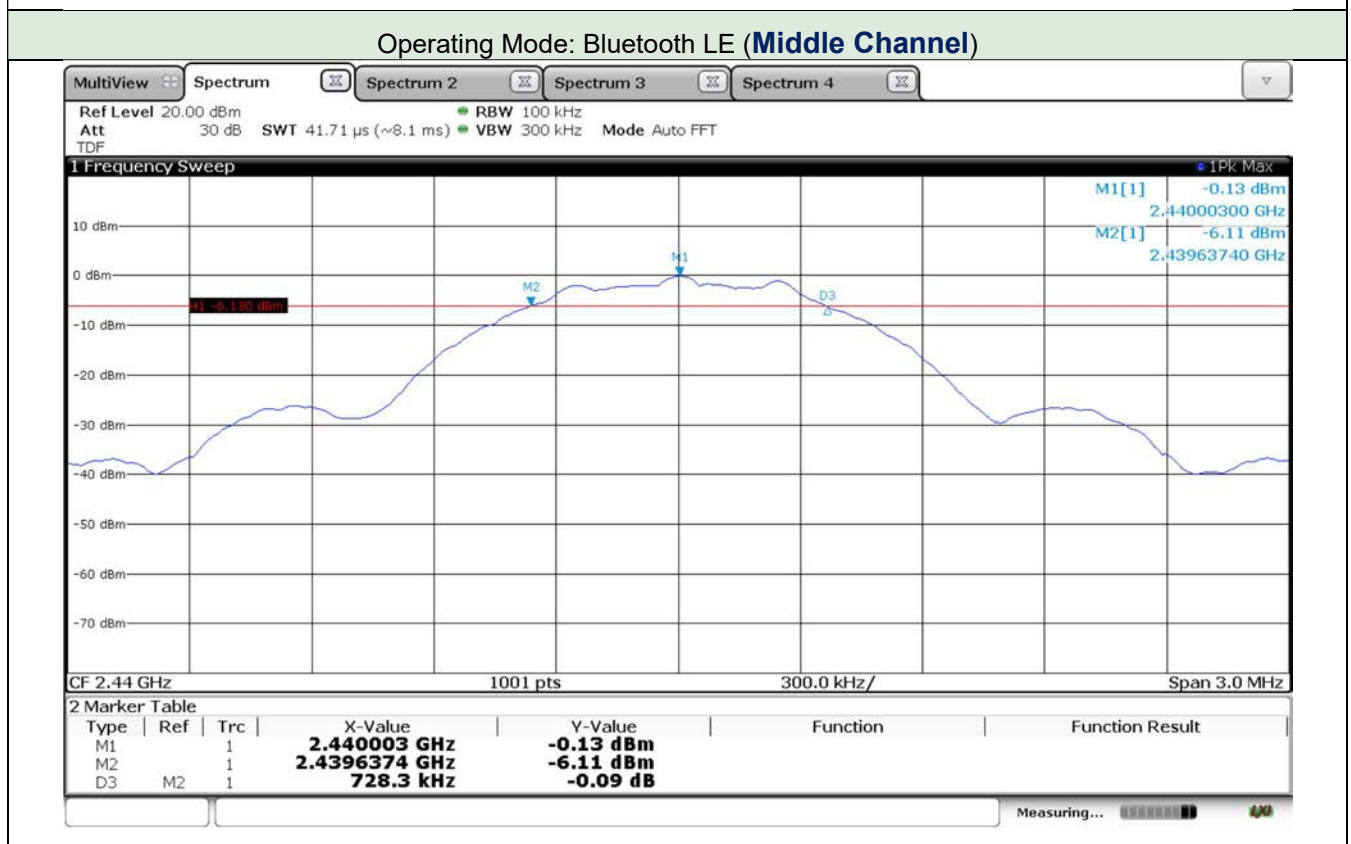
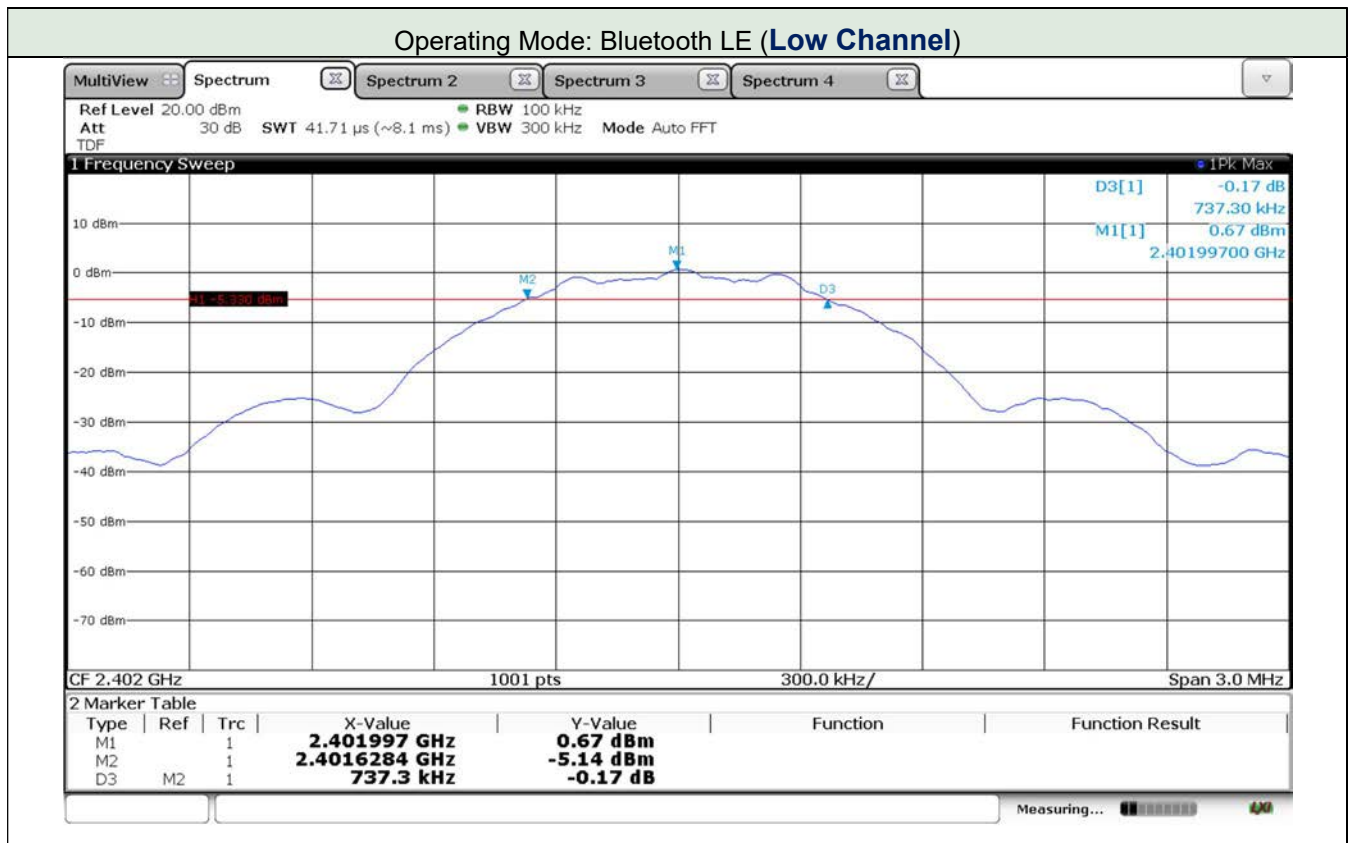
Reference to KDB 558074 D01 DTS Meas Guidance v05r02: 8.2

The transmitter output is connected to a spectrum analyzer with the RBW set to 100 kHz, VBW $\geq 3 \times$ RBW, peak detector and max hold.

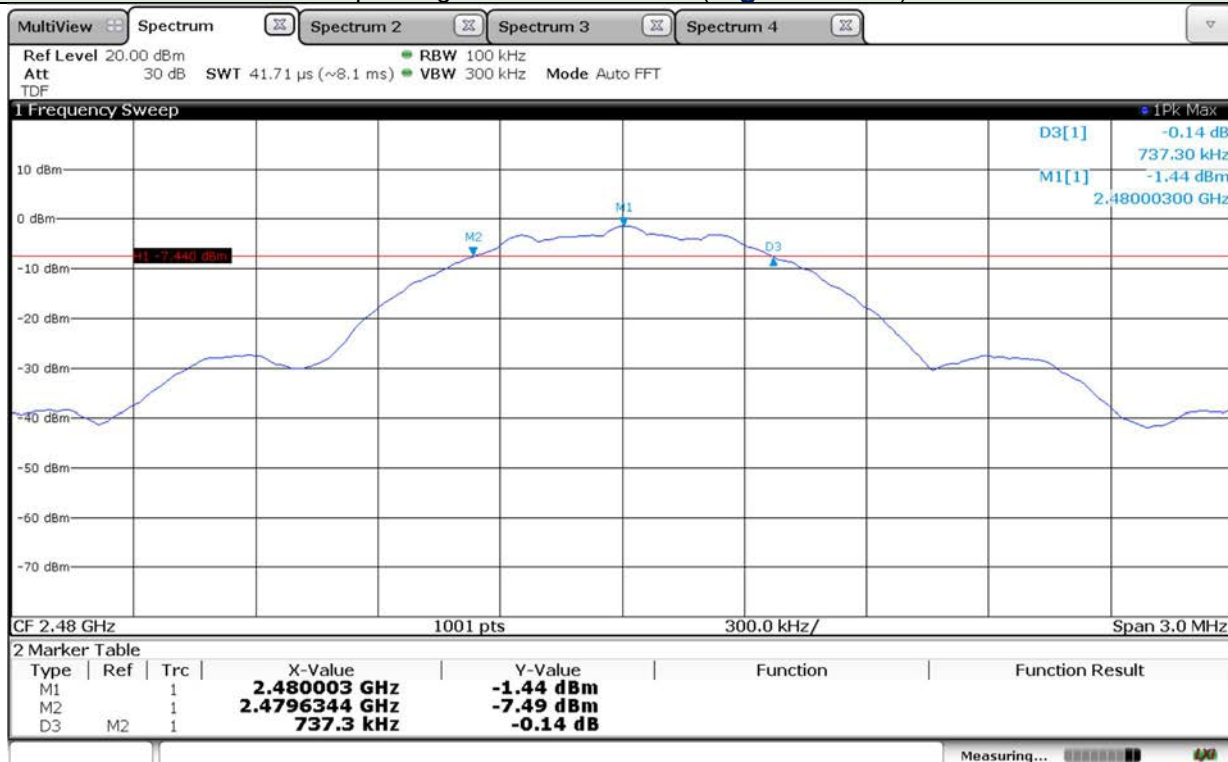
5.1.3 Test Data

Date of Test	2019-11-29	Temperature	(22.5 $\pm$ 0.5) °C
		Relative humidity	(41.1 $\pm$ 3.1) % R.H.
Test Result	PASS	Tested by	Do-heon Kim 
Operating Mode: Bluetooth LE			
Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)
Low	2 402	0.74	0.5
Middle	2 440	0.73	
High	2 480	0.74	

5.1.4 Test Plots



Operating Mode: Bluetooth LE (High Channel)



5.2 99 % Bandwidth

5.2.1 Limit

Not applicable.

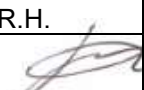
5.2.2 Method of Measurement

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1 % to 5 % of the OBW.

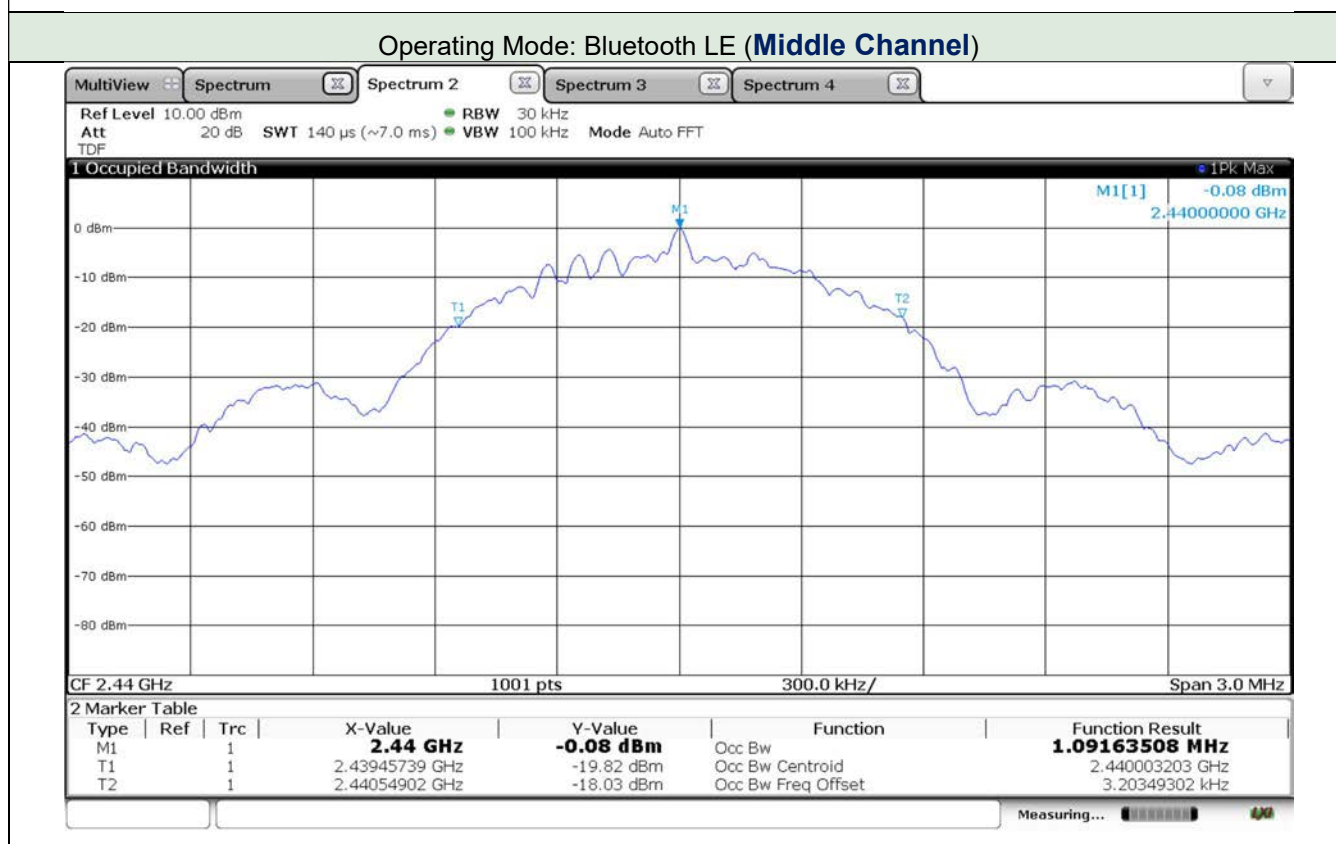
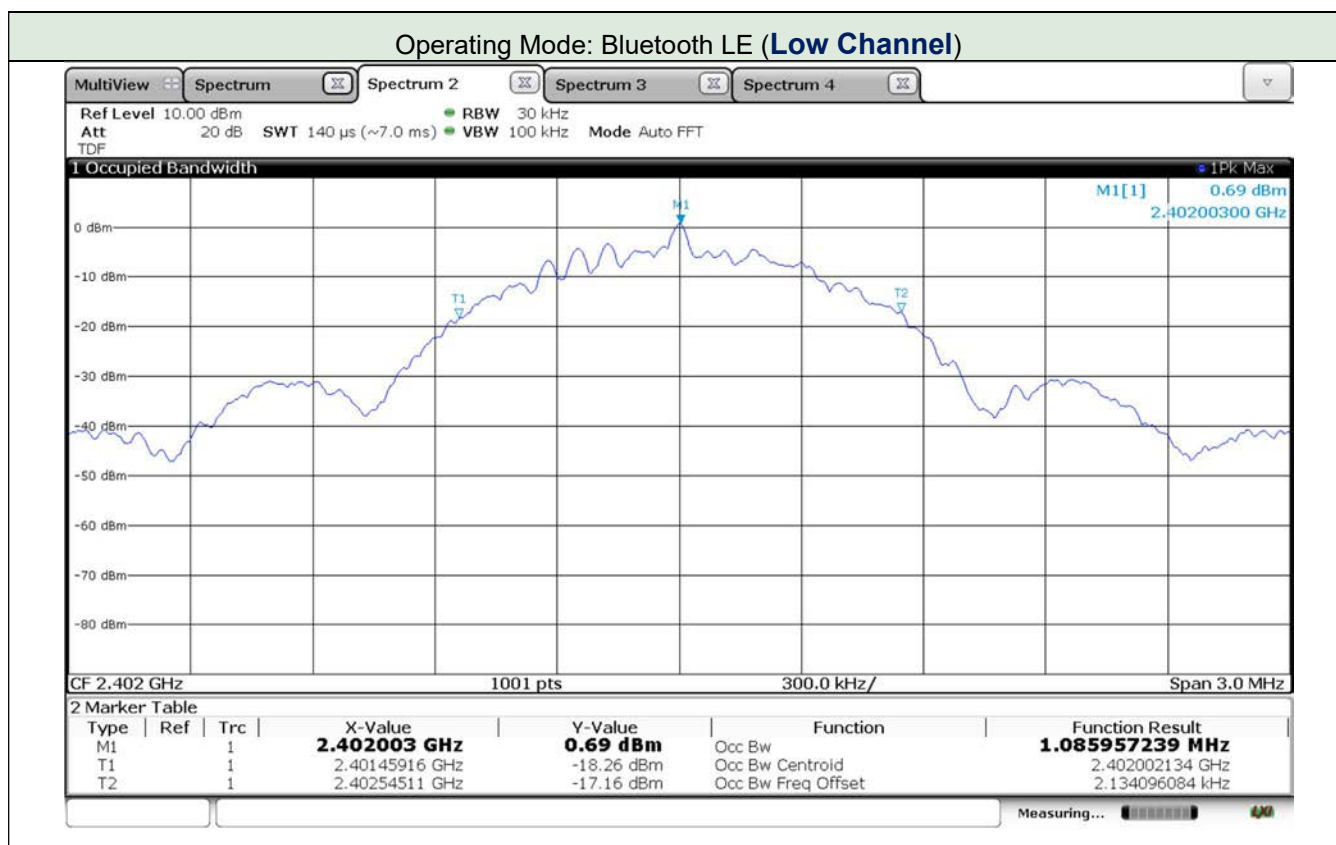
The span is set to capture all products of the modulation process, including the emission skirts.

The VBW is set to 3 times the RBW. The sweep time is coupled and peak detection and max hold mode is used. The spectrum analyzer internal 99% bandwidth function is utilized.

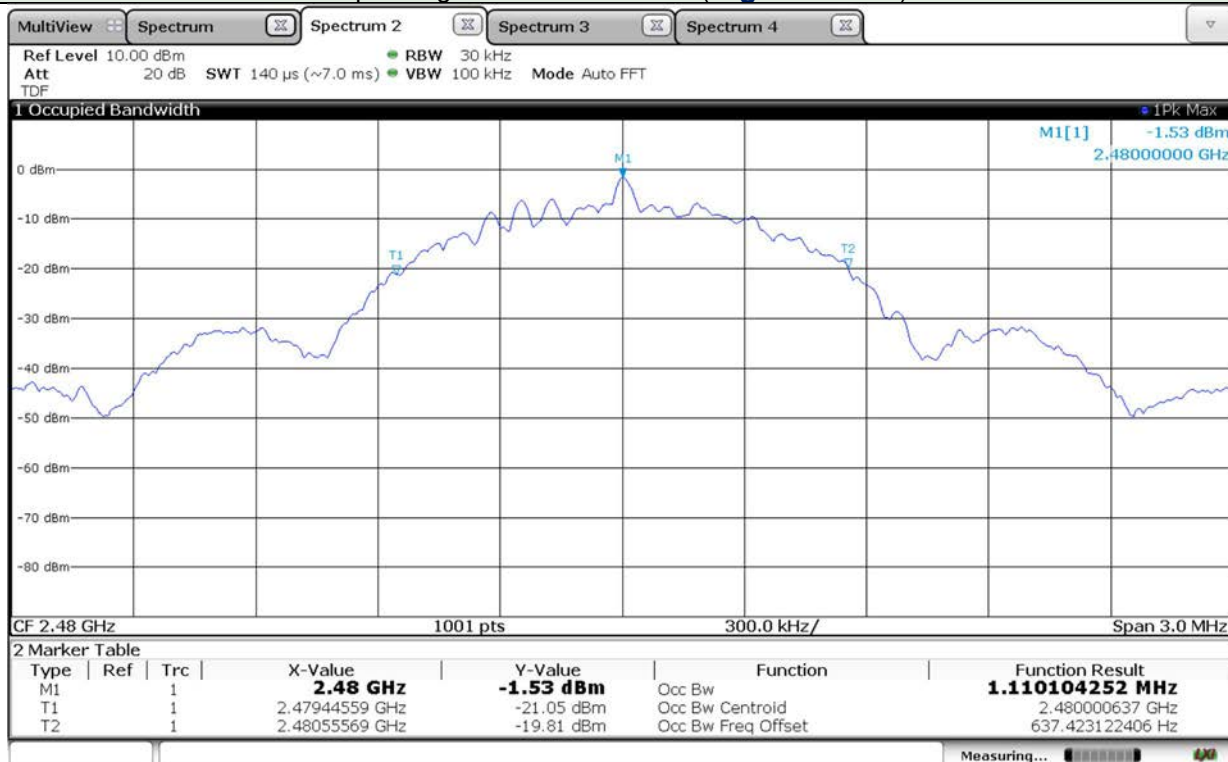
5.2.3 Test Data

Date of Test	2019-11-29	Temperature	(22.5 ± 0.5) °C
		Relative humidity	(41.1 ± 3.1) % R.H.
Test Result	PASS	Tested by	Do-heon Kim 
Operational Mode: Bluetooth LE			
Channel	Frequency (MHz)		99 % Bandwidth (MHz)
Low	2 402		1.09
Middle	2 440		1.09
High	2 480		1.11

5.2.4 Test Plots



Operating Mode: Bluetooth LE (High Channel)



5.3 Maximum Peak Output Power

5.3.1 Limit

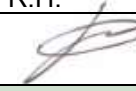
Acc. To section 15.247 and RSS-247 5.4 d), For system using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt, based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.3.2 Method of Measurement

Reference to KDB 558074 D01 DTS Meas Guidance v05r02: 8.3.1.1 RBW $\geq$ DTS bandwidth

The cable assembly insertion loss was entered as an offset in the spectrum analyzer to allow for direct reading of power.

5.3.3 Test Data for Output Power

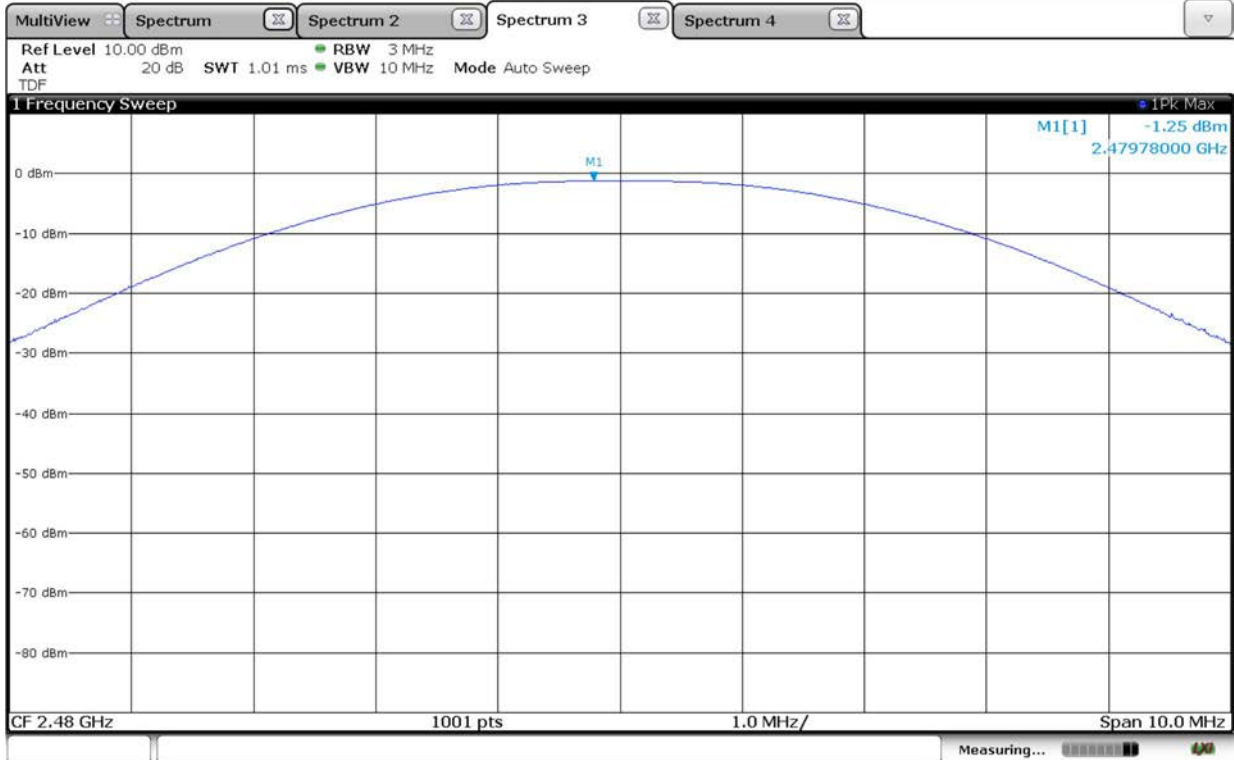
Date of Test	2019-11-29	Temperature	(22.5 ± 0.5) °C	
		Relative humidity	(41.1 ± 3.1) % R.H.	
Test Result	PASS	Tested by	Do-heon Kim 	
Operating Mode: Bluetooth LE				
Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402	0.76	30	29.24
Middle	2 440	0.22		29.78
High	2 480	-1.25		31.25

Remark. Margin = Limit – Measured Value

5.3.4 Test Plots



Operating Mode: Bluetooth LE (High Channel)



5.4 Peak Power Spectral Density

5.4.1 Limit

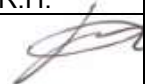
Acc. To section 15.247 and RSS-247 5.2 b), the power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.4.2 Method of Measurement

Reference to KDB 558074 D01 DTS Meas Guidance v05r02: 8.4 Method PKPSD (peak PSD).

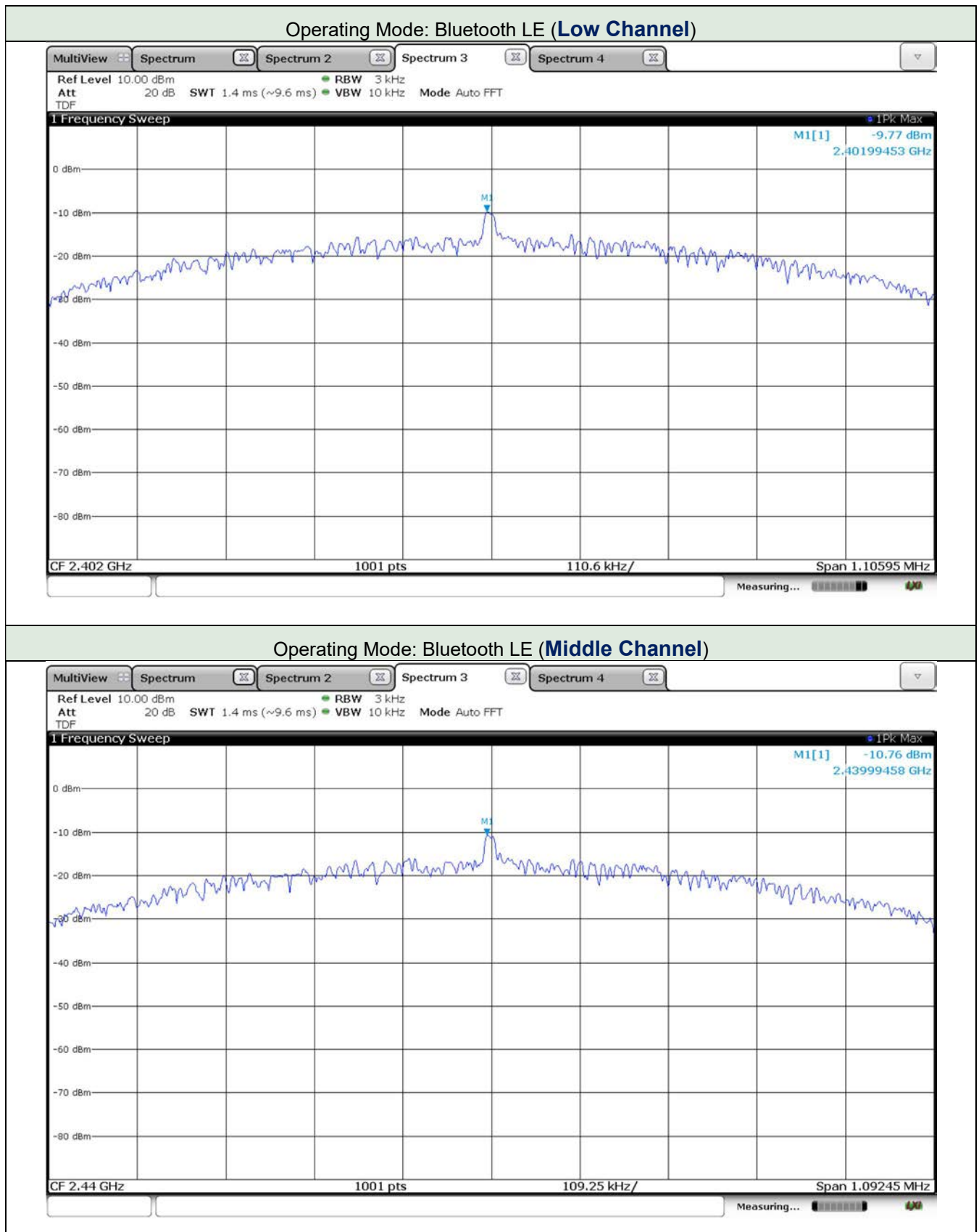
The transmitter output is connected to a spectrum analyzer with the RBW set from 3 kHz to 100 kHz,
VBW $\geq$ 3 X RBW, peak detector and max hold.

5.4.3 Test Data

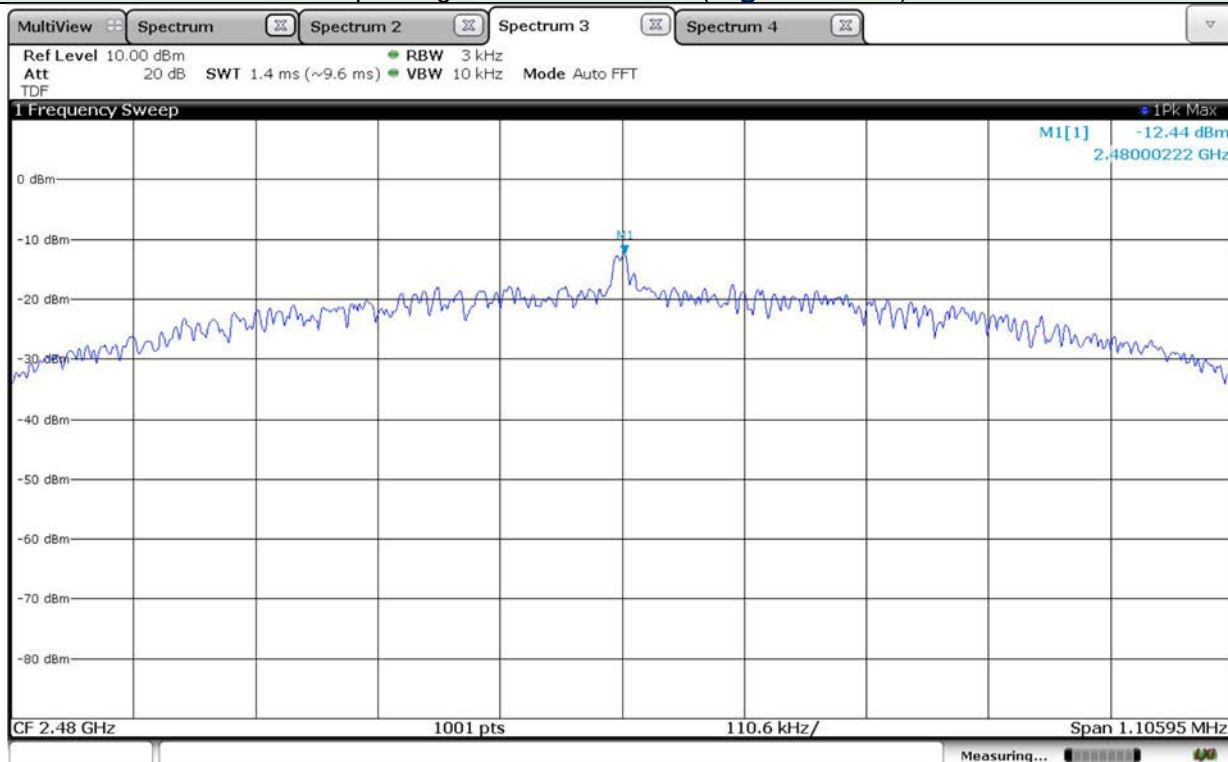
Date of Test		2019-11-29	Temperature	(22.5 ± 0.5) °C
			Relative humidity	(41.1 ± 3.1) % R.H.
Test Result		PASS	Tested by	Do-heon Kim 
Operating Mode: Bluetooth LE				
Channel	Frequency (MHz)	Measured Value (dBm)	Limit (dBm)	Margin (dB)
Low	2 402	-9.77	8	17.77
Middle	2 440	-10.76		18.76
High	2 480	-12.44		20.44

Remark. Margin = Limit – Measured Value

5.4.4 Test Plots



Operating Mode: Bluetooth LE (High Channel)



5.5 Out of Band Emission

5.5.1 Limit

Acc. To section 15.247(d) and RSS-247 5.5, 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 15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section §15.205(a), must also comply the radiated emission limits specified in section §15.209(a) (see section §15.205(c))

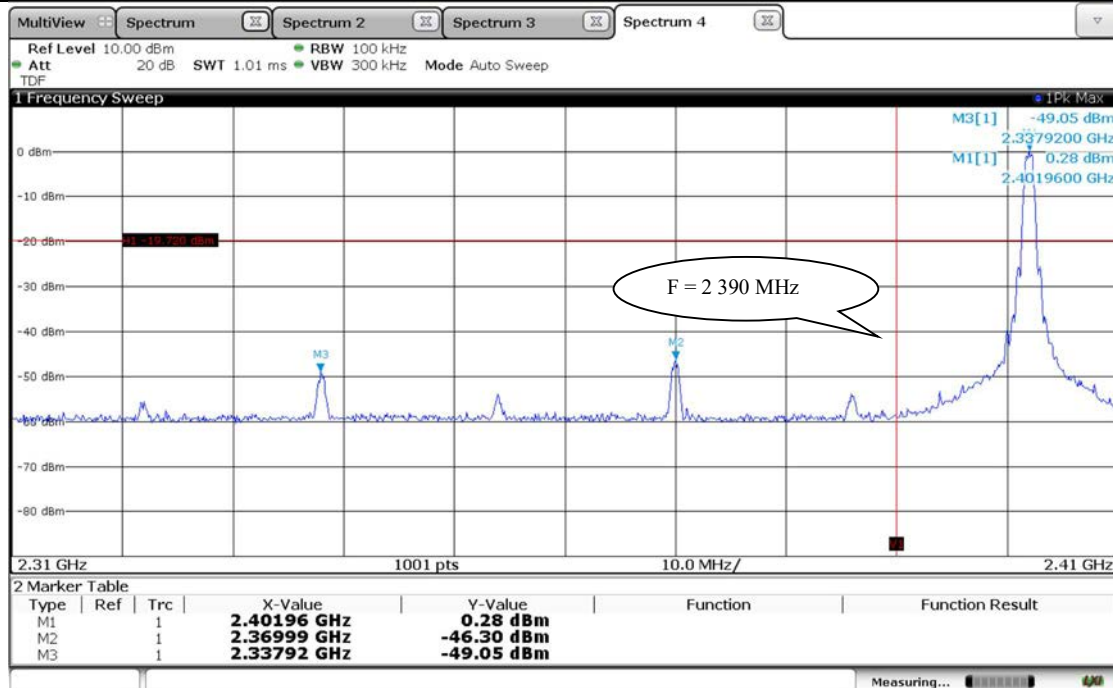
5.5.2 Method of Measurement

Reference to KDB 558074 D01 DTS Meas Guidance v05r02: 8.5 Emissions in non-restricted frequency bands. The transmitter output is connected to a spectrum analyzer with the RBW set to 100 kHz, VBW $\geq 3 \times$ RBW, peak detector and max hold. Measurements utilizing these settings are made of the in-band reference level, band-edge (where measurements to the general radiated limits will not be made) and out-of-band emissions.

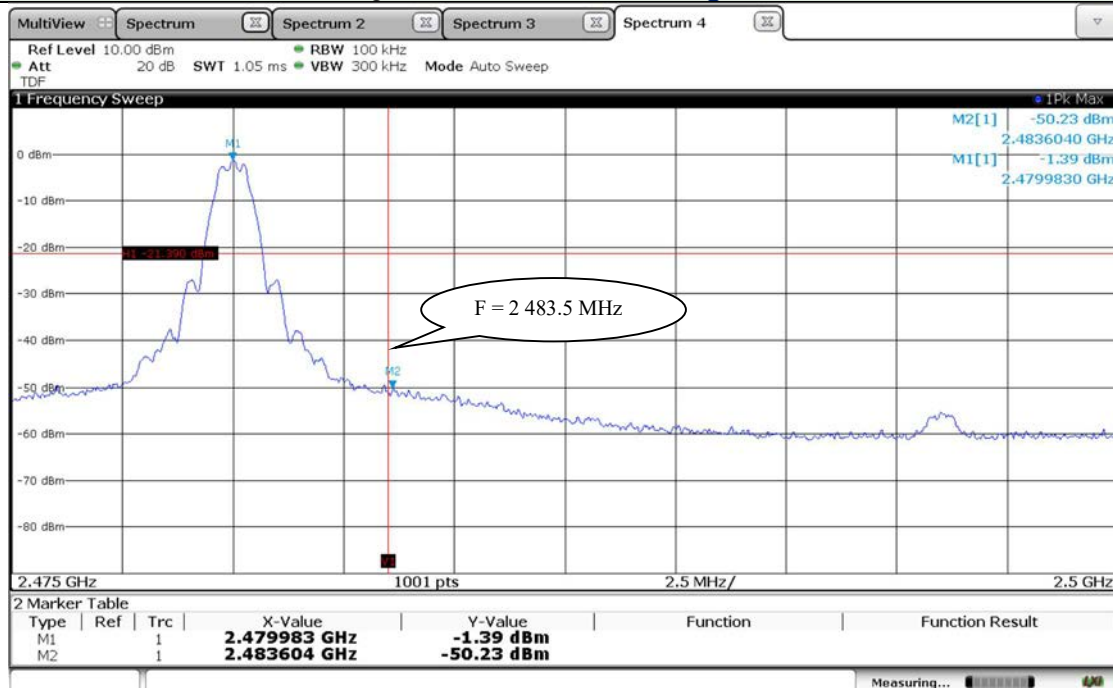
5.5.3 Test Data for Operating mode: Bluetooth LE

Date of Test	2019-11-29	Temperature	(22.5 ± 0.5) °C
		Relative humidity	(41.1 ± 3.1) % R.H.
Test Result	PASS	Tested by	Do-heon Kim 

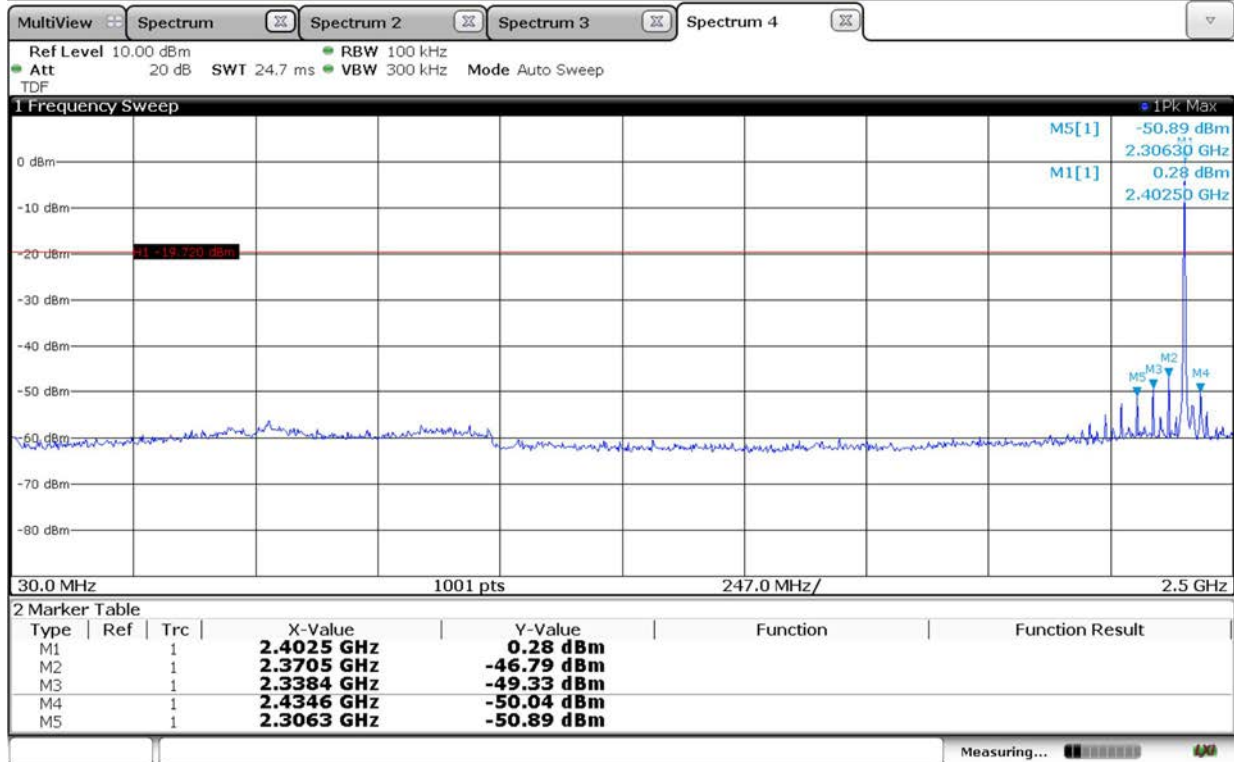
Band-edge and Restricted band – Low channel



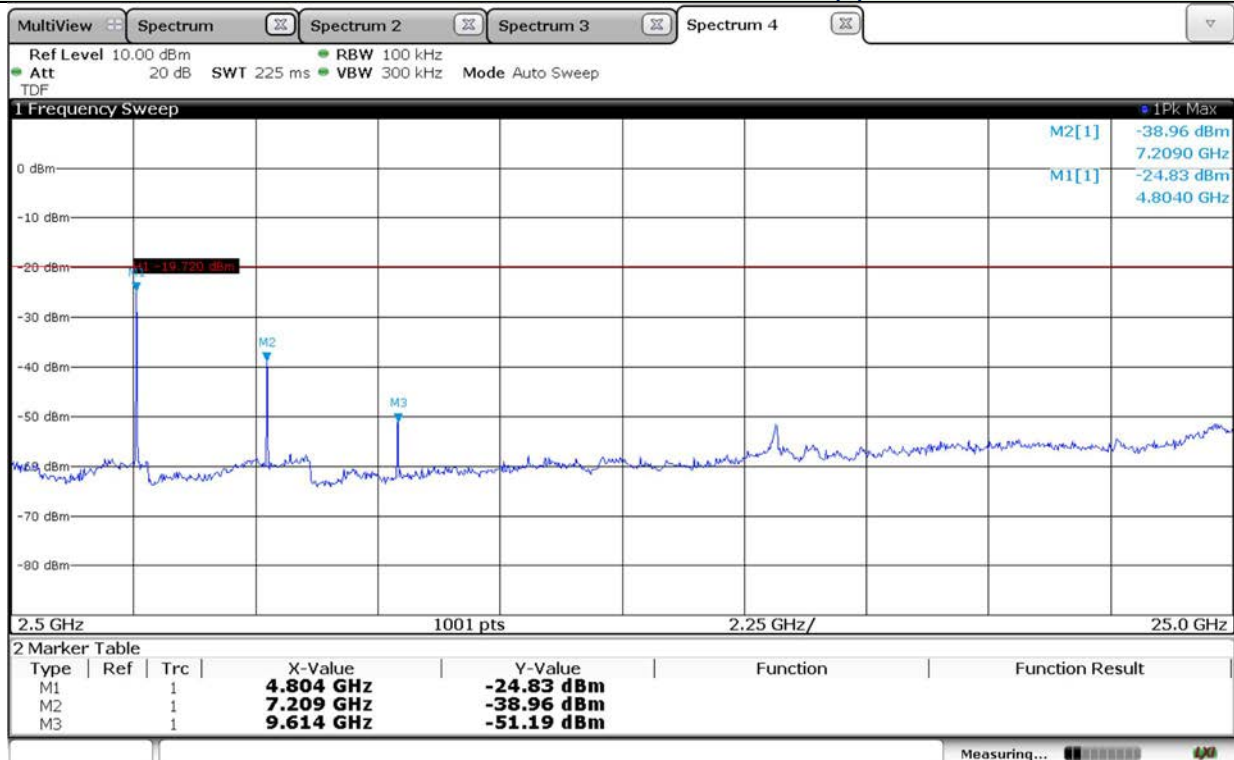
Band-edge and Restricted band – High channel



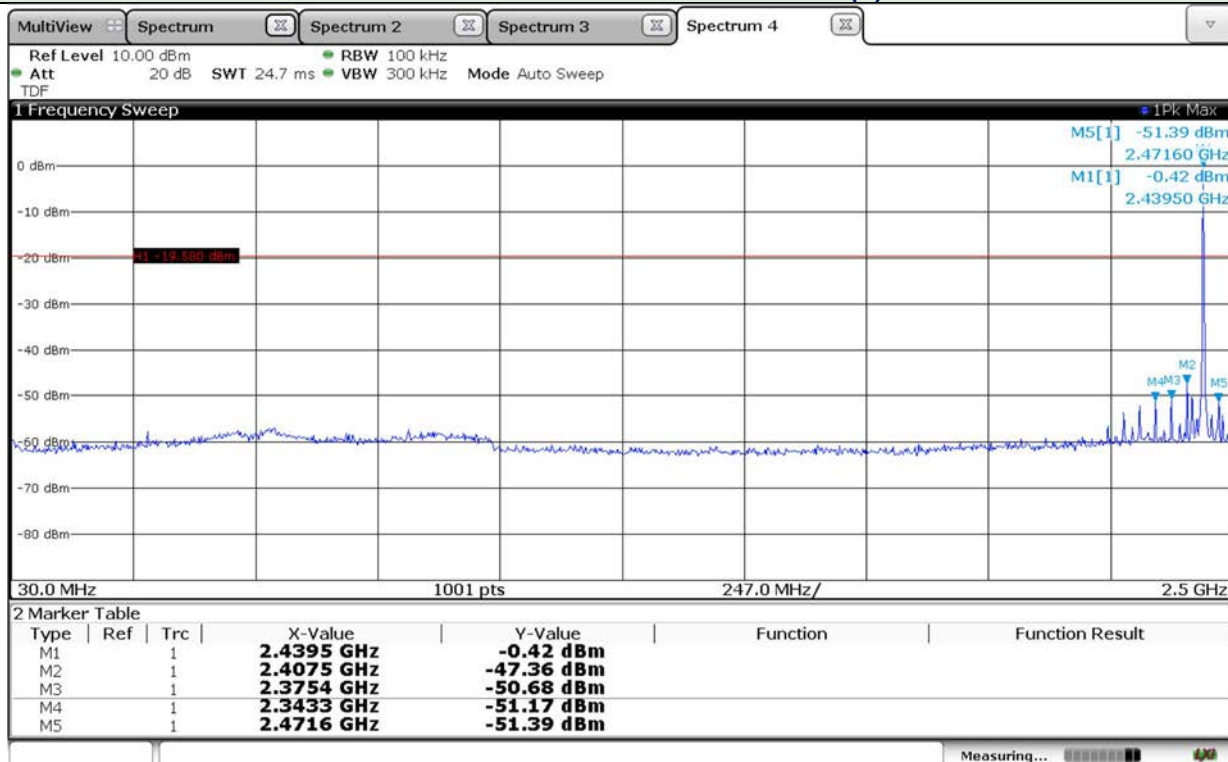
Non-restricted band – Low Channel (1)



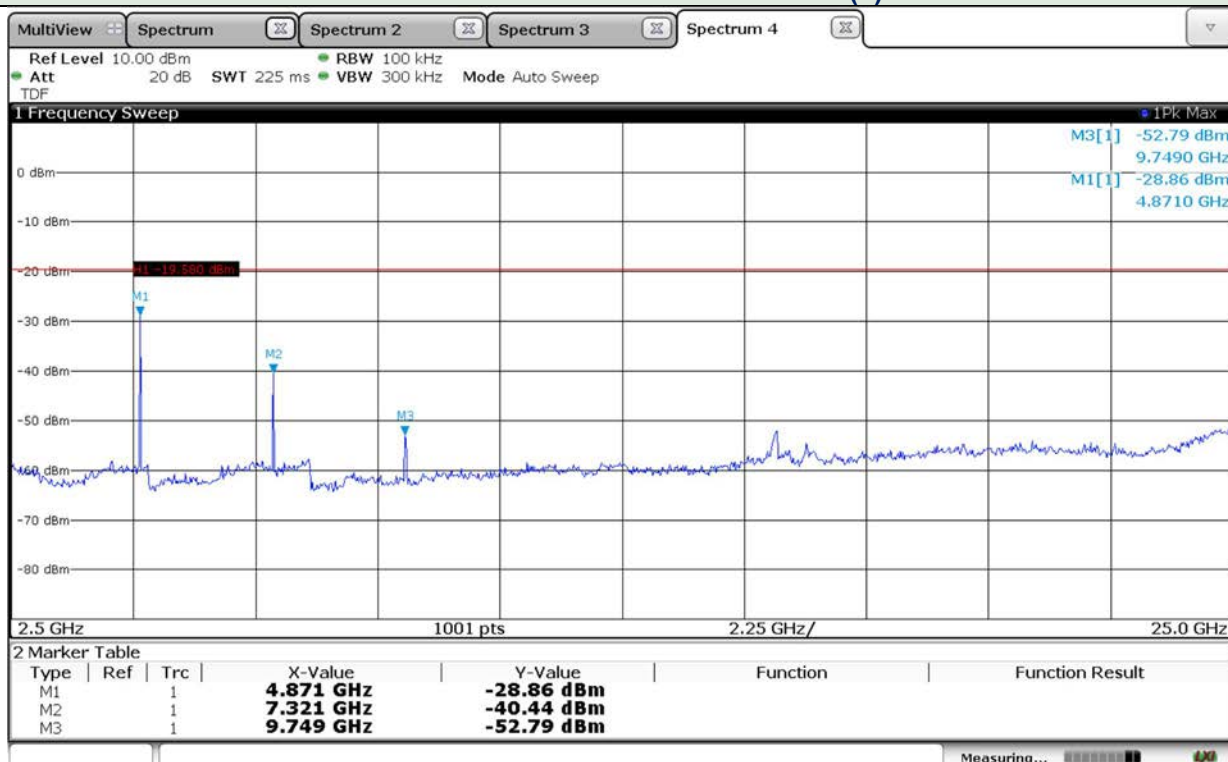
Non-restricted band – Low Channel (2)



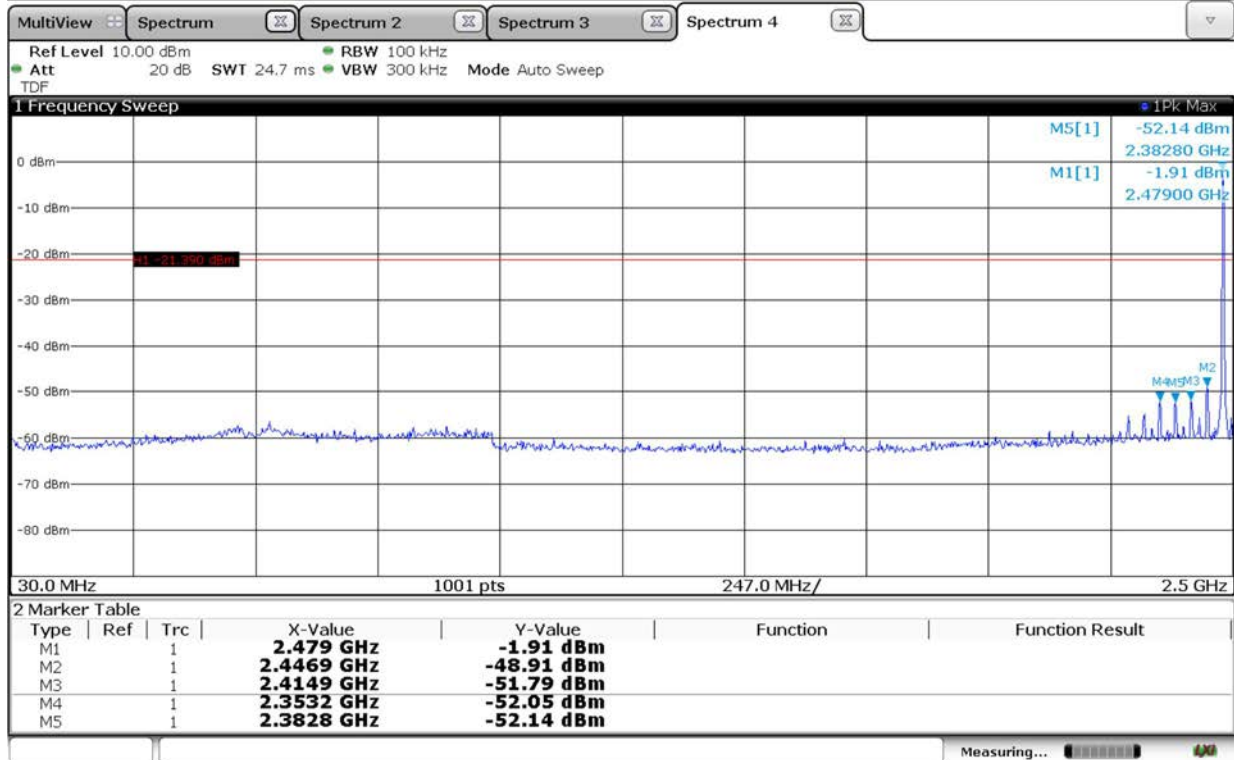
Non-restricted band – Middle Channel (1)



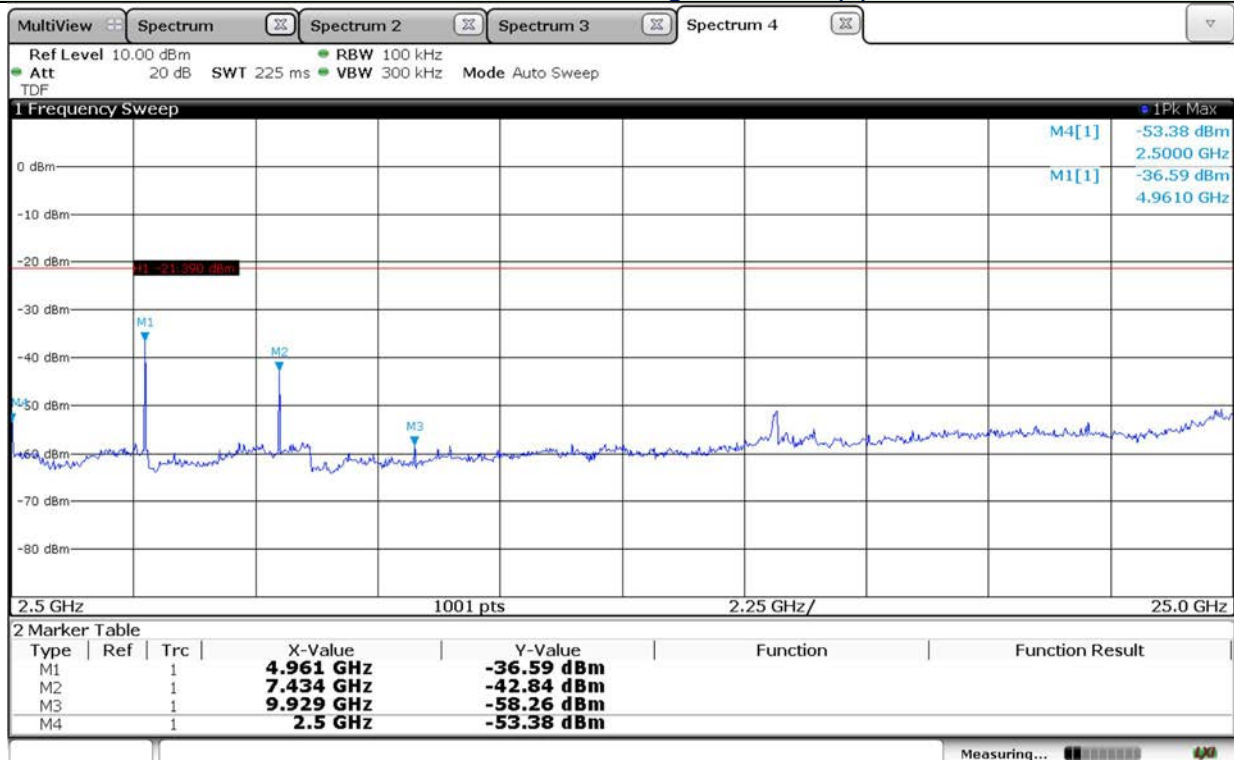
Non-restricted band – Middle Channel (2)



Non-restricted band – High Channel (1)



Non-restricted band – High Channel (2)



5.6 Radiated Emission

5.6.1 Limit

Acc. To section 15.205, 15.209, RSS-GEN 8.9, following table shall be applied.

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
30 – 88	100	40
88 – 216	150	43.5
216 – 960	200	46
Above 960	500	24

5.6.2 Method of Measurement

Reference to KDB 558074 D01 DTS Meas Guidance v05r02: 8.6 Radiated emission measurements.

The radiated emissions measurements were on 3 m, semi-anechoic chamber. The EUT and other support equipment were placed on a non-conductive table 80 cm for below 1 GHz and 1.5 m for above 1 GHz above the ground plane. The interconnecting cables from outside test site were inserted into ferrite clamps at the point where the cables reach the turntable.

The frequency spectrum from 30 MHz to 25 GHz was scanned and emission levels maximized at each frequency recorded. The system was rotated 360°, and the antenna was varied in height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for both horizontal and vertical polarization of the receiving antenna.

For measurement below 1 GHz, the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

For peak emission measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz and for average measurement, resolution bandwidth is set to 1 MHz; and the video bandwidth is set to 10 Hz, when duty cycle is more than 98 %. If duty cycle is less than 98 %, the video bandwidth is set to $\geq 1/T$, where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

For measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz. The spectrum from 30 MHz to 25 GHz is investigated with the transmitter set to the lowest, middle, and highest channels in each applicable band.

5.6.3 Test Site Requirement for KDB 414788 D01

Acc. to KDB 414788 D01 Radiated Test Site v01, Semi Anechoic Chamber (SAC) shall be verified test results below 30 MHz with Open Area Test Site (OATS), so we compared test results between the measurements from our SAC and an OATS and found test results almost same, so we **declare test result for below 30 MHz from our SAC is valid and met the requirement acc. to KDB 414788 D01 Radiated Test Site v01.**

5.6.4 Measurement Uncertainty

Measurement uncertainties were not taken into account and following uncertainty levels have been estimated for tests performed on the apparatus. The measurement uncertainties are given with at least 95 % confidence.

Frequency Range	Uncertainty	Frequency Range	Uncertainty
9 kHz ~ 30 MHz	± 2.6 dB	30 MHz ~ 1 GHz	± 4.5 dB
1 GHz ~ 18 GHz	± 5.0 dB	18 GHz ~ 25 GHz	± 5.2 dB

5.6.5 Sample Calculated Example

At 80 MHz

Limit = 40.0 dBuV/m

Result (dBuV/m)

= Receiver Reading (dBuV) + Antenna Factor (dB/m) - Pre-amplifier Gain (dB) + Cable Loss (dB) = 30

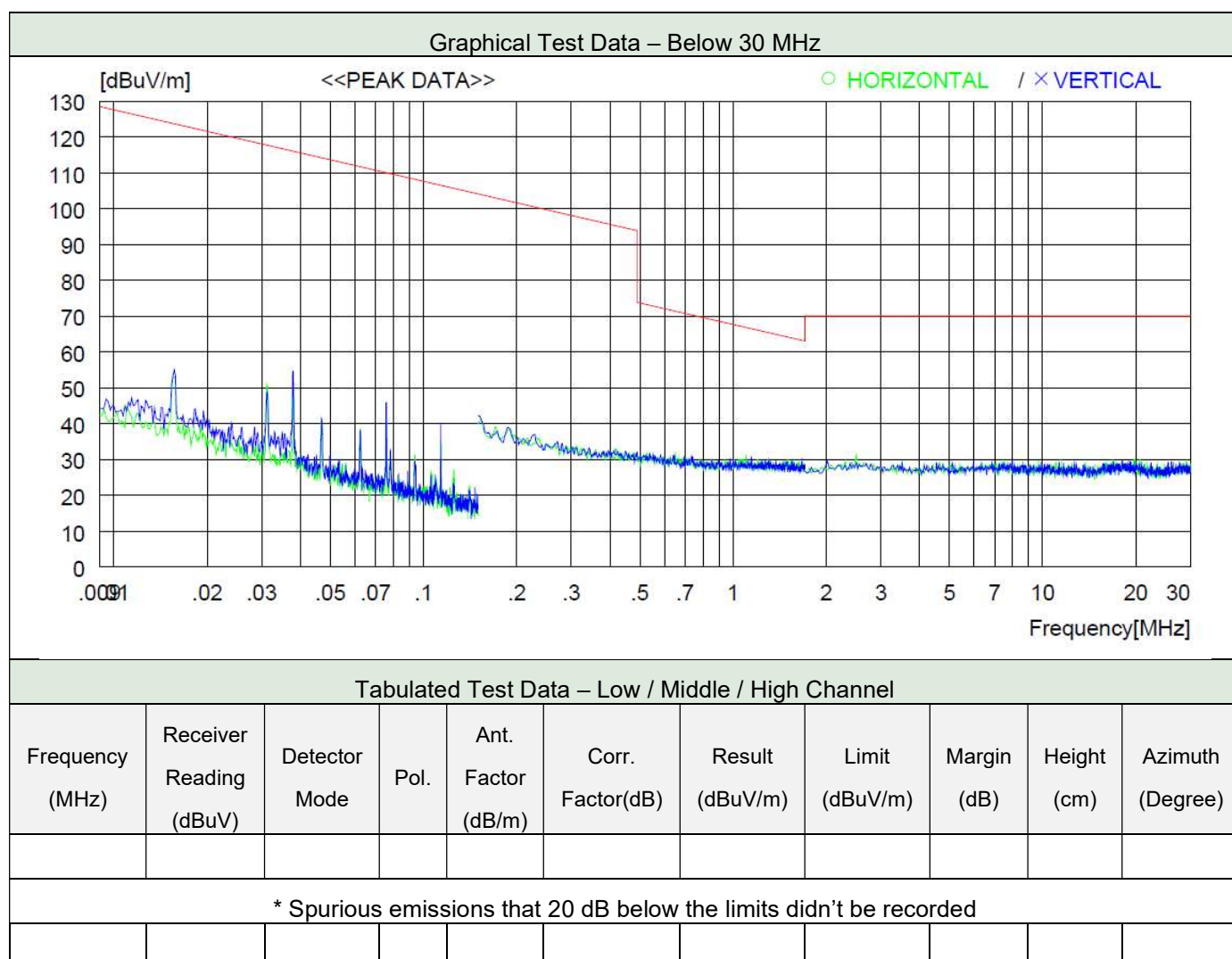
Margin = Limit – Result = 40 – 30 = 10

so the EUT has 10.0 dB margin at 80 MHz

5.6.6 Test Data

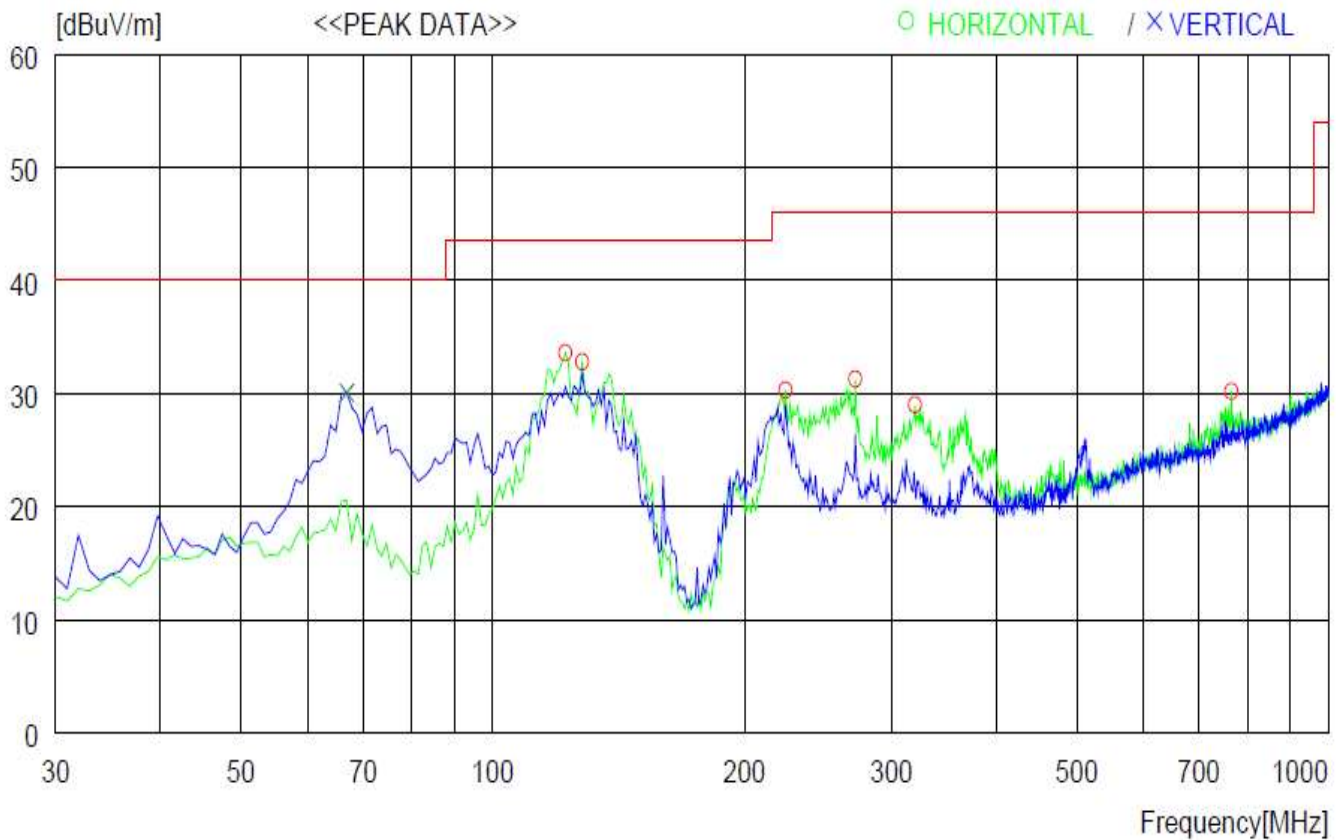
Date of Test	2019-12-02	Temperature		(22.1 ± 2.7) °C	
		Relative humidity		(40.9 ± 5.9) % R.H.	
Measurement Frequency Range		9 kHz ~ 25 GHz			
Test Result	PASS	Tested By		Do-heon Kim 	
Frequency range	Detector Mode	Resolution BW	Video BW	Video Filtering	Measurement distance
Below 30 MHz	Peak or Q.P.	9 kHz	100 kHz	-	3 m
30 MHz ~ 1 000 MHz	Peak or Q.P.	100 kHz	300 kHz	-	3 m
Above 1 GHz	Peak	1 MHz	3 MHz		3 m
	Average	1 MHz	3 MHz		3 m

5.6.6.1 Test Data below 30 MHz



5.6.6.2 Test Data from 30 MHz to 1 GHz

Graphical Test Data – Below 1 GHz – **Low Channel (Peak)**



No.	FREQ [MHz]	READING [dBuV]	ANT PEAK FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
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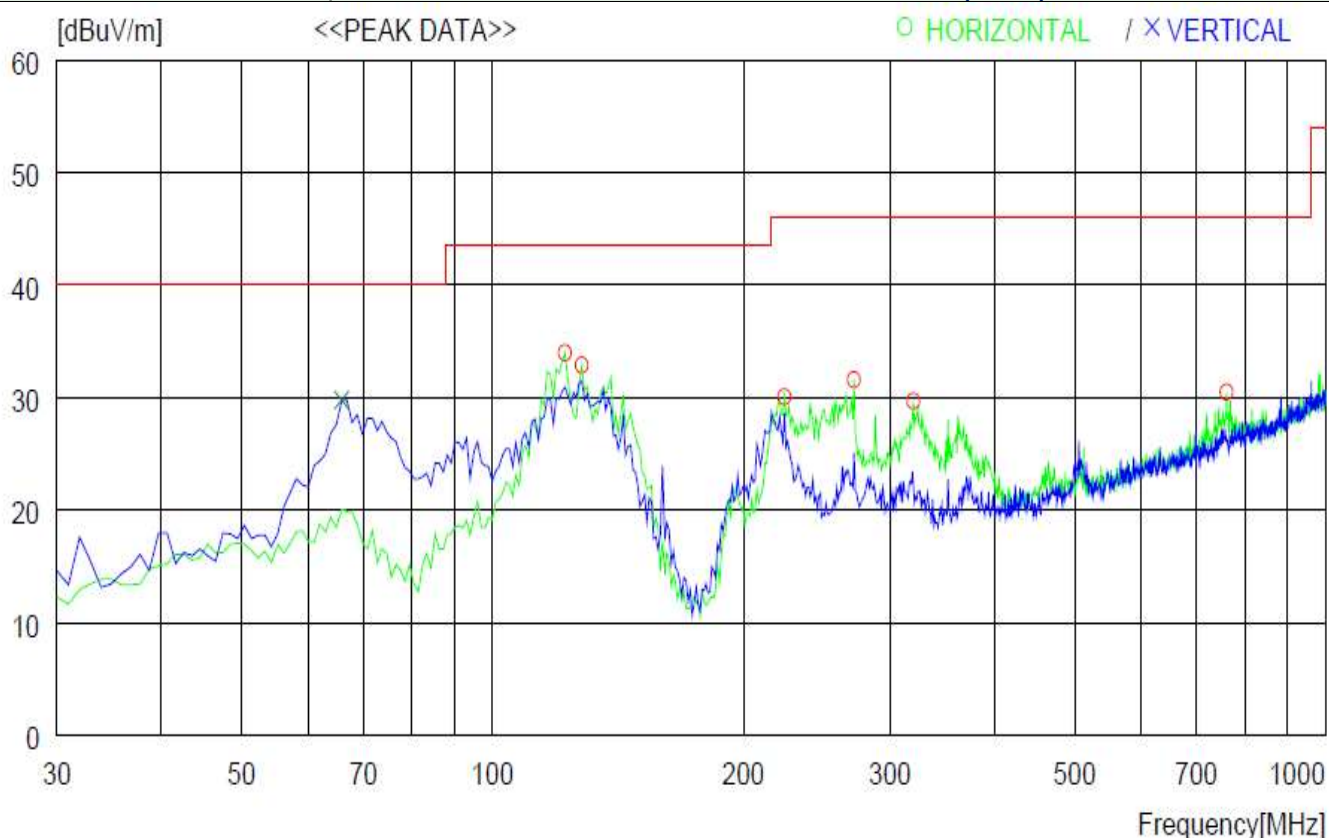
----- Horizontal -----

1	122.150	48.5	9.5	8.2	32.6	33.6	43.5	9.9	200	295
2	127.970	48.3	8.9	8.2	32.6	32.8	43.5	10.7	200	0
3	224.000	42.1	11.8	9.0	32.6	30.3	46.0	15.7	100	275
4	271.530	41.7	12.8	9.4	32.6	31.3	46.0	14.7	100	252
5	320.030	38.1	13.7	9.8	32.6	29.0	46.0	17	100	359
6	765.253	30.3	20.6	12.1	32.8	30.2	46.0	15.8	100	119

----- Vertical -----

7	66.860	44.4	10.7	7.6	32.6	30.1	40.0	9.9	100	202
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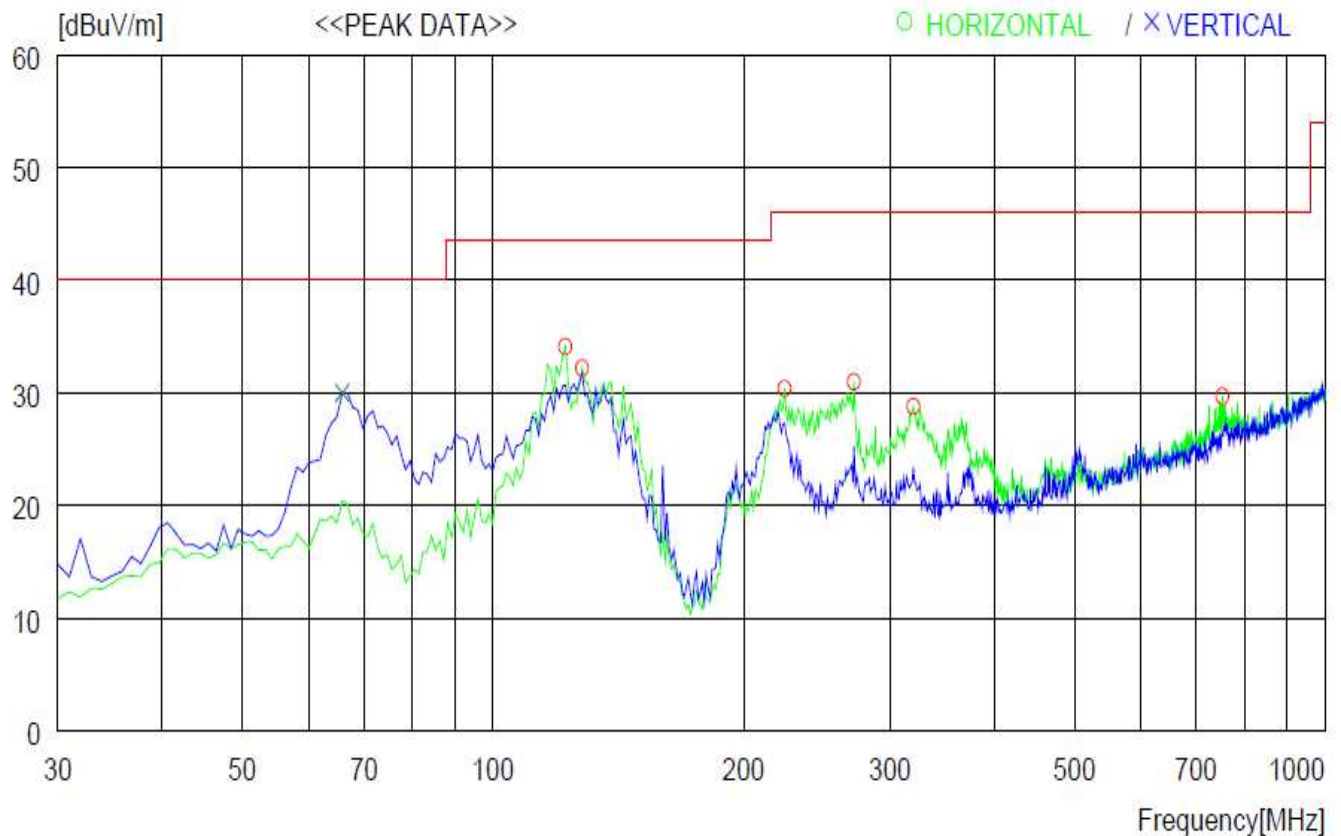
Graphical Test Data – Below 1 GHz – Middle Channel (Peak)



No.	FREQ [MHz]	READING [dBuV]	ANT PEAK FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
----- Horizontal -----										
1	122.150	48.9	9.5	8.2	32.6	34.0	43.5	9.5	200	0
2	127.970	48.4	8.9	8.2	32.6	32.9	43.5	10.6	200	279
3	224.000	41.9	11.8	9.0	32.6	30.1	46.0	15.9	100	299
4	271.530	42.0	12.8	9.4	32.6	31.6	46.0	14.4	100	262
5	320.030	38.8	13.7	9.8	32.6	29.7	46.0	16.3	100	269
6	760.403	30.6	20.6	12.1	32.8	30.5	46.0	15.5	100	112
----- Vertical -----										
7	65.890	43.8	11.0	7.6	32.6	29.8	40.0	10.2	100	0

Note: "H" means Horizontal polarity, "V" means Vertical polarity.

Graphical Test Data – Below 1 GHz – High Channel (Peak)



No.	FREQ [MHz]	READING [dBuV]	ANT PEAK FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
-----	---------------	-------------------	----------------------------	--------------	--------------	--------------------	-------------------	----------------	-----------------	----------------

----- Horizontal -----

1	122.150	49.0	9.5	8.2	32.6	34.1	43.5	9.4	200	294
2	127.970	47.7	8.9	8.2	32.6	32.2	43.5	11.3	200	294
3	224.000	42.2	11.8	9.0	32.6	30.4	46.0	15.6	100	274
4	271.530	41.4	12.8	9.4	32.6	31.0	46.0	15	100	250
5	320.030	37.9	13.7	9.8	32.6	28.8	46.0	17.2	100	359
6	752.643	30.0	20.5	12.0	32.8	29.7	46.0	16.3	100	359

----- Vertical -----

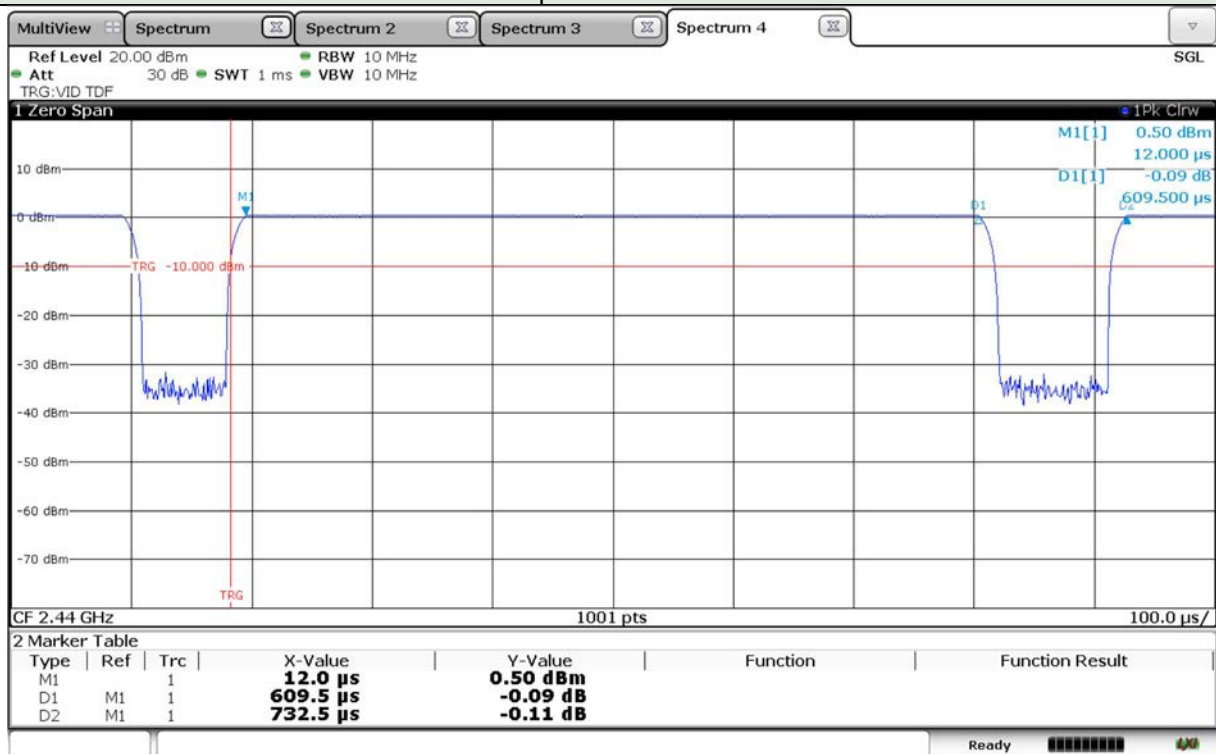
7	65.890	44.0	11.0	7.6	32.6	30.0	40.0	10	100	0
---	--------	------	------	-----	------	------	------	----	-----	---

5.6.6.3 Test Data above 1 GHz

5.6.6.3.1 Duty Cycle

Date of Test	2019-12-02	Temperature	(22.1 ± 2.7) °C
		Relative humidity	(40.9 ± 5.9) % R.H.
Measurement Distance	3 m	Tested By	Do-heon Kim 
Detector Mode	Resolution BW	Video BW	Sweep Time
PEAK	1 MHz	3 MHz	Auto
AVERAGE	1 MHz	3 MHz	Auto

Graphical Test Data



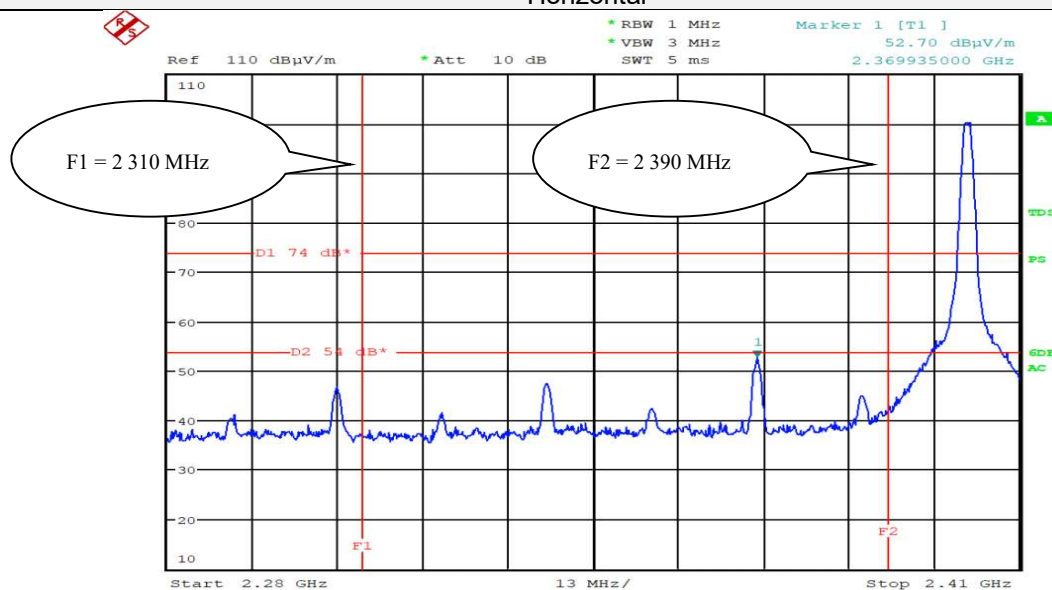
Tabulated Test Data

Operating Mode	On Time (ms)	On + Off Time (ms)	Duty Cycle (%)	Duty Factor (dB)
Bluetooth LE	609.5	732.5	83.21	0.80

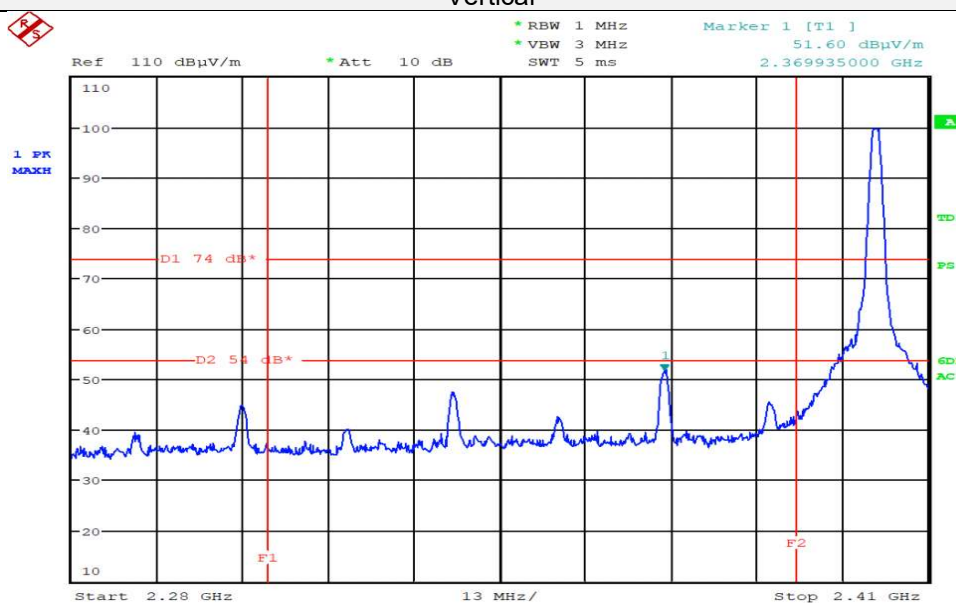
5.6.6.3.2 Test Data for Band edge (Restricted band)

Graphical Test Data – Low Channel (Peak)

Horizontal



Vertical



Tabulated Test Data – Low Channel

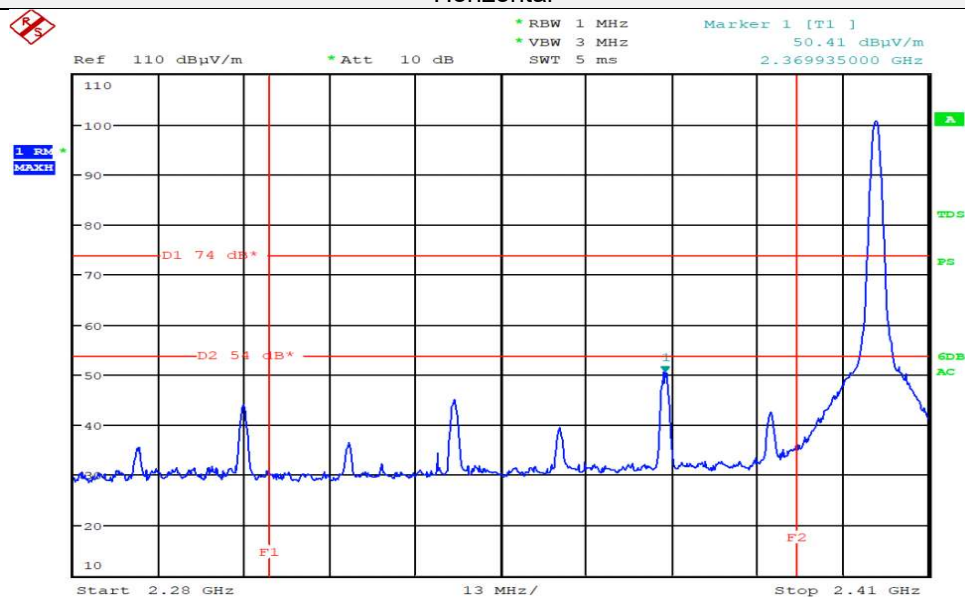
Freq. (MHz)	Detector Mode	Pol.	Measured Value (dBuV/m)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
2 369.9	Peak	H	52.70	-	52.70	74.00	21.30	130	250
2 369.9	Peak	V	51.60	-	51.60	74.00	22.40	140	10

NOTE: “H” means Horizontal polarity, “V” means Vertical polarity.

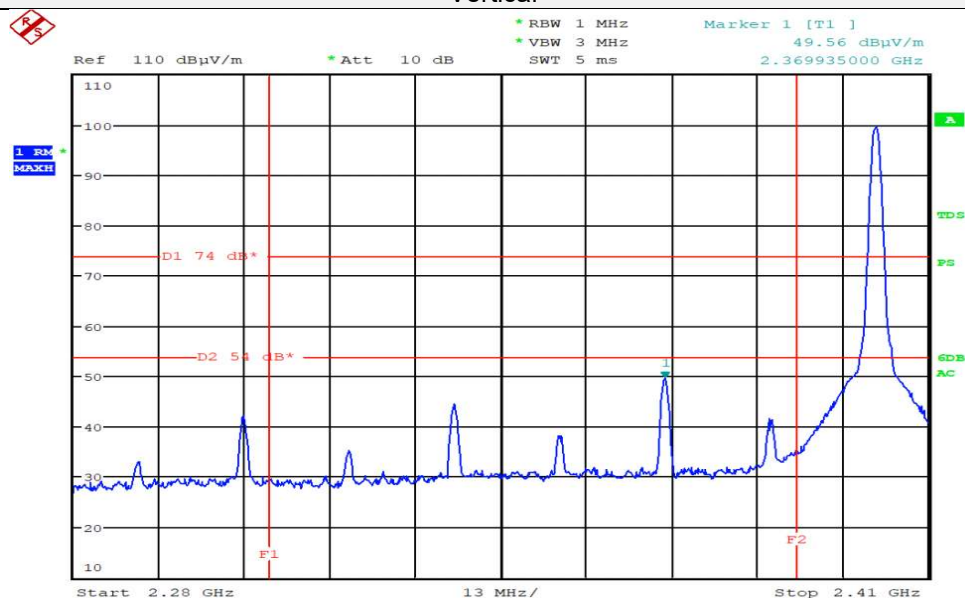
Measured Value = Receiver reading + Antenna Factor + Cable Loss - Pre-amplifier Gain

Graphical Test Data – Low Channel (Average)

Horizontal



Vertical



Tabulated Test Data – Low Channel

Freq. (MHz)	Detector Mode	Pol.	Measured Value (dBμV/m)	Duty Factor (dB)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
2 369.9	RMS	H	50.41	0.80	51.21	54.00	2.79	130	250
2 369.9	RMS	V	49.56	0.80	50.36	54.00	3.64	140	10

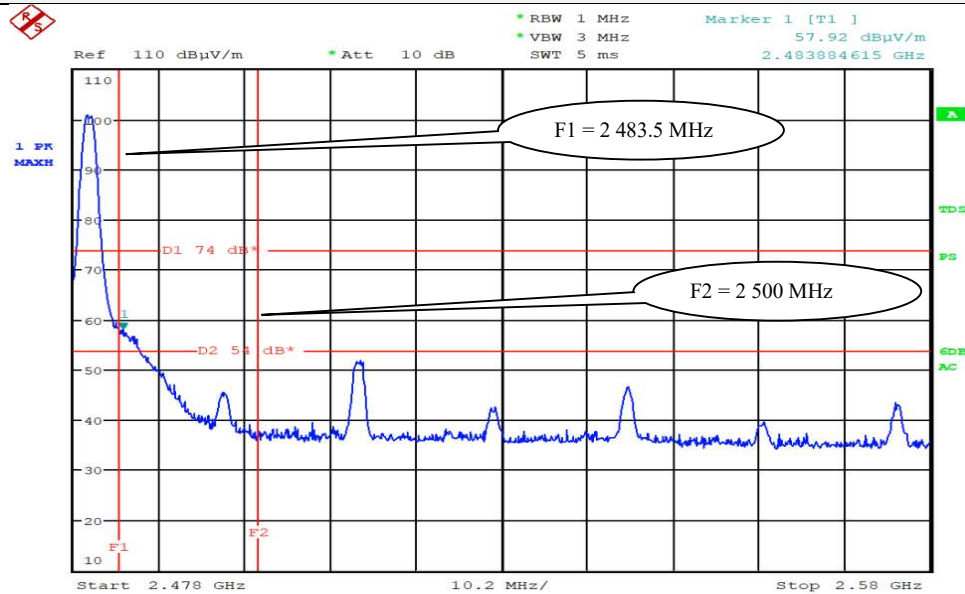
NOTE: “H” means Horizontal polarity, “V” means Vertical polarity.

Measured Value = Receiver reading + Antenna Factor + Cable Loss - Pre-amplifier Gain

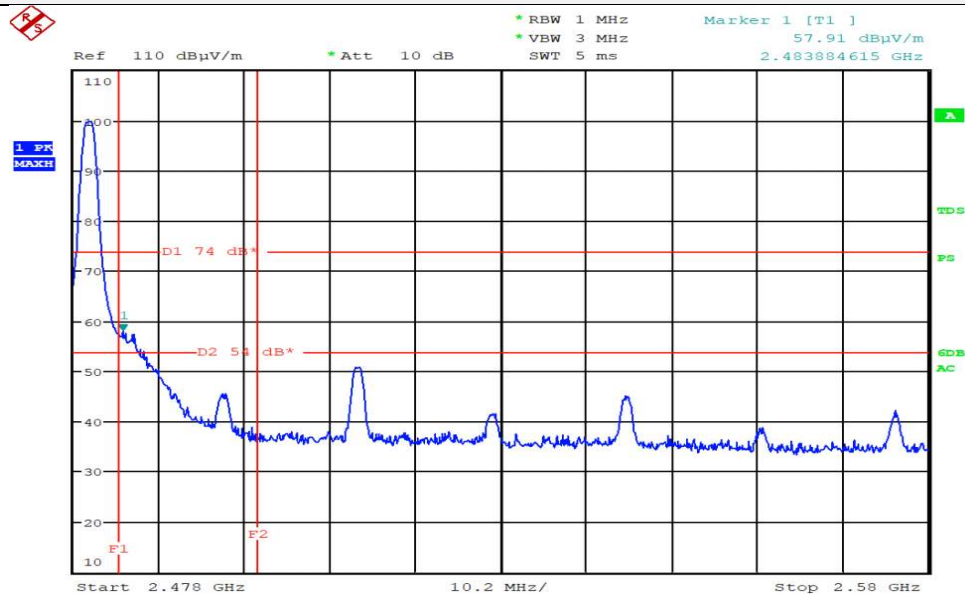
Result = Measured Value + Duty Factor

Graphical Test Data – High Channel (Peak)

Horizontal



Vertical



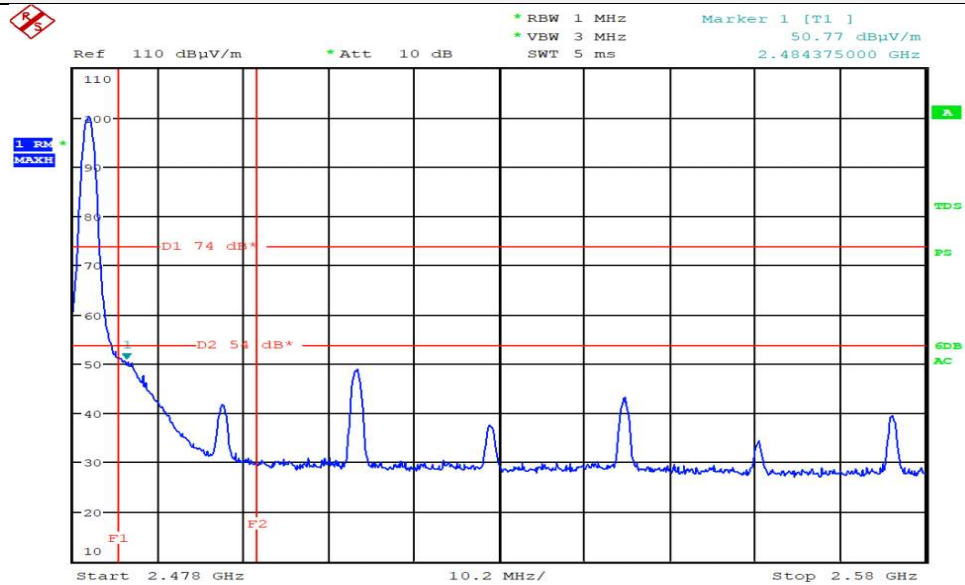
Tabulated Test Data – High Channel

Freq. (MHz)	Detector Mode	Pol.	Measured Value (dBuV/m)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
2 483.9	Peak	H	57.92	-	57.92	74.00	16.08	140	250
2 483.9	Peak	V	57.91	-	57.91	74.00	16.09	200	20

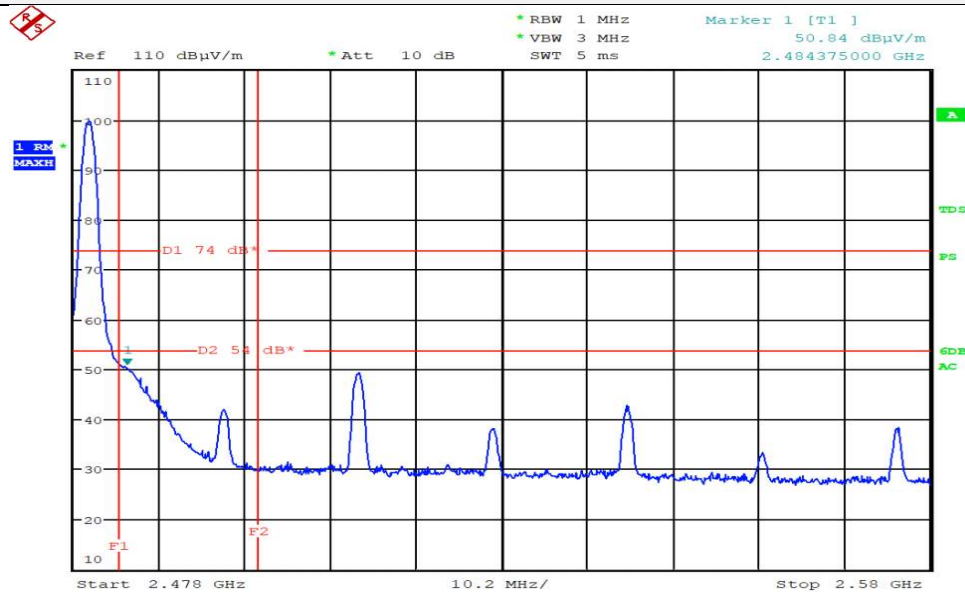
NOTE: "H" means Horizontal polarity, "V" means Vertical polarity.

Graphical Test Data – High Channel (Average)

Horizontal



Vertical



Tabulated Test Data – High Channel

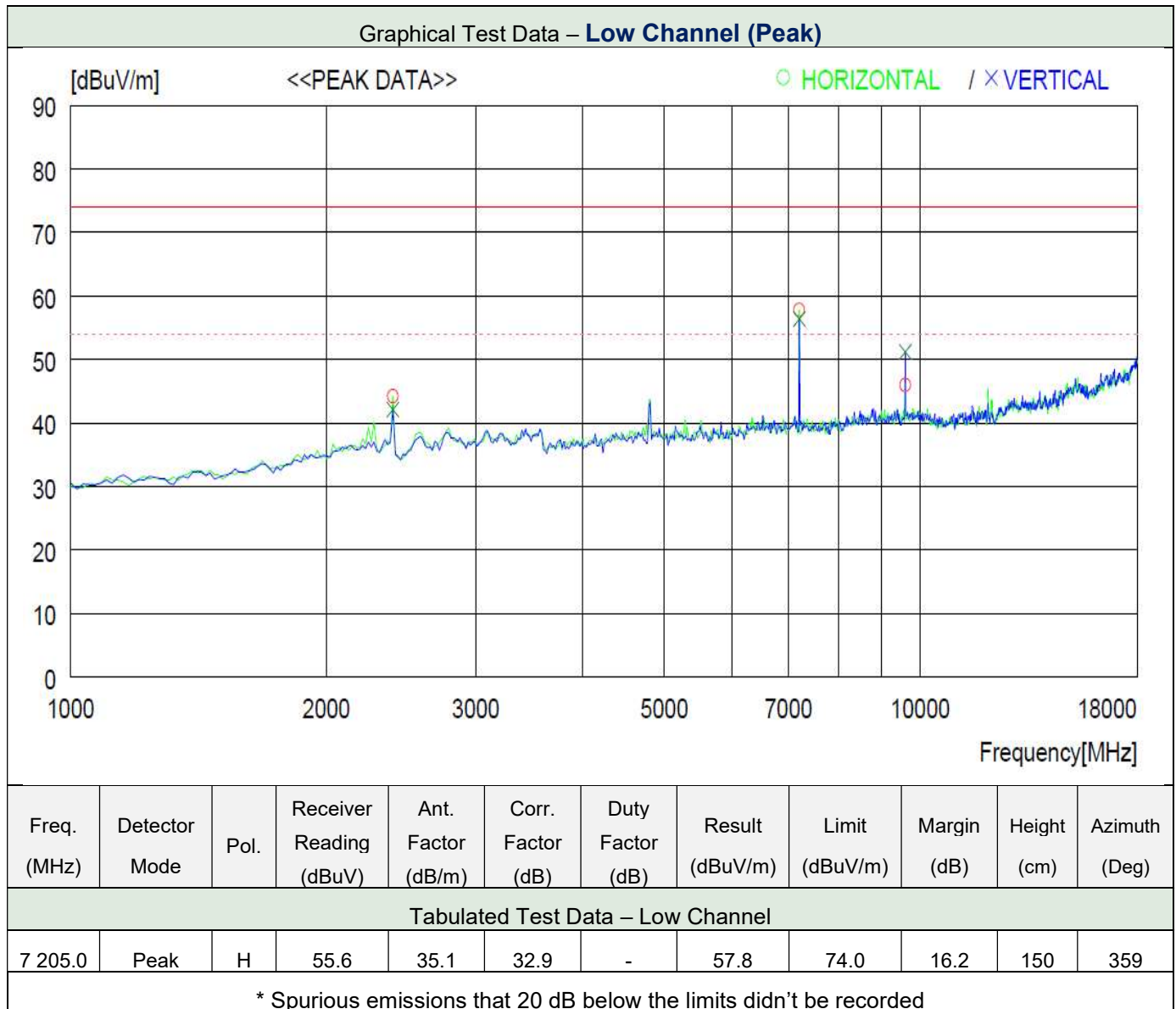
Freq. (MHz)	Detector Mode	Pol.	Measured Value (dBμV/m)	Duty Factor (dB)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
2 484.4	RMS	H	50.77	0.80	51.57	54.00	2.43	140	250
2 484.4	RMS	V	50.84	0.80	51.64	54.00	2.36	200	20

NOTE: “H” means Horizontal polarity, “V” means Vertical polarity.

Result = Measured Value + Duty Factor

5.6.6.4 Test Data for Harmonic & Spurious emission (1 GHz to 18 GHz)

5.6.6.4.1 Operating mode: Bluetooth LE



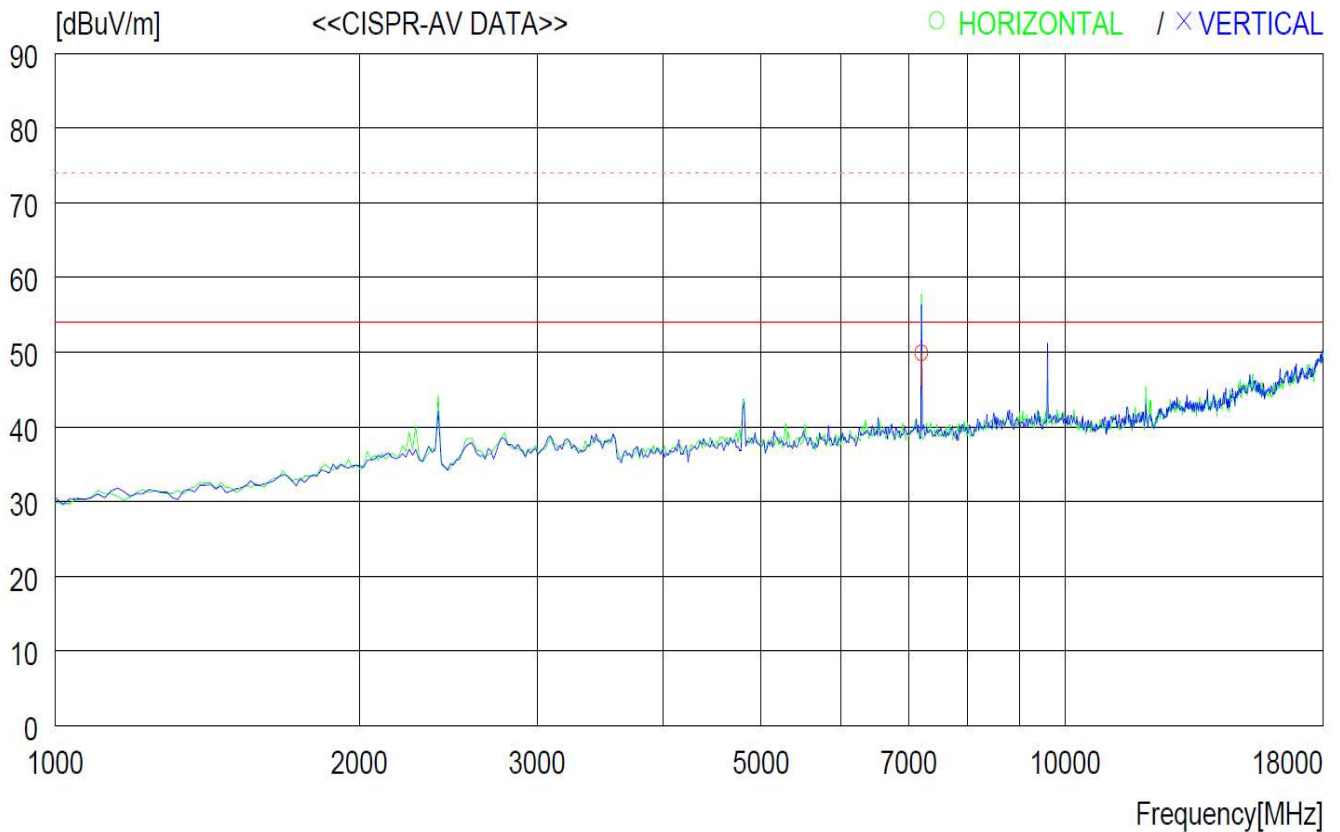
Note. "H" means Horizontal polarity, "V" means Vertical polarity.

Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Graphical Test Data – Low Channel (Average)



Freq. (MHz)	Detector Mode	Pol.	Receiver Reading (dBuV)	Ant. Factor (dB/m)	Corr. Factor (dB)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
Tabulated Test Data – Low Channel											
7 205.0	Average	H	47.7	35.1	32.9	-	49.9	54.0	4.1	150	359

Note. "H" means Horizontal polarity, "V" means Vertical polarity.

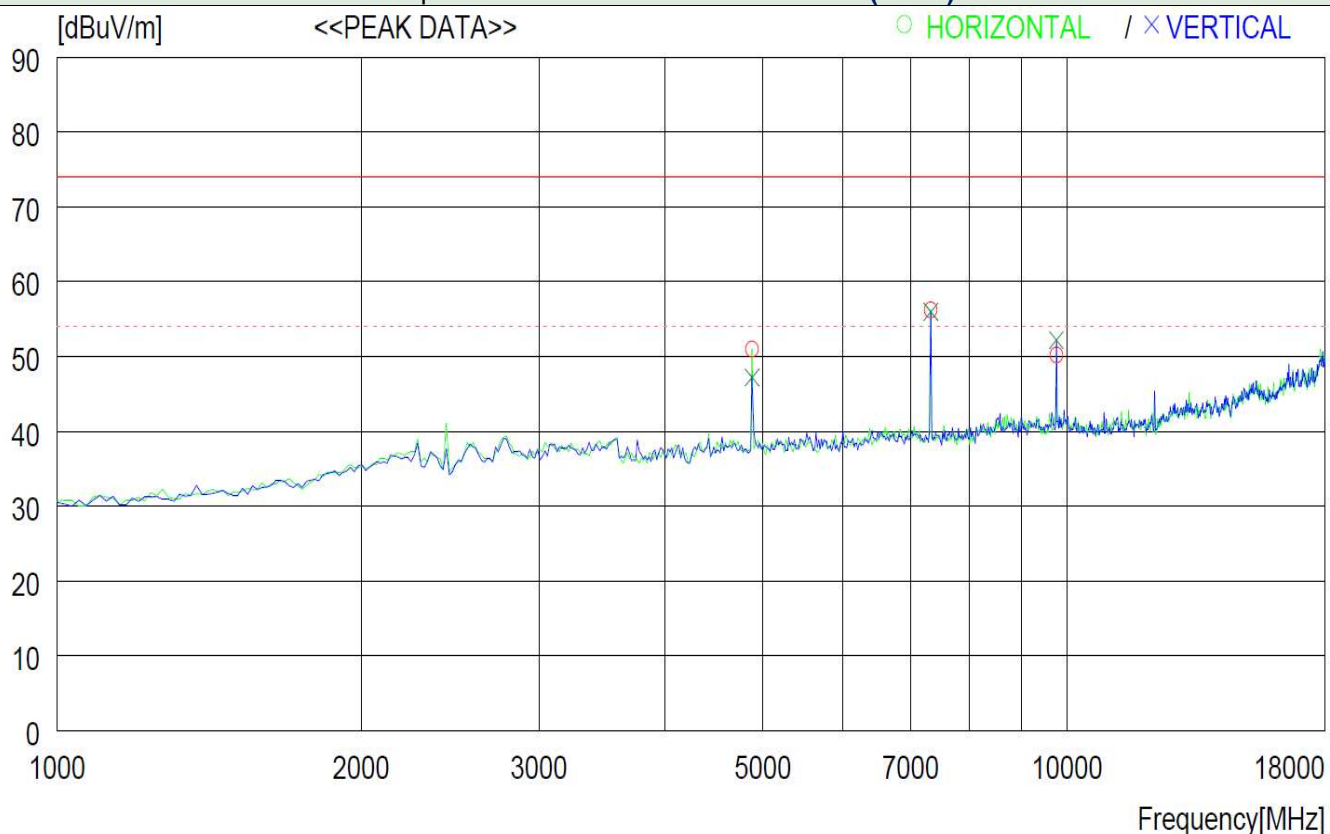
Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Non-restricted band emission is not added duty factor.

Graphical Test Data – Middle Channel (Peak)



Freq. (MHz)	Detector Mode	Pol.	Receiver Reading (dBuV)	Ant. Factor (dB/m)	Corr. Factor (dB)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
Tabulated Test Data – Low Channel											
7 324.0	Peak	H	53.9	35.2	32.9	-	56.2	74.0	17.8	150	186
* Spurious emissions that 20 dB below the limits didn't be recorded											

Note. "H" means Horizontal polarity, "V" means Vertical polarity.

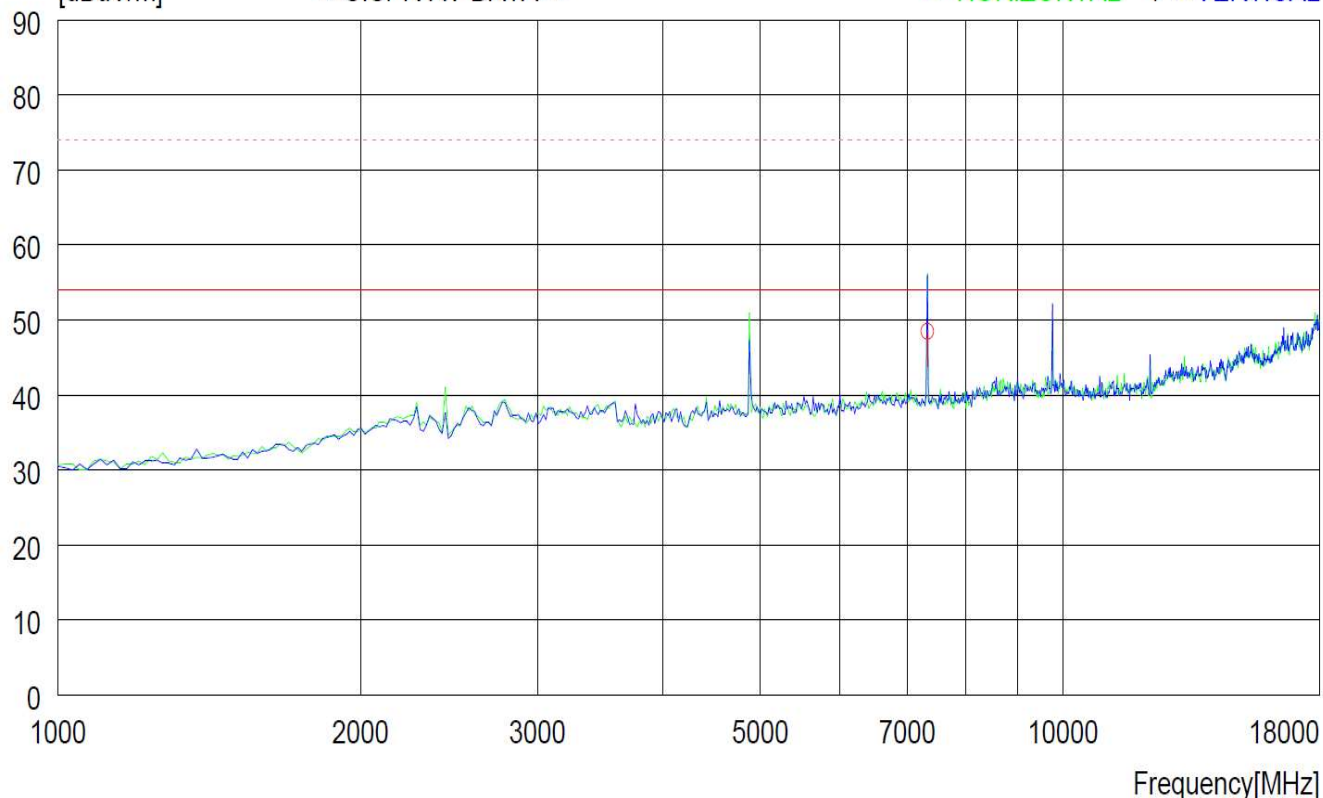
Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Graphical Test Data – Middle Channel (Average)

[dBuV/m] <<CISPR-AV DATA>> ○ HORIZONTAL / × VERTICAL



Freq. (MHz)	Detector Mode	Pol.	Receiver Reading (dBuV)	Ant. Factor (dB/m)	Corr. Factor (dB)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
Tabulated Test Data – Low Channel											
7 324.0	Average	H	46.2	35.2	32.9	-	49.3	54.0	4.7	150	186

Note. "H" means Horizontal polarity, "V" means Vertical polarity.

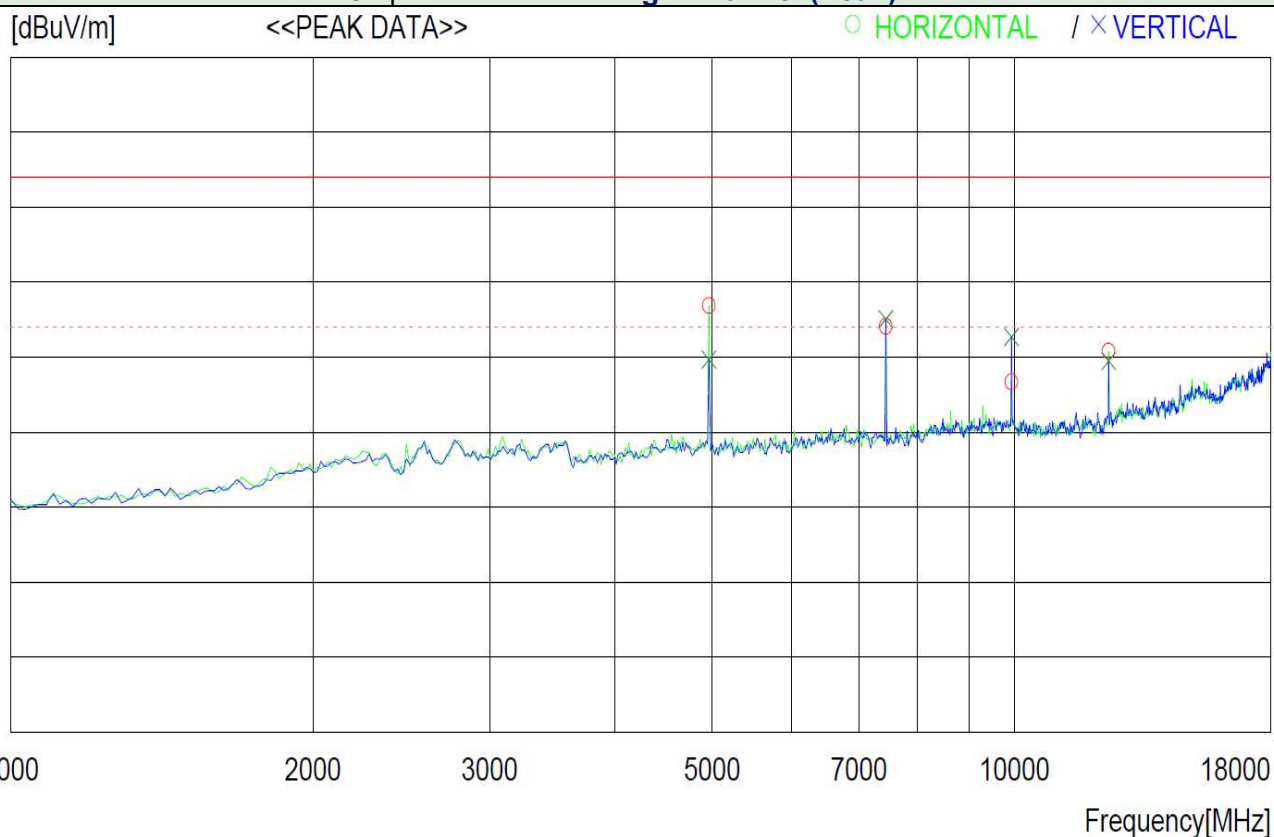
Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Non-restricted band emission is not added duty factor.

Graphical Test Data – High Channel (Peak)



Freq. (MHz)	Detector Mode	Pol.	Receiver Reading (dBuV)	Ant. Factor (dB/m)	Corr. Factor (dB)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
Tabulated Test Data – Low Channel											
4 961.0	Peak	H	57.2	33.8	34.1	-	56.9	74.0	17.1	150	193
7 443.0	Peak	V	52.7	35.3	32.9	-	55.1	74.0	18.9	150	359
* Spurious emissions that 20 dB below the limits didn't be recorded											

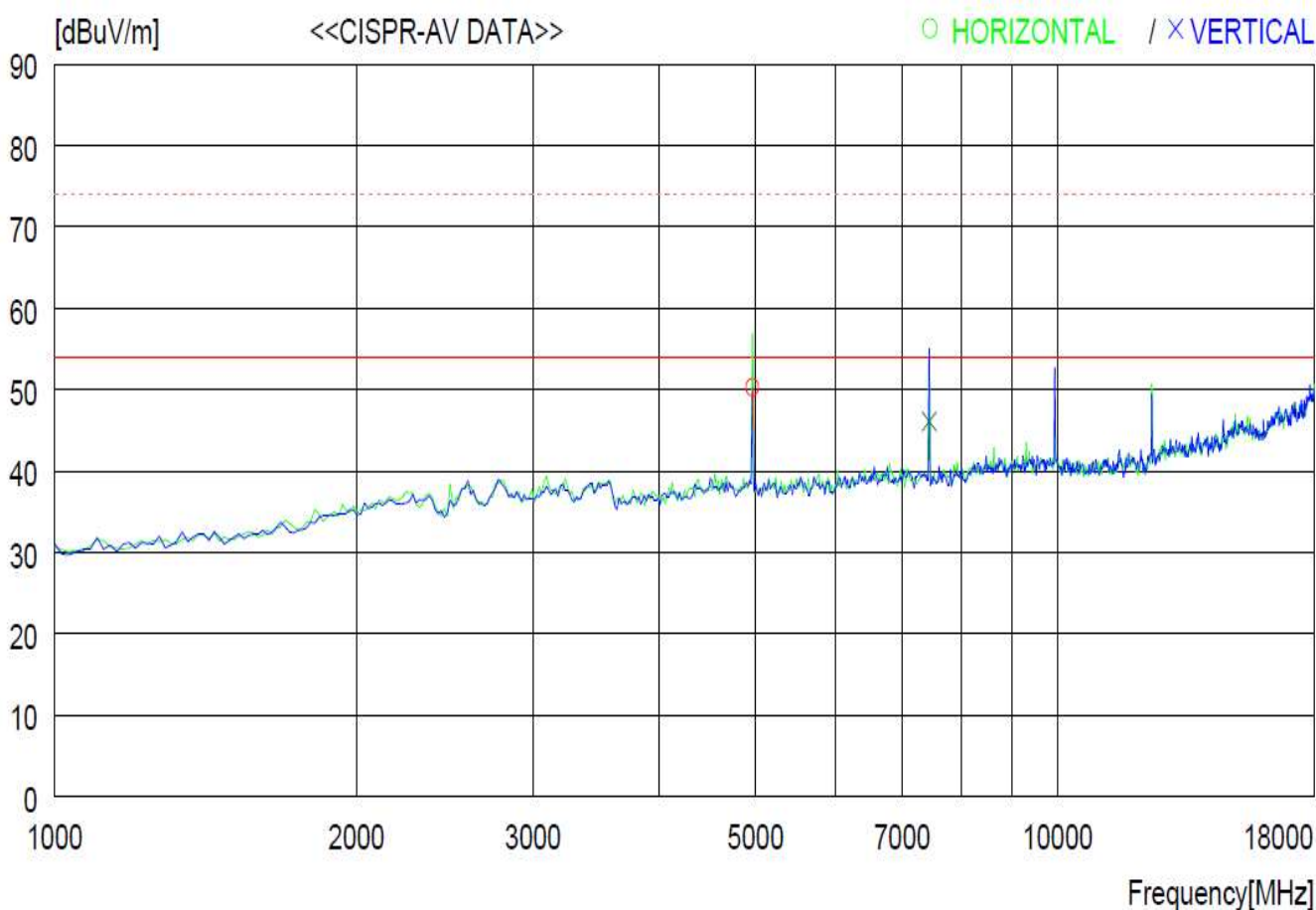
Note. "H" means Horizontal polarity, "V" means Vertical polarity.

Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Graphical Test Data – High Channel (Average)



Freq. (MHz)	Detector Mode	Pol.	Receiver Reading (dBuV)	Ant. Factor (dB/m)	Corr. Factor (dB)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
Tabulated Test Data – Low Channel											
4 961	Average	H	50.6	33.8	34.1	-	50.3	54.0	3.7	150	193
7 443	Average	V	43.7	35.3	32.9	-	46.1	54.0	7.9	150	359

Note. "H" means Horizontal polarity, "V" means Vertical polarity.

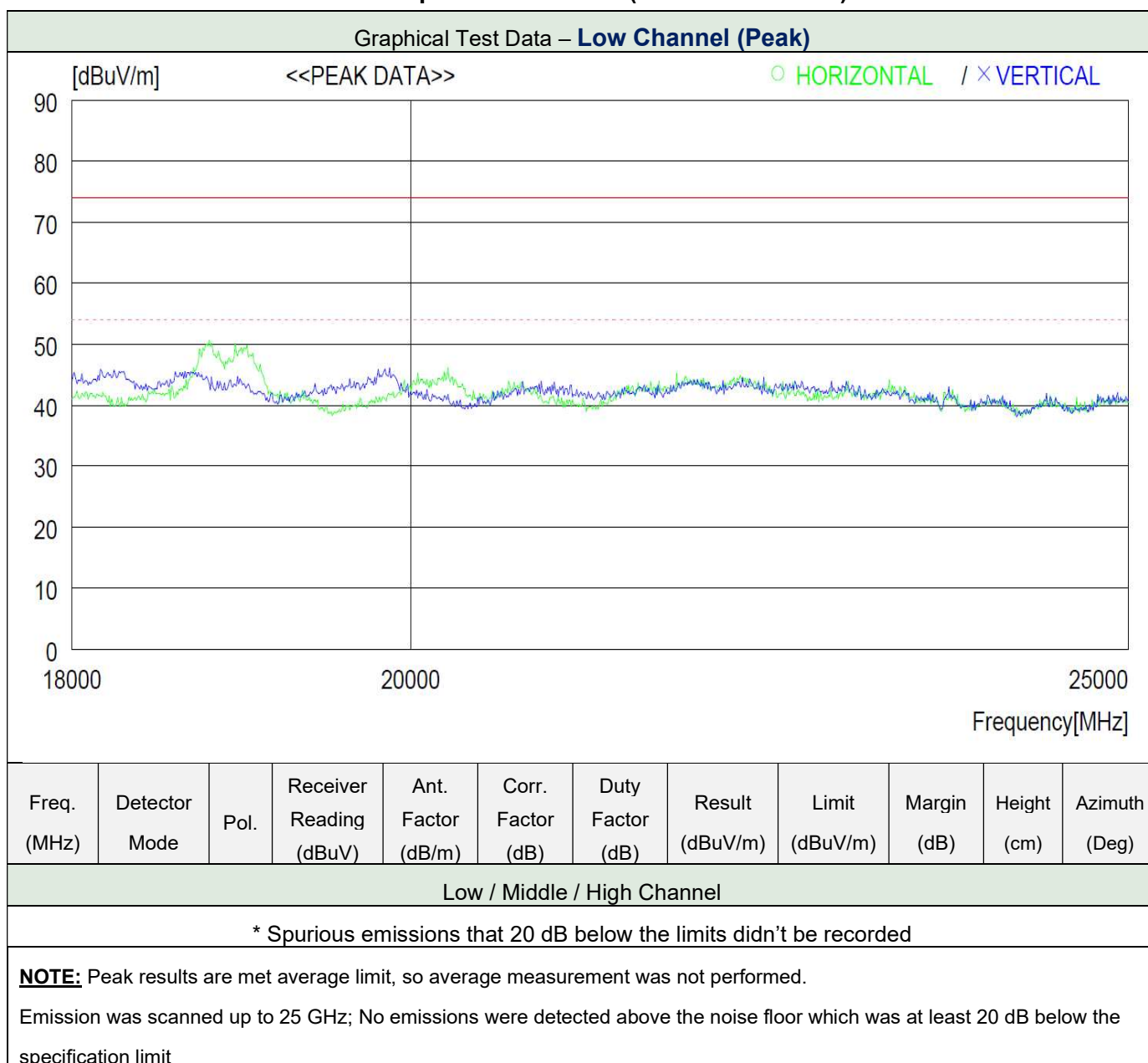
Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Non-restricted band emission is not added duty factor.

5.6.6.5 Test Data for Harmonic & Spurious emission (18 GHz to 25 GHz)



Note. "H" means Horizontal polarity, "V" means Vertical polarity.

Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

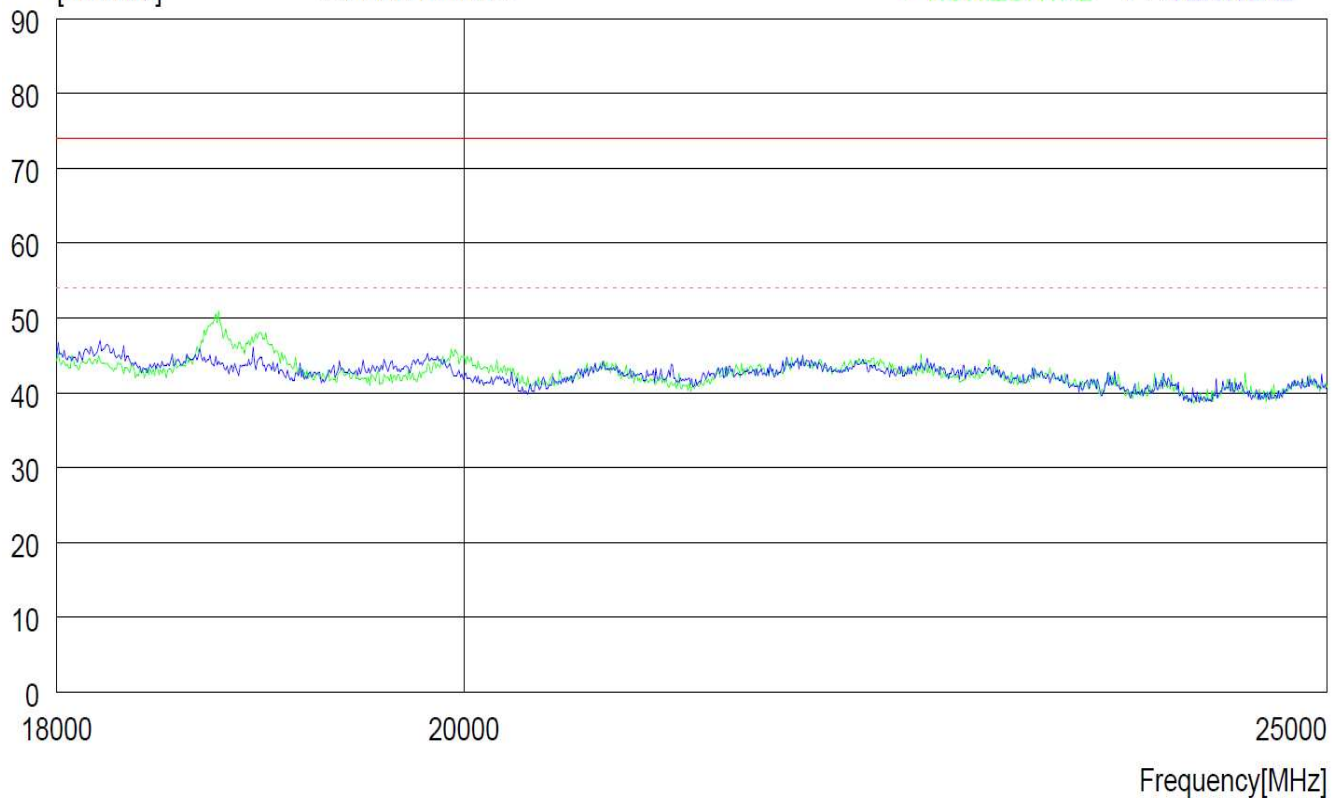
Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Graphical Test Data – Middle Channel (Peak)

[dBuV/m] <<PEAK DATA>>

○ HORIZONTAL / × VERTICAL



Freq. (MHz)	Detector Mode	Pol.	Receiver Reading (dBuV)	Ant. Factor (dB/m)	Corr. Factor (dB)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
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Low / Middle / High Channel

* Spurious emissions that 20 dB below the limits didn't be recorded

NOTE: Peak results are met average limit, so average measurement was not performed.

Emission was scanned up to 25 GHz; No emissions were detected above the noise floor which was at least 20 dB below the specification limit

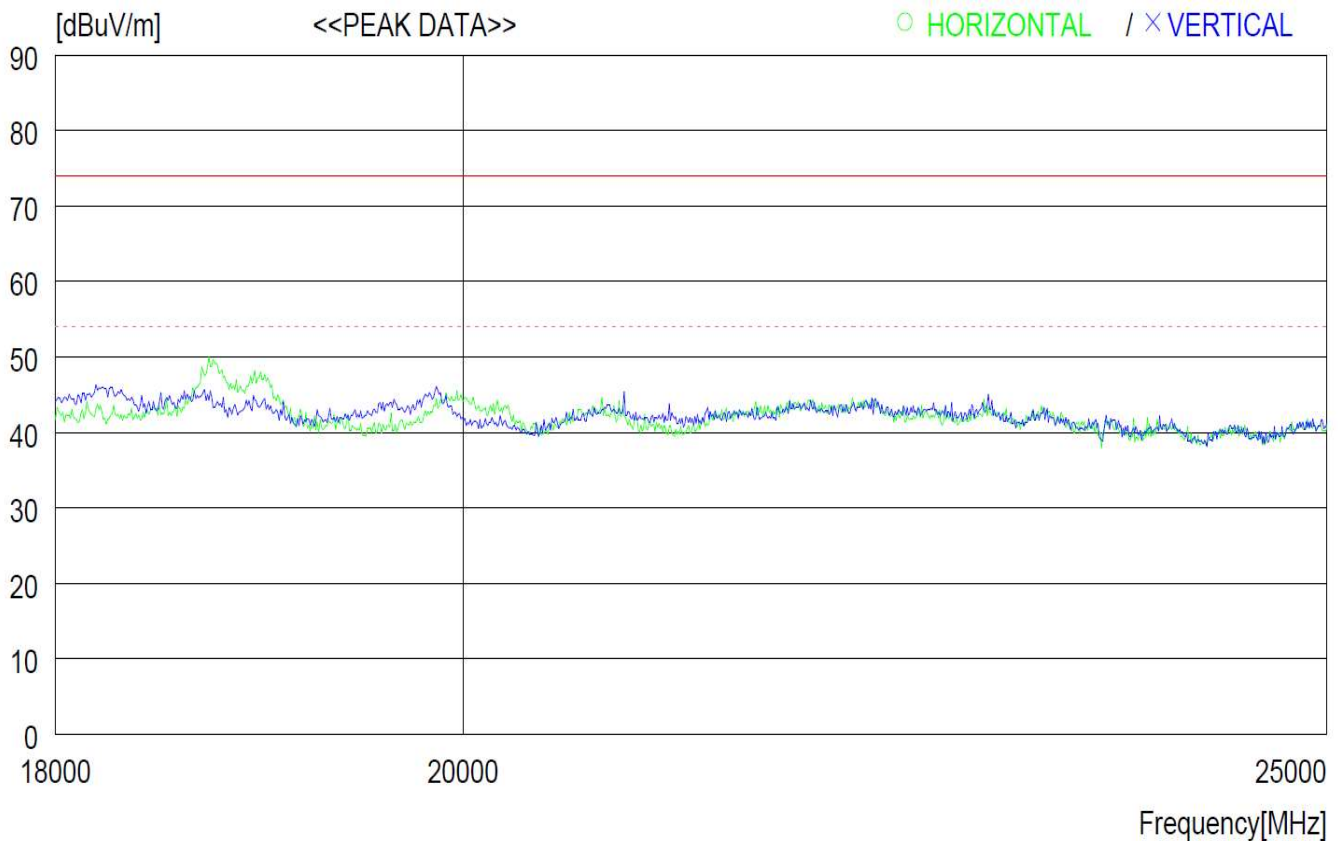
Note. "H" means Horizontal polarity, "V" means Vertical polarity.

Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

Graphical Test Data – High Channel (Peak)



Freq. (MHz)	Detector Mode	Pol.	Receiver Reading (dBuV)	Ant. Factor (dB/m)	Corr. Factor (dB)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Azimuth (Deg)
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Low / Middle / High Channel

* Spurious emissions that 20 dB below the limits didn't be recorded

NOTE: Peak results are met average limit, so average measurement was not performed.

Emission was scanned up to 25 GHz; No emissions were detected above the noise floor which was at least 20 dB below the specification limit

Note. "H" means Horizontal polarity, "V" means Vertical polarity.

Corr. Factor (dB) = Pre-amplifier gain - Cable Loss

Result = Receiver Reading + Antenna Factor - Corr. Factor + Duty factor

Margin = Limit – Result

5.7 AC Power Line Conducted Emission

5.7.1 Limit

Acc. to section 15.207 (a), RSS-GEN 8.8 following table shall be applied.

Frequency Range (MHz)	Quasi-Peak (dBuV)	Average (dBuV)
0.15 - 0.5	66 to 56	56 to 46
0.5 - 5	56	46
5 -30	60	50

5.7.2 Method of Measurement

The EUT was placed on a wooden table, 0.8 m height above the horizontal ground plane and 40 cm from the vertical ground plane. Power was fed to the EUT through a 50 Ω / 50 μ H + 5 Ω Artificial Mains Network (AMN). The ground plane was electrically bonded to the reference ground system and all power lines were filtered from ambient.

The receiver is set to a resolution bandwidth of 9 kHz. Peak detection is used unless otherwise noted as quasi-peak or average.

The test was performed for both Neutral and Hot lines.

5.7.3 Measurement Uncertainty

Measurement uncertainties were not taken into account and following uncertainty levels have been estimated for tests performed on the apparatus. The measurement uncertainties are given with at least 95 % confidence.

Frequency Range	Uncertainty	Frequency Range	Uncertainty
9 kHz ~ 150 kHz	$\pm$ 2.00 dB	150 kHz ~ 30 MHz	$\pm$ 2.00 dB

5.7.4 Sample Calculated Example

At 5.31 MHz

QP Limit = 60.0 dBuV

Correction Factor (C. Factor) of LISN, Pulse Limiter and cable loss at 5.31 MHz = 9.7 dB

Q.P Reading from the Test receiver = 20.8 dBuV

(Calculated value for system losses by software EMC32 manufactured by Rohde & Schwarz)

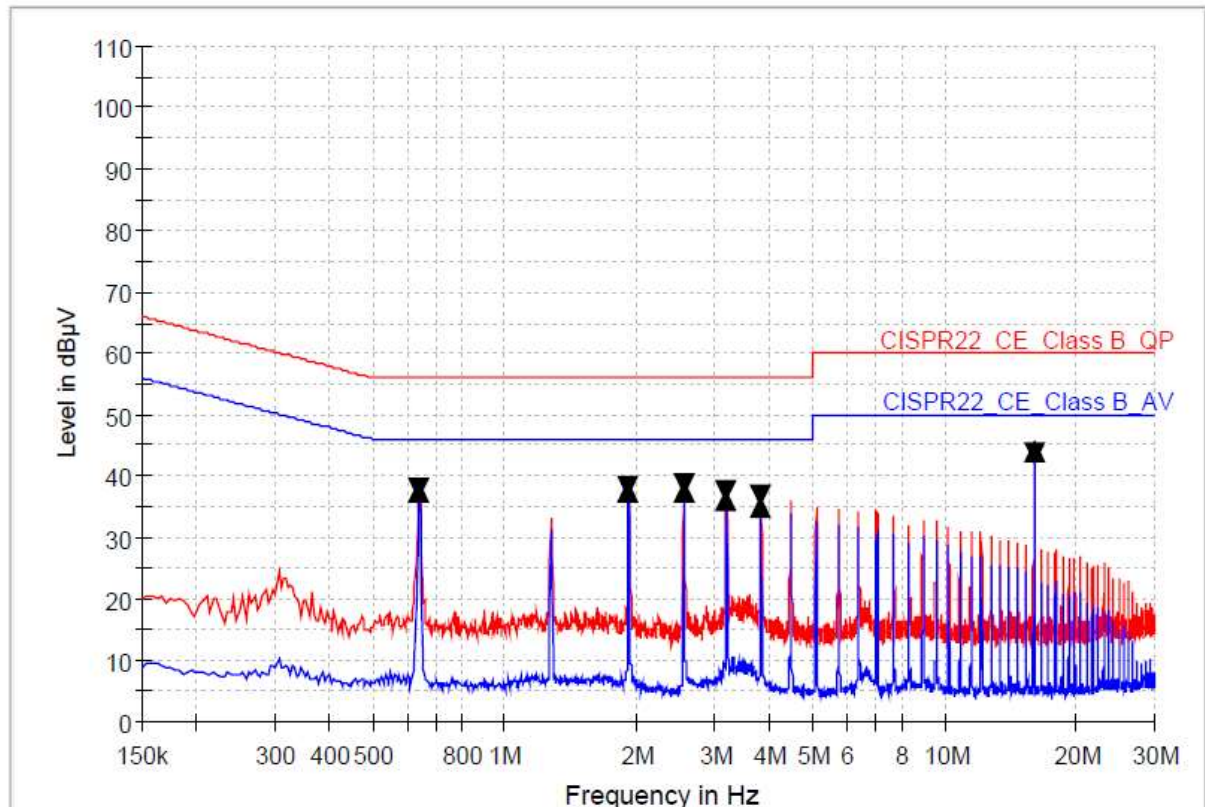
Therefore Q.P Margin = 60 - 20.8 = 39.2

so the EUT has 39.2 dB margin at 5.31 MHz

5.7.5 Worst Case Test Data

Date of Test	2019-11-29	Temperature	22.8 °C
		Relative humidity	40.9 % R.H.
Measurement Frequency Range		9 kHz ~ 30MHz	
Test Result	PASS	Tested By	Do-heon Kim 

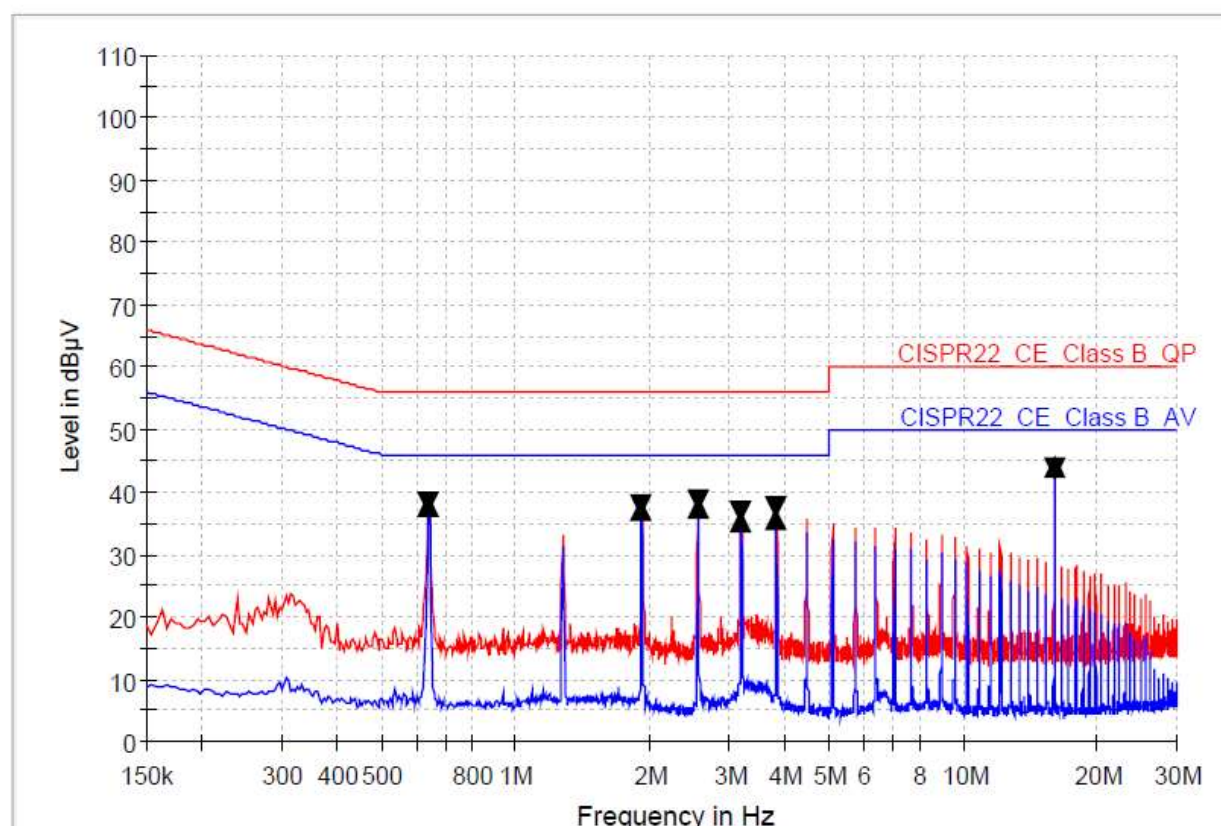
Hot Line



Limit and Margin1

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBμV)	Margin - CAV (dB)	Limit - CAV (dBμV)
0.638000	37.9	37.4	9.000	L1	9.7	18.1	56.0	8.6	46.0
1.914000	38.1	37.4	9.000	L1	9.8	17.9	56.0	8.6	46.0
2.554000	38.5	37.4	9.000	L1	9.9	17.5	56.0	8.6	46.0
3.190000	37.6	36.2	9.000	L1	10.0	18.4	56.0	9.8	46.0
3.826000	36.7	34.9	9.000	L1	10.0	19.3	56.0	11.1	46.0
16.002000	43.7	44.0	9.000	L1	10.3	16.3	60.0	6.0	50.0

Neutral Line



Limit and Margin1

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Bandwidth (kHz)	Line	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBμV)	Margin - CAV (dB)	Limit - CAV (dBμV)
0.638000	38.2	37.8	9.000	N	9.7	17.8	56.0	8.2	46.0
1.914000	37.8	37.1	9.000	N	9.8	18.2	56.0	8.9	46.0
2.554000	38.6	37.6	9.000	N	9.9	17.4	56.0	8.4	46.0
3.194000	36.9	35.2	9.000	N	10.0	19.1	56.0	10.8	46.0
3.830000	37.4	35.5	9.000	N	10.0	18.6	56.0	10.5	46.0
16.002000	43.7	44.0	9.000	N	10.3	16.3	60.0	6.0	50.0

Appendix I – Test Instrumentation

Description	Model No.	Serial No.	Manufacturer.	Due for Cal. Date	Cal. Interval
Signal & Spectrum Analyzer	FSW 43	100578	Rohde & Schwarz	2020-04-24	1 Y
Attenuator	56-10	58769	WEINSCHL	2020-01-22	1 Y
Test Receiver	ESU 26	100303	Rohde & Schwarz	2020-01-18	1 Y
Loop Antenna	HFH2-Z2	100341	Rohde & Schwarz	2021-04-22	2 Y
DC Power Supply	6032A	SG41000637	Agilent	2020-03-29	1 Y
TRILOG Broadband Antenna	VULB9163	9163.799	Schwarzbeck	2021-11-12	2 Y
Horn Antenna	HF 907	102426	Rohde & Schwarz	2021-01-11	2 Y
Horn Antenna	BBHA 9170	BBHA 9170 #783	Schwarzbeck	2020-11-26	2 Y
Notch Filter	BRM50702	G318	MICRO-TRONICS	2020-11-07	1 Y
Attenuator	6dB	272.4110.50	Rohde & Schwarz	2020-01-18	1 Y
Pre-Amplifier	310N	344015	Sonoma Instrument	2020-01-18	1 Y
Pre-Amplifier	SCU 18D	19006450	Rohde & Schwarz	2020-04-19	1 Y
Pre-Amplifier	CBL18265035	28706	CERNEX	2020-04-01	1 Y
Turn Table	DT3000-3t	1310814	INNCO SYSTEM	N/A	N/A
Antenna Master	MA4000-EP	4600814	INNCO SYSTEM	N/A	N/A
Antenna Master	MA4000-XP-ET	-	INNCO SYSTEM	N/A	N/A
Camera Controller	HDCon4102	6531445048	PONTIS	N/A	N/A
CO3000 Controller	Co3000-4Port	CO3000/806/34130814/L	INNCO SYSTEM	N/A	N/A
CO3000 Controller	Co3000-4Port	CO3000/807/34130814/L	INNCO SYSTEM	N/A	N/A
EMI Test Receiver	ESCI 7	100722	Rohde & Schwarz	2020-01-18	1 Y
LISN	ENV216	100110	Rohde & Schwarz	2020-01-14	1 Y

The measuring equipment utilized to perform the tests documented in this test report has been calibrated in accordance with manufacturer's recommendations, and is traceable to recognized national standards.