TEST REPORT

Reference No.	:	WTF23F03045657W
FCC ID	:	2ASCM-PBR-05XS
Applicant	:	PowerBox-Systems GmbH
Address	:	Ludwig-Auer-Strasse 5 Donauwörth, 86609 Germany
Manufacturer	:	The same as above
Address	:	The same as above
Product Name	:	PBR-5XS
Model No.	:	PBR-5XS
Test specification	:	FCC CFR47 Part 15 Subpart C (Section 15.247): 2021
Date of Receipt sample	:	2023-03-15
Date of Test	:	2023-04-28 to 2023-05-05
Date of Issue	:	2023-05-23
Test Report Form No.	:	WEW-15247A-01A
Test Result		**Pass**

Remarks:
The results shown in this test report refer only to the sample(s) tested, this test report cannot be reproduced, except in full, without prior written permission of the company. The report would be invalid without specific stamp of test institute and the signatures of approver.

Prepared By:
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Tested by:

Roy Hong

Approved by:

Danny Zhou

1 Revision History

Test Report No.	Date of Issue	Description	Status
WTF23F03045657W	2023-05-23	Original	Valid

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3 General Information

3.1 General Description of E.U.T

Product Name ..... : PBR-5XS

Model No. ..... : PBR-5XS

Model Description ..... : ---

Rated Voltage..... : DC 4V-9V

Battery Capacity ..... : ---

Power Adapter ..... : ---

3.2 Technical Characteristics of EUT

Frequency Range ..... : 2402-2467MHz

Max. RF Output Power ..... : 14.22 dBm (Conducted)

Modulation ..... : MSK

Quantity of Channels ..... : 66

Channel Separation..... : 1MHz

Type of Antenna ..... : Ceramic Chip Antenna

Antenna Gain ..... : 5.19dBi

3.3 Standards Applicable for Testing

The tests were performed according to following standards:

FCC Rules Part 15.247	Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz
558074 D01 15.247 Meas Guidance v05r02	Guidance For Compliance Measurements On Digital Transmission System, Frequency Hopping Spread Spectrum System, And Hybrid System Devices Operating Under Section 15.247 Of The FCC Rules
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices

3.4 Channel List

Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
0	2402	1	2403	2	2404	3	2405
4	2406	5	2407	6	2408	7	2409
8	2410	9	2411	10	2412	11	2413
12	2414	13	2415	14	2416	15	2417
16	2418	17	2419	18	2420	19	2421
20	2422	21	2423	22	2424	23	2425
24	2426	25	2427	26	2428	27	2429
28	2430	29	2431	30	2432	31	2433
32	2434	33	2435	34	2436	35	2437
36	2438	37	2439	38	2440	39	2441
40	2442	41	2443	42	2444	43	2445
44	2446	45	2447	46	2448	47	2449
48	2450	49	2451	50	2452	51	2453
52	2454	53	2455	54	2456	55	2457
56	2458	57	2459	58	2460	59	2461
60	2462	61	2463	62	2464	63	2465
64	2466	65	2467	---	---	---	---

3.5 Test Facility

The test facility has a test site registered with the following organizations:

- **ISED – Registration No.: 21895**

Waltek Testing Group (Foshan) Co., Ltd. has been registered and fully described in a report filed with the Innovation, Science an Economic Development Canada(ISED). The acceptance letter from the ISED is maintained in our files. Registration ISED number:21895, March 12, 2019

- **FCC – Registration No.: 820106**

Waltek Testing Group (Foshan) Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration 820106, August 16, 2018

- **FCC – Designation No.: CN5034**

Waltek Testing Group (Foshan) Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Designation No. CN5034.

- **NVLAP – Lab Code: 600191-0**

Waltek Testing Group (Foshan) Co., Ltd. EMC Laboratory is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP/NIST). NVLAP Code: 600191-0.
This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

3.6 Subcontracted

Whether parts of tests for the product have been subcontracted to other labs:

☐ Yes ☒ No

If Yes, list the related test items and lab information:

Test items: ---

Lab information: ---

3.7 Abnormalities from Standard Conditions

None.

3.8 Disclaimer

The antenna gain information is provided by the customer. The laboratory is not responsible for the accuracy of the antenna gain information.

4 EUT Setup and Test Mode

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. All testing shall be performed under maximum output power condition, with a duty cycle equal to 100%, and to measure its highest possible emissions level, more detailed description as follows:

Test Mode List

Test Mode	Description	Remark
TM1	Low Channel	2402MHz
TM2	Middle Channel	2434MHz
TM3	High Channel	2467MHz

Test Conditions

Temperature:	22~25℃
Relative Humidity:	50~55%
Atmospheric pressure:	101.9kPa

5 Equipment Used during Test

5.1 Equipment List

☐Conducted Emissions 1#						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal Date**	**Cal Due Date**
1.	EMI Test Receiver	R&S	ESR3	102423	2023-01-05	2024-01-04
2.	LISN	R&S	ENV216	101343	2023-01-05	2024-01-04
3.	Cable	HUBER+SUHNER	CBL2-NN-6M	223NN624	2023-01-05	2024-01-04
4.	Switch	CD	RSU-A4 18G	RSUA4008	2023-01-05	2024-01-04

☐Conducted Emissions 2#						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal Date**	**Cal Due Date**
1.	EMI Test Receiver	R&S	ESCI	101178	2023-01-05	2024-01-04
2.	LISN	R&S	ENV216	101215	2023-01-05	2024-01-04
3.	Cable	HUBER+SUHNER	CBL2-NN-6M	6102701	2023-01-05	2024-01-04
4.	Switch	ESE	RSU/M2	---	2023-01-05	2024-01-04

☐Conducted Emissions 3#						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal Date**	**Cal Due Date**
1.	EMI Test Receiver	R&S	ESR3	102842	2023-01-05	2024-01-04
2.	LISN	R&S	ENV216	101542	2023-01-05	2024-01-04
3.	Cable	YIHENG	LMR195UF-NMNM-2.5	---	2023-01-05	2024-01-04
4.	Manual RF Switch	YIHENG	SW-2	RSU0402	2023-01-05	2024-01-04

☒Radiation Emissions						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Calibration Date**	**Calibration Due Date**
1.	3m Semi-anechoic Chamber	CHANGCHUANG	9m×6m×6m	-	2021-01-11	2024-01-10
2.	EMI Test Receiver	RS	ESR7	101566	2023-01-05	2024-01-04
3.	EMC Analyzer	Agilent	N9020A	MY48011796	2022-05-17	2023-05-16
4.	Active Loop Antenna	SCHWARZBECK	FMZB1519B	00004	2023-01-05	2024-01-04
5.	Trilog Broadband Antenna	SCHWARZBECK	VULB 9162	9162-117	2023-03-10	2024-03-09
6.	Coaxial Cable (below 1GHz)	H+S	CBL3-NN-12+3 m	214NN320	2023-01-06	2024-01-05
7.	Broad-band Horn Antenna	SCHWARZBECK	BBHA 9120 D	01561	2023-01-06	2024-01-05
8.	Broad-band Horn Antenna	SCHWARZBECK	BBHA 9170	01119	2023-01-06	2024-01-05
9.	Coaxial Cable (above 1GHz)	Times-Micorwave	CBL5-NN	-	2023-01-05	2024-01-04
10.	Amplifier	Lunar E M	LNA1G18-40	20160501002	2023-01-05	2024-01-04

☒RF Conducted Testing						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Calibration Date**	**Calibration Due Date**
1.	Spectrum Analyzer	Agilent	N9020A	MY48011796	2022-05-17	2023-05-16
2.	Analog Signal Generator	Agilent	N5181A	MY48180720	2023-01-05	2024-01-04
3.	RF Control Unit	CHANGCHUANG	JS0806-2	-	2023-01-06	2024-01-05

☐: ***Not Used***

☒: ***Used***

5.2 Test Software

Description	Manufacturer	Model	Version
EMI Test Software (Conducted Emission 1#)	FARATRONIC	EZ-EMC	EMEC-3A1
EMI Test Software (Conducted Emission 2#)	FARATRONIC	EZ-EMC	CON-03A1
EMI Test Software (Conducted Emission 3#)	FARATRONIC	EZ-EMC	COM 3A1.1
EMI Test Software (Radiated Emission)	FARATRONIC	EZ-EMC	RA-03A1-1
RF Conducted Test Software	TONSCEND	JS1120-2	V2.6

5.3 Special Accessories and Auxiliary Equipment

Item	Equipment	Manufacturer	Model No.	Serial No.
1.	/	/	/	/

5.4 Measurement Uncertainty

Parameter	Uncertainty
RF Output Power	±2.2dB
Occupied Bandwidth	±1.5%
Conducted Emission	±2.6dB
Transmitter Spurious Emission	±3.8dB (for 25MHz-1GHz)
	±5.0dB (for 1GHz-18GHz)

6 Summary of Test Result

Test Items	FCC Rules	Result
Conducted Emissions	§15.207(a)	N/A
Radiated Spurious Emissions	§15.209(a)	Compliant
Band edge Emissions	§15.247(d)	Compliant
20 dB Bandwidth	15.247(a)(1)	Compliant
Occupied bandwidth (99%)	§2.202(a)	Compliant
Maximum Peak Output Power	§15.247(b)(1)	Compliant
Carrier Frequency Separation	§15.247(a)(1)	Compliant
Number of Hopping Frequency	§15.247(a)(1)(iii)	Compliant
Time of occupancy Dwell time	§15.247(d)(1)(iii)	Compliant
Antenna Requirement	§15.203	Compliant

Remark:

Pass Test item meets the requirement

Fail Test item does not meet the requirement

N/A Test case does not apply to the test object

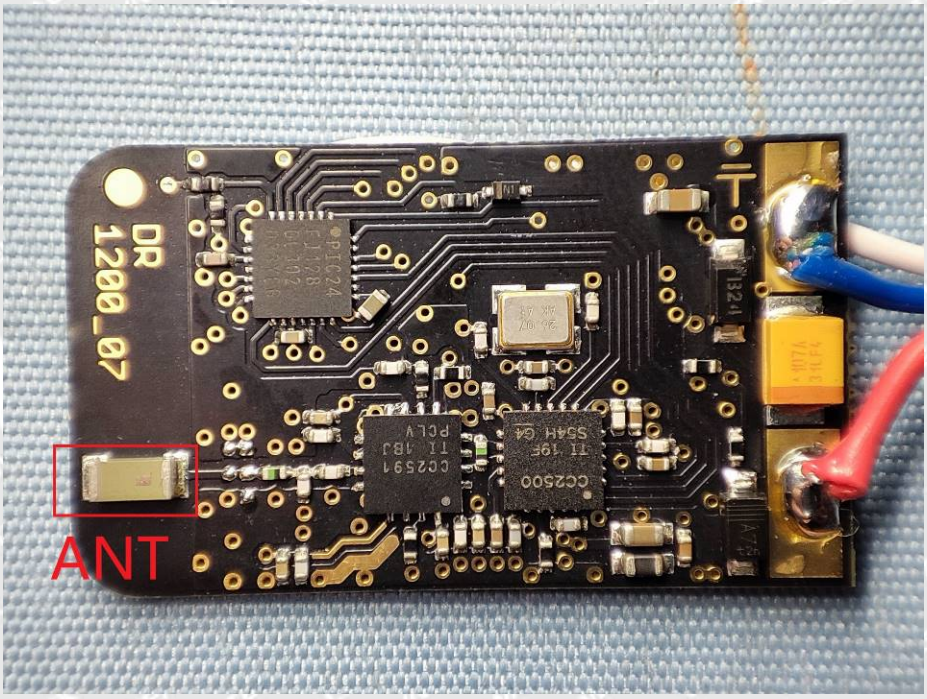
6.1 Antenna Requirement

6.1.1 Standard Applicable

According to FCC Part 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.

6.1.2 Evaluation Information

The EUT has a ceramic chip antenna, the gain is 5.19dBi, fulfil the requirement of this section.



6.2 Radiated Spurious Emissions

6.2.1 Standard Applicable

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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

The emission limit in this paragraph is based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply. Spurious Radiated Emissions measurements starting below or at the lowest crystal frequency.

6.2.2 Test Procedure

1) The EUT is placed on a turntable, which is 0.8m(Below 1G) 1.5m(above 1G)above ground plane.

2) The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

3) EUT is set 3m away from the receiving antenna, which is moved from 1m to 4m to find out the maximum emissions. The spectrum was investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

4) Maximum procedure was performed on the six highest emissions to ensure EUT compliance.

5) And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.

6) Repeat above procedures until the measurements for all frequencies are complete.

7) The radiation measurements are tested under 3-axes(X, Y, Z) position(X denotes lying on the table, Y denotes side stand and Z denotes vertical stand), After pre-test, It was found that the worse radiation emission was get at the Z position. So the data shown was the Z position only.

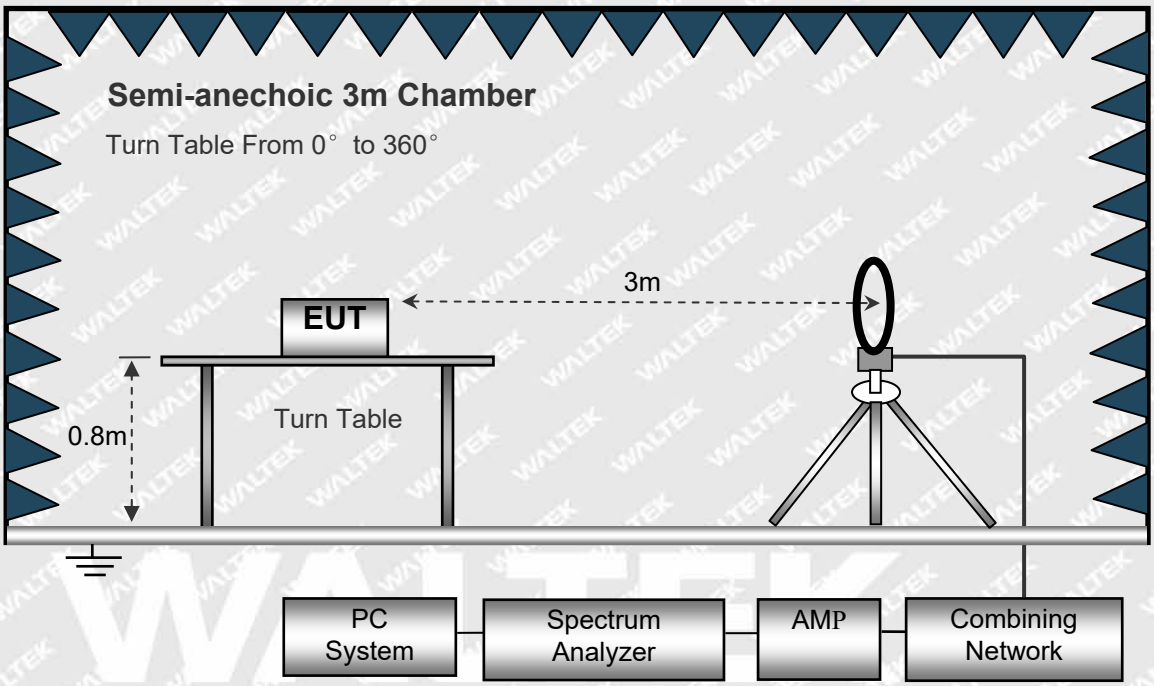
6.2.3 Test Setup

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.205 15.247(a) and FCC Part 15.209 Limit.

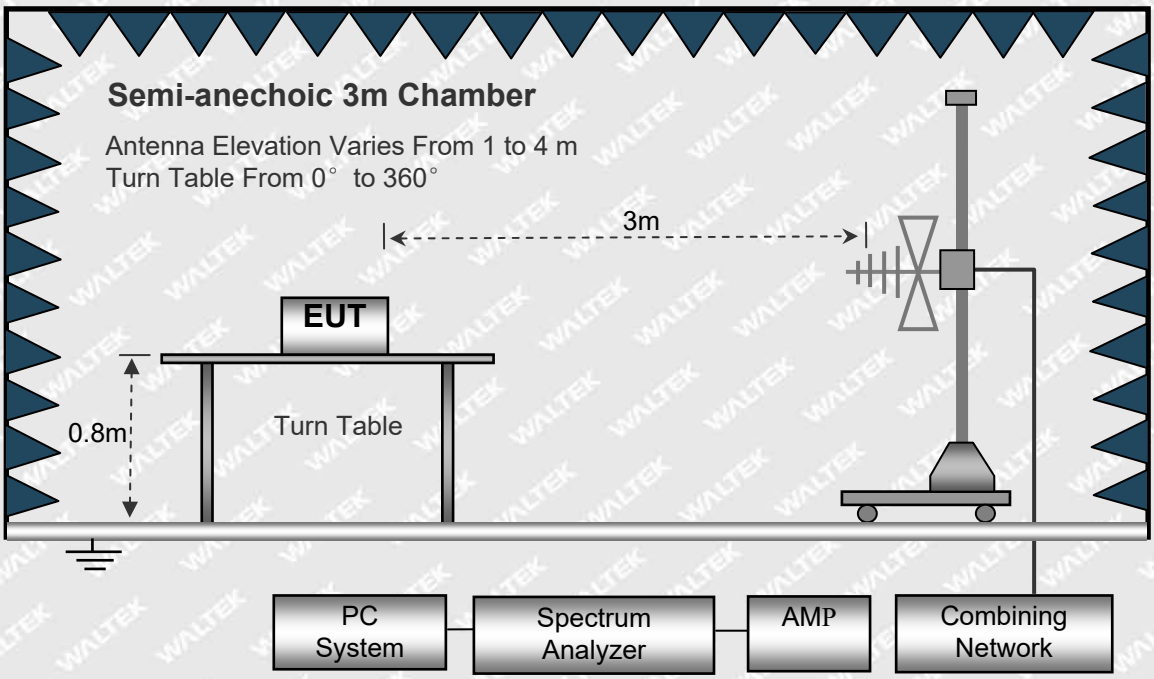
The external I/O cables were draped along the test table and formed a bundle 30 to 40 cm long in the middle.

The spacing between the peripherals was 10 cm.

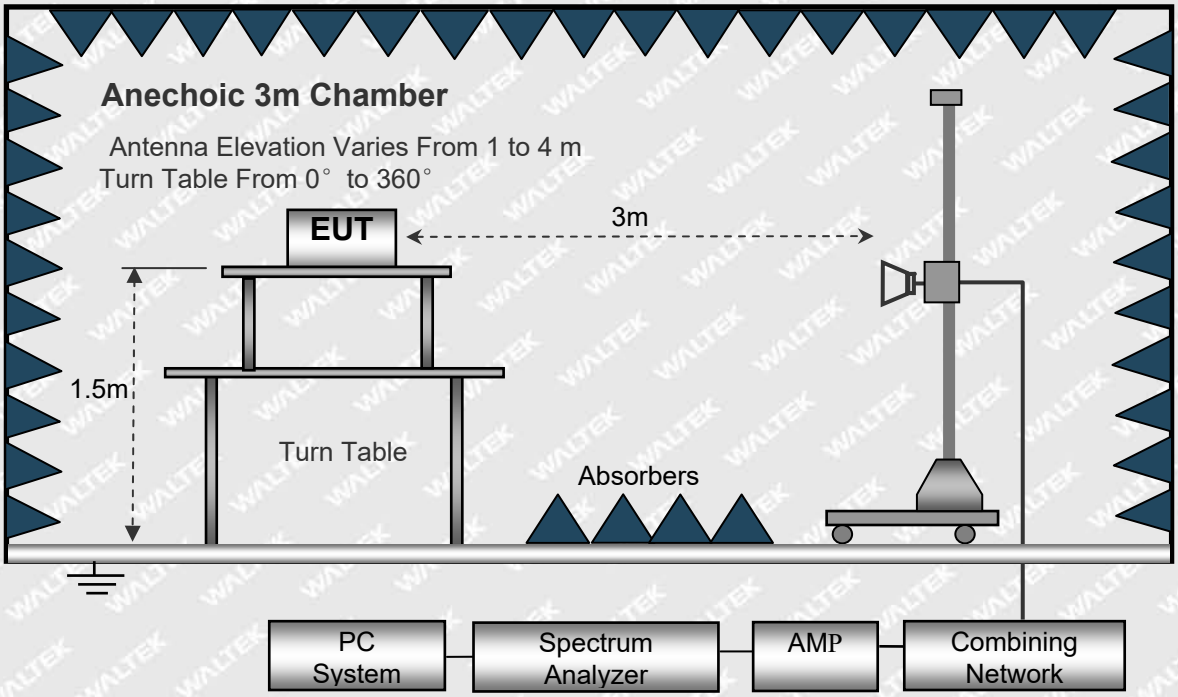
The test setup for emission measurement below 30MHz.



The test setup for emission measurement from 30 MHz to 1 GHz.



The test setup for emission measurement above 1 GHz.



6.2.4 Spectrum Analyzer Setup

9KHz-30MHz	30MHz-1GHz	Above 1GHz
RBW=10kHz	RBW=120kHz	RBW=1MHz
VBW=30kHz	VBW=300kHz	VBW=3MHz(Peak), 10MHz(AV)
Sweep time=Auto	Sweep time=Auto	Sweep time=Auto
Trace=Max hold	Trace=Max hold	Trace=Max hold
Detector function=peak	Detector function=peak, QP	Detector function=peak, AV

6.2.5 Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain from the Amplitude reading. The basic equation is as follows:

Corr. Ampl. = Indicated Reading + Corr. Factor

Corr.Factor=Antenna Factor + Cable Factor - Amplifier Gain

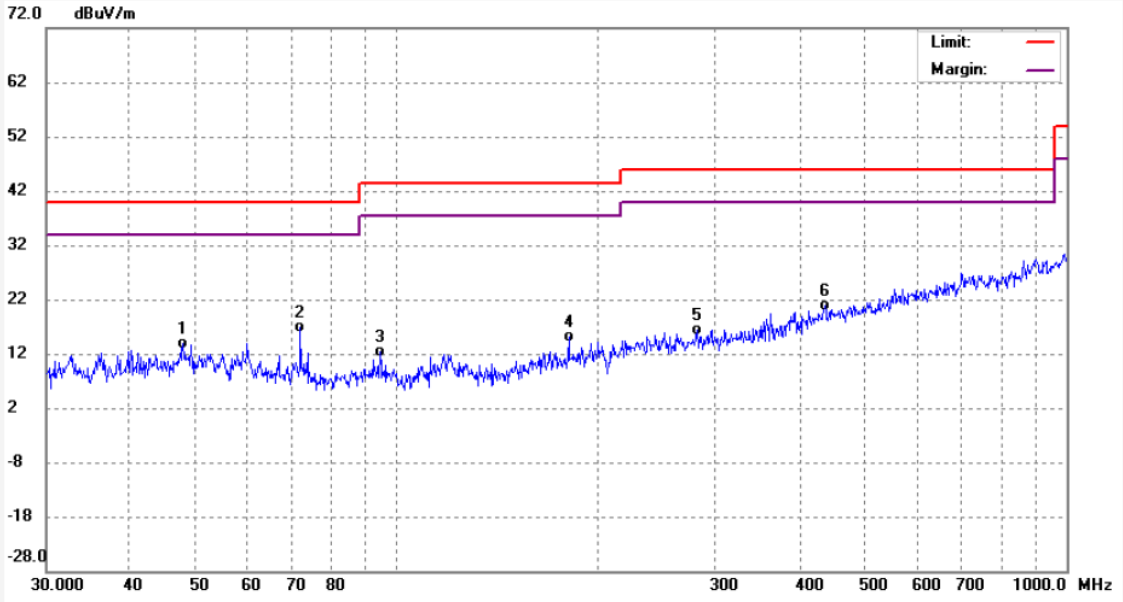
The “Margin” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -7dB means the emission is 7dB below the maximum limit for Class B. The equation for margin calculation is as follows:

Margin = Corr. Ampl. – Limit

6.2.6 Test Results

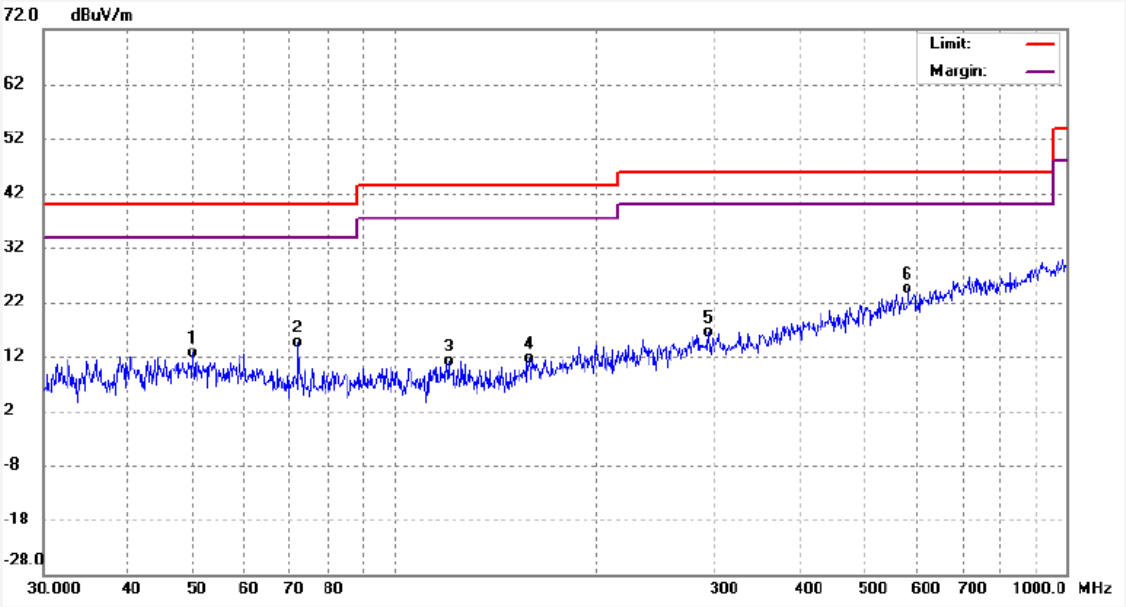
Test Frequency: Below 1GHz

Test Channel Low Channel **Polarization** Vertical



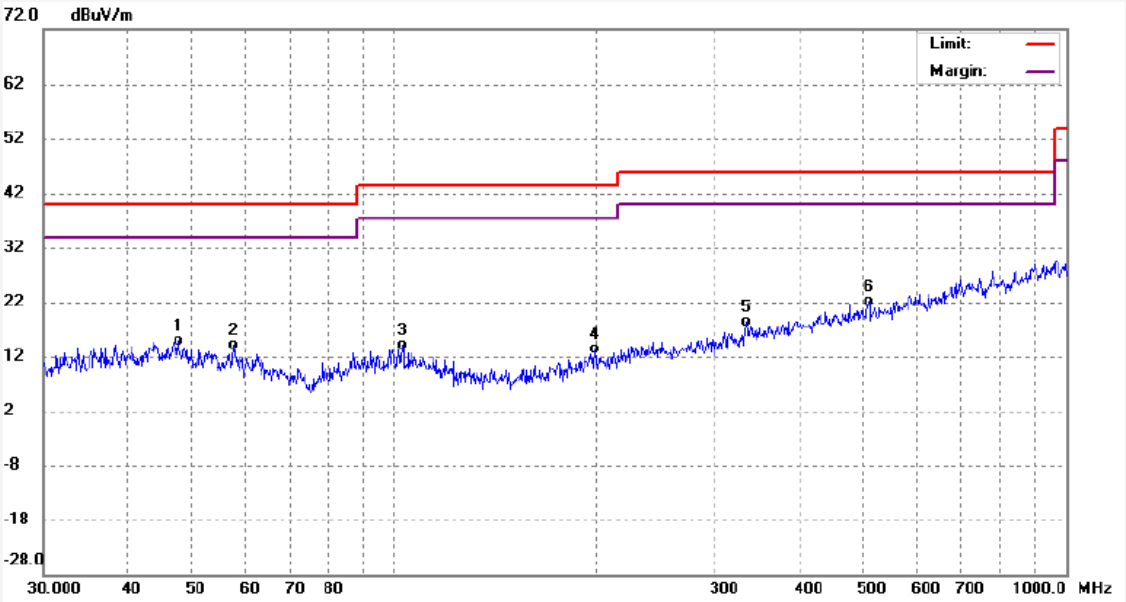
No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	48.0276	-0.02	13.89	13.87	40.00	-26.13	QP	
2	72.0085	6.05	10.79	16.84	40.00	-23.16	QP	
3	94.5940	0.80	11.57	12.37	43.50	-31.13	QP	
4	181.1563	1.09	14.16	15.25	43.50	-28.25	QP	
5	281.6980	-0.49	16.90	16.41	46.00	-29.59	QP	
6	436.2012	0.35	20.56	20.91	46.00	-25.09	QP	

Test Channel Low Channel **Polarization** Horizontal



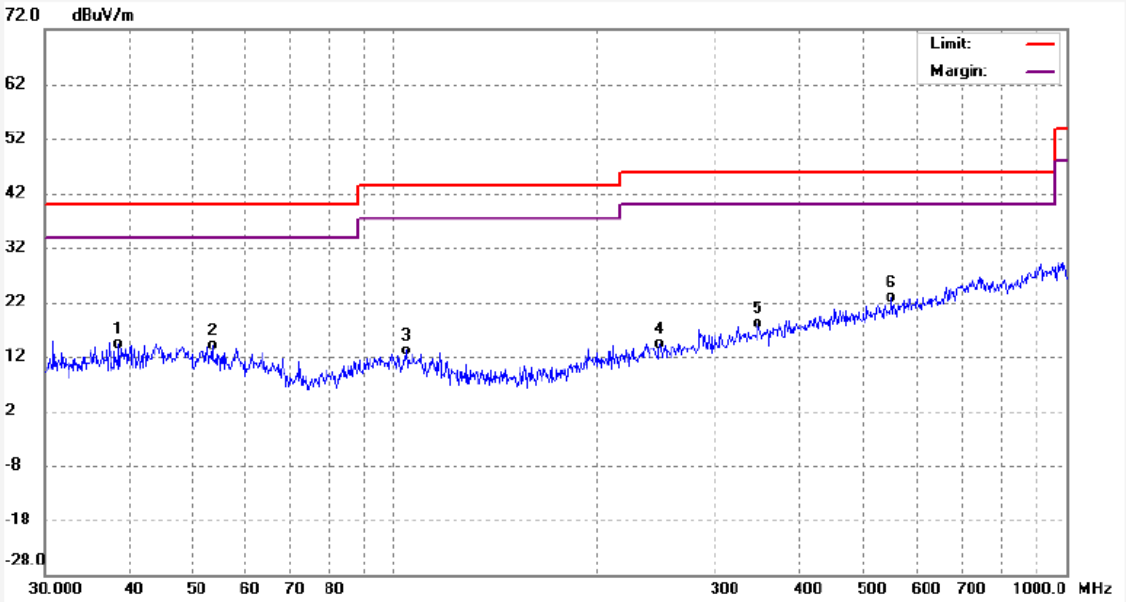
No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	50.0741	-2.67	15.31	12.64	40.00	-27.36	QP	
2	71.9833	3.95	10.67	14.62	40.00	-25.38	QP	
3	120.5300	-1.11	12.31	11.20	43.50	-32.30	QP	
4	158.8904	0.42	11.19	11.61	43.50	-31.89	QP	
5	293.7015	0.04	16.24	16.28	46.00	-29.72	QP	
6	580.7026	2.27	22.21	24.48	46.00	-21.52	QP	

Test Channel Middle Channel **Polarization** Vertical



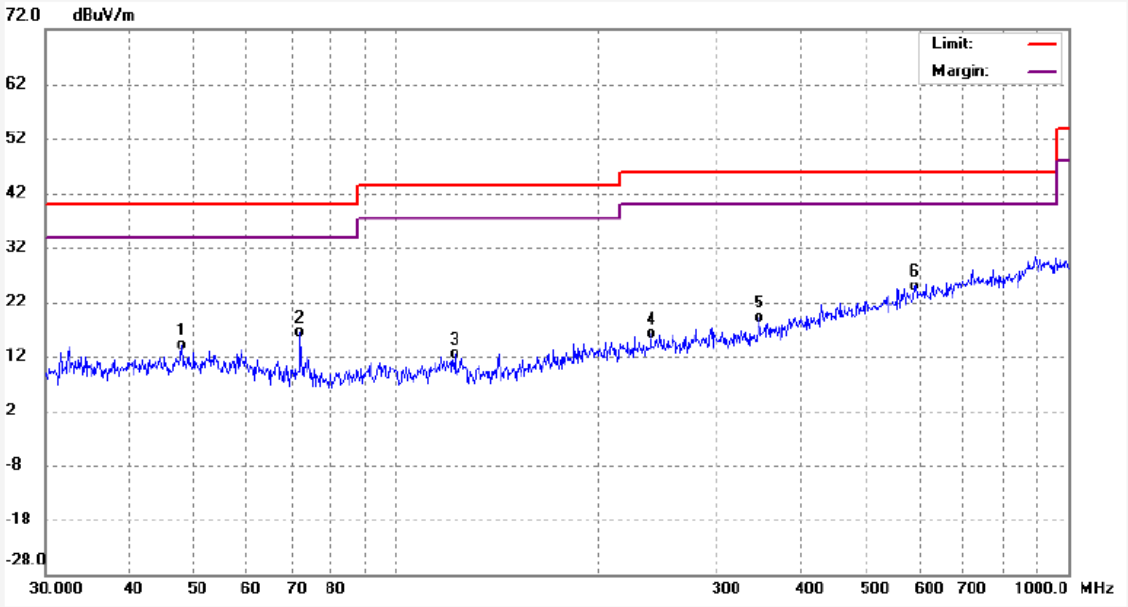
No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	47.7589	-0.65	15.53	14.88	40.00	-25.12	QP	
2	57.7354	-0.22	14.24	14.02	40.00	-25.98	QP	
3	103.0438	-0.28	14.52	14.24	43.50	-29.26	QP	
4	198.8666	0.05	13.39	13.44	43.50	-30.06	QP	
5	334.2722	0.55	17.94	18.49	46.00	-27.51	QP	
6	508.9716	1.01	21.20	22.21	46.00	-23.79	QP	

Test Channel Middle Channel **Polarization** Horizontal



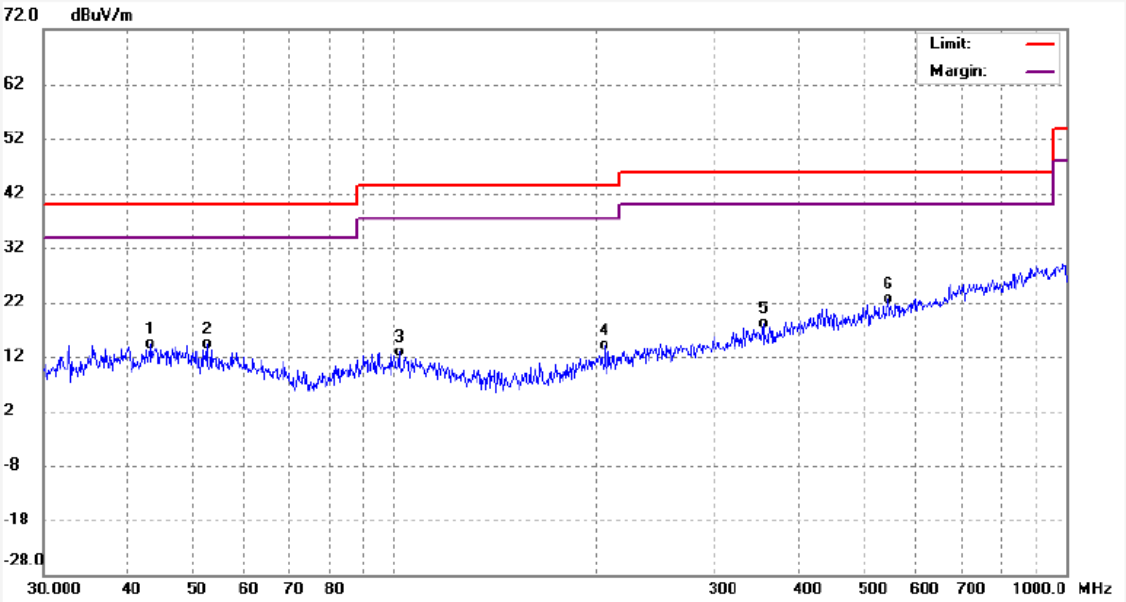
No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	38.7653	-0.39	14.82	14.43	40.00	-25.57	QP	
2	53.3740	-0.74	14.85	14.11	40.00	-25.89	QP	
3	103.9876	-1.44	14.59	13.15	43.50	-30.35	QP	
4	248.4647	-0.77	15.16	14.39	46.00	-31.61	QP	
5	347.7834	0.18	18.07	18.25	46.00	-27.75	QP	
6	549.2120	1.13	21.75	22.88	46.00	-23.12	QP	

Test Channel High Channel **Polarization** Vertical



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	48.0276	0.23	13.89	14.12	40.00	-25.88	QP	
2	72.0085	5.54	10.79	16.33	40.00	-23.67	QP	
3	122.3181	-0.36	12.70	12.34	43.50	-31.16	QP	
4	239.5669	0.13	16.02	16.15	46.00	-29.85	QP	
5	347.9054	1.04	18.00	19.04	46.00	-26.96	QP	
6	592.8417	0.63	24.35	24.98	46.00	-21.02	QP	

Test Channel High Channel **Polarization** Horizontal



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	43.4600	-1.37	15.65	14.28	40.00	-25.72	QP	
2	52.6860	-0.67	14.95	14.28	40.00	-25.72	QP	
3	101.8941	-1.67	14.44	12.77	43.50	-30.73	QP	
4	205.9637	0.52	13.67	14.19	43.50	-29.31	QP	
5	354.1831	0.16	17.99	18.15	46.00	-27.85	QP	
6	544.2275	0.93	21.68	22.61	46.00	-23.39	QP	

Test Frequency: Above 1GHz

Frequency (MHz)	Reading (dBμV/m)	Detector	Polar (H/V)	Corrected Factor (dB)	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Low Channel							
4804.00	54.14	Peak	H	-3.45	50.69	74	-23.31
4804.00	45.81	AVG	H	-3.45	42.36	54	-11.64
7206.00	41.54	Peak	H	2.00	43.54	74	-30.46
7206.00	33.78	AVG	H	2.00	35.78	54	-18.22
4804.00	54.50	Peak	V	-3.86	50.64	74	-23.36
4804.00	46.78	AVG	V	-3.86	42.92	54	-11.08
7206.00	43.73	Peak	V	2.02	45.75	74	-28.25
7206.00	35.51	AVG	V	2.02	37.53	54	-16.47
Middle Channel							
4868.00	54.86	Peak	H	-3.31	51.55	74	-22.45
4868.00	46.36	AVG	H	-3.31	43.05	54	-10.95
7302.00	43.65	Peak	H	2.12	45.77	74	-28.23
7302.00	35.70	AVG	H	2.12	37.82	54	-16.18
4868.00	53.76	Peak	V	-3.31	50.45	74	-23.55
4868.00	45.81	AVG	V	-3.31	42.50	54	-11.50
7302.00	43.12	Peak	V	2.12	45.24	74	-28.76
7302.00	35.35	AVG	V	2.12	37.47	54	-16.53
High Channel							
4934.00	53.92	Peak	H	-3.50	50.42	74	-23.58
4934.00	45.99	AVG	H	-3.50	42.49	54	-11.51
7401.00	43.63	Peak	H	2.40	46.03	74	-27.97
7401.00	36.33	AVG	H	2.40	38.73	54	-15.27
4934.00	54.92	Peak	V	-3.50	51.42	74	-22.58
4934.00	46.92	AVG	V	-3.50	43.42	54	-10.58
7401.00	43.39	Peak	V	2.40	45.79	74	-28.21
7401.00	35.5	AVG	V	2.40	37.90	54	-16.10

Note:

1.Testing is carried out with frequency rang 9kHz to the tenth harmonics, other than listed in the table above are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

2. Average measurement was not performed if peak level is lower than average limit(54 dBuV/m) for above 1GHz.

6.3 Band Edge Measurement

6.3.1 Standard Applicable

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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

6.3.2 Test Procedure

According to the KDB 558074 D01 v05r02 Subclause 8.4 and ANSI C63.10-2013 Subclause 11.11, the Emissions in nonrestricted frequency bands test method as follows:

a) Set the center frequency and span to encompass frequency range to be measured.
b) Set the RBW = 100 kHz.
c) Set the VBW ≥ [3 × RBW].
d) Detector = peak.
e) Sweep time = auto couple.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use the peak marker function to determine the maximum amplitude level.

According to the KDB 558074 D01 v05r02 Subclause 8.5 and ANSI C63.10-2013 Subclause 11.12, the Emissions in restricted frequency bands test method as follows:

A. Radiated emission measurements:
Set span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge,
as well as any modulation products which fall outside of the authorized band of operation (2310MHz to 2420MHz
for low bandedge, 2460MHz to 2500MHz for the high bandedge)
RBW = 1MHz, VBW = 1MHz for peak value measured
RBW = 1MHz, VBW = 10Hz for average value measured
Sweep = auto; Detector function = peak/average; Trace = max hold
All the trace to stabilize, set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission. Those emissions must comply with the 15.209 limit for fall in the restricted bands listed in section 15.205.

Note that the method of measurement KDB publication number: 913591 may be used for the radiated band edge measurements.

B. Antenna-port conducted measurements

Peak emission levels are measured by setting the instrument as follows:

a) RBW = as specified in Table 9/

b) VBW ≥ [3 × RBW].

c) Detector = peak.

d) Sweep time = auto.

e) Trace mode = max hold.

f) Allow sweeps to continue until the trace stabilizes. (Note that the required measurement time may be lengthened for low-duty-cycle applications.)

Table 9—RBW as a function of frequency

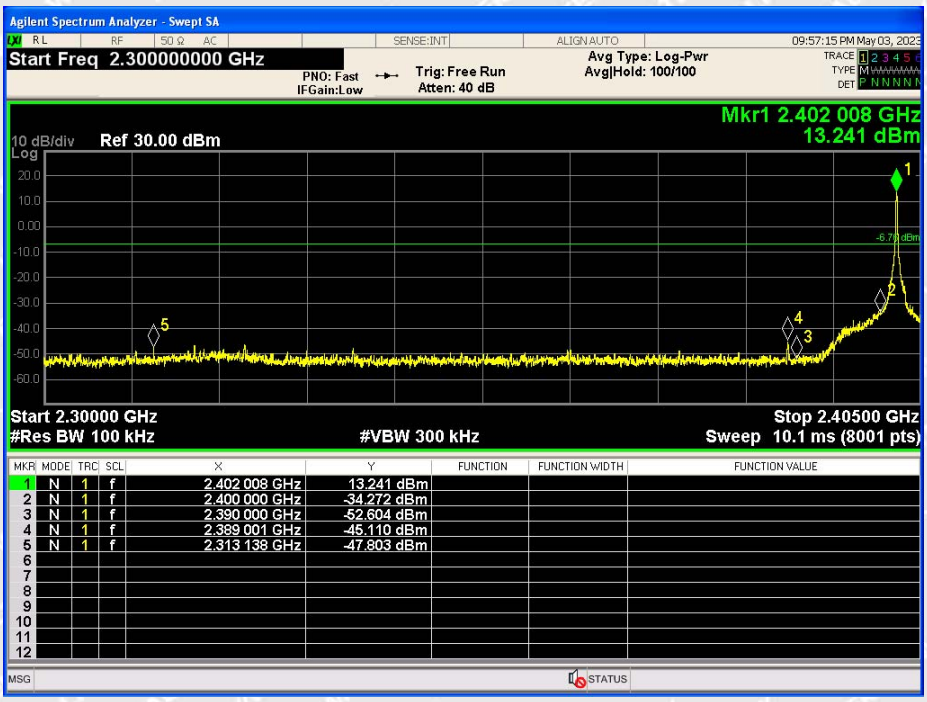
Frequency	RBW
9 kHz to 150 kHz	200 Hz to 300 Hz
0.15 MHz to 30 MHz	9 kHz to 10 kHz
30 MHz to 1000 MHz	100 kHz to 120 kHz
>1000 MHz	1 MHz

If the peak-detected amplitude can be shown to comply with the average limit, then it is not necessary to perform a separate average measurement.

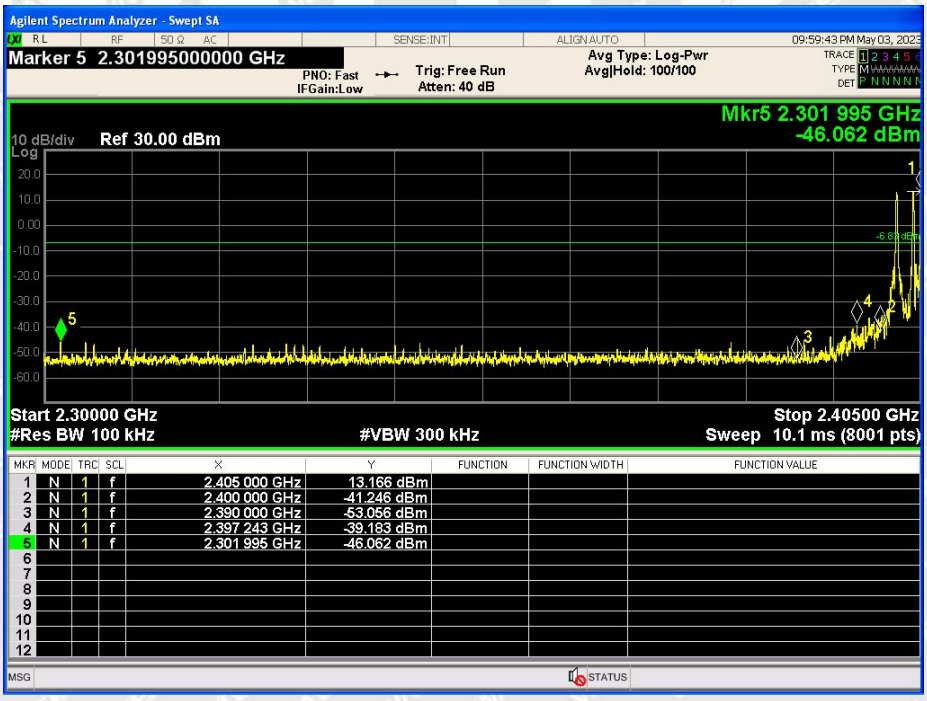
Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) are attenuated by at least the minimum requirements specified in section 8.1.

6.3.3 Test Result

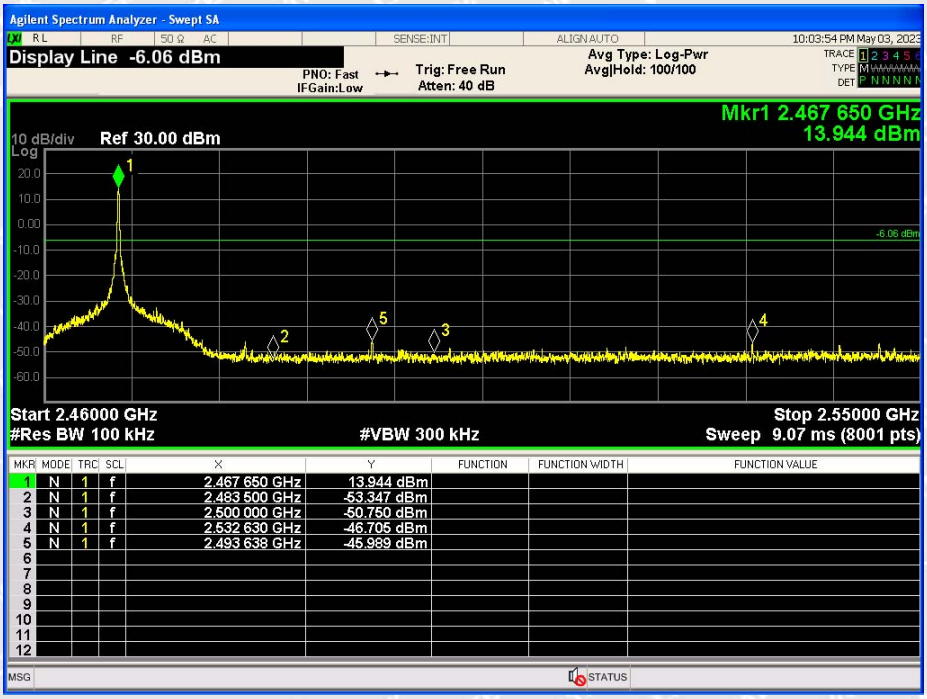
Transmitting Band edge-left side



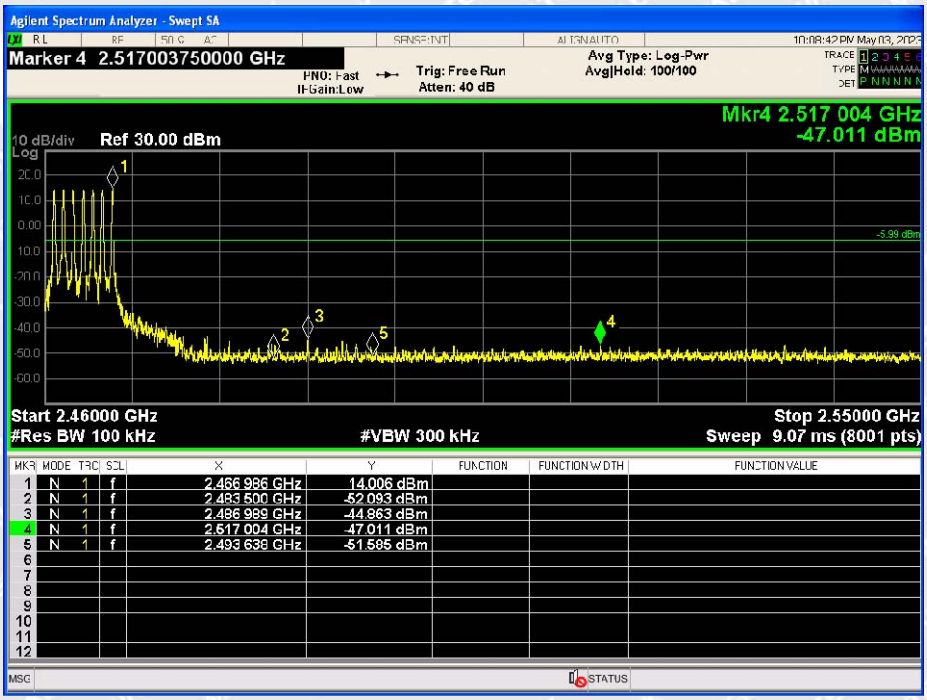
Hopping Band edge-left side



Transmitting Band edge-right side



Hopping Band edge-right side



6.4 20 dB Bandwidth Measurement

6.4.1 Standard Applicable

According to §15.215(c), intentional radiators operating under the alternative provisions to the general emission limits must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

The specific rule section under which the equipment operates is §15.247. According to §15.247(a)(2), for systems using digital modulation techniques (DTS), the 6 dB bandwidth (DTS bandwidth) is specified as the bandwidth of the emission. In this case, measuring the 20 dB bandwidth is not required.

6.4.2 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;

2) Set the spectrum analyzer: RBW = 10kHz, VBW = 30kHz

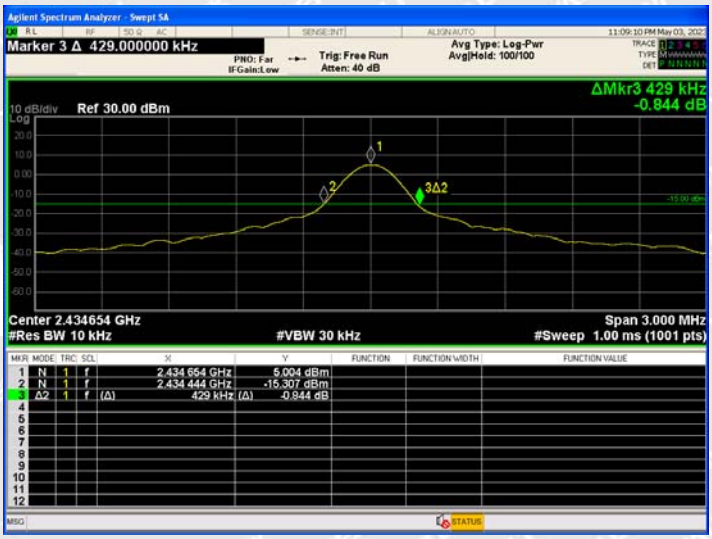
6.4.3 Test Result

Modulation	Test Channel	20dB Bandwidth (kHz)	Band edge left		Band edge right		Result
			Frequency (MHz)	Limit (MHz)	Frequency (MHz)	Limit (MHz)	
MSK	Low	453	2401.772	>2400	2402.000	<2483.5	Pass
MSK	Middle	429	2434.444	>2400	2434.654	<2483.5	Pass
MSK	High	423	2467.441	>2400	2467.657	<2483.5	Pass

Test result plot as follow:

Low Channel

Middle Channel



High Channel

6.5 Occupied Bandwidth Measurement

6.5.1 Standard Applicable

According to section 5.2 of KDB Publication 558074, document D01, the 99 % occupied bandwidth is necessary for setting the proper reference level and input attenuation.

Although there is no limit specified, the occupied bandwidth has to be recorded and reported.

6.5.2 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;

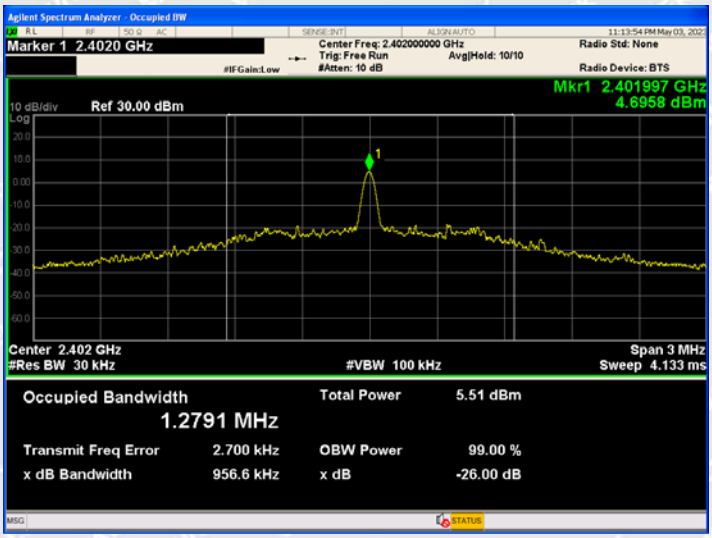
2) Set the spectrum analyzer: RBW = 30kHz, VBW = 100kHz

6.5.3 Test Result

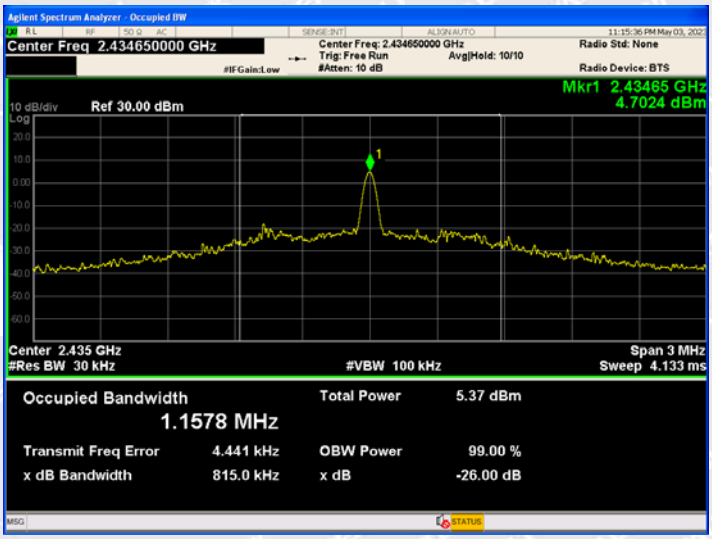
Modulation	Test Channel	99% Occupied Bandwidth (kHz)	Result
MSK	Low	1.2791	Pass
MSK	Middle	1.1578	Pass
MSK	High	1.1513	Pass

Test result plot as follow:

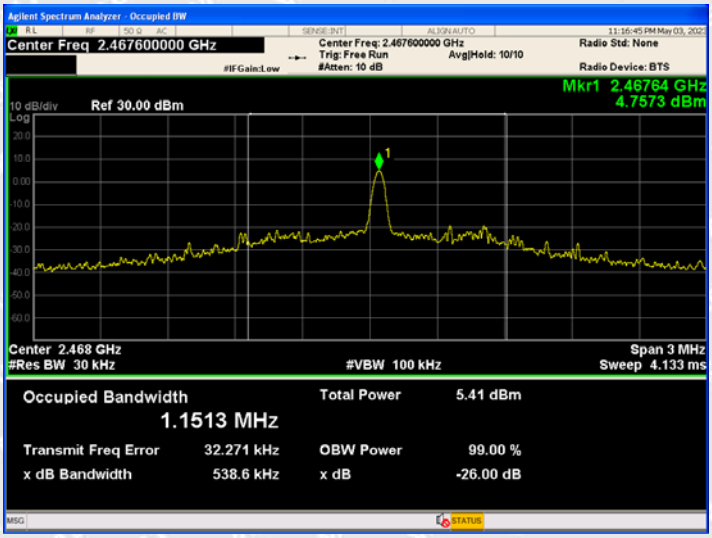
Low Channel



Middle Channel



High Channel



6.6 Maximum Peak Output Power

6.6.1 Standard Applicable

According to 15.247(b)(1), For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

6.6.2 Test Procedure

According to the ANSI C63.10-2013 section 7.8.5,

This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation. The hopping shall be disabled for this test:

a) Use the following spectrum analyzer settings:

1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
2) RBW > 20 dB bandwidth of the emission being measured.
3) VBW ≥ RBW.
4) Sweep: Auto.
5) Detector function: Peak.
6) Trace: Max hold.

b) Allow trace to stabilize.

c) Use the marker-to-peak function to set the marker to the peak of the emission.

d) The indicated level is the peak output power, after any corrections for external attenuators and cables.

e) A plot of the test results and setup description shall be included in the test report.

NOTE-A peak responding power meter may be used, where the power meter and sensor system video bandwidth is greater than the occupied bandwidth of the unlicensed wireless device, rather than a spectrum analyzer.

6.6.3 Test Result

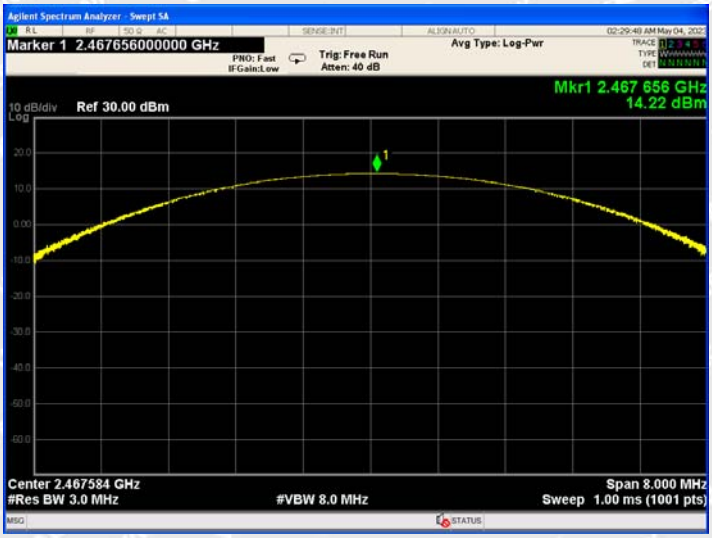
Modulation	Test Channel	Reading (dBm)	Output Power (mW)	Limit (mW)
MSK	Low	13.95	24.83	125
MSK	Middle	14.07	25.53	125
MSK	High	14.22	26.42	125

Test result plot as follow:

Low Channel

Middle Channel

High Channel



6.7 Carrier Frequency Separation

6.7.1 Standard Applicable

As specified in section 15.247(a) of 47 CFR Part 15, for frequency hopping systems the carrier frequency separation shall not be less than 25 KHz or 20 dB bandwidth of the hopping channel, whichever is greater. For frequency hopping systems operating in the 2400-2483.5 MHz band the carrier frequency separation shall be 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

6.7.2 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.

2) Set the spectrum analyzer: RBW = 30kHz. VBW = 100kHz , Span = 3.0MHz. Sweep = auto; Detector Function = Peak. Trace = Max hold.

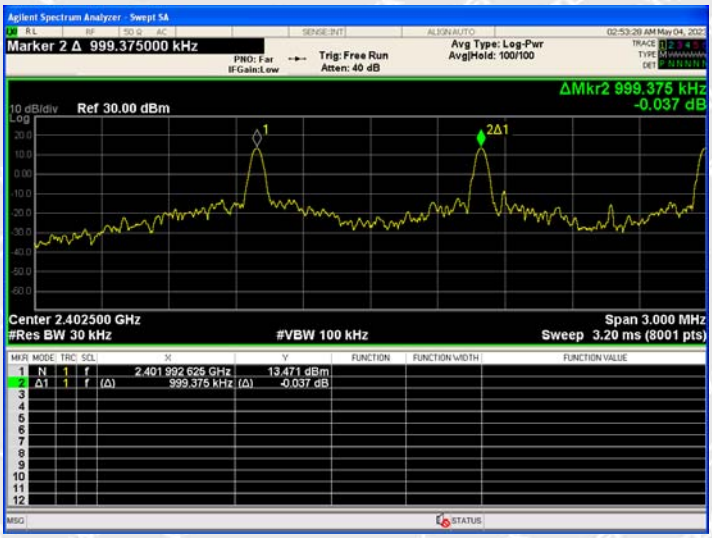
3) Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. The limit is specified in one of the subparagraphs of this Section Submit this plot.

6.7.3 Test Result

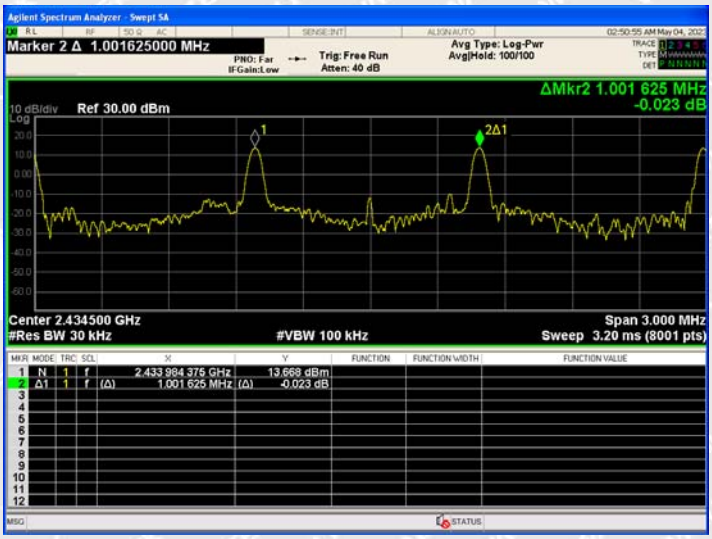
Modulation	Test Channel	Separation (MHz)	Result
MSK	Low	0.999	Pass
MSK	Middle	1.002	Pass
MSK	High	0.998	Pass

Test result plot as follow:

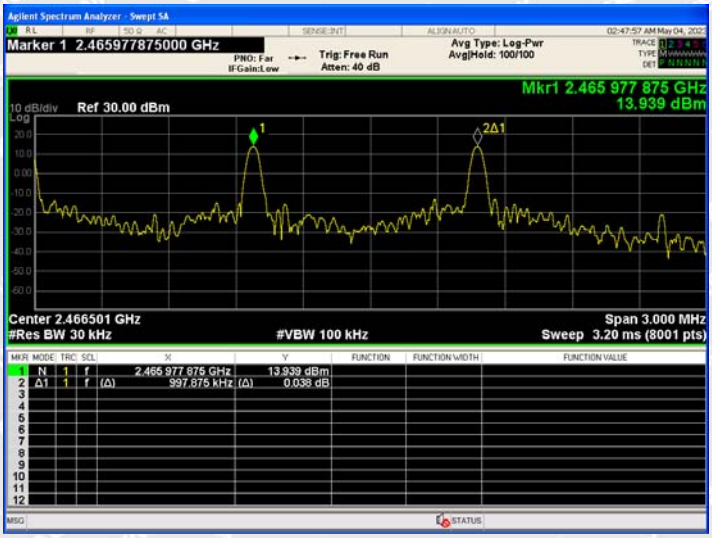
Low Channel



Middle Channel



High Channel



6.8 Number of Hopping Frequency

6.8.1 Standard Applicable

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

6.8.2 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.

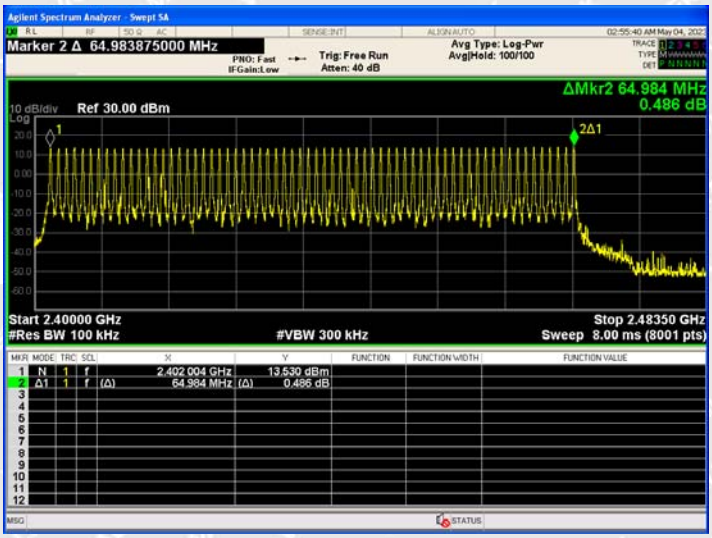
2) Set the spectrum analyzer: RBW = 100 KHz. VBW = 300 KHz. Sweep = auto; Detector Function = Peak. Trace = Max hold.

3) Allow the trace to stabilize. It may prove necessary to break the span up to sections. in order to clearly show all of the hopping frequencies. The limit is specified in one of the subparagraphs of this Section.

4) Set the spectrum analyzer: Start Frequency = 2.4GHz, Stop Frequency = 2.483GHz. Sweep=auto.

6.8.3 Test Result

66 Channels in total



6.9 Time of occupancy (Dwell Time)

6.9.1 Standard Applicable

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

6.9.2 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.

2) Set spectrum analyzer span = 0. Centred on a hopping channel;

3) Set RBW = 1MHz and VBW = 3MHz.Sweep = as necessary to capture the entire dwell time per hopping channel.

4) Use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g.. data rate. modulation format. etc.). repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

6.9.3 Test Result

As declared in §15.247(a)(iii) the observation period should 0.4 s multiplied by the number of hopping channels. So in this case the observation period is

t=0.4s*66=26.4s

Chart of number of bursts in 26s

Chart of burst length in 30ms (trigger offset-0.5ms)

Number of hops in 26s	Burst length in 30 ms	Time of occupancy (ms)	Limit (ms)
37	7.121	263.477	400

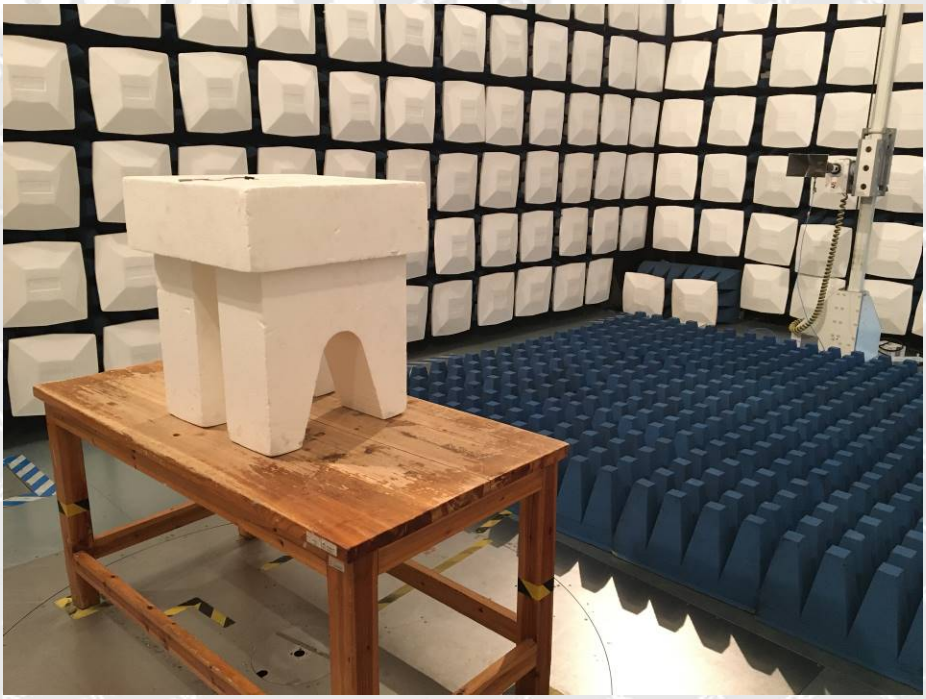
*Remark: Time of occupancy = (Number of hops) x (Burst length)

7 Photographs Test Setup

7.1 Photographs - Radiated Emission Test Setup

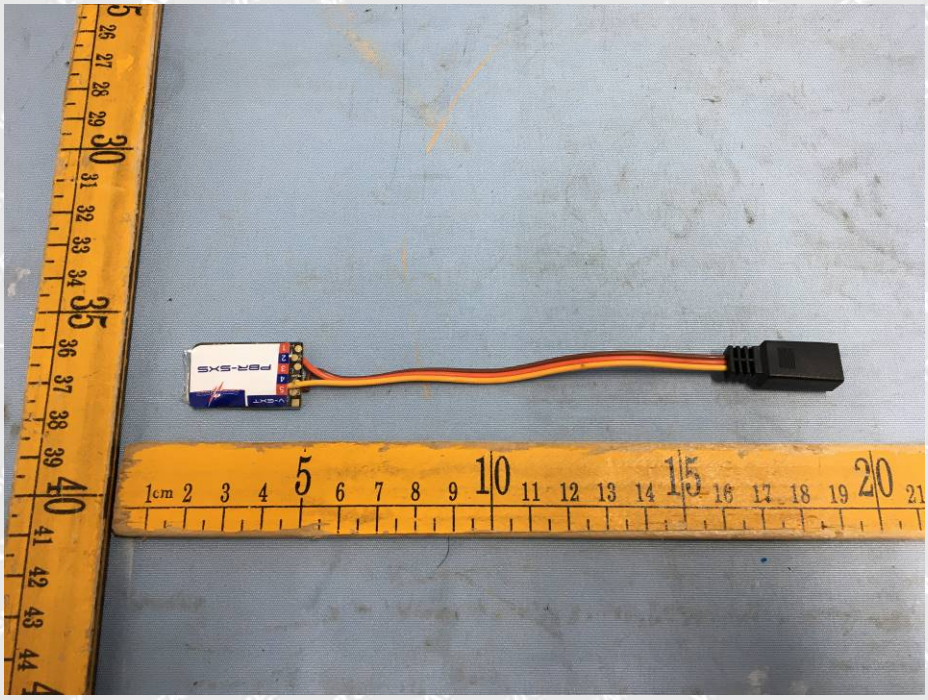
30MHz-1GHz

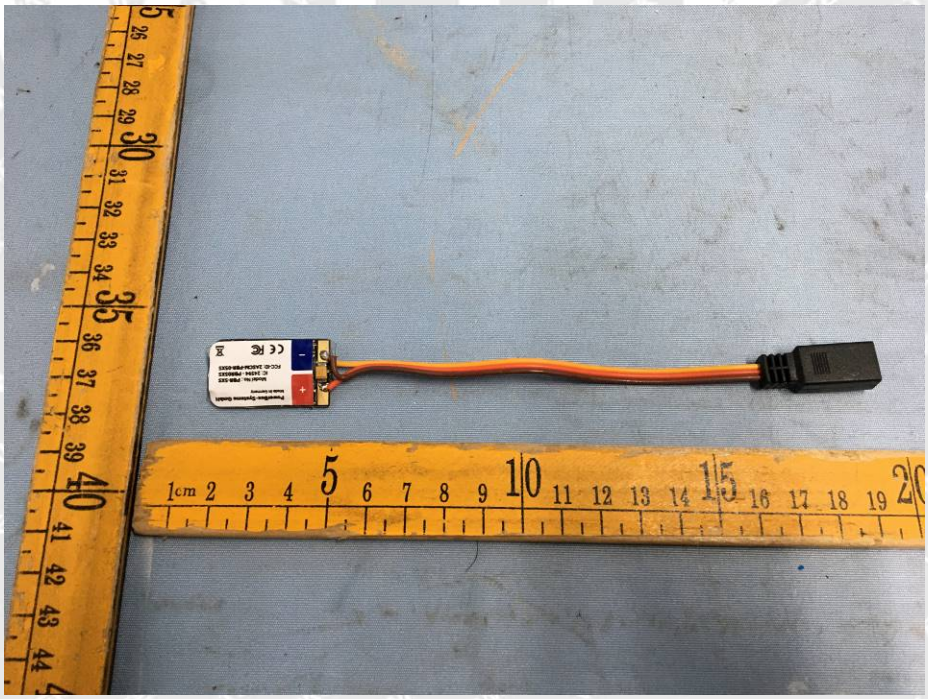
Above 1GHz



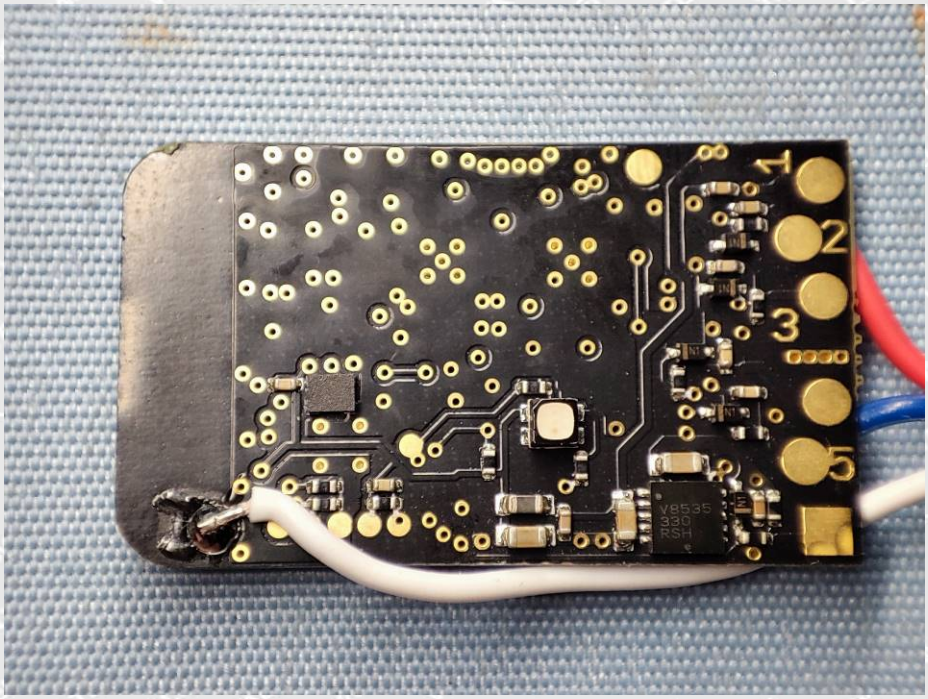
8 Photographs - Constructional Details

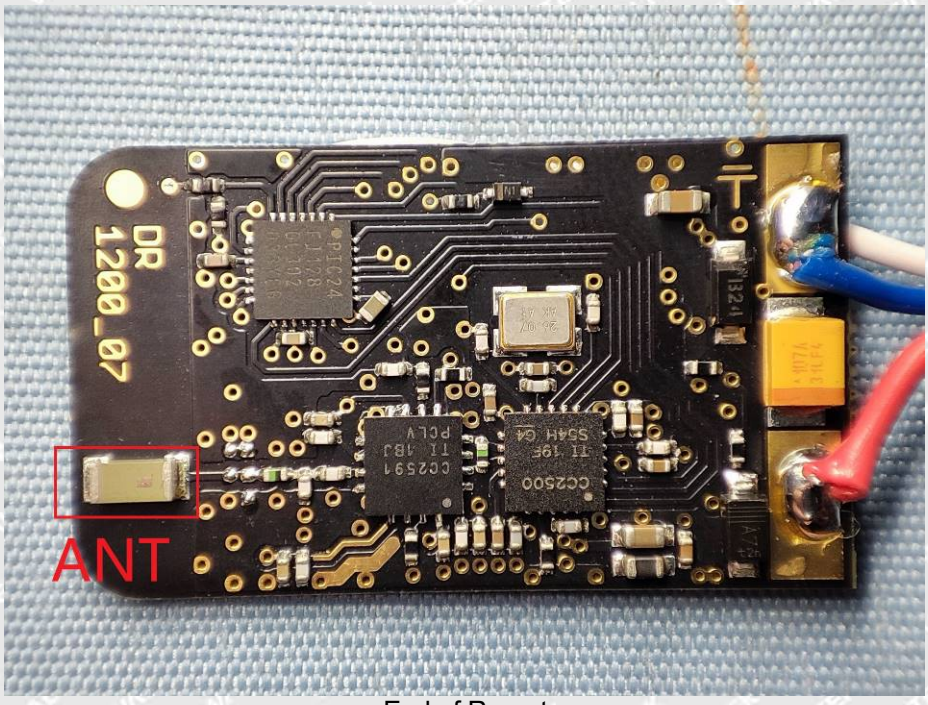
8.1 EUT - External Photos





8.2 EUT – Internal Photos





======End of Report======