

ELECTROMAGNETIC EMISSIONS COMPLIANCE REPORT

Applicant: Microsoft Corporation
One Microsoft Way Redmond, WA 98052-6399, U.S.A

Product Name: Portable Computing Device

Brand Name: Microsoft

Model No.: 1952, 1953

Model Difference: The difference between 1952 and 1953 models is the C-Cover. 1952 - Config 1 and 1953 - Config 2

Report Number: E2/2020/70006

FCC ID: C3K1952

FCC Rule Part: §15.247, Cat: DSS

Issue Date: Feb. 24, 2021

Date of Test: Jul. 08, 2020 ~ Sep. 02, 2020, Dec. 04, 2020


Date of EUT Received: Jul. 06, 2020

We hereby certify that:

The above equipment was tested by SGS Taiwan Ltd. Central RF Lab. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.10:2013 and the energy emitted by the sample EUT tested as described in this report is in compliance with conducted and radiated emission limits.

The test results of this report relate only to the tested sample identified in this report.

Approved By:


Blue Yang / Asst. Manager



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Revision History

Report Number	Revision	Description	Issue Date	Remark
E2/2020/70006	Rev.00	Original.	Feb. 24, 2021	Revised By: Karen Huang

Note:**1、Multiple Model numbers or Trademarks**

The variant model numbers are assessed as identical in hardware and software to each other, hence all variants are fully covered by the test results in this test report without further verification test.

2、Disclaimer

Antenna information and Variant information between model numbers are provided by the applicant, test results of this report are applicable to the sample EUT received.

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1 GENERAL INFORMATION

1.1 Product description

Product Name:	Portable Computing Device
Brand Name:	Microsoft
Model No.:	1952, 1953
Model Difference:	The difference between 1952 and 1953 models is the C-Cover. 1952 - Config 1 and 1953 - Config 2
HW Version (Product):	EV2
SW Version (Product):	MTEOS.1.311.0
HW Version (Radio):	N/A
SW Version (Radio):	21.80.2.1
Radio Test Tool & Version:	DRTU: 21.21080.0.0-10722
Power Supply:	From Rechargeable Lithium-Ion Polymer Battery or AC/DC Adapter

Radio Technology:	Bluetooth BR+EDR
Channel number:	79 channels
Modulation type:	GFSK + $\pi/4$ DQPSK + 8DPSK
Transmit Power:	10.75dBm
Frequency Range:	2.402GHz – 2.480GHz
Dwell Time:	$\leq 0.4s$

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1.2 Antenna Designation

Antenna Type	Config 1 / Config 2	Chain 0 / Chain 1	Antenna Part No.	Freq. (MHz)	Peak Antenna Gain (dBi)	Worst Antenna Gain
PIFA	Config 1	Chain 0	N/A	2402-2480	-0.1	V
	Config 2	Chain 0	N/A	2402-2480	-0.5	

Note: Pre-scanned was done on the above 2 antennas, the Config 1 results higher emission at 2.4GHz. Therefore, the completed set of measurement was done on the antenna to be presented on this test report.

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1.3 Test Methodology of Applied Standards

FCC Part 15, Subpart C §15.247

FCC KDB 558074 D01 15.247 Meas. Guidance v05r02

ANSI C63.10:2013

1.4 Test Facility

SGS Taiwan Ltd. Central RF Lab (TAF code 3702)

No.2, Keji 1st Rd., Guishan District, Taoyuan City, Taiwan 333

FCC Designation number: TW0028

1.5 Special Accessories

There is no special accessory used while test was conducted.

1.6 Equipment Modifications

There was no modification incorporated into the EUT.

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2 SYSTEM TEST CONFIGURATION

2.1 EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner which intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT Exercise

An engineering test mode (software/firmware) that applicant provided was utilized to manipulate the EUT into transmit, selection of the test channel, and modulation scheme.

2.3 Test Procedure

2.3.1 Conducted Emissions

The EUT is placed on a table which is 0.8 m above ground plane. Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz. The CISPR Quasi-Peak and Average detector mode is employed. The two LISNs provide 50uH/50 ohm of coupling impedance for the measuring instrument. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.

2.3.2 Conducted Test (RF)

The active antenna port of the unlicensed wireless device is connected to the spectrum analyzer with attenuator to protect the instrumentation. If a second antenna port is available, it is tested at one operating frequency, with other port(s) appropriately terminated, to verify it has similar output characteristics as the fully tested port.

2.3.3 Radiated Emissions

The EUT is placed on a turn table. For emissions testing at or below 1 GHz, the table height shall be 0.8 m above the reference ground plane. For emission measurements above 1 GHz, the table height shall be 1.5 m. The turn table shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this transmitter (EUT) was rotated through three orthogonal axes and measurement procedures for electric field radiated emissions above 1 GHz the EUT measurement is to be made "while keeping the antenna in the 'cone of radiation' from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response." is still within the 3dB illumination BW of the measurement antenna.

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2.4 Measurement Results Explanation Example

2.4.1 Radiated Emission Test Sites For Measurements From 9 kHz To 30 MHz

Radiated emission below 30MHz is measured in a 9m*9m*6m semi-anechoic chamber, the measurements correspond to those obtained at an open-field test site.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

2.4.2 For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuation factor between EUT conducted port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly EUT RF output level.

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2.5 Configuration of Tested System

Fig. 2-1 Conducted (Antenna Port) Emission Configuration



Fig. 2-3 Conduction (AC Power Line) Emission



Fig 2-2 Radiated Emission



Table 2-1 Equipment Used in Tested System

Item	Equipment	Mfr/Brand	Model/Type No.	Series No.	Data Cable	Power Cord
1	DRTU	INTEL	21.21080.0.0-10722	N/A	N/A	N/A

Note: The EUT is tested with all external accessory ports populated.

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3 SUMMARY OF TEST RESULTS

FCC Rules	Description Of Test	Result
§15.207(a)	AC Power Line Conducted Emission	Compliant
§15.247(b)(1)	Peak Output Power	Compliant
§15.247(a)(1)	20dB Bandwidth	Compliant
§15.205 §15.209 §15.247(d)	Conducted & Radiated Band Edge and Spurious Emission	Compliant
§15.247(a)(1)	Frequency Separation	Compliant
§15.247(a)(1)(iii)	Number of hopping frequency Time of Occupancy	Compliant
§15.203	Antenna Requirement	Compliant

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4 DESCRIPTION OF TEST MODES

4.1 Operated in 2400 ~ 2483.5MHz Band

79 channels are provided for Bluetooth

CH	FREQUENCY	CH	FREQUENCY	CH	FREQUENCY	CH	FREQUENCY
0	2402 MHz	20	2422 MHz	40	2442 MHz	70	2462 MHz
1	2403 MHz	21	2423 MHz	41	2443 MHz	71	2463 MHz
2	2404 MHz	22	2424 MHz	42	2444 MHz	72	2464 MHz
3	2405 MHz	23	2425 MHz	43	2445 MHz	73	2465 MHz
4	2406 MHz	24	2426 MHz	44	2446 MHz	74	2466 MHz
5	2407 MHz	25	2427 MHz	45	2447 MHz	75	2467 MHz
6	2408 MHz	26	2428 MHz	46	2448 MHz	76	2468 MHz
7	2409 MHz	27	2429 MHz	47	2449 MHz	77	2469 MHz
8	2410 MHz	28	2430 MHz	48	2450 MHz	78	2470 MHz
9	2411 MHz	29	2431 MHz	49	2451 MHz	79	2471 MHz
10	2412 MHz	30	2432 MHz	50	2452 MHz	70	2472 MHz
11	2413 MHz	31	2433 MHz	51	2453 MHz	71	2473 MHz
12	2414 MHz	32	2434 MHz	52	2454 MHz	72	2474 MHz
13	2415 MHz	33	2435 MHz	53	2455 MHz	73	2475 MHz
14	2416 MHz	34	2436 MHz	54	2456 MHz	74	2476 MHz
15	2417 MHz	35	2437 MHz	55	2457 MHz	75	2477 MHz
16	2418 MHz	36	2438 MHz	56	2458 MHz	76	2478 MHz
17	2419 MHz	37	2439 MHz	57	2459 MHz	77	2479 MHz
18	2420 MHz	38	2440 MHz	58	2460 MHz	78	2480 MHz
19	2421 MHz	39	2441 MHz	59	2461 MHz		

EUT	Serial Number	Note
Portable Computing Device	04529170235 (Config 2)	
Portable Computing Device	00658810245 (Config 1)	

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4.2 The Worst Test Modes and Channel Details

- 1 The EUT has been tested under operating condition.
- 2 Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.
- 3 Investigation has been done on all the possible configurations for searching the worst case.

MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION	PACKET TYPE
RADIATED EMISSION TEST (BELOW 1 GHz)				
Bluetooth	0 to 78	39	GFSK	DH5
RADIATED EMISSION TEST (ABOVE 1 GHz)				
Bluetooth	0 to 78	0,39,78	GFSK	DH5
Note: The field strength of radiation emission was measured as NB plane for Bluetooth BR+EDR Transmitter for channel Low, Mid and High.				

ANTENNA PORT CONDUCTED TEST				
MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION	PACKET TYPE
Peak Output Power, 20dB Band Width				
Bluetooth	0 to 78	0,39,78	GFSK, $\pi/4$ -DQPSK, 8-DPSK	DH5/2DH5/3DH5
Band Edge				
Bluetooth	0 to 78	0,78	GFSK, 8-DPSK	DH5/3DH5
Frequency Separation				
Bluetooth	0 to 78	0,1,2	GFSK	DH5
Number of hopping frequency				
Bluetooth	0 to 78	0 to 78	GFSK	DH5
Time of Occupancy (Dwell time)				
Bluetooth	0 to 78	0,39,78	GFSK, $\pi/4$ -DQPSK, 8-DPSK	DH5/2DH5/3DH5

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5 MEASUREMENT UNCERTAINTY

Test Items	Uncertainty
AC Power Line Conducted Emission	+/- 2.586 dB
Peak Output Power	+/- 0.84 dB
20dB Bandwidth	+/- 51.33 Hz
100 KHz Bandwidth Of Frequency Band Edges	+/- 0.84 dB
Frequency Separation	+/- 51.33 Hz
Number of hopping frequency	+/- 51.33 Hz
Time of Occupancy	+/- 51.33 Hz
Temperature	+/- 0.65 °C
Humidity	+/- 4.6 %
DC / AC Power Source	DC= +/- 0.13%, AC= +/- 0.2%

Radiated Spurious Emission Measurement Uncertainty	
Polarization: Vertical	9kHz~30MHz: +2.3dB
	30MHz - 180MHz: +/- 3.37dB
	180MHz -417MHz: +/- 3.19dB
	0.417GHz-1GHz: +/- 3.19dB
	1GHz - 18GHz: +/- 4.04dB
	18GHz - 40GHz: +/- 4.04dB
Polarization: Horizontal	9kHz~30MHz: +2.3dB
	30MHz - 167MHz: +/- 4.22dB
	167MHz -500MHz: +/- 3.44dB
	0.5GHz-1GHz: +/- 3.39dB
	1GHz - 18GHz: +/- 4.08dB
	18GHz - 40GHz: +/- 4.08dB

Note:

1. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.
2. The conformity assessment statement in this report is based solely on the test results, measurement uncertainty is excluded.

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6 CONDUCTED EMISSION TEST

6.1 Standard Applicable

Frequency within 150 kHz to 30MHz shall not exceed the limit table as below.

Frequency range MHz	Limits dB(uV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

Note

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

6.2 Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
LISN	SCHWARZBECK Mess-Elektronik	NSLK8127	974	03/25/2020	03/24/2021
EMI Test Receiver	R&S	ESCI	101342	04/28/2020	04/27/2021

6.3 EUT Setup

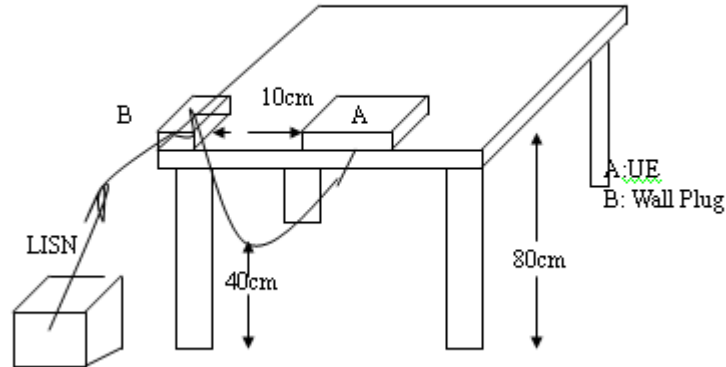
1. The conducted emission tests were performed in the test site, using the setup in accordance with the ANSI 63.10:2013.
2. The AC/DC Power adaptor of EUT was plug-in LISN. The EUT was placed flushed with the rear of the table.
3. The LISN was connected with 120Vac/60Hz power source.

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6.4 Test SET-UP (Block Diagram of Configuration)



6.5 Measurement Procedure

1. The EUT was placed on a table which is 0.8m above ground plan.
2. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
3. Repeat above procedures until all frequency measured were complete.

6.6 Measurement Result

Note: Refer to next page for measurement data and plots.

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AC POWER LINE CONDUCTED EMISSION TEST DATA

Adapter 1

Report Number :E2/2020/70006

Test Site :Conduction Room C

Test Mode :BT

Test Date :2020-09-02

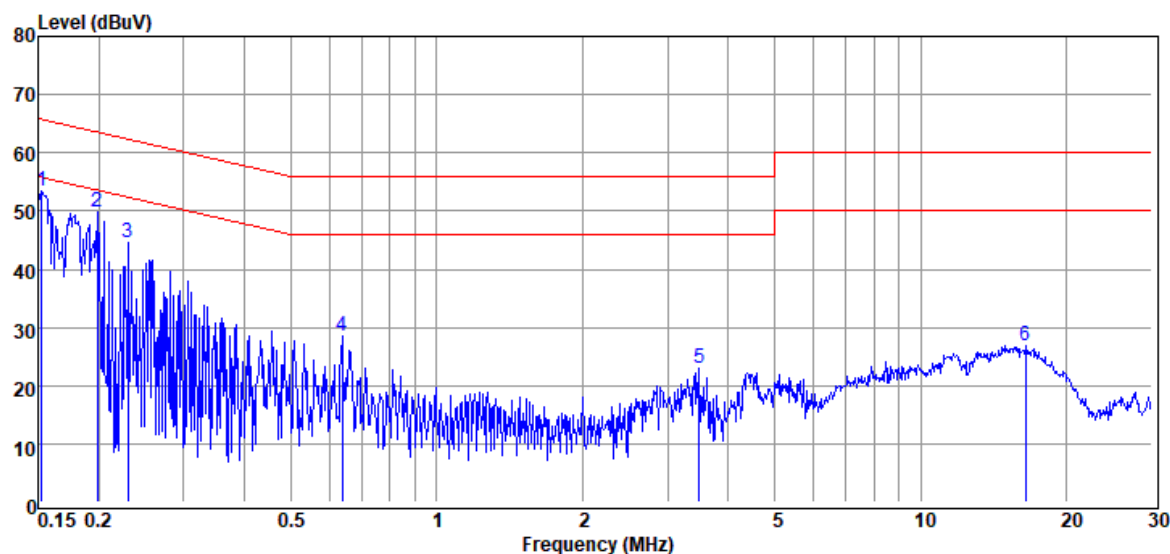
Power :120V/60Hz

Temp./Humi. :23.7/63

Probe :L1

Engineer :Ashton

Note: :EUT_ Config 1



Freq.	Detector	Spectrum	Factor	Actual	Limit	Margin
MHz	Mode	Reading Level		FS		
	PK/QP/AV	dBμV	dB	dBμV	dBμV	dB
0.15	Peak	43.21	10.22	53.43	65.87	-12.44
0.20	Peak	39.55	10.22	49.77	63.67	-13.90
0.23	Peak	34.47	10.22	44.69	62.44	-17.75
0.64	Peak	18.14	10.29	28.43	56.00	-27.57
3.49	Peak	12.45	10.47	22.92	56.00	-33.08
16.49	Peak	16.12	10.81	26.93	60.00	-33.07

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Report Number :E2/2020/70006

Test Site :Conduction Room C

Test Mode :BT

Test Date :2020-09-02

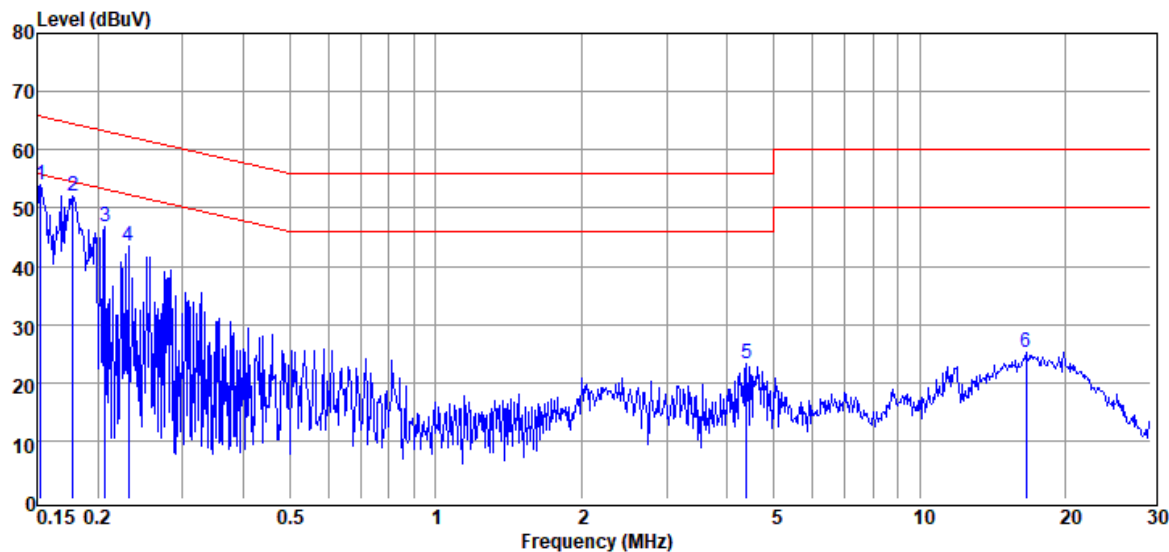
Power :120V/60Hz

Temp./Humi. :23.7/63

Probe :N

Engineer :Ashton

Note: :EUT_ Config 1



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV	Limit dBμV	Margin dB
0.15	Peak	43.71	10.21	53.92	65.87	-11.95
0.18	Peak	41.91	10.21	52.12	64.59	-12.47
0.21	Peak	36.44	10.21	46.65	63.32	-16.67
0.23	Peak	33.14	10.21	43.35	62.39	-19.04
4.38	Peak	12.65	10.50	23.15	56.00	-32.85
16.57	Peak	14.38	10.82	25.20	60.00	-34.80

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Report Number :E2/2020/70006

Test Site :Conduction Room C

Test Mode :BT

Test Date :2020-09-02

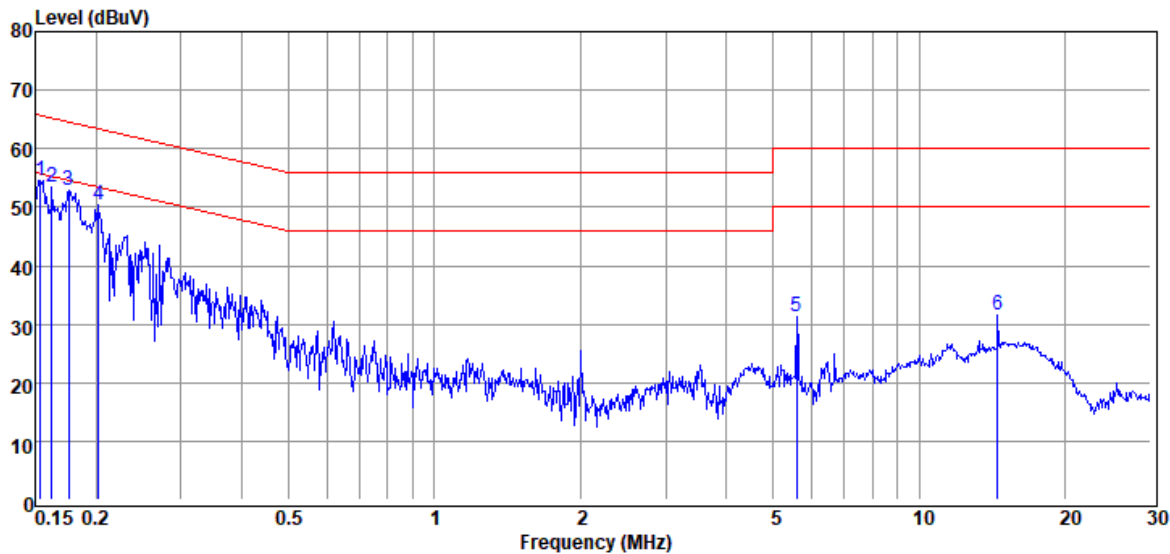
Power :120V/60Hz

Temp./Humi. :24.0/64

Probe :L1

Engineer :Ashton

Note: :EUT_ Config 2



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBUV	Factor dB	Actual FS dBUV	Limit dBUV	Margin dB
0.15	Peak	44.44	10.22	54.66	65.78	-11.12
0.16	Peak	43.18	10.22	53.40	65.34	-11.94
0.18	Peak	42.61	10.22	52.83	64.68	-11.85
0.20	Peak	40.23	10.22	50.45	63.49	-13.04
5.59	Peak	20.87	10.54	31.41	60.00	-28.59
14.52	Peak	20.88	10.78	31.66	60.00	-28.34

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Report Number :E2/2020/70006

Test Site :Conduction Room C

Test Mode :BT

Test Date :2020-09-02

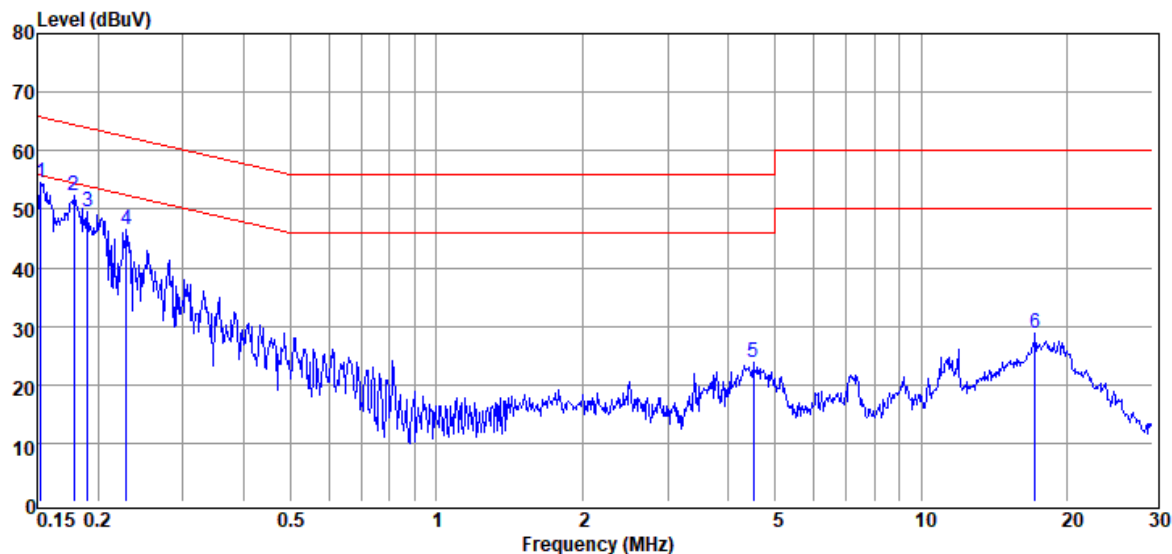
Power :120V/60Hz

Temp./Humi. :24.0/64

Probe :N

Engineer :Ashton

Note: :EUT_ Config 2



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBUV	Factor dB	Actual FS dBUV	Limit dBUV	Margin dB
0.15	Peak	44.44	10.21	54.65	65.87	-11.22
0.18	Peak	42.04	10.21	52.25	64.55	-12.30
0.19	Peak	39.37	10.21	49.58	64.02	-14.44
0.23	Peak	36.21	10.21	46.42	62.48	-16.06
4.50	Peak	13.43	10.51	23.94	56.00	-32.06
17.20	Peak	17.94	10.83	28.77	60.00	-31.23

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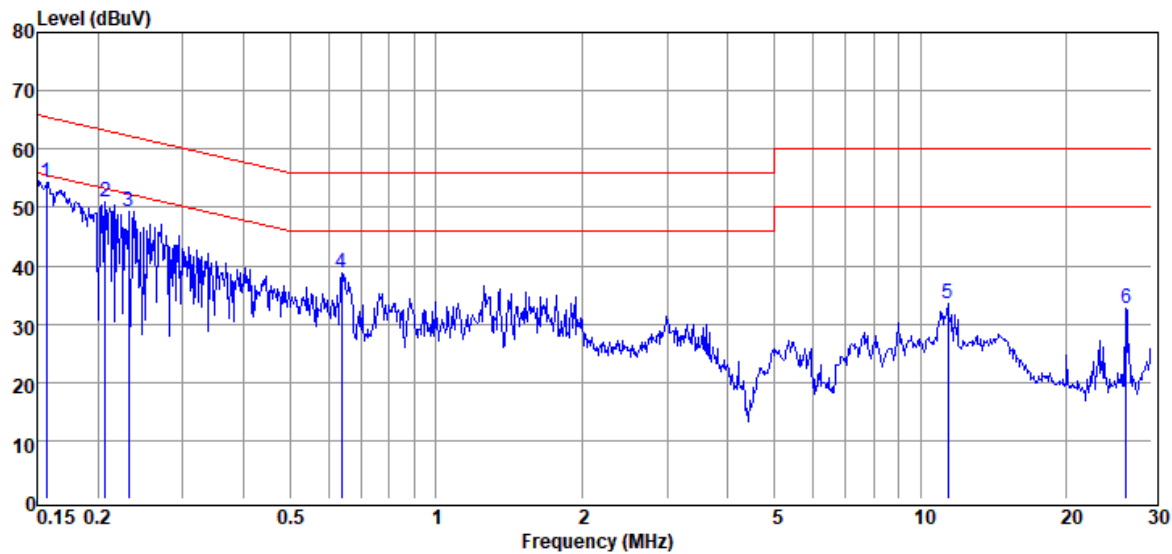
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Adapter 2

Report Number :E2/2020/70006
Test Mode :BT
Power :120V/60Hz
Probe :L1
Note: : Config 1

Test Site :Conduction Room C
Test Date :2020-08-14
Temp./Humi. :24.1/61
Engineer :Ashton



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV	Limit dBμV	Margin dB
0.16	Peak	44.11	10.22	54.33	65.65	-11.32
0.21	Peak	40.76	10.22	50.98	63.32	-12.34
0.23	Peak	38.98	10.22	49.20	62.39	-13.19
0.64	Peak	28.38	10.29	38.67	56.00	-17.33
11.38	Peak	22.87	10.73	33.60	60.00	-26.40
26.56	Peak	21.57	11.01	32.58	60.00	-27.42

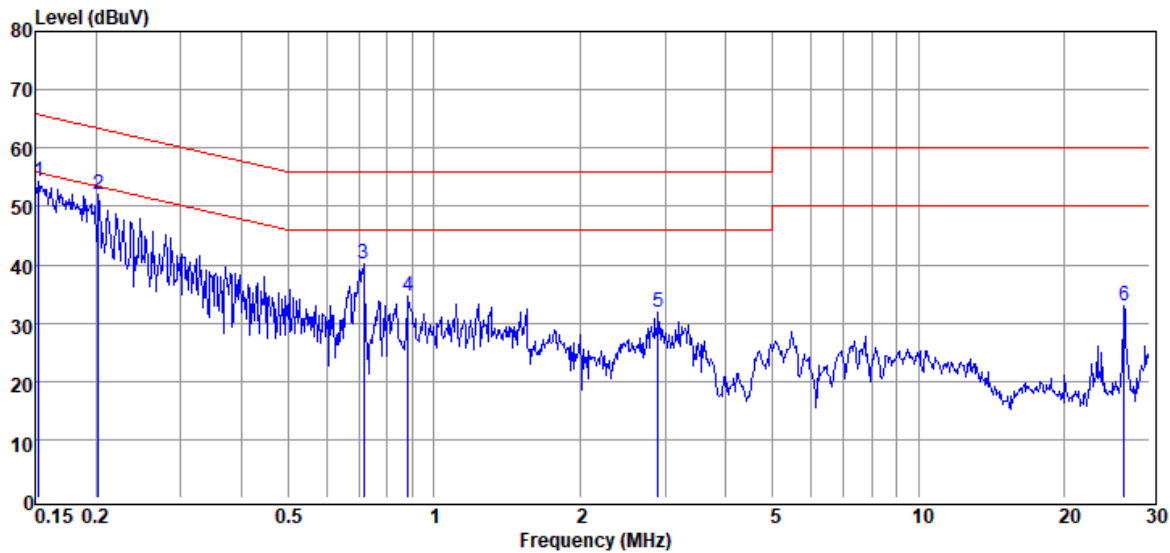
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Report Number :E2/2020/70006
Test Mode :BT
Power :120V/60Hz
Probe :N
Note: : Config 1

Test Site :Conduction Room C
Test Date :2020-08-14
Temp./Humi. :24.1/61
Engineer :Ashton



Freq.	Detector	Spectrum	Factor	Actual	Limit	Margin
MHz	Mode	Reading Level		FS		
	PK/QP/AV	dBμV	dB	dBμV	dBμV	dB
0.15	Peak	44.09	10.21	54.30	65.87	-11.57
0.20	Peak	41.80	10.21	52.01	63.49	-11.48
0.72	Peak	29.70	10.33	40.03	56.00	-15.97
0.88	Peak	24.26	10.39	34.65	56.00	-21.35
2.90	Peak	21.31	10.47	31.78	56.00	-24.22
26.56	Peak	21.89	11.01	32.90	60.00	-27.10

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Report Number :E2/2020/70006

Test Site :Conduction Room C

Test Mode :BT

Test Date :2020-08-14

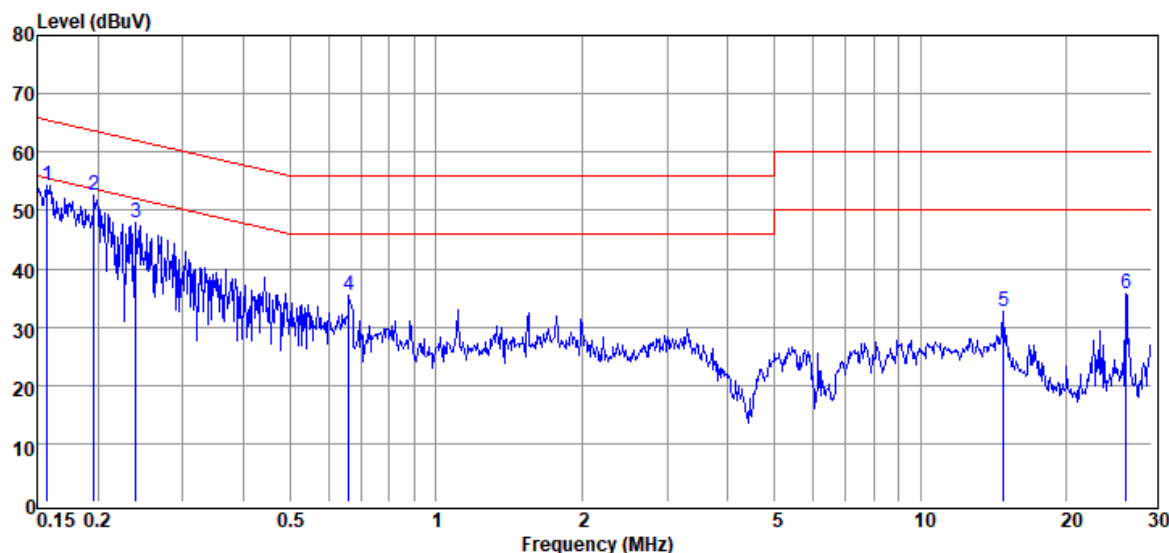
Power :120V/60Hz

Temp./Humi. :24.1/61

Probe :L1

Engineer :Ashton

Note: : Config 2



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV	Limit dBμV	Margin dB
0.16	Peak	44.14	10.22	54.36	65.60	-11.24
0.20	Peak	42.38	10.22	52.60	63.76	-11.16
0.24	Peak	37.59	10.22	47.81	62.08	-14.27
0.66	Peak	25.13	10.31	35.44	56.00	-20.56
14.83	Peak	21.76	10.79	32.55	60.00	-27.45
26.56	Peak	24.73	11.01	35.74	60.00	-24.26

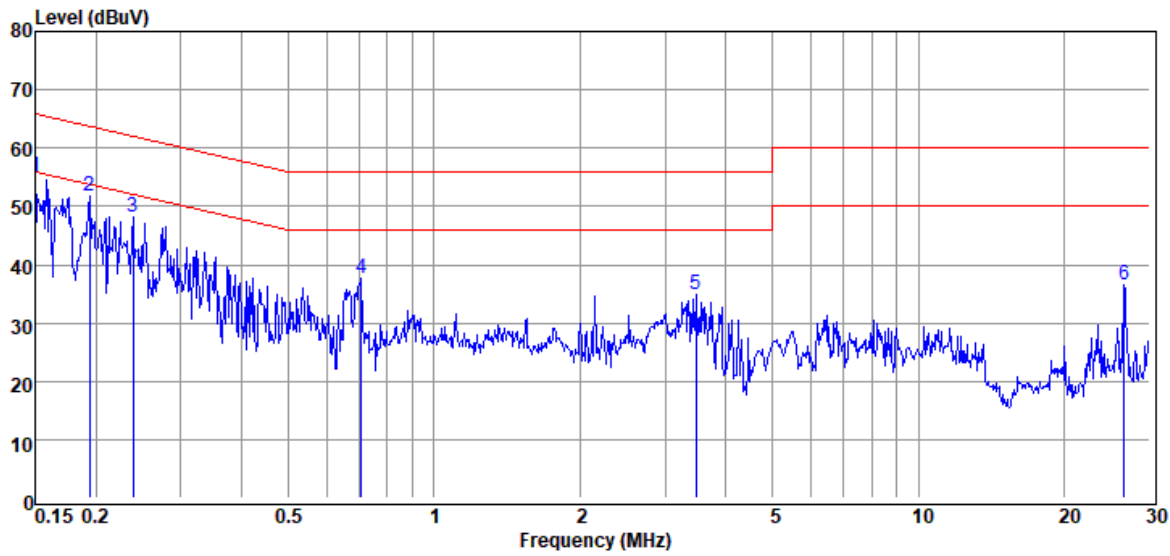
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Report Number :E2/2020/70006
Test Mode :BT
Power :120V/60Hz
Probe :N
Note: : Config 2

Test Site :Conduction Room C
Test Date :2020-08-14
Temp./Humi. :24.1/61
Engineer :Ashton



Freq.	Detector	Spectrum	Factor	Actual	Limit	Margin
MHz	Mode	Reading Level		FS		
	PK/QP/AV	dBμV	dB	dBμV	dBμV	dB
0.15	Peak	44.98	10.21	55.19	66.00	-10.81
0.19	Peak	41.52	10.21	51.73	63.84	-12.11
0.24	Peak	37.97	10.21	48.18	62.13	-13.95
0.71	Peak	27.40	10.33	37.73	56.00	-18.27
3.47	Peak	24.43	10.48	34.91	56.00	-21.09
26.56	Peak	25.66	11.01	36.67	60.00	-23.33

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7 PEAK OUTPUT POWER MEASUREMENT

7.1 Standard Applicable

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 hopping channels, The Limit: 1Watt. For all other frequency hopping systems in the 2400 – 2483.5MHz band: The Limit: 0.125 Watts. The power limit for 1Mbps is 1watt, and 2Mbps, 3Mbps and AFH mode are 0.125 watts.

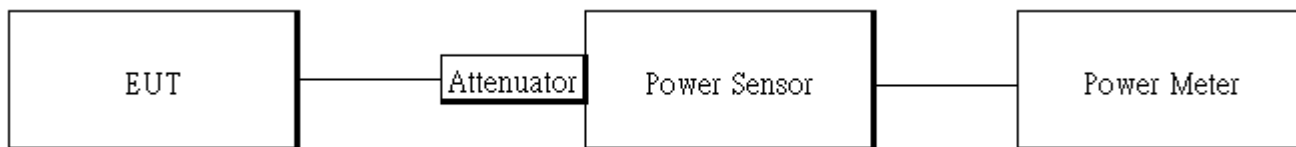
7.2 Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Power Meter	Anritsu	ML2496A	1804002	04/06/2020	04/05/2021
Power Sensor	Anritsu	MA2411B	1726105	04/06/2020	04/05/2021
Power Sensor	Anritsu	MA2411B	1726106	04/06/2020	04/05/2021
Attenuator	Marvelous	MVE2213-10	RF80	11/20/2019	11/19/2020
IPEX-4 Cable	Woken	00100A1H646027	N/A	N/A	N/A

Note: The measurement was taken place with the long duration of the time, and additional equipment list as shown blow indicate those equipment of which has been subject to undertake the calibration in intermediate period of time of the measurement.

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Attenuator	Marvelous	MVE2213-10	RF80	11/19/2020	11/18/2021

7.3 Test Set-up:



7.4 Measurement Procedure:

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10 Measurement Guidelines.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the power meter or spectrum. (Max Hold, Detector = Peak, RBW >=20dB bandwidth)
4. Record the max. reading.
5. Repeat above procedures until all default test channel is completed.

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7.5 Peak & Average Power Measurement Result

1M BR mode (Peak):

CH	Freq. (MHz)	Peak Output Power (dBm)	Output Power (mW)	Limit (mW)
Low	2402	10.68	11.695	125
Mid	2441	10.75	11.885	125
High	2480	10.69	11.722	125

1M BR mode (Average):

CH	Freq. (MHz)	Avg. Output Power (dBm)	Output Power (mW)	Limit (mW)
Low	2402	10.54	11.334	125
Mid	2441	10.64	11.598	125
High	2480	10.50	11.230	125

2M EDR mode (Peak):

CH	Freq. (MHz)	Peak Output Power (dBm)	Output Power (mW)	Limit (mW)
Low	2402	9.42	8.750	125
Mid	2441	9.37	8.650	125
High	2480	9.22	8.356	125

2M EDR mode (Average):

CH	Freq. (MHz)	Avg. Output Power (dBm)	Output Power (mW)	Limit (mW)
Low	2402	7.36	5.450	125
Mid	2441	7.30	5.375	125
High	2480	7.27	5.338	125

3M EDR mode (Peak):

CH	Freq. (MHz)	Peak Output Power (dBm)	Output Power (mW)	Limit (mW)
Low	2402	9.56	9.036	125
Mid	2441	9.54	8.995	125
High	2480	9.36	8.630	125

3M EDR mode (Average):

CH	Freq. (MHz)	Avg. Output Power (dBm)	Output Power (mW)	Limit (mW)
Low	2402	7.39	5.488	125
Mid	2441	7.39	5.488	125
High	2480	7.26	5.326	125

NOTE: cable loss as 10.4dB that offsets in the spectrum

*Note: Avg. Output Power measured by using average detector.

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8 20dB BANDWIDTH MEASUREMENT

8.1 Standard Applicable

For frequency hopping systems operating in the 2400 MHz-2483.5 MHz no limit for 20dB bandwidth.

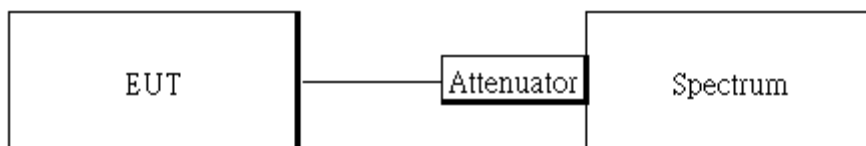
8.2 Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Spectrum Analyzer	KEYSIGHT	N9010A	MY54510568	07/08/2020	07/07/2021
DC Block	PASTERNAK	PE8210	RF256	11/20/2019	11/19/2020
Attenuator	Marvelous	MVE2213-10	RF80	11/20/2019	11/19/2020
IPEX-4 Cable	Woken	00100A1H646027	N/A	N/A	N/A

Note: The measurement was taken place with the long duration of the time, and additional equipment list as shown blow indicate those equipment of which has been subject to undertake the calibration in inter-mediate period of time of the measurement.

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
DC Block	PASTERNAK	PE8210	RF256	11/19/2020	11/18/2021
Attenuator	Marvelous	MVE2213-10	RF80	11/19/2020	11/18/2021

8.3 Test Set-up



8.4 Measurement Procedure

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10:2013.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
4. Set the spectrum analyzer as
RBW= 1 % to 5% of OBW ,
VBW = 3 X RBW,
Span= 2 to 5 times of the OBW,
Sweep=auto,
Detector = Peak, and Max hold for 20dB Bandwidth test.
5. Mark the peak frequency and -20dB (upper and lower) frequency
6. Repeat above procedures until all test default channel is completed

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8.5 20dB Bandwidth

GFSK

CH	20 dB BW (MHz)	2/3 BW (MHz)
Low	0.9226	0.62
Mid	0.9226	0.62
High	0.9236	0.62

$\pi/4$ -DQPSK

CH	20 dB BW (MHz)	2/3 BW (MHz)
Low	1.407	0.94
Mid	1.405	0.94
High	1.431	0.95

8-DPSK

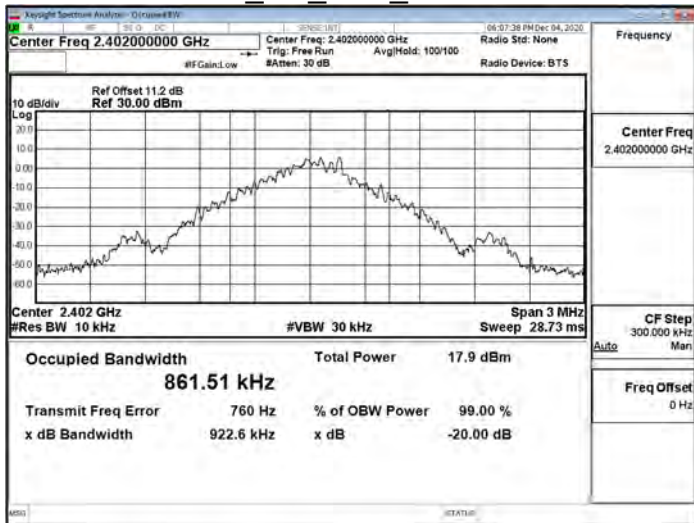
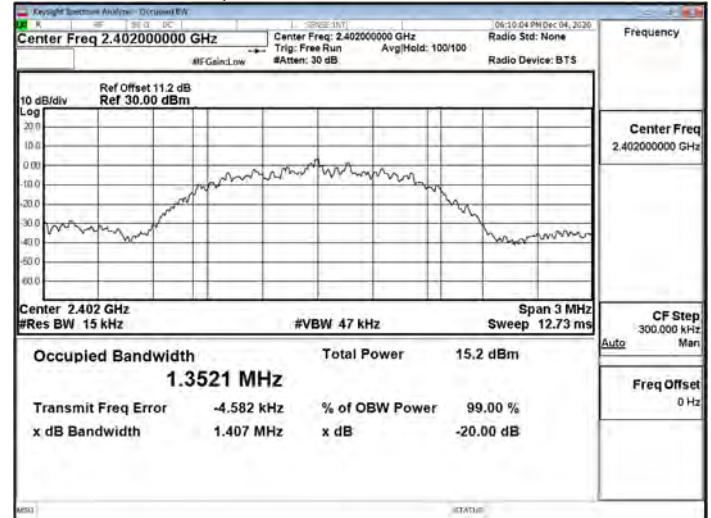
CH	20 dB BW (MHz)	2/3 BW (MHz)
Low	1.386	0.92
Mid	1.390	0.93
High	1.387	0.92

Note: For the test plots, Detector: PEAK, Trace: MAX Hold

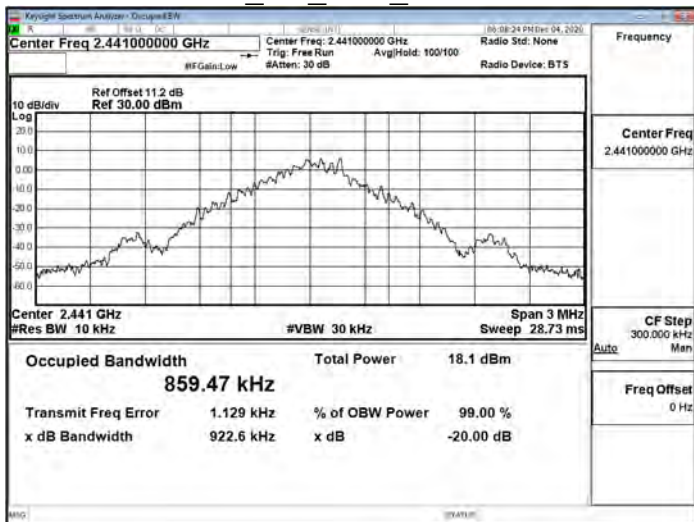
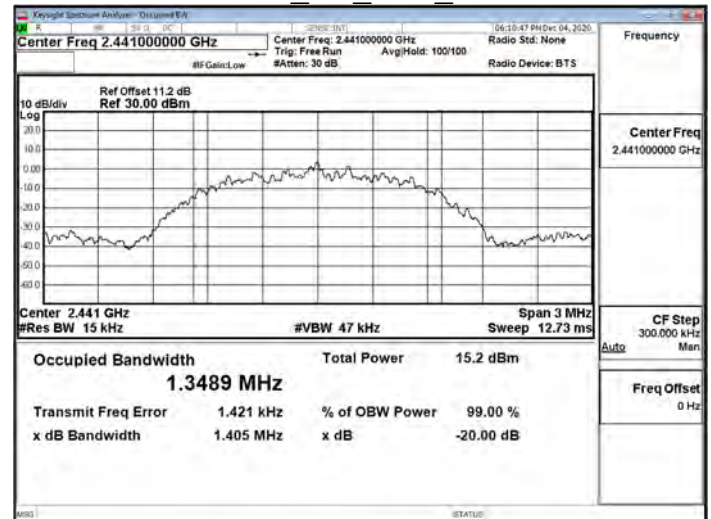
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GFSK_1M_DH5_2402MHz

 $\pi/4$ DQPSK_2M_DH5_2402MHz

GFSK_1M_DH5_2441MHz

 $\pi/4$ DQPSK_2M_DH5_2441MHz

GFSK_1M_DH5_2480MHz

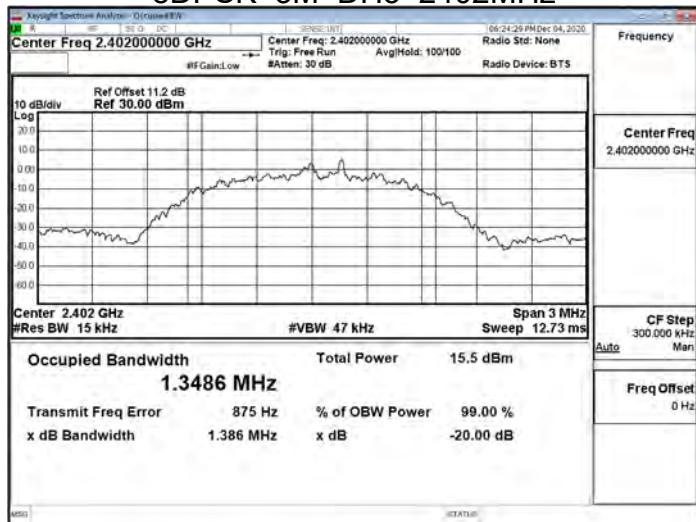
 $\pi/4$ DQPSK_2M_DH5_2480MHz

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8DPSK 3M DH5 2402MHz



8DPSK 3M DH5 2441MHz



8DPSK 3M DH5 2480MHz



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9 CONDUCTED BAND EDGES AND SPURIOUS EMISSION MEASUREMENT

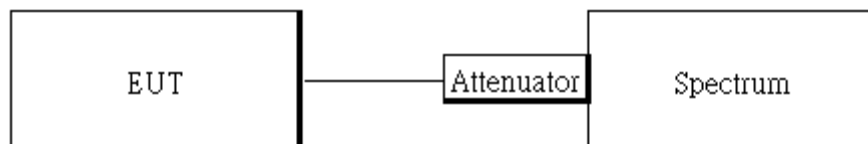
9.1 Standard Applicable

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. 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).

9.2 Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Spectrum Analyzer	KEYSIGHT	N9010A	MY54510568	07/08/2020	07/07/2021
DC Block	PASTERNAK	PE8210	RF256	11/20/2019	11/19/2020
Attenuator	Marvelous	MVE2213-10	RF80	11/20/2019	11/19/2020
IPEX-4 Cable	Woken	00100A1H64 6027	N/A	N/A	N/A

9.3 Test SET-UP



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9.4 Measurement Procedure

9.4.1 Conducted Band Edge:

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10:2013.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
4. Set center frequency of spectrum analyzer = operating frequency.
5. Set the spectrum analyzer as RBW=100 kHz, VBW=300 kHz, Sweep = auto
6. Mark Peak, 2.3999GHz and 2.4836GHz and record the max. level.
7. Repeat above procedures until all frequency measured were complete.

9.4.2 Conducted Spurious Emission:

1. To connect Antenna Port of EUT to Spectrum.
2. The testing follows ANSI C63.10:2013.
3. Set RBW = 100 kHz & VBW = 300 kHz, Detector =Peak, Sweep = Auto
4. Allow trace to fully stabilize.
5. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.
6. Repeat above procedures until all default test channel measured were complete.

9.5 Measurement Result

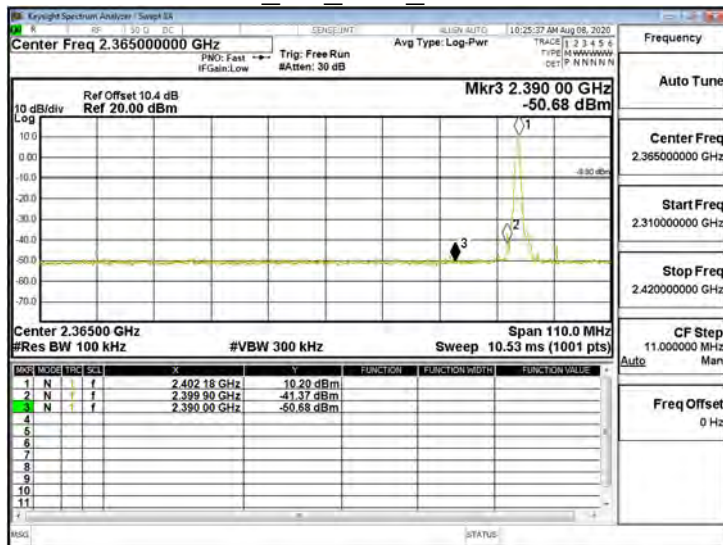
See next page for test plots.

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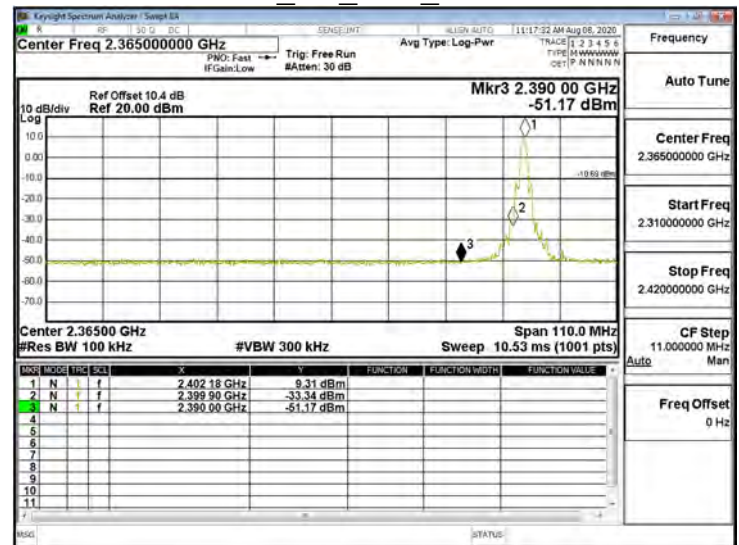
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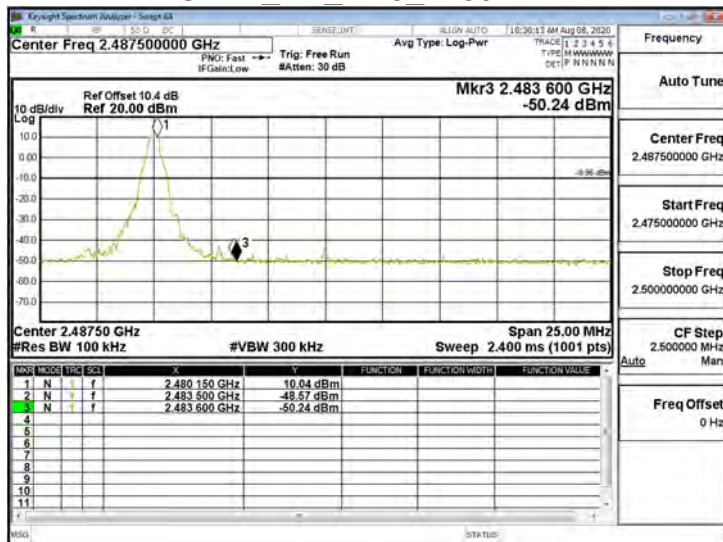
GFSK 1M DH5 2402MHz



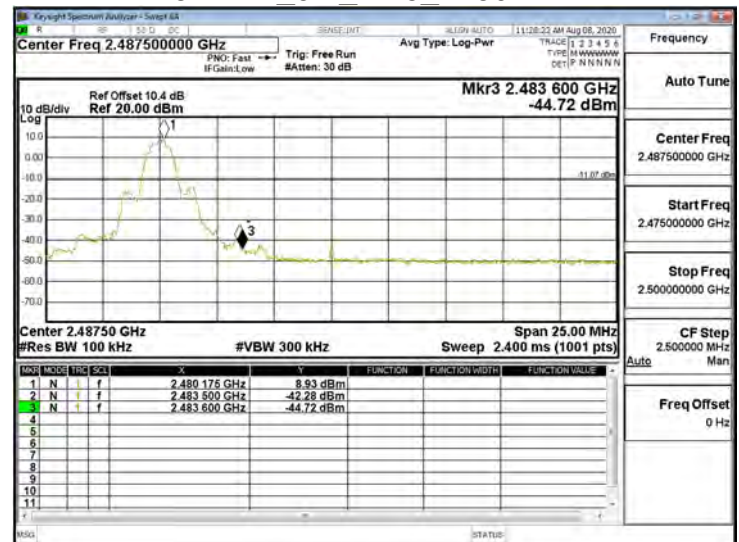
8DPSK 3M DH5 2402MHz



GFSK 1M DH5 2480MHz



8DPSK 3M DH5 2480MHz

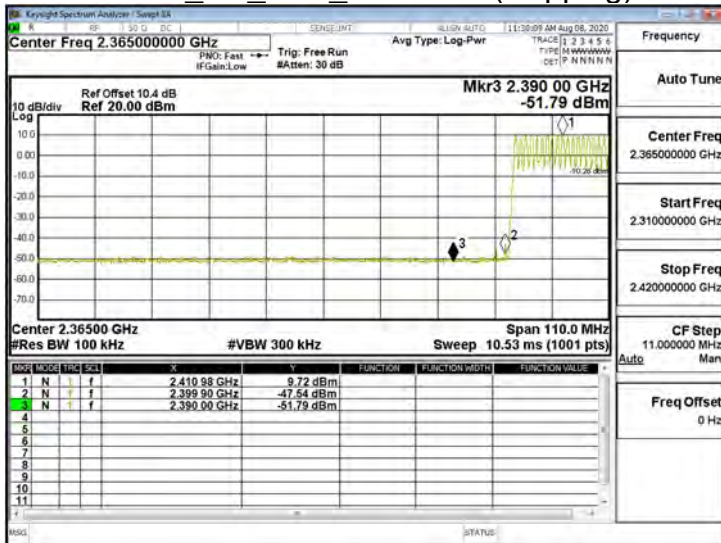


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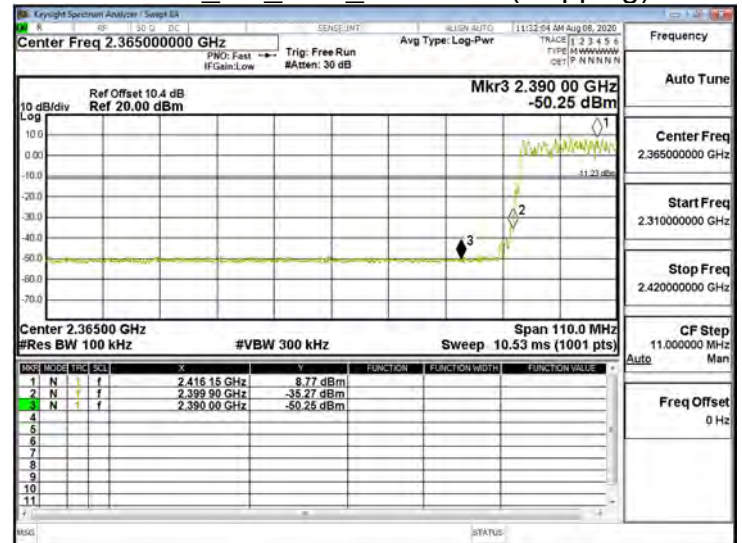
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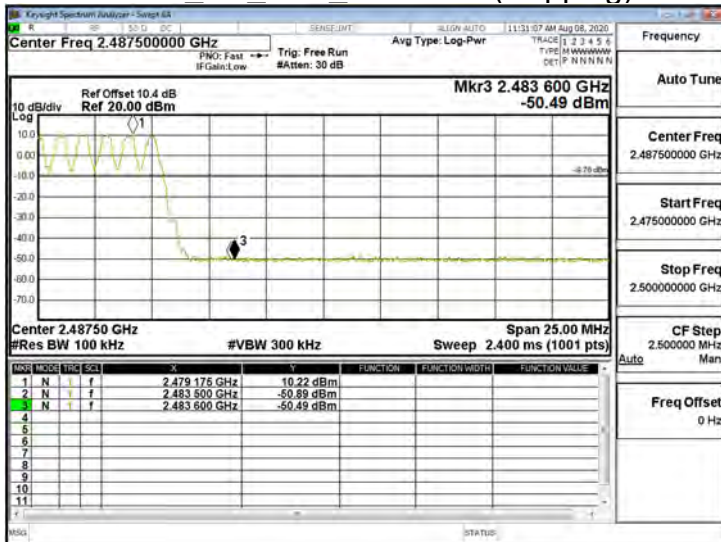
GFSK 1M DH5 2402MHz (Hopping)



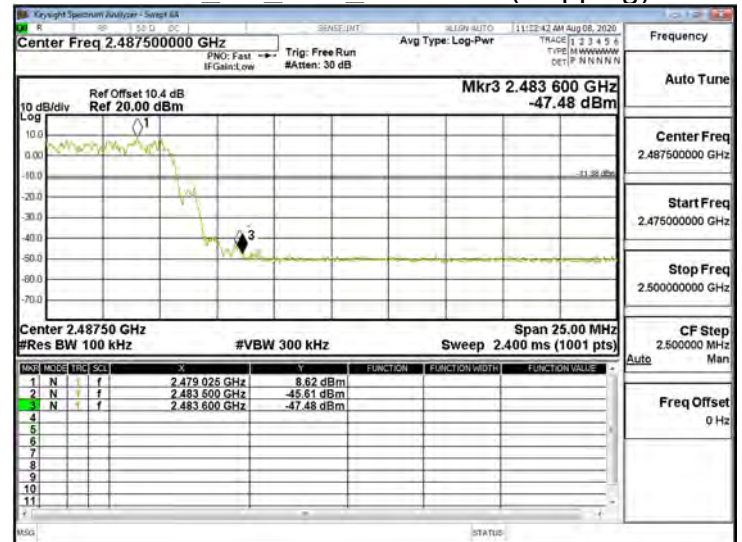
8DPSK 3M DH5 2402MHz (Hopping)



GFSK 1M DH5 2480MHz (Hopping)



8DPSK 3M DH5 2480MHz (Hopping)

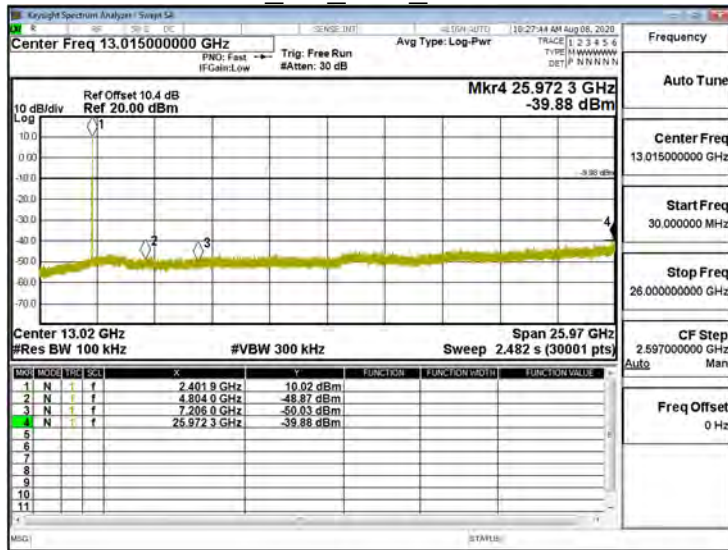


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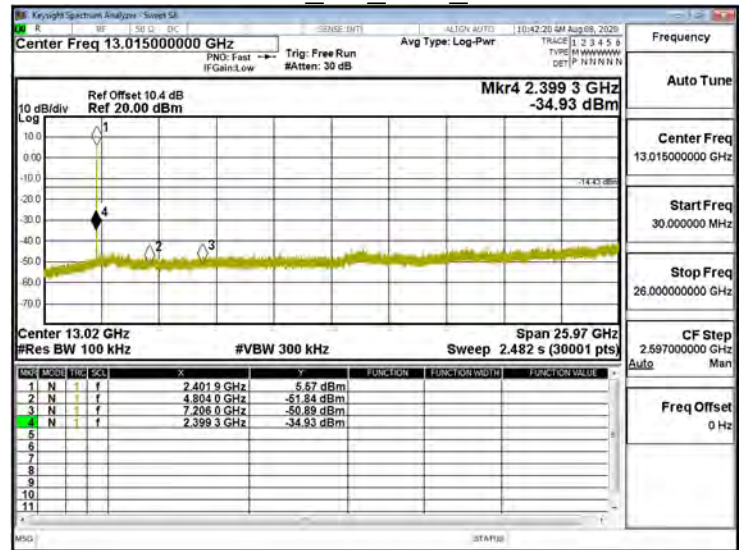
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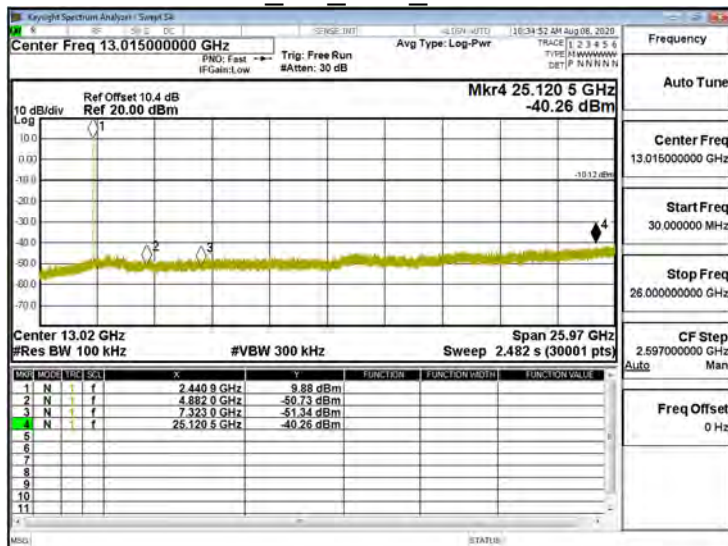
GFSK_1M_DH5_2402MHz



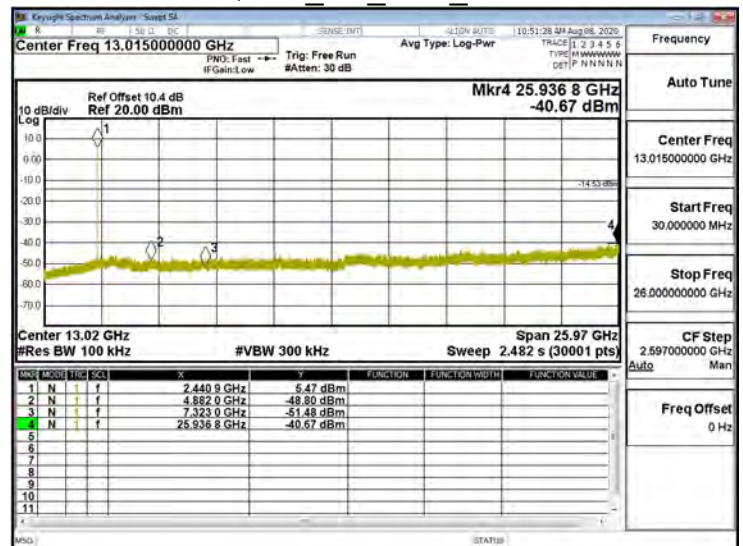
π /4DQPSK_2M_DH5_2402MHz



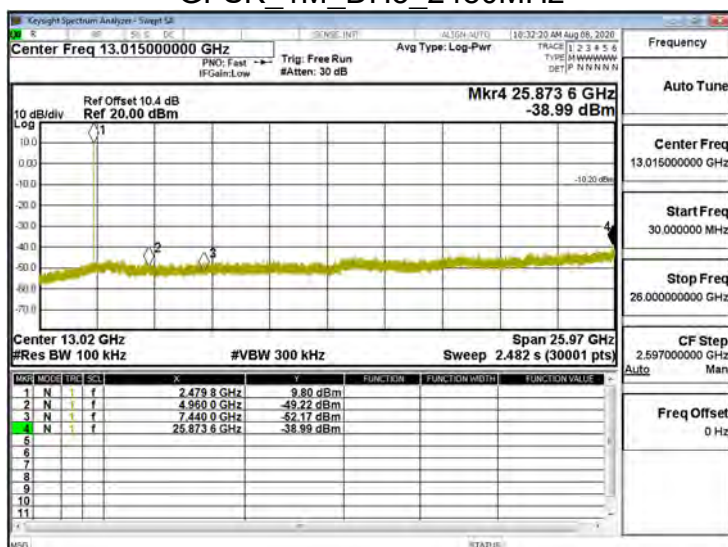
GFSK_1M_DH5_2441MHz



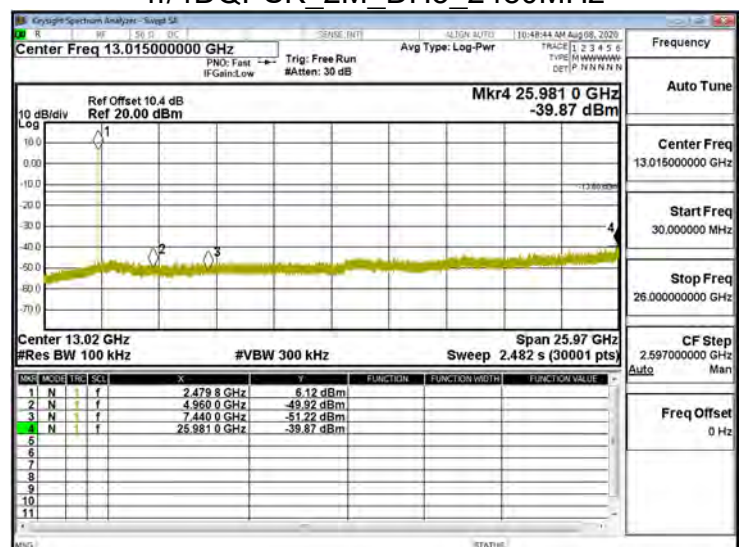
π /4DQPSK_2M_DH5_2441MHz



GFSK_1M_DH5_2480MHz



π /4DQPSK_2M_DH5_2480MHz

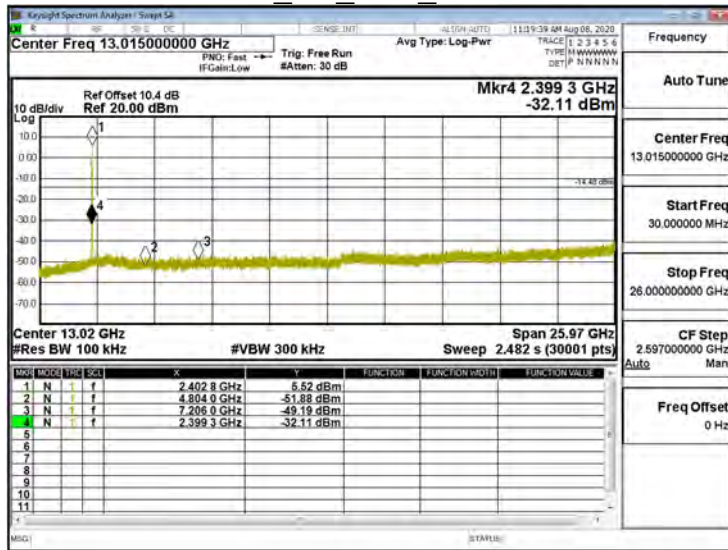


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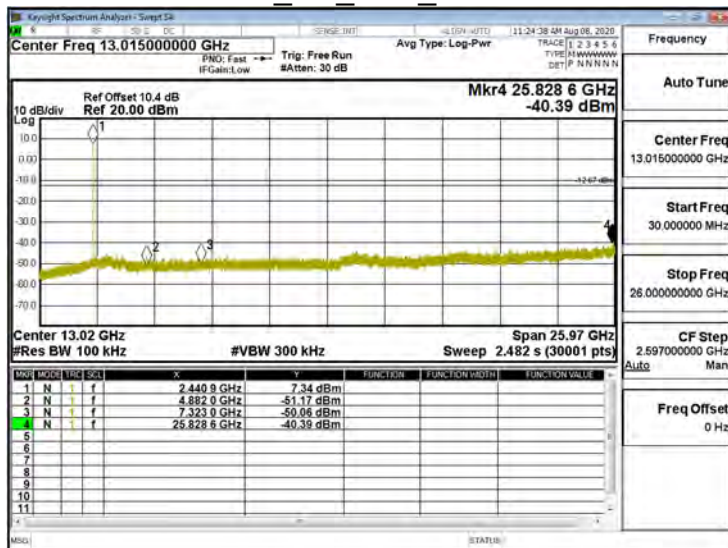
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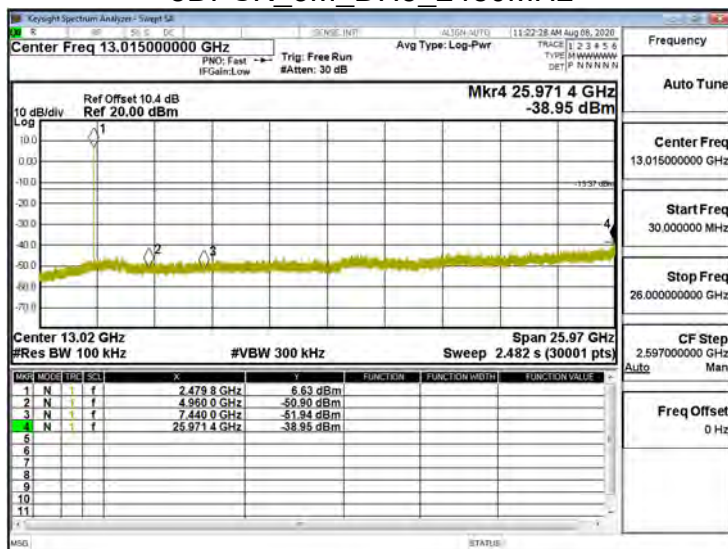
8DPSK_3M_DH5_2402MHz



8DPSK_3M_DH5_2441MHz



8DPSK_3M_DH5_2480MHz



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10 RADIATED BANDEDGE AND SPURIOUS EMISSION MEASUREMENT

10.1 Standard Applicable

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. In addition, radiated emissions which fall in the restricted bands must also comply with the §15.209 limit as below.

And according to §15.33(a) (1), for an intentional radiator operates below 10GHz, the frequency range of measurements: to the tenth harmonic of the highest fundamental frequency or to 40GHz, whichever is lower.

Frequency (MHz)	Field strength (microvolts/meter)	Distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30	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 (dBμV/m) = 20 log Emission level (μV/m)

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10.2 Measurement Equipment Used

966 Chamber					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Broadband Antenna	TESEQ	CBL 6112D	35240	09/09/2019	09/08/2020
Horn Antenna	Schwarzbeck	BBHA9170	184	12/25/2019	12/24/2020
Horn Antenna	Schwarzbeck	BBHA9120D	1187	01/10/2020	01/09/2021
Loop Antenna	ETS.LINDGREN	6502	143303	04/28/2020	04/27/2021
EMI Test Receiver	R&S	ESU 40	100363	04/29/2020	04/28/2021
Pre-Amplifier	EMC Instruments	EMC330	980096	11/20/2019	11/19/2020
Pre-Amplifier	EMC Instruments	EMC0011830	980199	11/20/2019	11/19/2020
Pre-Amplifier	EMC Instruments	EMC184045B	980135	11/20/2019	11/19/2020
Attenuator	Woken	WATT-218FS-10	RF25	11/20/2019	11/19/2020
Highpass Filter	Micro Tronics	BRM50701-01	G008	11/20/2019	11/19/2020
Coaxial Cable	Huber Suhner	SUCOFLEX 104	MY17388/4	11/20/2019	11/19/2020
Coaxial Cable	Huber Suhner	RG 214/U	W22.03	11/20/2019	11/19/2020

NOTE: N.C.R refers to Not Calibrated Required.

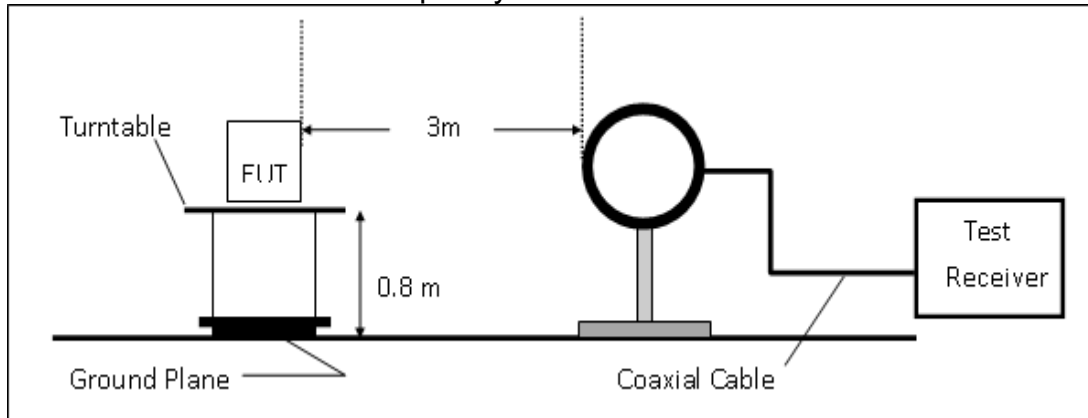
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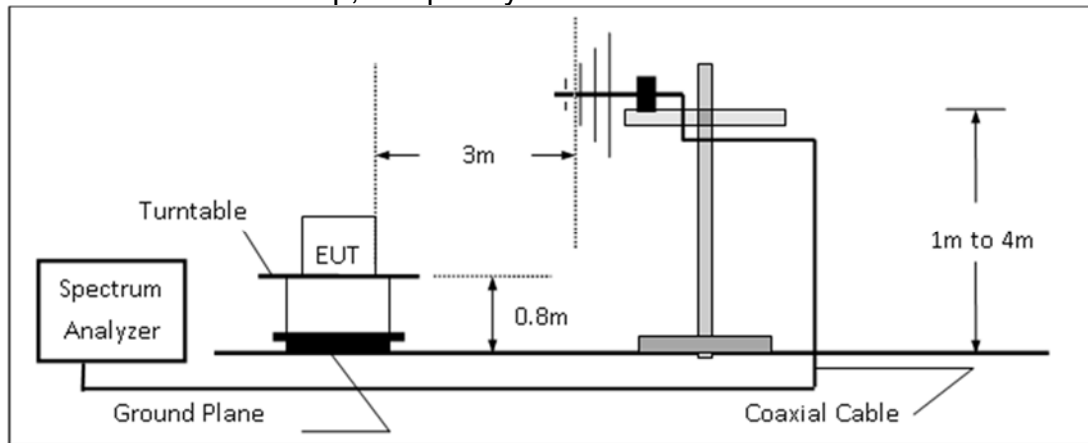
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10.3 Test SET-UP

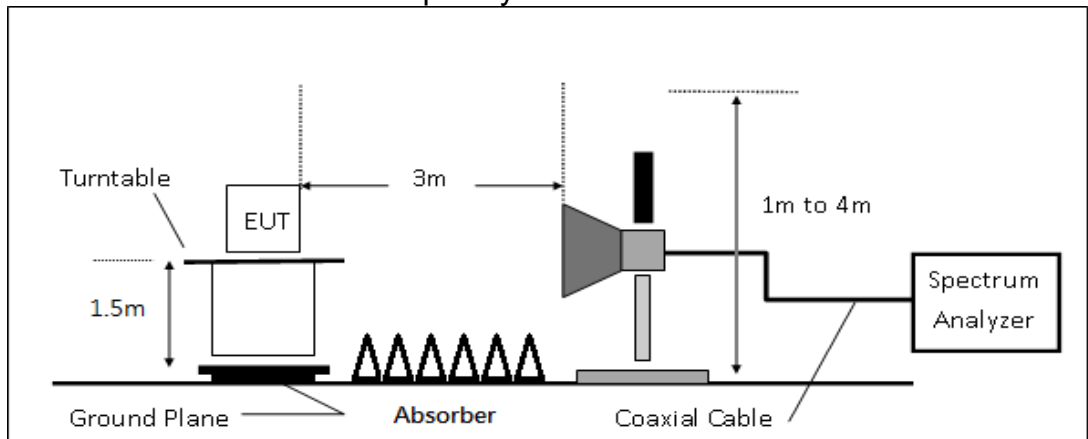
(A) Radiated Emission Test Set-UP Frequency Below 30MHz.



(B) Radiated Emission Test Set-Up, Frequency form 30MHz to 1000MHz



(C) Radiated Emission Test Set-UP Frequency Over 1 GHz



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10.4 Measurement Procedure

10.4.1 Radiated Emission

1. The testing follows the Measurement Procedure of ANSI C63.10:2013.
2. The EUT was placed on a turn table with 0.8m for frequency < 1GHz and 1.5m for frequency > 1GHz above ground plan.
3. The turn table shall rotate 360 degrees to determine the position of maximum emission level.
4. EUT is set 3m away from the receiving antenna which varied from 1m to 4m to find out the highest emissions.
5. Set the spectrum analyzer as RBW=120 kHz and VBW=300 kHz for Peak Detector (PK) and Quasi-peak (QP) at frequency below 1 GHz.
6. Set the spectrum analyzer as RBW=1 MHz, VBW=3 MHz for Peak Detector at frequency above 1 GHz.
7. Set the spectrum analyzer as RBW=1 MHz, VBW=10 Hz (Duty cycle > 98%) or VBW ≥ 1/T (Duty cycle < 98%) for Average Detector at frequency above 1 GHz.
8. When measurement procedures for electric field radiated emissions above 1 GHz the EUT measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” is still within the 3dB illumination BW of the measurement antenna.
9. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
10. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. On spectrum, change spectrum mode in linear display mode, and reduce VBW = 10Hz if average reading is measured.
11. Repeat above procedures until all default test channel measured were complete.

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10.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF + CL - AG$$

Where *FS* = Field Strength

CL = Cable Attenuation Factor (Cable Loss)

RA = Reading Amplitude

AG = Amplifier Gain

AF = Antenna Factor

The limit of the emission level is expressed in dBuV/m, which converts $20 \cdot \log(uV/m)$

Actual FS(dBμV/m) = SPA. Reading level(dBμV) + Factor(dB)

Factor(dB) = Antenna Factor(dBμV/m) + Cable Loss(dB) – Pre_Amplifier Gain(dB)

10.6 Test Results of Radiated Spurious Emissions form 9 kHz to 30 MHz

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit per 15.31(o) was not reported.

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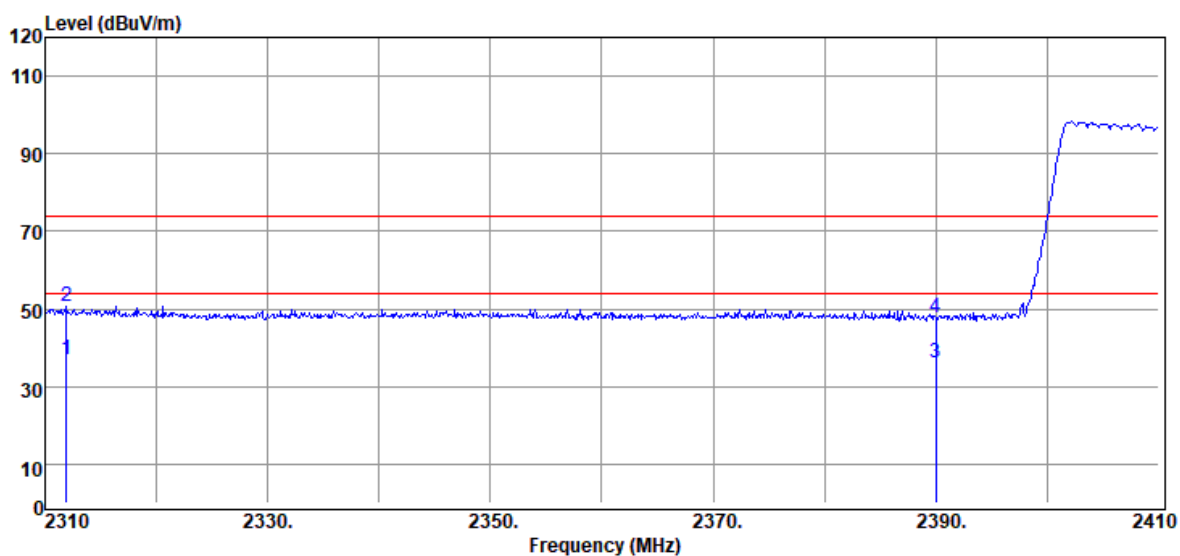
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10.7 Measurement Result:

10.7.1 Radiated Bandedge Result (Hopping Mode)

Report Number	:E2/2020/70006	Test Site	:966 Chamber C
Operation Mode	:BT BR Hopping	Test Date	:2020-08-17
Test Frequency	:2402 MHz	Temp./Humi.	:21.9/62
Test Mode	:BE CH LOW	Antenna Pol.	:VERTICAL
EUT Pol	:NB Plane	Engineer	:Enzo
Ant Path / EUT	:Config 1		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2311.90	Average	33.27	3.61	36.88	54.00	-17.12
2311.90	Peak	46.99	3.61	50.60	74.00	-23.40
2390.00	Average	32.44	3.76	36.20	54.00	-17.80
2390.00	Peak	43.90	3.76	47.66	74.00	-26.34

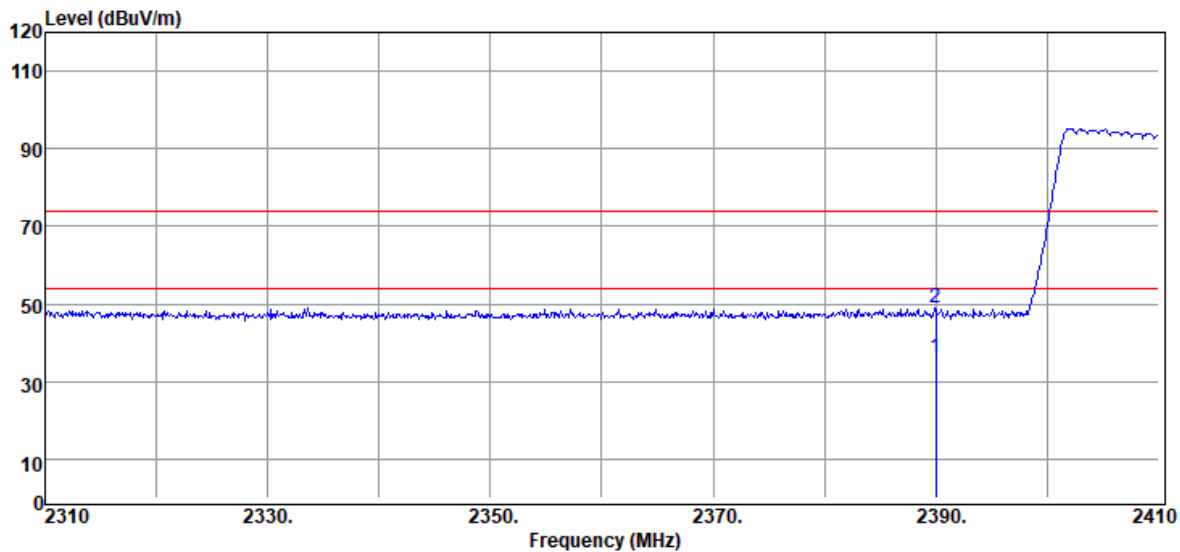
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Report Number :E2/2020/70006
Operation Mode :BT BR Hopping
Test Frequency :2402 MHz
Test Mode :BE CH LOW
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2390.00	Average	32.51	3.76	36.27	54.00	-17.73
2390.00	Peak	45.21	3.76	48.97	74.00	-25.03

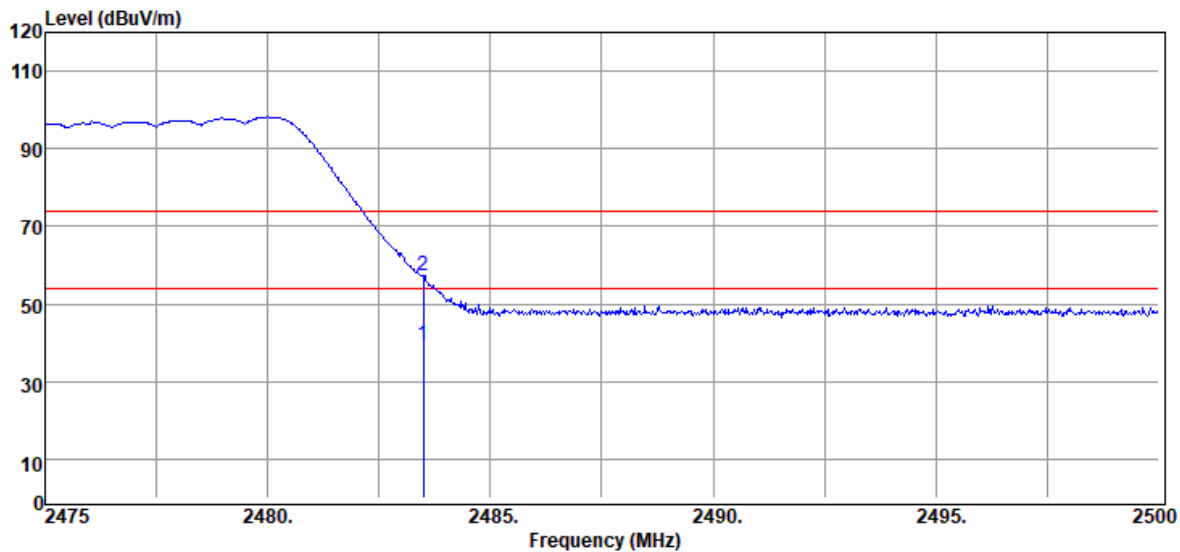
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Report Number :E2/2020/70006
Operation Mode :BT BR Hopping
Test Frequency :2480 MHz
Test Mode :BE CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :VERTICAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Average	35.18	4.42	39.60	54.00	-14.40
2483.50	Peak	52.98	4.42	57.40	74.00	-16.60

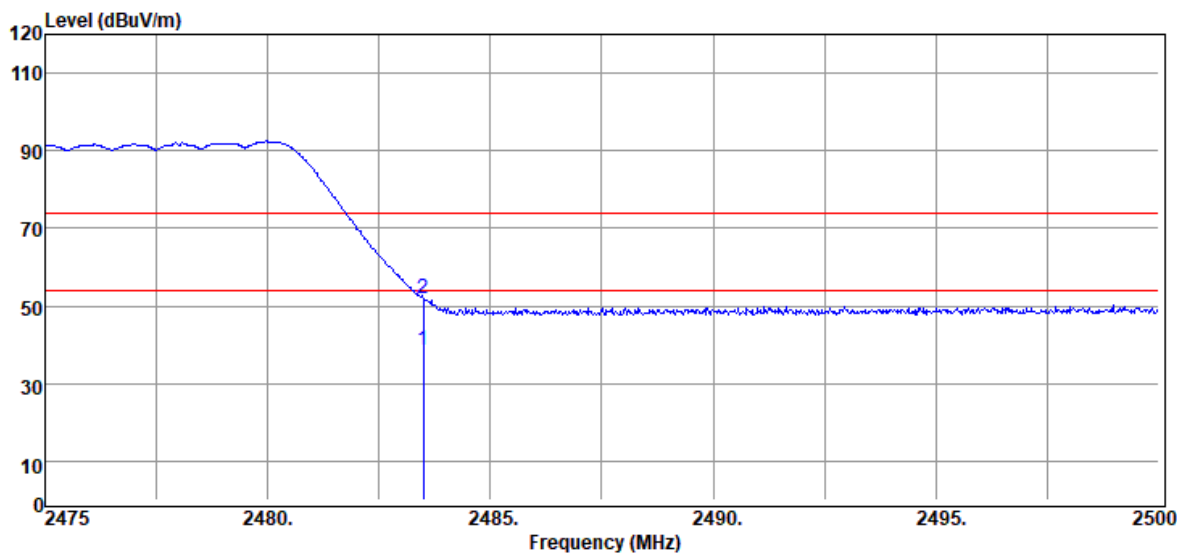
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Report Number :E2/2020/70006
Operation Mode :BT BR Hopping
Test Frequency :2480 MHz
Test Mode :BE CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Average	34.27	4.42	38.69	54.00	-15.31
2483.50	Peak	47.52	4.42	51.94	74.00	-22.06

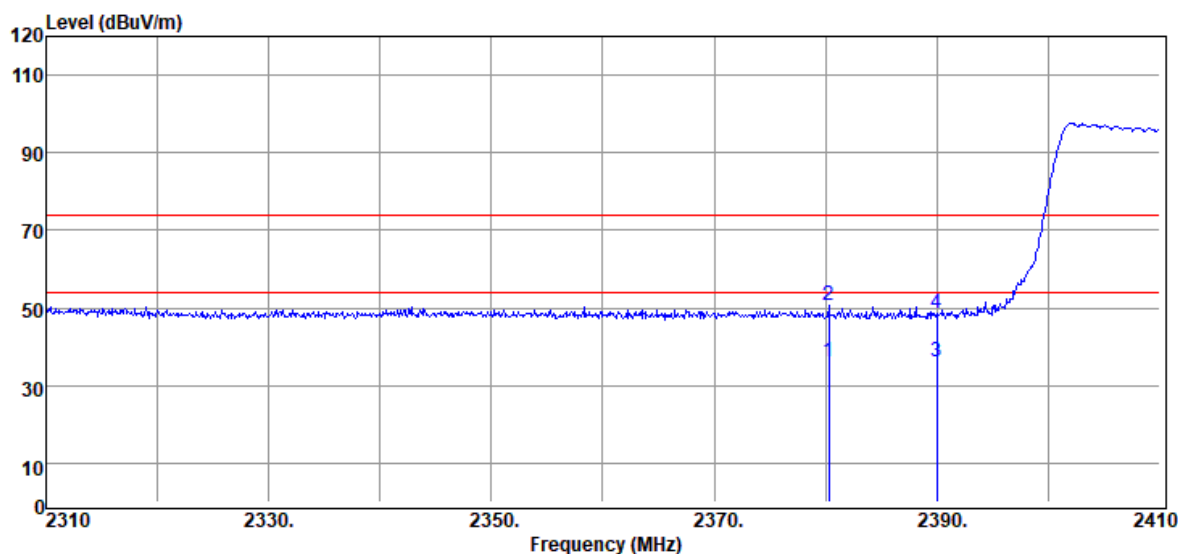
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Report Number :E2/2020/70006
Operation Mode :BT EDR Hopping
Test Frequency :2402 MHz
Test Mode :BE CH LOW
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-18
Temp./Humi. :22.4/64
Antenna Pol. :VERTICAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2380.30	Average	32.58	3.74	36.32	54.00	-17.68
2380.30	Peak	46.83	3.74	50.57	74.00	-23.43
2390.00	Average	32.48	3.76	36.24	54.00	-17.76
2390.00	Peak	44.74	3.76	48.50	74.00	-25.50

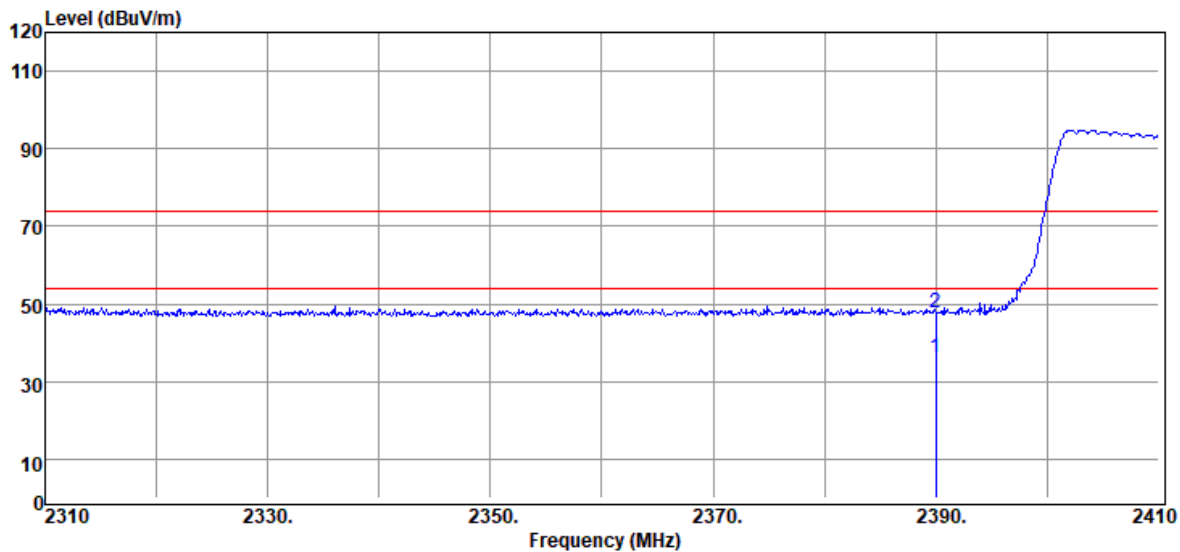
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Report Number :E2/2020/70006
Operation Mode :BT EDR Hopping
Test Frequency :2402 MHz
Test Mode :BE CH LOW
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-18
Temp./Humi. :22.4/64
Antenna Pol. :HORIZONTAL
Engineer :Enzo

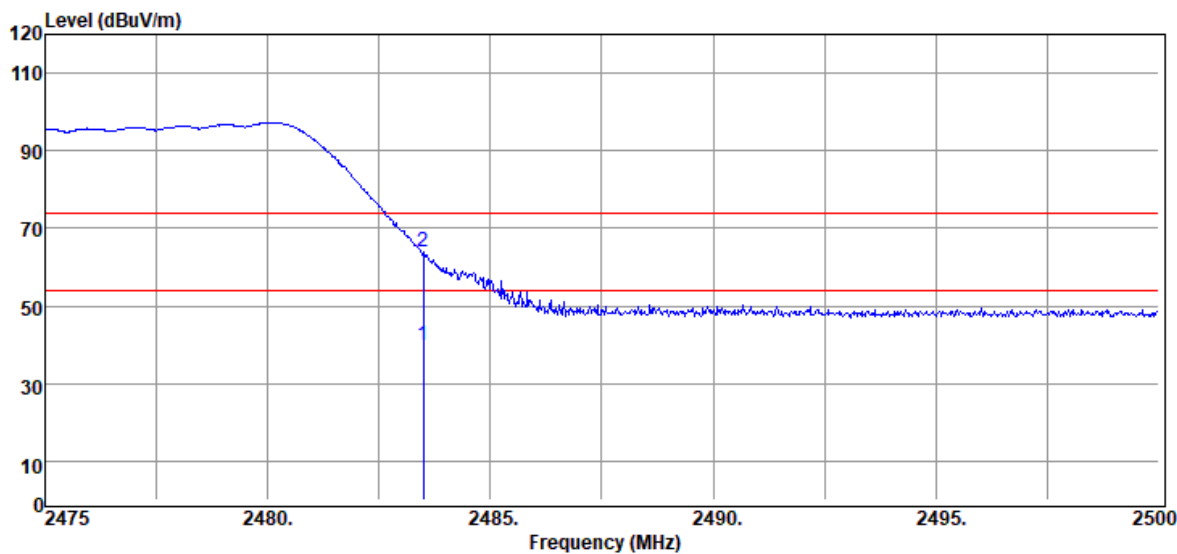


Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2390.00	Average	32.57	3.76	36.33	54.00	-17.67
2390.00	Peak	44.03	3.76	47.79	74.00	-26.21

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Report Number	:E2/2020/70006	Test Site	:966 Chamber C
Operation Mode	:BT EDR Hopping	Test Date	:2020-08-17
Test Frequency	:2480 MHz	Temp./Humi.	:21.9/62
Test Mode	:BE CH HIGH	Antenna Pol.	:VERTICAL
EUT Pol	:NB Plane	Engineer	:Enzo
Ant Path / EUT	:Config 1		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Average	35.42	4.42	39.84	54.00	-14.16
2483.50	Peak	59.69	4.42	64.11	74.00	-9.89

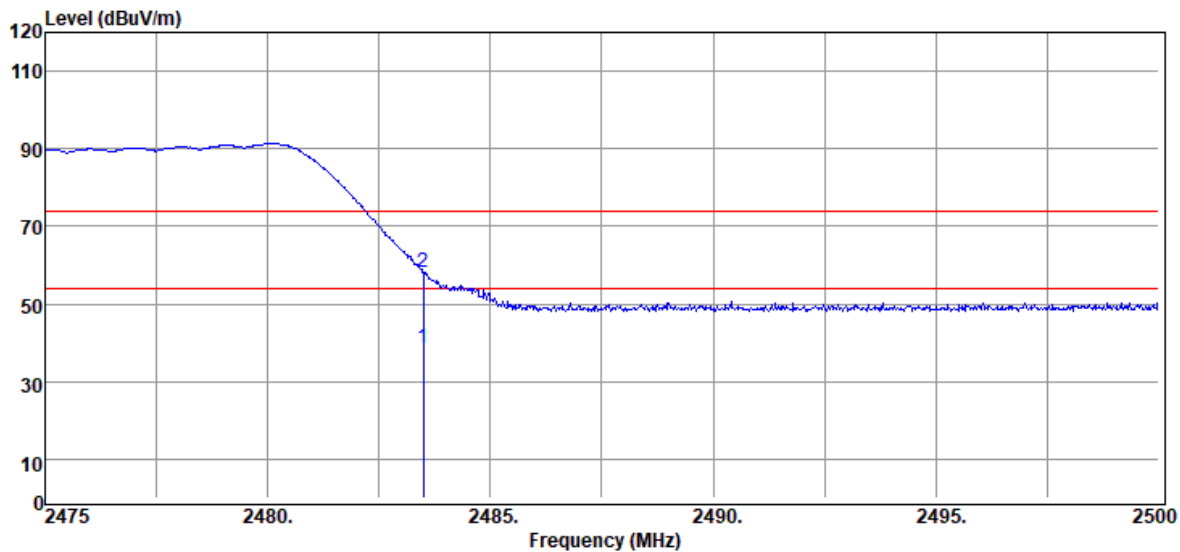
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Report Number :E2/2020/70006
Operation Mode :BT EDR Hopping
Test Frequency :2480 MHz
Test Mode :BE CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dB μ V	Factor dB	Actual FS dB μ V/m	Limit @3m dB μ V/m	Margin dB
2483.50	Average	34.24	4.42	38.66	54.00	-15.34
2483.50	Peak	53.86	4.42	58.28	74.00	-15.72

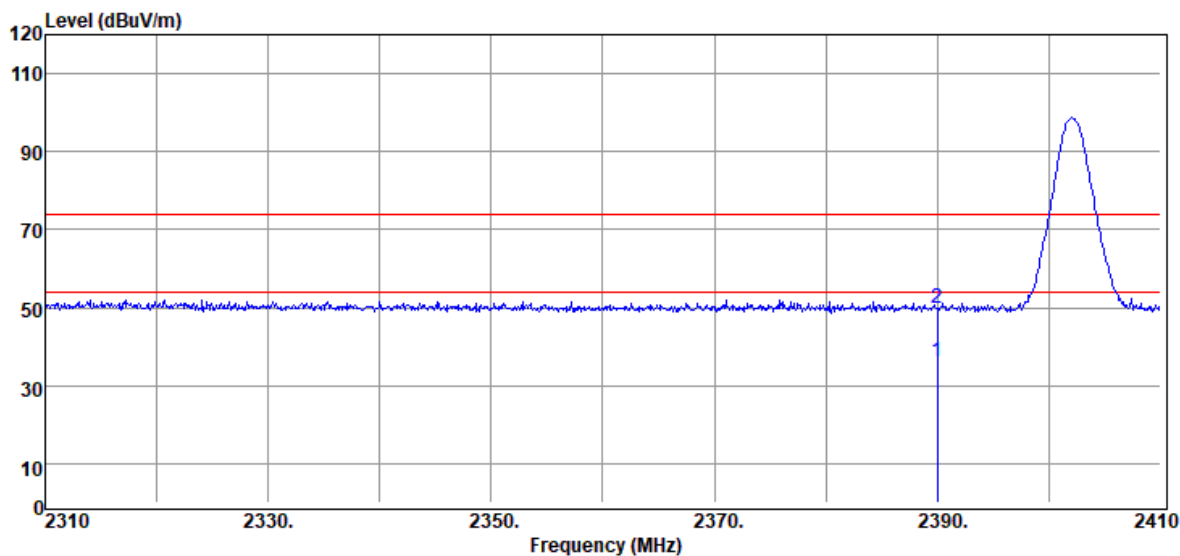
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10.7.2 Radiated Bandedge Result (Non-Hopping Mode)

Report Number	:E2/2020/70006	Test Site	:966 Chamber C
Operation Mode	:BT BR	Test Date	:2020-08-17
Test Frequency	:2402 MHz	Temp./Humi.	:21.9/62
Test Mode	:BE CH LOW	Antenna Pol.	:VERTICAL
EUT Pol	:NB Plane	Engineer	:Enzo
Ant Path / EUT	:Config 1		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2390.00	Average	32.38	3.76	36.14	54.00	-17.86
2390.00	Peak	46.23	3.76	49.99	74.00	-24.01

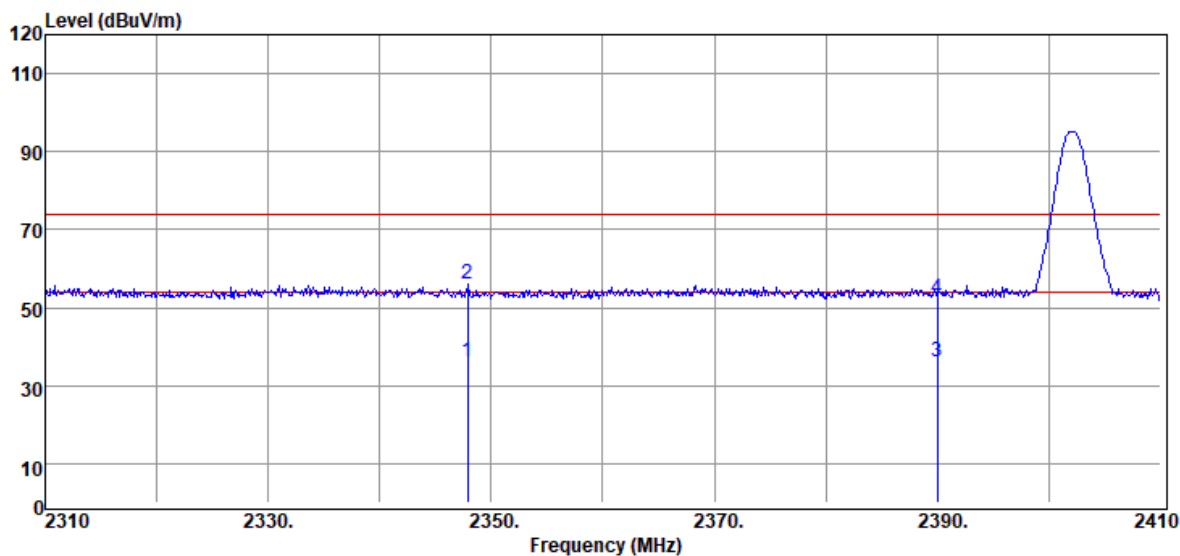
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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2402 MHz
Test Mode :BE CH LOW
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2347.90	Average	32.27	3.69	35.96	54.00	-18.04
2347.90	Peak	52.31	3.69	56.00	74.00	-18.00
2390.00	Average	32.41	3.76	36.17	54.00	-17.83
2390.00	Peak	48.63	3.76	52.39	74.00	-21.61

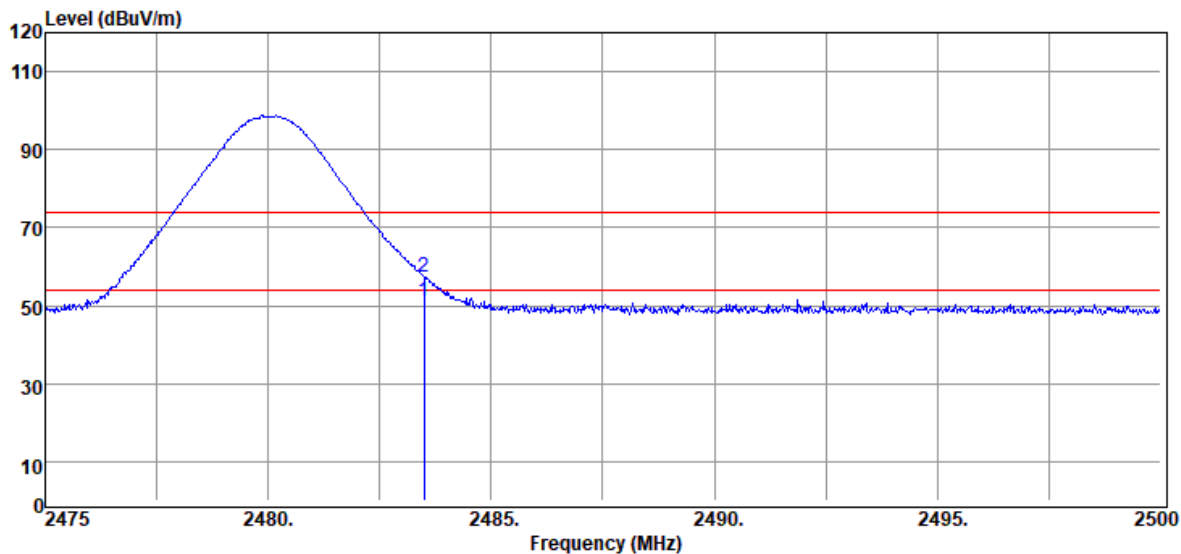
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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2480 MHz
Test Mode :BE CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :VERTICAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Average	46.49	4.42	50.91	54.00	-3.09
2483.50	Peak	52.92	4.42	57.34	74.00	-16.66

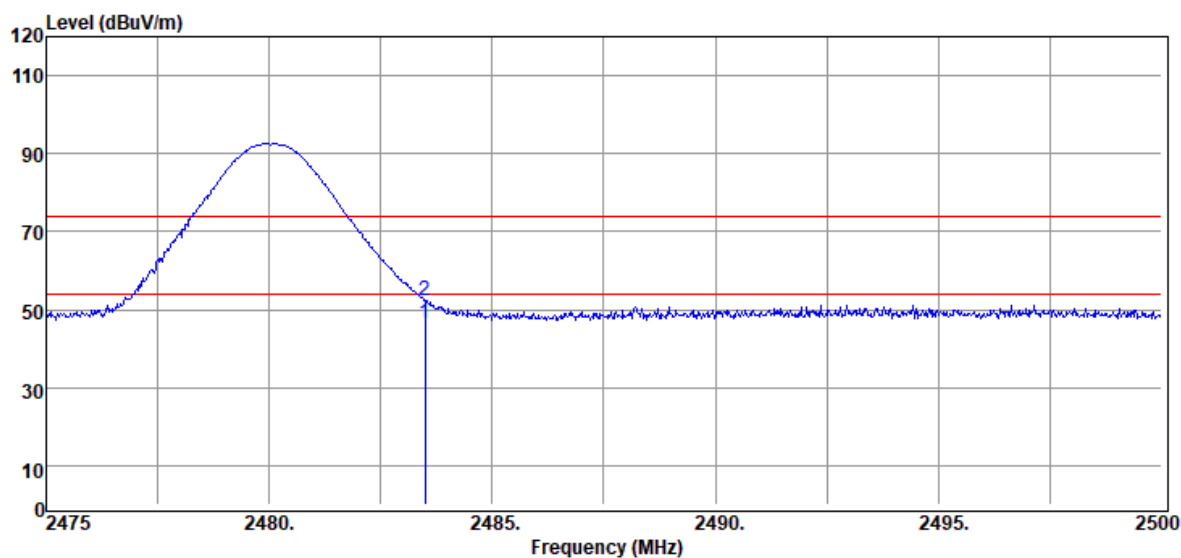
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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2480 MHz
Test Mode :BE CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Average	42.14	4.42	46.56	54.00	-7.44
2483.50	Peak	47.71	4.42	52.13	74.00	-21.87

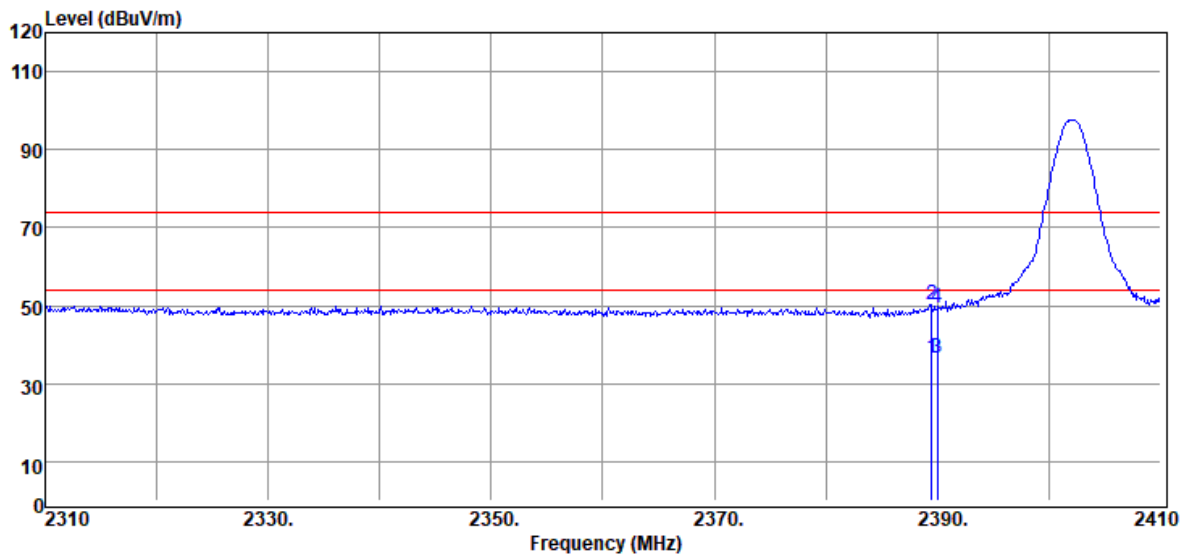
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Report Number :E2/2020/70006
Operation Mode :BT EDR
Test Frequency :2402 MHz
Test Mode :BE CH LOW
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :VERTICAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2389.50	Average	32.71	3.76	36.47	54.00	-17.53
2389.50	Peak	46.33	3.76	50.09	74.00	-23.91
2390.00	Average	32.73	3.76	36.49	54.00	-17.51
2390.00	Peak	45.78	3.76	49.54	74.00	-24.46

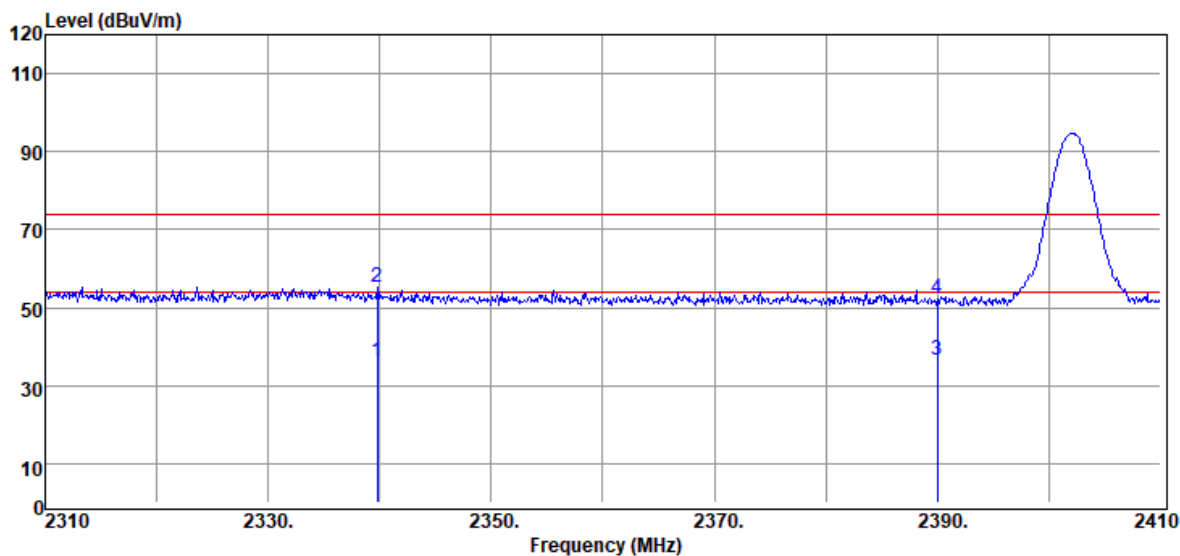
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Report Number :E2/2020/70006
Operation Mode :BT EDR
Test Frequency :2402 MHz
Test Mode :BE CH LOW
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2339.80	Average	32.36	3.67	36.03	54.00	-17.97
2339.80	Peak	51.49	3.67	55.16	74.00	-18.84
2390.00	Average	32.59	3.76	36.35	54.00	-17.65
2390.00	Peak	48.42	3.76	52.18	74.00	-21.82

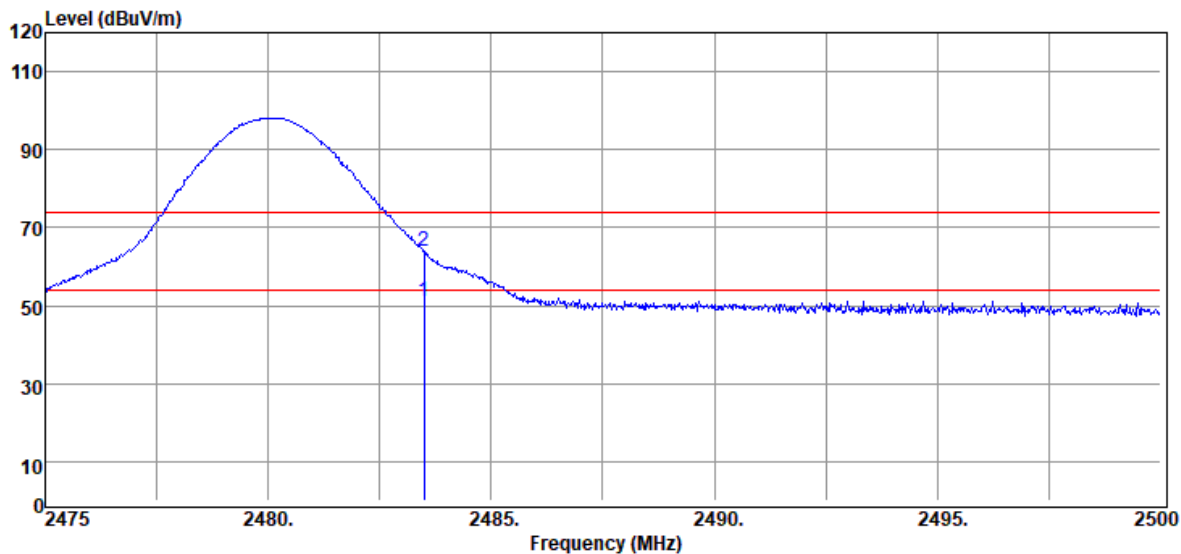
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Report Number :E2/2020/70006
Operation Mode :BT EDR
Test Frequency :2480 MHz
Test Mode :BE CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :VERTICAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Average	46.52	4.42	50.94	54.00	-3.06
2483.50	Peak	59.48	4.42	63.90	74.00	-10.10

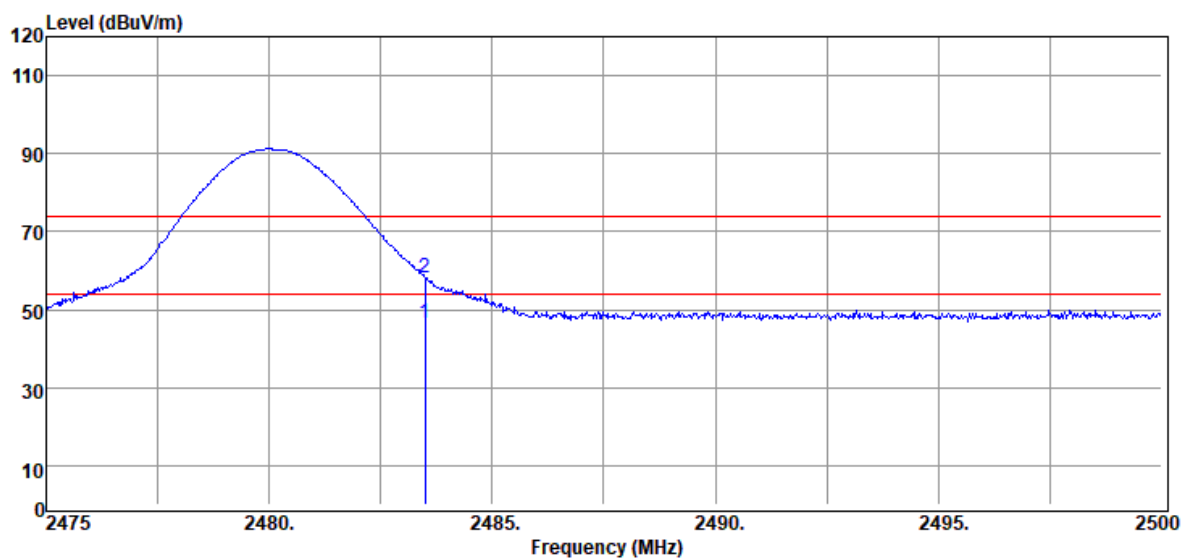
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Report Number :E2/2020/70006
Operation Mode :BT EDR
Test Frequency :2480 MHz
Test Mode :BE CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :21.9/62
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
2483.50	Average	42.23	4.42	46.65	54.00	-7.35
2483.50	Peak	53.70	4.42	58.12	74.00	-15.88

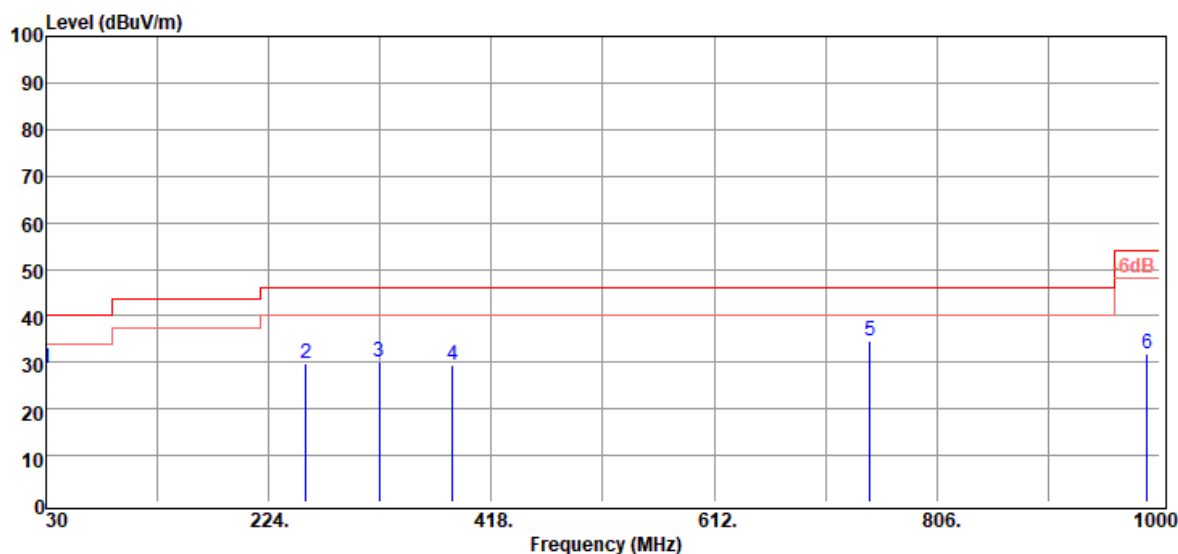
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10.7.3 Radiated Spurious Emission form 30MHz to 1000MHz:

Report Number	:E2/2020/70006	Test Site	:966 Chamber C
Operation Mode	:BT BR	Test Date	:2020-08-17
Test Frequency	:2441 MHz	Temp./Humi.	:23.1/58
Test Mode	:TX CH MID	Antenna Pol.	:VERTICAL
EUT Pol	:NB Plane	Engineer	:Ashton
Ant Path / EUT	:Config 1		



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBuV	Factor dB	Actual FS dBuV/m	Limit @3m dBuV/m	Margin dB
30.00	Peak	32.22	-3.33	28.89	40.00	-11.11
256.01	Peak	40.59	-10.80	29.79	46.00	-16.21
320.03	Peak	39.88	-9.66	30.22	46.00	-15.78
384.05	Peak	37.46	-8.03	29.43	46.00	-16.57
747.80	Peak	36.32	-1.67	34.65	46.00	-11.35
989.33	Peak	30.03	1.75	31.78	54.00	-22.22

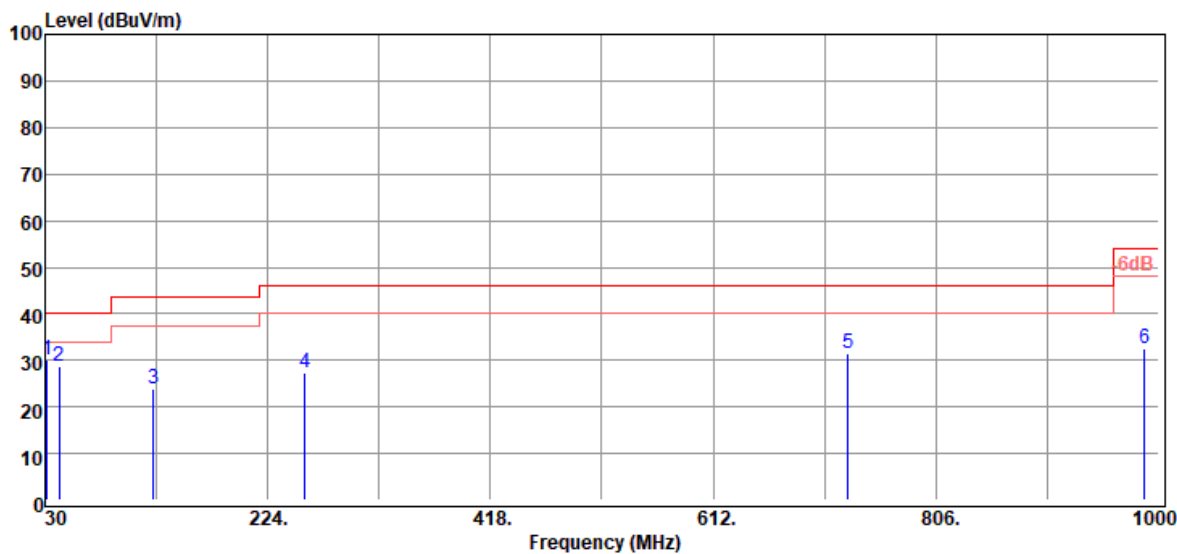
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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2441 MHz
Test Mode :TX CH MID
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-17
Temp./Humi. :23.1/58
Antenna Pol. :HORIZONTAL
Engineer :Ashton



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
31.94	Peak	34.32	-4.26	30.06	40.00	-9.94
42.61	Peak	39.29	-10.46	28.83	40.00	-11.17
124.09	Peak	36.71	-12.85	23.86	43.50	-19.64
256.01	Peak	38.24	-10.80	27.44	46.00	-18.56
729.37	Peak	33.56	-2.08	31.48	46.00	-14.52
987.39	Peak	30.93	1.76	32.69	54.00	-21.31

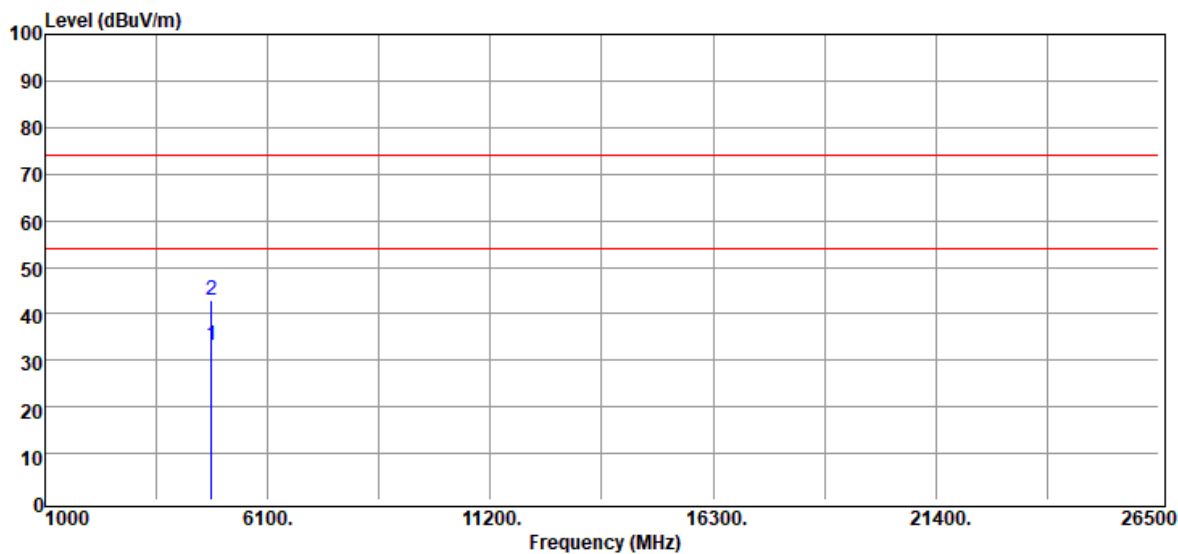
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10.7.4 Radiated Spurious Emission above 1 GHz:

Report Number	:E2/2020/70006	Test Site	:966 Chamber C
Operation Mode	:BT BR	Test Date	:2020-08-18
Test Frequency	:2402 MHz	Temp./Humi.	:22.6/67
Test Mode	:TX CH LOW	Antenna Pol.	:VERTICAL
EUT Pol	:NB Plane	Engineer	:Enzo
Ant Path / EUT	:Config 1		



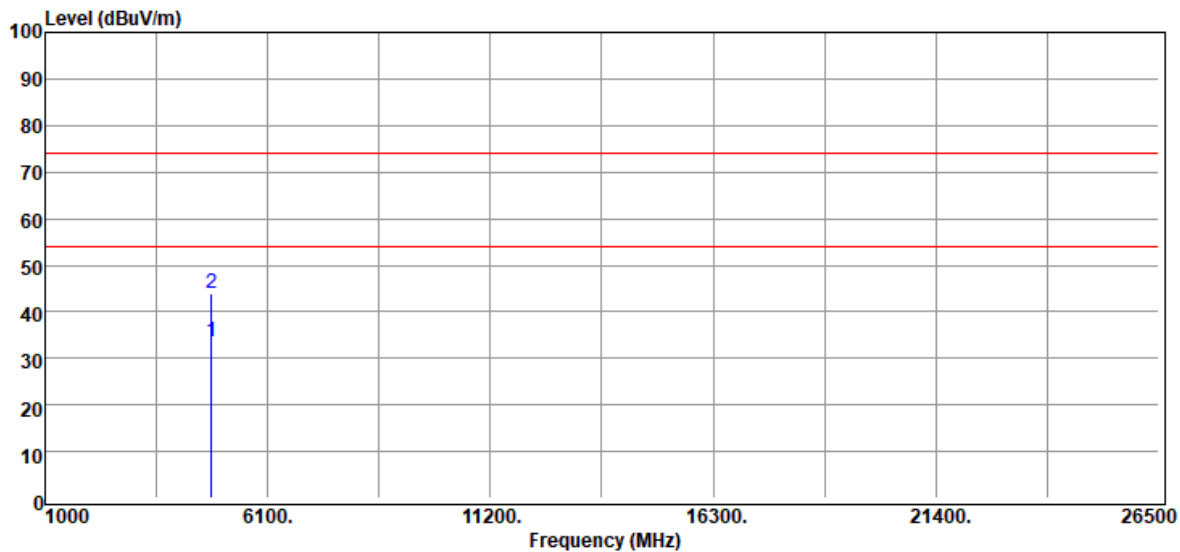
Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4804.00	Average	19.03	14.07	33.10	54.00	-20.90
4804.00	Peak	28.77	14.07	42.77	74.00	-31.23

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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2402 MHz
Test Mode :TX CH LOW
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-18
Temp./Humi. :22.6/67
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4804.00	Average	19.44	14.07	33.51	54.00	-20.49
4804.00	Peak	29.77	14.07	43.84	74.00	-30.16

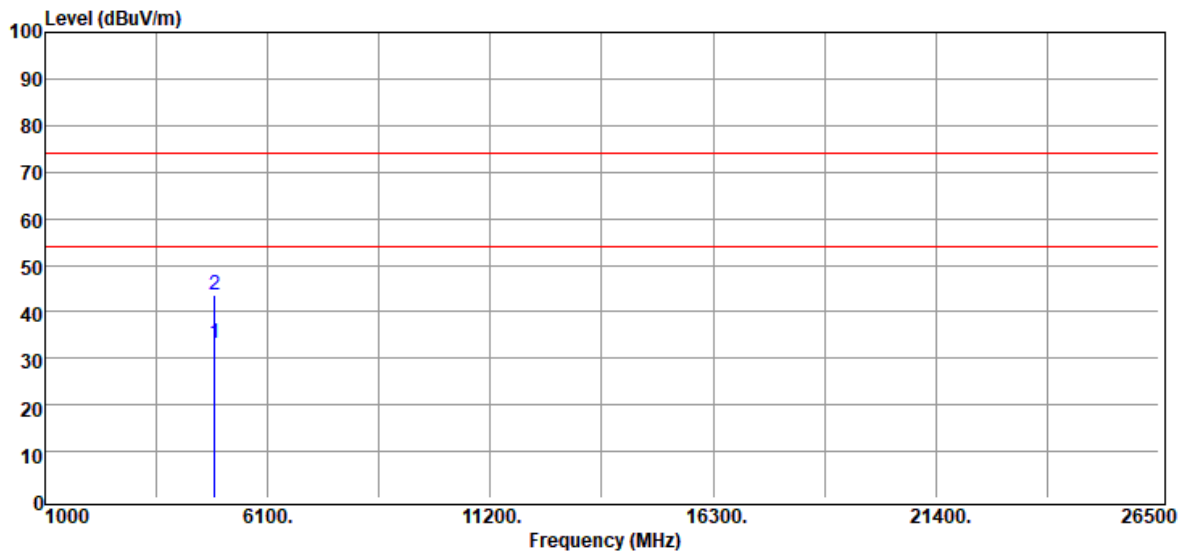
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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2441 MHz
Test Mode :TX CH MID
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-18
Temp./Humi. :22.6/67
Antenna Pol. :VERTICAL
Engineer :Enzo



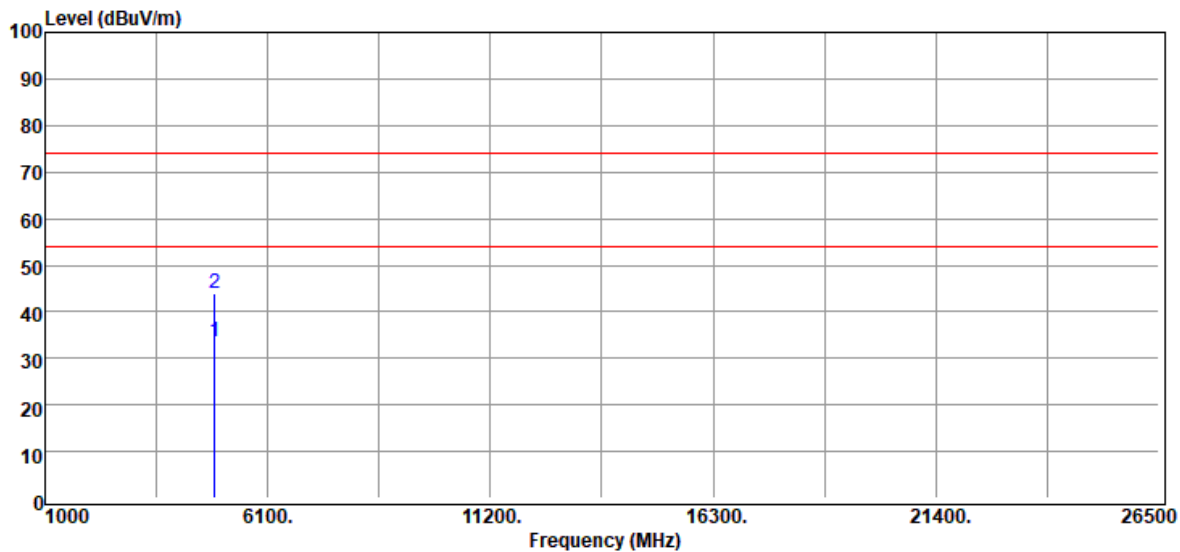
Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4882.00	Average	19.11	14.21	33.32	54.00	-20.68
4882.00	Peak	29.54	14.21	43.75	74.00	-30.25

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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2441 MHz
Test Mode :TX CH MID
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-18
Temp./Humi. :22.6/67
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4882.00	Average	19.45	14.21	33.66	54.00	-20.34
4882.00	Peak	29.66	14.21	43.87	74.00	-30.13

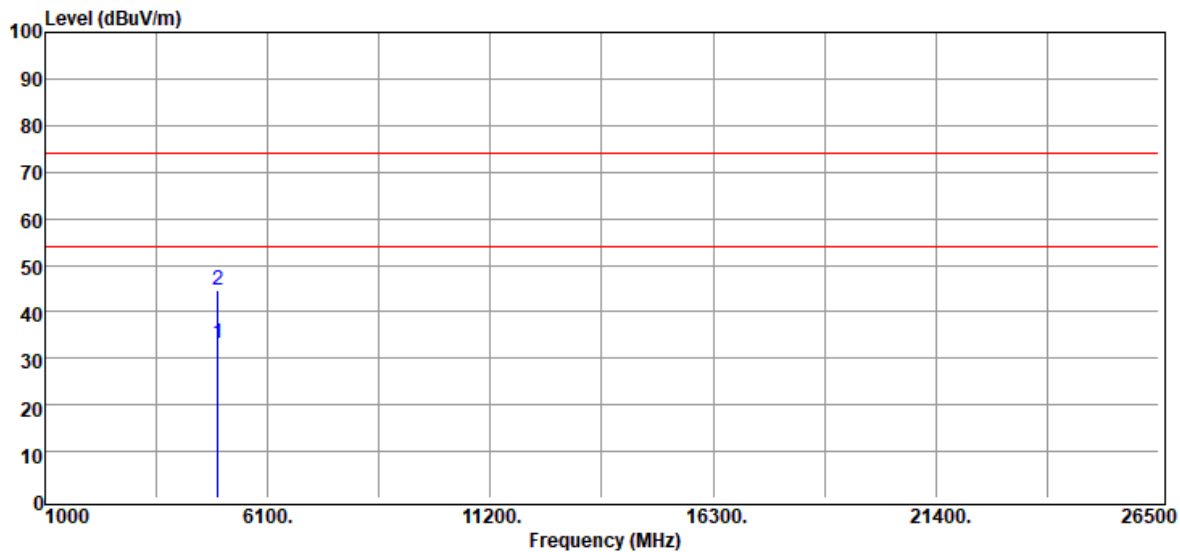
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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2480 MHz
Test Mode :TX CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-18
Temp./Humi. :22.6/67
Antenna Pol. :VERTICAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4960.00	Average	19.21	14.13	33.34	54.00	-20.66
4960.00	Peak	30.53	14.13	44.66	74.00	-29.34

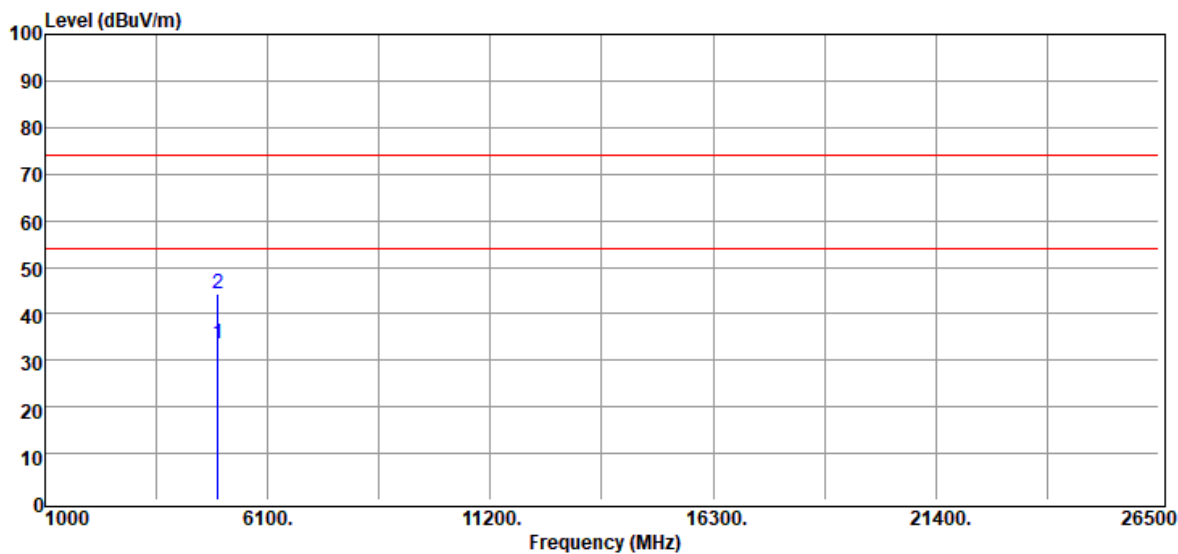
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Report Number :E2/2020/70006
Operation Mode :BT BR
Test Frequency :2480 MHz
Test Mode :TX CH HIGH
EUT Pol :NB Plane
Ant Path / EUT :Config 1

Test Site :966 Chamber C
Test Date :2020-08-18
Temp./Humi. :22.6/67
Antenna Pol. :HORIZONTAL
Engineer :Enzo



Freq. MHz	Detector Mode PK/QP/AV	Spectrum Reading Level dBμV	Factor dB	Actual FS dBμV/m	Limit @3m dBμV/m	Margin dB
4960.00	Average	19.34	14.13	33.47	54.00	-20.53
4960.00	Peak	30.19	14.13	44.32	74.00	-29.68

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11 FREQUENCY SEPARATION

11.1 Standard Applicable

Frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25 kHz or the $2/3 \times 20\text{dB}$ bandwidth of the hopping channel, whichever is greater.

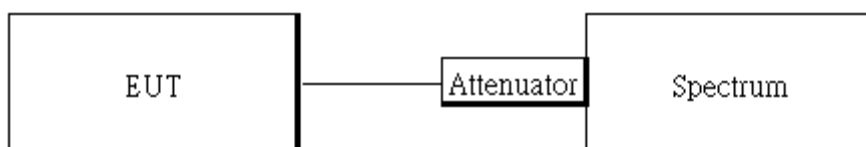
11.2 Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Spectrum Analyzer	KEYSIGHT	N9010A	MY54510568	07/08/2020	07/07/2021
DC Block	PASTERNAK	PE8210	RF256	11/20/2019	11/19/2020
Attenuator	Marvelous	MVE2213-10	RF80	11/20/2019	11/19/2020
IPEX-4 Cable	Woken	00100A1H6460 27	N/A	N/A	N/A

Note: The measurement was taken place with the long duration of the time, and additional equipment list as shown blow indicate those equipment of which has been subject to undertake the calibration in intermediate period of time of the measurement.

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
DC Block	PASTERNAK	PE8210	RF256	11/19/2020	11/18/2021
Attenuator	Marvelous	MVE2213-10	RF80	11/19/2020	11/18/2021

11.3 Test Set-up



11.4 Measurement Procedure

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10:2013.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
4. Set center frequency of spectrum analyzer = middle of hopping channel.
5. Set the spectrum analyzer as RBW, VBW=100 kHz, Adjust Span to 5MHz, Sweep = auto.
6. Max hold. Mark 3 Peaks of hopping channel and record the 3 peaks frequency.

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11.5 Measurement Result

Channel separation (MHz)	Limit	Result
1	≥ 25 kHz or 2/3 times 20dB bandwidth	PASS

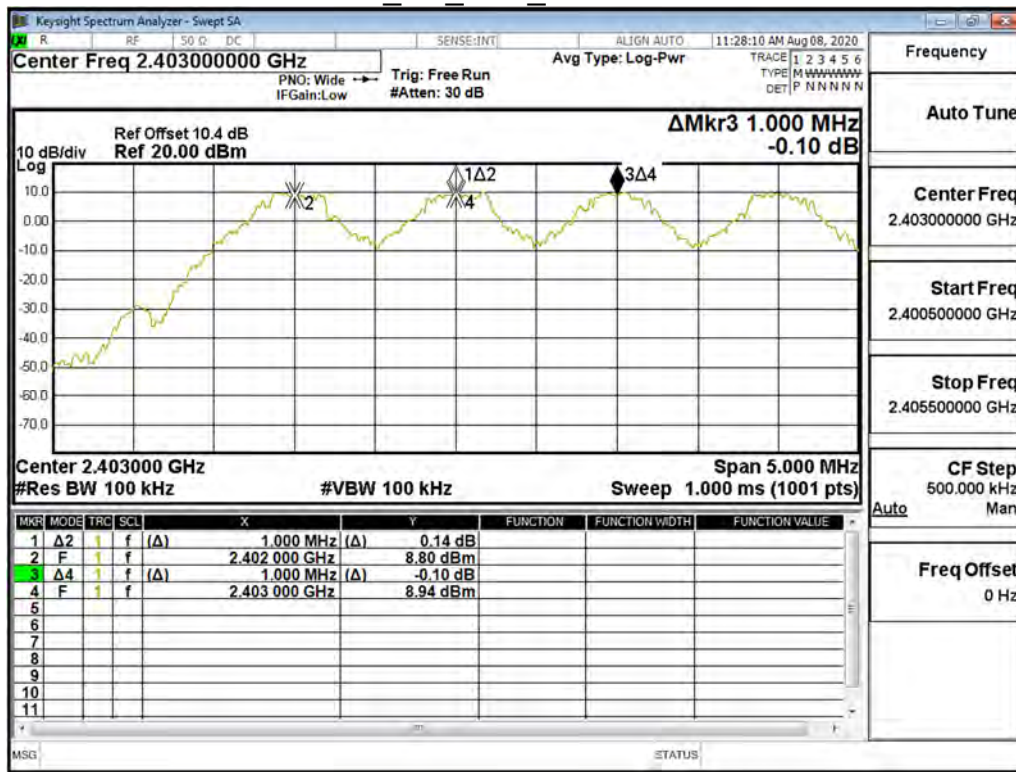
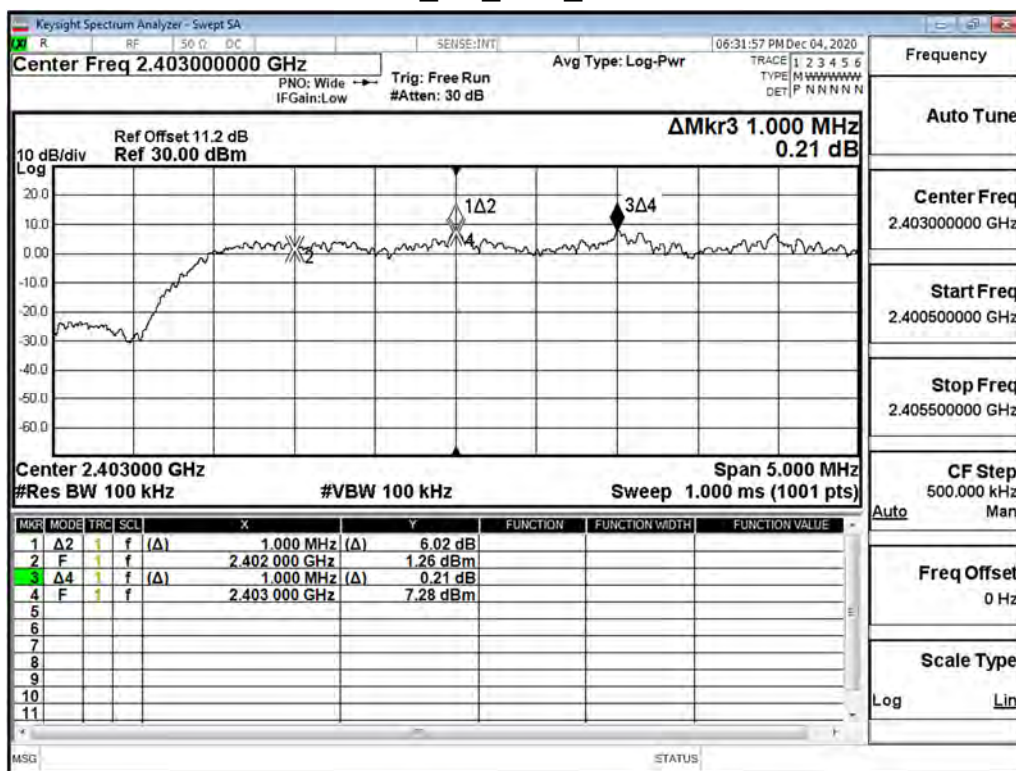
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11.6 Frequency Separation Test Plots

GFSK_1M_DH5_CH0CH1CH2

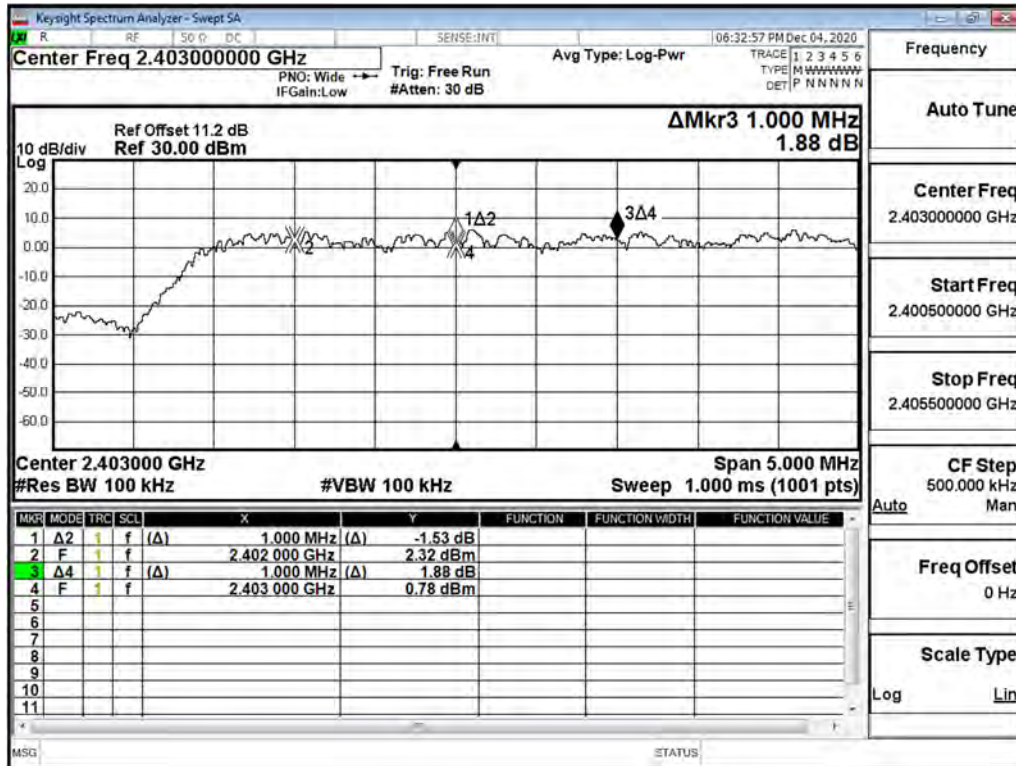

 $\pi/4$ QPSK_2M_DH5_CH0CH1CH2


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8DPSK_3M_DH5_CH0CH1CH2



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12 NUMBER OF HOPPING FREQUENCY

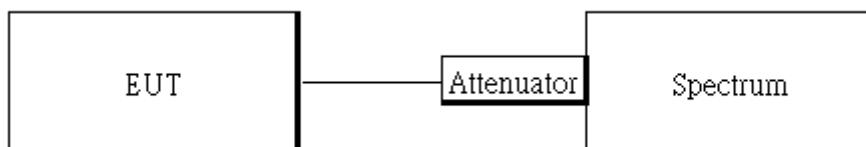
12.1 Standard Applicable

Frequency hopping systems operating in the 2400MHz-2483.5 MHz bands shall use at least 15 hopping frequencies.

12.2 Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Spectrum Analyzer	KEYSIGHT	N9010A	MY54510568	07/08/2020	07/07/2021
DC Block	PASTERNAK	PE8210	RF256	11/20/2019	11/19/2020
Attenuator	Marvelous	MVE2213-10	RF80	11/20/2019	11/19/2020

12.3 Test Set-up



12.4 Measurement Procedure

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10:2013.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
4. Set spectrum analyzer Start=2400MHz, Stop = 2483.5MHz, Sweep = auto.
5. Set the spectrum analyzer as RBW=430kHz, VBW=1.5MHz., Detector = Peak
6. Max hold, view and count how many channel in the band.

12.5 Measurement Result

Tabular Data of Total Channel Number

	Channel Number	Limit
2.4 GHz – 2.441 GHz	40	>15
2.441 GHz – 2.4835 GHz	39	
2.4 GHz ~2.4835 GHz	(40+39) = 79	

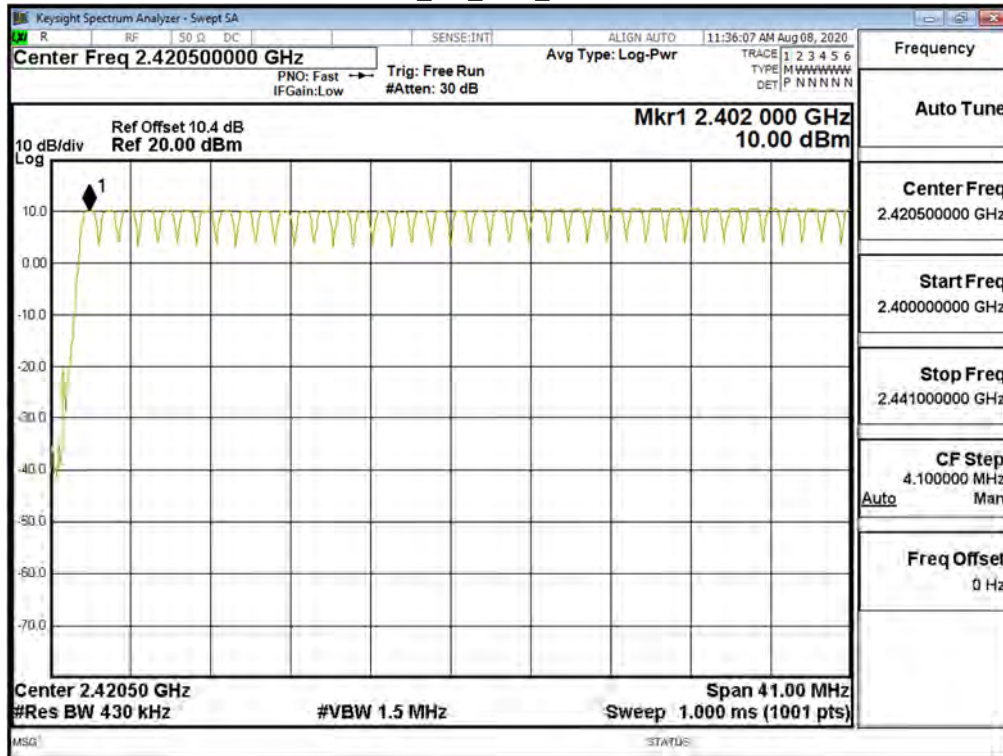
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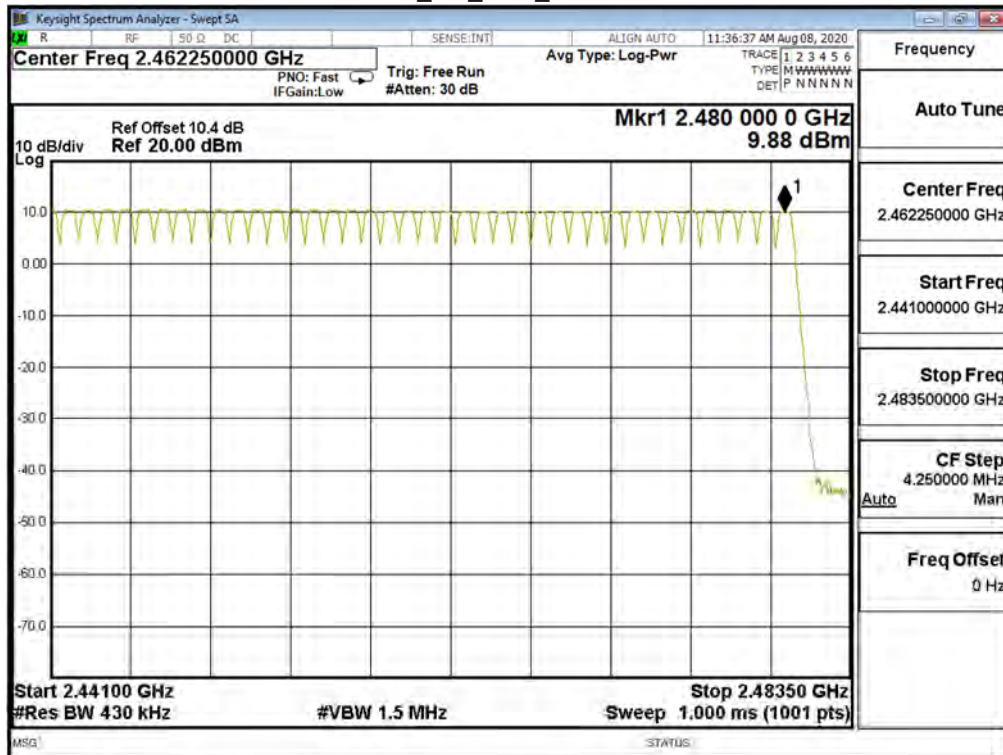
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12.6 Channel Number Test Plots

GFSK_1M_DH5_2400-2441



GFSK_1M_DH5_2441-2480



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13 TIME OF OCCUPANCY (DWELL TIME)

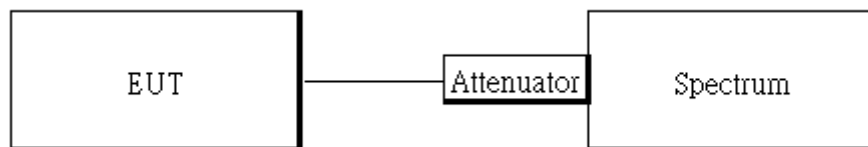
13.1 Standard Applicable

Frequency hopping systems operating in the 2400MHz-2483.5MHz. The average time of occupancy on any frequency shall not greater than 0.4 s within period of 0.4 seconds multiplied by the number of hopping channel employed.

13.2 Measurement Equipment Used

Conducted Emission Test Site					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Spectrum Analyzer	KEYSIGHT	N9010A	MY54510568	07/08/2020	07/07/2021
DC Block	PASTERNAK	PE8210	RF256	11/20/2019	11/19/2020
Attenuator	Marvelous	MVE2213-10	RF80	11/20/2019	11/19/2020
IPEX-4 Cable	Woken	00100A1H64 6027	N/A	N/A	N/A

13.3 Test Set-up



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13.4 Measurement Procedure

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C6310:2015.
3. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
4. Set center frequency of spectrum analyzer = operating frequency.
5. Set the spectrum analyzer as RBW, VBW=1MHz, 3MHz, Span = 0Hz , Detector = Peak, Adjust Sweep = 2~8ms.
6. Repeat above procedures until all frequency of the interest measured were complete.

Formula Deduced: time occupancy of one time slot X Hopping rate / total slot in one channel / total channel that hops X period of working channels.

Where, standard hopping rate is 1600 hops/s, slot in one channel for DH1, DH3, and DH5 is 2, 4, and 6, respectively.

DH1 consists of single time slot of the uplink, and one slot of the downlink Total Slot: 2

DH3 consists of three time slot of the uplink, and one slot of the downlink. Total Slot: 4

DH5 consists of five time slot of the uplink, and one slot of the downlink. Total Slot: 6

In AFH mode, hopping rate is 800 hop/s with 6 slots in 20 hopping channels with channel hopping rate $(800 / 6 / 20)$ in Occupancy Time Limit $(0.4 * 20)$ (S), Hop Over Occupancy Time comes to $(800 / 6 / 20) * (0.4 * 20) = 53.33$

Note: the result of the complete test default channel at 1Mbps is recorded on the test report, 2Mbps, and 3Mbps only records the measurement result at middle channel that reveals no much deviation.

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13.5 Tabular Result of the Measurement

GFSK (1Mbps)

Channel	PACKET TYPE	Measurement Result (ms)	Limit (ms)	1/T (kHz)	VBW setting (kHz)
Low	DH1	123.20	400ms	2.597	3.00
	DH3	262.40	400ms	0.610	1.00
	DH5	308.80	400ms	0.345	1.00
Mid	DH1	121.60	400ms	2.632	3.00
	DH3	262.40	400ms	0.610	1.00
	DH5	308.80	400ms	0.345	1.00
High	DH1	123.20	400ms	2.597	3.00
	DH3	262.40	400ms	0.610	1.00
	DH5	308.80	400ms	0.003	1.00

$\pi/4$ DQPSK (2Mbps)

Channel	PACKET TYPE	Measurement Result (ms)	Limit (ms)	1/T (kHz)	VBW setting (kHz)
Mid	2DH1	124.80	400ms	2.564	3.00
	2DH3	262.40	400ms	0.610	1.00
	2DH5	308.80	400ms	0.345	1.00

8-DPSK (3Mbps)

Channel	PACKET TYPE	Measurement Result (ms)	Limit (ms)	1/T (kHz)	VBW setting (kHz)
Mid	3DH1	124.80	400ms	2.564	3.00
	3DH3	262.40	400ms	0.610	1.00
	3DH5	307.20	400ms	0.347	1.00

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GFSK (1Mbps):

CH Low	DH1 time slot	=	0.385	*	(1600/2/79)	*	31.6	=	123.20	(ms)
	DH3 time slot	=	1.640	*	(1600/4/79)	*	31.6	=	262.40	(ms)
	DH5 time slot	=	2.895	*	(1600/6/79)	*	31.6	=	308.80	(ms)
CH Mid	DH1 time slot	=	0.380	*	(1600/2/79)	*	31.6	=	121.60	(ms)
	DH3 time slot	=	1.640	*	(1600/4/79)	*	31.6	=	262.40	(ms)
	DH5 time slot	=	2.895	*	(1600/6/79)	*	31.6	=	308.80	(ms)
CH High	DH1 time slot	=	0.385	*	(1600/2/79)	*	31.6	=	123.20	(ms)
	DH3 time slot	=	1.640	*	(1600/4/79)	*	31.6	=	262.40	(ms)
	DH5 time slot	=	2.895	*	(1600/6/79)	*	31.6	=	308.80	(ms)

 $\pi/4$ -DQPSK (2Mbps):

CH Mid	2DH1 time slot	=	0.390	*	(1600/2/79)	*	31.6	=	124.80	(ms)
	2DH3 time slot	=	1.640	*	(1600/4/79)	*	31.6	=	262.40	(ms)
	2DH5 time slot	=	2.895	*	(1600/6/79)	*	31.6	=	308.80	(ms)

8-DPSK (3Mbps):

CH Mid	3DH1 time slot	=	0.390	*	(1600/2/79)	*	31.6	=	124.80	(ms)
	3DH3 time slot	=	1.640	*	(1600/4/79)	*	31.6	=	262.40	(ms)
	3DH5 time slot	=	2.880	*	(1600/6/79)	*	31.6	=	307.20	(ms)

A period time = 0.4 (s) * 79 = 31.6 (s)

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GFSK (1Mbps) for AFH Mode			
Hopping Channel Number	PACKET TYPE	Measurement Result (ms)	Limit (ms)
20	DH5	154.40	400ms
$\pi/4$ DQPSK (2Mbps) for AFH Mode			
Hopping Channel Number	PACKET TYPE	Measurement Result (ms)	Limit (ms)
20	2DH5	154.40	400ms
8-DPSK (3Mbps) for AFH Mode			
Hopping Channel Number	PACKET TYPE	Measurement Result (ms)	Limit (ms)
20	3DH5	153.60	400ms

13.6 Measurement Result

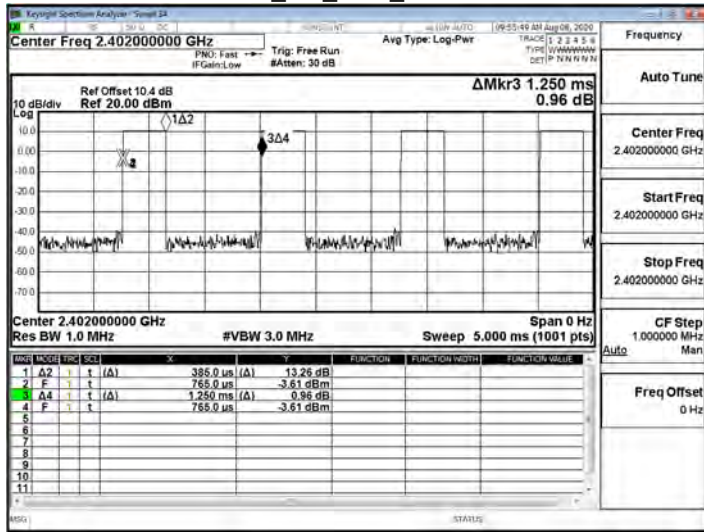
Note: Refer to next page for plots.

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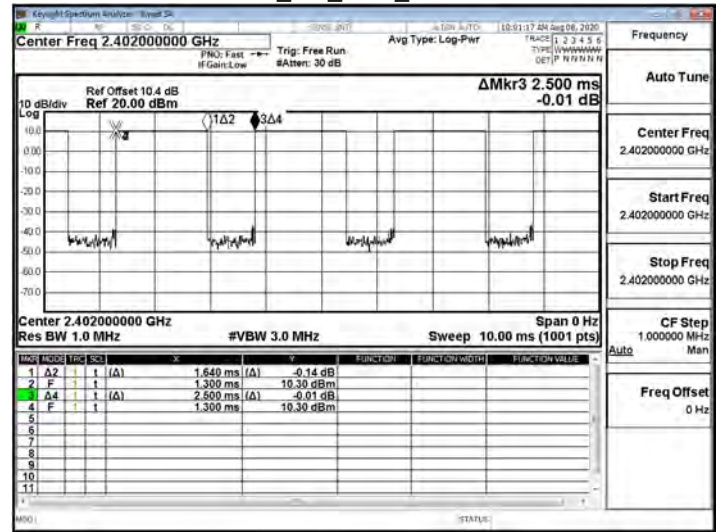
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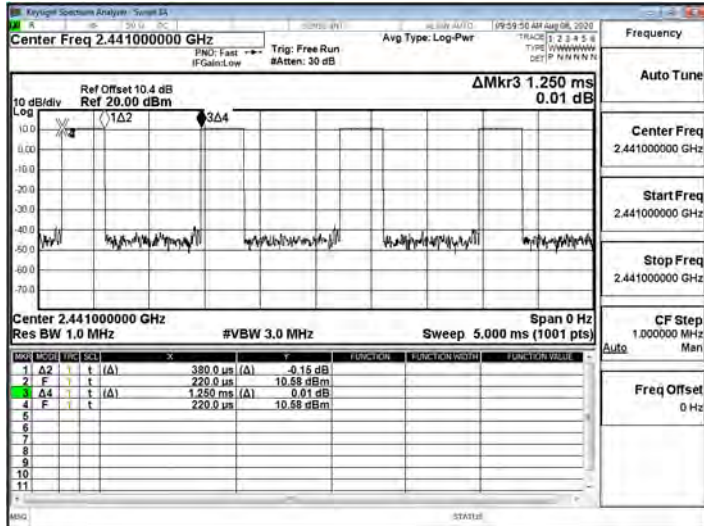
GFSK_1M_DH1_2402MHz



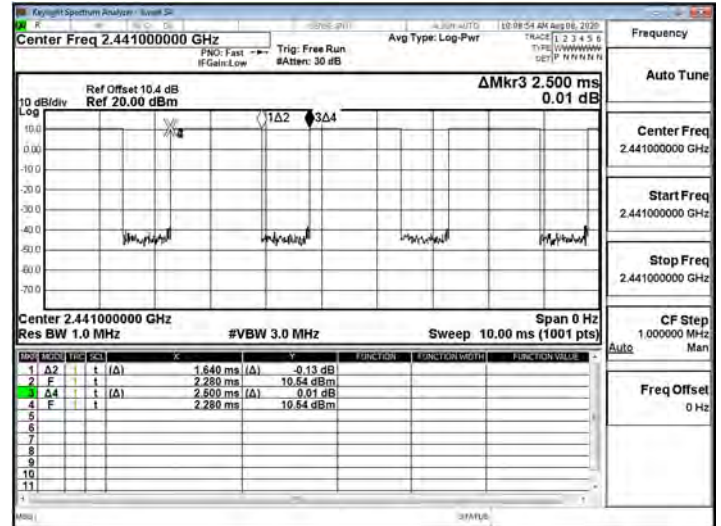
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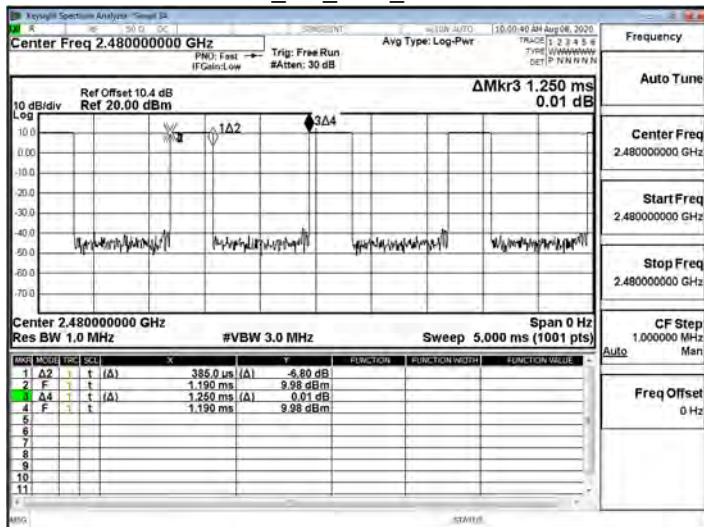
GFSK_1M_DH1_2441MHz



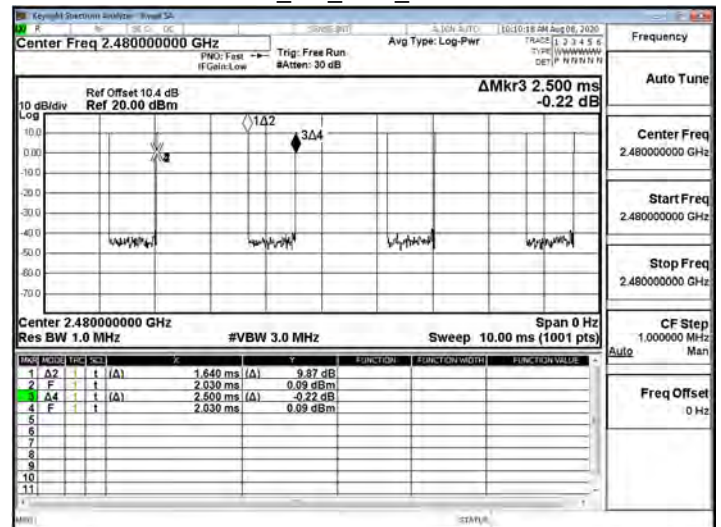
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GFSK_1M_DH1_2480MHz



GFSK_1M_DH3_2480MHz

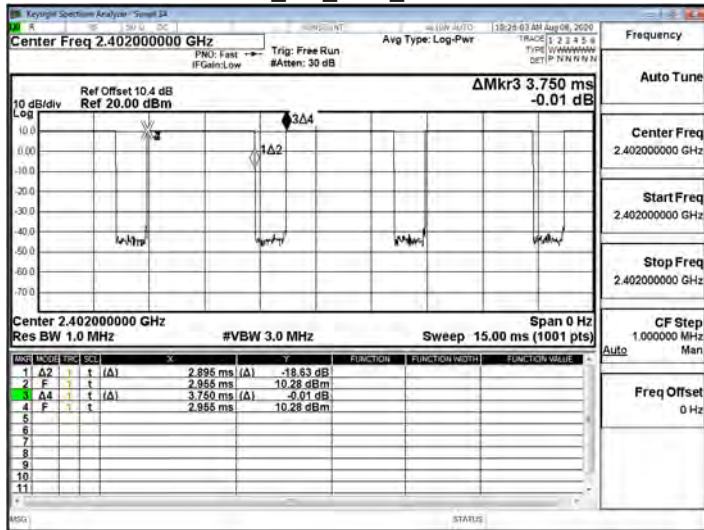
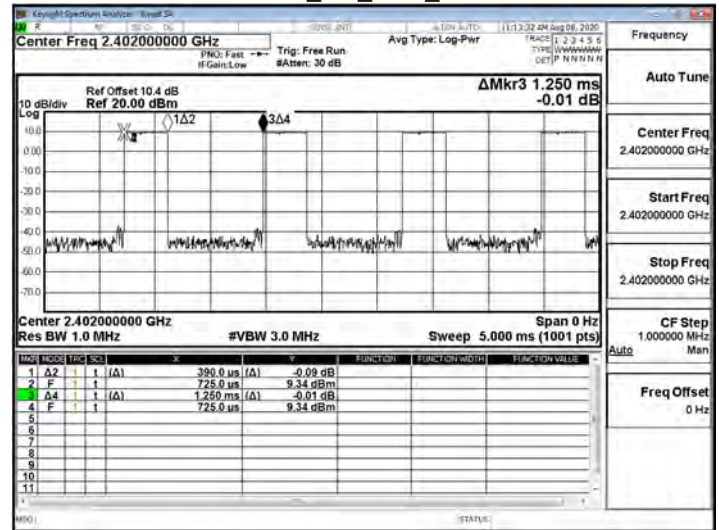


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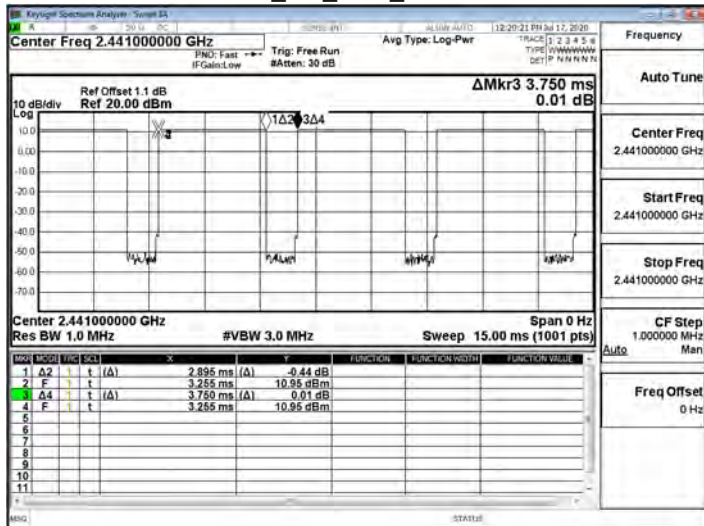
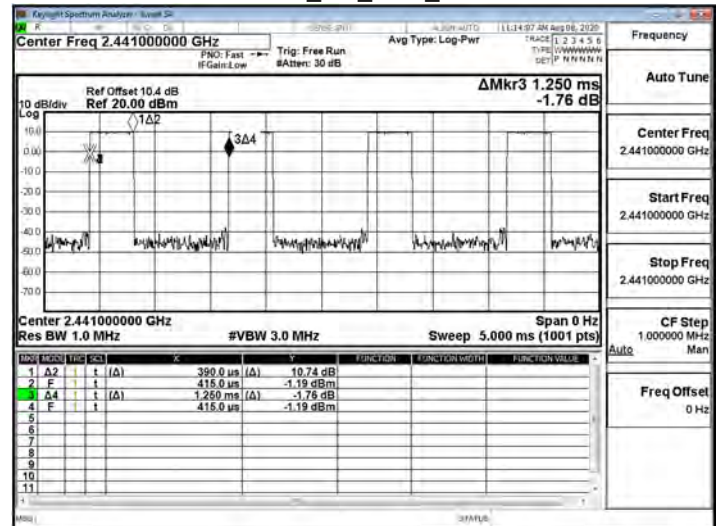
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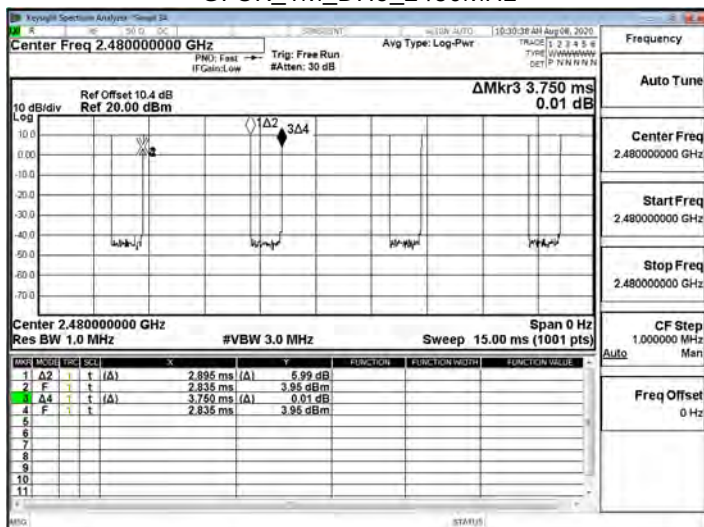
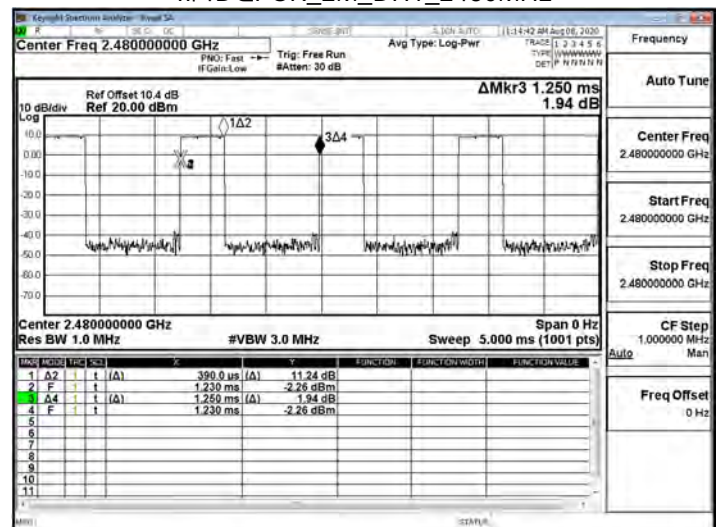
GFSK_1M_DH5_2402MHz


 $\pi/4$ DQPSK_2M_DH1_2402MHz


GFSK_1M_DH5_2441MHz


 $\pi/4$ DQPSK_2M_DH1_2441MHz


GFSK_1M_DH5_2480MHz

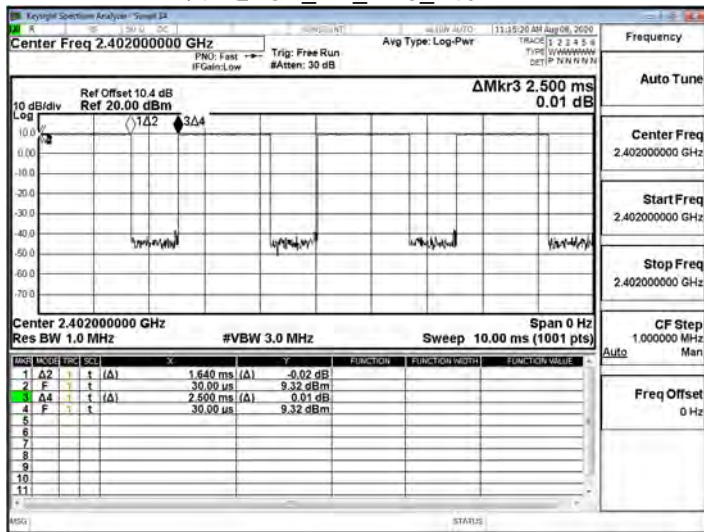

 $\pi/4$ DQPSK_2M_DH1_2480MHz


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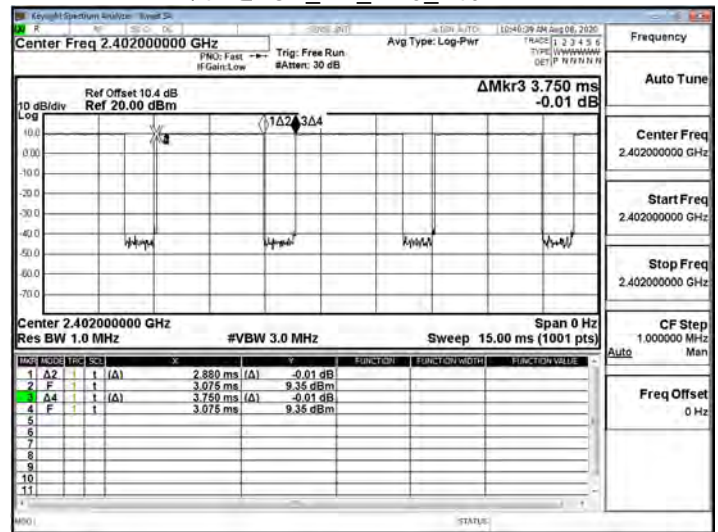
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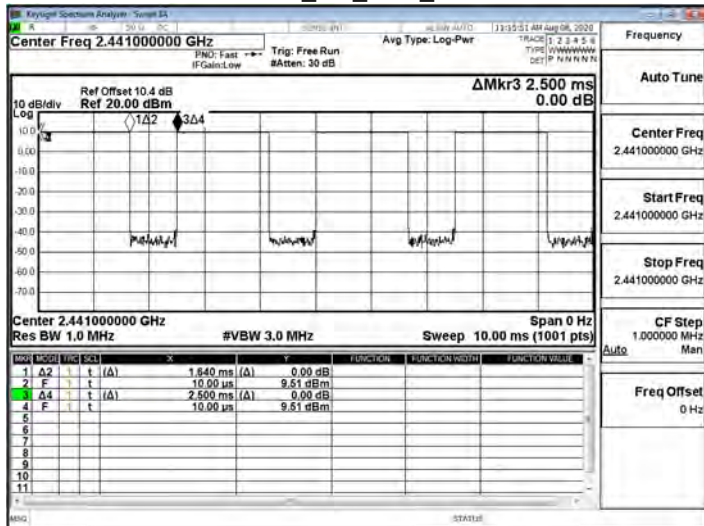
$\pi/4$ DQPSK_2M_DH3_2402MHz



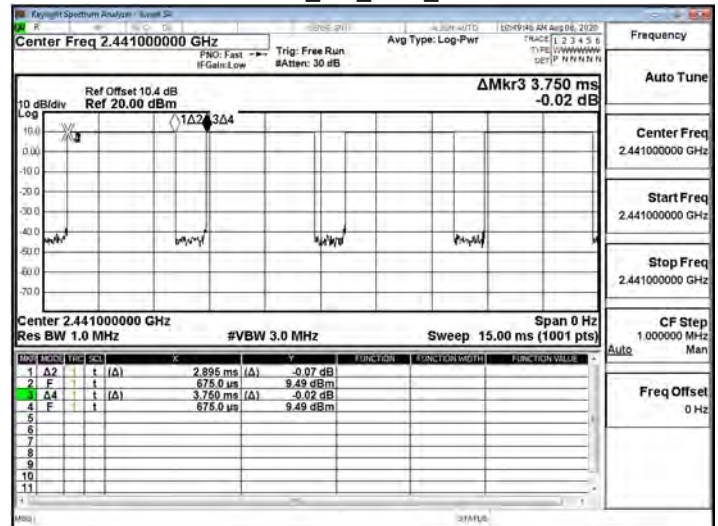
$\pi/4$ DQPSK_2M_DH5_2402MHz



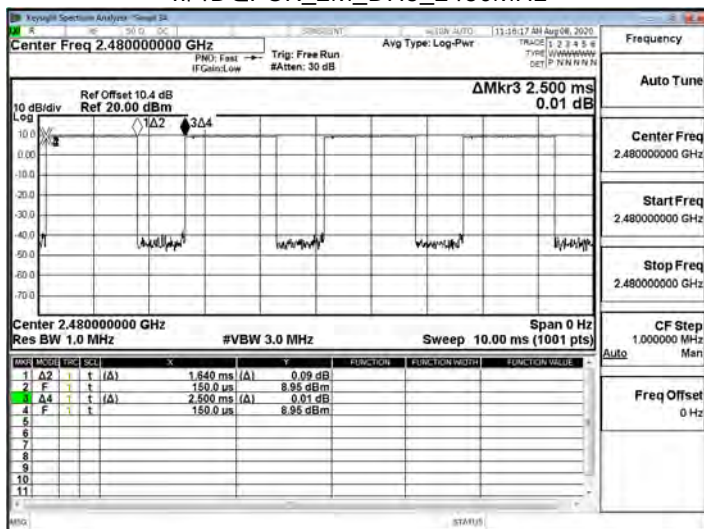
$\pi/4$ DQPSK_2M_DH3_2441MHz



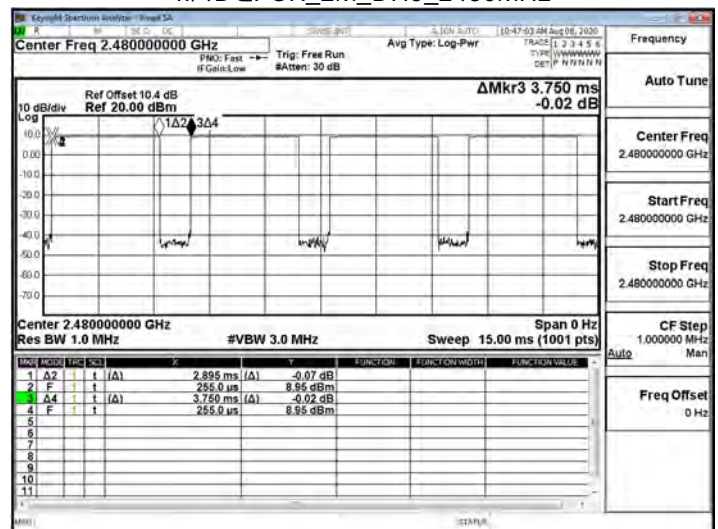
$\pi/4$ DQPSK_2M_DH5_2441MHz



$\pi/4$ DQPSK 2M DH3 2480MHz



$\pi/4$ DQPSK 2M DH5 2480MHz

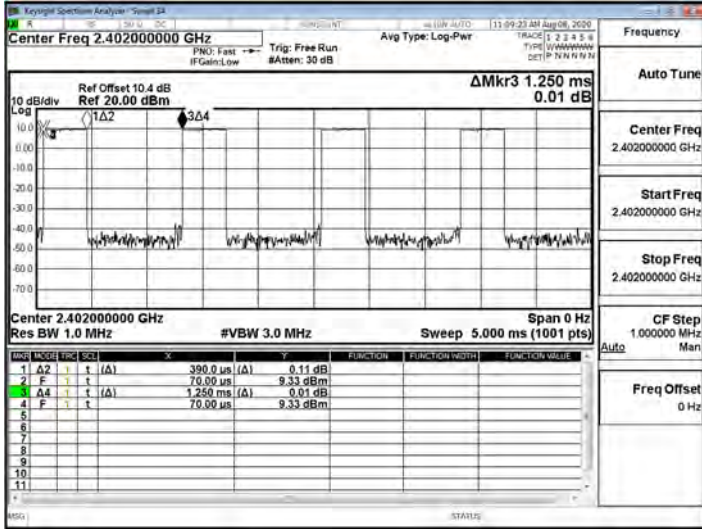


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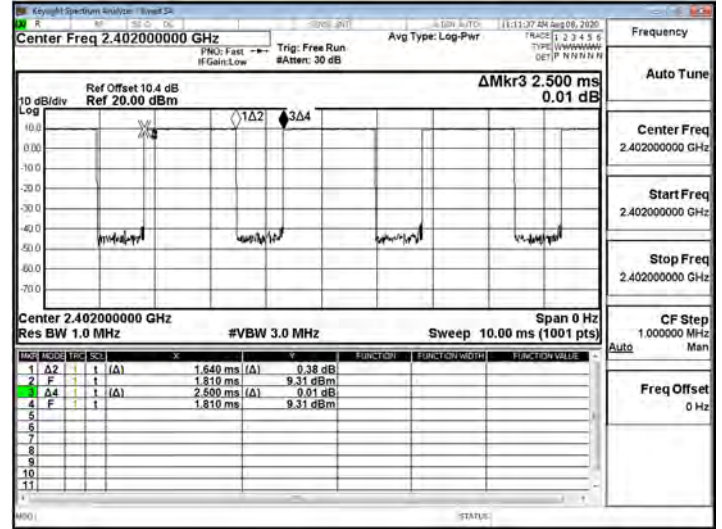
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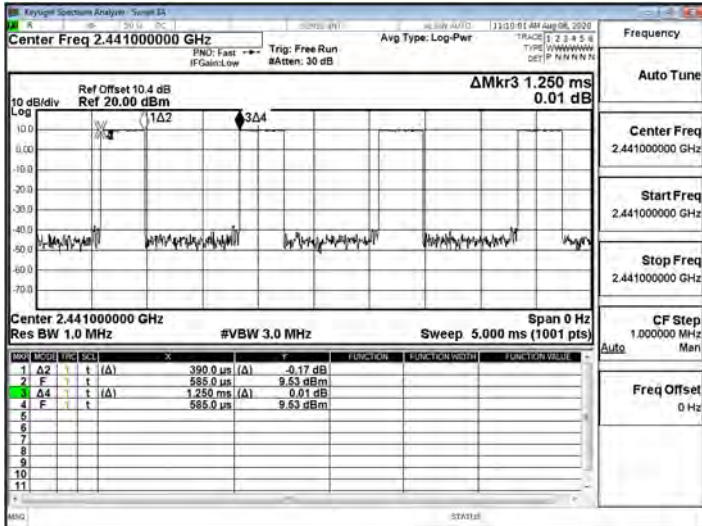
8DPSK_3M_DH1_2402MHz



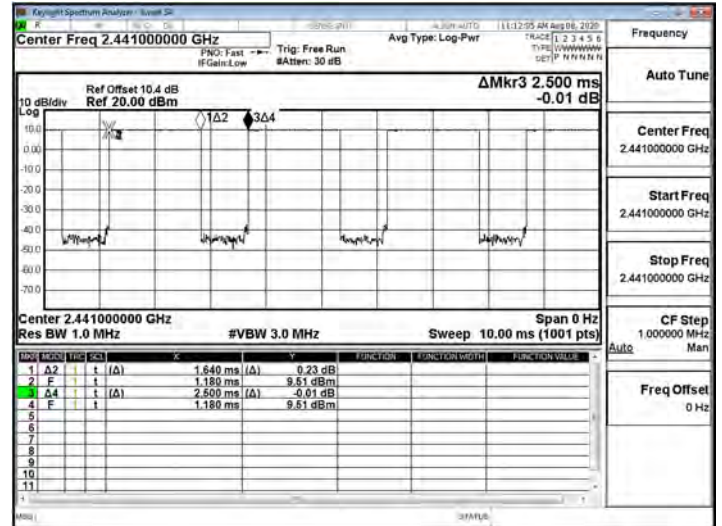
8DPSK_3M_DH3_2402MHz



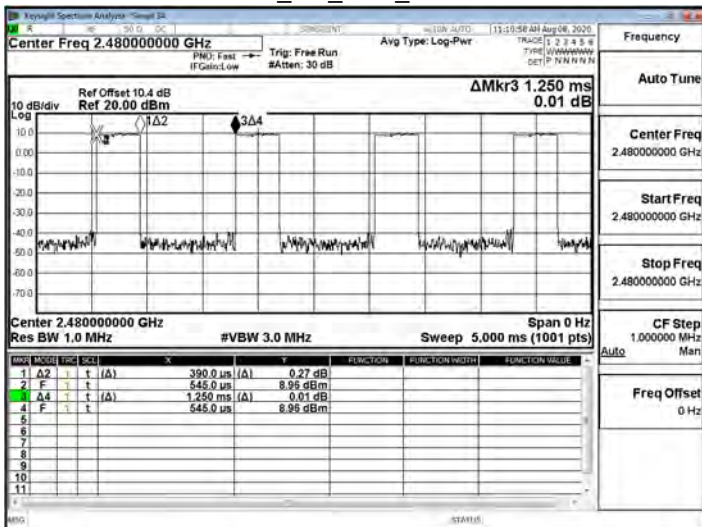
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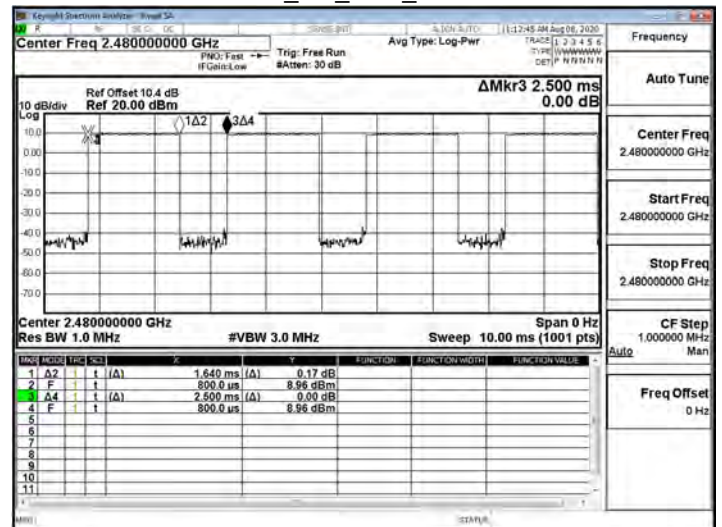
8DPSK_3M_DH3_2441MHz



8DPSK_3M_DH1_2480MHz



8DPSK_3M_DH3_2480MHz

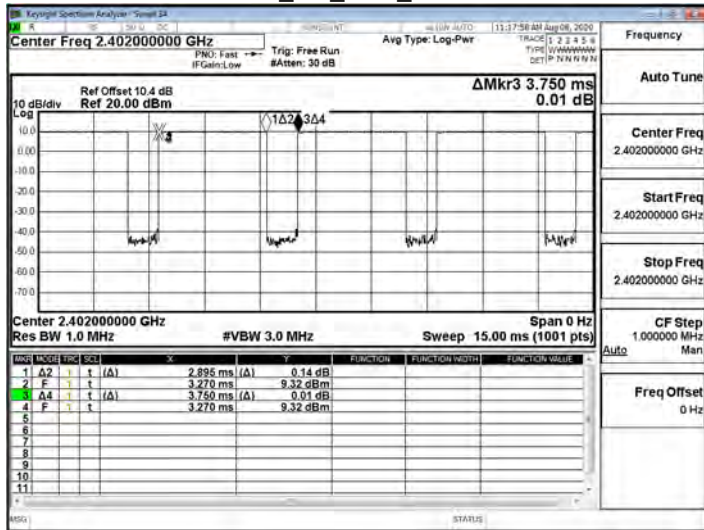


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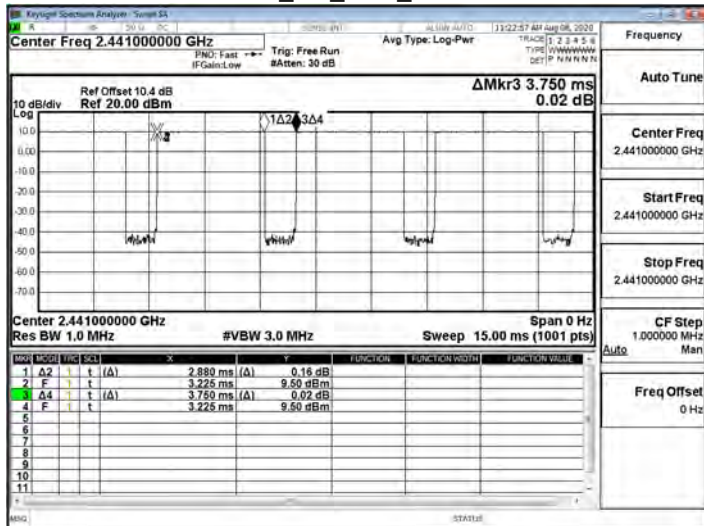
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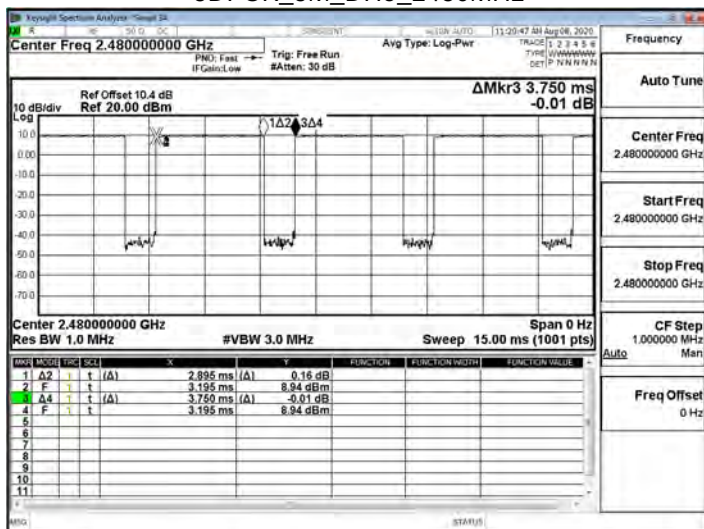
8DPSK_3M_DH5_2402MHz



8DPSK_3M_DH5_2441MHz



8DPSK_3M_DH5_2480MHz



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14 ANTENNA REQUIREMENT

14.1 Standard Applicable

For intentional device, according to §15.203, an intentional radiator shall be designed to ensure that no antenna other than furnished by the responsible party shall be used with the device.

If the transmitting antenna is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi.

14.2 Antenna Connected Construction

The antenna is designed as permanently attached and no consideration of replacement. Please see EUT photo for details.

~ End of Report ~

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