FCC RF Test Report

Report No.:	FCC_RF_ SL21022601-HAR-283_R1 INT ER 3B_BT
FCC ID:	2AHPN-BE2861
Test Model:	R1 INT ER 3B
Received Date:	3/15/2021
Test Date:	4/15/2021-7/21/2021
Issued Date:	8/11/2021
Applicant:	HARMAN INTERNATIONAL
Address:	30001 Cabot Drive, Novi, MI 48377, USA
Manufacturer:	HARMAN INTERNATIONAL
Address:	30001 Cabot Drive, Novi, MI 48377, USA
Issued By:	Bureau Veritas Consumer Products Services, Inc.
Lab Address:	775 Montague Expressway, Milpitas, CA 95035
FCC Registration / Designation Number:	540430

ACCREDITED
TESTING CERT # 2742-01

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Release Control Record

Issue No.	Description	Date Issued
FCC_RF_ SL21022601-HAR-283_BT	Original Report	7/9/2021
FCC_RF_ SL21022601-HAR-283_R1 INT ER 3B_BT	Update Section4.2	8/11/2021

1 Certificate of Conformity

Product:	Automotive Infotainment Unit
Brand:	HARMAN
Test Model:	R1 INT ER 3B
Sample Status:	Final Product
Applicant:	HARMAN INTERNATIONAL
Test Date:	4/15/2021-7/21/2021
Standards:	47 CFR FCC Part 15, Subpart C (Section 15.247) ANSI C63.10: 2013

The above equipment has been tested by **Bureau Veritas Consumer Products Services, Inc., Milpitas Branch**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report.

Prepared by : _____ **Date:** *8/11/2021*

Jude Semana / Compliance Engineer

Approved by : _____ **Date:** *8/11/2021*

Gary Chou / Engineer Reviewer

2 Summary of Test Results

47 CFR FCC Part 15, Subpart C (SECTION 15.247)			
FCC Clause	Test Item	Result	Remarks
15.207	AC Power Conducted Emission	N/A	EUT is powered via DC power supply.
15.247(a)(1) (iii)	Number of Hopping Frequency Used	PASS	Meet the requirement of limit.
15.247(a)(1) (iii)	Dwell Time on Each Channel	PASS	Meet the requirement of limit.
15.247(a)(1)	1. Hopping Channel Separation 2. Spectrum Bandwidth of a Frequency Hopping Sequence Spread Spectrum System	PASS	Meet the requirement of limit.
15.247(b)	Maximum Peak Output Power	PASS	Meet the requirement of limit.
15.205 & 15.209 & 15.247(d)	Radiated Emissions & Band Edge Measurement	PASS	Meet the requirement of limit. Minimum passing QP margin
15.247(d)	Antenna Port Emission	PASS	Meet the requirement of limit.
15.203	Antenna Requirement	PASS	The device has an internal PCB antenna

1. If The Frequency Hopping System operating in 2400-2483.5MHz band and the output power less than 125mW. The hopping channel carrier frequencies separated by a minimum of 25kHz or two-thirds of the 20dB bandwidth of hopping channel whichever is greater.
2. Determining compliance based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.

2.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Measurement	Frequency	Expanded Uncertainty (k=2) (±)
Conducted Emissions at mains ports	150kHz ~ 30MHz	3.856 dB
Radiated Emissions up to 1 GHz	30MHz ~ 1GHz	4.638 dB
Radiated Emissions above 1 GHz	Above 1GHz	4.580dB

2.2 Modification Record

There were no modifications required for compliance.

3 General Information

3.1 General Description of EUT

Product Type	Automotive Infotainment Unit
Brand	HARMAN
Test Model	R1 INT ER 3B
Status of EUT	Final Product
Power Supply Rating	12Vdc
Modulation Type	GFSK, π/4-DQPSK, 8DPSK
Modulation Technology	FHSS
Transfer Rate	BDR/EDR: up to 3MB/s
Operating Frequency	2402~2480MHz
Number of Channel	79
Output Power	3.38 mW
Antenna Type	PCB Antenna
Antenna Gain	-1.41dBi
Antenna Connector	U.FL

3.2 Description of Test Modes

79 channels are provided for BT-BDR/EDR mode:

Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
0	2402	20	2422	40	2442	60	2462
1	2403	21	2423	41	2443	61	2463
2	2404	22	2424	42	2444	62	2464
3	2405	23	2425	43	2445	63	2465
4	2406	24	2426	44	2446	64	2466
5	2407	25	2427	45	2447	65	2467
6	2408	26	2428	46	2448	66	2468
7	2409	27	2429	47	2449	67	2469
8	2410	28	2430	48	2450	68	2470
9	2411	29	2431	49	2451	69	2471
10	2412	30	2432	50	2452	70	2472
11	2413	31	2433	51	2453	71	2473
12	2414	32	2434	52	2454	72	2474
13	2415	33	2435	53	2455	73	2475
14	2416	34	2436	54	2456	74	2476
15	2417	35	2437	55	2457	75	2477
16	2418	36	2438	56	2458	76	2478
17	2419	37	2439	57	2459	77	2479
18	2420	38	2440	58	2460	78	2480
19	2421	39	2441	59	2461		

3.2.1 Test Mode Applicability and Tested Channel Detail

EUT CONFIGURE MODE	APPLICABLE TO				DESCRIPTION
	RE≥1G	RE<1G	PLC	APCM	
-	√	√	-	√	-

Where **RE≥1G:** Radiated Emission above 1GHz **RE<1G:** Radiated Emission below 1GHz
PLC: Power Line Conducted Emission **APCM:** Antenna Port Conducted Measurement

NOTE:
1. The EUT had been pre-tested on the positions of each 3 axis. The worst case was found when positioned on **X-plane**.
2. "-" means no effect.

Radiated Emission Test (Above 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	PACKET TYPE
-	0 to 78	0, 39, 78	FHSS	GFSK	DH5
-	0 to 78	0, 39, 78	FHSS	8DPSK	3DH5

Radiated Emission Test (Below 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	PACKET TYPE
-	0 to 78	39	FHSS	GFSK	DH5
-	0 to 78	39	FHSS	8DPSK	3DH5

Antenna Port Conducted Measurement:

☒ This item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION TECHNOLOGY	MODULATION TYPE	PACKET TYPE
-	0 to 78	0, 39, 78	FHSS	GFSK	DH5
-	0 to 78	0, 39, 78	FHSS	8DPSK	3DH5

Test Condition:

APPLICABLE TO	ENVIRONMENTAL CONDITIONS	INPUT POWER	TESTED BY
RE≥1G	25deg. C, 65%RH	12VDC	Jude Semana
RE<1G	25deg. C, 65%RH	12VDC	Jude Semana
APCM	21deg. C, 60%RH	12VDC	Jude Semana

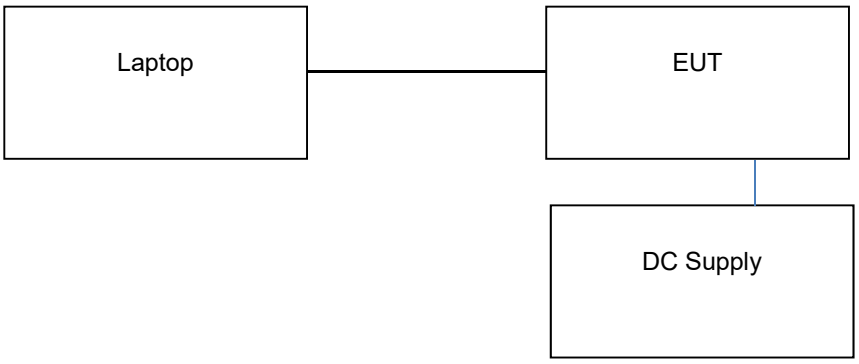
3.3 Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

ID	Product	Brand	Model No.	Serial No.	FCC ID	Remarks
A.	Laptop	Acer	Aspire 3	N/A	N/A	Provided by Lab

Note: The core(s) is (are) originally attached to the cable(s).

3.3.1 Configuration of System under Test



3.4 General Description of Applied Standards

The EUT is a RF Product. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

FCC Part 15, Subpart C (15.247)
KDB 558074 D01 15.247 Meas Guidance v05r02
ANSI C63.10-2013

All test items have been performed and recorded as per the above standards.

4 Test Types and Results

4.1 Radiated Emission and Bandedge Measurement

4.1.1 Limits of Radiated Emission and Bandedge Measurement

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 20dB below the highest level of the desired power:

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 ~ 0.490	2400/F(kHz)	300
0.490 ~ 1.705	24000/F(kHz)	30
1.705 ~ 30.0	30	30
30 ~ 88	100	3
88 ~ 216	150	3
216 ~ 960	200	3
Above 960	500	3

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

4.1.2 Test Instruments

DESCRIPTION & MANUFACTURER	MODEL NO.	SERIAL NO.	DATE OF CALIBRATION	DUE DATE OF CALIBRATION
EMI Receiver , Rohde and Schwarz	ESW44	1328.4100K-101662-MH	10/23/2020	10/23/2021
Biconilog Antenna , Sunol	JB6	A111717	9/4/2020	9/4/2021
Horn Antenna , ETS-Lindgren	3117	218554	7/24/2020	7/24/2021
Pre-Amplifier , RF-Lambda	RAMP00M50GA	18040300055	10/1/2020	10/1/2021
Spectrum Analyzer, Keysight	N9030B	MY57140100	07/22/2020	07/22/2022

NOTE:

1. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
2. The horn antenna and HP preamplifier (model: 3117) are used only for the measurement of emission frequency above 1GHz if tested.

TEST PROCEDURES
For Radiated emission below 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. Both Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

NOTE:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

For Radiated emission above 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.

f. The test-receiver system was set to peak and average detect function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

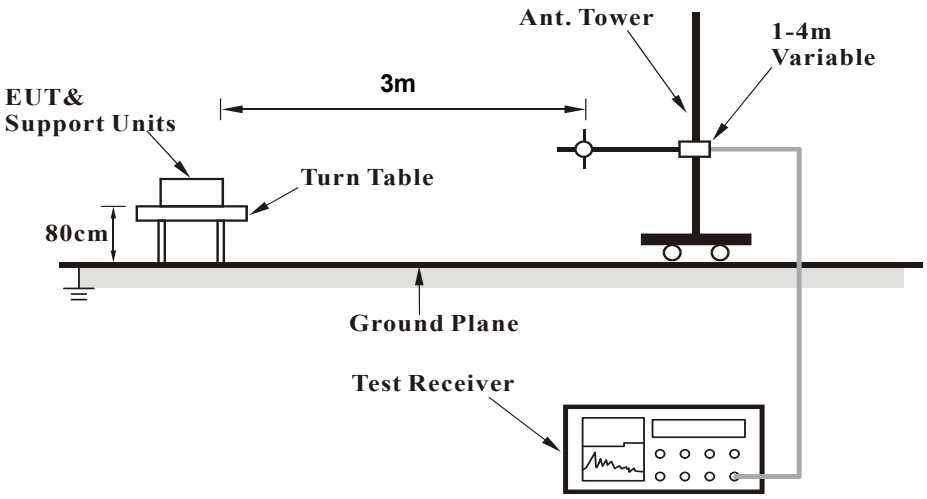
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is ≥ 1/T (Duty cycle < 98%) or 10Hz (Duty cycle ≥ 98%) for Average detection (AV) at frequency above 1GHz.
4. All modes of operation were investigated and the worst-case emissions are reported.

4.1.3 Deviation from Test Standard

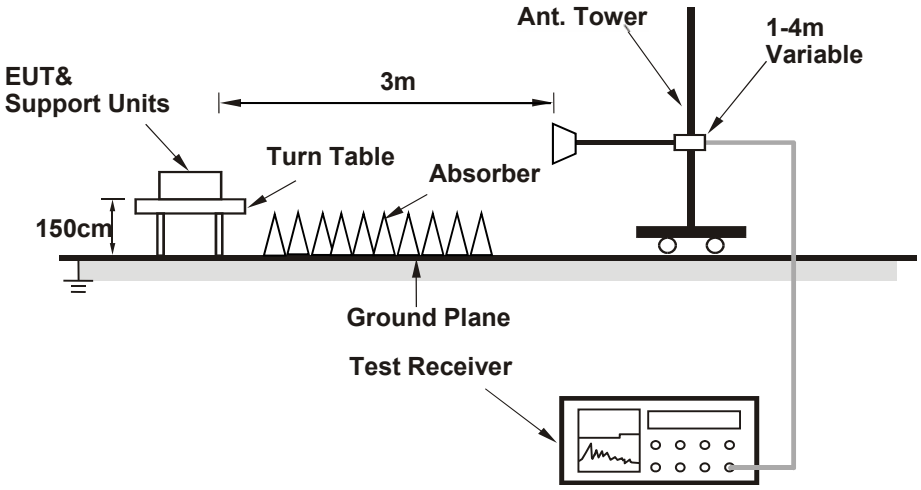
No deviation.

4.1.4 Test Setup

For Radiated emission 30MHz to 1GHz



For Radiated emission above 1GHz



For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.1.5 EUT Operating Conditions

a. Connected the EUT with the Notebook Computer which is placed on remote site.
b. Controlling software has been activated to set the EUT on specific status.

4.1.6 Test Results

Above 1GHz Data:

BT_GFSK

CHANNEL	TX MODE 2402 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	1GHz ~ 25GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	1756.915	V	44.1	Average	-14.4	29.7	54	-24.3	184.9	212.9	Pass
2	2995.423	V	40.1	Average	-10.3	29.8	54	-24.2	194.4	356	Pass
3	4995.589	V	35.8	Average	-5.8	30	54	-24	100	131.3	Pass
4	1756.915	V	59	Peak	-14.4	44.6	74	-29.4	184.9	212.9	Pass
5	2995.423	V	57.9	Peak	-10.3	47.6	74	-26.4	194.4	356	Pass
6	4995.589	V	55.4	Peak	-5.8	49.6	74	-24.4	100	131.3	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

CHANNEL	TX MODE 2441 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	1GHz ~ 25GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	5841.21	V	35.5	Average	-3.9	31.6	54	-22.4	100.4	208.2	Pass
2	11608.16	V	27.2	Average	6.2	33.4	54	-20.6	137.7	173.2	Pass
3	2125.096	V	45.2	Average	-12.5	32.7	54	-21.3	111.7	202.6	Pass
4	5841.21	V	65.2	Peak	-3.9	61.3	74	-12.7	100.4	208.2	Pass
5	11608.16	V	39.5	Peak	6.2	45.7	74	-28.3	137.7	173.2	Pass
6	2125.096	V	65	Peak	-12.5	52.5	74	-21.5	111.7	202.6	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

CHANNEL	TX MODE 2480 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	1GHz ~ 25GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	1757.334	V	43.7	Average	-14.4	29.3	54	-24.7	116.1	0	Pass
2	3194.792	V	39.1	Average	-9.4	29.7	54	-24.3	111.4	279.4	Pass
3	4976.051	H	35.3	Average	-5.9	29.4	54	-24.6	195.3	319.1	Pass
4	1757.334	V	63.5	Peak	-14.4	49.1	74	-24.9	116.1	0	Pass
5	3194.792	V	52.8	Peak	-9.4	43.4	74	-30.6	111.4	279.4	Pass
6	4976.051	H	51.4	Peak	-5.9	45.5	74	-28.5	195.3	319.1	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

BT_8DPSK

CHANNEL	TX MODE 2402 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	1GHz ~ 25GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2129.461	H	41.9	Average	-12.5	29.4	54	-24.6	146.2	118.6	Pass
2	3196.39	H	38.6	Average	-9.4	29.2	54	-24.8	163.9	341.1	Pass
3	4987.544	H	35.5	Average	-5.8	29.7	54	-24.3	128.4	357.2	Pass
4	2129.461	H	55.6	Peak	-12.5	43.1	74	-30.9	146.2	118.6	Pass
5	3196.39	H	53	Peak	-9.4	43.6	74	-30.4	163.9	341.1	Pass
6	4987.544	H	50.9	Peak	-5.8	45.1	74	-28.9	128.4	357.2	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

CHANNEL	TX MODE 2441 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	1GHz ~ 25GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	1757.885	V	44.6	Average	-14.4	30.2	54	-23.8	184.2	355.8	Pass
2	3186.762	V	38.7	Average	-9.4	29.3	54	-24.7	135.9	162.5	Pass
3	4989.287	V	37	Average	-5.8	31.2	54	-22.8	128.2	355.8	Pass
4	1757.885	V	68.7	Peak	-14.4	54.3	74	-19.7	184.2	355.8	Pass
5	3186.762	V	55.8	Peak	-9.4	46.4	74	-27.6	135.9	162.5	Pass
6	4989.287	V	52.5	Peak	-5.8	46.7	74	-27.3	128.2	355.8	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

CHANNEL	TX MODE 2480 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	1GHz ~ 25GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	1756.725	V	43	Average	-14.4	28.6	54	-25.4	104.4	348.6	Pass
2	2124.538	V	45	Average	-12.5	32.5	54	-21.5	214.4	186.7	Pass
3	3194.235	V	38.7	Average	-9.4	29.3	54	-24.7	156.5	349.4	Pass
4	1756.725	V	67	Peak	-14.4	52.6	74	-21.4	104.4	348.6	Pass
5	2124.538	V	65.8	Peak	-12.5	53.3	74	-20.7	214.4	186.7	Pass
6	3194.235	V	56.2	Peak	-9.4	46.8	74	-27.2	156.5	349.4	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Below 1GHz Data:

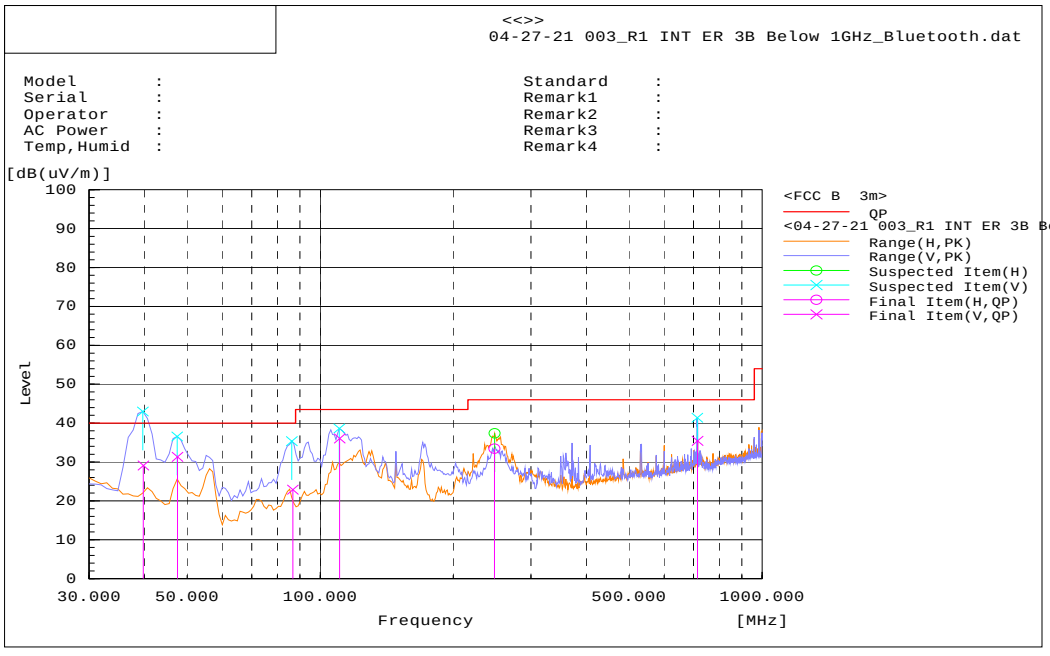
BT_GFSK

CHANNEL	TX MODE 2441 MHz	**DETECTOR FUNCTION**	Quasi Peak
FREQUENCY RANGE	30MHz – 1GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m										
No.	Frequency (MHz)	Polarization (H/V)	Reading QP [dB(uV)]	Factor [dB(1/m)]	Level QP [dB(uV/m)]	Limit\QP dB(uV/m)	Margin QP [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	39.803	V	10.5	18.6	29.1	40	-10.9	101.5	0	Pass
2	110.714	V	17.5	18.6	36.1	43.5	-7.4	99	140.2	Pass
3	714.288	V	7.4	28.1	35.5	46	-10.5	102.1	9.8	Pass
4	247.855	H	15.1	18.3	33.4	46	-12.6	114	69	Pass
5	47.569	V	17.3	14	31.3	40	-8.7	100.2	227.8	Pass
6	86.756	V	9	13.9	22.9	40	-17.1	160.1	340.2	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)



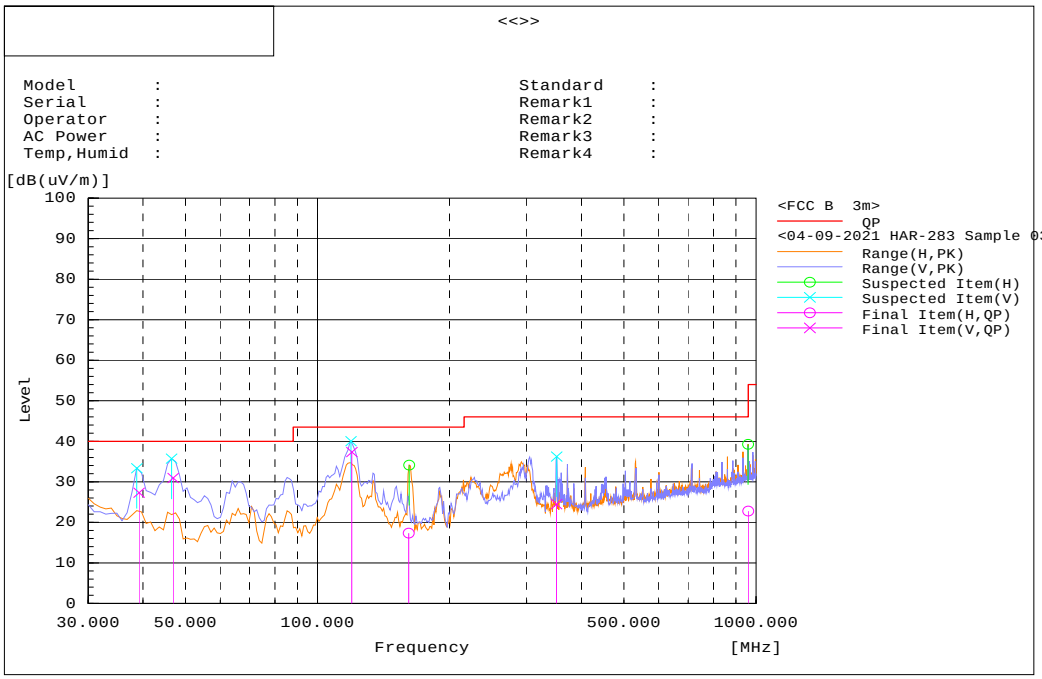
BT_8DPSK

CHANNEL	TX MODE 2441 MHz	**DETECTOR FUNCTION**	Quasi Peak
FREQUENCY RANGE	30MHz – 1GHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m										
No.	Frequency (MHz)	Polarization (H/V)	Reading QP [dB(uV)]	Factor [dB(1/m)]	Level QP [dB(uV/m)]	Limit\QP dB(uV/m)	Margin QP [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	46.878	V	16.7	14.3	31	40	-9	100	247.1	Pass
2	119.737	V	18	19.3	37.3	43.5	-6.2	100.3	234.5	Pass
3	39.167	V	8.2	19.1	27.3	40	-12.7	105	0	Pass
4	161.438	H	-1.4	18.7	17.3	43.5	-26.2	150.6	0.1	Pass
5	350.744	V	3	21.5	24.5	46	-21.5	160.4	3.4	Pass
6	959.628	H	-8.6	31.4	22.8	46	-23.2	351.1	321.8	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)



RESTRICTED BAND

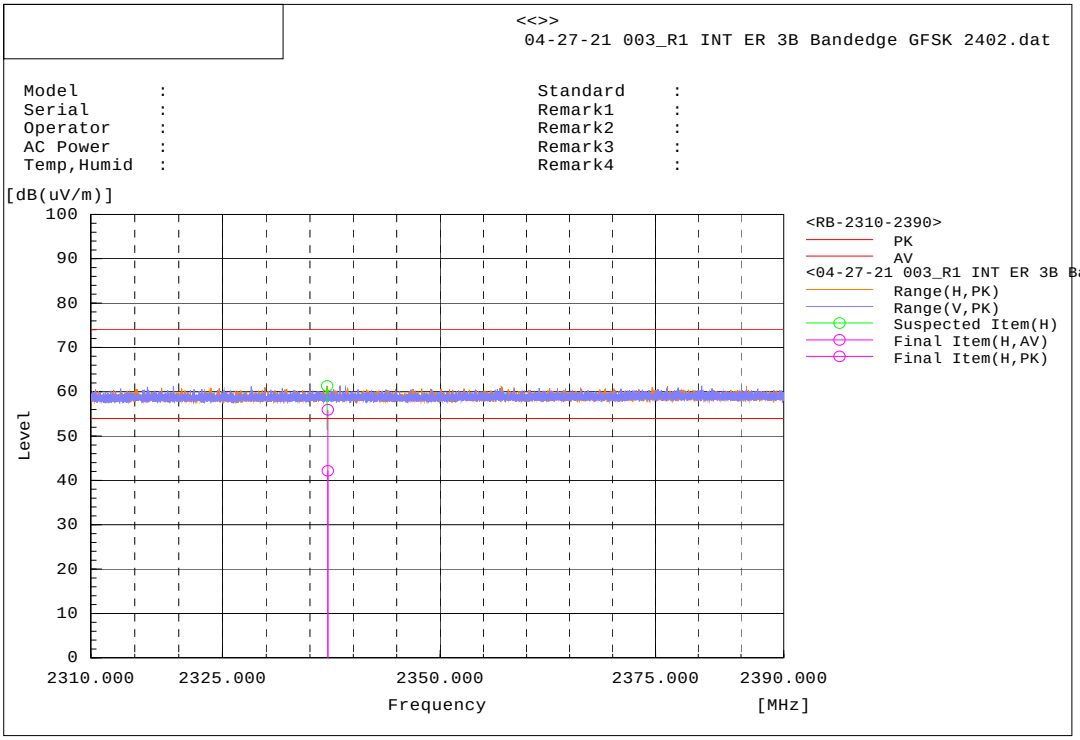
BT_GFSK

CHANNEL	TX MODE 2402 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	2310MHz-2390MHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2337.072	H	7.4	Average	34.8	42.2	54	-11.8	113.8	223	Pass
2	2337.072	H	21.1	Peak	34.8	55.9	74	-18.1	113.8	223	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)



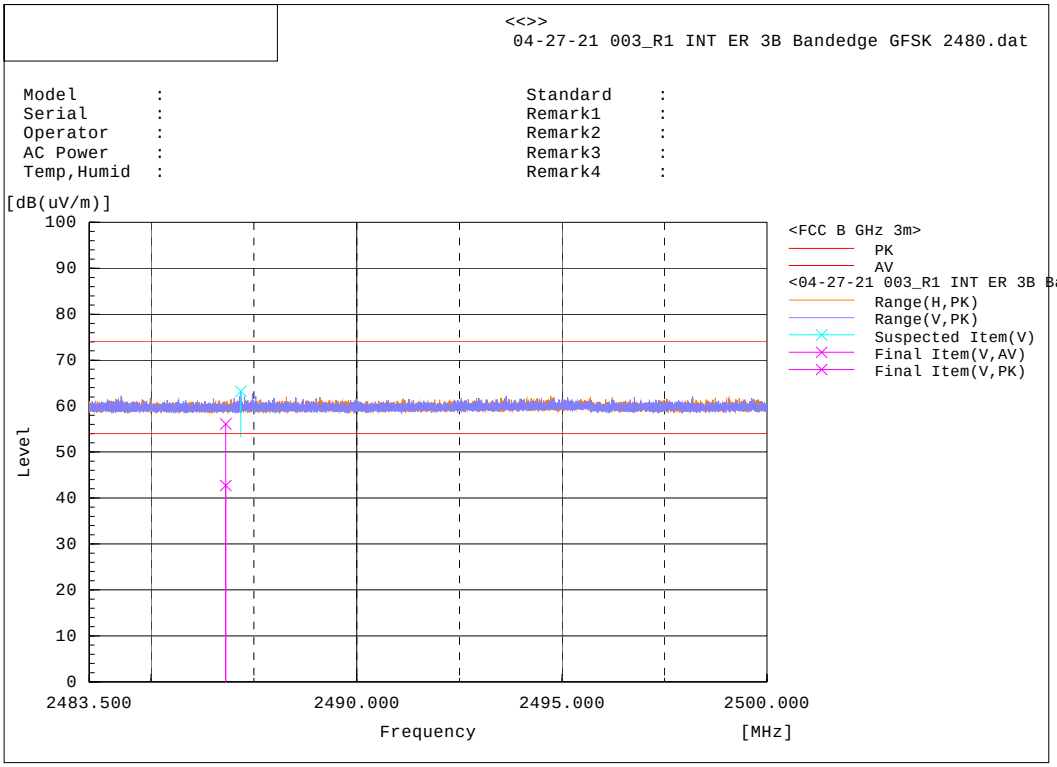
RESTRICTED BAND

CHANNEL	TX MODE 2480 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	2483.5MHz-2500MHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2486.814	V	7.4	Average	35.4	42.8	54	-11.2	177	144.1	Pass
2	2486.814	V	20.7	Peak	35.4	56.1	74	-17.9	177	144.1	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)



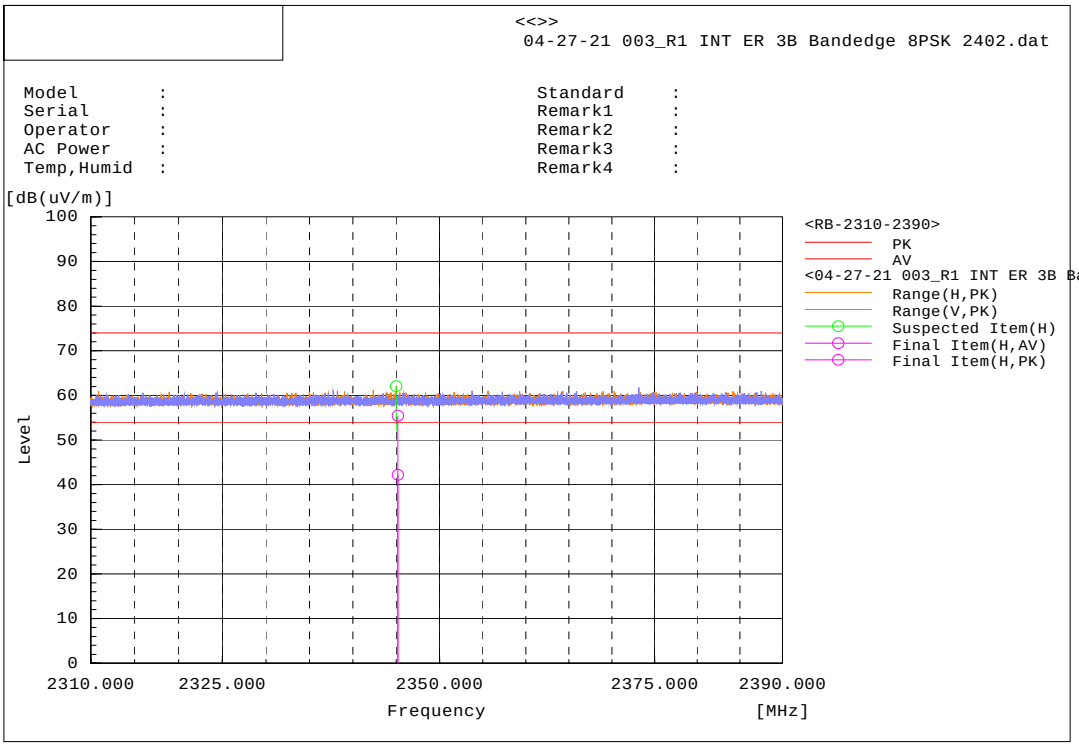
BT_8DPSK

CHANNEL	TX MODE 2402 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	2310MHz-2390MHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2345.178	H	7.4	Average	34.8	42.2	54	-11.8	106.1	316.2	Pass
2	2345.178	H	20.6	Peak	34.8	55.4	74	-18.6	106.1	316.2	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)



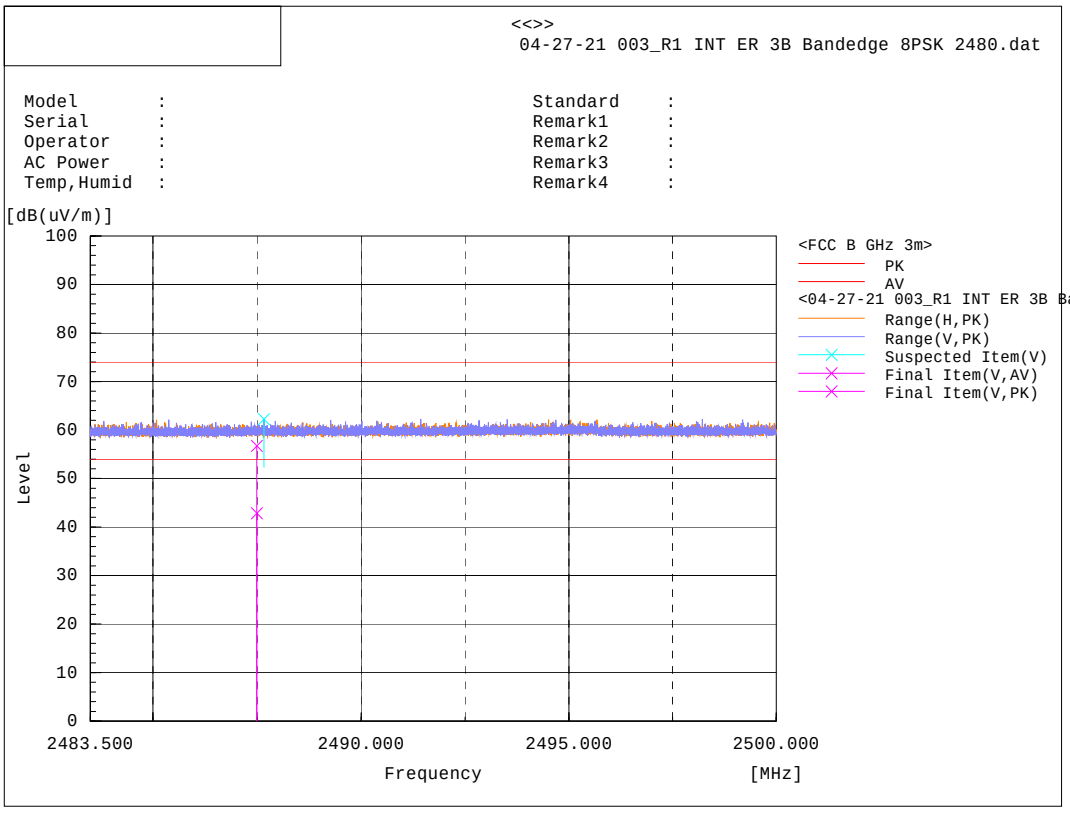
RESTRICTED BAND

CHANNEL	TX MODE 2480 MHz	**DETECTOR FUNCTION**	Peak Average
FREQUENCY RANGE	2483.5MHz-2500MHz		

Antenna Polarity & Test Distance: Vertical and Horizontal at 3m											
No.	Frequency (MHz)	Polarization (H/V)	Reading [dB(uV)]	Detector	Factor [dB(1/m)]	Level dB(uV/m)	Limit dB(uV/m)	Margin [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2487.493	V	7.4	Average	35.5	42.9	54	-11.1	197.1	358.8	Pass
2	2487.493	V	21.2	Peak	35.5	56.7	74	-17.3	197.1	358.8	Pass

REMARKS:

1. Level (dBuV) = Reading (dBuV) + Factor (dB(1/m)).
2. Factor (dB(1/m)) = Antenna Factor(AF) (dB(1/m)) + Cable Loss (dB) –Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

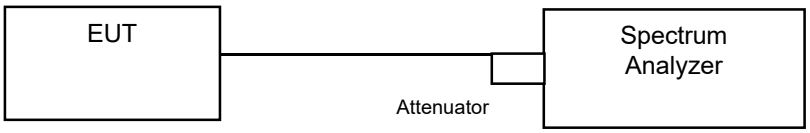


4.2 Number of Hopping Frequency Used

4.2.1 Limits of Hopping Frequency Used Measurement

At least 15 channels frequencies, and should be equally spaced.

4.2.2 Test Setup



4.2.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.2.4 Test Procedure

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

b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.

c. Set the SA on MaxHold Mode, and then keep the EUT in hopping mode. Record all the signals from each channel until each one has been recorded.

d. Set the SA on View mode and then plot the result on SA screen.

e. Repeat above procedures until all frequencies measured were complete.

4.2.5 Deviation from Test Standard

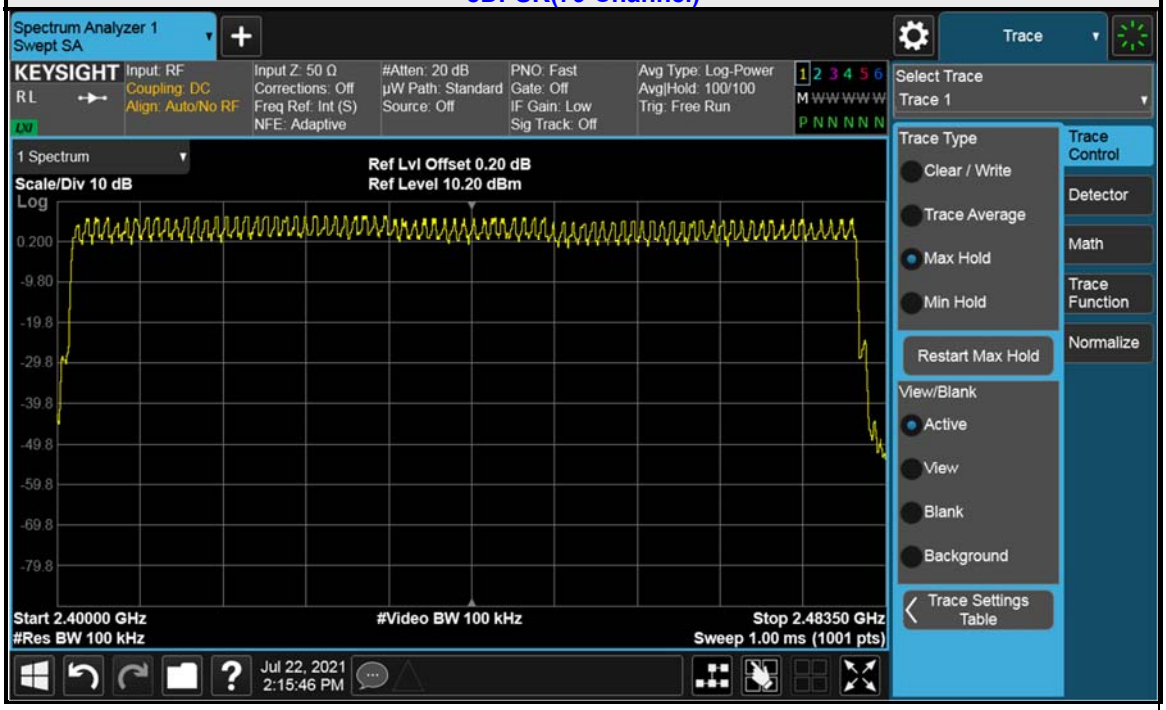
No deviation.

4.2.6 Test Results

There are 79 hopping frequencies in the hopping mode. Please refer to next page for the test result.
On the plots, it shows that the hopping frequencies are equally spaced.

GFSK (79 Channel)

8DPSK(79 Channel)

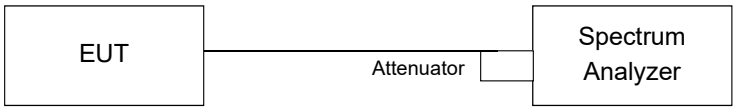


4.3 Dwell Time on Each Channel

4.3.1 Limits of Dwell Time on Each Channel Measurement

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.

4.3.2 Test Setup



4.3.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.3.4 Test Procedures

a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
c. Adjust the center frequency of SA on any frequency be measured and set SA to zero span mode. And then, set RBW and VBW of spectrum analyzer to proper value.
d. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
e. Repeat above procedures until all different time-slot modes have been completed.

.

4.3.5 Deviation from Test Standard

No deviation.

4.3.6 Test Results

GFSK

Mode	Number of Hopping Channel	Number of transmission in a period(channel number * 0.4 sec)				Length of transmission time (msec)	Result (msec)	Limit (msec)	PASS /FAIL
		Period (sec)	Sweep time (sec)	Times in a sweep	Times in a period				
DH1	79	31.6	3.16	33	330	0.400	132.00	400	PASS
DH3	79	31.6	3.16	17	170	1.680	285.6	400	PASS
DH5	79	31.6	3.16	13	130	2.960	384.8	400	PASS

NOTE: Test plots of the transmitting time slot are shown on next page.

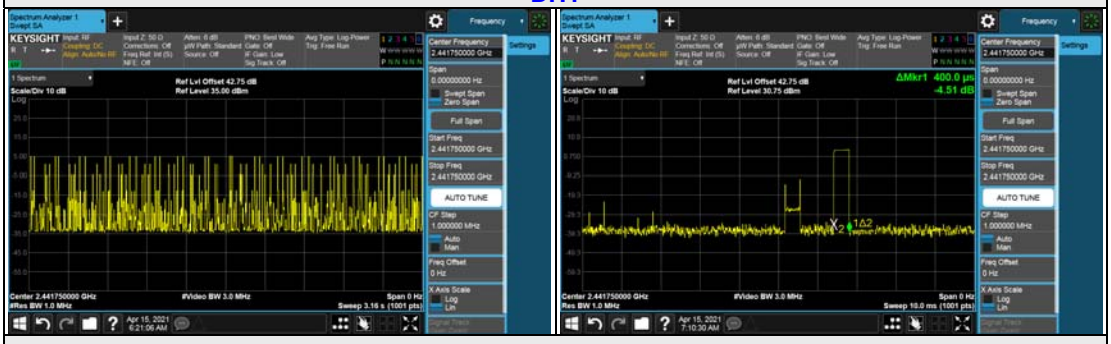
8DPSK

Mode	Number of Hopping Channel	Number of transmission in a period(channel number * 0.4 sec)				Length of transmission time (msec)	Result (msec)	Limit (msec)	PASS /FAIL
		Period (sec)	Sweep time (sec)	Times in a sweep	Times in a period				
3DH1	79	31.6	3.16	30	300	0.410	123	400	PASS
3DH3	79	31.6	3.16	16	160	1.734	277.4	400	PASS
3DH5	79	31.6	3.16	13	130	2.960	384.8	400	PASS

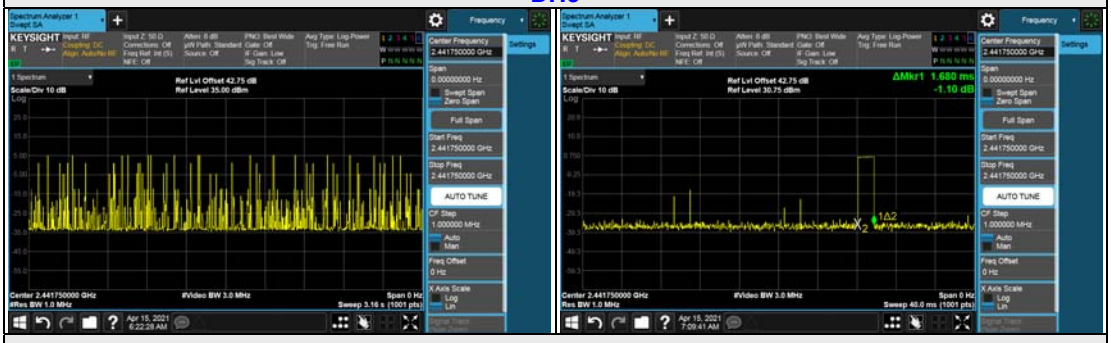
NOTE: Test plots of the transmitting time slot are shown on next page

GFSK

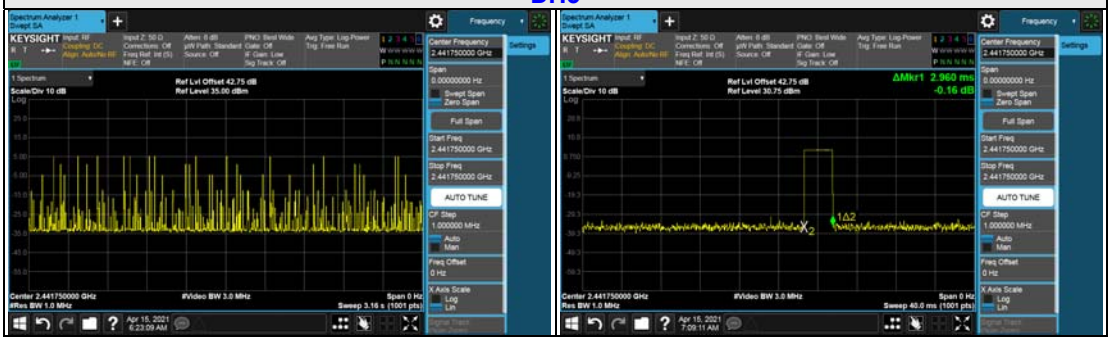
DH1



DH3

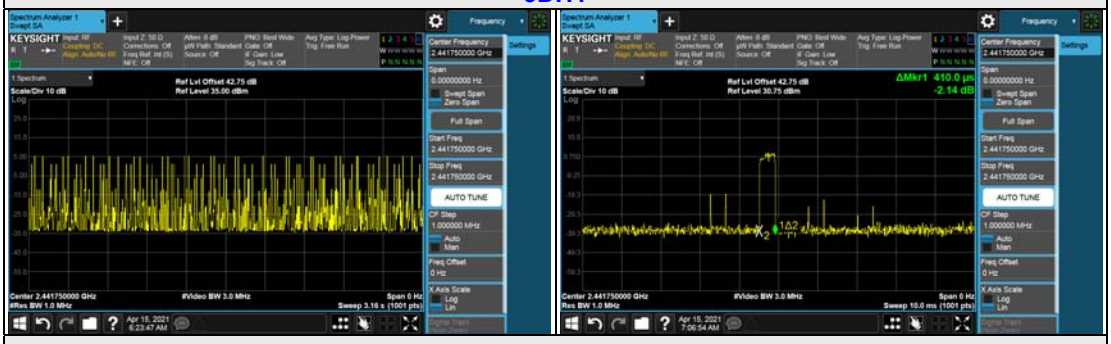


DH5

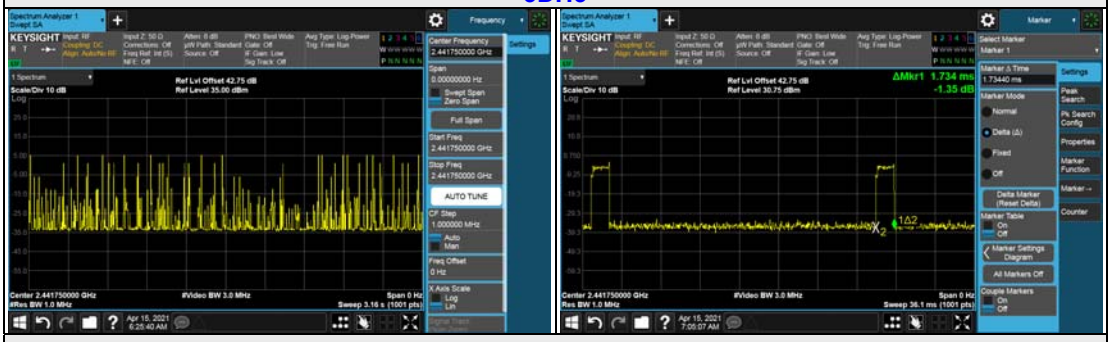


8DPSK

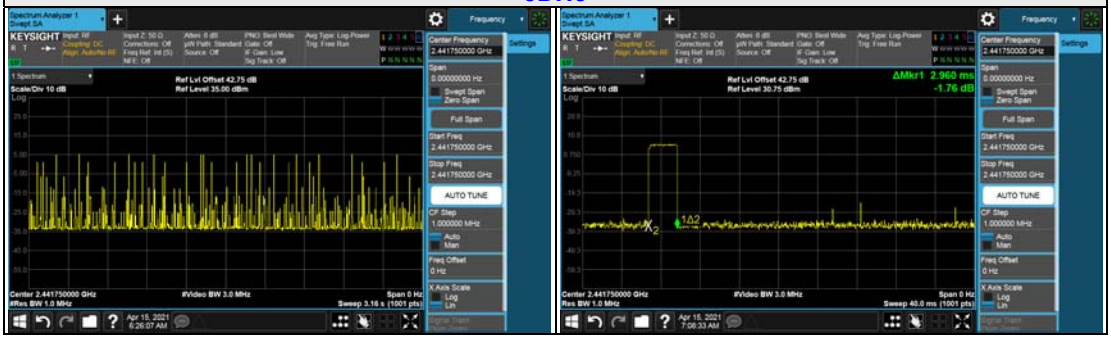
3DH1



3DH3



3DH5

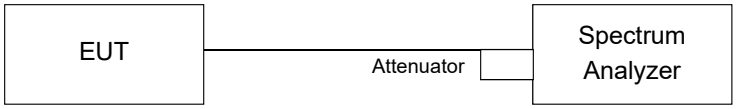


4.4 Channel Bandwidth

4.4.1 Limits of Channel Bandwidth Measurement

For frequency hopping system operating in the 2400-2483.5MHz, If the 20dB bandwidth of hopping channel is greater than 25kHz, two-thirds 20dBbandwidth of hopping channel shell be a minimum limit for the hopping channel separation.

4.4.2 Test Setup



4.4.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.4.4 Test Procedure

a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
c. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
d. Repeat above procedures until all frequencies measured were complete.

4.4.5 Deviation from Test Standard

No deviation.

4.4.6 EUT Operating Condition

The software provided by client enabled the EUT to Test mode and transmit and receive data at lowest, middle and highest channel frequencies individually.

4.4.7 Test Results

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	
		GFSK	8DPSK
0	2402	0.963	1.319
39	2441	1.053	1.357
78	2480	1.067	1.362

Spectrum Plots

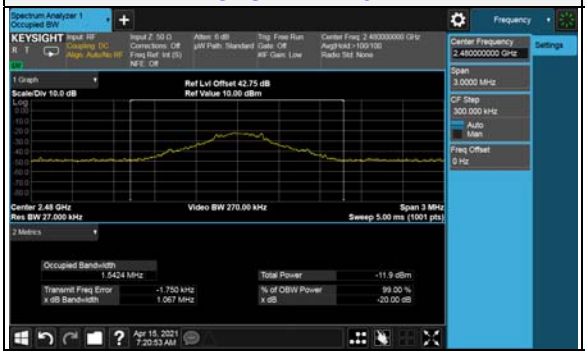
GFSK / CH 00

8DPSK / CH 00

GFSK / CH 39

8DPSK / CH 39

GFSK / CH 78



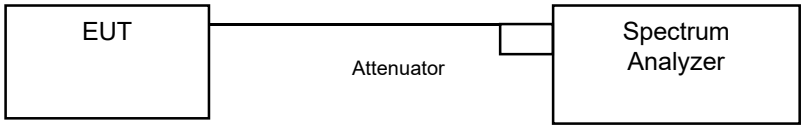
8DPSK / CH 78

4.5 Hopping Channel Separation

4.5.1 Limits of Hopping Channel Separation Measurement

At least 25kHz or two-third of 20dB hopping channel bandwidth (whichever is greater).

4.5.2 Test Setup



4.5.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.5.4 Test Procedure

Measurement Procedure REF

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

b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.

c. By using the MaxHold function record the separation of two adjacent channels.

d. Measure the frequency difference of these two adjacent channels by SA MARK function. And then plot the result on SA screen.

e. Repeat above procedures until all frequencies measured were complete.

4.5.5 Deviation from Test Standard

No deviation.

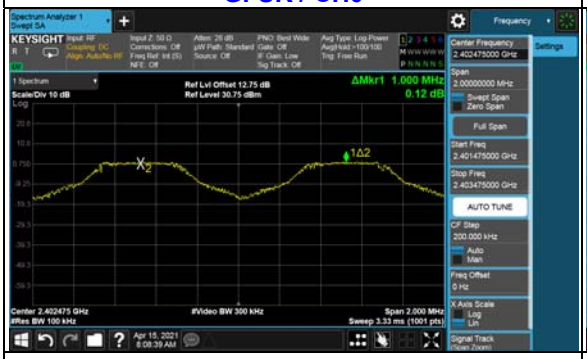
4.5.6 Test Results

Channel	Frequency (MHz)	Adjacent Channel Separation (MHz)		20dB Bandwidth (MHz)		Minimum Limit (MHz)		Pass / Fail
		GFSK	8DPSK	GFSK	8DPSK	GFSK	8DPSK	
0	2402	1.00	1.00	0.963	1.319	0.635	0.870	Pass
39	2441	1.00	1.00	1.053	1.357	0.694	0.895	Pass
78	2480	1.00	1.00	1.057	1.352	0.697	0.892	Pass

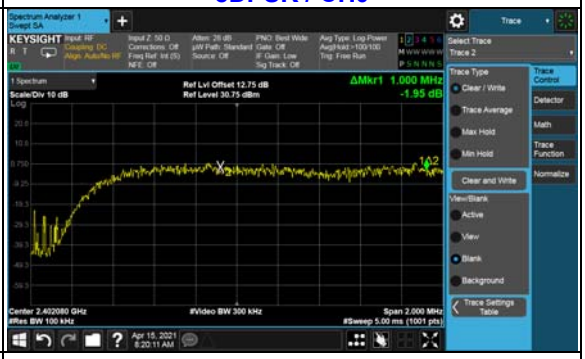
NOTE: The minimum limit is two-third 20dB bandwidth.

Spectrum Plots

GFSK / CH0

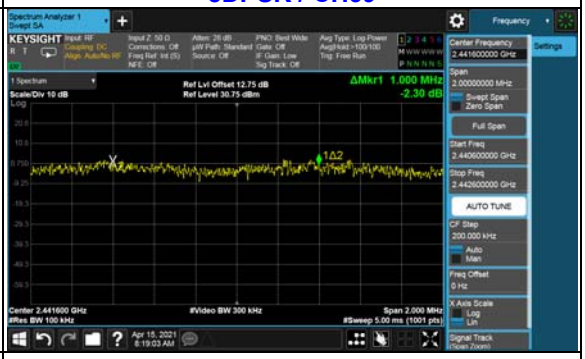


8DPSK / CH0



GFSK / CH39

8DPSK / CH39



GFSK / CH78

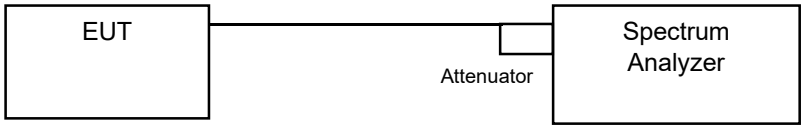
8DPSK / CH78

4.6 Maximum Output Power

4.6.1 Limits of Maximum Output Power Measurement

The Maximum Output Power Measurement is 1W.

4.6.2 Test Setup



4.6.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.6.4 Test Procedure

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

b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.

c. The center frequency of the spectrum analyzer is set to the fundamental frequency and using 3MHz RBW and 10 MHz VBW.

d. Measure the captured power within the band and recording the plot.

e. Repeat above procedures until all frequencies required were complete.

4.6.5 Deviation from Test Standard

No deviation.

4.6.6 EUT Operating Condition

The software provided by client enabled the EUT to transmit and receive data at lowest, middle and highest channel frequencies individually.

4.6.7 Test Results

Channel	Frequency (MHZ)	Output Power (mW)		Output Power (dBm)		Power Limit (W)	Pass / Fail
		GFSK	8DPSK	GFSK	8DPSK		
0	2402	2.66	2.66	4.25	4.25	1	Pass
39	2441	3.38	3.35	5.29	5.26	1	Pass
78	2480	2.95	2.95	4.70	4.70	1	Pass

Spectrum Plot of Worst Value	
GFSK / CH0	8DPSK / CH0
	
GFSK / CH39	8DPSK / CH39
	
GFSK / CH78	8DPSK / CH78
	

4.7 Conducted Out of Band Emission Measurement

4.7.1 Limits of Conducted Out of Band Emission Measurement

Below –20dB of the highest emission level of operating band (in 100kHz Resolution Bandwidth).

4.7.2 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.7.3 Test Procedure

The transmitter output was connected to the spectrum analyzer via a low loss cable. Set both RBW and VBW of spectrum analyzer to 100 kHz and 300 kHz with suitable frequency span including 100 MHz bandwidth from band edge. The band edges was measured and recorded.

4.7.4 Deviation from Test Standard

No deviation.

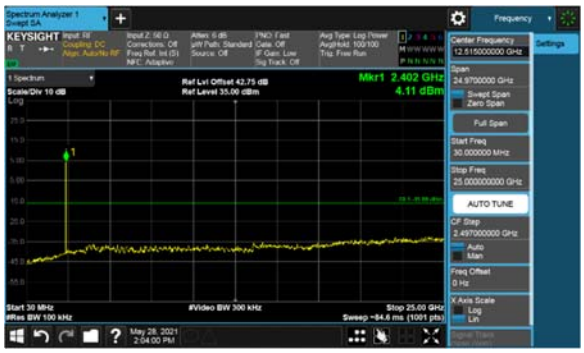
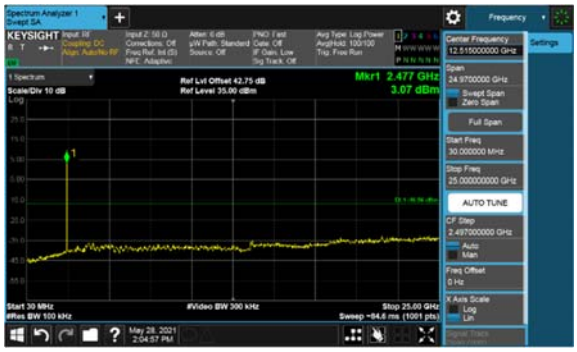
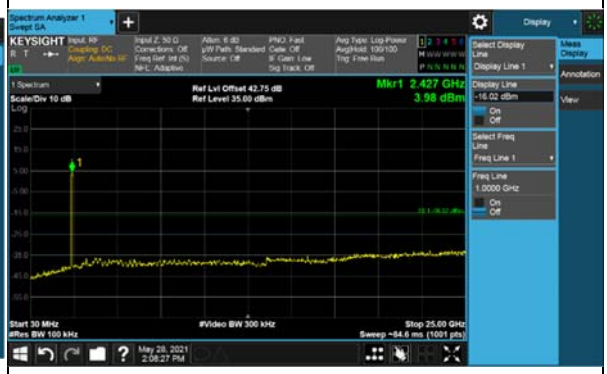
4.7.5 EUT Operating Condition

The software provided by client enabled the EUT to test mode and transmit and receive data at lowest, middle and highest channel frequencies individually.

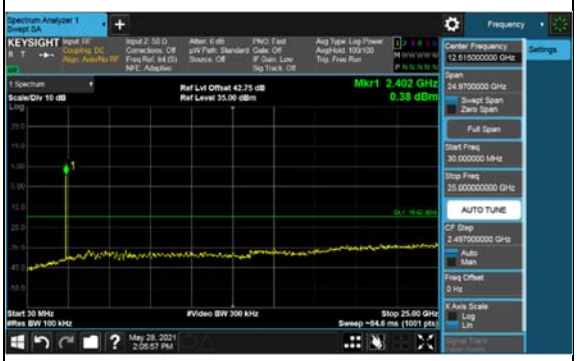
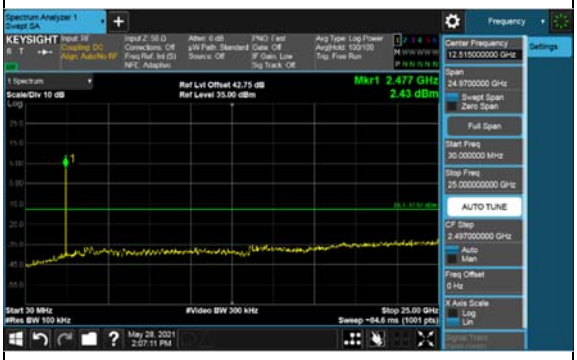
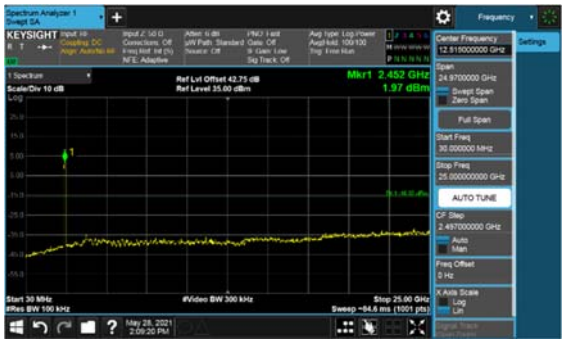
4.7.6 Test Results

The spectrum plots are attached on the following images. D1 line indicates the highest level, Mark 2 indicates the 20dB offset below D1. It shows compliance with the requirement.

GFSK

Hopping disabled_ Low Channel 2307MHz-2407MHz	Hopping disabled_ Low Channel 30 MHz-25 GHz
	
Hopping disabled_ High Channel 2473MHz-2573MHz	**Hopping disabled_ High Channel 30 MHz-25 GHz**
	
Hopping enabled_ Low Channel 2307MHz-2407MHz	**Hopping enabled 30 MHz-25 GHz**
	
Hopping enabled_ High Channel 2473MHz-2573MHz	
	

8DPSK

Hopping disabled_ Low Channel 2307MHz-2407MHz	Hopping disabled_ Low Channel 30 MHz-25 GHz
	
Hopping disabled_ High Channel 2473MHz-2573MHz	**Hopping disabled_ High Channel 30 MHz-25 GHz**
	
Hopping enabled_ Low Channel 2307MHz-2407MHz	**Hopping enabled 30 MHz-25 GHz**
	
Hopping enabled_ High Channel 2473MHz-2573MHz	
	

5 Pictures of Test Arrangements

Please refer to the attached file (Test Setup Photo).

Appendix – Information on the Testing Laboratories

Bureau Veritas is a global leader in testing, inspection and certification (TIC) services. We help businesses improve safety, sustainability and productivity; and our clients include the majority of leading brands in retail, manufacturing and other industries. With a presence in every major country around the world, our quality assurance and compliance solutions are vital in helping our customers enhance product quality and concept-to-consumer journeys. We also assist with increasing speed to market, profitability and brand equity throughout the supply chain. Bureau Veritas is a leading wireless/IoT testing, inspection, audit and certification provider, with a global network of test laboratories to support the IoT industry in areas of connectivity, security, interoperability as well as quality, health & safety, and environmental/chemical requirements.

If you have any comments, please feel free to contact us at the following:

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The address and road map of all our labs can be found in our web site also.

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