TEST REPORT

Applicant Name :	PVSure Pte Ltd
Address :	31 Toh Guan Road East 06-02 Singapore 608608 Singapore
Report Number :	RA230130-04403E-RF-00A
FCC ID:	2BAHAPVS01

Test Standard (s)

FCC PART 15.247

Sample Description

Product Type:	PVBuddy™ Sensor
Model No.:	PVS01
Multiple Model(s) No.:	N/A
Trade Mark:	N/A
Date Received:	2023/01/30
Report Date:	2023/03/29

Test Result:	Pass*

* In the configuration tested, the EUT complied with the standards above.

Prepared and Checked By:

Andy Yu
EMC Engineer

Approved By:

Candy Li
EMC Engineer

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	RA230130-04403E-RF-00A	Original Report	2023/03/29

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Frequency Range	Bluetooth: 2402~2480MHz
Maximum conducted Peak output power	Bluetooth: 12.16 dBm
Modulation Technique	Bluetooth: GFSK, π/4-DQPSK, 8DPSK
Antenna Specification*	3.42 dBi (provided by the applicant)
Voltage Range	DC5V from USB Port
Sample serial number	1ZIL-2 for Conducted and Radiated Emissions Test 1ZIB-1 for RF Conducted Test (Assigned by ATC)
Sample/EUT Status	Good condition

Objective

This test report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

All emissions measurement was performed at Shenzhen Accurate Technology Co., Ltd. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Each test item follows test standards and with no deviation.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		5%
RF output power, conducted		0.73dB
Unwanted Emission, conducted		1.6dB
AC Line Conducted emission		2.72dB
Emissions, Radiated	30MHz - 1GHz	4.28dB
	1GHz - 18GHz	4.98dB
	18GHz - 26.5GHz	5.06dB
Temperature		1℃
Humidity		6%
Supply voltages		0.4%

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The test site used by Shenzhen Accurate Technology Co., Ltd. to collect test data is located on the 1/F., Building A, Changyuan New Material Port, Science & Industry Park, Nanshan District, Shenzhen, Guangdong, P.R. China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 708358, the FCC Designation No.: CN1189. Accredited by American Association for Laboratory Accreditation (A2LA) The Certificate Number is 429 7.01.

Listed by Innovation, Science and Economic Development Canada (ISEDC), the Registration Number is 5077A.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode.

Channel List

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	39	2441
1	2403	40	2442
2	2404	…	…
….	…	76	2478
37	2439	77	2479
38	2440	78	2480

EUT was tested with Channel 0, 39 and 78.

EUT Exercise Software

"EspRFTestTool_v2.8_Manual *" exercise software was used and the power level is 8*. The software and power level was provided by the manufacturer.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

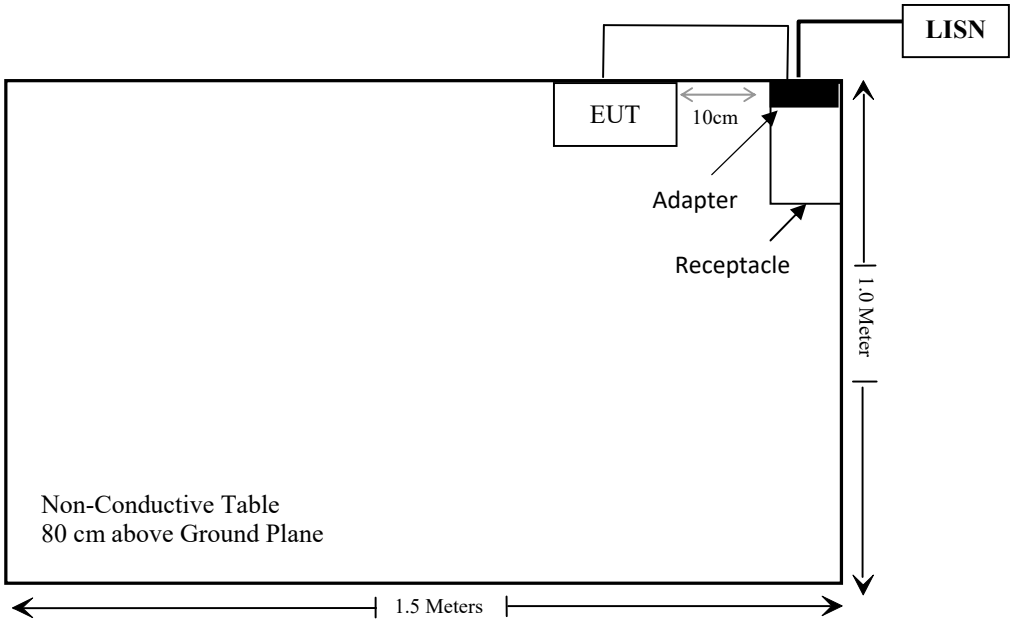
Manufacturer	Description	Model	Serial Number
TECNO	Adapter	U330TSA	Unknown

External I/O Cable

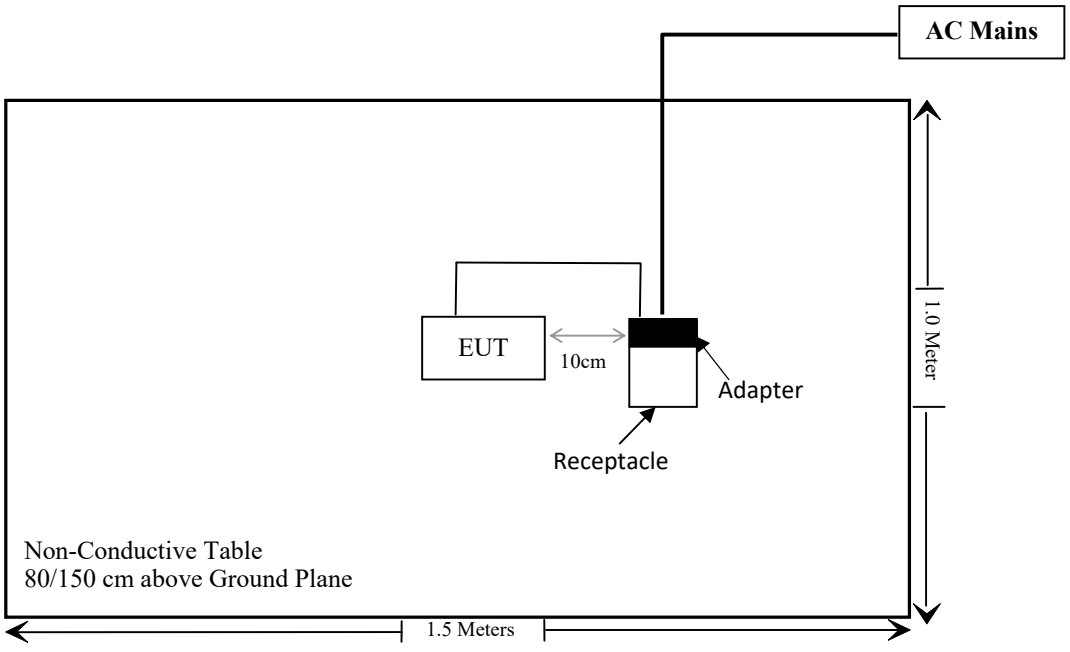
Cable Description	Length (m)	From Port	To
Un-shield Un-Detachable DC Power Cable	0.3	Adapter	EUT

Block Diagram of Test Setup

For conducted emission:



For Radiated Emissions:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (i), §1.1307 (b) (3) & §2.1091	RF Exposure	Compliant
§15.203	Antenna Requirement	Compliant
§15.207(a)	AC Line Conducted Emissions	Compliant
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliant
§15.247(a)(1)	20 dB Emission Bandwidth & 99% Occupied Bandwidth	Compliant
§15.247(a)(1)	Channel Separation Test	Compliant
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Compliant
§15.247(a)(1)(iii)	Quantity of hopping channel Test	Compliant
§15.247(b)(1)	Peak Output Power Measurement	Compliant
§15.247(d)	Band edges	Compliant

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted emission test					
Rohde& Schwarz	EMI Test Receiver	ESCI	100784	2022/11/25	2023/11/24
Rohde & Schwarz	L.I.S.N.	ENV216	101314	2022/11/25	2023/11/24
Anritsu Corp	50 Coaxial Switch	MP59B	6100237248	2022/12/07	2023/12/06
Unknown	RF Coaxial Cable	No.17	N0350	2022/11/25	2023/11/24
Conducted Emission Test Software: e3 19821b (V9)					
Radiated emission test					
Rohde& Schwarz	Test Receiver	ESR	102725	2022/11/25	2023/11/24
Rohde&Schwarz	Spectrum Analyzer	FSV40	101949	2022/11/25	2023/11/24
SONOMA INSTRUMENT	Amplifier	310 N	186131	2022/11/08	2023/11/07
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2022/11/08	2023/11/07
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2022/11/08	2023/11/07
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2021/07/06	2024/07/05
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2022/11/30	2025/11/29
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2022/12/26	2025/12/25
Radiated Emission Test Software: e3 19821b (V9)					
Unknown	RF Coaxial Cable	No.10	N050	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.11	N1000	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.12	N040	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.13	N300	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.14	N800	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.15	N600	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.16	N650	2022/11/25	2023/11/24
Wainwright	High Pass Filter	WHKX3.6/18G-10SS	5	2022/11/25	2023/11/24

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
RF conducted test					
Rohde&Schwarz	Spectrum Analyzer	FSV-40	101948	2022/11/25	2023/11/24
SPECTRUM ANALYZER	Rohde & Schwarz	FSU26	200982	2022/07/04	2023/07/03
WEINSCHEL	10dB Attenuator	5324	AU 3842	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.31	RF-01	Each time	

*** Statement of Traceability:** Shenzhen Accurate Technology Co., Ltd. attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC§15.247 (i), §1.1307 (b) (3) &§2.1091 – RF EXPOSURE

Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

According to KDB 447498 D04 Interim General RF Exposure Guidance

MPE-Based Exemption:

General frequency and separation-distance dependent MPE-based effective radiated power(ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] to support an exemptionfrom further evaluation from 300 kHz through 100 GHz.

Table 1 to § 1.1307(b)(3)(i)(C) - Single RF Sources Subject to Routine Environmental Evaluation

RF Source frequency (MHz)	Threshold ERP (watts)
0.3-1.34	1,920 R^2.
1.34-30	3,450 R^2/f^2.
30-300	3.83 R^2.
300-1,500	0.0128 R^2f.
1,500-100,000	19.2R^2.

Ris the minimum separation distance in meters
f = frequency in MHz

Result

Frequency (MHz)	Antenna Gain		Tune up conducted power	ERP		Evaluation Distance (m)	ERP Limit (W)
	(dBi)	(dBd)	(dBm)	(dBm)	(W)		
2402-2480	3.42	1.27	13.0	14.27	0.028	0.2	0.768

Note: To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Compliance

FCC §15.203 – ANTENNA REQUIREMENT

Applicable Standard

According to FCC § 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.

Antenna Connector Construction

The EUT has one internal antenna, which was permanently attached, and the maximum antenna gain is 3.42dBi, fulfill the requirement of this section. Please refer to the EUT photos.

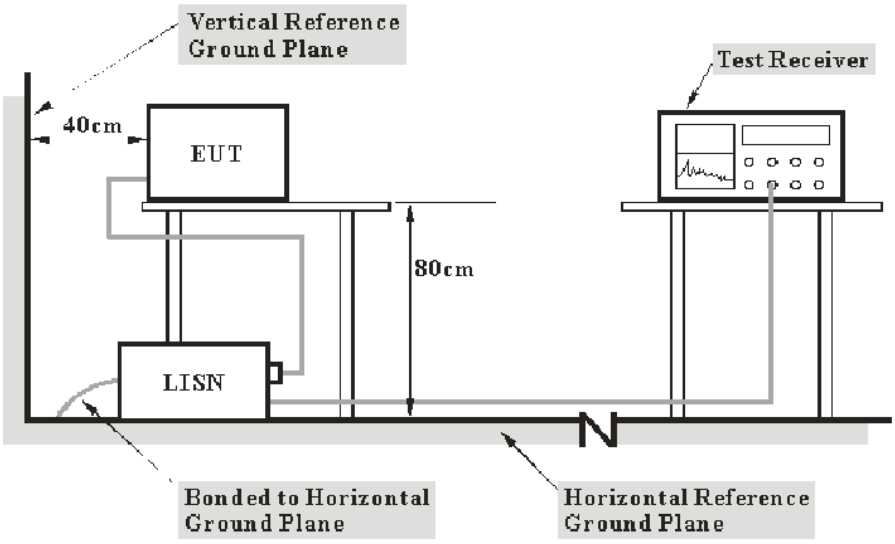
Result: Compliant.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Transd Factor & Margin Calculation

The Transd factor is calculated by adding LISN VDF (Voltage Division Factor) and Cable Loss. The basic equation is as follows:

Transd Factor = LISN VDF + Cable Loss

The "**Over limit**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, an Over limit of -7 dB means the emission is 7 dB below the limit. The equation for calculation is as follows:

Over Limit = Level – Limit
Level = Read Level + Factor

Test Data

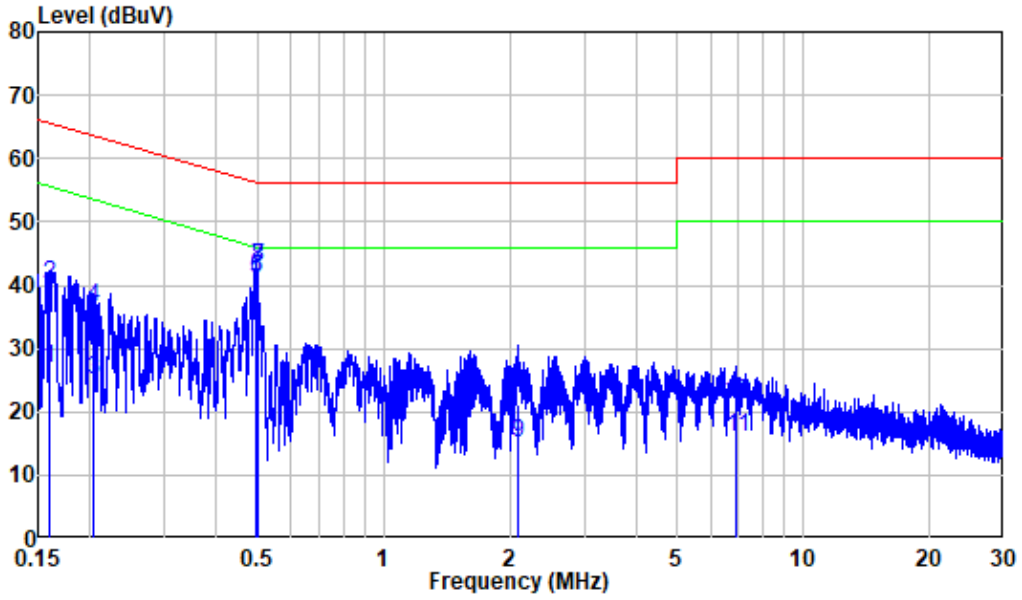
Environmental Conditions

Temperature:	23 ℃
Relative Humidity:	52 %
ATM Pressure:	101.0 kPa

The testing was performed by Lipa Wu on 2023-02-07.

EUT operation mode: Transmitting (the worst case is 8DPSK Mode, Low channel)

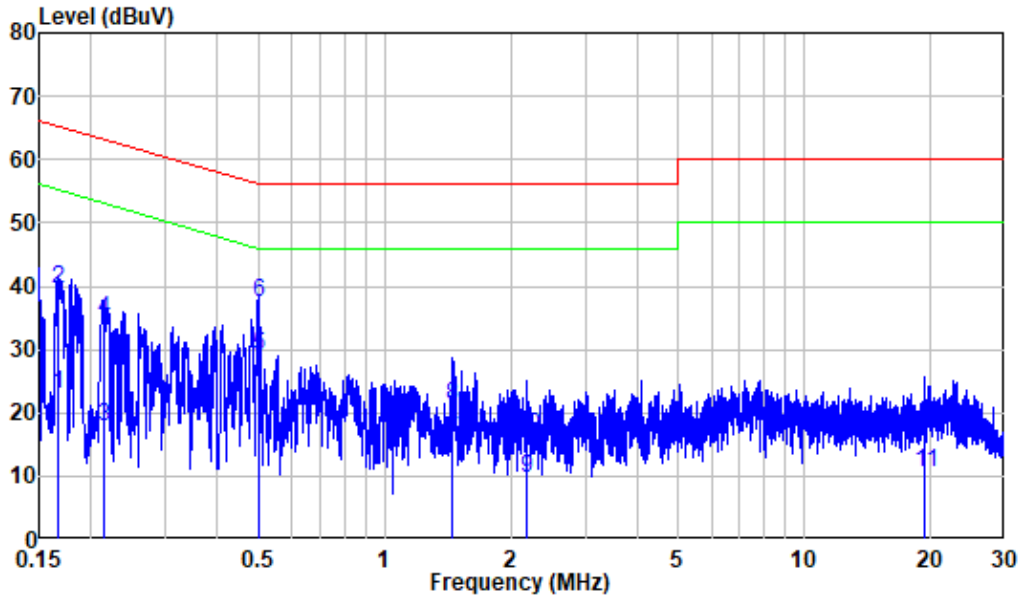
AC 120V/60 Hz, Line



Site : Shielding Room
Condition: Line
Job No. : RA230130-04403E-RF
Mode : BT&Transmitting
Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.160	9.90	16.89	26.79	55.44	-28.65	Average
2	0.160	9.90	30.12	40.02	65.44	-25.42	QP
3	0.203	9.90	15.27	25.17	53.50	-28.33	Average
4	0.203	9.90	26.70	36.60	63.50	-26.90	QP
5	0.497	9.80	31.21	41.01	46.05	-5.04	Average
6	0.497	9.80	31.26	41.06	56.05	-14.99	QP
7	0.500	9.80	33.02	42.82	46.00	-3.18	Average
8	0.500	9.80	33.07	42.87	56.00	-13.13	QP
9	2.082	9.92	5.21	15.13	46.00	-30.87	Average
10	2.082	9.92	11.35	21.27	56.00	-34.73	QP
11	6.942	9.97	6.05	16.02	50.00	-33.98	Average
12	6.942	9.97	11.56	21.53	60.00	-38.47	QP

AC 120V/60 Hz, Neutral



Site : Shielding Room
Condition: Neutral
Job No. : RA230130-04403E-RF
Mode : BT&Transmitting
Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.167	9.80	13.18	22.98	55.10	-32.12	Average
2	0.167	9.80	29.70	39.50	65.10	-25.60	QP
3	0.213	9.81	8.11	17.92	53.07	-35.15	Average
4	0.213	9.81	24.82	34.63	63.07	-28.44	QP
5	0.500	9.90	19.00	28.90	46.00	-17.10	Average
6	0.500	9.90	27.42	37.32	56.00	-18.68	QP
7	1.447	9.81	6.00	15.81	46.00	-30.19	Average
8	1.447	9.81	11.28	21.09	56.00	-34.91	QP
9	2.185	9.82	-0.10	9.72	46.00	-36.28	Average
10	2.185	9.82	6.58	16.40	56.00	-39.60	QP
11	19.364	10.18	0.39	10.57	50.00	-39.43	Average
12	19.364	10.18	6.84	17.02	60.00	-42.98	QP

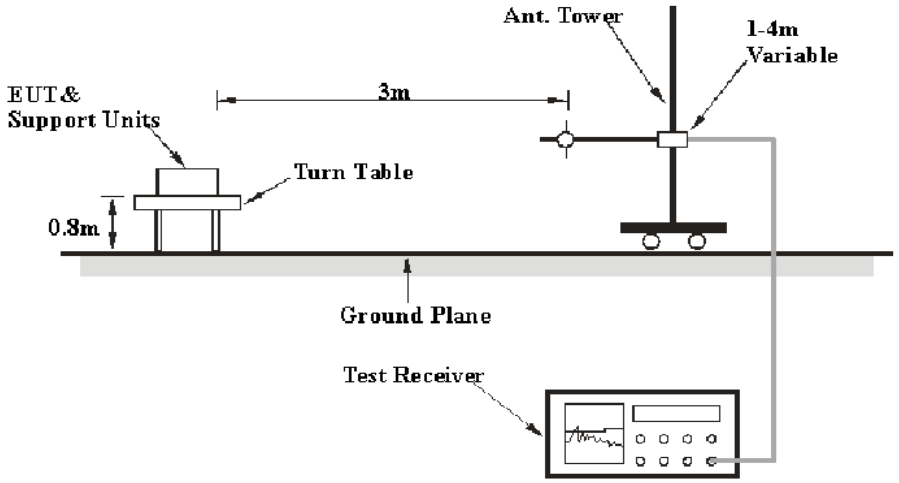
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

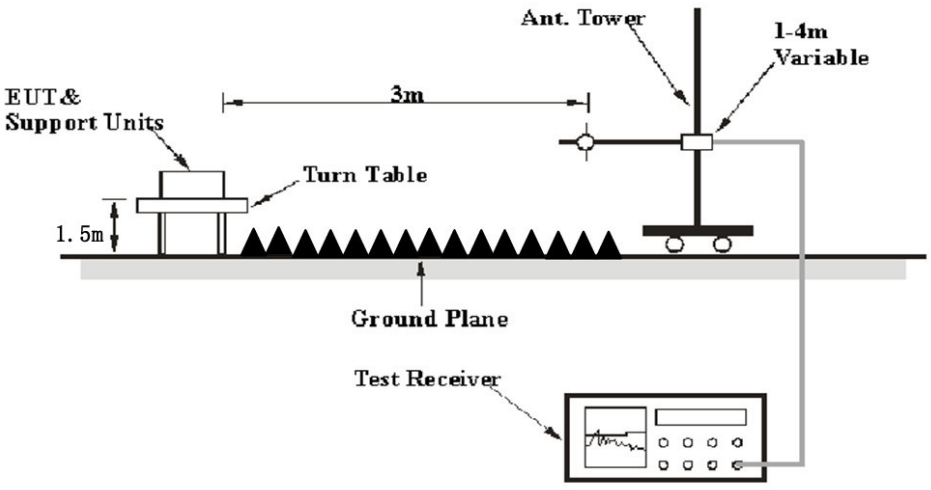
FCC §15.205; §15.209; §15.247(d)

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

EMI Test Receiver & Spectrum Analyzer Setup

The EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1 MHz	3 MHz	/	PK

For average measurement:

Use the duty cycle factor correction factor method per 15.35(c).
Duty cycle=On time/100milliseconds, On time=N1*L1+N2*L2+…Nn-1*Ln-1+Nn*Ln,
where N1 is number of type 1 pulses, L1 is length of type 1 pulse, etc.
Average Emission Level=Peak Emission Level+20*log(Duty cycle)

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

Factor & Margin Calculation

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

Factor = Antenna Factor + Cable Loss - Amplifier Gain

The "**Over Limit/Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, an Over Limit/margin of -7dB means the emission is 7dB below the limit. The equation for calculation is as follows:

Over Limit/Margin = Level / Corrected Amplitude – Limit
Level / Corrected Amplitude = Read Level + Factor

Test Data

Environmental Conditions

Temperature:	24~25.5 ℃
Relative Humidity:	52~59 %
ATM Pressure:	101.0 kPa

The testing was performed by Jimi Zheng on 2023-02-08 for below 1GHz and Jimi Zheng on 2023-02-10 for above 1GHz

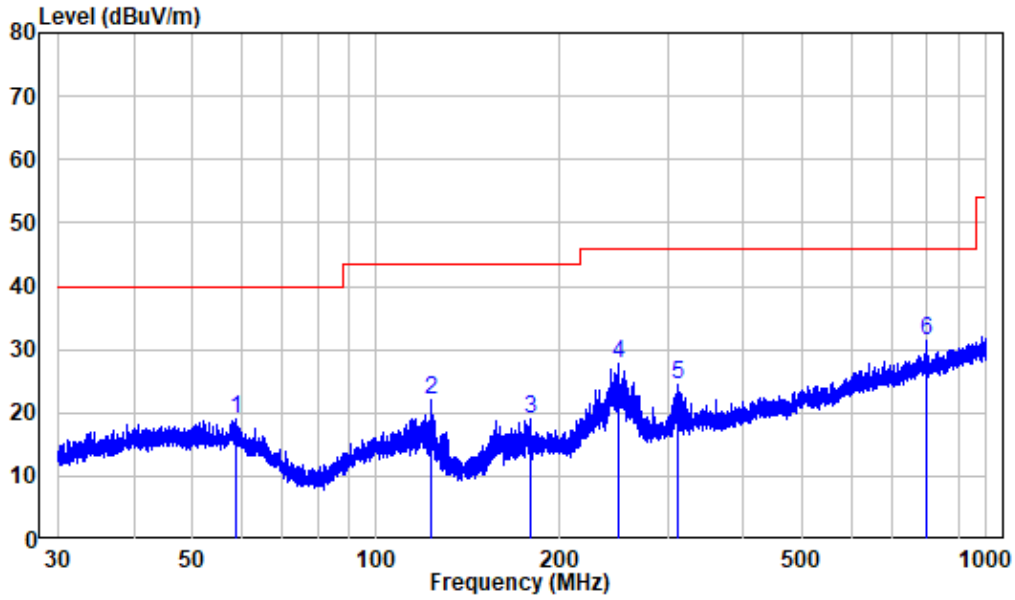
EUT operation mode: Transmitting

Note: Pre-scan in the X, Y and Z axes of orientation, the worst case X-axis of orientation was recorded

30MHz-1GHz: *(worst case is GFSK Mode, high channel)*

Note: When the test result of Peak was less than the limit of QP, just the peak value was recorded.

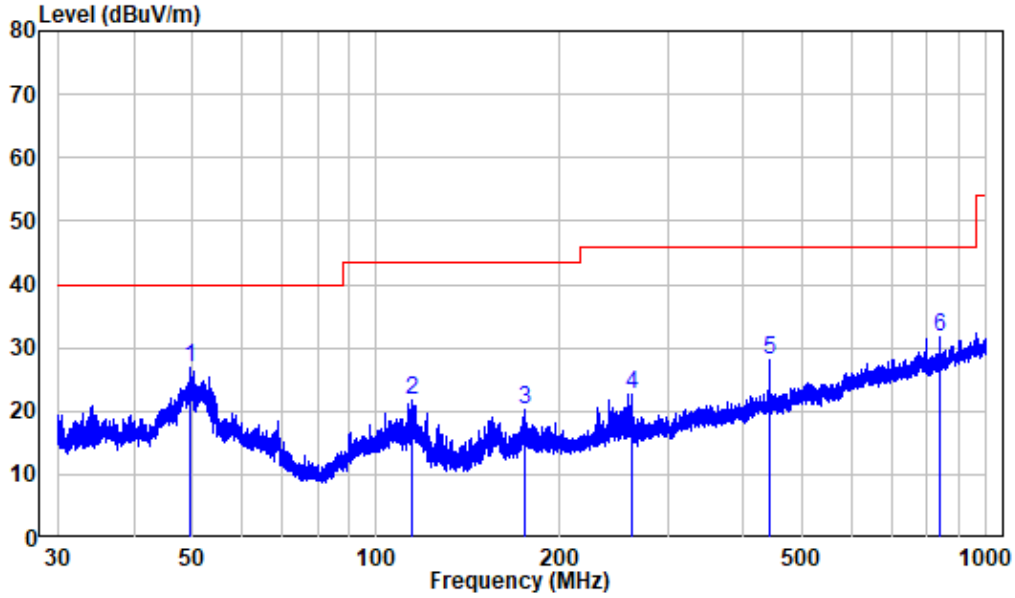
Horizontal:



Site : chamber
Condition: 3m HORIZONTAL
Job No. : RA230130-04403E-RF
Test Mode: BT Transmitting

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	58.690	-10.16	29.08	18.92	40.00	-21.08	Peak
2	123.157	-14.09	36.12	22.03	43.50	-21.47	Peak
3	179.072	-12.86	31.87	19.01	43.50	-24.49	Peak
4	248.770	-10.70	38.46	27.76	46.00	-18.24	Peak
5	312.864	-8.79	33.35	24.56	46.00	-21.44	Peak
6	800.031	-0.35	31.69	31.34	46.00	-14.66	Peak

Vertical



Site : chamber
Condition: 3m VERTICAL
Job No. : RA230130-04403E-RF
Test Mode: BT Transmitting

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	49.576	-9.93	36.87	26.94	40.00	-13.06	Peak
2	114.665	-12.67	34.43	21.76	43.50	-21.74	Peak
3	174.807	-13.13	33.45	20.32	43.50	-23.18	Peak
4	261.516	-10.54	33.09	22.55	46.00	-23.45	Peak
5	440.003	-5.64	33.68	28.04	46.00	-17.96	Peak
6	840.286	0.28	31.28	31.56	46.00	-14.44	Peak

Above 1GHz: *(worst case is 8DPSK Mode, 3DH5)*

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel(2402MHz)									
2315.15	63.17	PK	239	1.4	H	-7.23	55.94	74	-18.06
2344.1	62.77	PK	342	1.8	V	-7.19	55.58	74	-18.42
2390	62.41	PK	66	2.4	H	-7.22	55.19	74	-18.81
2390	62.22	PK	22	2.2	V	-7.22	55.00	74	-19.00
4804	57.68	PK	26	2.4	H	-3.51	54.17	74	-19.83
4804	57.76	PK	87	2.4	V	-3.51	54.25	74	-19.75
Middle Channel(2441MHz)									
4882	58.42	PK	154	1.6	H	-3.37	55.05	74	-18.95
4882	57.99	PK	232	1.6	V	-3.37	54.62	74	-19.38
High Channel(2480 MHz)									
2483.5	64.06	PK	355	1.3	H	-7.20	56.86	74	-17.14
2483.5	63.81	PK	146	1.4	V	-7.20	56.61	74	-17.39
2498.41	65.28	PK	220	2.4	H	-7.18	58.10	74	-15.90
2486.75	64.94	PK	21	1.3	V	-7.2	57.74	74	-16.26
4960	57.66	PK	302	2.2	H	-3.01	54.65	74	-19.35
4960	57.45	PK	267	2.2	V	-3.01	54.44	74	-19.56

Field Strength of Average						
Frequency (MHz)	Peak Measurement @3m (dBμV/m)	Polar (H/V)	Duty Cycle Correction Factor (dB)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
Low Channel(2402MHz)						
2315.15	55.94	H	-24.73	31.21	54	-22.79
2344.1	55.58	V	-24.73	30.85	54	-23.15
2390	55.19	H	-24.73	30.46	54	-23.54
2390	55.00	V	-24.73	30.27	54	-23.73
4804	54.17	H	-24.73	29.44	54	-24.56
4804	54.25	V	-24.73	29.52	54	-24.48
Middle Channel(2441MHz)						
4882	55.05	H	-24.73	30.32	54	-23.68
4882	54.62	V	-24.73	29.89	54	-24.11
High Channel(2480MHz)						
2483.5	56.86	H	-24.73	32.13	54	-21.87
2483.5	56.61	V	-24.73	31.88	54	-22.12
2498.41	58.10	H	-24.73	33.37	54	-20.63
2486.75	57.74	V	-24.73	33.01	54	-20.99
4960	54.65	H	-24.73	29.92	54	-24.08
4960	54.44	V	-24.73	29.71	54	-24.29

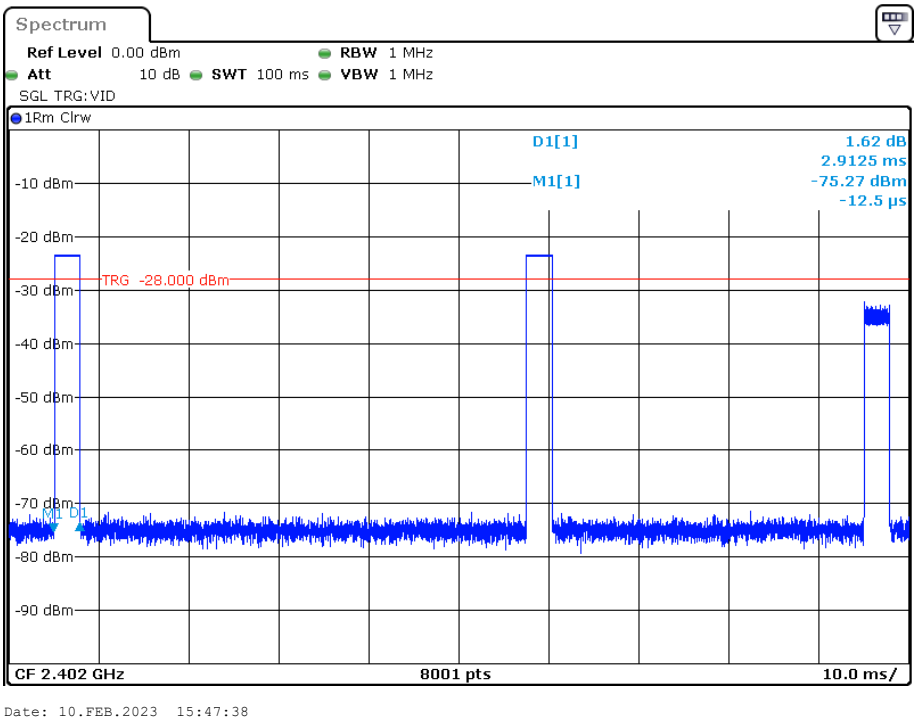
Note:

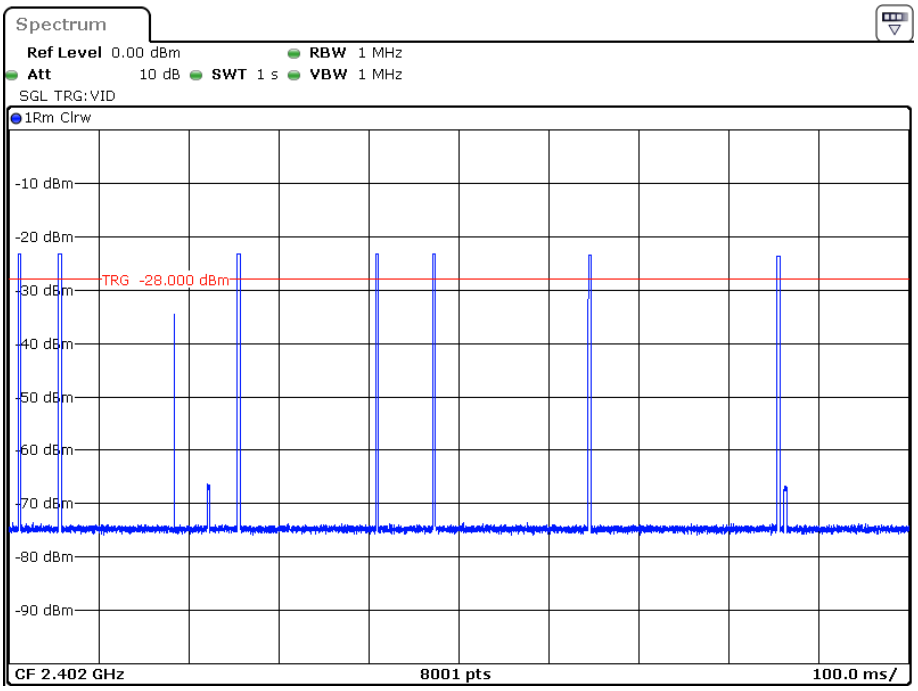
Corrected. Amplitude = Corrected Factor + Reading
Margin = Corrected. Amplitude - Limit
Average level= Peak level+ Duty Cycle Corrected Factor
The other spurious emission which is in the noise floor level was not recorded.

The worst case duty cycle as below:

Duty cycle = Ton/100ms = 2.9*2/100=0.058
Duty Cycle Corrected Factor = 20lg (Duty cycle) = 20lg0.058 = -24.73

Duty cycle

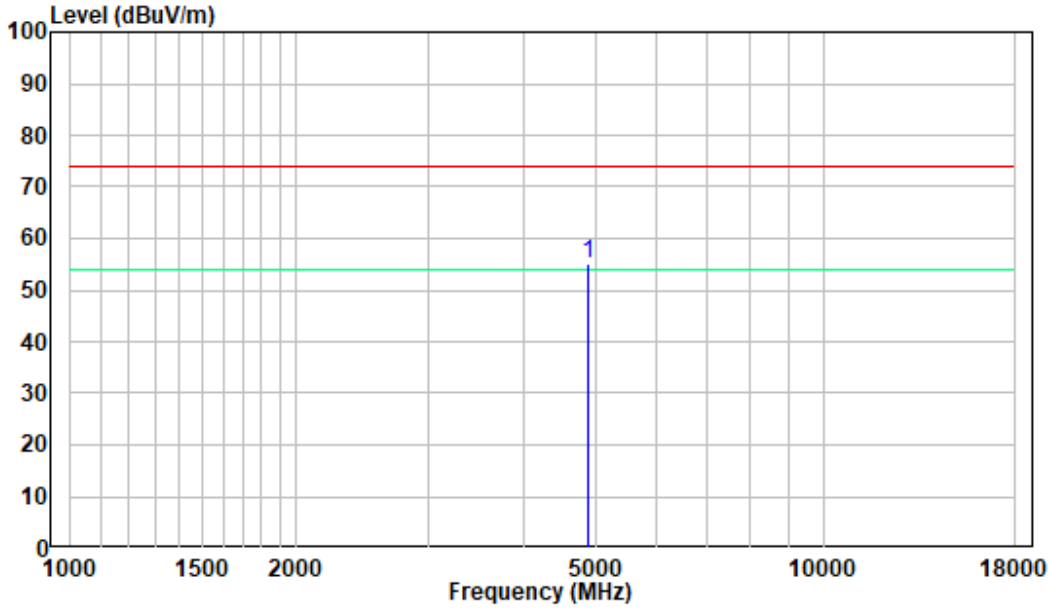



Spectrum
Ref Level 0.00 dBm
RBW 1 MHz
Att 10 dB SWT 1 s VBW 1 MHz
SGL TRG:VID
1Rm Clrw
-10 dBm
-20 dBm
TRG -28.000 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
-90 dBm
CF 2.402 GHz
8001 pts
100.0 ms/
Date: 10.FEB.2023 15:49:50

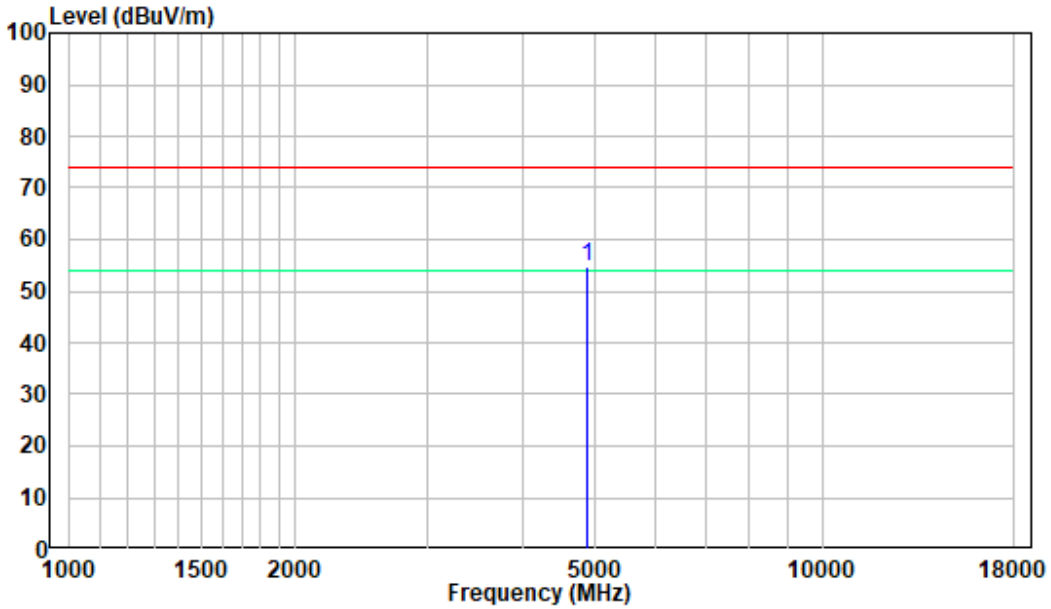
1-18GHz

Pre-scan for Middle Channel

Horizontal:



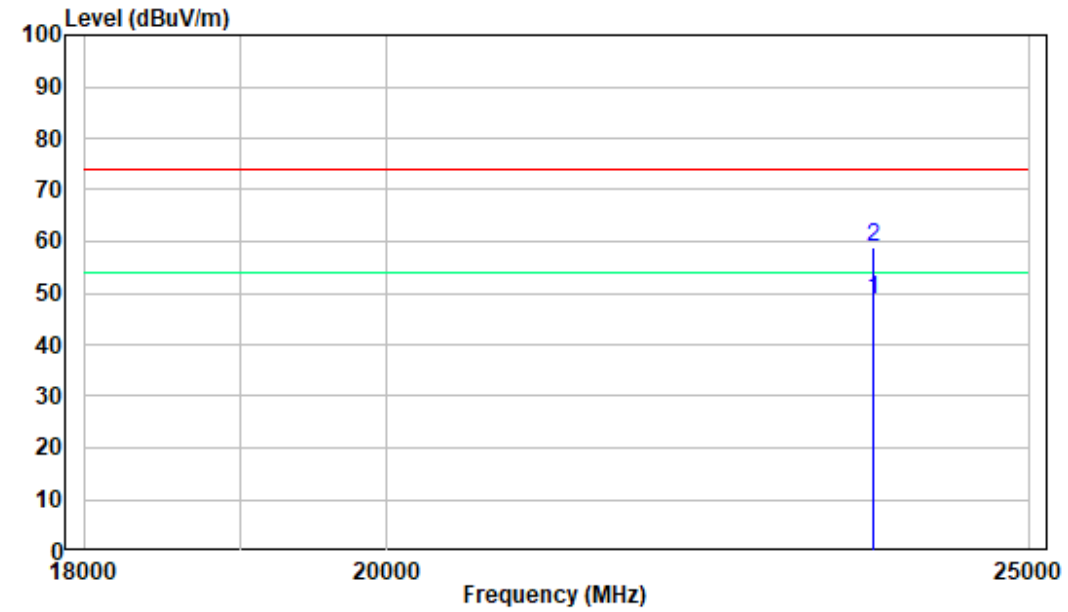
Vertical:



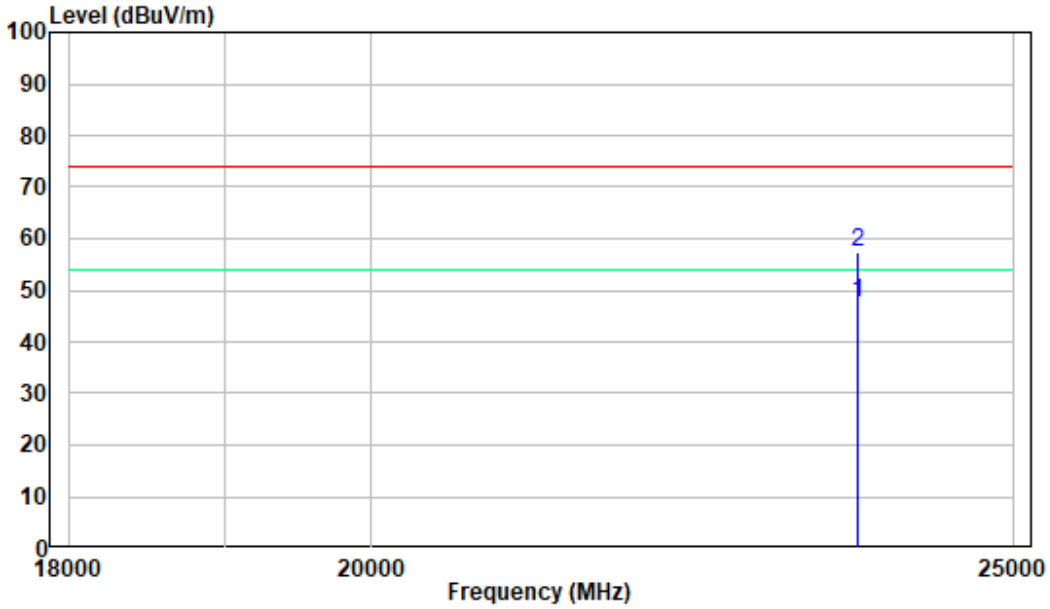
18-25GHz

Pre-scan for Middle Channel

Horizontal:



Vertical:



FCC §15.247(a) (1)-CHANNEL SEPARATION TEST

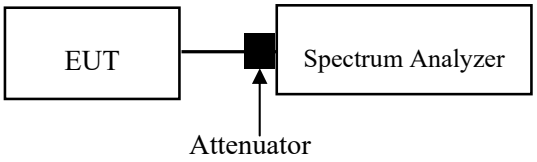
Applicable Standard

Frequency hopping systems shall have hoping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 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. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.2

1. Set the EUT in transmitting mode, maxhold the channel.
2. Set the adjacent channel of the EUT and maxhold another trace.
3. Measure the channel separation.



Test Data

Environmental Conditions

Temperature:	26.8 ℃
Relative Humidity:	37 %
ATM Pressure:	101.0 kPa

The testing was performed by Gleen Jiang on 2023-02-11.

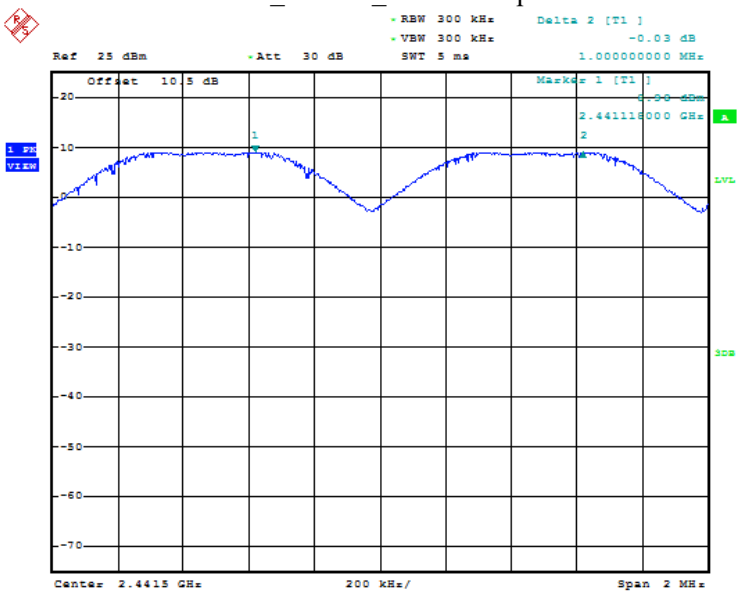
EUT operation mode: Transmitting

Test Result: Compliant.

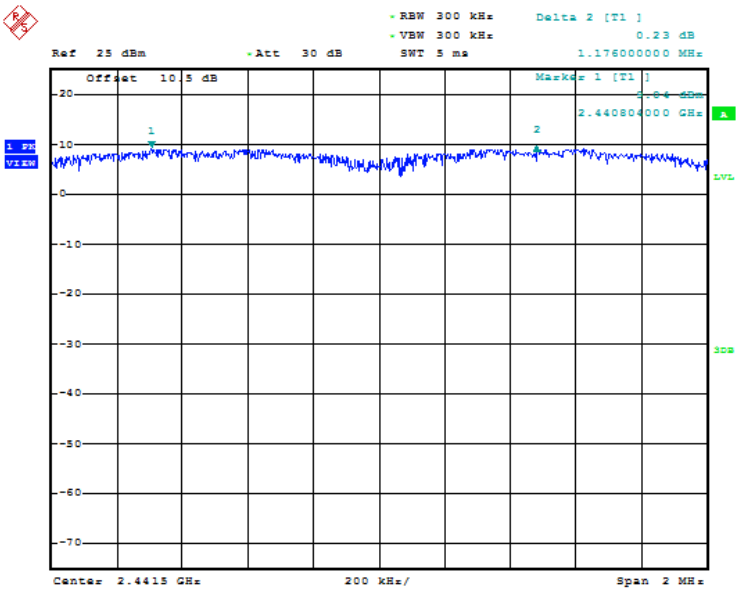
Channel	Channel Separation (MHz)	20 dBc BW (MHz)	Two-thirds of the 20 dB bandwidth (MHz)	Channel Separation Limit
BDR(GFSK)				
Middle	1.000	0.948	0.632	> two-thirds of the 20 dB bandwidth
EDR(π/4-DQPSK)				
Middle	1.176	1.305	0.870	> two-thirds of the 20 dB bandwidth
EDR(8DPSK)				
Middle	1.172	1.308	0.872	> two-thirds of the 20 dB bandwidth

Note: The limit > two-thirds of the 20 dB bandwidth

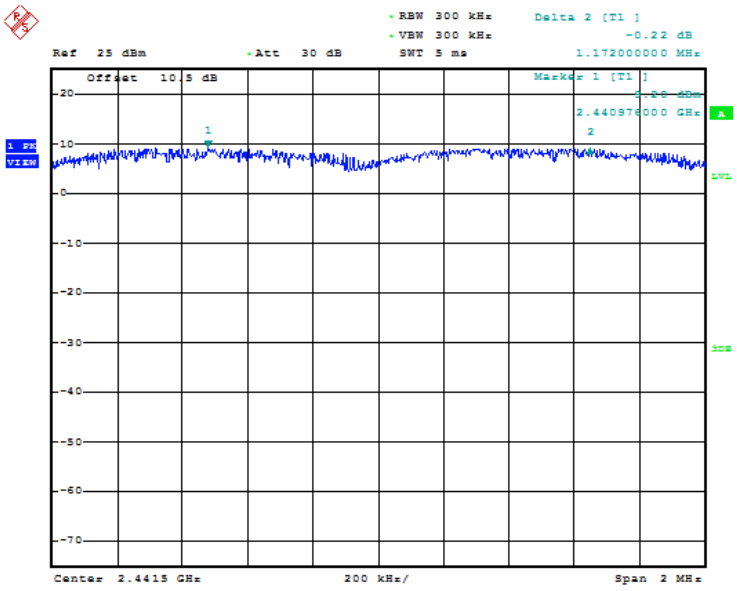
BT_ GFSK _Channel Separation



BT_ π /4-DQPSK _Channel Separation



BT_8DPSK _Channel Separation



FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH

Applicable Standard

Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 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.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.7 & Clause 6.9.2

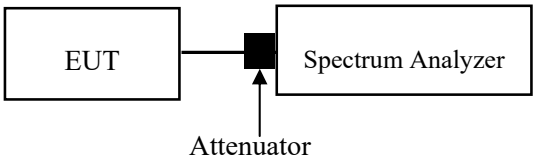
The following conditions shall be observed for measuring the occupied bandwidth and 20 dB bandwidth:
• The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

• The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / 20 dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / 20 dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.
For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).



Test Data

Environmental Conditions

Temperature:	26.8 ℃
Relative Humidity:	37 %
ATM Pressure:	101.0 kPa

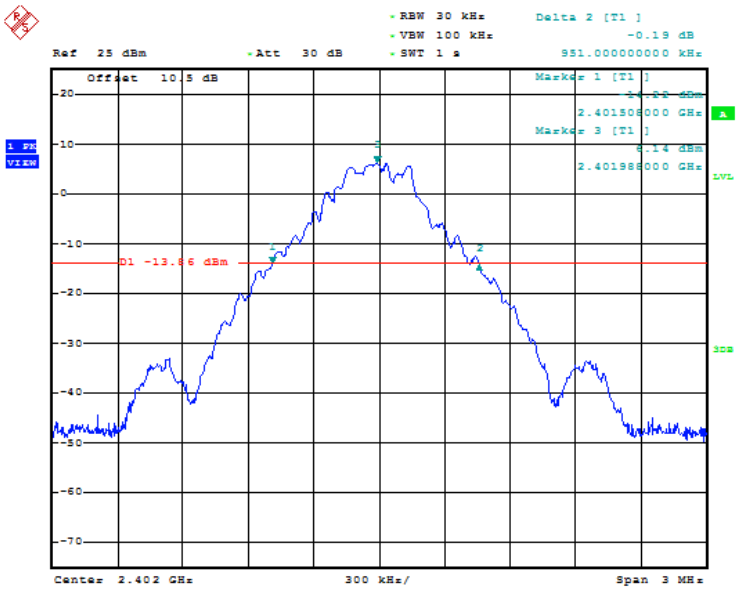
The testing was performed by Gleen Jiang on 2023-02-11.

EUT operation mode: Transmitting

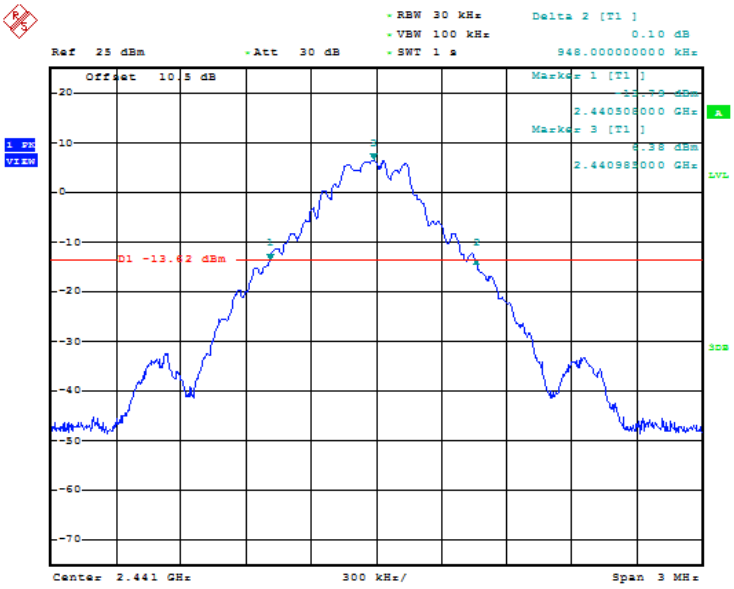
Test Result: Compliant.

Mode	Channel	Frequency (MHz)	99% Emission Bandwidth (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	Low	2402	0.837	0.951
	Middle	2441	0.840	0.948
	High	2480	0.840	0.948
EDR (π/4-DQPSK)	Low	2402	1.176	1.305
	Middle	2441	1.176	1.305
	High	2480	1.176	1.320
EDR (8DPSK)	Low	2402	1.176	1.311
	Middle	2441	1.176	1.308
	High	2480	1.179	1.308

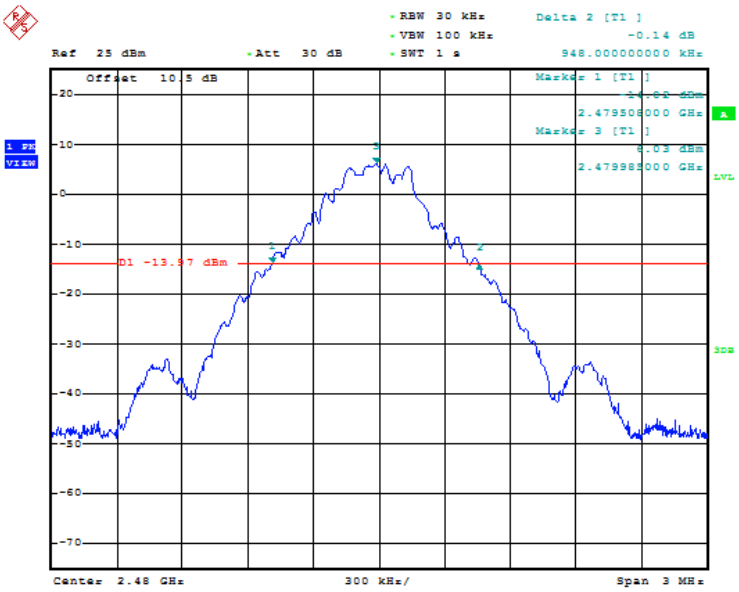
BT_DH5_2402MHz-20dB Bandwidth



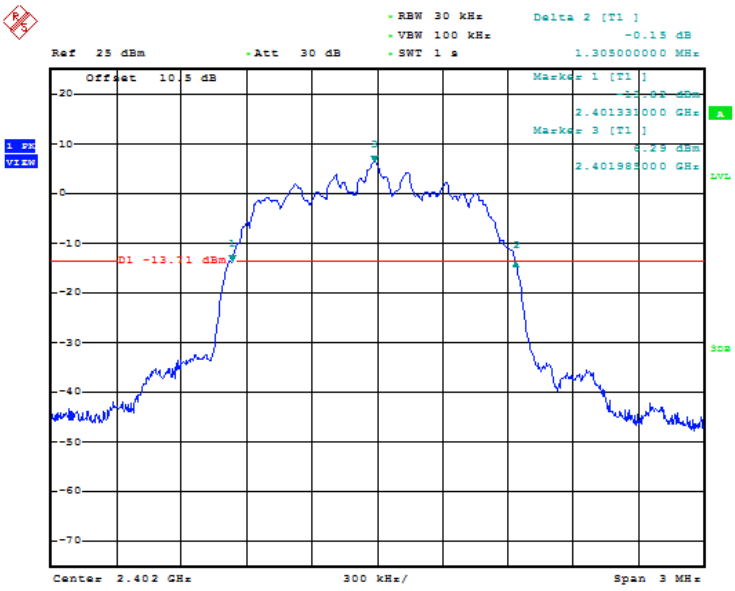
BT_DH5_2441MHz-20dB Bandwidth



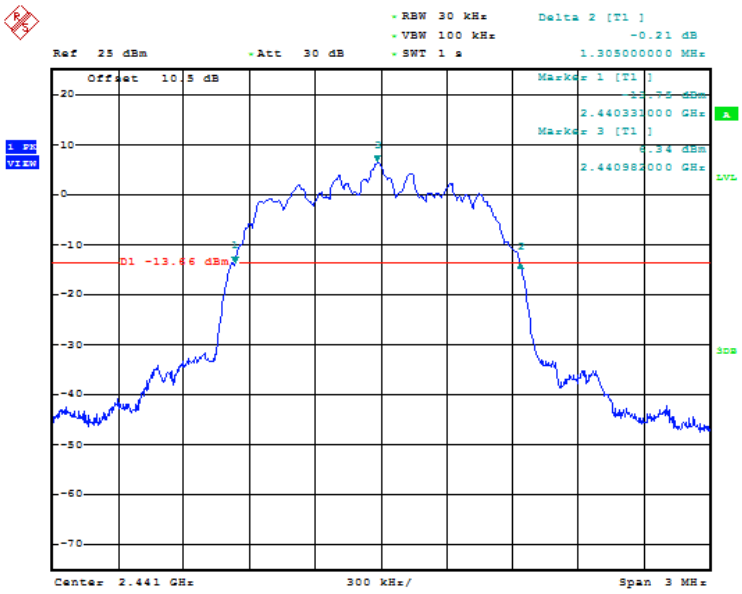
BT_DH5_2480MHz-20dB Bandwidth



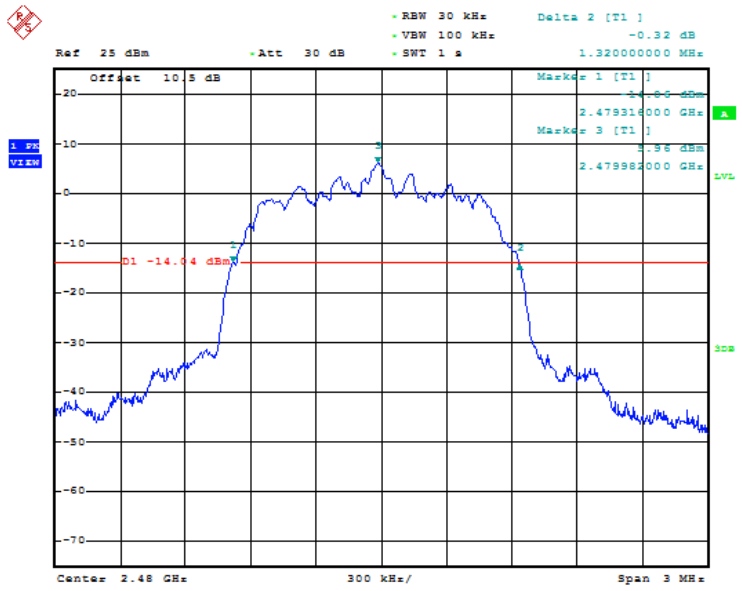
BT_2DH5_2402MHz-20dB Bandwidth



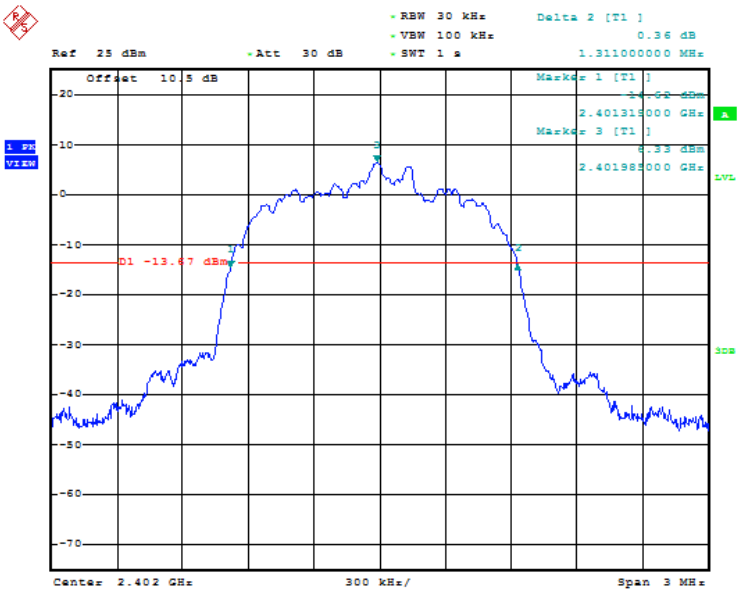
BT_2DH5_2441MHz-20dB Bandwidth



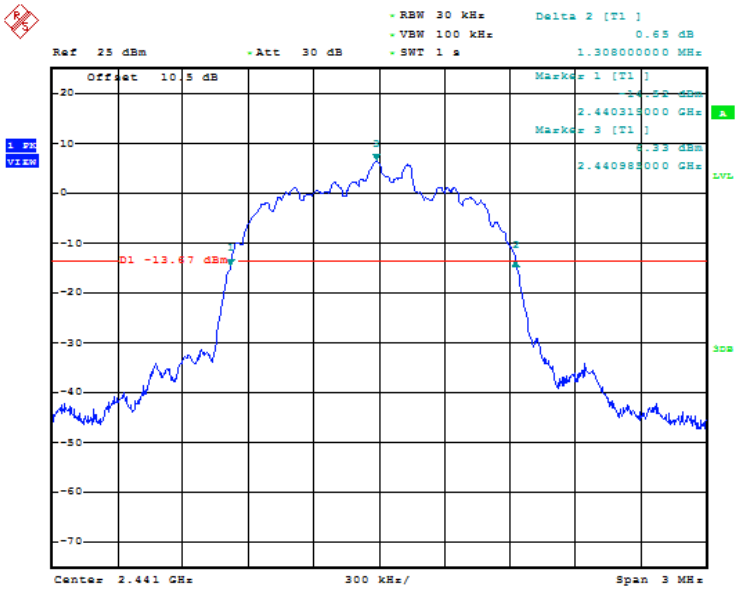
BT_2DH5_2480MHz-20dB Bandwidth



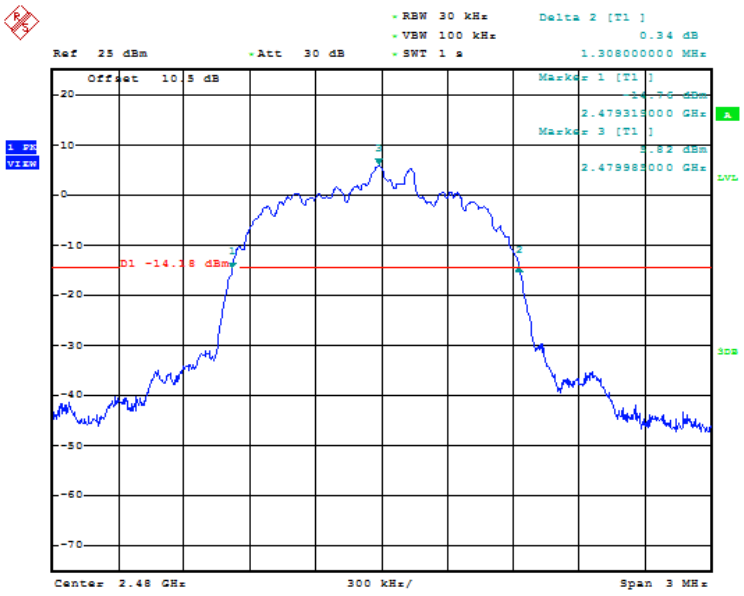
BT_3DH5_2402MHz-20dB Bandwidth



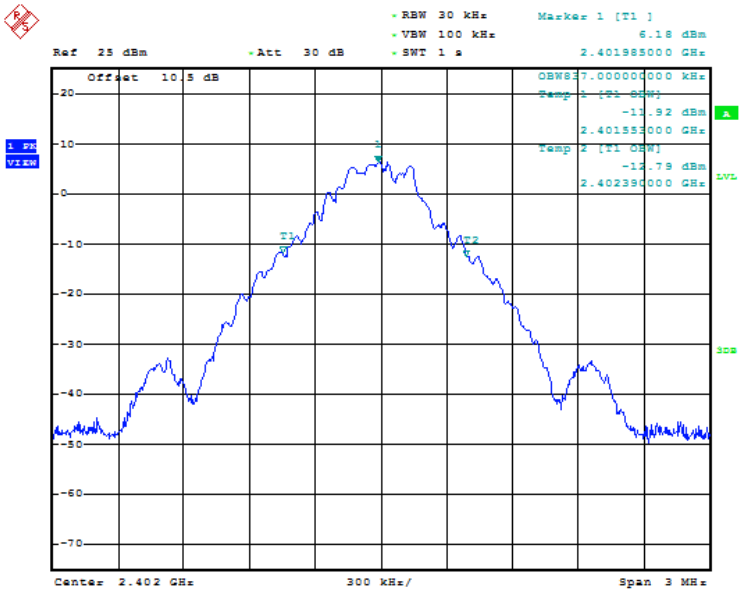
BT_3DH5_2441MHz-20dB Bandwidth



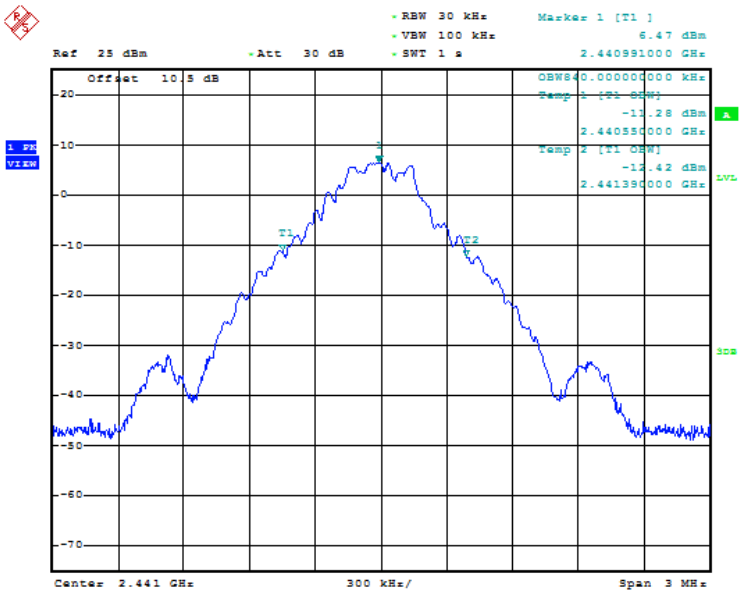
BT_3DH5_2480MHz-20dB Bandwidth



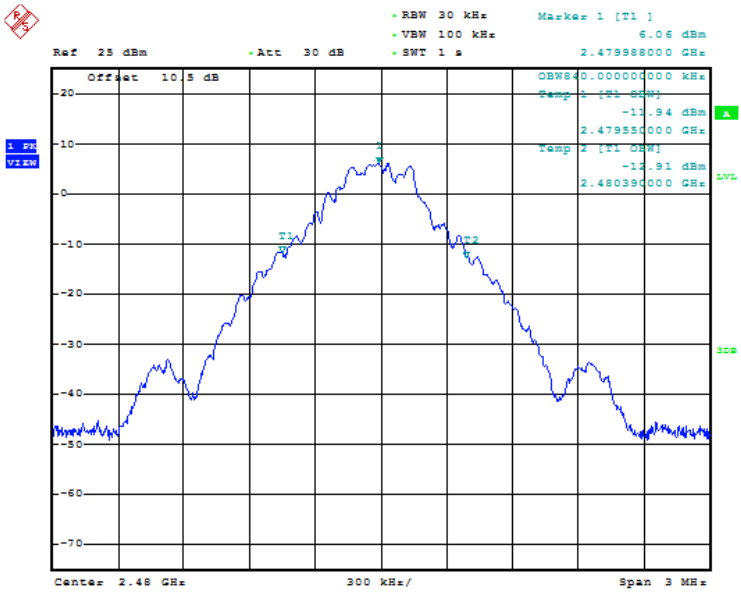
BT_DH5_2402MHz-OBW



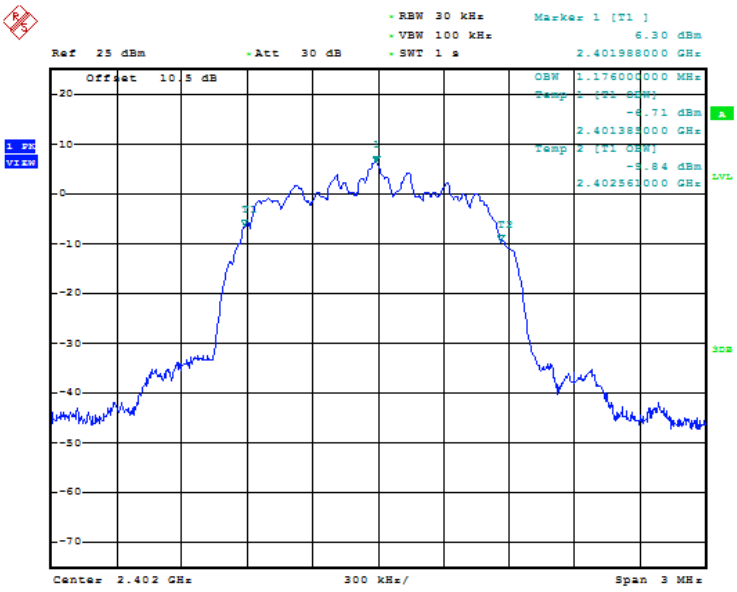
BT_DH5_2441MHz-OBW



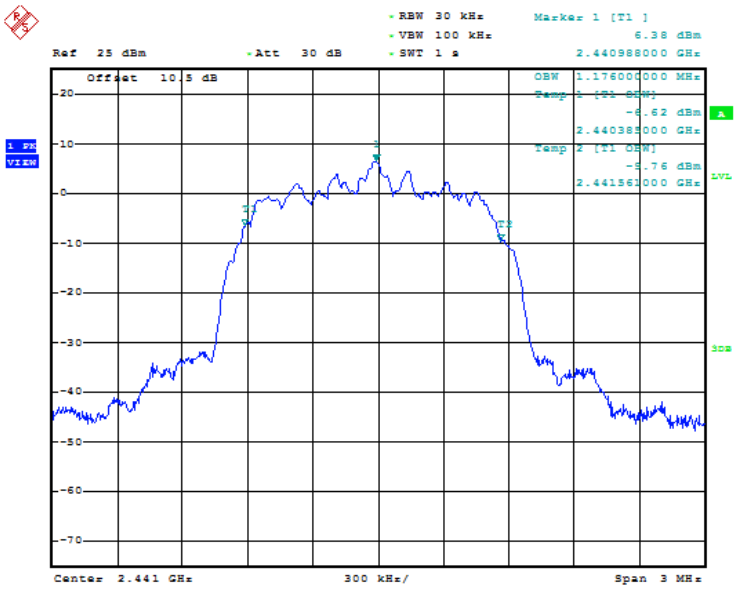
BT_DH5_2480MHz-OBW



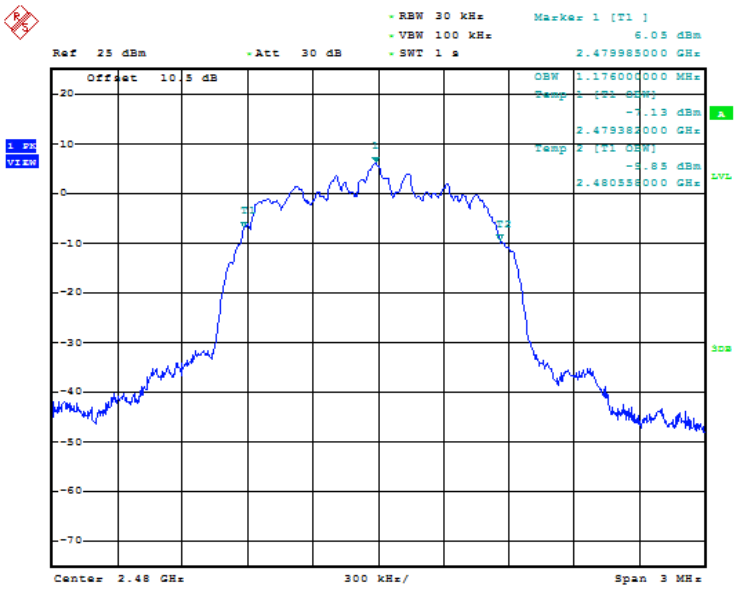
BT_2DH5_2402MHz-OBW



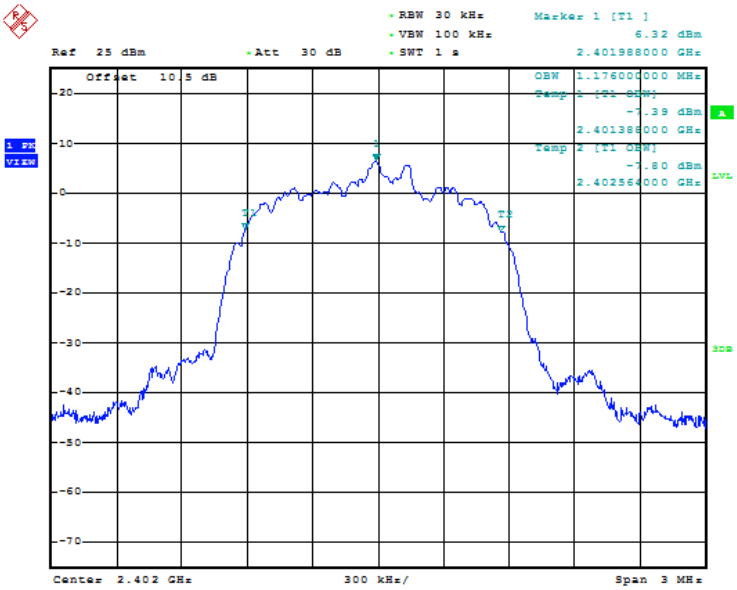
BT_2DH5_2441MHz-OBW



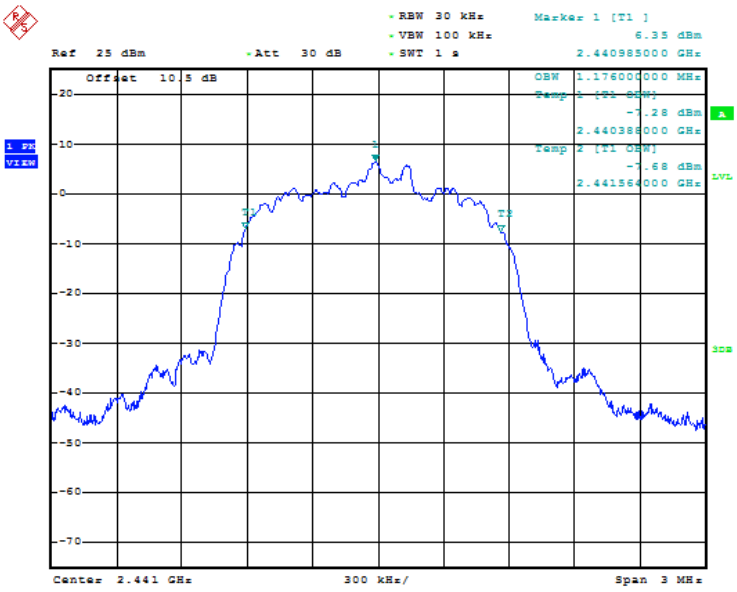
BT_2DH5_2480MHz-OBW



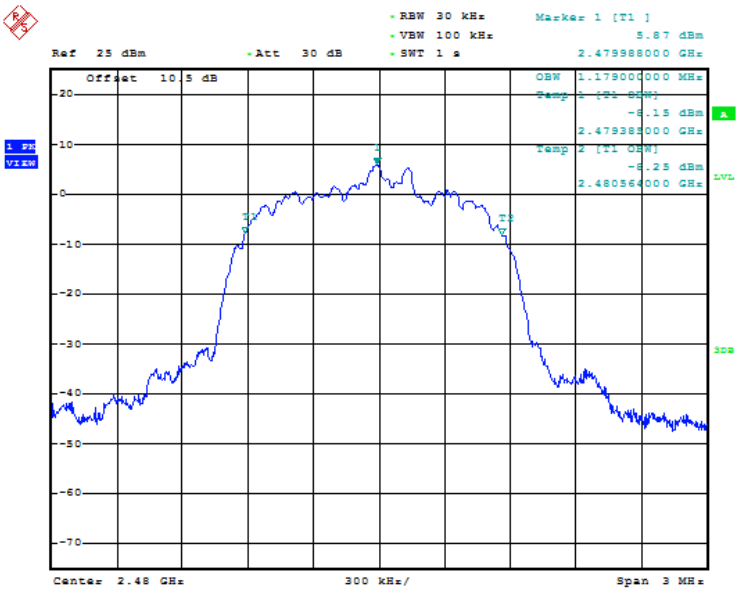
BT_3DH5_2402MHz-OBW



BT_3DH5_2441MHz-OBW



BT_3DH5_2480MHz-OBW



FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST

Applicable Standard

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

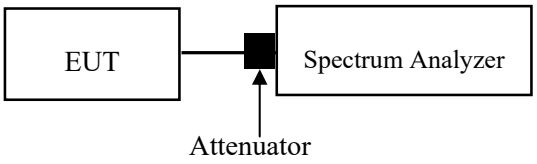
Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.3

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.

2. Set the EUT in hopping mode from first channel to last.

3. By using the max-hold function record the quantity of the channel.



Test Data

Environmental Conditions

Temperature:	26.8 ℃
Relative Humidity:	37 %
ATM Pressure:	101.0 kPa

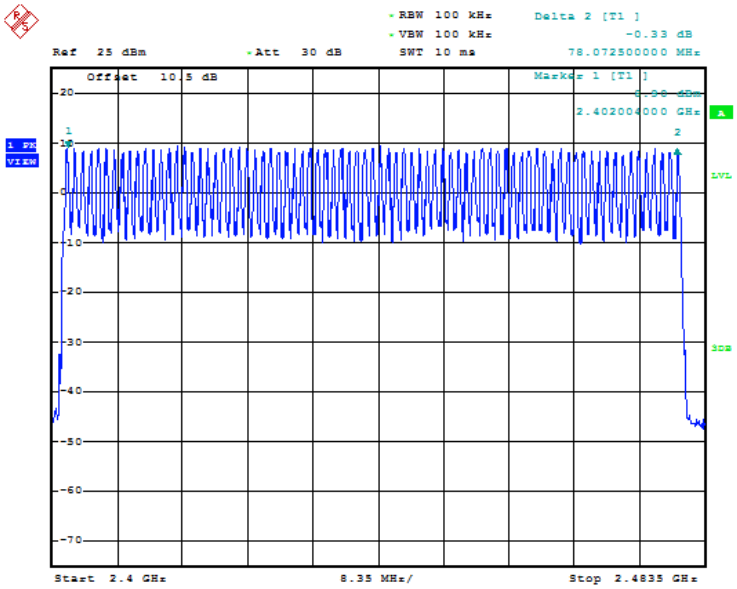
The testing was performed by Gleen Jiang on 2023-02-11.

EUT operation mode: Transmitting

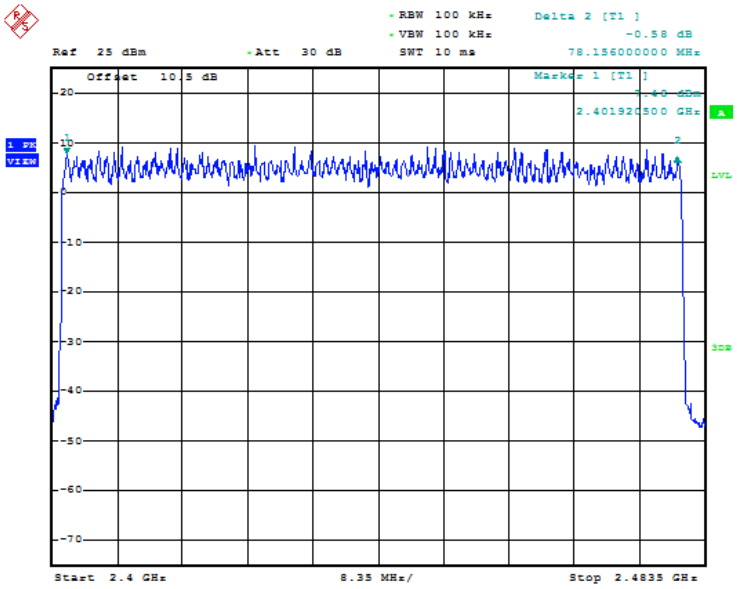
Test Result: Compliant.

Mode	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
BDR (GFSK)	2400-2483.5	79	≥15
EDR (π/4-DQPSK)	2400-2483.5	79	≥15
EDR (8DPSK)	2400-2483.5	79	≥15

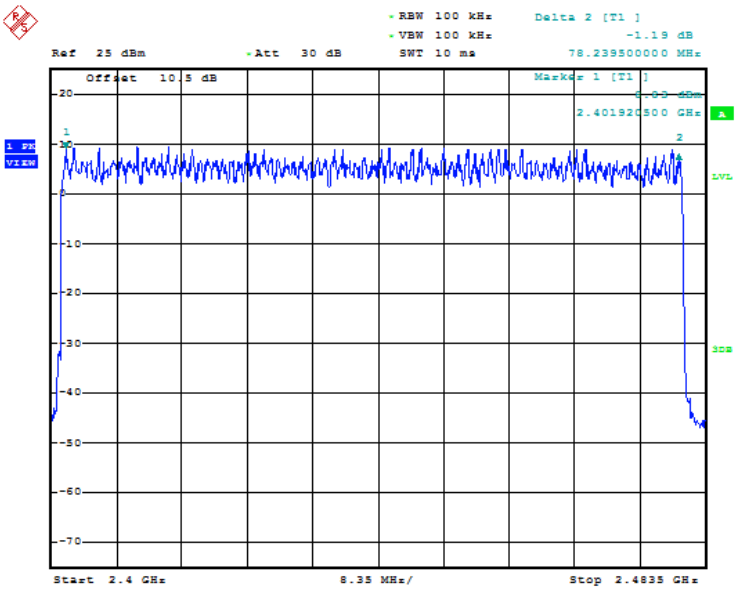
BT_DH5_Number of Hopping Channel



BT_2DH5_Number of Hopping Channel



BT_3DH5_Number of Hopping Channel



FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME)

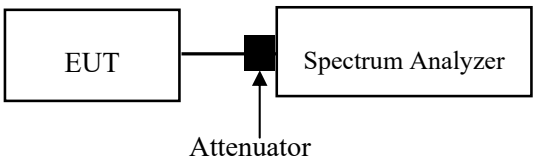
Applicable Standard

Frequency hopping systems in the 2400-2483.5 MHz shall use at least 15 channels. 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.4

1. The EUT was worked in channel hopping.
2. Set the RBW to: 1MHz.
3. Set the VBW ≥ 3×RBW.
4. Set the span to 0Hz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Recorded the time of single pulses



Test Data

Environmental Conditions

Temperature:	26.8 ℃
Relative Humidity:	37 %
ATM Pressure:	101.0 kPa

The testing was performed by Gleen Jiang on 2023-02-11.

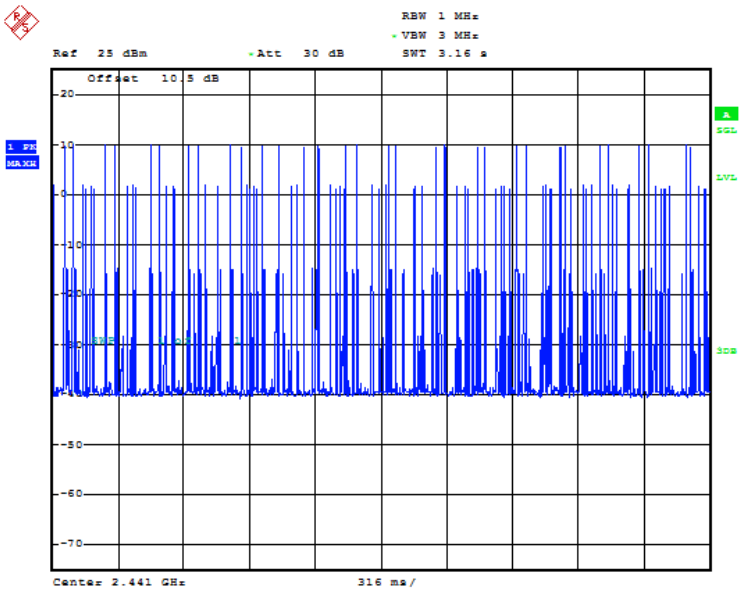
EUT operation mode: Transmitting

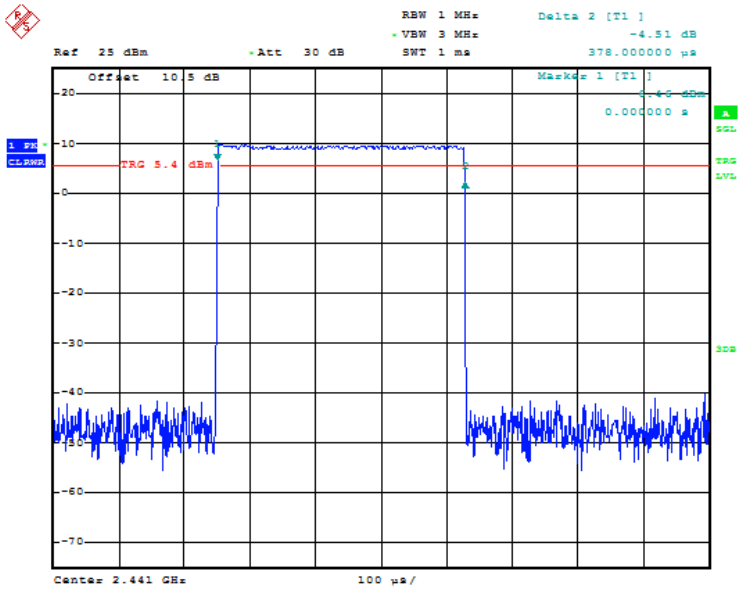
Test Result: Compliant.

Test Mode	Channel	Pulse Time [ms]	Total Hops [Num]	Result[s]	Limit[s]	Verdict
DH1	Hop	0.378	320	0.121	<=0.4	PASS
DH3	Hop	1.635	140	0.229	<=0.4	PASS
DH5	Hop	2.900	120	0.348	<=0.4	PASS
2DH1	Hop	0.390	310	0.121	<=0.4	PASS
2DH3	Hop	1.644	140	0.230	<=0.4	PASS
2DH5	Hop	2.910	80	0.233	<=0.4	PASS
3DH1	Hop	0.390	290	0.113	<=0.4	PASS
3DH3	Hop	1.644	130	0.214	<=0.4	PASS
3DH5	Hop	2.910	100	0.291	<=0.4	PASS

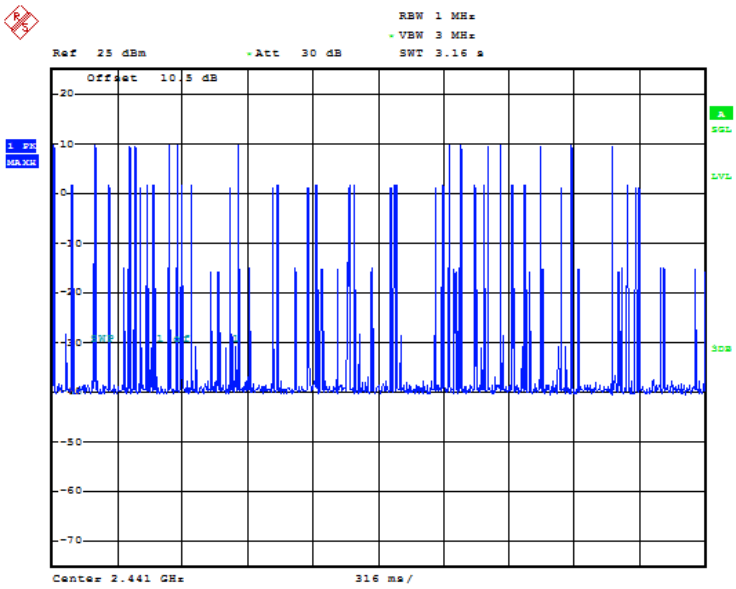
Note 1: A period time=0.4*79=31.6(S), Result= Pulse Time *Total hops
Note 2: Total hops=Hopping Number in 3.16s*10
Note 3: Hopping Number in 3.16s=Total of highest signals in 3.16s (Second high signals were other channel)

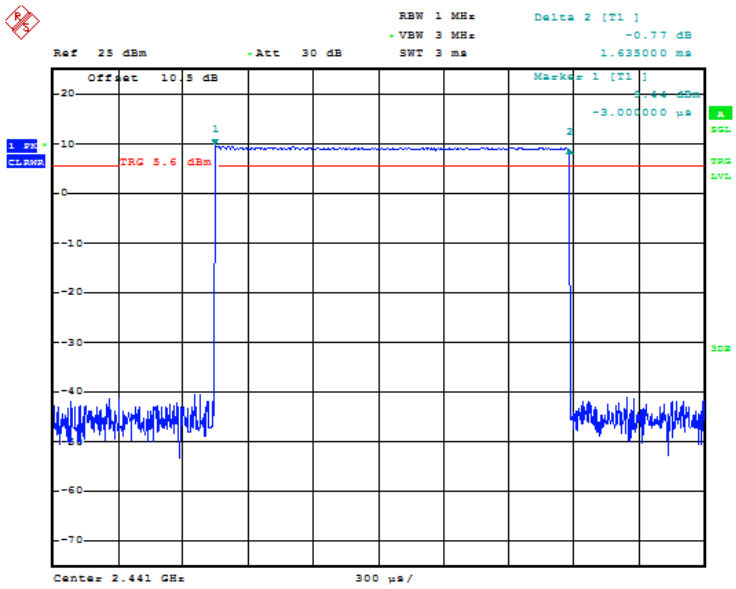
BT_DH1_Dwell time



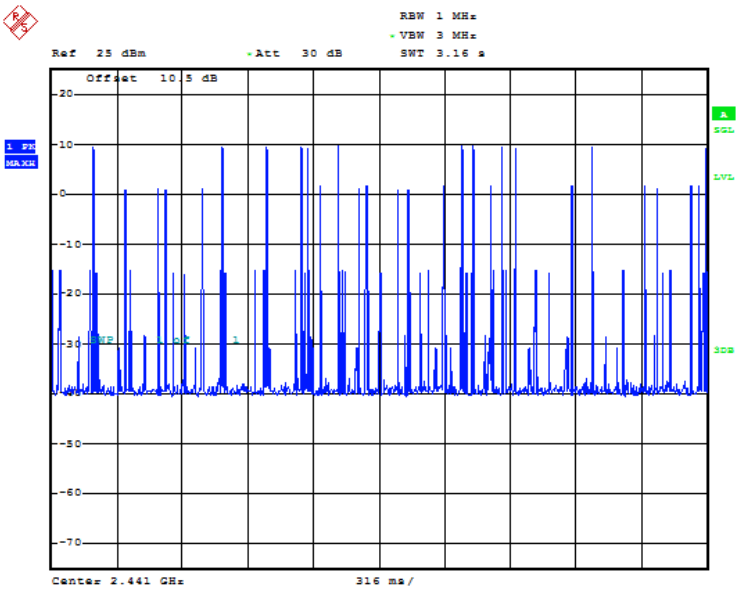


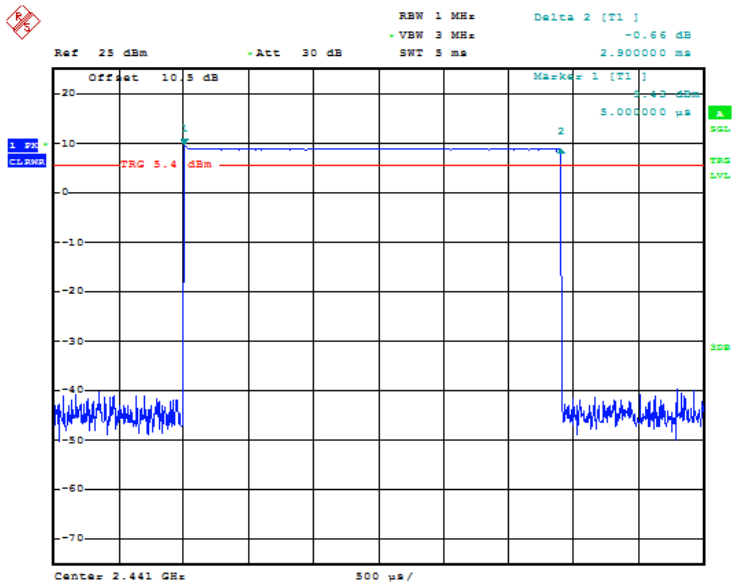
BT_DH3_Dwell time



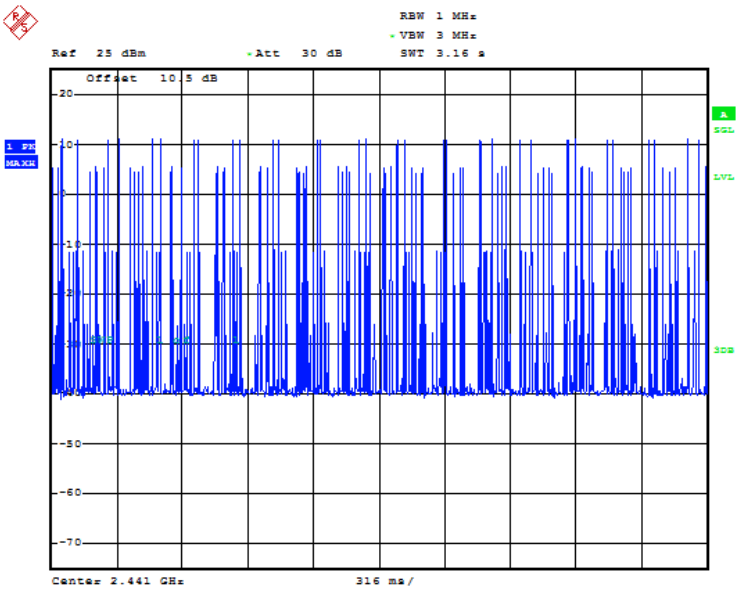


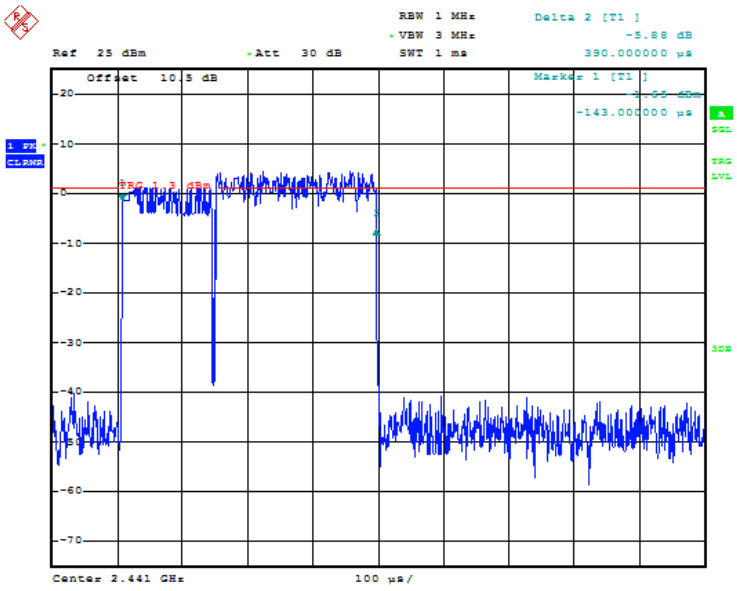
BT_DH5_Dwell time



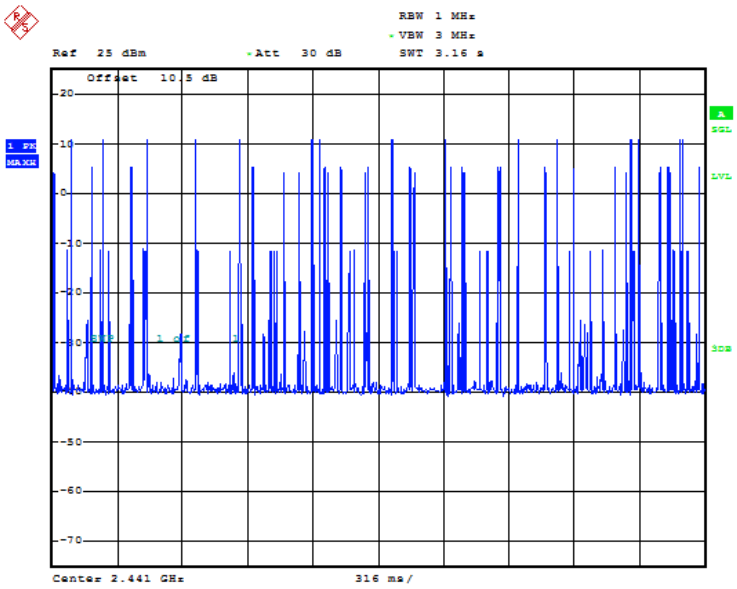


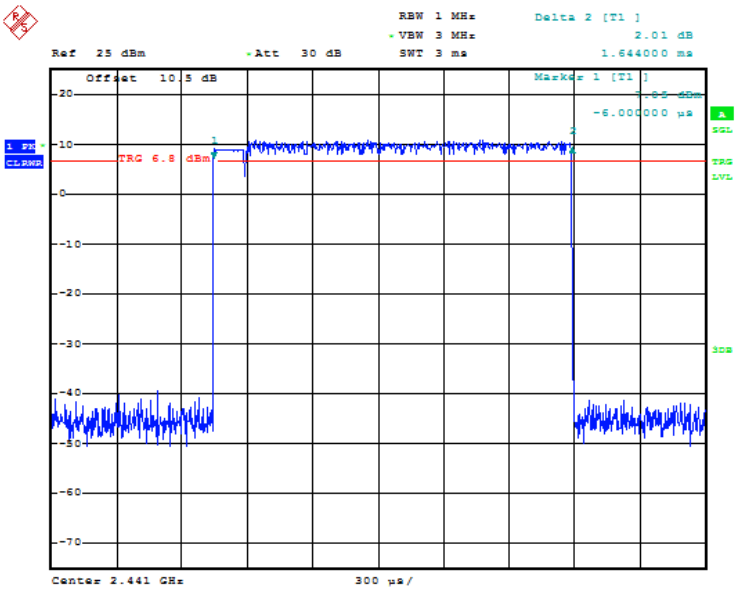
BT_2DH1_Dwell time



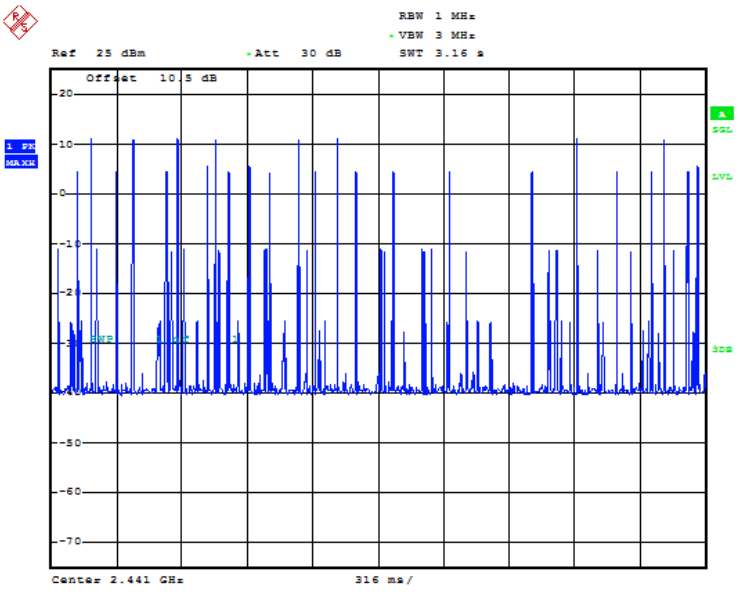


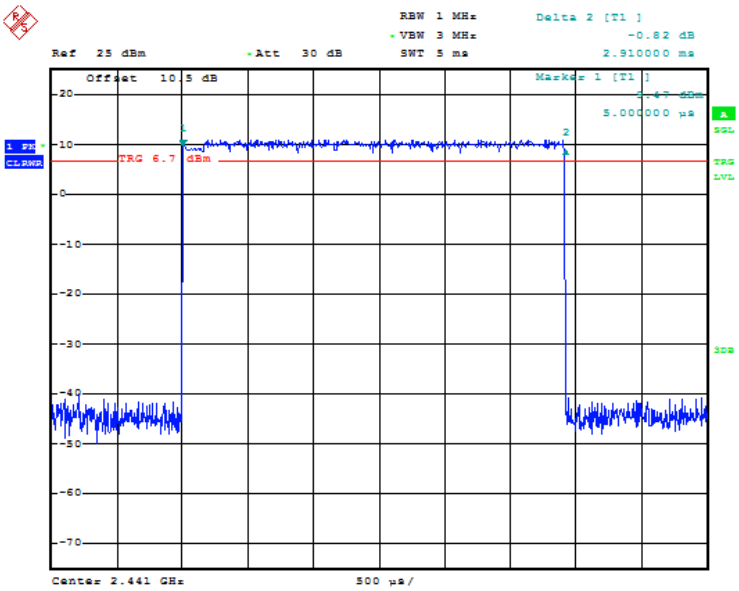
BT_2DH3_Dwell time





BT_2DH5_Dwell time





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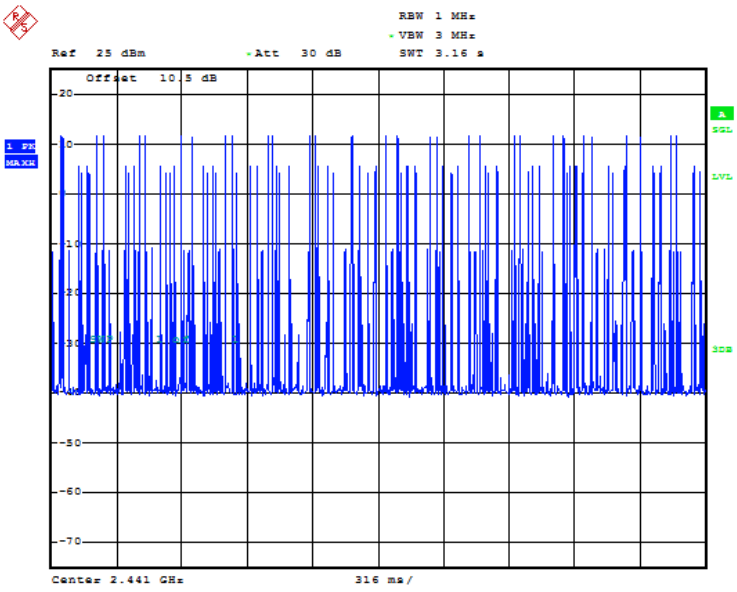

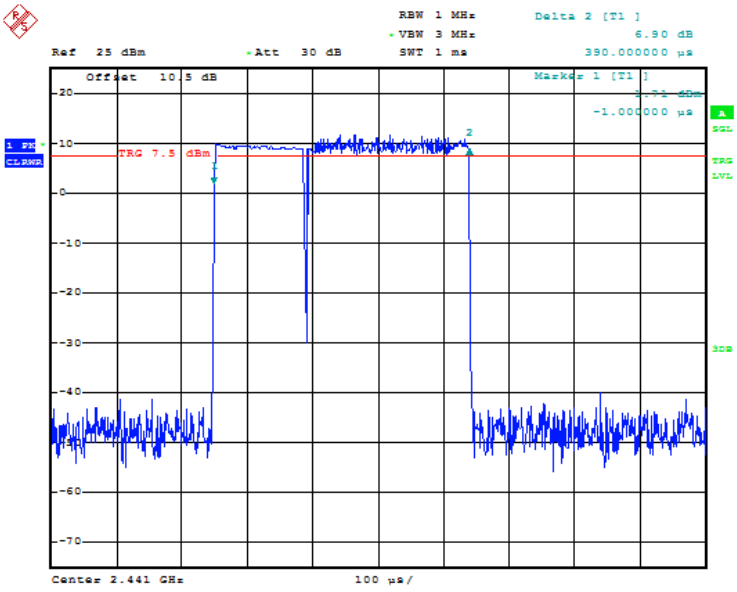

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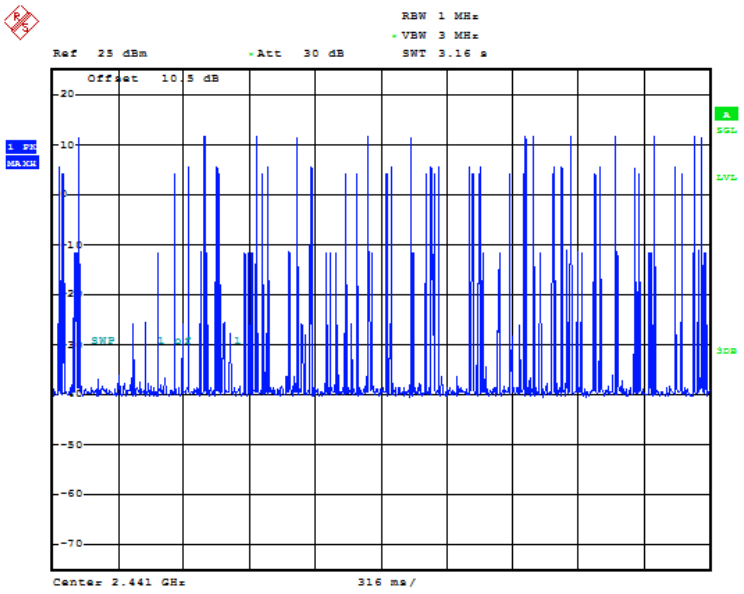

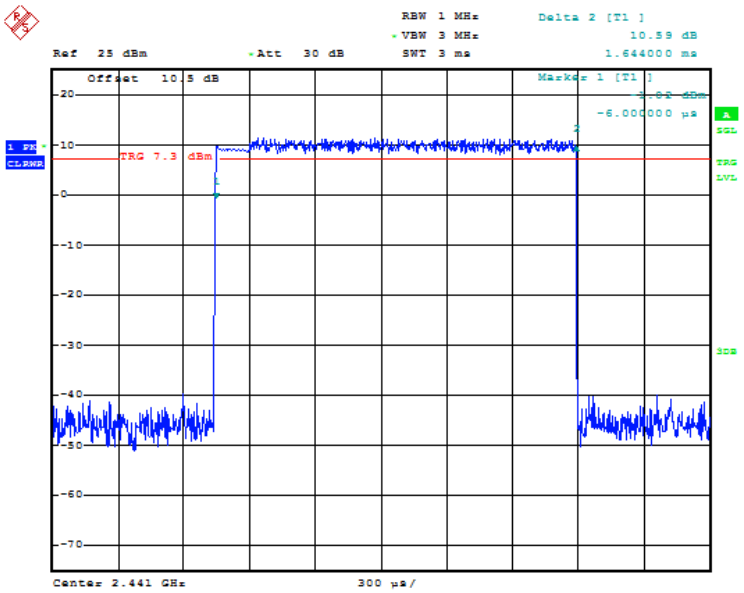

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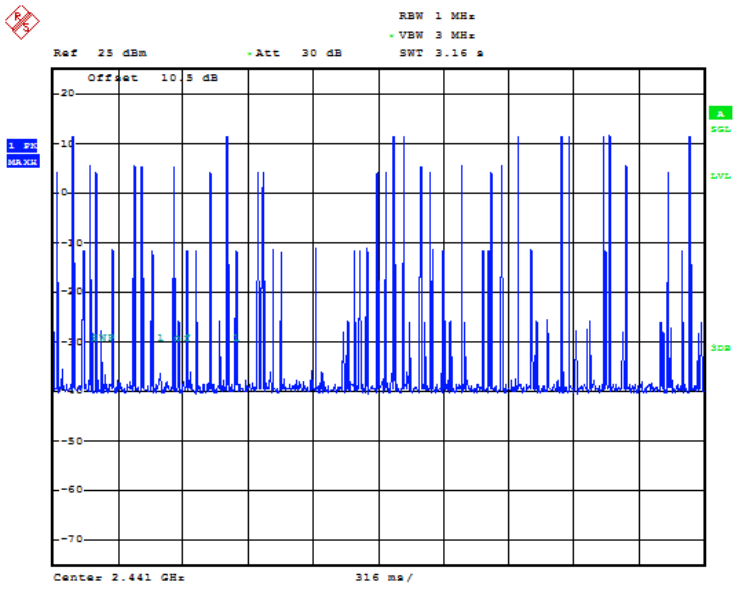
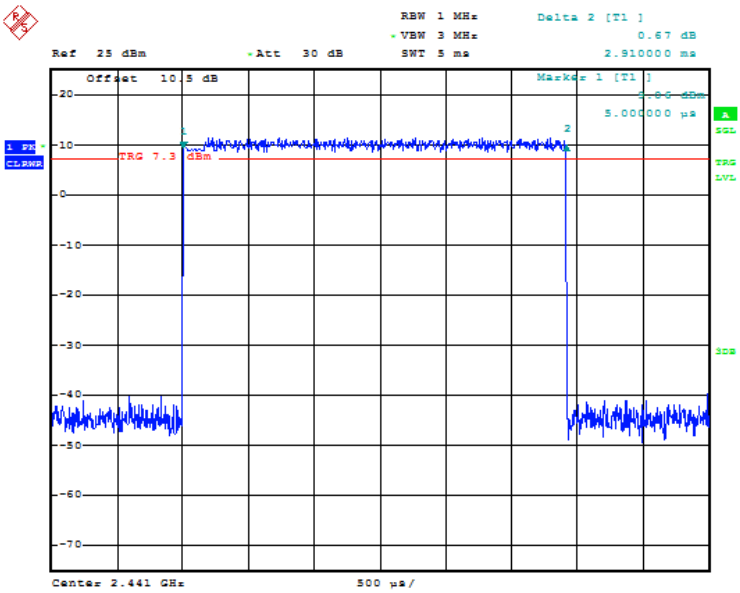




FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT

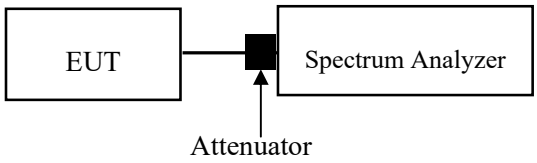
Applicable Standard

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. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.5

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.



Test Data

Environmental Conditions

Temperature:	26.8 ℃
Relative Humidity:	37 %
ATM Pressure:	101.0 kPa

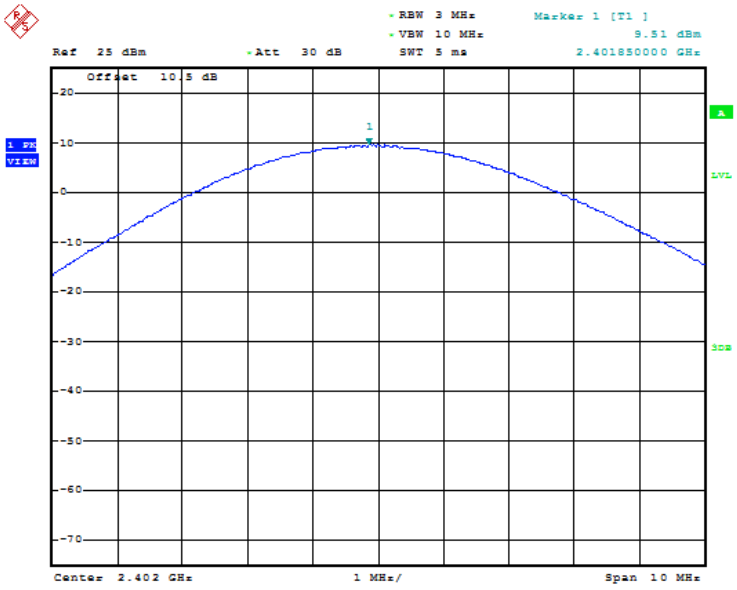
The testing was performed by Gleen Jiang on 2023-02-11.

EUT operation mode: Transmitting

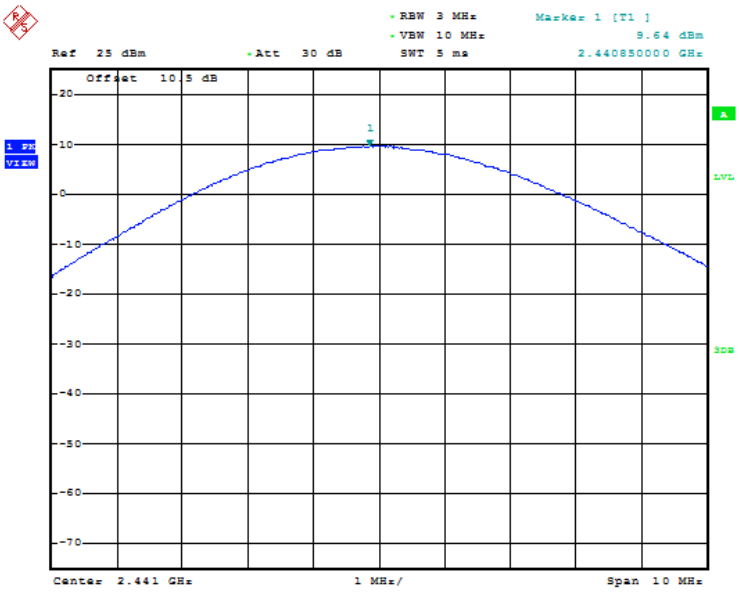
Test Result: Compliant.

Mode	Channel	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)
BDR (GFSK)	Low	2402	9.51	20.97
	Middle	2441	9.64	20.97
	High	2480	9.35	20.97
EDR (π/4-DQPSK)	Low	2402	11.54	20.97
	Middle	2441	11.76	20.97
	High	2480	11.47	20.97
EDR (8DPSK)	Low	2402	12.05	20.97
	Middle	2441	12.16	20.97
	High	2480	11.72	20.97

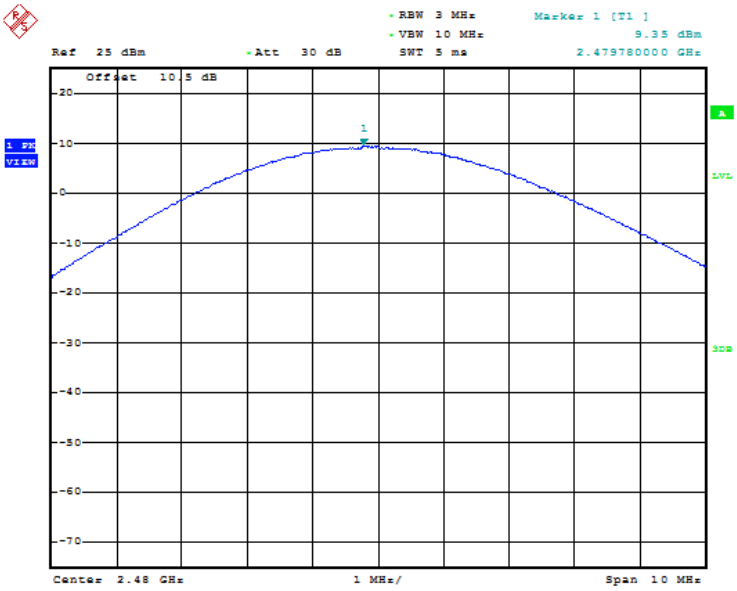
BT_DH5_2402MHz-Power



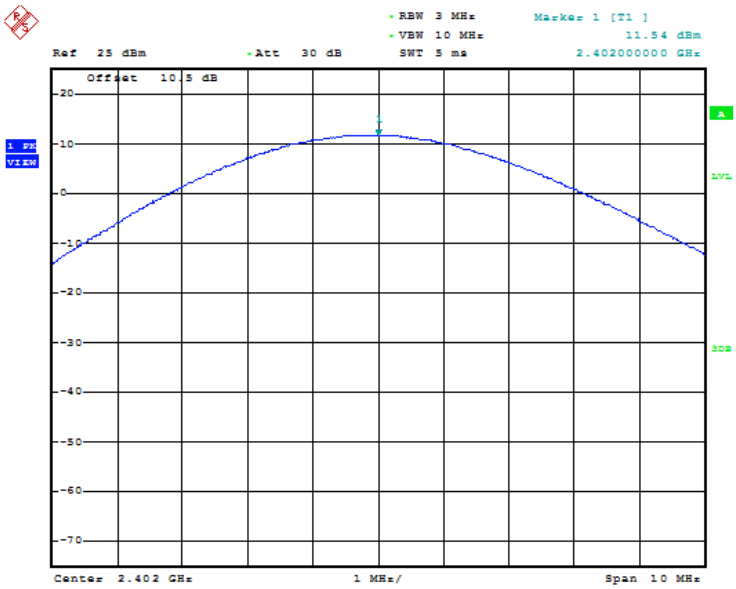
BT_DH5_2441MHz-Power



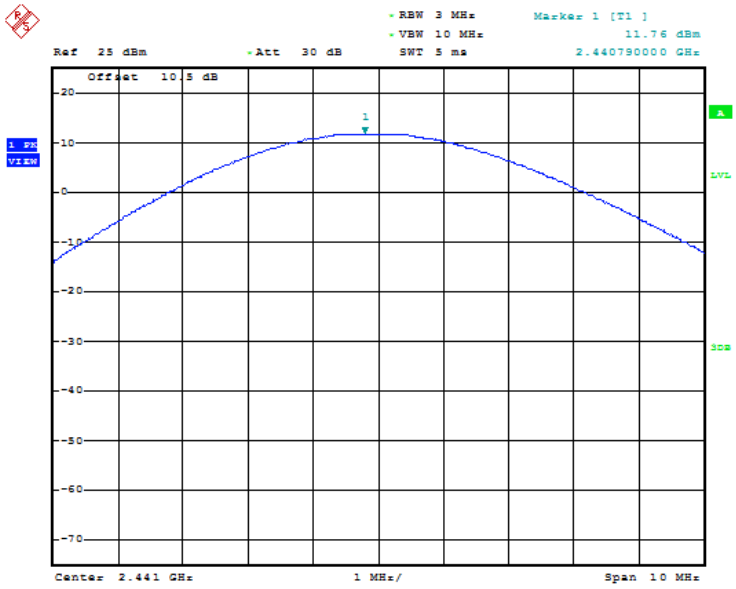
BT_DH5_2480MHz-Power



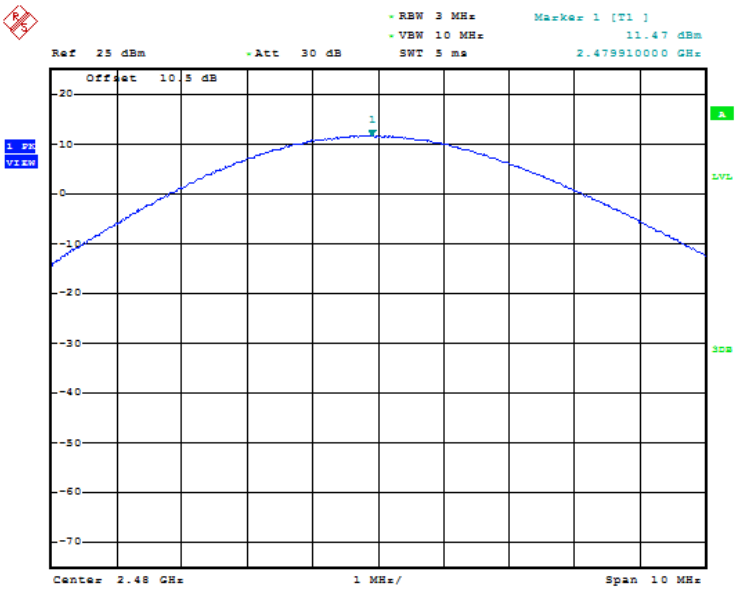
BT_2DH5_2402MHz-Power



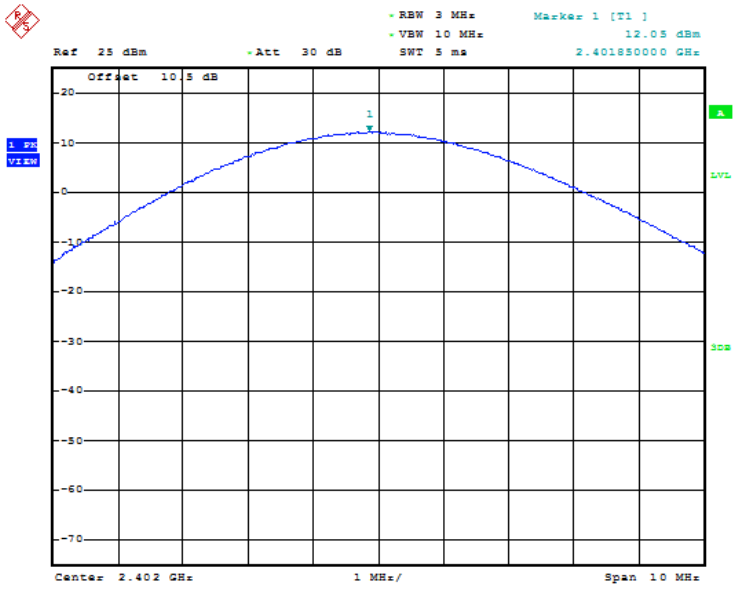
BT_2DH5_2441MHz-Power



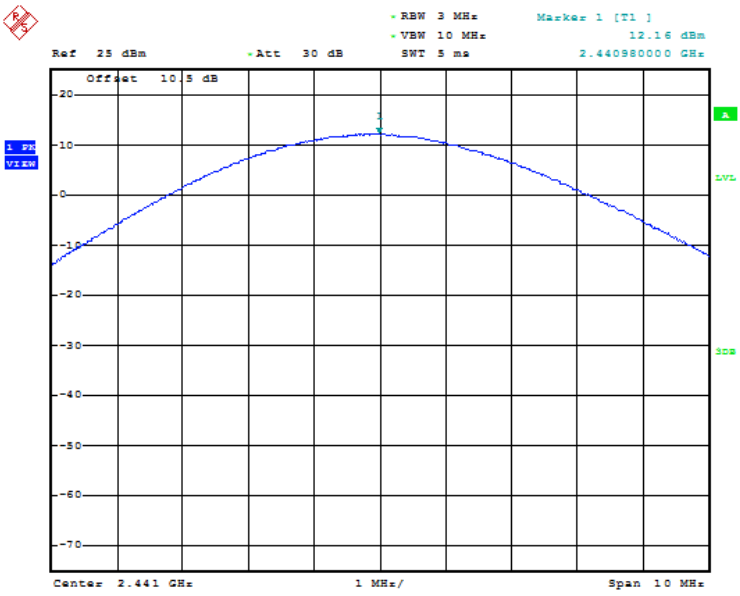
BT_2DH5_2480MHz-Power



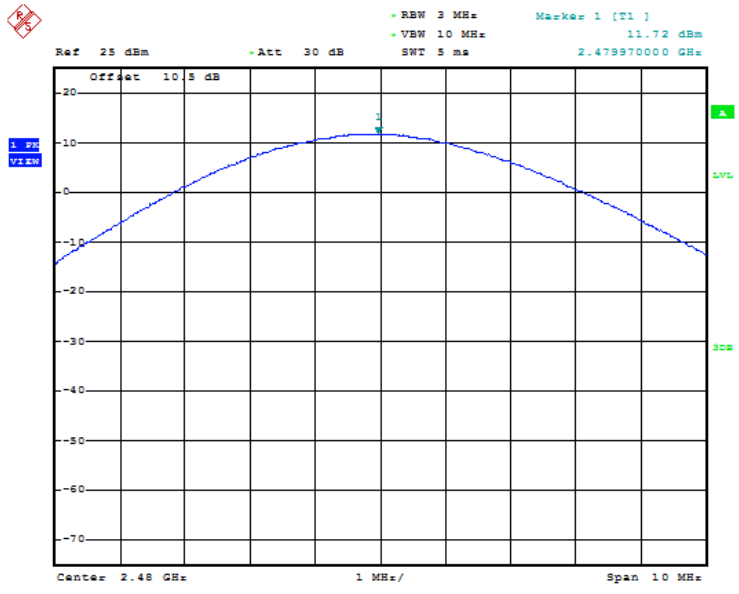
BT_3DH5_2402MHz-Power



BT_3DH5_2441MHz-Power



BT_3DH5_2480MHz-Power



FCC §15.247(d) - BAND EDGES TESTING

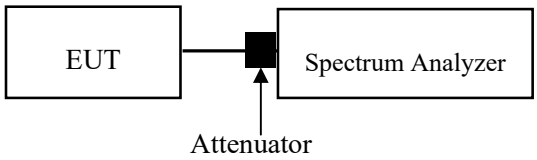
Applicable Standard

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) (see §15.205(c)).

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.6 & Clause 6.10

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.



Test Data

Environmental Conditions

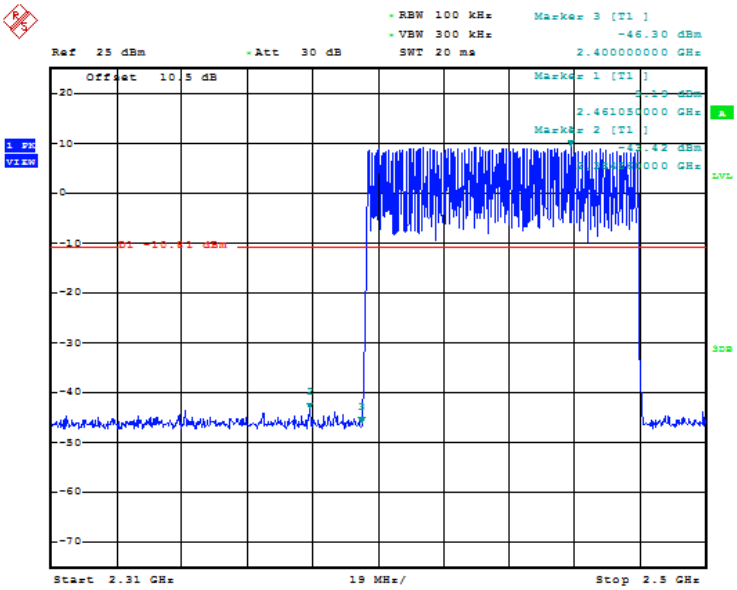
Temperature:	26.8 ℃
Relative Humidity:	37 %
ATM Pressure:	101.0 kPa

The testing was performed by Gleen Jiang on 2023-02-11.

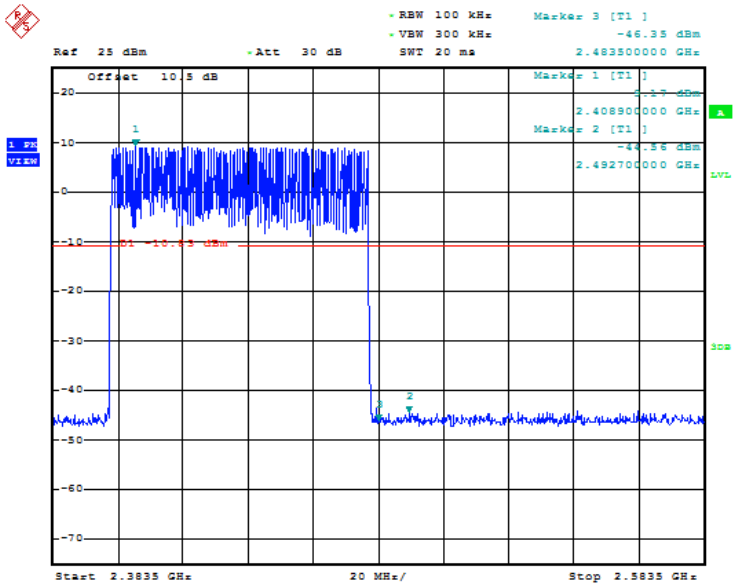
EUT operation mode: Transmitting

Test Result: Compliant.

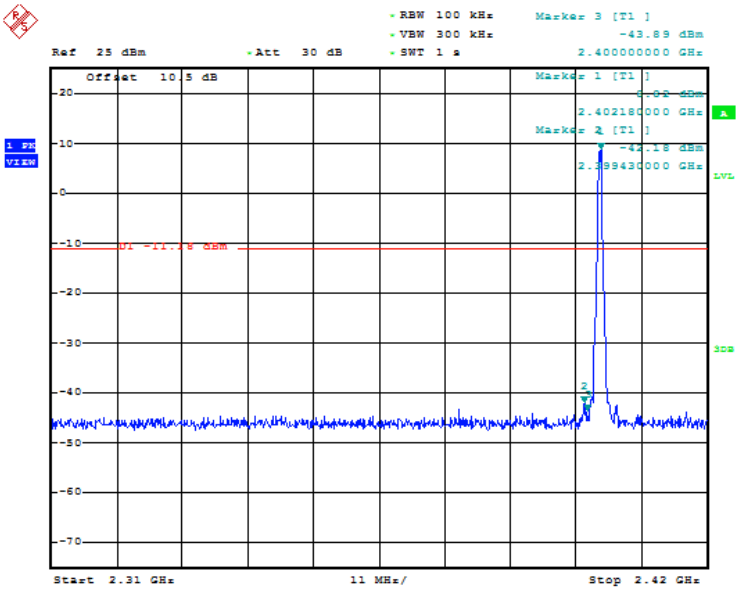
BT_DH5_Hopping Mode Low Bandedge



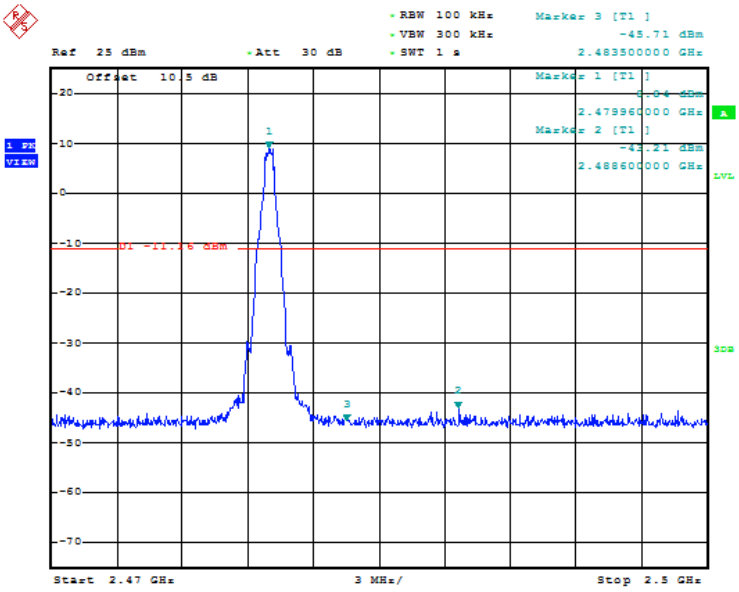
BT_DH5_-Hopping Mode High Bandedge



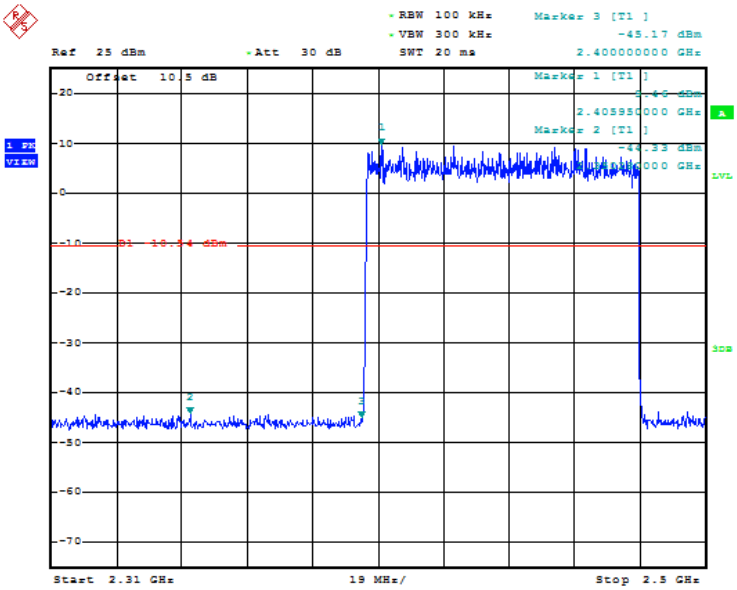
BT_DH5_2402MHz-Bandedge



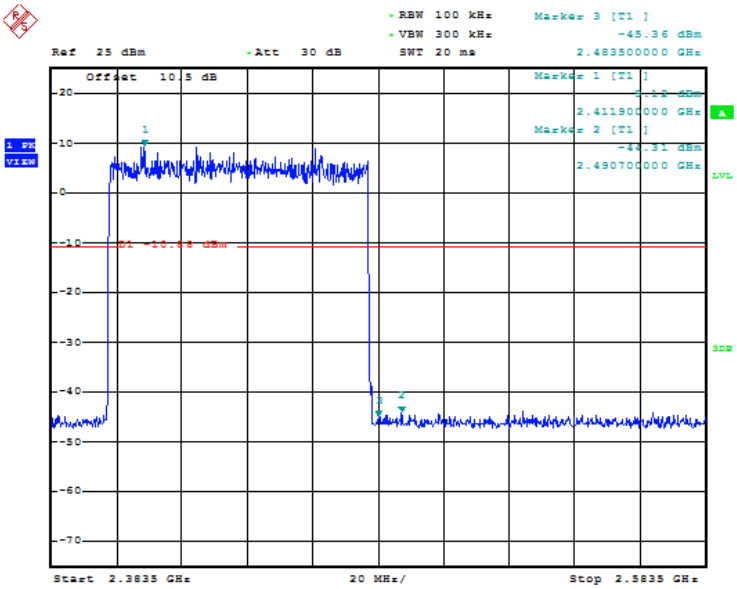
BT_DH5_2480MHz-Bandedge



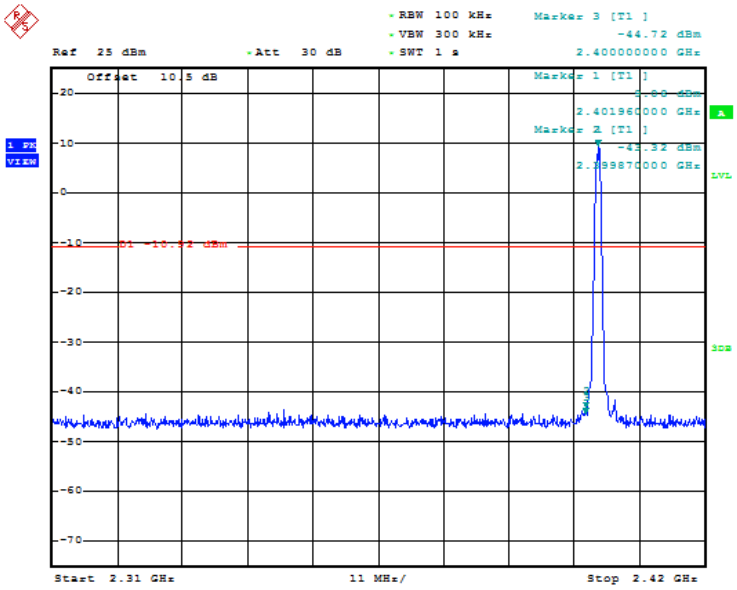
BT_2DH5_Hopping Mode Low Bandedge



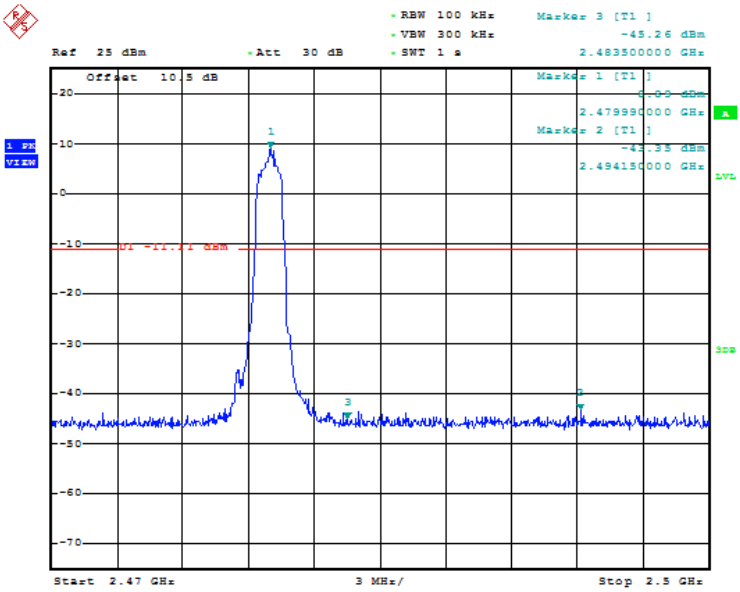
BT_2DH5_-Hopping Mode High Bandedge



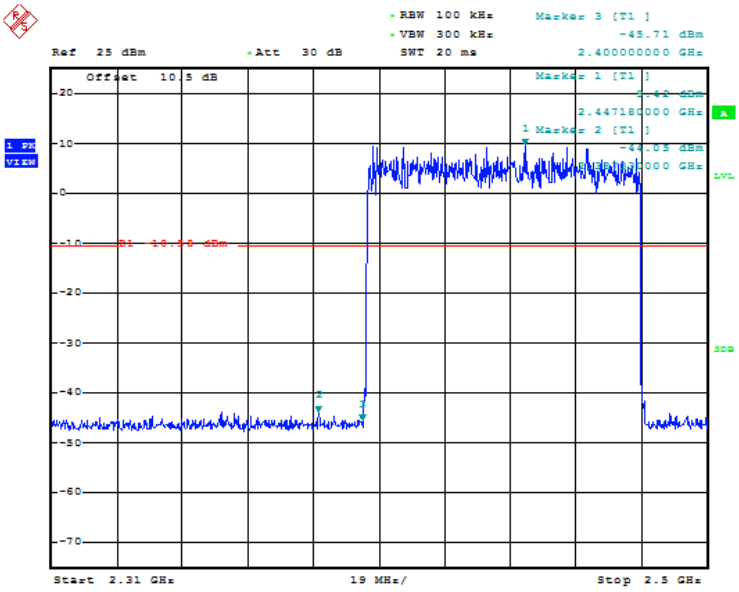
BT_2DH5_2402MHz-Bandedge



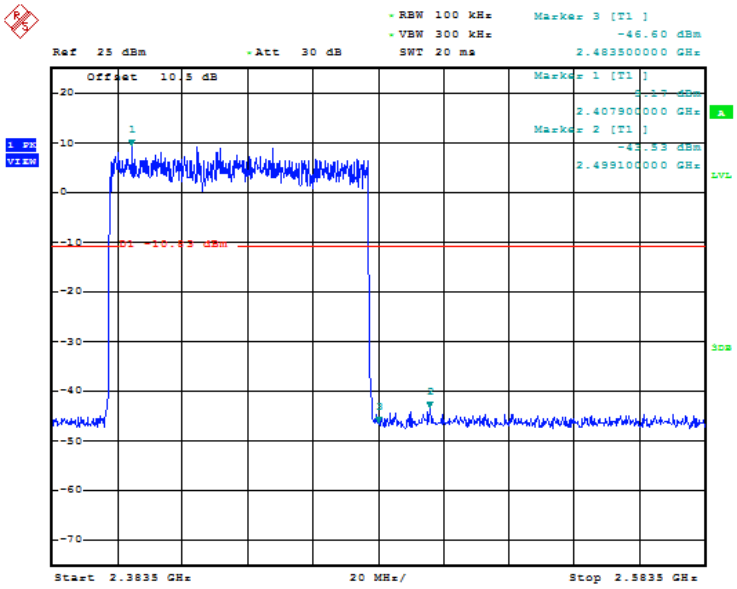
BT_2DH5_2480MHz-Bandedge



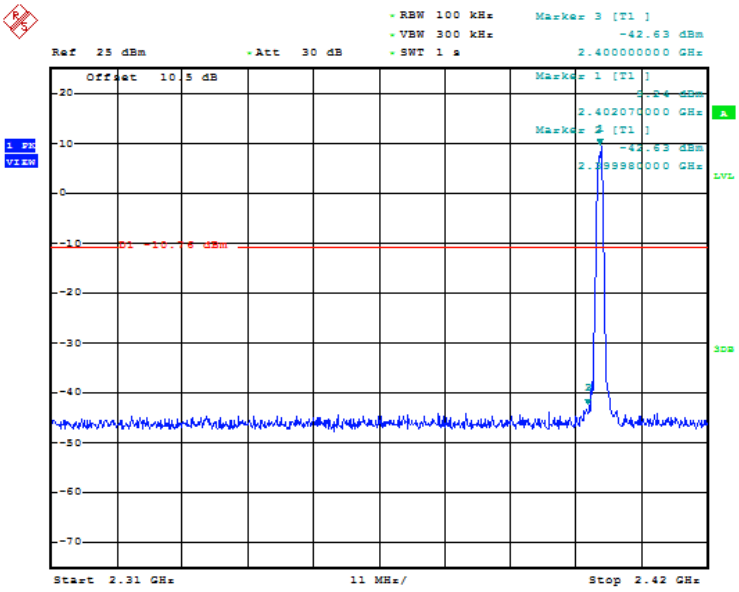
BT_3DH5_Hopping Mode Low Bandedge



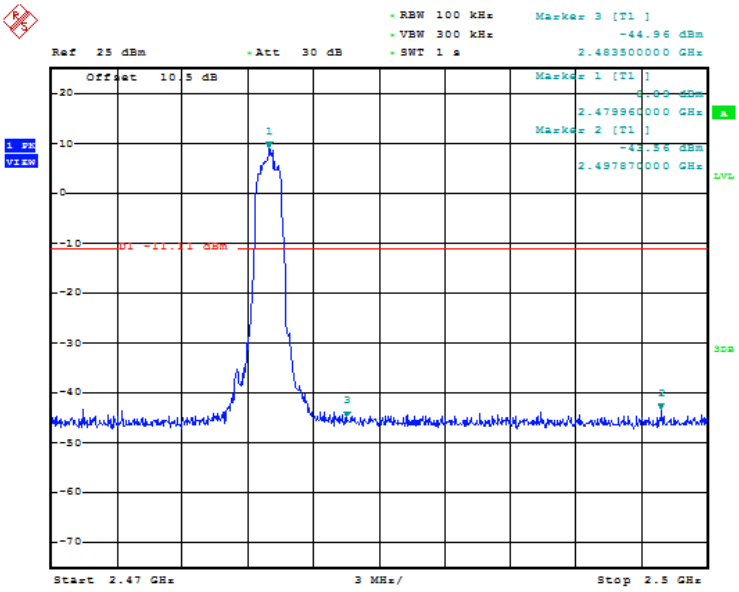
BT_3DH5_-Hopping Mode High Bandedge



BT_3DH5_2402MHz-Bandedge



BT_3DH5_2480MHz-Bandedge



******* END OF REPORT *******