FCC / ISED RF Test Report

Report No.:	FCC_IC_RF_SL20012201-HAR-084_BT
FCC ID:	2AHPN-BE2850
IC ID:	6434C-BE2850
Model:	A55BT
Received Date:	05/04/2020
Test Date:	05/05/2020 - 05/13/2020
Issued Date:	05/13/2020
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 / 4842D

ACCREDITED
TESTING CERT # 2742-01

Table of Contents

Release Control Record

Issue No.	Description	Date Issued
FCC_IC_RF_SL20012201-HAR-084_BT	Original Report	05/13/2020

1 Certificate of Conformity

Product:	Automotive Bluetooth Headphones
Brand:	HARMAN
Model:	A55BT
Sample Status:	Engineering Sample
Applicant:	HARMAN INTERNATIONAL
Test Date:	05/05/2020 - 05/13/2020
Standards:	47 CFR FCC Part 15, Subpart C (Section 15.247) RSS-247 Issue 2, February 2017 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 : Gary Chou **Date:** 05/13/2020

Gary Chou / Compliance Engineer

Approved by : **Date:** 05/13/2020

Ge Chen / Engineer Reviewer

2 Summary of Test Results

47 CFR FCC Part 15, Subpart C (SECTION 15.247) / ISED RSS-247 RSS 247 Issue2, RSS Gen Issue5				
FCC Clause	RSS Section(s)	Test Item	Result	Remarks
15.207	RSS-Gen [8.8]	AC Power Conducted Emission	PASS	Meet the requirement of limit.
15.247(a)(1)(iii)	RSS-Gen [8.9] RSS-247 [5.5]	Number of Hopping Frequency Used	PASS	Meet the requirement of limit.
15.247(a)(1)(iii)	RSS-247 [5.5]	Dwell Time on Each Channel	PASS	Meet the requirement of limit.
15.247(a)(1)	RSS-247[5.2]	1. Hopping Channel Separation 2. Spectrum Bandwidth of a Frequency Hopping Sequence Spread Spectrum System	PASS	Meet the requirement of limit.
15.247(b)	RSS-247 [5.4(4)]	Maximum Peak Output Power	PASS	Meet the requirement of limit.
15.205 & 15.209 & 15.247(d)	RSS-247 [5.2)]	Radiated Emissions & Band Edge Measurement	PASS	Meet the requirement of limit. Minimum passing QP margin.
15.247(d)	RSS-Gen [8.8]	Antenna Port Emission	PASS	Meet the requirement of limit.
15.203		Antenna Requirement	PASS	PCB antenna with U.FL connector

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 Bluetooth Headphones
Brand	HARMAN
Test Model	A55BT
Status of EUT	Engineering Sample
Power Input	5Vdc
Power Supply Rating	120Vav/ 60Hz
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	6.745mW (8.29 dBm)
Antenna Type	PCB Antenna
Antenna Gain	2.15 dBi
Antenna Connector	N/A

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	120Vac	Gary Chou
RE<1G	25deg. C, 65%RH	120Vac	Gary Chou
APCM	21deg. C, 60%RH	120Vac	Gary Chou

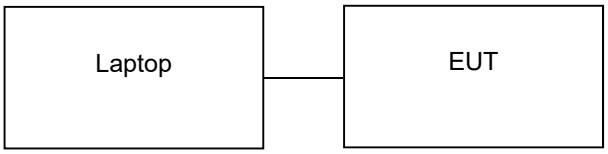
3.3 Description of Support Units

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	Dell	Latitude 3550	2MHWY32	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
ISED RSS-247
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
PXA Signal Analyzer KEYSIGHT	N9030B	MY57140374	07/22/2019	07/22/2020
Horn Antenna ETS-Lindgren	3117	218554	11/06/2019	11/06/2020
Biconilog Antenna Sunol	JB6	A111717	08/27/2019	08/27/2020
Preamplifier RF BAY INC	LPA-6-30	11170602	05/06/2019	05/06/2020

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:

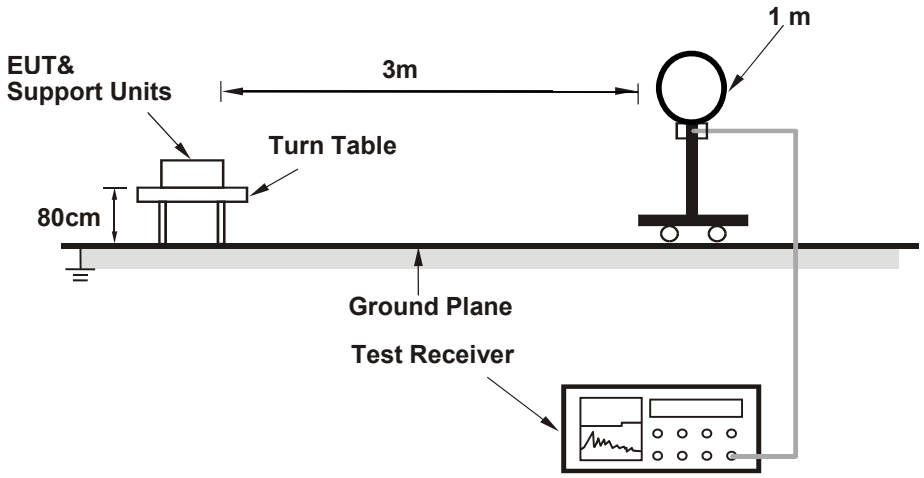
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
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

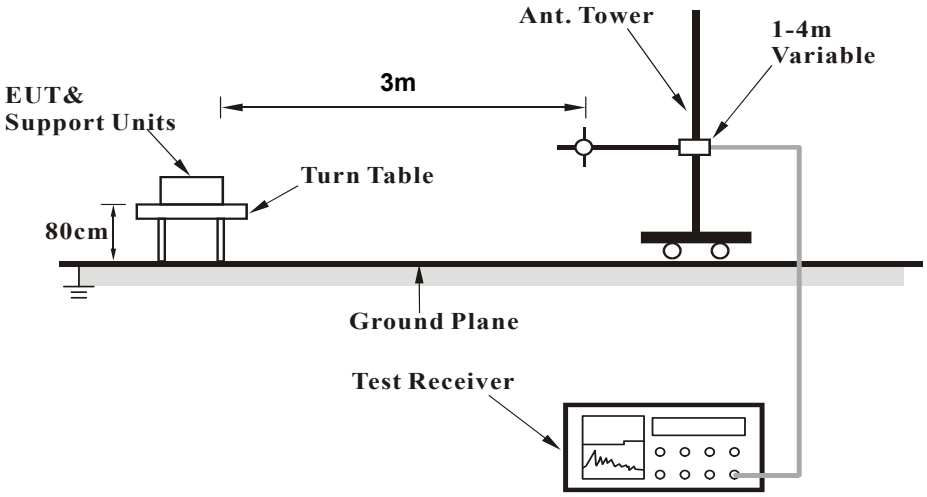
No deviation.

4.1.4 Test Setup

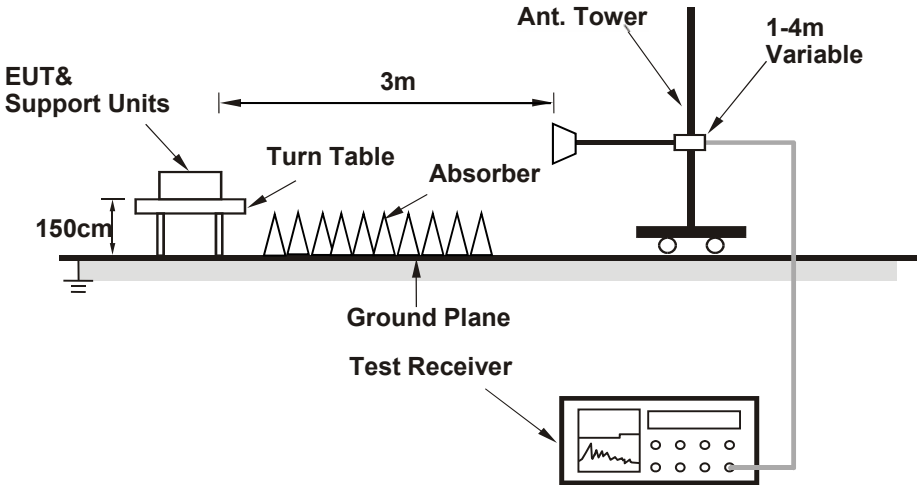
For Radiated emission below 30MHz



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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	4803.944	H	52.4	59.5	-5.9	46.5	53.6	54	74	-7.5	-20.4	147	256.9	Pass
2	7206.325	H	49	57.3	-0.9	48.1	56.4	54	74	-5.9	-17.6	177	198	Pass
3	9607.748	H	36.6	48.9	2.1	38.7	51	54	74	-15.3	-23	100	134	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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	4882.076	H	52.2	59.5	-6.1	46.1	53.4	54	74	-7.9	-20.6	117	26.4	Pass
2	7323.302	H	49.5	57.5	-1.2	48.3	56.3	54	74	-5.7	-17.7	117	200.8	Pass
3	9763.95	H	36.6	48.1	2.5	39.1	50.6	54	74	-14.9	-23.4	389	53.9	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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	4960.065	H	54.1	59.9	-6	48.1	53.9	54	74	-5.9	-20.1	162	359.9	Pass
2	7439.837	H	45.4	54.8	-0.8	44.6	54	54	74	-9.4	-20	298	253.6	Pass
3	9920.483	H	35.8	48	2.7	38.5	50.7	54	74	-15.5	-23.3	359	301.5	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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	4803.87	H	44.3	55.6	-5.9	38.4	49.7	54	74	15.6	24.3	100	264.5	Pass
2	7206.088	H	40	51.5	-0.9	39.1	50.6	54	74	14.9	23.4	253	271.2	Pass
3	9609.149	H	36.4	48.7	2.1	38.5	50.8	54	74	15.5	23.2	132	239.2	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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	4881.924	H	49.1	57.2	-6.1	43	51.1	54	74	-11	-22.9	117	0.1	Pass
2	7323.15	H	44.1	53.6	-1.2	42.9	52.4	54	74	-11.1	-21.6	253	303.1	Pass
3	9763.027	H	36.3	48	2.5	38.8	50.5	54	74	-15.2	-23.5	132	109.8	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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	4804.175	H	41.9	52.6	-5.9	36	46.7	54	74	-18	-27.3	207	312.7	Pass
2	7206.47	H	38	50.4	-0.9	37.1	49.5	54	74	-16.9	-24.5	223	359.9	Pass
3	9608.141	H	37.1	47.9	2.1	39.2	50	54	74	-14.8	-24	103	74.9	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:

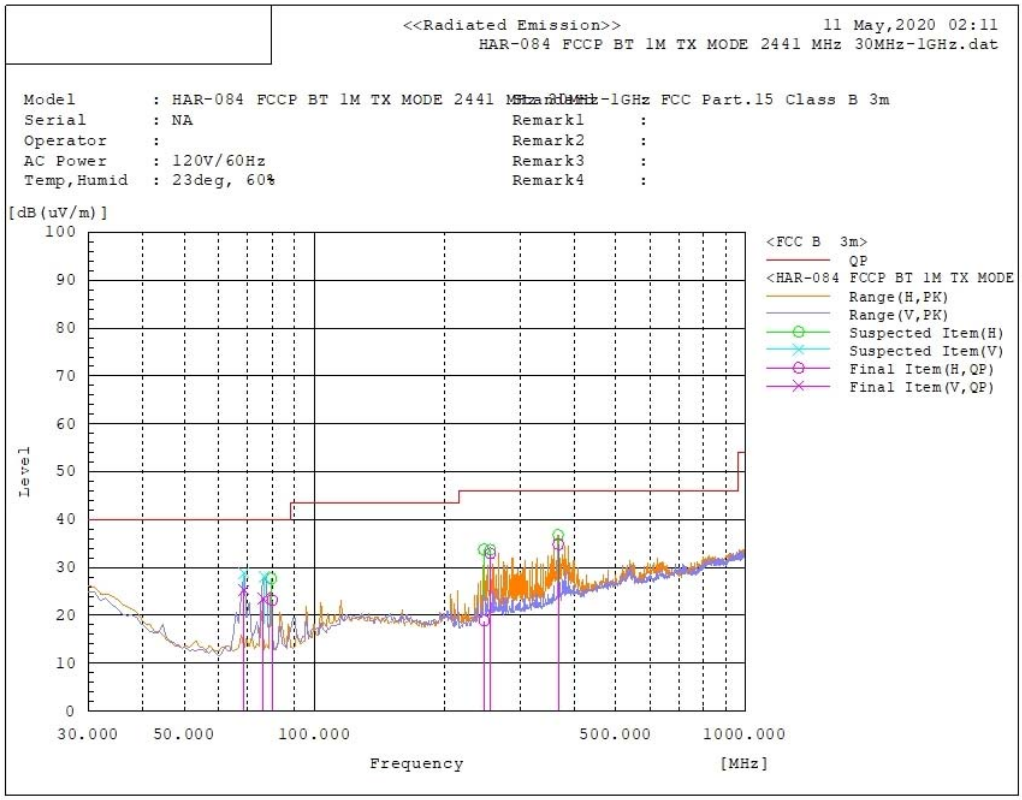
BT_GFSK

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	68.757	V	12.3	13	25.3	40	-14.7	152	359.3	Pass
2	76.074	V	10.4	13.1	23.5	40	-16.5	100	359.8	Pass
3	79.968	H	10.1	13.1	23.2	40	-16.8	256	264.3	Pass
4	247.779	H	0.7	18.3	19	46	-27	115	261.2	Pass
5	255.997	H	14.5	18.4	32.9	46	-13.1	134	284.5	Pass
6	368.009	H	12.4	22.5	34.9	46	-11.1	100	112.9	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)



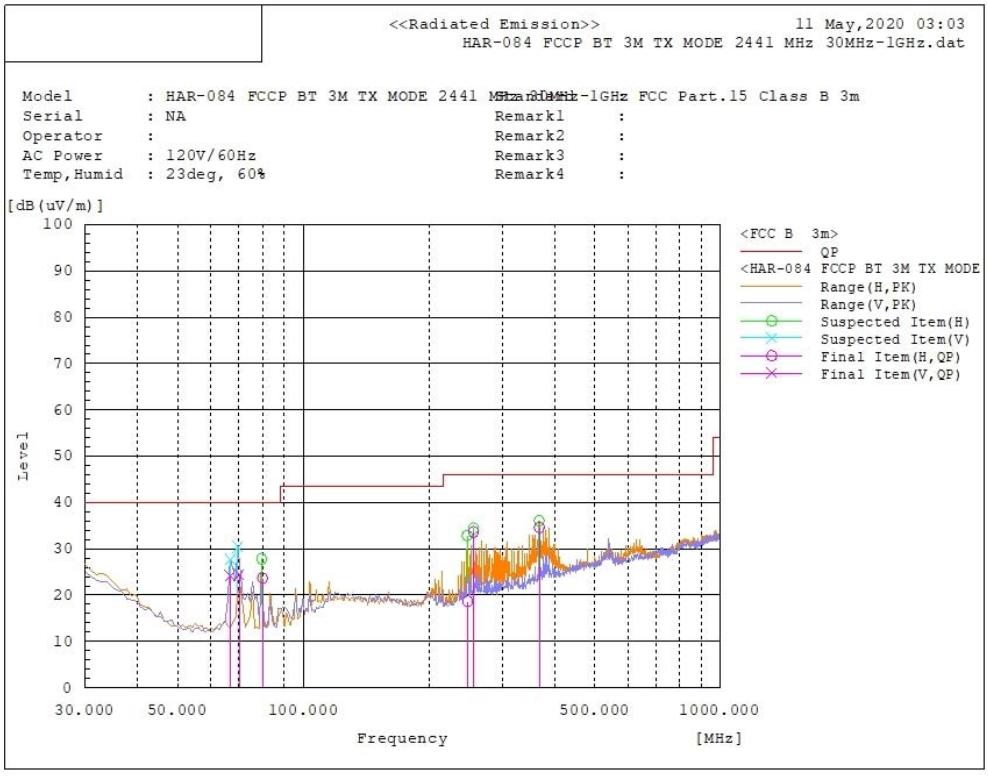
BT_8DPSK

CHANNEL	TX MODE 2440 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	66.782	V	11.3	12.9	24.2	40	-15.8	106	359	Pass
2	70.22	V	11.4	13	24.4	40	-15.6	378	73.9	Pass
3	79.97	H	10.6	13.1	23.7	40	-16.3	228	88.5	Pass
4	247.737	H	0.3	18.4	18.7	46	-27.3	134	261.4	Pass
5	256	H	15.2	18.4	33.6	46	-12.4	115	271.1	Pass
6	368.005	H	12.1	22.5	34.6	46	-11.4	100	113.3	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)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)



RESTRICTED BAND

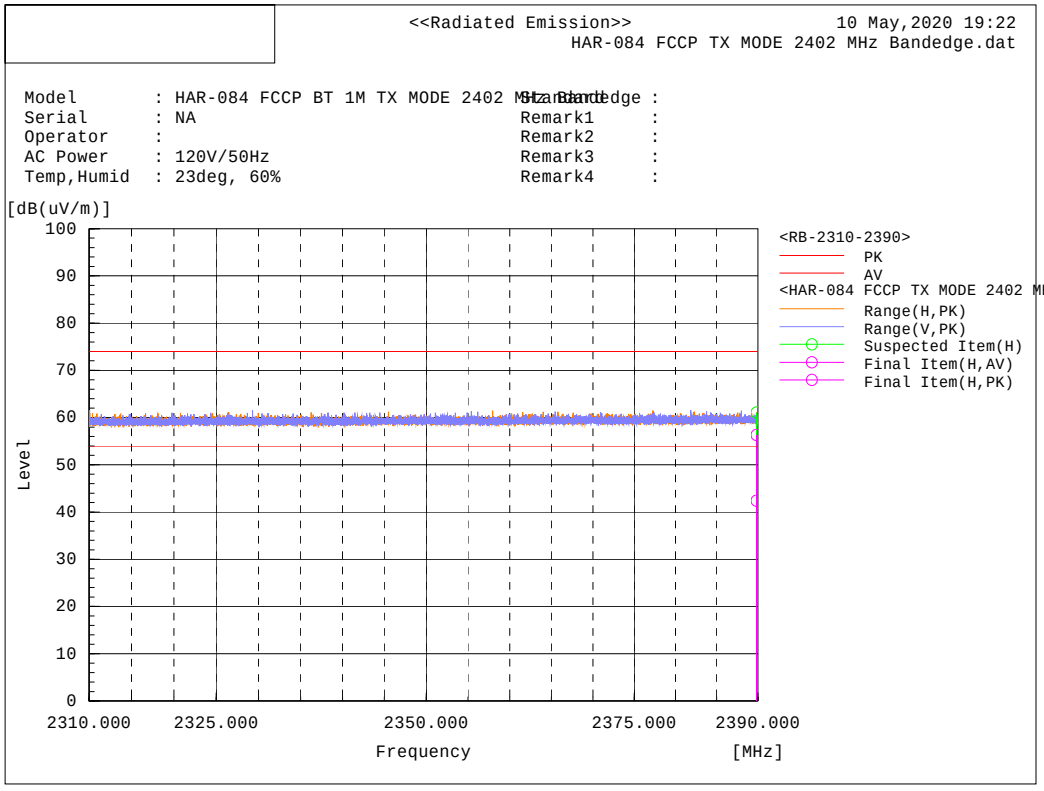
BT_GFSK

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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2389.832	H	7.3	21.2	35.1	42.4	56.3	54	74	-11.6	-17.7	134	14.5	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)



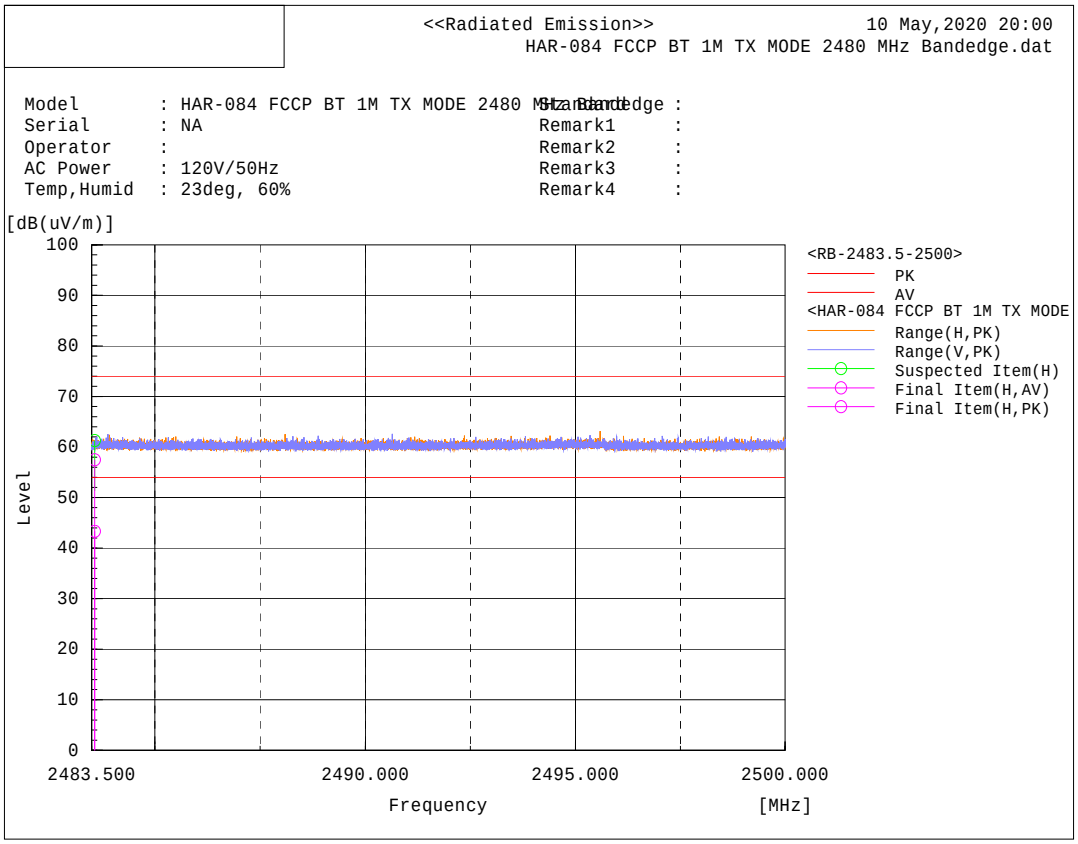
RESTRICTED BAND

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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2483.574	H	7.7	21.9	35.6	43.3	57.5	54	74	-10.7	-16.5	341	240.6	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)



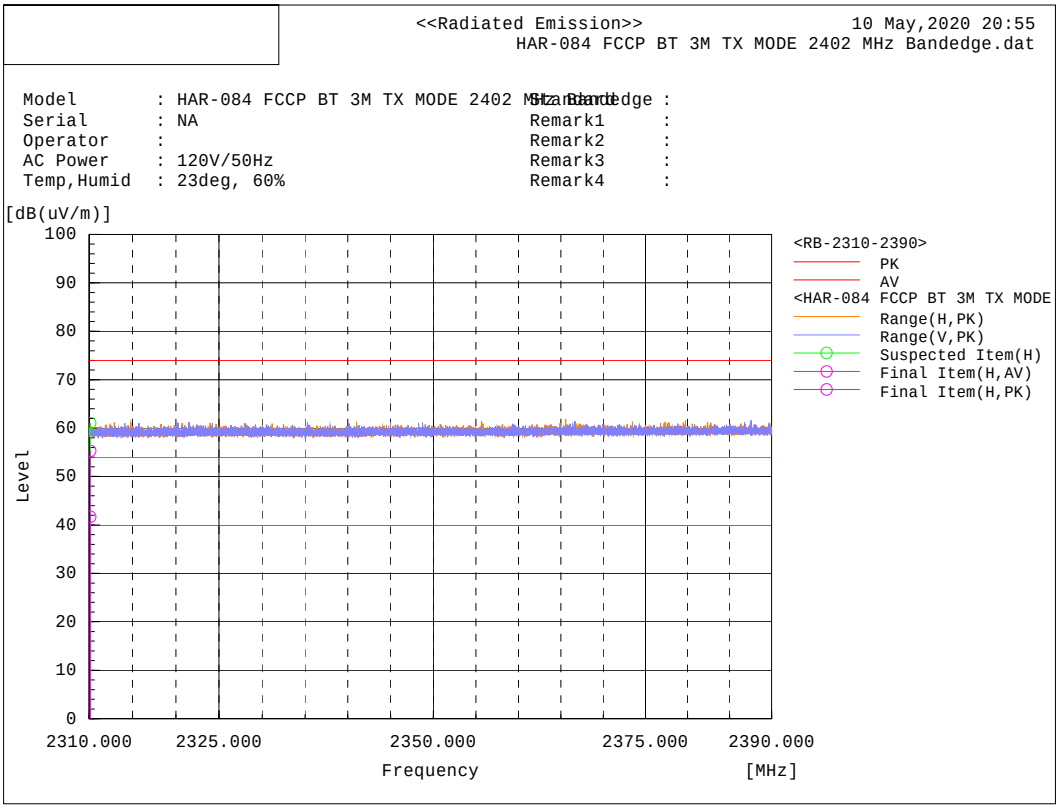
BT_8DPSK

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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2310.12	H	7	20.6	34.7	41.7	55.3	54	74	-12.3	-18.7	167	155.8	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)



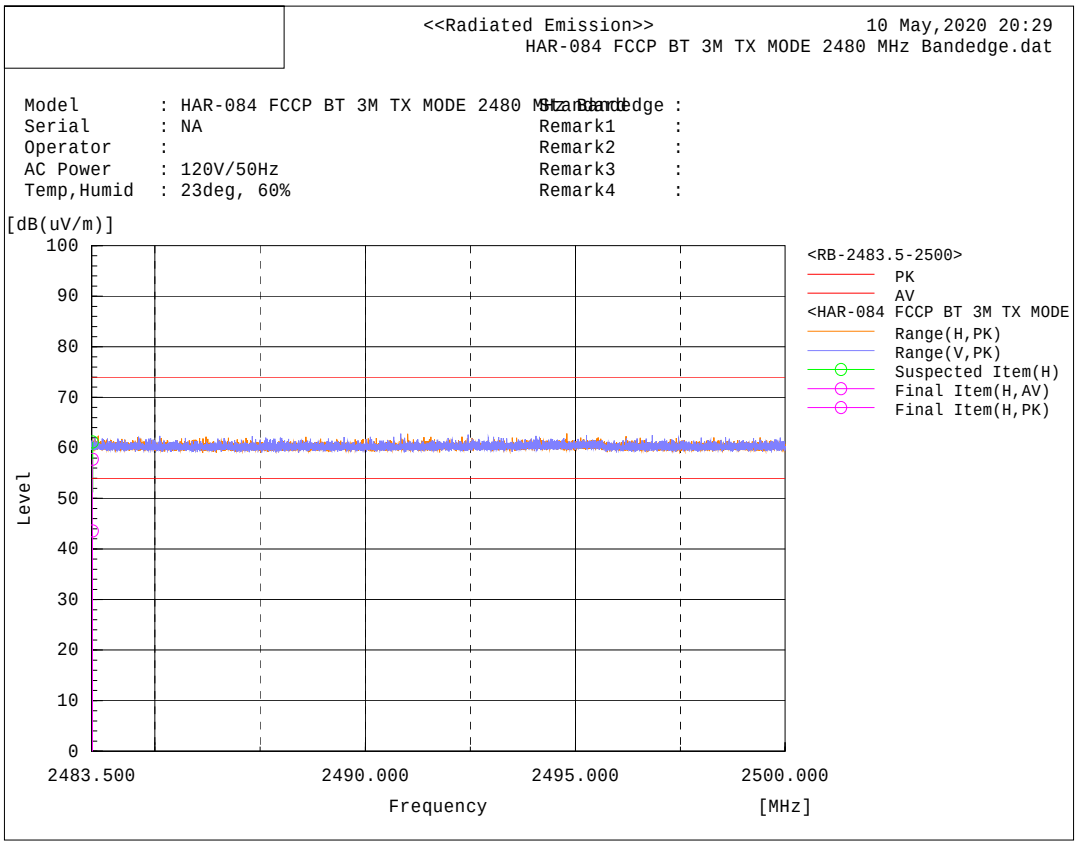
RESTRICTED BAND

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 AV [dB(uV)]	Reading PK [dB(uV)]	Factor [dB(1/m)]	Level AV [dB(uV/m)]	Level PK dB(uV/m)	Limit\AV dB(uV/m)	Limit\PK [dB(uV/m)	Margin AV [dB]	Margin PK [dB]	Height (cm)	Angle (Deg)	Pass/ Fail
1	2483.525	H	8	22.1	35.6	43.6	57.7	54	74	-10.4	-16.3	347	342	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 Conducted Emission Measurement

4.2.1 Limits of Conducted Emission Measurement

Frequency (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.5	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

4.2.2 Test Instruments

Description & Manufacturer	Model No.	Serial No.	Cal. Date	Cal. Due
EMI Test Receiver Rohde & Schwarz	ESIB 40	100179	11/01/2019	11/01/2020
Transient Limiter Electro-Metrics	EM-7600-5	106	12/31/2019	12/31/2020
LISN ETS-Lindgren	3816/2NM	214372	1/14/2020	1/14/2021

NOTE: N/A

4.2.3 Test Procedures

a. The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.

b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.

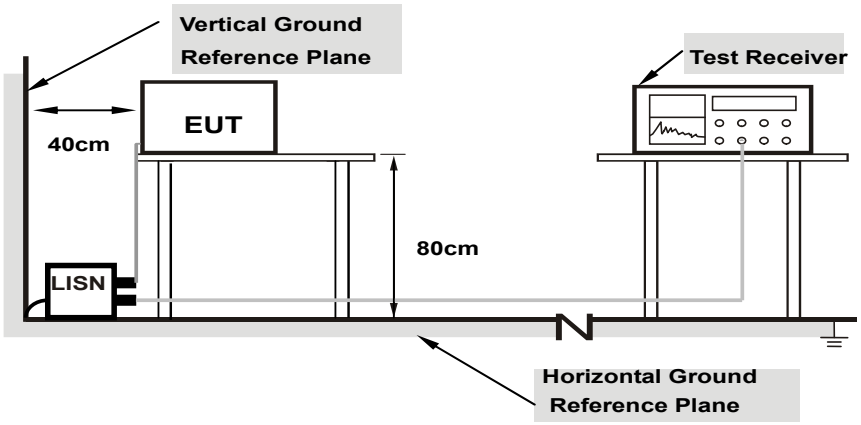
c. The frequency range from 150kHz to 30MHz was searched. Emission levels under (Limit -20dB) was not recorded.

NOTE: The resolution bandwidth and video bandwidth of test receiver is 9kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz.

4.2.4 Deviation From Test Standard

No deviation.

4.2.5 Test Setup



Note: 1.Support units were connected to second LISN.

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

4.2.6 EUT Operating Condition

Same as 4.1.6.

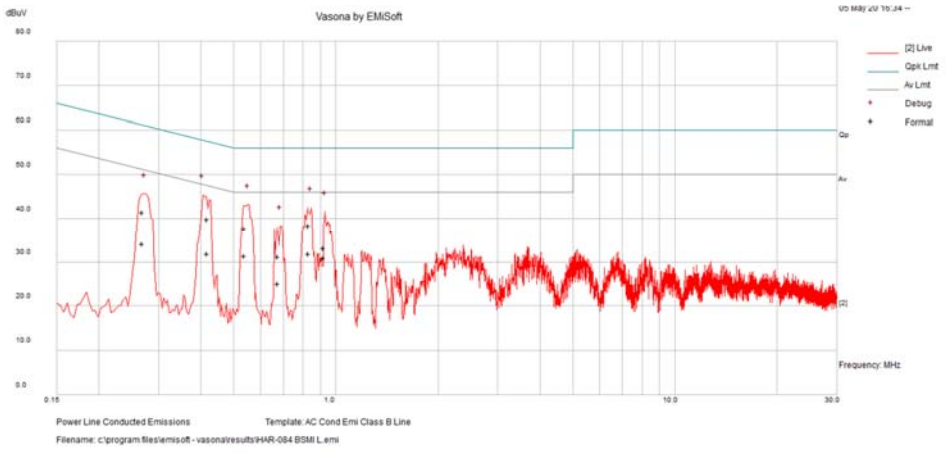
4.2.7 Test Results

Frequency Range	0.15-30 MHz	Phase	Line
Input Power	120 Vac, 60 Hz	Environmental Conditions	24 °C, 50% RH
Tested by	Deon Dai	Test Date	05/05/2020
Test Mode	Mode 1		

No	Frequency (MHz)	Reading Value (dBuV)	Cable Loss (dB)	Insertion Loss (dB)	Emission Level Corrected (dBuV)	Measurement Type	Line/ Neutral	Limit (dBuV)	Margin (dB)	Pass/ Fail
1	0.417451	30.35	9.45	0.04	39.84	Quasi Peak	Live	57.5	-17.66	Pass
2	0.538906	28.21	9.45	0.04	37.7	Quasi Peak	Live	56	-18.3	Pass
3	0.833315	28.84	9.47	0.04	38.35	Quasi Peak	Live	56	-17.65	Pass
4	0.92186	23.66	9.48	0.04	33.18	Quasi Peak	Live	56	-22.82	Pass
5	0.269038	31.98	9.43	0.04	41.46	Quasi Peak	Live	61.15	-19.69	Pass
6	0.673888	21.63	9.46	0.04	31.13	Quasi Peak	Live	56	-24.87	Pass
7	0.417451	22.37	9.45	0.04	31.86	Average	Live	47.5	-15.64	Pass
8	0.538906	21.83	9.45	0.04	31.32	Average	Live	46	-14.68	Pass
9	0.833315	22.35	9.47	0.04	31.86	Average	Live	46	-14.14	Pass
10	0.92186	21.3	9.48	0.04	30.82	Average	Live	46	-15.18	Pass
11	0.269038	24.59	9.43	0.04	34.06	Average	Live	51.15	-17.08	Pass
12	0.673888	15.49	9.46	0.04	25	Average	Live	46	-21	Pass

Remarks:

1. The emission levels of other frequencies were very low against the limit.
2. Margin value = Emission level – Limit value
3. Correction factor = Insertion loss + Cable loss
4. Emission Level = Correction Factor + Reading Value

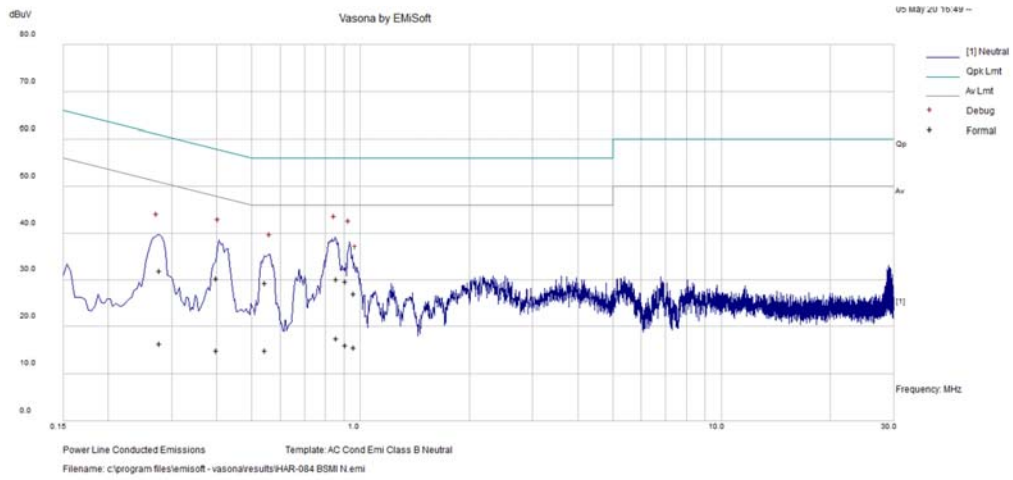


Frequency Range	0.15-30 MHz	Phase	Neutral
Input Power	120 Vac, 60 Hz	Environmental Conditions	24 °C, 50% RH
Tested by	Deon Dai	Test Date	05/05/2020
Test Mode	Mode 1		

No	Frequency (MHz)	Reading Value (dBuV)	Cable Loss (dB)	Insertion Loss (dB)	Emission Level Corrected (dBuV)	Measurement Type	Line/ Neutral	Limit (dBuV)	Margin (dB)	Pass/ Fail
1	0.860068	20.62	9.47	0.03	30.13	Quasi Peak	Neutral	56	-25.87	Pass
2	0.914056	20.05	9.48	0.03	29.56	Quasi Peak	Neutral	56	-26.44	Pass
3	0.399776	20.74	9.44	0.03	30.21	Quasi Peak	Neutral	57.86	-27.65	Pass
4	0.54695	19.75	9.45	0.03	29.23	Quasi Peak	Neutral	56	-26.77	Pass
5	0.27885	22.39	9.44	0.03	31.86	Quasi Peak	Neutral	60.85	-28.99	Pass
6	0.960024	17.53	9.48	0.03	27.04	Quasi Peak	Neutral	56	-28.96	Pass
7	0.860068	7.87	9.47	0.03	17.38	Average	Neutral	46	-28.62	Pass
8	0.914056	6.47	9.48	0.03	15.98	Average	Neutral	46	-30.02	Pass
9	0.399776	5.34	9.44	0.03	14.82	Average	Neutral	47.86	-33.04	Pass
10	0.54695	5.33	9.45	0.03	14.82	Average	Neutral	46	-31.18	Pass
11	0.27885	6.93	9.44	0.03	16.4	Average	Neutral	50.85	-34.45	Pass
12	0.960024	6.02	9.48	0.03	15.53	Average	Neutral	46	-30.47	Pass

Remarks:

1. The emission levels of other frequencies were very low against the limit.
2. Margin value = Emission level – Limit value
3. Correction factor = Insertion loss + Cable loss
4. Emission Level = Correction Factor + Reading Value

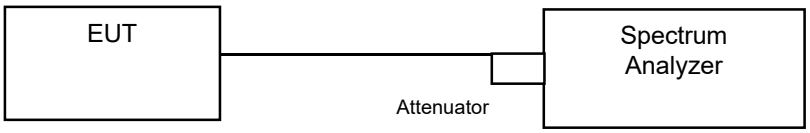


4.3 Number of Hopping Frequency Used

4.3.1 Limits of Hopping Frequency Used Measurement

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

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 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.

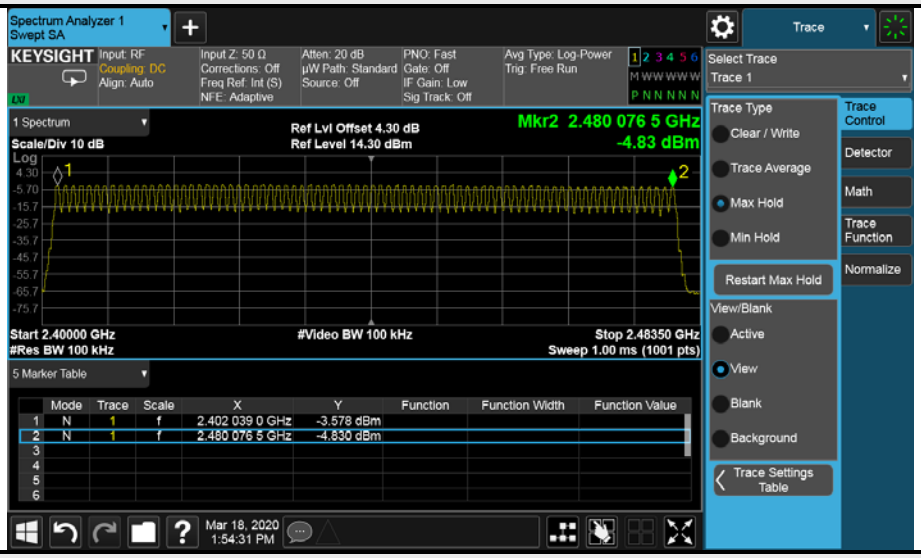
4.3.5 Deviation from Test Standard

No deviation.

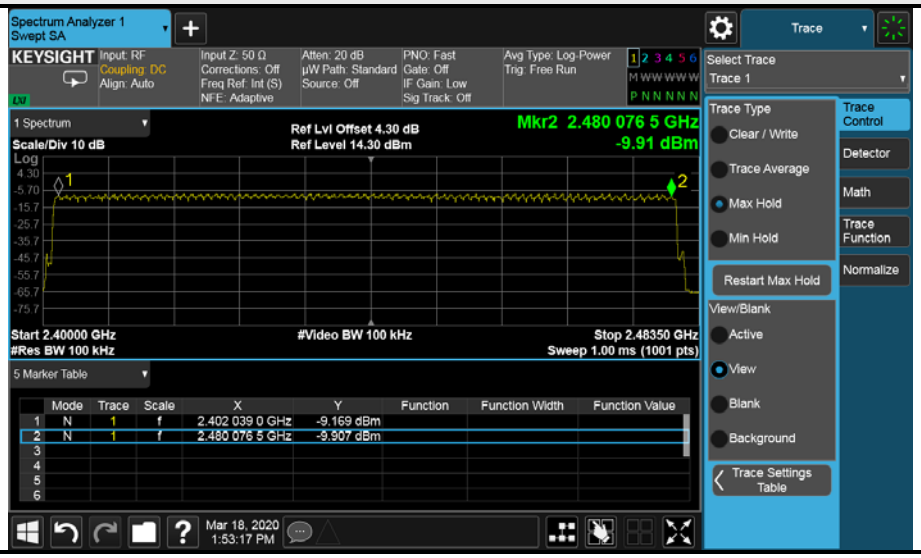
4.3.6 Test Results

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


Spectrum Analyzer 1
Swept SA
KEYSIGHT
Input: RF
Coupling: DC
Align: Auto
Input Z: 50 Ω
Corrections: Off
Freq Ref: Int (S)
NFE: Adaptive
Atten: 20 dB
µW Path: Standard
Source: Off
PNO: Fast
Gate: Off
IF Gain: Low
Sig Track: Off
Avg Type: Log-Power
Trig: Free Run
1 Spectrum
Scale/Div 10 dB
Ref Lvl Offset 4.30 dB
Ref Level 14.30 dBm
Mkr2 2.480 076 5 GHz
-4.83 dBm
Start 2.40000 GHz
#Res BW 100 kHz
#Video BW 100 kHz
Stop 2.48350 GHz
Sweep 1.00 ms (1001 pts)
5 Marker Table
Mode Trace Scale X Y Function Function Width Function Value
1 N 1 f 2.402 039 0 GHz -3.578 dBm
2 N 1 f 2.480 076 5 GHz -4.830 dBm
Mar 18, 2020
1:54:31 PM
Trace
Select Trace
Trace 1
Trace Type
Clear / Write
Trace Average
Max Hold
Min Hold
Restart Max Hold
View/Blank
Active
View
Blank
Background
Trace Settings Table
Trace Control
Detector
Math
Trace Function
Normalize

8DPSK

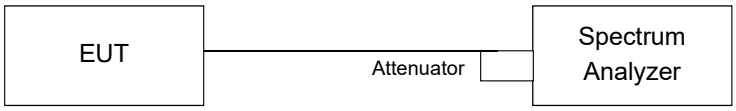

Spectrum Analyzer 1
Swept SA
KEYSIGHT
Input: RF
Coupling: DC
Align: Auto
Input Z: 50 Ω
Corrections: Off
Freq Ref: Int (S)
NFE: Adaptive
Atten: 20 dB
µW Path: Standard
Source: Off
PNO: Fast
Gate: Off
IF Gain: Low
Sig Track: Off
Avg Type: Log-Power
Trig: Free Run
1 Spectrum
Scale/Div 10 dB
Ref Lvl Offset 4.30 dB
Ref Level 14.30 dBm
Mkr2 2.480 076 5 GHz
-9.91 dBm
Start 2.40000 GHz
#Res BW 100 kHz
#Video BW 100 kHz
Stop 2.48350 GHz
Sweep 1.00 ms (1001 pts)
5 Marker Table
Mode Trace Scale X Y Function Function Width Function Value
1 N 1 f 2.402 039 0 GHz -9.169 dBm
2 N 1 f 2.480 076 5 GHz -9.907 dBm
Mar 18, 2020
1:53:17 PM
Trace
Select Trace
Trace 1
Trace Type
Clear / Write
Trace Average
Max Hold
Min Hold
Restart Max Hold
View/Blank
Active
View
Blank
Background
Trace Settings Table
Trace Control
Detector
Math
Trace Function
Normalize

4.4 Dwell Time on Each Channel

4.4.1 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.

4.4.2 Test Setup



4.4.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.4.4 Test 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.

.

4.4.5 Deviation from Test Standard

No deviation.

4.4.6 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	32	320	0.459	146.88	400	PASS
DH3	79	31.6	3.16	16	160	1.723	275.68	400	PASS
DH5	79	31.6	3.16	11	110	3.03	333.3	400	PASS

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

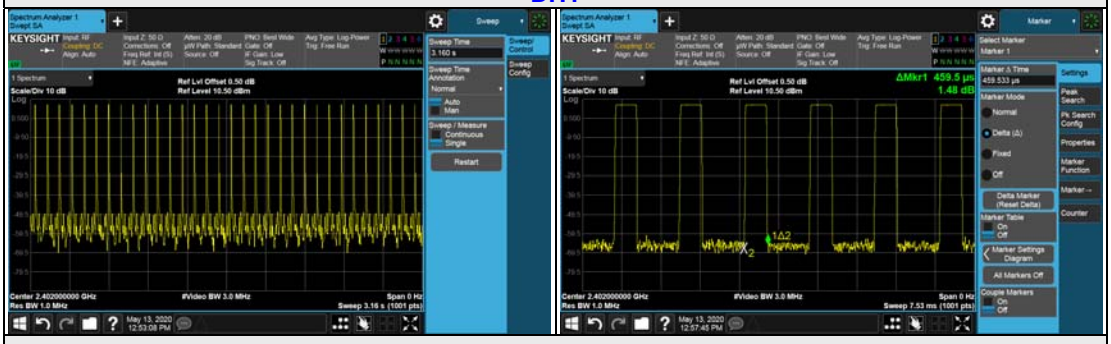
8DPSK

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	32	320	0.465	148.8	400	PASS
3DH3	79	31.6	3.16	16	160	1.68	268.8	400	PASS
3DH5	79	31.6	3.16	11	110	2.99	328.9	400	PASS

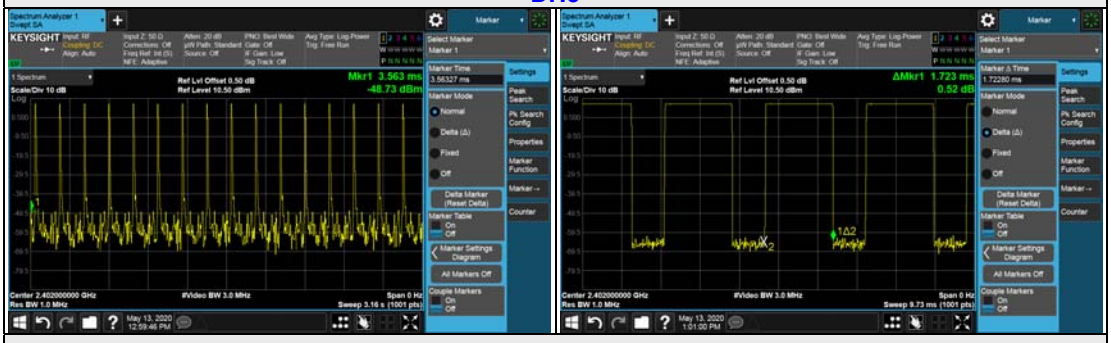
NOTE: Test plots of the transmitting time slot are shown on next page

GFSK

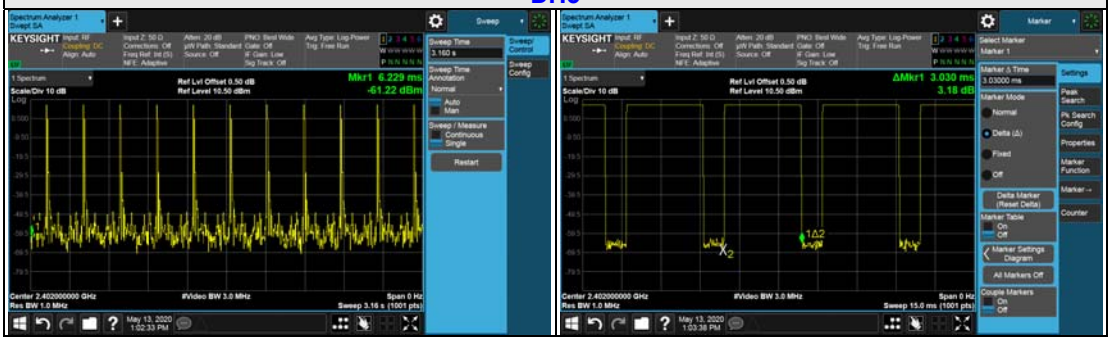
DH1



DH3

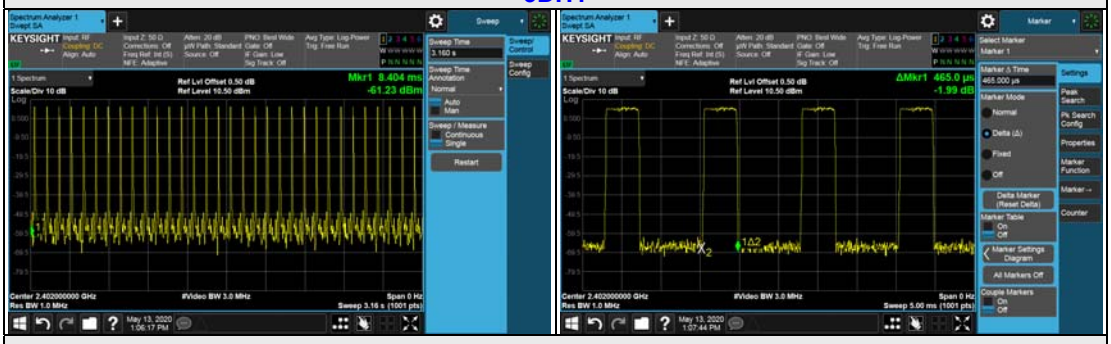


DH5

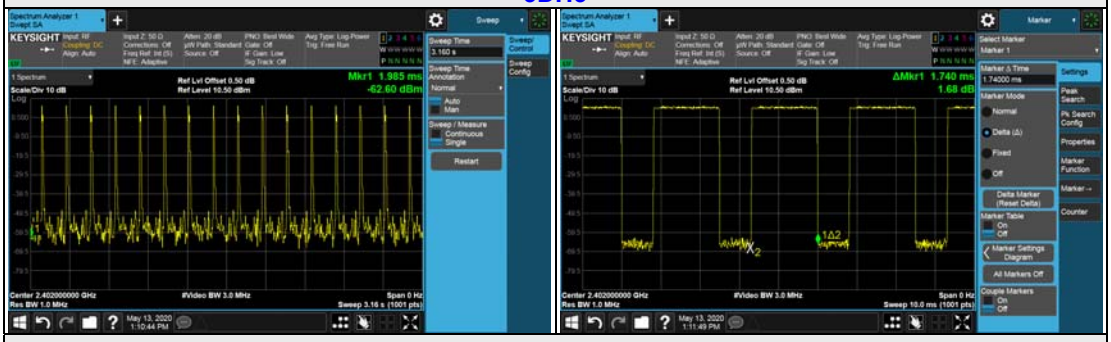


8DPSK

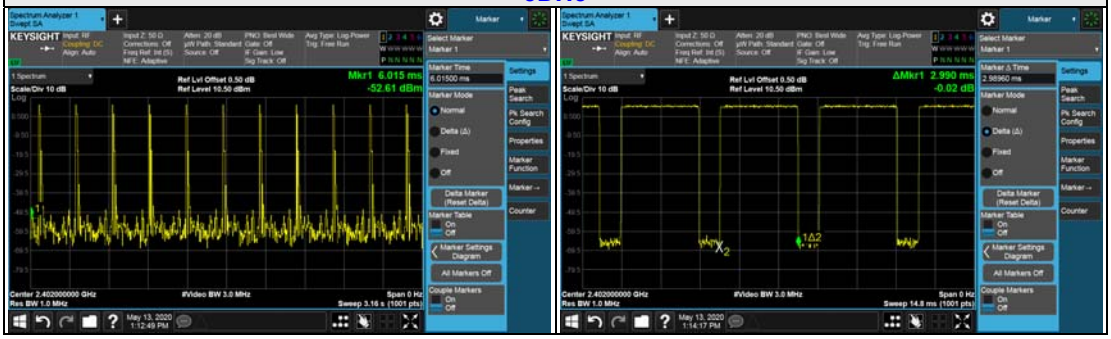
3DH1



3DH3



3DH5

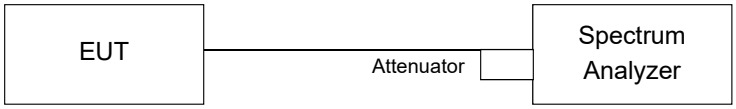


4.5 Channel Bandwidth

4.5.1 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.

4.5.2 Test Setup



4.5.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.5.4 Test Procedure

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.

4.5.5 Deviation from Test Standard

No deviation.

4.5.6 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.

4.5.7 Test Results

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	
		GFSK	8DPSK
0	2402	0.9755	1.341
39	2441	0.9355	1.376
78	2480	0.942	1.348

Spectrum Plots

GFSK / CH 00

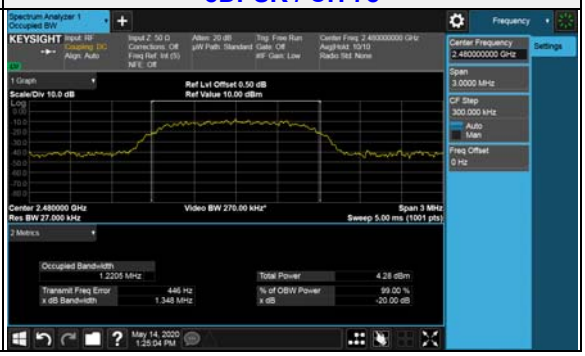
8DPSK / CH 00

GFSK / CH 39

8DPSK / CH 39

GFSK / CH 78

8DPSK / CH 78

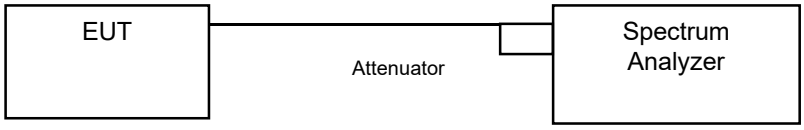


4.6 Hopping Channel Separation

4.6.1 Limits of Hopping Channel Separation Measurement

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

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

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.

4.6.5 Deviation from Test Standard

No deviation.

4.6.6 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	1.002	1.005	0.9755	1.341	0.65	0.89	Pass
39	2441	1	1.005	0.9355	1.376	0.62	0.92	Pass
78	2480	1.036	1.005	0.942	1.348	0.63	0.90	Pass

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

Spectrum Plots

GFSK / CH0

8DPSK / CH0

GFSK / CH39

8DPSK / CH39

GFSK / CH78

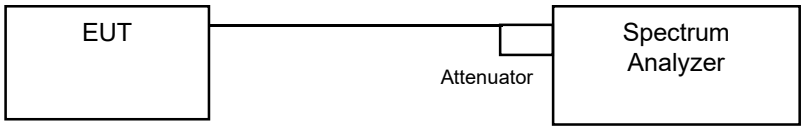
8DPSK / CH78

4.7 Maximum Output Power

4.7.1 Limits of Maximum Output Power Measurement

The Maximum Output Power Measurement is 1W.

4.7.2 Test Setup



4.7.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.7.4 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.

4.7.5 Deviation from Test Standard

No deviation.

4.7.6 EUT Operating Condition

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

4.7.7 Test Results

Channel	Frequency (MHZ)	Output Power (mW)		Output Power (dBm)		Power Limit (W)	Pass / Fail
		GFSK	8DPSK	GFSK	8DPSK		
0	2402	5.89	4.395	7.7	6.43	1	Pass
39	2441	6.745	5.284	8.29	7.23	1	Pass
78	2480	6.592	5.14	8.19	7.11	1	Pass

Spectrum Plot of Worst Value

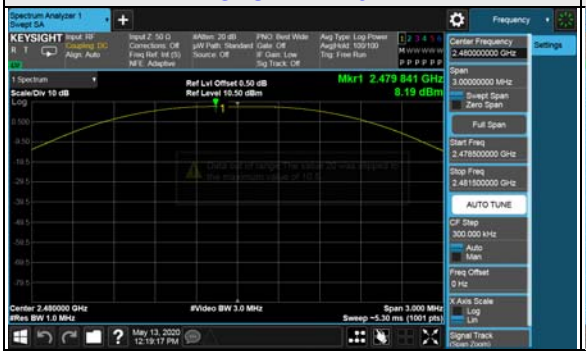
GFSK / CH0

8DPSK / CH0

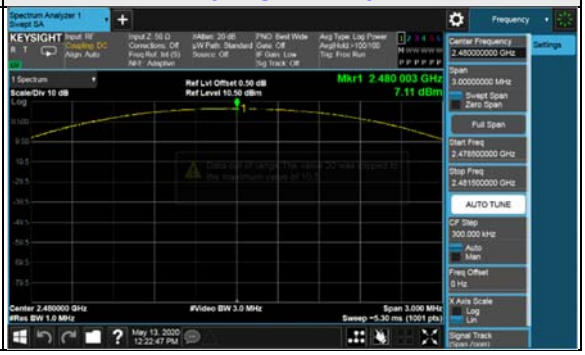
GFSK / CH39

8DPSK / CH39

GFSK / CH78



8DPSK / CH78



4.8 Conducted Out of Band Emission Measurement

4.8.1 Limits of Conducted Out of Band Emission Measurement

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

4.8.2 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.8.3 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.

4.8.4 Deviation from Test Standard

No deviation.

4.8.5 EUT Operating Condition

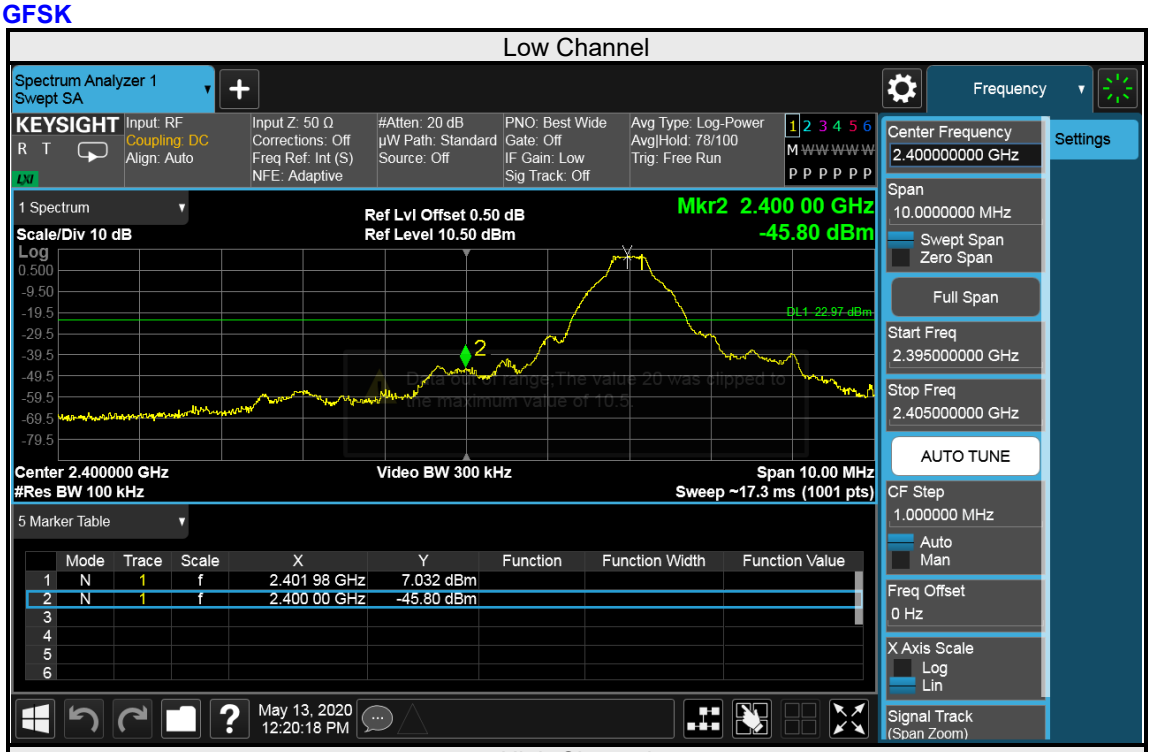
The software provided by client enabled the EUT to test mode and transmit and receive data at lowest, middle and highest channel frequencies individually.

4.8.6 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

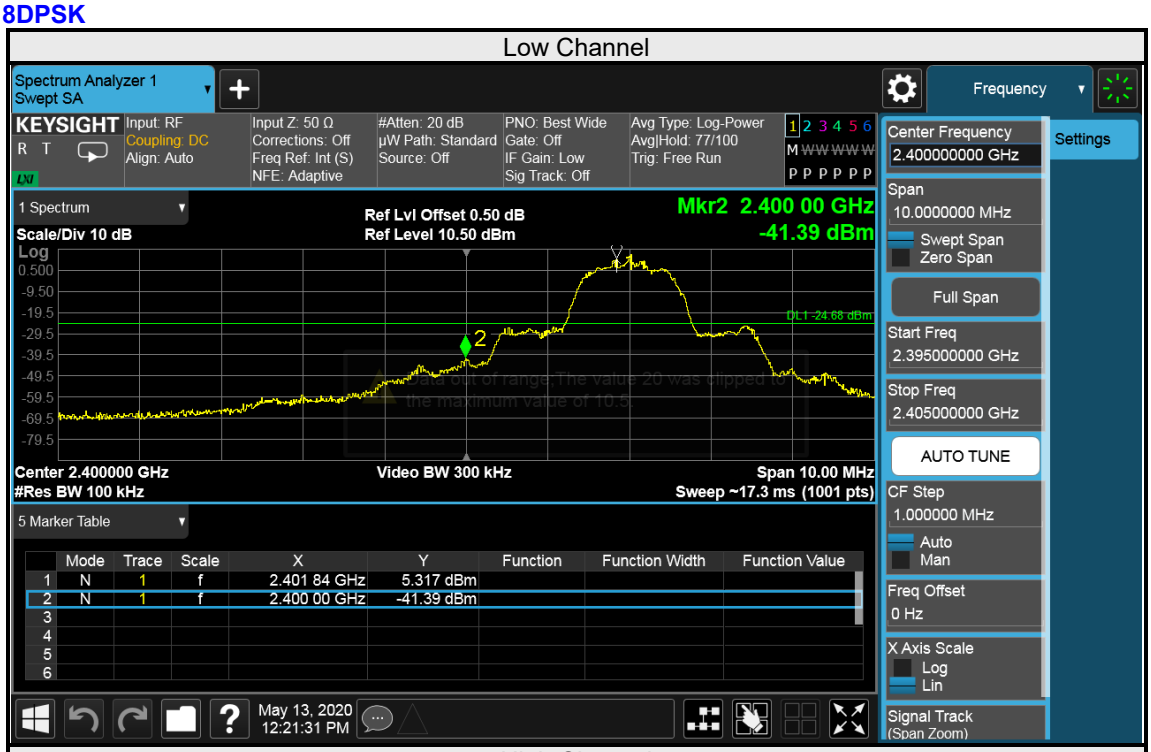
Low Channel



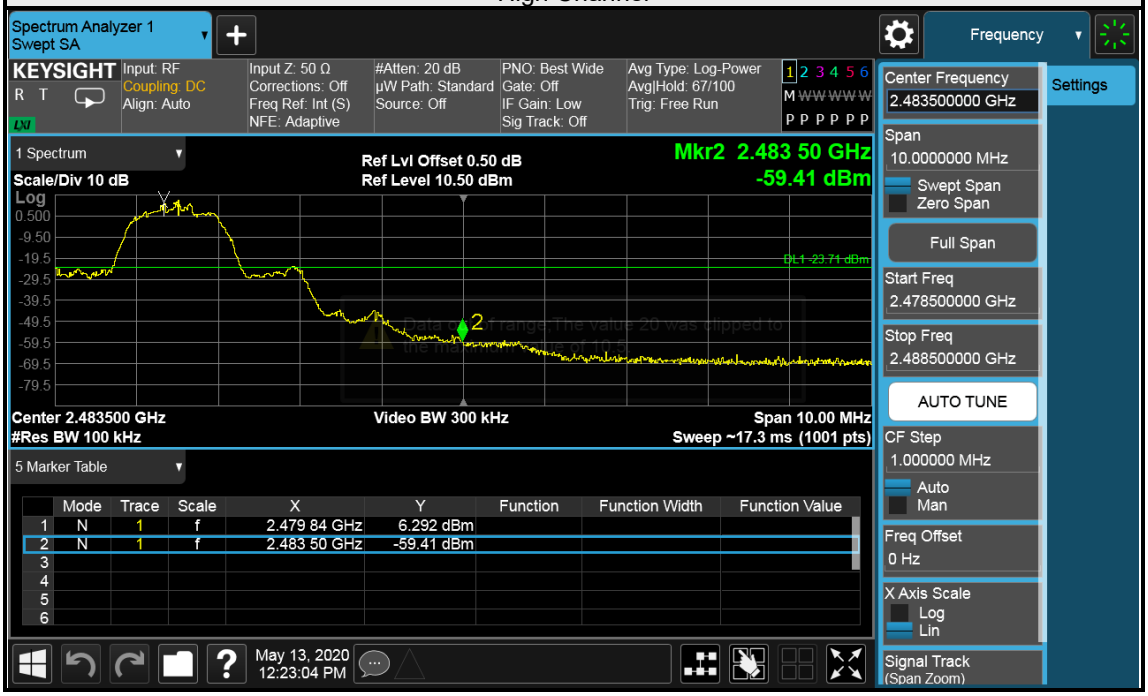
High Channel

8DPSK

Low Channel



High Channel



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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